GEI Consultants

Consulting
Engineers and
Scientists

2023 Aquatic Biological Monitoring Report for Gold Run Creek and Whitewood Creek, South Dakota

January 2024

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Consulting Engineers and Scientists

Submitted to:
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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 (Sanford). This site was formerly the Homestake underground mine and has been converted into an underground research laboratory. Sanford is dewatering the underground facility with 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 Sanford and GEI Consultants, Inc. (GEI) to monitor the biological communities (Figure 1-1). Site locations are in accordance with the study plan developed for Sanford (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. Sampling has continued at Site WWC-B, on Whitewood Creek downstream of the confluence with Gold Run Creek, at the discretion of Sanford. 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 Sanford.

This report presents the fifteenth year of monitoring data for Site GR-A, the fourteenth year for sites GR-B and WWC-B, and the thirteenth year at Site WWC-A. Fish populations, benthic invertebrate populations, and periphyton populations were sampled by GEI on August 21-23, 2023 at these four sites. Habitat measurements were also taken, and Brown Trout tissues were retained for selenium analysis from both Whitewood Creek sites. The purpose of the continued monitoring on Gold Run and Whitewood Creeks is to identify any potential effects on biological communities in Whitewood and Gold Run Creeks resulting from discharge approved through the Sanford 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 2023 are presented and compared to data collected since 2009 (GEI 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023).

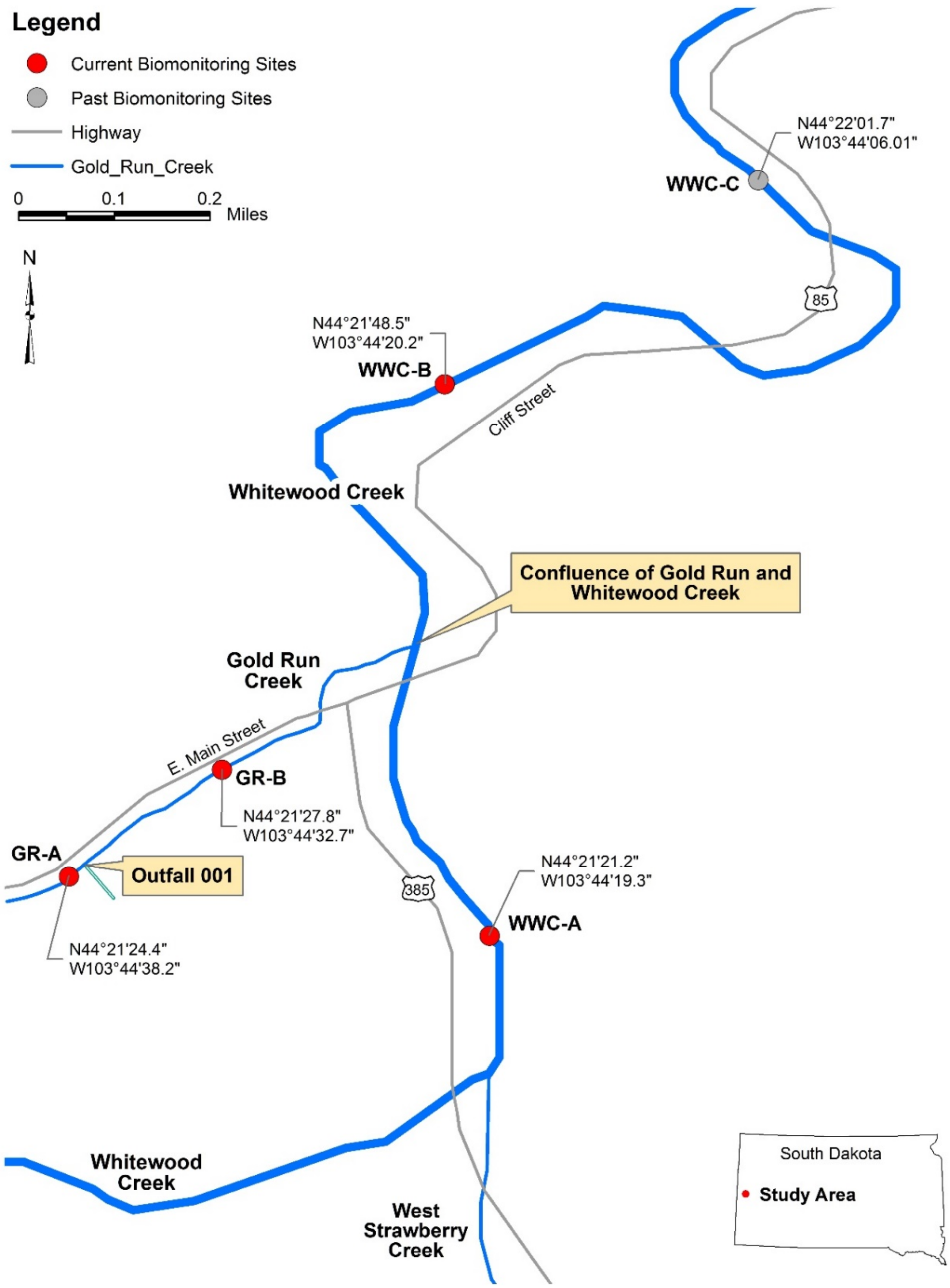

Figure 1-1: Current and past aquatic biological monitoring sites on Whitewood Creek and Gold Run Creek near Lead and Deadwood, South Dakota. GPS coordinates were collected at downstream site boundaries.

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 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 Sanford 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 Sanford (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, Sanford 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 Whitewood Creek

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 (USGS Gage 06436180) near the study sites is highest from April through June when average flows ranged from 38 to 56 cubic feet per second (cfs) from 2010 through 2019, and in the remaining months, average flow ranges between 4 and 36 cfs (USGS 2021). Within the study area, Whitewood Creek is a third order stream. The location of the two current 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.

2.1.2 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 Sanford’s Outfall 001 discharges into Gold Run Creek below the former 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

Site WWC-C on Whitewood Creek (Figure 1-1) was eliminated from the biological monitoring plan in 2017 but is described here for historical reference.

Site WWC-C 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 21-23, 2023. 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 2023 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 the four sites in August 2023. At the two sites on Whitewood Creek a total of three electrofishing passes were conducted as per protocol specified by SDGFP to allow an estimate of total fish density and biomass within each site. At the sites on Gold Run Creek, where fish are not 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 from moving into or out of the site until sampling was complete and the nets were removed.

Fish captured on each pass were kept in separate live cars before being identified, weighed, measured, and then released back into the site. Quantitative population estimates were calculated using the counts from each pass for each species. Population estimates were calculated with MicroFish 3.0, which uses a maximum likelihood estimator based on the depletion rates between passes (Van Deventer and Platts 1983, 1989). These data were then used to provide species lists, estimates of density (number of fish/ha), and estimates of biomass (kg/ha) for each site.

Lengths of individual fish were also used to generate length-frequency histograms. Histograms can help to detect missing age classes and to determine whether reproduction is occurring locally (Everhart and Youngs 1981; Anderson and Neumann 1996). Because of the limited mobility of young-of-the-year (YOY) trout relative to larger trout (Petty et al. 2005), YOY trout within a given site can be used as indicators of local reproduction.

Lengths and weights of individual fish were also used to calculate an average relative weight (W_r) value as described by Wege and Anderson (1978) and Anderson and Neumann (1996). To determine relative weight, measured fish weights were compared to length-specific standard weights constructed to represent the range of variation for a given species across its range. Relative weight values are only calculated for Brown Trout greater than or equal to 140 millimeters (mm) in length and Brook Trout that greater than or equal to 120 mm in length (Anderson and Neumann 1996). Expected values of the relative weight index have the same general range across species. Relative weight values generally fall between 70 and 130 (Murphy and Willis 1991). Relative weight values between 95 and 105 are considered optimal for most species (Anderson 1980; Anderson and Neumann 1996). Relative weight values were compared among sites to evaluate the health of the fish at these sites and to identify potential environmental stressors that may be affecting the populations.

Further analysis of Brown Trout populations at Site WWC-A and Site WWC-B was conducted using quartile analysis that examines current year density at each site compared to the historical density of each site up to and including the previous study year. Data collected at these two sites since the study began in 2010 were used to develop the quartile analysis. Brown Trout density quartile analysis was partitioned into two separate length-classes; one for individuals less than 150 mm in length and the other for individuals equal to or over 150 mm in length. This provides an additional way to describe the annual status of fish populations in relation to previous data.

Fish sampling from before 2010 was conducted at Site WWC-B by KNK Aquatic Ecology (KNK) from 1998 through 2000 (Knudson 2001). However, fish sampling by KNK did not consistently capture young-of-the-year (YOY), and these fish were not incorporated into fish population estimates by KNK. Therefore, KNK fish data are not completely comparable to GEI data from 2010 to present at this site and may have density and biomass values that are underestimates compared to the GEI data.

3.3 Fish Tissues

Brown Trout were collected for fish tissue analysis during fish population sampling. The intent was to collect five replicate whole-body Brown Trout samples at each site, provided that appropriately-sized fish were present. Attempts were made to collect fish of similar sizes, with the smallest fish being at least 75 percent of the length of the largest fish retained for tissue analyses. The fish targeted for these analyses over the years are those that are at least one year old and were mostly between 150 mm and 190 mm in length. In 2023, five fish each were collected from sites WWC-A and WWC-B and were all between 133 mm and 162 mm in length.

Whole-body fish samples were placed in separate zip locking plastic bags and were immediately stored on ice in a cooler. Upon completion of sampling, fish samples were shipped overnight to ACZ Laboratories (ACZ) in Steamboat Springs, Colorado, where they were analyzed for wet weight total recoverable selenium and percent solids. Dry weight selenium concentrations were calculated by dividing the wet weight selenium concentration by the percent solids for each sample. Both forms of whole-body concentrations are presented in this report.

Both prior to and following tissue sampling at each site, all equipment used to collect, hold, or measure fish and equipment that came in contact with water was thoroughly rinsed in stream water to avoid possible contamination between samples from different sites.

In June 2016, EPA published the final updated national chronic aquatic life criterion for selenium in fresh water (EPA 2016). This criterion consists of multiple elements: whole-body fish tissue, fish muscle, fish egg-ovary, and water column criteria. Fish tissue concentrations are given precedence over the water column concentrations when data for both are available. The fish collected from Whitewood Creek were analyzed as whole-body fish tissues and are thus comparable to the whole-body fish tissue criterion of 8.5 mg/kg dry weight (dw) value included in the final document.

Total selenium wet weight concentrations were analyzed using the M6020 ICP-MS method. The minimum detection limit using this method was 0.013 to 0.018 µg/g wet weight, depending upon samples analyzed.

3.4 Benthic Macroinvertebrate Populations

Benthic invertebrate samples were collected at each site in August 2023 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. Some samples required subsampling due to the large numbers of organisms (i.e., >300 organisms/sample). Subsampling included sorting at least 300 organisms from at least 20 percent of the sample, with a subsequent search for rare taxa in the remainder of the sample (Vinson and Hawkins 1996; Carter and Resh 2001). 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 2023 was 99 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.

3.4.1 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.

3.4.1.1 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 and Whitewood creeks, 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

3.4.1.2 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.

3.4.1.3 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.

3.4.1.4 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.

3.4.1.5 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, we also included the number of merovoltine taxa which require three or more years to complete their life cycle.

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).

3.5 Periphyton Populations

Periphyton samples were collected at the four monitoring sites on August 21-23, 2023 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.

3.6 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 and Whitewood creeks, 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

3.6.1.1 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.

3.6.1.2 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.

3.6.1.3 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).

3.7 Water Quality Monitoring

Water quality samples were collected at each of the biological monitoring sites by Sanford personnel on August 29, 2023. Results are included in Appendix D for reference.

3.8 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 2023 were compared to those from 2009 through 2022.

Fish population data, macroinvertebrate data, and periphyton data sometimes did not meet the assumptions of parametric tests (i.e., normal distribution and equal variance) and, therefore, nonparametric statistical methods were sometimes used to analyze data. These tests produced p-values which were considered significant when compared to an $\alpha = 0.05$ level.

Fish population density and biomass estimates were quantitatively compared among years. Relative weight values were also compared among years to evaluate the health of individual fish and to determine whether environmental stressors may be affecting the populations. Fish density and fish biomass were examined from 2009 (or 2010) through 2023 to identify any trends through time. Potential temporal patterns were identified by examining the graphs of density and biomass over the study period.

Potential trends in fish population data were evaluated with linear regression in NCSS 12 (2021). Linear regression analyses of long-term density and biomass were conducted to identify trends over the study period in these metrics.

Selenium levels in the replicate fish tissue samples from 2023 and from long-term data were compared among years and to the whole-body fish tissue thresholds of 11.6 µg/g dw and 8.5 µg/g dw. Linear regression analyses of selenium levels were conducted to identify possible long-term trends over the study period.

A single benthic macroinvertebrate sample was collected from each site. This lack of replicate sampling provides no measure of variance, and the usual non-normal distributions of macroinvertebrate metrics fail to meet assumptions required for statistical analyses. Therefore, these metrics were compared qualitatively. Metrics calculated in 2023 on Gold Run Creek were compared between the upstream control site, Site GR-A, and Site GR-B downstream of Outfall 001. Similar comparisons were made on Whitewood Creek between the control site, Site WWC-A, and monitoring Site WWC-B, downstream of the confluence with Gold Run Creek.

Within each site, the macroinvertebrate metrics were compared from 2009 (or 2010) through 2023 to identify any temporal patterns in the macroinvertebrate community. 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 ANOVA comparisons. Pairwise comparisons of means used a Tukey-Kramer adjustment for multiple comparisons Linear regression analyses were also conducted.

Similarly, periphyton samples consisted of one composite sample at each site, so statistical tests comparing 2023 data among sites are not feasible. Therefore, periphyton metrics calculated in 2023 were compared among sites but statistical analyses were not performed among 2023 samples.

Within each site, periphyton density and number of taxa metrics were compared from 2009 (or 2010) through 2023 to identify any temporal trends in the periphyton community. Long-term differences in means for periphyton density and number of taxa were identified statistically between sites using ANOVA analyses; pairwise comparisons of means used a Tukey-Kramer adjustment for multiple comparisons. Linear regression analyses were also conducted for density, number of taxa, and Shannon-Weaver Diversity values. 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, runs, and step runs were the most common habitat types at the Whitewood and Gold Run Creek sampling sites in 2023 (Table 4-1). All sites had at least one pool present during 2023 surveys, and one cascade at Site GR-A and one high gradient riffle at Site WWC-B were also found during habitat surveys.

Table 4-1: Habitat characteristics for sites on Whitewood Creek and Gold Run Creek, August 2023. HGR = high gradient riffle; LGR = low gradient riffle; RUN = run; SRN = step run; SLR = lateral scour pools formed by rocks; SMW, SMB = mid-scour pool formed by woody debris and boulders; SPW, SPB, SPC= plunge pools formed by woody debris, boulders, and a culvert; CAS = cascade; STP = step pool complex.

Site/Habitat Type	Number of Units	Total Length (m)	Average Water Width (m)	Average Depth (cm)
Whitewood Creek				
Site WWC-A				
LGR	2	50.7	6.0	28
RUN	3	33.2	4.7	31
SLR	1	7.9	6.8	45
SMW	1	15.5	4.7	50
Site WWC-B				
HGR	1	9.2	3.0	40
LGR	2	31.9	6.5	21
RUN	2	50.4	5.1	26
SLR	1	24.3	5.8	51
Gold Run Creek				
Site GR-A				
LGR	2	18.9	2.2	9
SRN	3	37.3	2.0	8
SLR	1	9.9	2.2	60
SPC	2	32.8	2.3	15
CAS	1	7.0	0.6	7
Site GR-B				
LRG	3	35.7	3.7	16
SRN	4	55.8	3.4	16
SPW	1	3.9	2.9	20
SPB	1	5.7	4.2	23
SMB	1	4.7	3.2	27

Pools found at the study sites were formed by bedrock, boulders, culverts, and large woody debris such as logs or downed trees. Diversity of habitat can increase the suitability of sites for both macroinvertebrates and fish, and pools act 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 had narrower wetted widths compared to the sites on Whitewood Creek. Gold Run Creek is a smaller, first-order stream and Whitewood Creek is a larger, higher order stream with multiple tributaries. Depths were also slightly shallower at the Gold Run Creek sites, aside from one deep pool 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 2023. Overhanging vegetation and undercut banks, which can serve as protective fish habitat, are not found at Site GR-A.

Figure 4-1: Site GR-A as viewed from the shoulder of State Highway 85, August 2021.

Site GR-B has more riparian vegetation, particularly in the lower reach of the site, but exposed rock is abundant, and gabions border the stream adjacent to the roadway for the upstream half of this site. 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 wider wetted widths than at the upstream control site.

Site WWC-A has abundant riparian vegetation along the entirety of its reach, with grasses, sedges, forbs, willows, and trees all present in the riparian area. No undercut banks were found at this site, but a small amount of overhanging vegetation was present. A small amount of exposed bank was observed at this site. Streamflow at this site, and at Site WWC-B, is much higher than on both Gold Run Creek sites. No turbidity was evident at this site.

Streambanks at Site WWC-B were heavily vegetated, with grasses, sedges and forbs, willows, and trees all present along portions of the reach. A small percentage of this vegetation is overhanging, providing additional aquatic habitat for fish within this reach. A few areas of exposed banks were observed but these comprised only a small portion of the reach, similar to Site WWC-A. No turbidity was evident at Site WWC-B, and flow was slightly higher than at Site WWC-A due to inflows from Gold Run Creek.

Boulders and bedrock were the most common substrate type at Site GR-A, while coarse sediments, gravel, and rubble were common at Site GR-B (Table 4-2). On Whitewood Creek, rubble, coarse sediment, and gravel were the dominant substrate types at Site WWC-A. Bedrock, rubble, and coarse sediments were the most abundant substrate sizes at Site WWC-B (Table 4-2). Fine sediments were relatively sparse at all sites, with slightly higher values at the Gold Run Creek sites.

Table 4-2: Substrate characteristics for sites on Whitewood and Gold Run creeks, August 2023. 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
Whitewood Creek						
Site WWC-A	6	3	23	32	33	9
Site WWC-B	21	4	22	19	24	31
Gold Run Creek						
Site GR-A	16	17	16	18	14	35
Site GR-B	11	6	42	20	24	8

Surface fines percentages were lowest at Site WWC-A and slightly higher at the remaining sites; however, average surface fine percentages were below 25% at all sites, indicating a lack of impacts due to fine sediments at these sites (Table 4-2). 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 all four sites showed a diversity of particle sizes.

Year-to-year variation in fine substrate metrics (surface fines and fine sediment) in Whitewood Creek and 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 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 all sites except Site WWC-A in 2022. In 2023, multiple rain events led to numerous spikes in stream flow during the summer months. Percentages of surface fines and fine sediments were lower at all sites than during the previous year. Year to year variations in fine sediment percentages may be influenced by inputs from the roadway adjacent to both Whitewood Creek and Gold Run Creek as well as the flow regime during a given year.

Site GR-A has much lower discharge than Site GR-B, and both sites on Gold Run Creek have much lower flows than Sites WWC-A and WWC-B on Whitewood Creek. 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. This was not as evident during 2023, however.

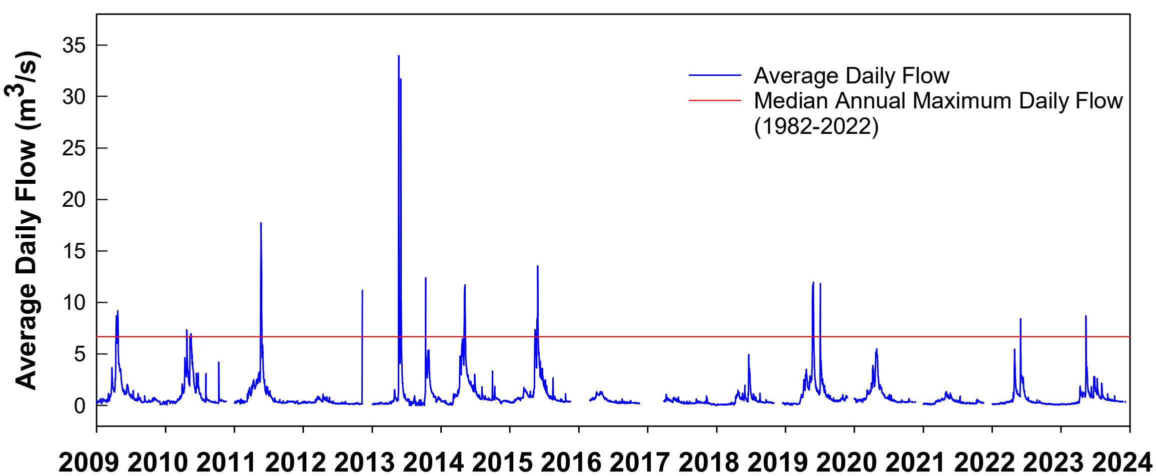

Figure 4-2: Average daily flow (in m^3/s) on Whitewood Creek from January 2000 through December 2023 (USGS 2023). Data are from USGS Gage 06436180 upstream of Whitewood, South Dakota. Median annual maximum flow from 1982 through 2022 is also presented for comparison.

Overall, the habitat at sites on Gold Run Creek are less suitable for abundant and varied macroinvertebrate populations and fish habitat than at the sites on Whitewood Creek. 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 in Whitewood Creek and Gold Run Creek have been mostly consistent over time since monitoring began and do not indicate negative impacts due to Outfall 001.

4.2 Fish Populations

4.2.1 2023 Data

Fish have never been collected from either site on Gold Run Creek during the study period, including during 2023 surveys. Brown Trout and Longnose Dace (*Rhinichthys cataractae*) were collected from sites WWC-A and WWC-B, although only a single dace was observed at the downstream site (Table 4-3, and Appendix A). Additionally, 9 Brook Trout (*Salvelinus fontinalis*) were collected from Site WWC-A, and one Mountain Sucker (*Catostomus platyrhynchus*) was collected at Site WWC-B during August 2023 sampling.

Brown Trout were the most abundant species at both sites (Table 4-3). Longnose Dace were present in low numbers at both sites, and only one Mountain Sucker was found at Site WWC-B, similar to the low numbers found in many previous sampling events at this location. Longnose Dace and Mountain Suckers are both fish species native to the Black Hills region of South Dakota and are listed as a heritage species with a restricted range or number of occurrences within South Dakota.

Table 4-3: Fish population parameters for sites on Whitewood Creeks, August 2023. "--" = not available.

Site/Species	Number Collected	Mean Length (mm)	Mean Weight (g)	Density (#/ha ± 95 percent C.I.)	Biomass (kg/ha)	Mean Wr
Whitewood Creek						
Site WWC-A						
Brook Trout	9	107	16	143 ± 32	2.3	80.8
Brown Trout	111	160	55	1,762 ± 16	97.6	90.6
Longnose Dace	9	66	3	127 ± 32	0.4	--
Site WWC-B						
Brown Trout	64	183	81	1,063 ± 95	86.0	91.4
Longnose Dace	1	99	11	16 ± 0	0.2	--
Mountain Sucker	1	209	122	16 ± 0	2.0	--

Length frequency analyses indicated the presence of multiple year classes of Brown Trout in 2023 at both Whitewood Creek sites (Figure 4-4, Figure 4-4). Brown Trout YOY (fish less than 1 year old; typically 100 mm or less), juveniles, and adults were collected over a wide range of sizes at both sites. Brown Trout YOY were common at both Site WWC-A and Site WWC-B, suggesting that spawning takes place within or near both sites in the fall, and that many newly hatched trout survived to be captured in our surveys in August 2023. Brook Trout were also present over wide range of sizes at Site WWC-A, with YOY also being found. No Brook Trout were collected at Site WWC-B in 2023.

The magnitude of peak flows during runoff can influence the abundance of YOY in a given stream (Chadwick et al. 2004). Strong spring runoff periods and higher flows overall displace YOY and can result in years with lower YOY survival, such as in 2019. However, in 2020 runoff was slightly below normal and in 2021 was well below normal (Figure 4-2), which led to higher numbers of YOY trout being collected in these years. Peak flows were higher in 2022, but YOY numbers remained relatively high (Figure 4-4, Figure 4-4). In 2023, more high flow events occurred after summer rainstorms and numbers of YOY trout were much lower than in 2021 and 2022. Competition with or predation by high numbers of trout may also lead to increased YOY mortality in some years.

The biomass estimates for the combined Brook Trout and Brown Trout biomass in 2023 at sites WWC-A and WWC-B (Table 4-3) were both greater than the average Rocky Mountain Region biomass of 77 kg/ha (Platts and McHenry 1988). Although South Dakota is not located in the Rocky Mountains, Whitewood Creek has characteristics similar to many Rocky Mountain streams with respect to size, geomorphology, and fish species. Therefore, estimates of trout biomass from the Rocky Mountains are appropriate for comparison to Whitewood Creek. The high biomass values measured at sites WWC-A and WWC-B indicate that conditions are favorable to support abundant and healthy Brown Trout populations, and biomass values in many years are above this 77 kg/ha benchmark at sites WWC-A and WWC-B.

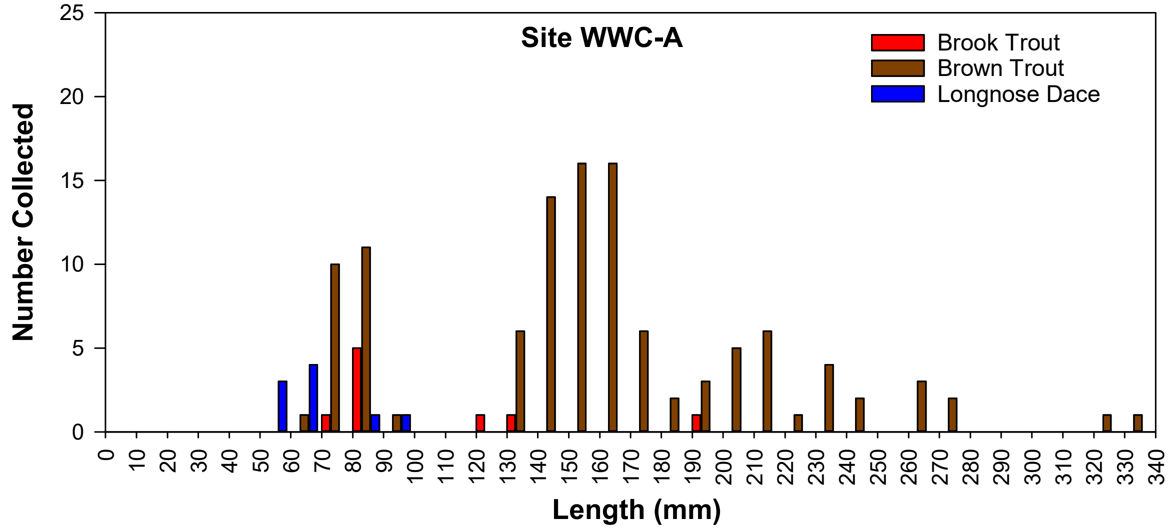

Figure 4-3: Length-frequency histograms for Brook Trout, Brown Trout, and Longnose Dace collected at Site WWC-A, August 2023.

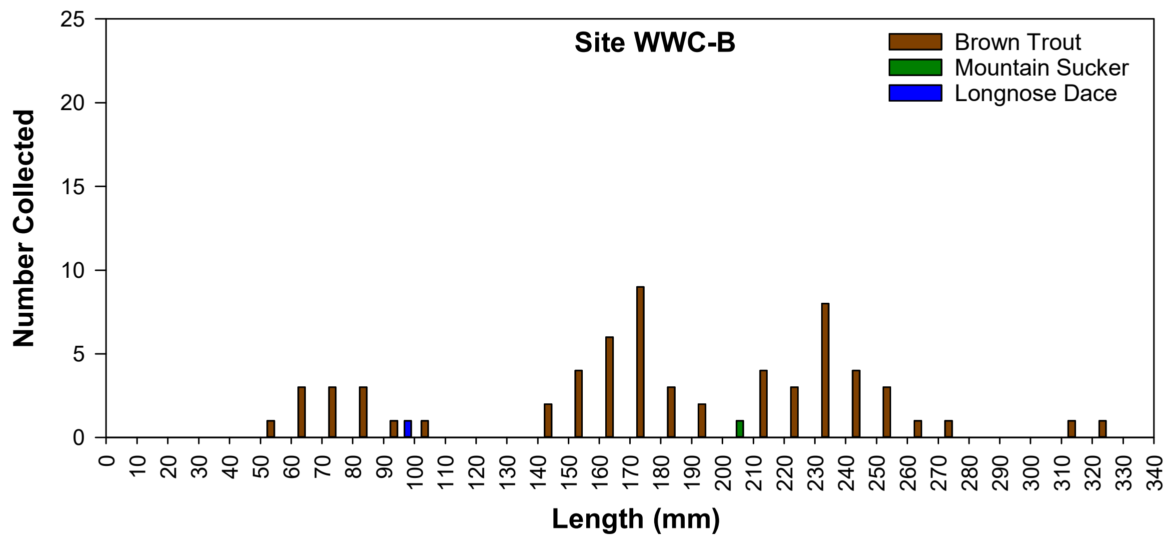

Figure 4-4: Length-frequency histograms for Brook Trout, Brown Trout, Mountain Suckers, and Longnose Dace collected at Site WWC-B, August 2023.

The presence of numerous age classes of Brown Trout at sites WWC-A and WWC-B indicates conditions are favorable for trout survival and growth within Whitewood Creek both upstream and downstream of the confluence with Gold Run Creek. Brown Trout were more numerous with higher density and biomass at Site WWC-A, as is sometimes observed (Figure 4-5), but biomass and density values were favorable at both sites during 2023 sampling (Table 4-3). This indicates no adverse effects from discharge to Gold Run Creek.

The mean relative weight values for both Brook and Brown Trout at both Whitewood Creek sites was below the optimal management range of 95 to 105 (Table 4-3), with a slightly higher relative weight for the Brown Trout at Site WWC-B than for those at Site WWC-A.

This could indicate that habitat or forage are more favorable or plentiful, respectively, when compared with Site WWC-A.

One large adult Mountain Sucker was collected at Site WWC-B. Mountain Suckers are often found in Whitewood Creek during sampling events, though not in high numbers. It appears that Mountain Suckers occur in low numbers in Whitewood Creek within and near sites WWC-A and WWC-B. Longnose Dace are also present throughout Whitewood Creek in varying levels of abundance.

4.2.2 Long-Term Data

Monitoring has occurred from 2009 to 2016 and in 2019 through 2023 at Site WWC-A, and from 2010 to 2023 at Site WWC-B. Brown Trout, the dominant species, have been collected from sites WWC-A and WWC-B on Whitewood Creek in all study years. YOY Brown Trout have also been collected in all years. Brook Trout have been collected at lower numbers than Brown Trout at Site WWC-A in all years and collected during some years at sites WWC-B. Multiple age-classes of Brook Trout are often found, indicating Brook Trout also reproduce successfully in Whitewood Creek (GEI 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023). YOY Brook Trout were collected at Site WWC-A in all years but 2012 and 2016. A few were also collected at Site WWC-B in 2010 and 2011.The higher numbers of Brook Trout at Site WWC-A, when compared to numbers at Site WWC-B, suggest that Brook Trout maintain larger populations in Whitewood Creek upstream of the confluence with Gold Run Creek. The downstream edge of their distribution is likely near Site WWC-A and is also likely influenced by competition with Brown Trout (e.g., Taniguchi et al. 1998). One Rainbow Trout was collected during sampling in 2016. Rainbow Trout occurring in Whitewood Creek are likely either stocked or escaped from a private pond; they are not known to naturally reproduce in Whitewood Creek.

Mountain Suckers and Longnose Dace, two fish species native to the Black Hills, also inhabit Whitewood Creek and have been collected intermittently over the study period. Mountain Suckers have been collected in low numbers at Site WWC-B in 2010, 2011, 2014, 2015, and 2017 through 2023, and Longnose Dace are often present in low numbers at one or more sites (GEI 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023). Densities of Mountain Suckers may be limited by available habitat or due to predation by trout (Belica and Nibbelink 2006). Longnose Dace inhabit the transition zone between mountain and plains streams, and their range does not extend up far into the mountains (Baxter and Stone 1995). In recent years, Mountain Suckers are present more often in sites downstream on Whitewood Creek (WWC-B, WWC-C) when compared to Site WWC-A, indicating that the locations of the study sites on Whitewood Creek may be near their upstream limit, or that conditions downstream of the confluence with Gold Run Creek are more favorable for Mountain Suckers. Mountain Suckers have been found at elevations of up to 10,000 feet, but their preference for lower gradients and instream cover (Belica and Nibbelink 2006) may limit their density in sections of Whitewood Creek.

Previous to the initiation of monitoring by GEI, sites WWC-A and WWC-B were also sampled in June 1998, 1999, and 2000 by KNK following an accidental release of slurry and process solution on May 29, 1998 into Gold Run Creek by Homestake Mining Company (Knudson 2001). Slurry and process solution were carried downstream through Gold Run Creek into Whitewood Creek. At the time of post-spill sampling in June 1998 trout were abundant at Site WWC-A, upstream of Gold Run Creek (Figure 4-5), but no fish were collected from Site WWC-B, downstream of the spill (Figure 4-6).

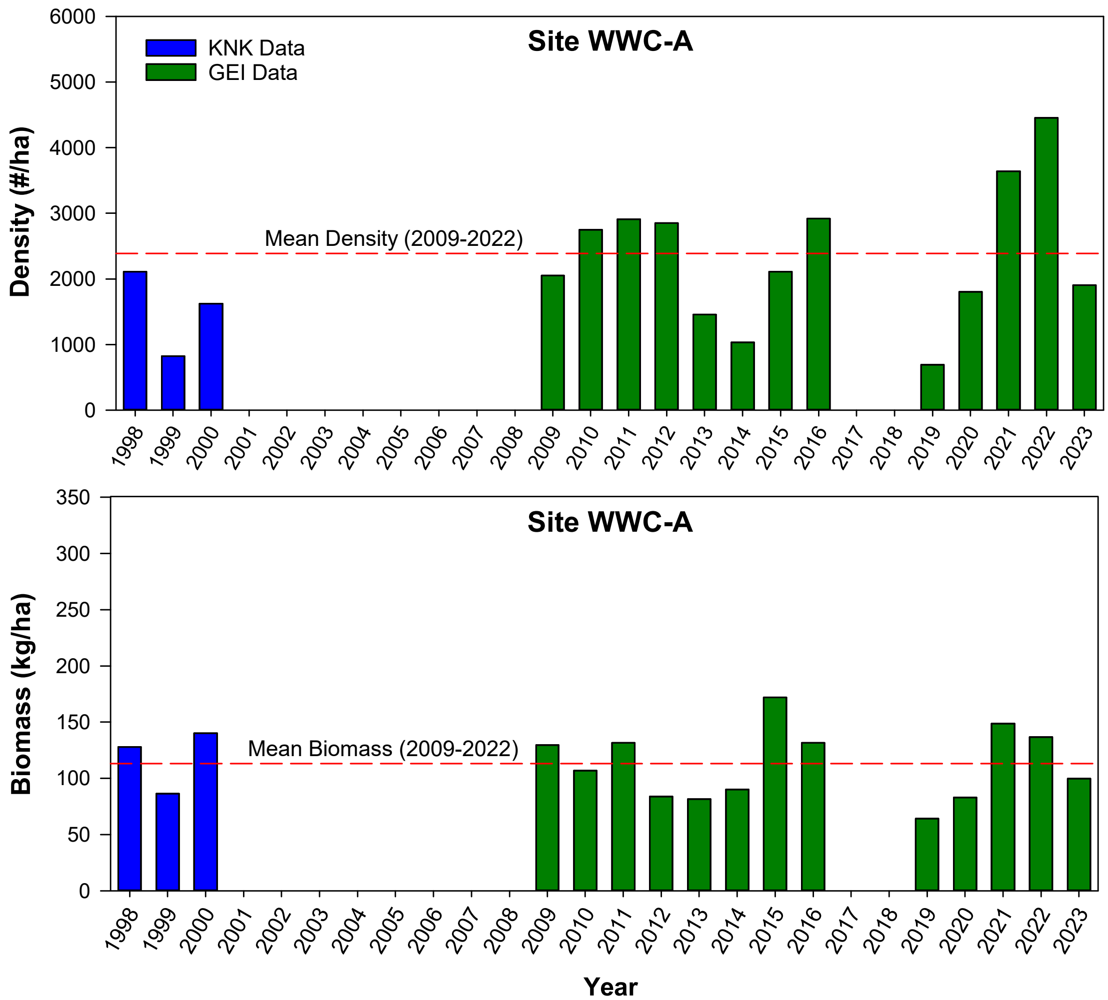

Figure 4-5: Long-term trout density and biomass values at Site WWC-A on Whitewood Creek, 1998-2023.

In 1999 and 2000, Brown Trout, Brook Trout, Mountain Suckers, and a single Longnose Dace were collected at Site WWC-B (Knudson 2001). Increases in both density and biomass of resident trout increased substantially from 1999 to 2000 at this site (Figure 4-6). Total trout density and biomass (Brown Trout plus Brook Trout) at Sites WWC-A and WWC-B in 1999 and 2000 were within the range of values observed by GEI from 2009 to present (Figure 4-5; Figure 4-6).

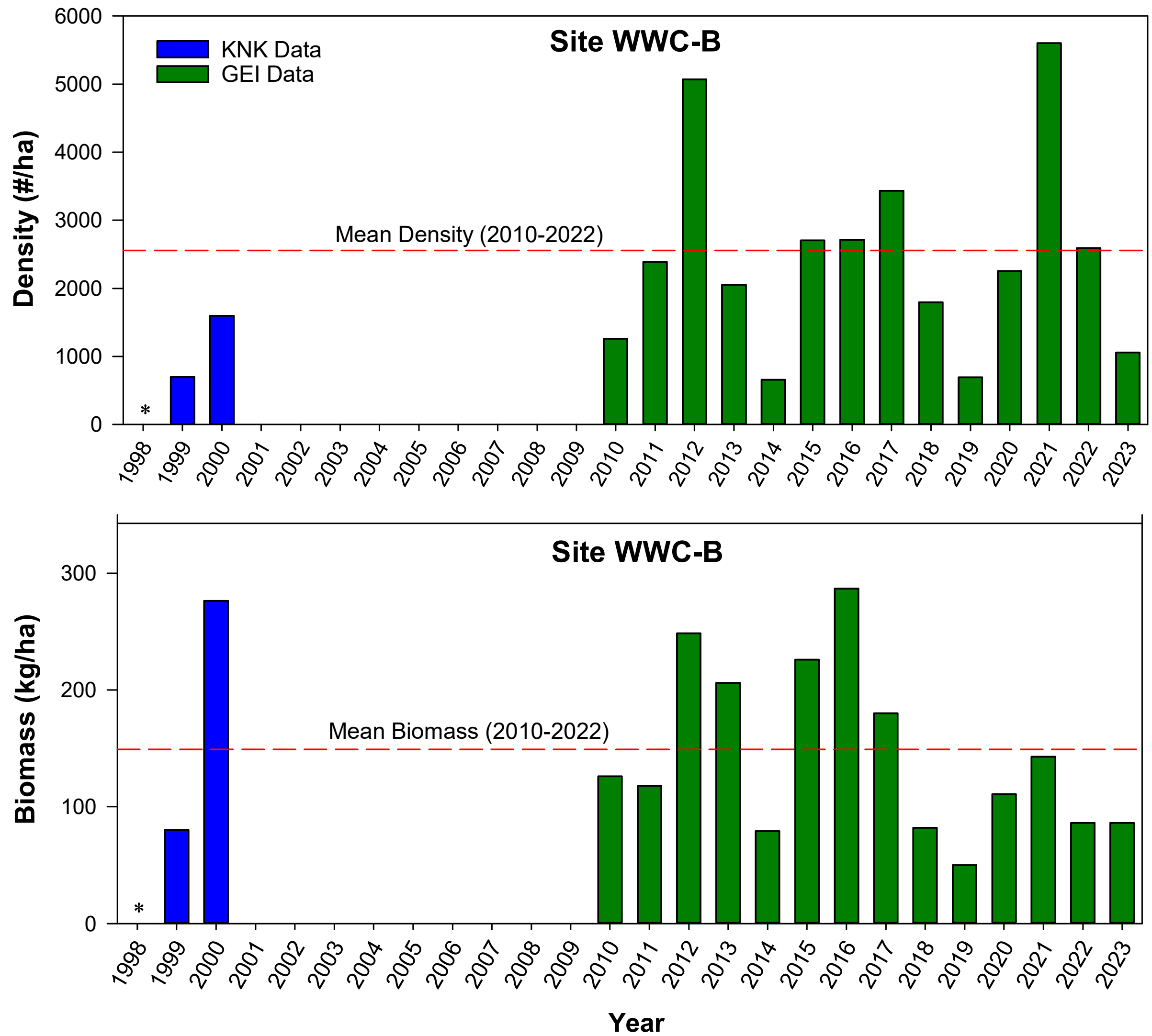

Figure 4-6: Long-term trout density and biomass values at Site WWC-B on Whitewood Creek, 1998 through 2023. * = No fish collected during 1998 sampling.

Density and biomass values for trout in 2021 and 2022 at Site WWC-A were substantially higher than in 2019 and 2020, and above the long-term mean values for both metrics (Figure 4-5). Density at Site WWC-A was the highest value measured in all years of sampling in 2022. Both density and biomass decreased from 2022 to 2023 at Site WWC-A, with a larger relative decrease in the density value. Density can be influenced by high numbers of YOY trout in some years, including 2021 and 2022 when high numbers of YOY Brown Trout were found at Site WWC-A (Figure 4-5). In 2023, much lower numbers of YOY trout were found.

At Site WWC-B, following the accidental spill in 1998, density in 1999 was still at the low end of the measured range of values, and total trout biomass in 1999 was slightly greater than the lowest value observed by GEI. Total trout biomass in 2000 at this site remains one of the highest values observed (Figure 4-6). The data from 1998 through 2000 demonstrate how quickly this reach of Whitewood Creek can recolonize by multiple fish species following substantial reduction in populations or local extirpation.

Relatively low density in 2010 at Site WWC-B was caused by severe thunderstorms and scouring flows a few days before sampling. However, lower spring runoff in 2012 contributed to a large YOY class, and much higher observed trout density at this site. Brown Trout density and biomass at Site WWC-B in 2019 were relatively low when compared to long-term means, similar to Site WWC-A (Figure 4-6, Figure 4-6). Lower density and biomass values at both sites in 2019 may have been partially due to higher spring peak flows (Figure 4-2). Density at Site WWC-B in 2021 was the highest value recorded since sampling began, due in large part to the high numbers of YOY trout collected at this site, similar to Site WWC-A. Conditions in fall 2020 and spring and summer 2021 were favorable to support the hatching and survival of high numbers of Brown Trout in Whitewood Creek in the vicinity of the confluence with Gold Run Creek. Density and biomass values both decreased from 2021 to 2022 at Site WWC-B, but trout populations remained abundant. In 2023, density decreased notably at Site WWC-B but biomass remained roughly the same; the decrease in density was due to a much lower number of YOY trout at this location when compared to 2021 and 2022. A similar decrease in YOY trout was noted at Site WWC-A in 2023 when compared to the previous two years of fish data. Juvenile trout were still found at both locations, but numbers were likely reduced by multiple high flow events due to rainstorms during 2023 (Figure 4-7).

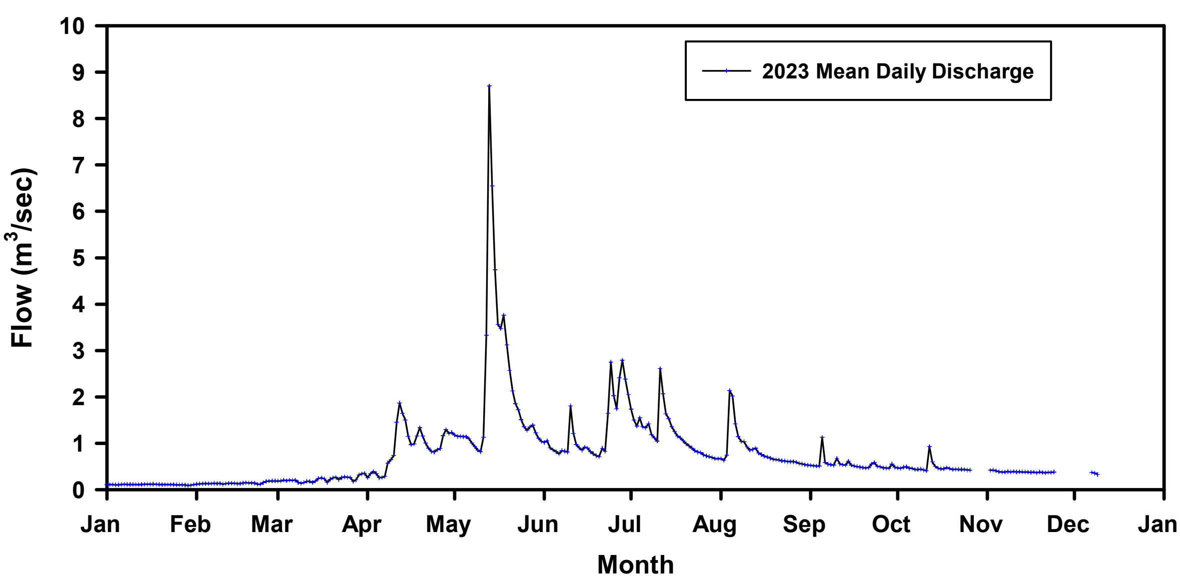

Figure 4-7: Average daily flow (in m^3/s) on Whitewood Creek during 2023. Data are from USGS Gage 06436180 upstream of Whitewood, South Dakota.

Density and biomass have fluctuated over the study period, and both metrics tend to either rise or fall together from year to year. Over time, years of lower density and biomass have often been followed by years of substantially higher values. These patterns are likely the result of variations in weather and flow conditions that negatively influence fish population metrics from year to year, followed by increased reproductive success and recruitment in the following years, such as 2020, when conditions improve and competition among the remaining adult trout is lessened due to decreased density. Density and biomass have varied throughout the study period but no statistically significant increasing or decreasing trends have been identified for either metric ($p \geq 0.614$, $p \geq 0.156$, respectively) at sites WWC-A and WWC-B, indicating that although annual fluctuations occur, overall conditions in Whitewood Creek remain favorable to support abundant trout populations.

Low recruitment of YOY fish can occur in high-flow years (Latterell et al. 1998), particularly in confined streams with limited floodplains, such as the study reach of Whitewood Creek. Spring flows were very high in 2013, and a large storm event occurred in fall 2013 (Figure 4-2), which coincides with the spawning period of both Brook Trout and Brown Trout. This increased mortality and displacement downstream, especially of YOY, and produced lower population estimates in 2013 and 2014. It is also likely that high flows in the fall of 2013 interrupted spawning and the incubation period of Brook Trout and Brown Trout and limited the number of YOY in 2014. Peak spring flows in 2012, and 2016 through 2018, were lower than most since 2000, and YOY year classes were relatively strong in these years. In 2019, peak flows were relatively high and YOY numbers were reduced in this year when compared to 2018. But in 2020 and 2021, there were abundant YOY at both sites, likely aided by the below average spring runoff flows. Similar patterns occur in other streams in the area monitored by GEI. In 2022, peak flows were higher but YOY trout were again abundant. In 2023, multiple storm events led to numerous spikes in flow in May through August, leading to decreased numbers of YOY trout at both Whitewood Creek locations (Figure 4-7).

Mean relative weights for Brown Trout at sites on Whitewood Creek have been variable since 2010. Lower relative weight values were measured in 2018 and were likely due to a decrease in habitat and food availability due to an extended period of low flows and possibly warmer water temperatures. These warmer, low flow conditions in 2018 may have caused physiological stress and reduced the average relative weight value at Site WWC-B. Fish data were not collected at Site WWC-A in 2018; however, in 2019 the mean relative weight value for Brown Trout at this site was favorable and relatively high, indicating a lack of stressors and favorable forage at Site WWC-A. In 2020 through 2023 relative weights at both sites have been comparable and slightly lower than the optimal management range. However, average relative wight values have been slightly higher at Site WWC-B than at Site WWC-A, which could indicated more favorable growing conditions for trout at this location downstream of the confluence with Gold Run Creek.

In 2023, as a result of the reduced numbers of YOY, trout density quartile analysis shows density of Brown Trout 149 mm or smaller at Site WWC-A was near the 25th percentile value. The density of this size class was near the previous minimum value at Site WWC-B (Figure 4-8). After very strong year classes of both Brook and Brown Trout in 2020, 2021, and 2022, density of smaller trout was reduced in 2023. The flow regime on Whitewood Creek in 2023 (Figure 4-7), as well as inter and intraspecific competition among these smaller trout from the past several years may have reduced abundances of trout 149 mm or smaller in 2023.

For trout over 150 mm, density in 2023 was moderate at Site WWC-A, falling between the 50th and 75th percentiles (Figure 4-8). Numbers at Site WWC-B were between the 25th and 50th percentile values for this site. Numbers of this larger size class do not tend to fluctuate as widely as the smaller size class from year to year, as evidenced by the narrower range from minimum to maximum density values when compared to the smaller size class (Figure 4-8). Also, mortality for early life stages of fish is often high, and numbers of small fish, particularly YOY, can be influenced strongly from year to year by high flow events and conditions during and after the fall spawning event while the trout eggs are incubating. Fluctuations in mortality for larger fish are less severe.

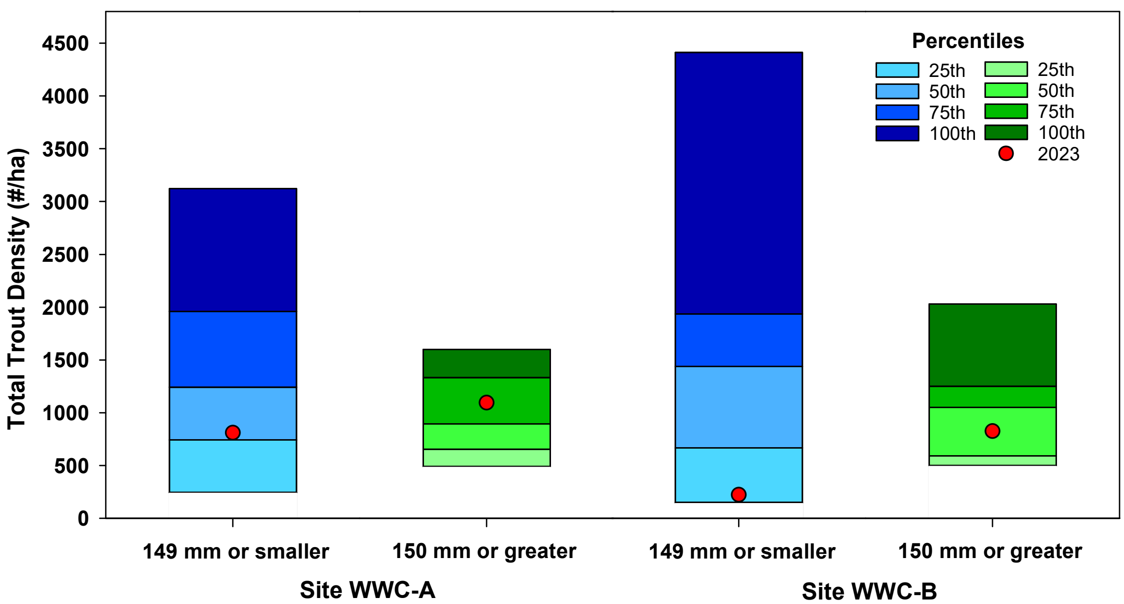

Figure 4-8: Quartile plots of long-term trout density at sites WWC-A and WWC-B from 2010 through 2022, with 2023 values represented by red dots. TL = total length

On Gold Run Creek, fish have never been collected at sites GR-A or GR-B (GEI 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023). In most years, Site GR-A has insufficient flow to support fish. Site GR-B supports better flow, habitat, and water quality (Appendix D) but fish are also absent from this site. The culvert under the road at the mouth of Gold Run Creek is a barrier preventing upstream fish migration from Whitewood Creek into Gold Run Creek, preventing colonization of this reach. The segment between the mouth of Gold Run Creek and Outfall 001 is only 0.5 km long and likely too short a segment to support self-sustaining fish populations (e.g., Young et al. 2005). Small stream sections may not sustain adequate fish population size necessary to maintain or recolonize an area after stochastic events (flood, mudslide, etc.).

Whitewood Creek supports self-sustaining fish populations, with successful spawning and recruitment observed in all years. Brook and Brown Trout population density and biomass have fluctuated over time in response to natural variations in flow and runoff but overall conditions to support fish since 2009 have been stable. Site WWC-B continues to support a healthy trout population as well as native fish species such as Mountain Suckers and Longnose Dace. No impacts on fish populations downstream of Outfall 001 have been observed at Site WWC-B.

4.3 Fish Tissues

4.3.1 2023 Data

Five Brown Trout were collected from sites WWC-A and WWC-B in 2023 for selenium whole-body tissue analysis (Table 4-4). The fish were similar in size, ranging from 133 mm to 162 mm in length. Brown Trout of this size are thought to be age-1 fish, which have likely spent most of their life in the vicinity of the individual study sites and have tissue concentrations representative of trout that inhabit the study site.

Table 4-4: Percent solids and selenium concentrations in whole-body Brown Trout for Whitewood Creek Site WWC-A and Site WWC-B, August 2023.

Replicate	Percent Solids	Wet Weight Se (µg/g)	Dry Weight Se (µg/g)
Whitewood Creek			
WWC-A-BRN-1	22.7	1.55	6.83
WWC-A-BRN-2	24.2	1.03	4.26
WWC-A-BRN-3	24.3	1.24	5.10
WWC-A-BRN-4	24.3	1.14	4.69
WWC-A-BRN-5	22.7	1.3	5.73
Mean	**23.6**	**1.25**	**5.32**
WWC-B-BRN -1	25.5	1.34	5.25
WWC-B-BRN -2	23.8	1.01	4.24
WWC-B-BRN -3	26.5	1.11	4.19
WWC-B-BRN -4	24.2	1.01	4.17
WWC-B-BRN -5	23.5	1.05	4.47
Mean	**24.7**	**1.10**	**4.47**

All replicate dry weight selenium concentrations in 2023 were below the EPA whole-body fish tissue criterion of 8.5 µg/g dw for aquatic life *(*Table 4-4*)*. The mean dry weight selenium concentrations were not significantly different between the two Whitewood Creek sites in the 2023 fish tissue samples ($p = 0.120$), and the mean value was in fact slightly lower at Site

WWC-B, downstream of Gold Run Creek. The data indicate discharge from Outfall 001 into Gold Run Creek is not increasing fish tissue selenium concentrations in Whitewood Creek.

4.3.2 Long-Term Data

The dry weight selenium concentration at Site WWC-A in 2023 was the highest mean value measured in all years of sampling, slightly exceeding the previous highest value from 2011 (Figure 4-9). At Site WWC-B, the mean tissue selenium value in 2023 was also somewhat high and was the third highest value measured at this site since sampling began. However, mean tissue selenium values during all years, as well as all individual replicate values collected each year, were less than the EPA chronic selenium threshold of 8.5 µg/g dw (GEI 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023). Linear regression analysis revealed no significant increasing or decreasing trends in tissue selenium concentrations during the study period ($p \geq 0.103$ for both sites). The data indicate no overall changes since 2009 in bioaccumulation of selenium in trout in this size range at the Whitewood Creek study sites.

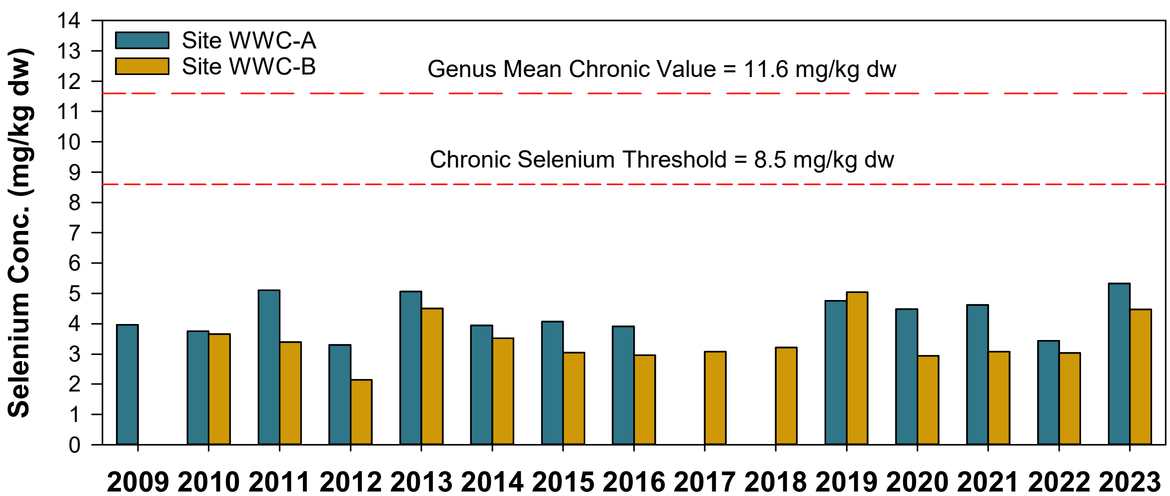

Figure 4-9: Mean concentration of selenium (dry weight, in µg/g) in whole Brown Trout collected from sites WWC-A and WWC-B, 2009 through 2023.

As was true in most years, the selenium concentrations in 2023 were lower at Site WWC-B than at the control site (Figure 4-9). Mean selenium concentrations in Brown Trout collected from 2010 through 2023 were significantly different between sites WWC-A and WWC-B on Whitewood Creek ($p < 0.001$), with fish from Site WWC-A, upstream of Outfall 001, containing a higher long-term mean value (4.29 µg/g dw) of tissue selenium than fish from site WWC-B (3.48 µg/g dw). These data indicate discharge from Outfall 001 does not increase selenium concentrations in fish downstream of the confluence of Gold Run Creek and Whitewood Creek and that conditions support higher bioaccumulation of selenium at Site WWC-A. Water quality analysis has recorded levels of selenium at all sites below the practical quantitation limit on Gold Run and Whitewood creeks since 2009 (GEI 2010, 2011, 2012, 2013a, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, and Appendix D).

4.4 Benthic Macroinvertebrate Populations

4.4.1 Community Composition and Abundance

4.4.1.1 2023 Data

In 2023, each of the monitoring sites supported macroinvertebrate communities that included mayflies (Ephemeroptera), beetles (Coleoptera), true flies (Diptera), water mites (Hydracarina), and segmented worms (Oligochaeta) (Table 4-5 and Appendix B). Stoneflies (Plecoptera), caddisflies (Trichoptera), and flatworms (Turbellaria) were each found at three of the four sampling sites. Dragonflies (Odonata), scuds (Amphipoda), roundworms (Nematoda), and snails (Gastropoda) were each found at one or two of the sampling sites in 2023.

Overall, the sites on Gold Run supported much lower densities and fewer total taxa and EPT taxa than the Whitewood Creek sites. While the number of taxa at both Gold Run sites was similar, Site GR-A also supports a more limited community than Site GR-B. The macroinvertebrate communities sampled at each of the Whitewood Creek sites scored more favorably in many metrics when compared to each of the Gold Run Creek sites (Table 4-5).

The somewhat tolerant and cosmopolitan mayfly species, *Baetis tricaudatus*, was one of the most abundant species at all four sites and was the dominant taxon at both Whitewood Creek sites (Appendix B). At Site GR-A, *B. tricaudatus* was still abundant, but *Parametriocnemus sp*., a moderately tolerant true fly species in the Chironomidae (midge) family, was the most abundant species. At GR-B, *Hydropsyche* caddisflies, another moderately tolerant species, was the most abundant species. Some of the groups present, such as dragonflies, water mites, scuds, roundworms, flatworms, and snails were represented by only a few individuals when collected at a given site.

Richness Metrics

4.4.1.2 2023 Data

In Whitewood Creek, density and most richness metrics were slightly more favorable at Site WWC-A, the control site, than at Site WWC-B in 2023 (Table 4-5), including numbers of EPT taxa and Plecoptera taxa. The number of total taxa, however, was higher at Site WWC-B. Differences among these metrics were slight. Both sites on Whitewood Creek support a diverse community of insects and other macroinvertebrates including favorable numbers of taxa and EPT taxa. Sites WWC-A and WWC-B contained 3 and 1 stonefly taxa, respectively, in the 2023 samples (Table 4-5). Stoneflies are a group considered particularly sensitive to pollutants. Metrics at both Whitewood Creek sites were also more favorable than at both Gold Run Creek sites.

Table 4-5: Benthic macroinvertebrate abundance and other summary population metrics for sites on Whitewood and Gold Run creeks, August 2023.

TAXA/ METRIC	Whitewood Creek		Gold Run Creek	
	WWC-A	WWC-B	GR-A	GR-B
INSECTA				
Ephemeroptera (Mayflies)	1,040	672	56	50
Odonata (Dragonflies & Damselflies)	--	--	--	8
Plecoptera (Stoneflies)	150	16	--	6
Coleoptera (Beetles)	900	352	12	16
Trichoptera (Caddisflies)	55	108	--	152
Diptera (True flies)	545	349	178	334
HYDRACARINA (Water mites)	10	20	7	4
CRUSTACEA				
Amphipoda (Scuds)	20	8	--	--
NEMATODA (Roundworms)	5	8	--	--
ANNELIDA				
Oligochaeta (Segmented worms)	155	48	56	16
TURBELLARIA (Flatworms)	--	4	1	2
MOLLUSCA				
Gastropoda (Snails)	20	--	--	--
Summary				
RICHNESS METRICS				
Density (# per sample)	2,900	1,585	310	588
Number of Taxa	32	36	26	25
Number of EPT Taxa	11	9	2	6
Number of Plecoptera Taxa	3	1	0	2
COMPOSITION METRICS				
Percent Sensitive EPT Taxa	25	17	4	16
Percent Dominant Taxon	32	42	31	25
Percent of non-Baetis Ephemeroptera	2	1	0	0
Percent of Oligochaeta and Hirudinea	5	3	18	3
TOLERANCE METRICS				
Hilsenhoff Biotic Index	4.27	4.48	5.80	5.50
Percent Intolerant Taxa	47	39	31	36
Number of Intolerant Taxa	15	14	8	9
TROPHIC HABIT METRICS				
Number of Shredder Taxa	4	4	2	5
Percent Collector-Gatherers	74	73	77	57
VOLTINISM METRICS				
Number of Semivoltine Taxa	1	1	0	1

TAXA/ METRIC	Whitewood Creek		Gold Run Creek	
	WWC-A	WWC-B	GR-A	GR-B
Percent of Semivoltine Taxa	3	3	0	4
Number of Univoltine Taxa	11	14	8	8

Both sites on Gold Run Creek contain relatively sparse benthic macroinvertebrate communities. However, the community at Site GR-B, contained six EPT taxa and two stonefly taxa; stonefly taxa were absent from Site GR-A in 2023 (Table 4-5). Numbers of total taxa differed by only 1 between sites GR-A and GR-B. Site GR-B had a higher density than Site GR-A, largely due to higher numbers of true flies at the downstream site, as well as caddisflies being present downstream that were not present at Site GR-A (Table 4-5).

Long-Term Data

Density values were moderate when comparing to previously measured range of values at all sites in 2023, except for at Site WWC-B, which had the lowest benthic macroinvertebrate density measured since sampling began (Figure 4-10). The total numbers of taxa collected in 2023 were moderate at both Whitewood Creek sites and moderate to moderately high at both Gold Run Creek sites in comparison to previous years. Numbers of EPT taxa were moderate at all four study sites (Figure 4-10). Benthic macroinvertebrate density values often fluctuate widely from year to year at sites on Whitewood Creek; fluctuations like those observed from 2022 to 2023 are commonplace. Values for numbers of taxa and EPT taxa are typically more stable. The changes observed for all of these metrics from the 2022 to 2023 sampling events are within the range of fluctuations that are to be expected in populations of benthic macroinvertebrates.

ANOVA analyses indicate that over the study period, sites WWC-A and WWC-B have supported a significantly higher benthic macroinvertebrate density and number of taxa than both Gold Run Creek sites ($p < 0.001$ for both comparisons). Linear regression analysis of density indicates values have followed a significant decreasing trend at Site WWC-B ($p = 0.031$); density values did not follow any significant trends at the remaining sites ($p \geq 0.169$). It should be noted that a decreasing trend in density is not indicative of a benthic macroinvertebrate assemblage becoming less healthy. Often communities with very high densities of benthic macroinvertebrates can be dominated by a single, tolerant species; this can be an indicator of some sort of stressor or stochastic event having impacted a given community.

Numbers of total taxa did not follow a significant trend at any of the Whitewood Creek or Gold Run Creek sites from 2009 to 2023 ($p \geq 0.066$). Over the study period, the mean number of taxa observed at the two Gold Run Creek sites has been similar, with no significant difference between the sites upstream and downstream of Outfall 001 on Gold Run Creek.

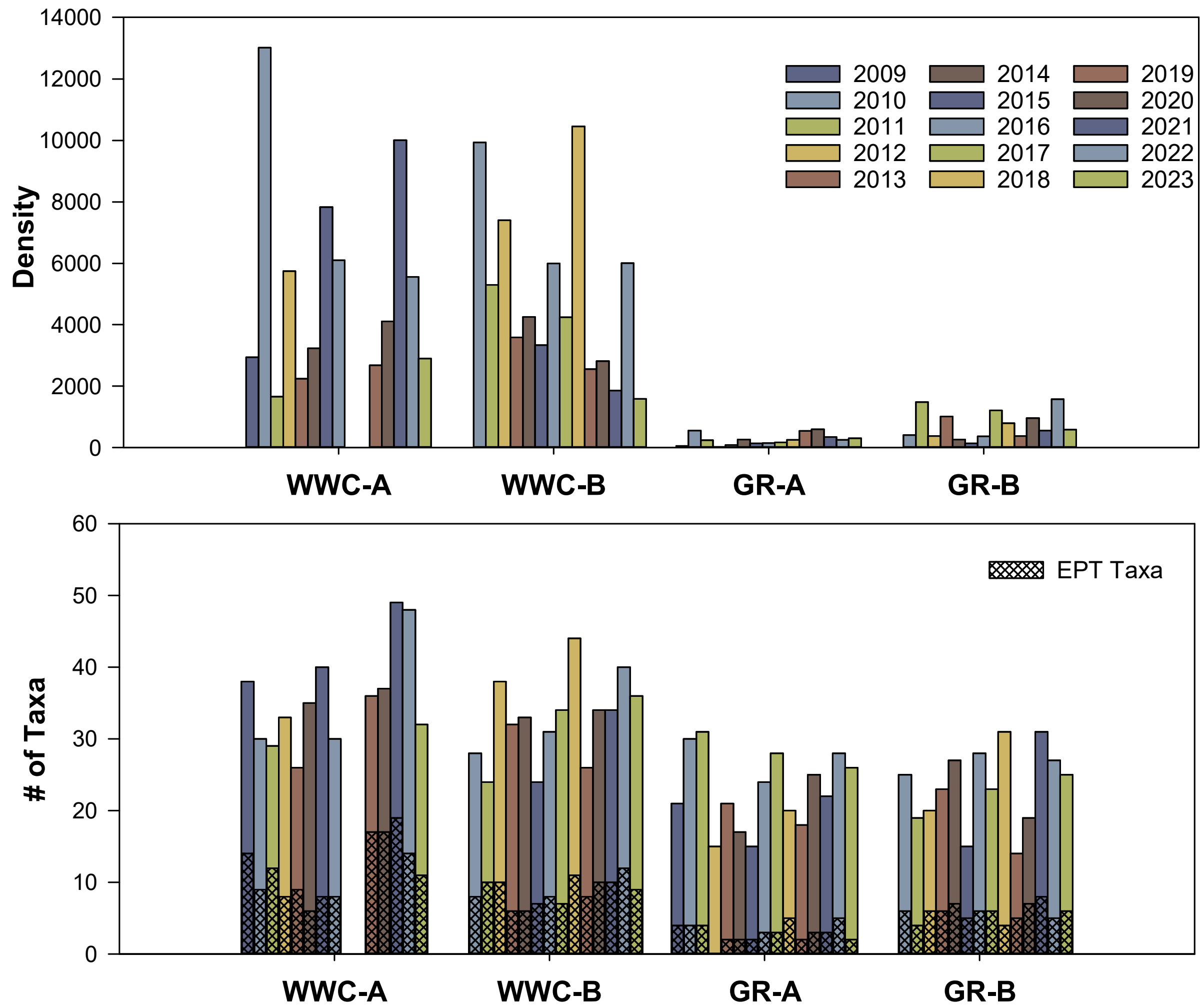

Figure 4-10: Total macroinvertebrate density and number of taxa and EPT taxa from Whitewood Creek and Gold Run Creek, 2009 through 2023. Sites WWC-B and GR-B were not sampled in 2009; Site WWC-A was not sampled in 2017 and 2018.

ANOVA analyses revealed a difference in the long-term numbers of EPT taxa at the four study sites ($p < 0.001$). Site GR-A had a significantly lower median than at the two Whitewood Creek sites. Site GR-B also contained a significantly lower median number of EPT taxa than Site WWC-A. While a significant difference was not found between sites GR-A and GR-B, the long-term mean number of EPT taxa at site GR-B is nearly double that of site GR-A. The effluent from Outfall 001 appears to be improving the conditions in Gold Run Creek below the outfall, likely due to the increased flows. Linear regression analysis of data revealed no long-term increasing or decreasing trends in numbers of EPT taxa at all study sites over time ($p \geq 0.084$). Previously, from 2009- 2022, an increasing trend in the number of EPT taxa was statistically significant at Site WWC-A. This may indicate that conditions at this site are also becoming more favorable to habitation for the more sensitive mayfly, stonefly, and caddisfly taxa. The data on density, number of taxa, and number of EPT taxa indicate overall conditions since 2009 have been stable at sites on Whitewood Creek and

Gold Run Creek, and conditions at the reference site on Whitewood Creek, upstream of Outfall 001 and Gold Run Creek, may have improved since the sampling program was initiated.

Stoneflies have been rare or absent at both Gold Run Creek sites during many years of sampling, including in 2023 when sites GR-A and GR-B contained 0 and 2 stonefly taxa, respectively. Inadequate flow appears to be the most important limiting factor in Gold Run Creek for this group (and many other metrics). In 2023, 3 and 1 stonefly taxa were found at sites WWC-A and WWC-B, respectively, indicating favorable conditions for some sensitive taxa in this stream. Limiting factors to stoneflies in some years may include occasional high temperatures, nutrient enrichment, or some other regional water quality constituent.

4.4.2 Composition Metrics

4.4.2.1 2023 Data

The percentages of sensitive EPT taxa were moderate at sites WWC-A, WWC-B, and GR-B in 2023 (Table 4-5). The percent sensitive EPT taxa value was relatively low at Site GR-A. This is likely due to very limited flows, sediment, and precipitates often found within Site GR-A. EPT species were present at the two sites on Gold Run but in limited abundance, particularly at Site GR-A (Appendix B). Only the common and somewhat tolerant mayflies in the genus *Baetis* were found within Site GR-A. No caddisfly or stonefly species were found. At Site GR-B, these same mayfly taxa were present in addition to 2 stonefly and 2 caddisfly species, indicating that effluent from Outfall 001 is improving the habitability for EPT species within Gold Run Creek. *Baetis tricaudatus* was also the most abundant taxon on both Whitewood Creek sites. Non-*Baetis* mayflies were uncommon at the Whitewood Creek sites and absent at the Gold Run Creek sites.

The percent of Oligochaeta and Hirudinea (leeches) metric was very low at both Whitewood Creek sites and Site GR-B (Table 4-5). At Site GR-A, the percent of Oligochaeta and Hirudinea comprised 18% of the total abundance due to the relatively high abundance of one species (*Nais* sp.) of oligochaete worms. No leeches were collected at any of the four study sites in 2023.

The Whitewood Creek sites support a more sensitive and diverse community of macroinvertebrates than the sites on Gold Run Creek. In Whitewood Creek, Site WWC-A had a few more favorable metrics when compared to those at Site WWC-B in 2023, but differences were relatively small. In Gold Run Creek, sites GR-A and GR-B had comparable values for most composition metrics, aside from the percent of Oligochaeta and Hirudinea.

4.4.2.2 Long-Term Data

At Site WWC-B, the percent sensitive EPT taxa has ranged considerably over the study period, from 9% in the monitoring years 2013 and 2017, to 33% in 2011 (Figure 4-11). A similar range was measured at Site WWC-A during the study period, with minimum and maximum values of 9% to 38% sensitive EPT taxa. At Site GR-B, this metric has also been variable, ranging from 7% in 2015 and 2022 to 26% in 2014 and 2020. The percent sensitive EPT value at Site GR-A has not exceeded 15% over the study period and has been 5% or less in seven of the twelve monitoring years, including 2023. 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. In some years, more than 30% of the benthic macroinvertebrate taxa are comprised of sensitive EPT taxa at the Whitewood Creek sites.

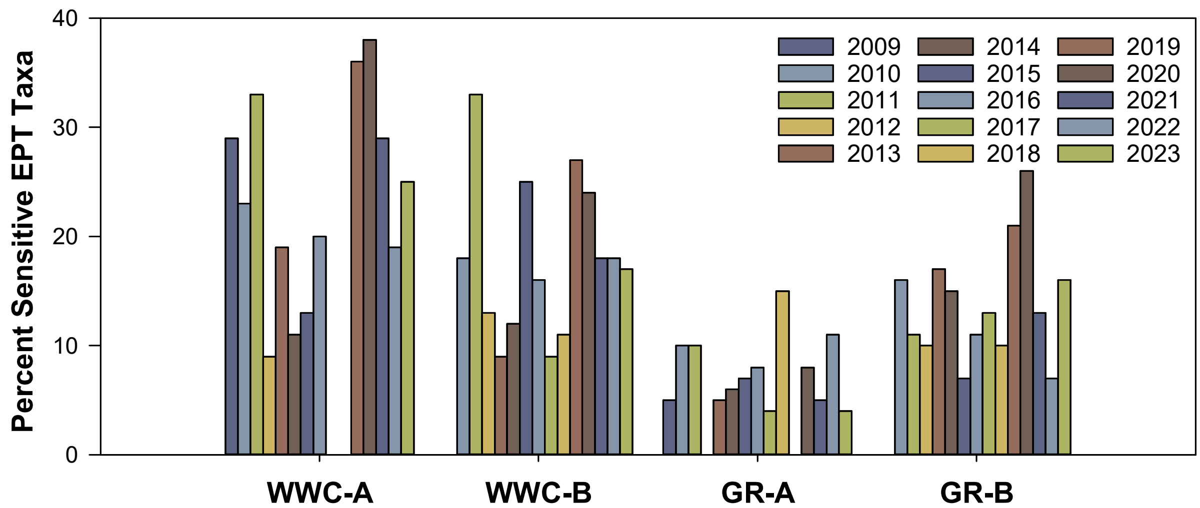

Figure 4-11: Percent sensitive EPT taxa from Whitewood Creek and Gold Run Creek, 2009 through 2023. Sites WWC-B and GR-B were not sampled in 2009; Site WWC-A was not sampled in 2017 and 2018.

The percent sensitive EPT taxa has been greater at sites WWC-A and WWC-B than at sites GR-A and GR-B in almost all years of the study indicating healthier communities in Whitewood Creek than in Gold Run. Statistical analysis identified significantly different long-term mean values at the study sites ($p < 0.001$), with multiple pairwise differences. A significantly higher number of percent sensitive EPT taxa were found at sites GR-B, WWC-A, and WWC-B than at Site GR-A. No significant increasing or decreasing trends for percent sensitive EPT taxa over the study period were identified for any of the monitoring sites ($p \geq 0.437$).

4.4.3 Tolerance Metrics

4.4.3.1 2023 Data

The Hilsenhoff Biotic Index (HBI) scores in 2023 at sites WWC-A and WWC-B were considered "Very Good" (Table 4-5). Values at sites GR-A and GR-B were categorized as "Fair" and "Good," respectively. High relative abundances of tolerant true fly and segmented worm species at Site GR-A caused a less favorable HBI score at this site in 2023.

Percentages of intolerant taxa ranged from 31% at Site GR-A to 47% at Site WWC-A in 2023. Numbers of intolerant taxa were comparable and higher at the Whitewood Creek sites.

Values for this metric were lower but also similar between the Gold Run Creek sites (Table 4-5). The HBI scores in particular illustrate that the benthic macroinvertebrate community at Site GR-A is comprised of more tolerant benthic macroinvertebrates than at the remaining sites.

4.4.3.2 Long-Term Data

The HBI scores at Site WWC-A have usually been rated as “Good” with ratings of “Very Good” in 2011, 2020, and 2023 and the unusual rating of “Fairly Poor” in 2012. The ratings at Site WWC-B have been categorized as “Good” in all years of the study except for 2023, when the rating was categorized as “Very Good.” HBI ratings at the Gold Run Creek sites have been more variable and generally less favorable than the values observed at the Whitewood Creek sites. Both sites on Gold Run Creek in 2013, 2016, and 2019 were rated as “Good,” as was Site GR-B in 2021 through 2023. Site GR-A was also rated “Good” in 2015 and 2020. Site GR-B in all other years was rated as “Fair”. Site GR-A in all other years was rated as “Poor,” “Fairly Poor,” or “Fair.” HBI scores were less favorable in some years due to a relatively high proportion of a single species, such as the moderately tolerant *B. tricaudatus*.

Significant decreasing trends in HBI scores were found for sites GR-B ($p = 0.046$) and WWC-B ($p = 0.007$); this indicates that HBI values are becoming more favorable (lower) at these two sites. ANOVA analyses revealed a significant difference in median values among sites ($p < 0.001$), with sites GR-A and GR-B having higher (less favorable) median values than sites WWC-A and WWC-B. These results are similar to the results for richness and composition metrics indicating more favorable conditions in Whitewood Creek than in Gold Run Creek.

4.4.4 Trophic Habit Metrics

4.4.4.1 2023 Data

Two to 5 shredder taxa were collected at all four sites in 2023 (Table 4-5). 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, in 2022, notable differences in the number of shredders among all 4 sampling sites were not found.

The percent collector-gatherer taxa values were 74 and 73%, respectively, at sites WWC-A and WWC-B, and were 77 and 57% at sites GR-A and GR-B (Table 4-5). Larger values for this metric can indicate disturbance. The cause of higher percent collector-gatherer metrics at all sites except for Site GR-B are not immediately clear; some flooding did occur in both 2022 and 2023 and this metric was relatively high during these two years.

4.4.5 Voltinism Metrics

4.4.5.1 2023 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, only taxa with shorter life histories, capable of producing one generation (univoltine) or multiple generations in a year (multivoltine) are favored. Semivoltine taxa were collected in very low numbers at all sites (1 species at both Whitewood Creek sites and Site GR-B, 0 species at Site GR-A) in 2023 (Table 4-5). Numerous univoltine taxa were found at all sites in 2023 indicating conditions continue to favor invertebrates with shorter life histories in both streams. Multiple high-flow events occurred on Whitewood Creek in 2023; although no flow gage exists on Gold Run Creek it is likely that some high flow events due to rainstorms occurred on this stream as well. These events may influence the occurrence of some taxa in Whitewood and Gold Run Creeks.

Data from Gold Run Creek 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 flowing through 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 4-12). Benthic macroinvertebrate metrics at all Whitewood Creek and Gold Run Creek continue to show that a more limited community is present upstream of Outfall 001 on Gold Run Creek, while healthier communities are found at sites GR-B, WWC-A, and WWC-B.

Figure 4-12: Photos of sites GR-A (left) and GR-B (right) on Gold Run Creek.

4.5 Periphyton Populations

4.5.1 Community Composition and Density

4.5.1.1 2023 Data

Pennate diatoms were the most common group found at the four sites in 2023. Centric diatoms were also found at Site WWC-A and green algae were found at Site WWC-B (Table 4-6). The species *Achnanthes minutissima* was the most abundant species at sites WWC-A, GR-A, and GR-B, and was the second most abundant species at Site WWC-B (Appendix C). *Cocconeis placentula* was the most abundant taxa at Site WWC-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 18 to 99.8% of the density at all study sites in 2023, with Site WWC-B being the only site with an *A. minutissima* percentage of less than 25% (Appendix C). These data indicate some degree of disturbance has occurred at sites on both Whitewood Creek and Gold Run Creek, with Site WWC-B having undergone less severe disturbance or stress. Multiple spikes in streamflow occurred on Whitewood Creek during the summer of 2023 (Figure 4-7).

Within the Whitewood Creek sites, the highest abundance of *A. minutissima* was found at Site WWC-A, upstream of the confluence with Gold Run Creek. This species accounted for nearly 100 percent of the density at Site GR-A. This indicates that high abundances of this species are unrelated to discharge from the outfall. *A. minutissima* comprised 46 percent of the periphyton sample collected at Site GR-B, indicating improvement of periphyton community metrics downstream of Outfall 001.

4.5.2 Richness Metrics

4.5.2.1 2023 Data

In 2023, the diatom density value was relatively low at all study sites, when compared to previous years values (Table 4-6, Figure 4-13). Numbers of taxa and diatom taxa were the highest at Site WWC-B, with similar or equal values at site WWC-A. Site GR-A contained only two taxa in the 2023 periphyton sample. The cause of the lower numbers of taxa at Site GR-A, upstream of Outfall 001 is likely due to low flows, fine sediments and an orange-colored precipitate that is often present in this reach. This poor habitat likely impacts both the periphyton and benthic macroinvertebrate communities (See 4.1 Habitat Assessment).

Table 4-6: Periphyton density (#/cm²) and community metrics for sites on Whitewood and Gold Run creeks, August 2023.

Taxa	Whitewood Creek		Gold Run Creek	
	WWC-A	WWC-B	GR-A⁺	GR-B
BACILLARIOPHYTA				
Pennales (Pennate diatoms)	31,314	8,900	46,315	52,932
Centrales (Centric diatoms)	259	--	--	--
CHLORIOPHYTA (Green Algae)	--	160	--	--
Summary				
RICHNESS METRICS				
Total Density (cells/mm²)	31,573	9,060	46,315	52,932
Number of Taxa	19	20	2	17
Number of Diatom Taxa	19	19	2	17
Number of Divisions	1	2	1	1
Number of Genera	11	10	2	9
COMPOSITION METRICS				
Shannon-Weaver Diatom Diversity (H')	3.09	3.19	0.02	2.78
Autotrophic Index	1271	138	86	418
Autecological Classes of Diatoms*(percent of diatom density)				
Eutrophic	43	48	<1	44
Acidophilic	1	0	0	0
Alkaliphilic	36	46	<1	42
Nitrogen Heterotrophs	7	3	0	14
High Oxygen	56	35	100	51
Motile	25	35	0	25
Saprobic	5	6	0	9
TOLERANCE METRICS				
Diatom Tolerance Values (percent of diatom density)				
(1) Tolerant	3	2	<1	9
(2) Less Tolerant	15	14	0	11
(3) Sensitive	82	84	99	80
Lange-Bertalot Pollution Tolerance Index	2.79	2.82	3.00	2.71
Ash-Free Dry Weight (mg/m²)	3,306	1,928	1,377	3,306
Chlorophyll a (mg/m²)	2.6	14.0	16.0	7.9

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

The downstream site, Site WWC-B, on Whitewood Creek had slightly more taxa, and a comparable number of genera to Site WWC-A. The effluent from Outfall 001 appears to be positively influencing the periphyton community on Gold Run Creek and makes little change to the community on Whitewood Creek downstream of the confluence.

4.5.2.2 Long-Term Data

Periphyton density has been highly variable at all four study sites over time (Figure 4-13). Compared to values observed over time, density at all sites in 2023 was relatively low. Low densities in 2013 through 2015 may be related to the thick mats of filamentous algae observed in these years that may have limited the abundance of diatoms. Low density measured in 2019 at sites WWC-A, WWC-B, and GR-B, and the lack of diatoms at Site GR-A are all likely related to high flows during 2019. As sites WWC-A and GR-A are upstream of Outfall 001, changes at these sites 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 as well as Site WWC-B. The August 19, 2021 high flow event on Gold Run Creek may have reduced periphyton densities at all three of these sites. In 2022 samples, density values at sites WWC-B, GR-A, and GR-B were moderate, while the periphyton density at Site WWC-A was the highest value recorded at any site since periphyton sampling began. It's not clear what caused such high periphyton density at this site in 2022. Multiple high flow events occurred on Whitewood Creek in 2023, and likely Gold Run Creek as well, and this may have caused some scouring of the substrate and reduced diatom densities at all sites.

Numbers of taxa supported at each site have shown less annual variability than density. In 2023, numbers of taxa were all near the median value for each site, with the exception of site GR-A which was well below the median value (Figure 4-13). Statistically significant differences were found among sites in ANOVA analyses for numbers of taxa ($p \leq 0.001$), with Site WWC-B typically supporting the highest number of taxa, followed by Site WWC-A and then Site GR-B. The mean taxa value at Site GR-A was lower than all other sites. Significant long-term trends for density ($p \geq 0.0503$) and number of taxa ($p \geq 0.325$) were not identified at any of the four sites that were sampled in 2023, although a decreasing trend at Site GR-B was marginally significant. Otherwise, there was no consistent increase or decrease in these metrics since the initiation of sampling in 2009.

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

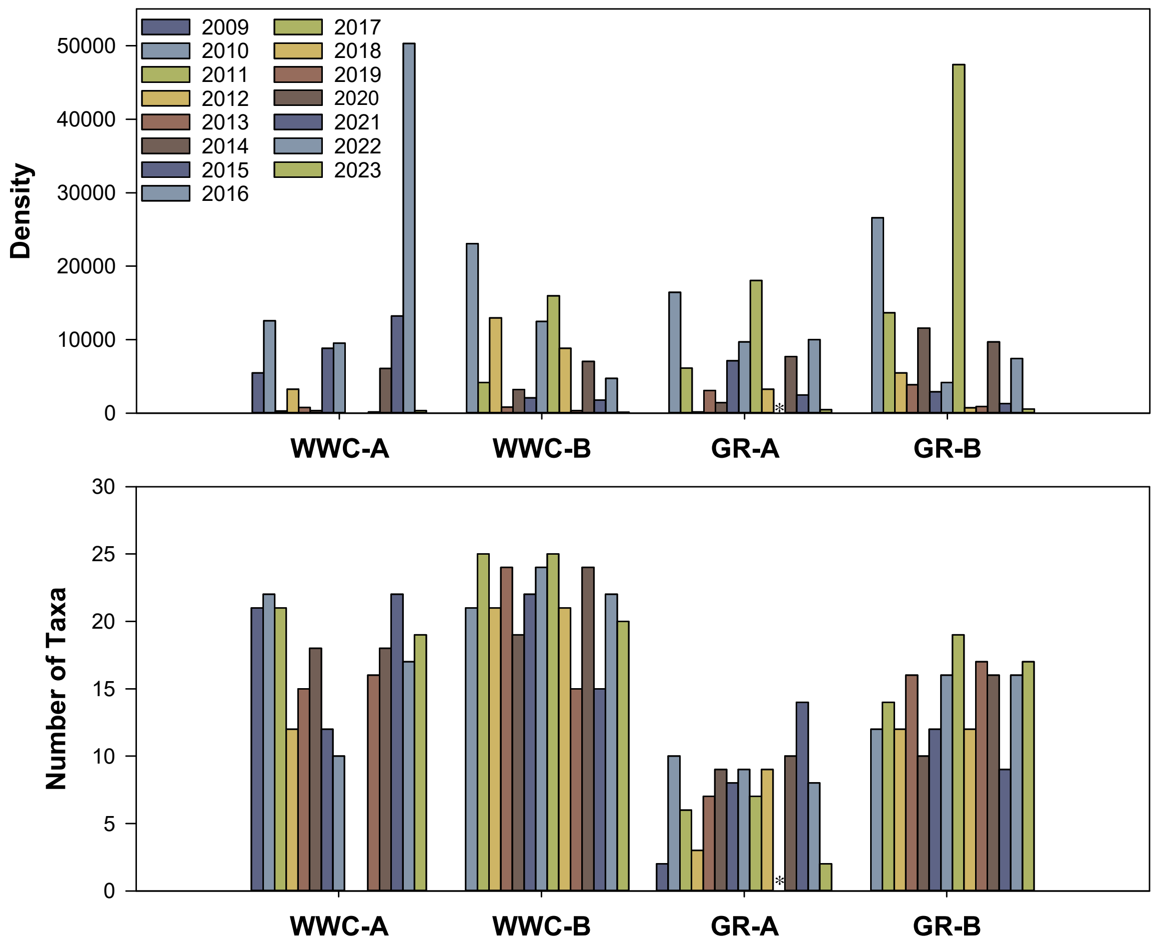

Figure 4-13: Total periphyton density (($\#/mm^2$) and number of taxa from all sites on Whitewood Creek and Gold Run Creek, 2009 through 2023. Sites WWC-B and GR-B were not sampled in 2009: Site WWC-A was not sampled in 2017 and 2018. += Periphyton present at low density. *= No periphyton cells found in sample.

4.5.3 Composition Metrics

4.5.3.1 2023 Data

The Shannon Weaver Diatom Diversity values at the sites on Whitewood Creek and at Site GR-B were comparable and favorable (Table 4-6). At Site GR-A, the diversity value was very low, representing an unbalanced periphyton community at this site. This is due to the occurrence of only two species of diatoms at this site in 2023. Similar to the richness metrics, these values indicate a more favorable periphyton community below Outfall 001 and at Site WWC-A, with a much less favorable community at Site GR-A. This improvement is likely due to increased flows below the outfall and more favorable water quality. Site GR-A has also had a very disturbed periphyton community in previous years, likely due to low flows, poor water quality, and the iron precipitate on the bottom substrate (Figure 4-1).

The Shannon-Weaver Diversity value for diatoms was found to follow a decreasing trend at Site WWC-B ($p = 0.041$), which could be caused by very high relative densities of a single diatom species during some recent years. The high abundance of a single species reduces the diversity score as the community is not evenly distributed among different taxa. Shannon-Weaver Diversity scores at the remaining sites have not followed a consistent trend over time.

Autotrophic Index (AI) values ranged from 86 to 1,271 across the four sites in 2023 (Table 4-6). Communities less disturbed by organic pollution usually contain AI values ranging from 50 to 100. In 2023, Site GR-A was the only site with an AI value within this range. Values greater than 400 indicate communities affected by organic pollution; Sites GR-B and WWC-A both scored greater than 400. Overall, AI values in 2023 indicate some degree of organic pollution impacts are occurring at all sites except for Site GR-A. Runoff from lawns in residential developments or along roadways may be affecting these sites.

The most abundant autecological group collected at all sites except for Site WWC-B was high oxygen diatoms; at Site WWC-B this group was plentiful but tied as the third most abundant autecological group (Table 4-6). This finding indicates that dissolved oxygen is high in Gold Run Creek and Whitewood Creek, and that pollution from organic matter is not common, which conflicts with the AI values discussed previously which indicate some organic pollution. Eutrophic and alkaliphilic diatoms were also relatively abundant at all sites except for Site GR-A. High abundances of these two groups could indicate both organic or inorganic nutrient inputs and the presence of alkaline salts from agricultural disturbance in the drainage for these two metrics, respectively. Percent motile diatoms was greatest at Site WWC-B, with slightly lower values at sites WWC-A and GR-B. Motile diatoms were absent from site GR-A, likely due to the depauperate periphyton community at this site. Acidophilic diatoms, nitrogen heterotrophs, and saprobic diatoms were either absent or collected in relatively low abundances across all four sites (Table 4-6). The absence or very low density of acidophilic diatoms at all 4 sites in 2023 indicates a lack of impacts due to acid mine drainage anywhere within the Gold Run and Whitewood Creek drainages upstream of the four study sites in 2023.

4.5.4 Tolerance Metrics

4.5.4.1 2023 Data

The percent of tolerant and less tolerant diatoms combined, ranged from <1 percent to 20 percent across sites in 2023 (Table 4-6). The large abundance of *A. minutissima*, which is considered a sensitive diatom species, has kept these tolerant diatom values relatively low throughout the study period. These low percentages suggest that both sites on Gold Run Creek support sensitive periphyton communities when, in fact, the communities at both sites are sometimes unbalanced and dominated by one or two species, as they were in 2023. Sites WWC-A, WWC-B, and GR-B have better water quality and in 2023 and supported more balanced diatom communities but scored lower metric values for sensitive diatoms than Site GR-A (Table 4-6). The Lange-Bertalot pollution tolerance index values were greater than 2.50 at all sites, indicating No Organic Enrichment. These pollution tolerance index values contradict the Autotrophic Index values discussed above; the cause of these conflicting metric values that examine organic enrichment is not clear.

High percentages of *A. minutissima* found in 2023 and every other year of study in Gold Run Creek result in metrics highly influenced by this single species. In 2023, this species accounted for 99 percent and 46 percent of the density at sites GR-A and GR-B, respectively. This dominance of the community by 1-2 diatom taxa results in in lower richness, diversity, and percent tolerant and motile diatom values. Since *A. minutissima* is classified as a sensitive species, this skews some of the autecological and tolerance metrics to indicate a very healthy community. The conflicting values of the Lange-Bertalot pollution tolerance index values and the Autotrophic index values at monitoring sites in 2023 and is due to the influence of *A. minutissima* on the pollution tolerance index metric.

5. Conclusions

Two sites on Whitewood Creek and two sites on Gold Run Creek were sampled in August 2023 to continue monitoring activities upstream and downstream of Sanford's permitted Outfall 001. Habitat surveys were conducted and fish, benthic macroinvertebrate, and periphyton populations were sampled. Fish tissues were also collected and analyzed for selenium concentrations at sites WWC-A and WWC-B; no fish are present in Gold Run Creek. The 2023 sampling event was the fifteenth consecutive year of sampling conducted since 2009 at Site GR-A, and the fourteenth consecutive year of sampling at sites GR-B and WWC-B. Site WWC-A has been sampled for 13 years total.

5.1 Habitat

5.1.1 Whitewood Creek

Habitat at sites WWC-A and WWC-B is diverse and provides sufficient habitat for both fish and macroinvertebrates, although Site WWC-A has lacked pools in some past years. One or two pools were found at each site during 2023 surveys, providing favorable habitat for larger trout. Gravel and rubble were the dominant substrate sizes at Site WWC-A, while boulder and bedrock were more common at the downstream site. The streambanks are mostly stable and covered with vegetation, although some exposed banks were found at both sites. Filamentous green algal mats were absent in 2023. General habitat conditions at both sites have not changed substantially over the last few years, with similar instream habitat observed over time. Both sites continue to provide favorable habitat to sustain healthy fish populations.

5.1.2 Gold Run Creek

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 2023 as well.

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. Exposed rock is also abundant. 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 color. Course substrates were the most common substrate size, followed by rubble and gravel. In 2021, scour and bank erosion from the August high flow event that year was evident; some areas of exposed banks due to this storm event remained evident in 2022 in

2023, although much has revegetated. The suitability of Site GR-B 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 Site GR-B remains isolated from the fish populations in Whitewood Creek.

5.2 Fish Populations

5.2.1 Whitewood Creek

Both sites WWC-A and WWC-B on Whitewood Creek support a robust self-sustaining population of Brown Trout and small numbers of Brook Trout, Mountain Suckers, and Longnose Dace are often found at one or both sites as well. Multiple age classes of Brown Trout were present in 2023, including some YOY, particularly at Site WWC-A where the highest density of 149 mm or smaller trout was measured. Densities of this smaller size class of trout were relatively low at both sites when compared to values from the previous two years. The density of large (150 mm or larger) trout was above the 50^{th} percentile value at Site WWC-A but was below the median value at Site WWC-B. Long-term fluctuations in density and biomass have been observed over the study period and have sometimes been linked to significant storm events or variations in streamflow from year to year. Lower than average spring runoff flows during 2020 and 2021 on Whitewood Creek likely resulted in high numbers of juvenile and YOY at these sites. Runoff in 2022 was higher, but YOY numbers remained high at both Whitewood Creek sites. In 2023, multiple high flow events occurred and YOY trout populations were likely reduced by these events at both sites. No evidence of impacts on the fish population from Outfall 001 have been observed in Whitewood Creek.

5.2.2 Gold Run Creek

No fish have been collected in Gold Run Creek over the study period. 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 Fish Tissues

5.3.1 Whitewood Creek

All 2023 fish tissue concentrations were well below the EPA whole-body fish tissue criterion of 8.5 µg/g dw for protection of aquatic life. Trend analysis indicates no significant increasing or decreasing trends in fish tissue selenium concentrations over the length of the study period. The potential for selenium accumulation in trout tissues in Whitewood Creek is limited. Trout from Site WWC-A, upstream of Outfall 001, contain a statistically significant higher concentration of tissue selenium than fish from site WWC-B. There is no evidence that discharge from Outfall 001 has increased selenium concentrations in trout tissues in Whitewood Creek. Selenium concentrations in water quality samples since monitoring began in 2009 through the most recent samples in 2023 have been below the practical quantitation limit, indicating that effluent from Outfall 001 is not acting as a source of selenium into Gold Run Creek.

5.4 Benthic Macroinvertebrate Populations

5.4.1 Whitewood Creek

In 2023, each of the four monitoring sites supported macroinvertebrate communities that included 25 or more taxa. Overall, the sites on Gold Run supported much lower densities than the Whitewood Creek sites. Site GR-A also supported substantially fewer EPT taxa and percentages of sensitive EPT taxa. Whitewood Creek provides greater flow and habitat diversity, better water quality, and is less vulnerable to drought and sedimentation than Gold Run Creek. These differences in hydrology and habitat support more abundant, diverse, and sensitive invertebrate communities compared to either site on Gold Run Creek.

The macroinvertebrate communities sampled at both Whitewood Creek sites scored favorably in many metrics. Most metrics had values were comparable between sites WWC-A and WWC-B in 2023, with a slightly higher number of total taxa at Site WWC-B and slightly more EPT taxa and proportionally more sensitive EPT taxa at Site WWC-A. All other metrics were similar in the 2023 samples. Site WWC-B supported a healthy and diverse community including numerous sensitive species in 2023 as in past years of biomonitoring. The macroinvertebrate communities at sites WWC-A and WWC-B over the years indicate no negative effects due to effluent from Outfall 001.

5.4.2 Gold Run Creek

Both sites on Gold Run support limited communities of benthic macroinvertebrates when compared to the Whitewood Creek sites, with Site GR-A having a very limited benthic macroinvertebrate community in 2023 and in many other years. The most notable differences were the much fewer EPT taxa and lower percent sensitive EPT taxa at Site GR-A than at Site GR-B in 2023.

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. 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. Dilution from

Outfall 001 also improves water quality in Gold Run Creek through reduction of turbidity and the concentration of metals, particularly iron.

5.5 Periphyton Populations

5.5.1 Whitewood Creek

Sites WWC-A and WWC-B in 2023 supported diverse communities of diatoms, with comparable communities at both WWC-A and WWC-B. Green algae were also present at low abundances at Site WWC-B. Abundance values were relatively low, when compared to the high values measured during 2022. Fluctuations in abundance from year to year are common and may be influenced by the occurrence of high flow events which can cause scouring within the stream channel. Numbers of diatom taxa and Shannon-Weaver diversity values were slightly higher at Site WWC-B. Both sites supported high percentages of sensitive diatoms, with these diatoms comprising 82 percent or more of the total density. Very high abundances of *A. minutissima*, a species that indicates disturbance but is also categorized as sensitive, were again observed in 2023, as in previous years, in both streams. High oxygen diatoms were also very common at both sites. Periphyton metrics at both sites indicate that healthy communities are present at both sites. The thick filamentous algae mats that were observed in Whitewood Creek in 2013 and 2014 were greatly reduced in 2015 and nearly absent from 2016 through 2023.

5.5.2 Gold Run Creek

Gold Run Creek Site GR-A supported a very limited periphyton community in 2023, while the community at Site GR-B was more balanced and similar to the communities at the Whitewood Creek sites. At Site GR-A only two taxa were collected. High percentages of *A. minutissima* found in 2023 and every other year of study at these sites result in metrics dominated by this single species. Percentages of this species were 99.8 and 46 percent of the total abundance at sites GR-A and GR-B, respectively. This results in lower richness, diversity, and percent tolerant and motile diatom values. Since *A. minutissima* is classified as a sensitive species, this skews some of the autecological and tolerance metrics to indicate a healthy community when, in fact, the communities at both sites are sometimes unbalanced and dominated by one or two species in many years, particularly Site GR-A.

Low flow, turbid water, and poor water quality are especially limiting to the periphyton community at Site GR-A. In 2023, only two taxa were found at this site, tying for the 2009 value for the lowest number of taxa collected at Site GR-A. Past data, as well as the Shannon-Weaver Diversity index value from 2023, 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 than at Site GR-A and this trend has continued in 2023.

5.6 Overall

5.6.1 Whitewood Creek

Aquatic biological monitoring in 2023 and in previous study years has indicated that sites WWC-A and WWC-B on Whitewood Creek supported healthy fish, benthic macroinvertebrate, and periphyton populations. Fish tissue analyses indicated that selenium tissue concentrations were well below the chronic selenium threshold at both sites. Aquatic communities are consistently healthier at Site WWC-B compared to sites on Gold Run Creek, which would not be expected if inflows from Outfall 001 were negatively impacting this site. No evidence for negative impacts from Outfall 001 were observed in fish, invertebrate, or periphyton population data in 2023.

5.6.2 Gold Run Creek

Benthic macroinvertebrates and periphyton were less diverse at the Gold Run Creek sites than at the Whitewood Creek sites, with much more limited communities at Site GR-A. Fish are absent from both sites on Gold Run Creek, as has been observed throughout the study period. However, Site GR-B directly downstream of Outfall 001 consistently supports more robust macroinvertebrate and periphyton communities relative to Site GR-A. 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

Anderson, R. O. 1980. Proportional stock density (PSD) and relative weight (Wr): Interpretive indices for fish populations in communities. Pp. 27-33 *in* Gloss, S., and B. Shupp (eds.). Practical Fisheries Management: More with Less in the 1980s. *Proceedings of the First Annual Workshop of the New York Chapter of the American Fisheries Society*, Ithaca, NY.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. Pp. 447-482 *in* Murphy, B. R., and D. W. Willis (eds.). Fisheries Techniques 2nd Edition. American Fisheries Society, Bethesda, MD.

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.

Baxter, G. T. and M. D. Stone. 1995. Fishes of Wyoming. Wyoming Game and Fish Department, Cheyenne, WY.

Belica, L. T. and N. P. Nibbelink. 2006. Mountain Sucker (*Catostomus platyrhynchus*): a technical conservation assessment. USDA Forest Service, Rocky Mountain Region. Available online: http://www.fs.fed.us/r2/projects/scp/assessments/mountainsucker.pdf. Accessed 11/2013.

Carter, J. L., and V. H. Resh. 2001. After site selection and before data analysis: sampling, sorting, and laboratory procedures used in stream benthic macroinvertebrate monitoring programs by USA state agencies. *Journal of the North American Benthological Society* 20:658-682.

Chadwick, J.W., L.C. Bergstedt, D.J. Conklin, and S.P. Canton. 2004. Drought and trout-sometimes less is more. Pp. 1-13 *in* de Carvalho Freitas, C.E., M. Petrere, Jr., A.A.F. Rivas, and D. Mackinlay (eds.). Symposium Proceedings, Fish Communities and Fisheries, VI International Congress on the Biology of Fish. Manaus, Brazil, August 1-5, 2004.

Everhart, W. H., and W. D. Youngs. 1981. Principles of Fishery Science, 2nd Edition. Cornell University Press, Ithaca, NY.

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.

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.

Latterell, J. J., K. D. Fausch, C. Gowan, and S. C. Riley. 1998. Relationship of trout recruitment to snowmelt runoff and adult trout abundance in six Colorado mountain streams. *Rivers* 6: 240-250.

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.

Murphy, B. R., and D. W. Willis. 1991. Application of Relative Weight (Wr) to Western Warmwater Fisheries. Warmwater Fisheries Symposium I, Phoenix, AZ.

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.

Petty, J. T., P.J. Lamothe, and P. M. Mazik. 2005. Spatial and seasonal dynamics of brook trout populations inhabiting a central Appalachian watershed. Transactions of the American Fisheries Society 134: 572-587.

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.

Platts, W. S., and M. L. McHenry. 1988. Density and Biomass of Trout and Char in Western Streams. INT-241. USDA, Forest Service, Intermountain Research Station.

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.

Taniguchi, Y., F. J. Rahel, D. C. Novinger, and K. G. Gerow. 1998. Temperature mediation of competitive interactions among three fish species that replace each other along longitudinal stream gradients. *Canadian Journal of Fisheries and Aquatic Sciences* 55:1894-1901.

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. Environmental Protection Agency (EPA). 2016. Aquatic Life Ambient Water Quality Criterion for Selenium- Freshwater 2016. EPA 822-R-16-006. June 2016. Office of Water, Washington, D.C.

U.S. Geological Survey (USGS). 2023. USGS 06436180 Whitewood Creek Above Whitewood, SD. Available online: http://waterdata.usgs.gov/sd/nwis/uv?site_no=06436180, accessed 2/2023.

Van Deventer, J. S., and W. S. Platts. 1983. Sampling and estimating fish populations from streams. *Transactions of the North American Wildlife and Natural Resource Conference* 48:349-354.

Van Deventer, J. S., and W. S. Platts. 1989. Microcomputer Software System for Generating Population Statistics from Electrofishing Data - Users Guide for MicroFish 3.0. General Technical Report INT-265/1989. U.S. Forest Service.

Vinson, M. R., and C. P. Hawkins. 1996. Effects of sampling area and subsampling procedure on comparisons of taxa richness among streams. *Journal of the North American Benthological Society* 15:392-399.

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

Wege, G. J., and R. O. Anderson. 1978. Relative weight (Wr): A new index of condition for largemouth bass. Pp. 79-91 *in* Novinger, G. D., and J. G. Dillard (eds.). *New Approaches* *to the Management of Small Impoundments.* Special Publication 5. North Central Division, American Fisheries Society.

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.

Young, M. K., P. M. Guenther-Gloss, and A. D. Ficke. 2005. Predicting cutthroat trout (*Oncorhynchus clarkii*) abundance in high-elevation streams: revisiting a model of translocation success. *Canadian Journal of Fisheries and Aquatic Sciences* 62:2399-2408

Appendix A 2023 Fish Data

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/22/2023
SITE: **WHITEWOOD CREEK, WWC-A**

PASS	SPECIES	LENGTH (mm)	WEIGHT (g)	K	Ws	Wr
1	BRK	199	71	0.90	88.6	80.2
1	BRK	135	23	0.93	26.6	86.6
1	BRK	128	17	0.81	22.5	75.5
1	BRK	86	5.9	0.93		
1	BRK	84	5.3	0.89		
1	BRK	71	3.1	0.87		
1	BRN	336	365	0.96	408.3	89.4
1	BRN	326	325	0.94	373.4	87.0
1	BRN	273	185	0.91	220.8	83.8
1	BRN	273	168	0.83	220.8	76.1
1	BRN	267	175	0.92	206.8	84.6
1	BRN	264	173	0.94	200.0	86.5
1	BRN	262	165	0.92	195.5	84.4
1	BRN	249	155	1.00	168.2	92.2
1	BRN	248	145	0.95	166.2	87.3
1	BRN	239	128	0.94	149.0	85.9
1	BRN	233	125	0.99	138.2	90.5
1	BRN	232	125	1.00	136.4	91.6
1	BRN	230	118	0.97	133.0	88.7
1	BRN	227	110	0.94	127.9	86.0
1	BRN	219	105	1.00	115.0	91.3
1	BRN	219	104	0.99	115.0	90.4
1	BRN	213	95	0.98	105.9	89.7
1	BRN	210	83	0.90	101.6	81.7
1	BRN	208	105	1.17	98.7	106.3
1	BRN	206	84	0.96	96.0	87.5
1	BRN	204	82	0.97	93.2	88.0
1	BRN	200	82	1.03	87.9	93.3
1	BRN	198	76	0.98	85.3	89.1
1	BRN	183	55	0.90	67.6	81.4
1	BRN	182	57	0.95	66.5	85.7
1	BRN	177	54	0.97	61.2	88.2
1	BRN	176	52	0.95	60.2	86.4
1	BRN	174	53	1.01	58.2	91.0
1	BRN	173	56	1.08	57.2	97.9
1	BRN	173	51	0.98	57.2	89.1
1	BRN	170	53	1.08	54.3	97.5
1	BRN	168	52	1.10	52.5	99.1
1	BRN	168	44	0.93	52.5	83.9
1	BRN	167	48	1.03	51.6	93.1
1	BRN	167	47	1.01	51.6	91.2
1	BRN	166	46	1.01	50.6	90.8
1	BRN	166	45	0.98	50.6	88.9
1	BRN	165	47	1.05	49.7	94.5
1	BRN	164	47	1.07	48.9	96.2
1	BRN	163	46	1.06	48.0	95.9
1	BRN	163	44	1.02	48.0	91.7
1	BRN	163	43	0.99	48.0	89.6
1	BRN	162	42	0.99	47.1	89.1
1	BRN	161	43	1.03	46.3	93.0
1	BRN	160	44	1.07	45.4	96.9

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/22/2023
SITE: **WHITEWOOD CREEK, WWC-A**

1	BRN	158	40	1.01	43.8	91.4
1	BRN	157	43	1.11	42.9	100.1
1	BRN	157	41	1.06	42.9	95.5
1	BRN	157	40	1.03	42.9	93.2
1	BRN	154	38	1.04	40.6	93.7
1	BRN	153	38	1.06	39.8	95.5
1	BRN	152	38	1.08	39.0	97.4
1	BRN	152	38	1.08	39.0	97.4
1	BRN	152	35	1.00	39.0	89.7
1	BRN	151	35	1.02	38.3	91.5
1	BRN	151	33	0.96	38.3	86.2
1	BRN	150	40	1.19	37.5	106.6
1	BRN	150	31	0.92	37.5	82.6
1	BRN	149	35	1.06	36.8	95.2
1	BRN	148	36	1.11	36.1	99.8
1	BRN	147	36	1.13	35.3	101.9
1	BRN	147	32	1.01	35.3	90.6
1	BRN	146	31	1.00	34.6	89.5
1	BRN	146	30	0.96	34.6	86.6
1	BRN	146	29	0.93	34.6	83.7
1	BRN	144	30	1.00	33.2	90.2
1	BRN	144	28	0.94	33.2	84.2
1	BRN	143	31	1.06	32.6	95.2
1	BRN	143	29	0.99	32.6	89.0
1	BRN	142	29	1.01	31.9	90.9
1	BRN	142	27	0.94	31.9	84.6
1	BRN	141	31	1.11	31.2	99.2
1	BRN	138	27	1.03		
1	BRN	138	25	0.95		
1	BRN	137	24	0.93		
1	BRN	134	24	1.00		
1	BRN	130	23	1.05		
1	BRN	88	6.9	1.01		
1	BRN	87	6.8	1.03		
1	BRN	86	6.0	0.94		
1	BRN	86	5.8	0.91		
1	BRN	83	5.2	0.91		
1	BRN	82	5.9	1.07		
1	BRN	81	5.0	0.94		
1	BRN	80	5.5	1.07		
1	BRN	80	4.8	0.94		
1	BRN	79	5.0	1.01		
1	BRN	79	4.8	0.97		
1	BRN	79	4.6	0.93		
1	BRN	78	4.7	0.99		
1	BRN	76	4.1	0.93		
1	BRN	75	3.9	0.92		
1	BRN	73	3.5	0.90		
1	BRN	72	3.5	0.94		
1	BRN	66	2.7	0.94		
1	LND	66	2.4	0.83		
1	LND	62	2.3	0.97		
1	LND	62	2.2	0.92		

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/22/2023
SITE: **WHITEWOOD CREEK, WWC-A**

1	LND	55	1.3	0.78		
1	LND	53	1.3	0.87		
2	BRK	88	6.1	0.90		
2	BRK	85	5.4	0.88		
2	BRN	211	93	0.99	103.0	90.3
2	BRN	210	88	0.95	101.6	86.6
2	BRN	198	82	1.06	85.3	96.1
2	BRN	198	73	0.94	85.3	85.5
2	BRN	167	43	0.92	51.6	83.4
2	BRN	154	38	1.04	40.6	93.7
2	BRN	136	23	0.91		
2	BRN	96	9.6	1.09		
2	BRN	83	5.8	1.01		
2	BRN	82	5.1	0.92		
2	BRN	75	3.8	0.90		
2	BRN	73	3.2	0.82		
2	LND	81	5.0	0.94		
2	LND	64	2.3	0.88		
2	LND	55	1.4	0.84		
3	BRK	88	6.1	0.90		
3	BRN	208	84	0.93	98.7	85.1
3	BRN	163	41	0.95	48.0	85.4
3	BRN	156	40	1.05	42.1	94.9
3	BRN	156	36	0.95	42.1	85.4
3	LND	96	8.7	0.98		

SUMMARY:

BRK		LENGTH (mm)	WEIGHT (g)	K	Wr
	N:	9	9	9	3
	MIN:	71	3.1	0.81	75.5
	MAX:	199	71	0.93	86.6
	MEAN:	107.1	15.9	0.89	80.8

BRN		LENGTH (mm)	WEIGHT (g)	K	Wr
	N:	111	111	111	82
	MIN:	66	2.7	0.82	76.1
	MAX:	336	365	1.19	106.6
	MEAN:	159.8	55.4	0.99	90.6

LND		LENGTH (mm)	WEIGHT (g)	K
	N:	9	9	9
	MIN:	53	1.3	0.78
	MAX:	96	8.7	0.98
	MEAN:	66.0	3.0	0.89

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/22/2023
SITE: **WHITEWOOD CREEK, WWC-A**

SUMMARY (cont.):

	1st Pass	2nd Pass	3rd Pass	Pop Est	95% CI		Site Area (acre)	Density (#/acre)	95% CI		Biomass (lbs/acre)
BRK	6	2	1	9	±	2	0.156	58	±	13	2.03
BRN	95	12	4	111	±	1	0.156	712	±	6	86.96
LND	5	2	1	8	±	2	0.156	51	±	13	0.34

	1st Pass	2nd Pass	3rd Pass	Pop Est	95% CI		Site Area (ha)	Density (#/ha)	95% CI		Biomass (kg/ha)
BRK	6	2	1	9	±	2	0.063	143	±	32	2.27
BRN	95	12	4	111	±	1	0.063	1762	±	16	97.61
LND	5	2	1	8	±	2	0.063	127	±	32	0.38

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/23/2023
SITE: **WHITEWOOD CREEK, WWC-B**

PASS	SPECIES	LENGTH (mm)	WEIGHT (g)	K	Ws	Wr
1	BRN	321	325	0.98	356.7	91.1
1	BRN	310	270	0.91	321.7	83.9
1	BRN	279	188	0.87	235.5	79.8
1	BRN	267	190	1.00	206.8	91.9
1	BRN	257	155	0.91	184.7	83.9
1	BRN	255	150	0.90	180.5	83.1
1	BRN	249	114	0.74	168.2	67.8
1	BRN	248	145	0.95	166.2	87.3
1	BRN	246	150	1.01	162.2	92.5
1	BRN	246	149	1.00	162.2	91.8
1	BRN	239	135	0.99	149.0	90.6
1	BRN	238	218	1.62	147.1	148.2
1	BRN	237	110	0.83	145.3	75.7
1	BRN	235	125	0.96	141.7	88.2
1	BRN	230	115	0.95	133.0	86.5
1	BRN	220	116	1.09	116.6	99.5
1	BRN	219	105	1.00	115.0	91.3
1	BRN	214	112	1.14	107.4	104.3
1	BRN	211	93	0.99	103.0	90.3
1	BRN	196	76	1.01	82.8	91.8
1	BRN	193	71	0.99	79.1	89.7
1	BRN	182	64	1.06	66.5	96.2
1	BRN	180	52	0.89	64.4	80.8
1	BRN	176	57	1.05	60.2	94.7
1	BRN	174	52	0.99	58.2	89.3
1	BRN	172	52	1.02	56.3	92.4
1	BRN	171	48	0.96	55.3	86.8
1	BRN	167	45	0.97	51.6	87.3
1	BRN	162	43	1.01	47.1	91.3
1	BRN	160	48	1.17	45.4	105.7
1	BRN	158	40	1.01	43.8	91.4
1	BRN	155	42	1.13	41.3	101.6
1	BRN	150	38	1.13	37.5	101.3
1	BRN	141	26	0.93	31.2	83.2
1	BRN	92	7.2	0.92		
1	BRN	88	6.7	0.98		
1	BRN	79	4.6	0.93		
1	BRN	78	4.1	0.86		
1	BRN	78	4.0	0.84		
1	BRN	69	3.0	0.91		
1	BRN	68	3.2	1.02		
1	LND	99	11	1.13		
2	BRN	108	12	0.95		
2	BRN	89	6.3	0.89		
2	BRN	60	1.2	0.56		
2	BRN	58	1.5	0.77		
2	BRN	252	155	0.97	174.2	89.0
2	BRN	239	135	0.99	149.0	90.6
2	BRN	226	122	1.06	126.2	96.6
2	BRN	182	59	0.98	66.5	88.7

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/23/2023
SITE: **WHITEWOOD CREEK, WWC-B**

2	BRN	176	58	1.06	60.2	96.3
2	BRN	175	52	0.97	59.2	87.8
2	BRN	174	54	1.03	58.2	92.8
2	BRN	167	48	1.03	51.6	93.1
2	BRN	162	43	1.01	47.1	91.3
2	BRN	154	38	1.04	40.6	93.7
2	BRN	148	33	1.02	36.1	91.5
2	BRN	81	4.7	0.88		
2	MTS	209	122	1.34		
3	BRN	236	130	0.99	143.5	90.6
3	BRN	230	110	0.90	133.0	82.7
3	BRN	223	104	0.94	121.3	85.7
3	BRN	211	102	1.09	103.0	99.0
3	BRN	178	56	0.99	62.3	89.9
3	BRN	177	54	0.97	61.2	88.2
3	BRN	162	44	1.03	47.1	93.4

SUMMARY:

BRN		LENGTH (mm)	WEIGHT (g)	K	Wr
	N:	64	64	64	52
	MIN:	58	1.2	0.56	67.8
	MAX:	321	325	1.62	148.2
	MEAN:	182.5	80.9	0.98	91.4

LND		LENGTH (mm)	WEIGHT (g)	K
	N:	1	1	1
	MIN:	99	11	1.13
	MAX:	99	11	1.13
	MEAN:	99.0	11.0	1.13

MTS		LENGTH (mm)	WEIGHT (g)	K
	N:	1	1	1
	MIN:	209	122	1.34
	MAX:	209	122	1.34
	MEAN:	209.0	122.0	1.34

	1st Pass	2nd Pass	3rd Pass	Pop Est	95% CI		Site Area (acre)	Density (#/acre)	95% CI		Biomass (lbs/acre)
BRN	41	16	7	67	±	6	0.155	432	±	39	77.00
LND	1	0	0	1	±	0	0.155	6	±	0	0.15
MTS	0	1	0	1	±	0	0.155	6	±	0	1.61

	1st Pass	2nd Pass	3rd Pass	Pop Est	95% CI		Site Area (ha)	Density (#/ha)	95% CI		Biomass (kg/ha)
BRN	41	16	7	67	±	6	0.063	1063	±	95	85.95
LND	1	0	0	1	±	0	0.063	16	±	0	0.18
MTS	0	1	0	1	±	0	0.063	16	±	0	1.95

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/22/2023
SITE: **GOLD RUN, GR-A**

PASS	SPECIES	LENGTH (mm)	WEIGHT (g)	K	Ws	Wr	**Comment**
1			NO FISH				

DATA: FISH
CLIENT: SDSTA
SAMPLED: 8/21/2023
SITE: **GOLD RUN, GR-B**

PASS	SPECIES	LENGTH (mm)	WEIGHT (g)	K	Ws	Wr	**Comment**
1			NO FISH				

Appendix B 2023 Benthic Invertebrate Data

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/22/223
Site: WHITEWOOD CREEK, WWC-A

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
INSECTA		
EPHEMEROPTERA	**1,040**	
Baetis flavistriga cx.	90	3.1
Baetis tricaudatus cx.	930	32.1
Diphetor hageni	5	0.2
Ephemerellidae	10	0.3
Tricorythodes explicatus	5	0.2
PLECOPTERA	**150**	
Claassenia sabulosa	15	0.5
Sweltsa sp.	55	1.9
Zapada cinctipes	80	2.8
COLEOPTERA	**900**	
Cleptelmis addenda	5	0.2
Optioservus divergens	435	15.0
Zaitzevia parvula	460	15.9
TRICHOPTERA	**55**	
Hydropsyche sp.	45	1.6
Leptoceridae	5	0.2
Micrasema bactro	5	0.2
DIPTERA	**545**	
Chelifera sp.	5	0.2
Diamesa sp.	205	7.1
Eukiefferiella sp.	20	0.7
Micropsectra sp.	20	0.7
Microtendipes sp.	20	0.7
Orthocladius/Cricotopus gr.	10	0.3
Pagastia sp.	200	6.9
Parametriocnemus sp.	10	0.3
Pericomaini sp.	10	0.3
Simulium sp.	40	1.4
Tipula (Sinotipula)	5	0.2
HYDRACARINA	**10**	
Protzia sp.	10	0.3
CRUSTACEA		
AMPHIPODA	**20**	
Gammarus sp.	20	0.7

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/22/223
Site: WHITEWOOD CREEK, WWC-A

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
NEMATODA	**5**	
Unid. Nematoda	5	0.2
ANNELIDA		
OLIGOCHAETA	**155**	
Eiseniella tetraedra	110	3.8
Unid. Immature Tubificidae w/o Capilliform Chaetae	5	0.2
Unid. Oligochaeta	40	1.4
MOLLUSCA		
GASTROPODA	**20**	
Physa sp.	20	0.7
TOTAL (#/sample)	2,900	
NUMBER OF TAXA	32	
SHANNON-WEAVER (H')	3.31	
TOTAL EPT TAXA	11	
EPT INDEX (% of Total Taxa)	34	
EPHEMEROPTERA ABUNDANCE (% of Total Number)	36	

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/23/2023
Site: WHITEWOOD CREEK, WWC-B

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
INSECTA		
EPHEMEROPTERA	**672**	
Baetis flavistriga cx.	8	0.5
Baetis tricaudatus cx.	660	41.6
Tricorythodes explicatus	4	0.3
PLECOPTERA	**16**	
Sweltsa sp.	16	1.0
COLEOPTERA	**352**	
Heterlimnius corpulentus	4	0.3
Optioservus sp.	196	12.4
Zaitzevia parvula	152	9.6
TRICHOPTERA	**108**	
Brachycentrus occidentalis	4	0.3
Hydropsyche sp.	52	3.3
Hydroptila sp.	28	1.8
Lepidostoma sp.	8	0.5
Ochrotrichia sp.	16	1.0
DIPTERA	**349**	
Cardiocladius sp.	12	0.8
Ceratopogoninae	8	0.5
Conchapelopia/Thienemannimyia gr.	4	0.3
Corynoneura sp.	4	0.3
Cricotopus sp.	4	0.3
Demicryptochironomus sp.	4	0.3
Diamesa sp.	44	2.8
Eukiefferiella sp.	40	2.5
Euparyphus sp.	4	0.3
Neoplasta sp.	4	0.3
Orthocladius/Cricotopus gr.	8	0.5
Pagastia sp.	152	9.6
Parametriocnemus sp.	12	0.8
Simulium sp.	44	2.8
Synorthocladius sp.	4	0.3
Tipula (Sinotipula)	1	0.1
HYDRACARINA	**20**	
Atractides sp.	8	0.5
Sperchon sp.	12	0.8

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/23/2023
Site: WHITEWOOD CREEK, WWC-B

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
CRUSTACEA		
AMPHIPODA	**8**	
Gammarus sp.	8	0.5
TURBELLARIA	**4**	
Girardia sp.	4	0.3
NEMATODA	**8**	
Unid. Nematoda	8	0.5
ANNELIDA		
OLIGOCHAETA	**48**	
Eiseniella tetraedra	32	2.0
Nais sp.	8	0.5
Unid. Oligochaeta	8	0.5
TOTAL (#/sample)	1,585	
NUMBER OF TAXA	36	
SHANNON-WEAVER (H')	3.23	
TOTAL EPT TAXA	9	
EPT INDEX (% of Total Taxa)	25	
EPHEMEROPTERA ABUNDANCE (% of Total Number)	42	

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/22/2023
Site: GOLD RUN, GR-A

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
INSECTA		
EPHEMEROPTERA	**56**	
Baetis flavistriga cx.	17	5.5
Baetis tricaudatus cx.	39	12.6
COLEOPTERA	**12**	
Agabus cx.	7	2.3
Hydroporinae	2	0.6
Optioservus divergens	2	0.6
Zaitzevia parvula	1	0.3
DIPTERA	**178**	
Brillia sp.	28	9.0
Caloparyphus/Euparyphus sp.	1	0.3
Eukiefferiella sp.	2	0.6
Muscidae	6	1.9
Pagastia sp.	6	1.9
Parametriocnemus sp.	95	30.6
Pericomaini sp.	1	0.3
Phaenopsectra sp.	6	1.9
Prodiamesa sp.	6	1.9
Psychodini sp.	13	4.2
Simulium sp.	1	0.3
Tipula sp.	12	3.9
Unid. Diptera	1	0.3
HYDRACARINA	**7**	
Oribatida sp.	7	2.3
TURBELLARIA	**1**	
Girardia sp.	1	0.3
ANNELIDA		
OLIGOCHAETA	**56**	
Eiseniella tetraedra	5	1.6
Enchytraeidae	7	2.3
Limnodrilus sp.	1	0.3
Nais sp.	39	12.6
Unid. Oligochaeta	4	1.3

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/22/2023
Site: GOLD RUN, GR-A

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
TOTAL (#/sample)	310	
NUMBER OF TAXA	26	
SHANNON-WEAVER (H')	3.51	
TOTAL EPT TAXA	2	
EPT INDEX (% of Total Taxa)	8	
EPHEMEROPTERA ABUNDANCE (% of Total Number)	18	

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/21/2023
Site: GOLD RUN, GR-B

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
INSECTA		
EPHEMEROPTERA	**50**	
Baetis flavistriga cx.	8	1.4
Baetis tricaudatus cx.	42	7.1
ODONATA	**8**	
Argia sp.	8	1.4
PLECOPTERA	**6**	
Sweltsa sp.	2	0.3
Zapada cinctipes	4	0.7
COLEOPTERA	**16**	
Dytiscidae	2	0.3
Microcylloepus pusillus	10	1.7
Optioservus sp.	4	0.7
TRICHOPTERA	**152**	
Hydropsyche sp.	146	24.8
Hydroptila sp.	6	1.0
DIPTERA	**334**	
Brillia sp.	16	2.7
Cricotopus sp.	26	4.4
Cricotopus trifascia	10	1.7
Eukiefferiella sp.	120	20.4
Neoplasta sp.	2	0.3
Orthocladius/Cricotopus gr.	4	0.7
Pagastia sp.	4	0.7
Parametriocnemus sp.	132	22.4
Simulium sp.	10	1.7
Tipula sp.	8	1.4
Unid. Diptera	2	0.3
HYDRACARINA	**4**	
Oribatida sp.	4	0.7
TURBELLARIA	**2**	
Girardia sp.	2	0.3
ANNELIDA		
OLIGOCHAETA	**16**	
Eiseniella tetraedra	6	1.0

DATA: BENTHIC MACROINVERTEBRATES
Client: SDSTA
Sampled: 8/21/2023
Site: GOLD RUN, GR-B

TAXA	REACH WIDE COMPOSITE (#/SAMPLE)	% OF TOTAL
OLIGOCHAETA (cont.)		
Enchytraeidae	10	1.7
TOTAL (#/sample)	588	
NUMBER OF TAXA	25	
SHANNON-WEAVER (H')	3.24	
TOTAL EPT TAXA	6	
EPT INDEX (% of Total Taxa)	24	
EPHEMEROPTERA ABUNDANCE (% of Total Number)	9	

Appendix C 2023 Periphyton Data

DATA: PERIPHYTON
Client: SDSTA
Sampled: 8/22/2023
Site: WHITEWOOD CREEK, WWC-A

TOTAL CELLS/cm^2	31,573
NUMBER OF TAXA	19
SHANNON-WEAVER DIVERSITY (H')	3.09
TROPHIC STATE INDEX	66.6

Organisms	Cells/cm^2	Rel % Conc.
BACILLARIOPHYTA		
Order Centrales		
Stephanodiscus hantzschii	259	0.8
Order Pennales		
Achnanthes linearis	1,035	3.3
Achnanthes minutissima	10,869	34.4
Amphora perpusilla	1,035	3.3
Cocconeis placentula	7,505	23.8
Cymbella affinis	259	0.8
Cymbella sinuata	1,294	4.1
Gomphonema angustatum	1,811	5.7
Navicula cryptocephala	1,294	4.1
Navicula cryptocephala veneta	259	0.8
Navicula tripunctata	2,070	6.6
Navicula viridula	1,035	3.3
Nitzschia frustulum	518	1.6
Nitzschia linearis	259	0.8
Nitzschia palea	1,035	3.3
Nitzschia paleacea	259	0.8
Pinnularia sp.	259	0.8
Rhoicosphenia curvata	259	0.8
Synedra ulna	259	0.8

DATA: PERIPHYTON ANALYSES
Client: SDSTA
Sampled: 8/23/2023
Site: WHITEWOOD CREEK, WWC-B

TOTAL CELLS/cm^2	9,060
NUMBER OF TAXA	20
SHANNON-WEAVER DIVERSITY (H')	3.27
TROPHIC STATE INDEX	58.0

Organisms	Cells/cm^2	Rel % Conc.
BACILLARIOPHYTA		
Order Pennales		
Achnanthes lanceolata	401	4.4
Achnanthes minutissima	1,604	17.7
Amphora perpusilla	401	4.4
Cocconeis placentula	2,727	30.1
Cymbella affinis	80	0.9
Cymbella sinuata	481	5.3
Fragilaria pinnata	80	0.9
Gomphonema angustatum	241	2.7
Gomphonema clevei	80	0.9
Navicula cryptocephala	1,363	15.0
Navicula cryptocephala veneta	401	4.4
Navicula tripunctata	481	5.3
Navicula viridula	80	0.9
Nitzschia communis	80	0.9
Nitzschia dissipata	80	0.9
Nitzschia frustulum	80	0.9
Nitzschia innominata	80	0.9
Nitzschia palea	80	0.9
Rhoicosphenia curvata	80	0.9
CHLOROPHYTA		
Cladophora sp.	160	1.8

DATA: PERIPHYTON ANALYSES
Client: SDSTA
Sampled: 8/22/2023
Site: GOLD RUN, GR-A

TOTAL CELLS/cm^2	46,315
NUMBER OF TAXA	2
SHANNON-WEAVER DIVERSITY (H')	0.02
TROPHIC STATE INDEX	56.6

Organisms	Cells/cm^2	Rel % Conc.
BACILLARIOPHYTA		
Order Pennales		
Achnanthes minutissima	46,212	99.8
Amphora coffeaeformis	103	0.2

DATA: PERIPHYTON ANALYSES
Client: SDSTA
Sampled: 8/21/2023
Site: GOLD RUN, GR-B

TOTAL CELLS/cm^2	52,932
NUMBER OF TAXA	17
SHANNON-WEAVER DIVERSITY (H')	2.78
TROPHIC STATE INDEX	64.5

Organisms	Cells/cm^2	Rel % Conc.
BACILLARIOPHYTA		
Order Pennales		
Achnanthes lanceolata	420	0.8
Achnanthes minutissima	24,366	46.0
Anomoeoneis vitrea	840	1.6
Caloneis ventricosa minuta	1,680	3.2
Cocconeis placentula	4,621	8.7
Cymbella microcephala	420	0.8
Cymbella minuta	840	1.6
Diatoma tenue	840	1.6
Navicula cryptocephala	2,101	4.0
Navicula tripunctata	420	0.8
Nitzschia communis	2,941	5.6
Nitzschia dissipata	420	0.8
Nitzschia fonticola	420	0.8
Nitzschia frustulum	2,101	4.0
Nitzschia palea	1,680	3.2
Nitzschia paleacea	420	0.8
Rhoicosphenia curvata	8,402	15.9

Appendix D 2023 Water Quality Data

MIDCONTINENT
TESTING LABORATORIES, INC.

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

Sample Site: WWC - A
Sampled: 08/29/23 at 09:10 AM
by Zachary Adam
Sample Matrix: Water

Lab ID#: 20230830302
Received: 08/29/23 at 12:08 PM
by Eric Fuehrer
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	0.168	5.00	SM 2510B	JAM	08/30/23
Hardness	522	mg/L	1			SM 2340 B	EJF	09/13/23
pH	8.37	S.U.	1			SM 4500-H+ B	JAM	08/30/23
Total Dissolved Solids	740	mg/L	100ml	12.8	50.0	SM 2540 C	MEM	08/30/23
Total Suspended Solids	2.40	mg/L	500ml	0.565	2.00	SM 2540 D	MEM	08/30/23
Non-Metallics								
Cyanide, WAD	< 0.010	mg/L	1	0.0007	0.010	Kelada 01	TMN	08/31/23
Nitrogen, Ammonia (NH3)	< 0.050	mg/L	1	0.004	0.050	Timberline-001	MEM	08/30/23
Nitrogen, Nitrate (NO3)	1.04	mg/L	1	0.007	0.050	SM 4500-NO3 F	BLL	08/31/23
Phosphorus (P) Dissolved	< 0.010	mg/L	1	0.005	0.010	SM 4500-P E	GRR	09/06/23
Metals - Dissolved								
Calcium (Ca)	101	mg/L	5	0.474	5.00	SM 3111 B	GRT	09/11/23
Magnesium (Mg)	65.7	mg/L	2	0.181	1.00	SM 3111 B	GRT	09/06/23
Metals - Total								
Mercury (Hg)	< 0.0002	mg/L	1	0.000033	0.0002	EPA 245.1	GRT	08/31/23
Metals - Total Recoverable								
Arsenic (As)	0.009	mg/L	10	0.000495	0.005	EPA 200.8	TNA	08/30/23
Cadmium (Cd)	< 0.001	mg/L	10	0.00035	0.001	EPA 200.8	TNA	08/30/23
Chromium (Cr)	< 0.001	mg/L	10	0.000053	0.001	EPA 200.8 DRC	TNA	08/30/23
Copper (Cu)	< 0.005	mg/L	10	0.000168	0.005	EPA 200.8	TNA	08/30/23
Iron (Fe)	0.391	mg/L	10	0.002	0.050	EPA 200.8	TNA	08/30/23
Lead (Pb)	< 0.001	mg/L	10	0.000094	0.001	EPA 200.8	TNA	08/30/23
Nickel (Ni)	< 0.005	mg/L	10	0.00023	0.005	EPA 200.8	TNA	08/30/23
Selenium (Se)	< 0.005	mg/L	10	0.00079	0.005	EPA 200.8	TNA	08/30/23
Silver (Ag)	< 0.001	mg/L	10	0.00032	0.001	EPA 200.8	TNA	08/30/23
Zinc (Zn)	< 0.050	mg/L	10	0.005	0.050	EPA 200.8	TNA	08/30/23
Metals - Speciation								
Selenium (IV) Speciation	< 0.001	mg/L	1			Selenium (IV) Speciation	SYS	09/15/23
Selenium (VI) Speciation	< 0.001	mg/L	1			Selenium (VI) Speciation	SYS	09/15/23

Report Approved By:

Eric Fuehrer

Report Approved On: 10/4/2023 3:13:35 PM

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MIDCONTINENT
TESTING LABORATORIES, INC.

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

Sample Site: WWC - B
Sampled: 08/29/23 at 08:55 AM by Zachary Adam
Sample Matrix: Water

Lab ID#: 20230830303
Received: 08/29/23 at 12:08 PM by Eric Fuehrer
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	545	µmhos/cm	1	0.168	5.00	SM 2510B	JAM	08/30/23
Hardness	250	mg/L	1			SM 2340 B	EJF	09/13/23
pH	8.40	S.U.	1			SM 4500-H+ B	JAM	08/30/23
Total Dissolved Solids	295	mg/L	100ml	12.8	50.0	SM 2540 C	MEM	08/30/23
Total Suspended Solids	2.20	mg/L	500ml	0.565	2.00	SM 2540 D	MEM	08/30/23
Non-Metallics								
Cyanide, WAD	< 0.010	mg/L	1	0.0007	0.010	Kelada 01	TMN	08/31/23
Nitrogen, Ammonia (NH3)	< 0.050	mg/L	1	0.004	0.050	Timberline-001	MEM	08/30/23
Nitrogen, Nitrate (NO3)	0.471	mg/L	1	0.007	0.050	SM 4500-NO3 F	BLL	08/31/23
Phosphorus (P) Dissolved	< 0.010	mg/L	1	0.005	0.010	SM 4500-P E	GRR	09/06/23
Metals - Dissolved								
Calcium (Ca)	59.5	mg/L	3	0.285	3.00	SM 3111 B	GRT	09/11/23
Magnesium (Mg)	24.6	mg/L	1	0.090	0.500	SM 3111 B	GRT	09/06/23
Metals - Total								
Mercury (Hg)	< 0.0002	mg/L	1	0.000033	0.0002	EPA 245.1	GRT	08/31/23
Metals - Total Recoverable								
Arsenic (As)	0.005	mg/L	10	0.000495	0.005	EPA 200.8	TNA	08/30/23
Cadmium (Cd)	< 0.001	mg/L	10	0.00035	0.001	EPA 200.8	TNA	08/30/23
Chromium (Cr)	< 0.001	mg/L	10	0.000053	0.001	EPA 200.8 DRC	TNA	08/30/23
Copper (Cu)	< 0.005	mg/L	10	0.000168	0.005	EPA 200.8	TNA	08/30/23
Iron (Fe)	0.488	mg/L	10	0.002	0.050	EPA 200.8	TNA	08/30/23
Lead (Pb)	< 0.001	mg/L	10	0.000094	0.001	EPA 200.8	TNA	08/30/23
Nickel (Ni)	< 0.005	mg/L	10	0.00023	0.005	EPA 200.8	TNA	08/30/23
Selenium (Se)	< 0.005	mg/L	10	0.00079	0.005	EPA 200.8	TNA	08/30/23
Silver (Ag)	< 0.001	mg/L	10	0.00032	0.001	EPA 200.8	TNA	08/30/23
Zinc (Zn)	< 0.050	mg/L	10	0.005	0.050	EPA 200.8	TNA	08/30/23
Metals - Speciation								
Selenium (IV) Speciation	< 0.001	mg/L	1			Selenium (IV) Speciation	SYS	09/15/23
Selenium (VI) Speciation	< 0.001	mg/L	1			Selenium (VI) Speciation	SYS	09/15/23

Report Approved By:

Report Approved On: 10/4/2023 3:13:35 PM

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MIDCONTINENT
TESTING LABORATORIES, INC.

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

Sample Site: GRC-A
Sampled: 08/29/23 at 08:40 AM by Zachary Adam
Sample Matrix: Water

Lab ID#: 20230830304
Received: 08/29/23 at 12:08 PM by Eric Fuehrer
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	1030	µmhos/cm	1	0.168	5.00	SM 2510B	JAM	08/30/23
Hardness	456	mg/L	1			SM 2340 B	EJF	09/13/23
pH	7.94	S.U.	1			SM 4500-H+ B	JAM	08/30/23
Total Dissolved Solids	635	mg/L	100ml	12.8	50.0	SM 2540 C	MEM	08/30/23
Total Suspended Solids	44.0	mg/L	150ml	1.88	6.67	SM 2540 D	MEM	08/30/23
Non-Metallics								
Cyanide, WAD	< 0.010	mg/L	1	0.0007	0.010	Kelada 01	TMN	08/31/23
Nitrogen, Ammonia (NH3)	< 0.050	mg/L	1	0.004	0.050	Timberline-001	MEM	08/30/23
Nitrogen, Nitrate (NO3)	1.80	mg/L	2	0.014	0.100	SM 4500-NO3 F	BLL	08/31/23
Phosphorus (P) Dissolved	< 0.010	mg/L	1	0.005	0.010	SM 4500-P E	GRR	09/06/23
Metals - Dissolved								
Calcium (Ca)	121	mg/L	6	0.569	6.00	SM 3111 B	GRT	09/11/23
Magnesium (Mg)	37.5	mg/L	1	0.090	0.500	SM 3111 B	GRT	09/06/23
Metals - Total								
Mercury (Hg)	< 0.0002	mg/L	1	0.000033	0.0002	EPA 245.1	GRT	08/31/23
Metals - Total Recoverable								
Arsenic (As)	0.038	mg/L	10	0.000495	0.005	EPA 200.8	TNA	08/30/23
Cadmium (Cd)	< 0.001	mg/L	10	0.00035	0.001	EPA 200.8	TNA	08/30/23
Chromium (Cr)	0.002	mg/L	10	0.000053	0.001	EPA 200.8 DRC	TNA	08/30/23
Copper (Cu)	0.043	mg/L	10	0.000168	0.005	EPA 200.8	TNA	08/30/23
Iron (Fe)	10.3	mg/L	10	0.002	0.050	EPA 200.8	TNA	08/30/23
Lead (Pb)	< 0.001	mg/L	10	0.000094	0.001	EPA 200.8	TNA	08/30/23
Nickel (Ni)	0.037	mg/L	10	0.00023	0.005	EPA 200.8	TNA	08/30/23
Selenium (Se)	< 0.005	mg/L	10	0.00079	0.005	EPA 200.8	TNA	08/30/23
Silver (Ag)	< 0.001	mg/L	10	0.00032	0.001	EPA 200.8	TNA	08/30/23
Zinc (Zn)	0.074	mg/L	10	0.005	0.050	EPA 200.8	TNA	08/30/23
Metals - Speciation								
Selenium (IV) Speciation	< 0.001	mg/L	1			Selenium (IV) Speciation	SYS	09/15/23
Selenium (VI) Speciation	0.002	mg/L	1			Selenium (VI) Speciation	SYS	09/15/23

Report Approved By:

Eric Fuehrer

Report Approved On: 10/4/2023 3:13:35 PM

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MIDCONTINENT
TESTING LABORATORIES, INC.

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

Sample Site: GRC-B
Sampled: 08/29/23 at 08:45 AM by Zachary Adam
Sample Matrix: Water

Lab ID#: 20230830305
Received: 08/29/23 at 12:08 PM by Eric Fuehrer
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	2450	µmhos/cm	1	0.168	5.00	SM 2510B	JAM	08/30/23
Hardness	1290	mg/L	1			SM 2340 B	EJF	09/13/23
pH	8.22	S.U.	1			SM 4500-H+ B	JAM	08/30/23
Total Dissolved Solids	2010	mg/L	100ml	12.8	50.0	SM 2540 C	MEM	08/30/23
Total Suspended Solids	2.60	mg/L	500ml	0.565	2.00	SM 2540 D	MEM	08/30/23
Non-Metallics								
Cyanide, WAD	< 0.010	mg/L	1	0.0007	0.010	Kelada 01	TMN	08/31/23
Nitrogen, Ammonia (NH3)	< 0.050	mg/L	1	0.004	0.050	Timberline-001	MEM	08/30/23
Nitrogen, Nitrate (NO3)	2.73	mg/L	5	0.036	0.250	SM 4500-NO3 F	BLL	08/31/23
Phosphorus (P) Dissolved	< 0.010	mg/L	1	0.005	0.010	SM 4500-P E	GRR	09/06/23
Metals - Dissolved								
Calcium (Ca)	206	mg/L	7	0.664	7.00	SM 3111 B	GRT	09/11/23
Magnesium (Mg)	188	mg/L	7	0.633	3.50	SM 3111 B	GRT	09/06/23
Metals - Total								
Mercury (Hg)	< 0.0002	mg/L	1	0.000033	0.0002	EPA 245.1	GRT	08/31/23
Metals - Total Recoverable								
Arsenic (As)	0.014	mg/L	10	0.000495	0.005	EPA 200.8	TNA	08/30/23
Cadmium (Cd)	< 0.001	mg/L	10	0.00035	0.001	EPA 200.8	TNA	08/30/23
Chromium (Cr)	< 0.001	mg/L	10	0.000053	0.001	EPA 200.8 DRC	TNA	08/30/23
Copper (Cu)	< 0.005	mg/L	10	0.000168	0.005	EPA 200.8	TNA	08/30/23
Iron (Fe)	0.570	mg/L	10	0.002	0.050	EPA 200.8	TNA	08/30/23
Lead (Pb)	< 0.001	mg/L	10	0.000094	0.001	EPA 200.8	TNA	08/30/23
Nickel (Ni)	0.007	mg/L	10	0.00023	0.005	EPA 200.8	TNA	08/30/23
Selenium (Se)	< 0.005	mg/L	10	0.00079	0.005	EPA 200.8	TNA	08/30/23
Silver (Ag)	< 0.001	mg/L	10	0.00032	0.001	EPA 200.8	TNA	08/30/23
Zinc (Zn)	< 0.050	mg/L	10	0.005	0.050	EPA 200.8	TNA	08/30/23
Metals - Speciation								
Selenium (IV) Speciation	< 0.001	mg/L	1			Selenium (IV) Speciation	SYS	09/15/23
Selenium (VI) Speciation	< 0.001	mg/L	1			Selenium (VI) Speciation	SYS	09/15/23

Report Approved By:

Eric Fuehrer