Biological Integrity of Streams in the Tongue River Basin and Rosebud Creek and Implications for Coalbed Natural Gas Development

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1.0 Introduction

Natural gas is an emerging component in the current trend towards increased development of domestic energy resources. Production in the Rocky Mountain region is projected to increase by more than 50% in the next two decades (EIA 2004), with extensive development already underway in areas such as the Powder River and Tongue River basins in Wyoming and Montana. Natural gas production provides energy resources and economic stimulus, but it has also generated substantial concern with regard to the potential for deleterious effects across the landscape.

Coalbed natural gas (CBNG) is methane associated with coal formations. The gas is extracted from coal seams by easing the groundwater pressure that maintains adsorption to the coal. This extraction method produces large quantities of water as a by-product that, although variable in quality, often has relatively high concentrations of salts and trace metals. Disposal options for this water include discharge to surface waters, storage in constructed reservoirs, irrigation, and reinjection into the ground. In Wyoming, discharge to surface waters is a common approach, although methane producers are also employing land application with soil amendments to counteract the high sodium concentrations. Construction of on- and off-stream infiltration or evaporation reservoirs is another conventional approach in Wyoming to dealing with product water. CBNG is at an earlier stage in Montana with considerably fewer wells producing water. Permitted disposal options in Montana include discharge of raw and treated produced water to the Tongue River

The effects of surface discharge on fisheries, aquatic life, and agricultural uses are poorly understood. Careful management is warranted, as relatively little guiding work has been done to describe pertinent ecological relationships within the study area. A previous report (Confluence 2003) described conditions at ten sites on seven tributary streams within the upper Tongue River basin. The present investigation expands on the previous report by identifying baseline aquatic conditions at seventeen sites within the upper Tongue River basin while comparing assessments made at ten sites sampled in both 2002 and 2004 and identifying changes in the aquatic ecosystem that are attributable to CBNG development. The goal of this document is to strengthen the base of scientific information with which to assess the affects of coalbed natural gas development in the Tongue River basin.

2.0 Literature Review

A supplemental component of this study was compilation of a literature review to facilitate interpretation of field data and augment the technical foundation to promote sustainable practices associated with coalbed natural gas development. This involves two parts. First is a review of the scientific literature addressing streambed chemistry and its influence on water quality and aquatic life. The rationale for this effort relates to the salt crusts that precipitate on the streambed on many prairie streams. Although this is a natural feature in many of these relatively saline streams, concerns exist regarding the effect of CBNG wastewater on the constituents present in salt crusts and the potential implications for aquatic life and irrigation.

The second part updates the literature review conducted in the first year of stream investigations (Confluence 2003). This entailed a search for recent studies relating to CBNG development and its potential effects on streams, water quality, and associated beneficial uses.

2.1 *Streambed Substrate and Associated Physiochemical Processes*

The characteristics of a streambed result from the dynamic interactions between climate and geology. Given the importance of fluvial processes and sedimentation to biota and to matters of civil engineering, these subjects have been well studied and described within numerous texts (e.g., Leopold 1964, Hynes 1970, and Rosgen 1996). In general, the composition of material comprising a streambed reflects processes of erosion and deposition occurring on multiple scales. Landscape-scale features that influence these processes include geology, topography, and climate. Interrelated factors operating at smaller scales include discharge, flow velocity, channel width and depth, bed resistance, and sediment load. Higher water velocities generally have the potential to create greater sheer stress on the substrate and thus to pick up or roll larger particles, although flows and sediment transport exhibit complex associations. Particles suspended in the water column deposit where water velocity decreases below some critical level. Fine sediment settles behind mid-channel obstructions, at channel margins, on the floodplain, or on the streambed of downstream, low gradient reaches. In a state of perfect equilibrium, sheer stress on the streambed would equal the stability of the substrate and create the impression of a stable channel. However, new sediment enters stream channels as a result of lateral erosion and from upland sources, and flows fluctuate according to seasonal patterns and with individual storm events. Further, vegetation can exert considerable influence on fluvial processes and contribute variability on multiple spatial and temporal scales. Thus, stream channels and their substrates are constantly in flux and the notion of stability is relative in nature.

The streambed substrate forms a critical component in the ecology of a stream (Hynes 1970, Allen 1995). Periphyton and aquatic macrophytes commonly require certain substrates as attachment surfaces or as media in which to anchor roots. Aquatic invertebrates use particular substrates as refuge from predators, as anchor sites for filter feeding, or for provision of food in the form of detritus, macrophytes, periphyton, or animal prey items. Numerous species in the EPT orders (mayflies, stoneflies, and caddisflies), for example, associate with unembedded substrates containing abundant interstices and relatively small amounts of fine sediment, whereas some varieties of mayfly larvae (e.g., Ephemeridae) burrow into soft substrates and certain Chironomidae midge larvae produce hemoglobin as an adaptation for life in soft, anoxic sediments. Fishes, as well, often exhibit strong association to specific substrates that harbor required food items or provide refuge from high current velocities and predators. Some fishes also require particular substrate conditions for spawning, as is the case with salmonids that bury their eggs in unembedded gravels.

Excessive sedimentation may be the most pervasive cause of impairment to streams (Waters 1995). Sediment enters channels due to natural erosion, but human land use practices have exacerbated loading of fine as well as coarse sediments, bringing serious repercussions for the health of stream biota. Inputs of fine materials can smother periphyton, macrophytes, macroinvertebrates, as well as the interstitial spaces they require. For fishes, the detriments of siltation include loss of pool space and interstitial refugia, and reductions in prey abundance and spawning success (impaired respiration in egg and larval stages; impaired emergence). Movement of coarse substrate materials can scour, dislodge, and uproot the biota, and excessive aggradation can bury stream channels and reduce or eliminate surface flow.

Chemistry of the streambed and its implications to aquatic life has received little study aside from the topic of contamination by industrial waste metals or artificial compounds. Most research on the effects of salinity in river systems has addressed the use of stream water to irrigate croplands. Agricultural concerns focus on consequences of salinity to soil texture as well as to plant growth directly (Singer and Warrington 1992, Warrence et al. 2002, LRES 2003). High concentrations of dissolved salts can have a flocculating effect on soil that decreases the amount of available water, and it can pose direct toxicity to plants (e.g., leaf burn, desiccation, impaired capacity to synthesize proteins). High levels of sodium ions relative to levels of calcium and magnesium ions (calculated as the sodium adsorption ratio or SAR) causes dispersion of soil particles, potentially leading to reduced infiltration and hydraulic conductivity and formation of a surface crust, all of which negatively affect survival and growth of plants. Increased conductivity can mitigate the effects of an elevated SAR, but with increasing conductivity comes eventual toxicity. The composition of a soil influences these effects, as ions more readily adsorb to clays but leach through sand.

Application to riparian, wetland, or within-channel soils of theory or numeric criteria developed from investigation of upland soils or substrates is complicated by inherent differences in their hydrology and soil properties (Horpestad et al. 2001). Hydrogeology in aquatic and riparian settings involves a complexity of infiltration and discharge to and from surface water and groundwater, and these dynamics change with stream discharge levels (National Research Council 2002, Kirk 2004). Because of low flood frequencies and low flow velocities, sediments deposited high on the floodplain may have relatively long resident times and little subsequent influence from surface water chemistry. The structural effects of elevated salinity and SAR described above probably apply better to soils at the periphery or in elevated portions of the riparian zone than to areas within the bankfull channel, where deposited sediments may have short residence times. Given the instability and recentness of deposits within the bankfull channel, as well as the tendency for more continuous saturation, soils (predominantly entisols) have little time to develop and thus effects of salinity or sodicity on soil structure probably differ from those described for upland soils. Highly saline water may have greater toxicity in saturated soils than in upland soils because of the longer duration of exposure (Horpestad et al. 2001). Groundwater may rise to the soil surface and leave a chemical salt crust upon evaporation (Horpestad et al. 2001), but the potential implications for erosion, infiltration, seedling emergence, and toxicity depend upon the durability of the crust and whether high flows flush accumulated salts (Kirk 2004). Within the wetted channel, sediment chemistry receives constant influence from ambient water chemistry. The response of the substrate to the differing chemistries of various flows is unknown, but deposits rich in clay potentially accumulate or retain ions to a greater extent than those dominated by sand or gravel (Horpestad et al. 2001; Warrence et al. 2002).

Ecological studies of saline basins allow inference on the effects of streambed substrate chemistry on aquatic life. Salinization has occurred across the globe, usually in associated with agriculture and alteration of natural flow regimes (Ghassemi et al. 1995). In the western United States, salt-tolerant species such as tamarisk (*Tamarix* spp.) and arrowleaf (*Pluchea sericea*) have replaced the native woody vegetation along river channels in drainages including the Colorado River, Powder River, and Rio Grande basins (Bush and Smith 1995; Everitt 1998; Vandersande et al. 2001; Confluence 2004). In comparison to native cottonwoods (*Populus* spp.) and willows (*Salix* spp.), tamarisk has been associated with reduced input of habitat-forming large woody debris and provision of allochthonous leaf litter supporting different aquatic invertebrate species assemblages, reduced species richness, and lower total abundance (Bailey et al. 2001). In western Australia, salinization has been associated with reduced richness and diversity of aquatic macroinvertebrates and aquatic, riparian, and wetland vegetation, as well as overall shifts to halotolerant taxa (Kay et al. 2001, Halse et al. 2003). These studies focus on water or soil chemistry rather than channel sediments, and the presence of multiple stressors (agricultural development, flow regulation) complicates the identification of effects specific to sediment chemistry. However, the observed effects are positively associated with salinity levels and indicate a general pattern of loss of biodiversity with excessive salinity.

The Tongue River study area contains a variety of streambed substrate conditions. Upper reaches of streams having perennial flow appear to hold sand and some gravel, whereas silt dominates intermittent reaches (Confluence 2003). A relatively low gradient stream, small substrates dominate the main stem of the Tongue River, although regulated flows and larger substrates occur downstream of the dam and impoundment causes settling of fine sediments above. Montmorillonite clays are common in the study area, and because clayey substrates may hold higher concentrations of dissolved ions than sand and gravels, organisms that inhabit silt and clay substrates may be more affected than those in sands and gravels (Horpestad et al. 2001). However, the highest concentrations of salt ions occur at the lowest stream flows (Horpestad et al. 2001), and so submerged sediments may present more stressful conditions than sediments that are covered only at higher flows. Further complicating matters, the chemistries of soils and shallow groundwater vary considerably within the study area (TetraTech 2003), suggesting that sediments at sites where highly saline groundwater discharges or evaporates to the soil surface might hold high salt concentrations. In addition, CBNG development has the potential to alter groundwater levels and discharges, and product water outfalls can affect erosion, deposition, and resulting sediment characteristics (Bauder 1999).

Such enormous variability within the stream channel and riparian areas brings extreme difficulty in establishing numeric standards for protection of aquatic and riparian biota, especially given the scarcity of information regarding tolerance levels of individual taxa to various chemicals (Horpestad et al. 2001). However, the literature clearly indicates that changes in environmental chemistry can have repercussions for biota. Tolerance data (conductivity, SAR, pH, flooding) for plant species native to the study area indicate that some species require relatively fresh soil water (conductivity < 2,000 μmhos/cm) (LRES 2001). Flora and fauna differ between oligosaline (800-4200 μmhos/cm) and mesosaline (9,300-23,500 μmhos/cm) high plains lakes in Wyoming (Wollheim and Lovvorn 1996). Periphyton, macroinvertebrate, and fish assemblages differ among Tongue River tributaries, and despite confounding factors, some correlations to salinity levels have been detected (Confluence 2002). Although changes to salinity must affect freshwater organisms to some degree, aquatic communities possess resiliency and effects may vary according to life stage or season (James et al. 2003). Given the lack of numeric standards or comparable reference samples for the Tongue River, streambed substrate samples best serve to provide baseline information for consideration in combination with water quality and the condition of the biota.

2.2 *Recent Reports Pertinent to CBNG Product Water and Its Effects on Aquatic Ecology*

The ecological effects of CBNG product water remain poorly understood. Confluence Consulting, Inc (2003) reviewed available information in 2003, and no controlled studies dealing with direct effects of CBNG development on aquatic biota have since been published. However, compilations of information specific to the Tongue River drainage have been issued in the final EIS and TMDL documents (USDI 2003, TetraTech 2003), several investigations related to CBNG or to pertinent aspects of aquatic ecology have been reported, and additional work is in progress.

Few investigations have assessed the effects of CBNG development on aquatic habitats. In the Powder River, a survey of biological, chemical, and physical habitat revealed elevated concentrations of dissolved salts below areas of CBNG development, correlated with abundant tamarisk and alarmingly low numbers of sturgeon chub (*Macrhybopsis gelida*) (Confluence 2004). A study of CNBG discharges to ephemeral tributaries of the Powder River found SAR and pH to increase in a downstream direction, and although only pH was significantly higher in the Powder River below the confluence relative to above, the additive effect of multiple discharge inputs may be substantial (Patz et al. 2004). Vegetation in these channels shifted from dryland plants to a few wetland halophyte species in about 12 months. The SAR values in the channels reached 29 (practical) and 45.5 (true) before the confluence with the Powder River, and the product water had pH = 7.1 and EC = 4300 µmhos/cm.

Numeric specification of critical chemical constituent values remains problematic, although investigators have employed WET testing to address this issue. WET tests using CBNG product water from the Prairie Dog Creek drainage and from other Wyoming locations were conducted to examine acute toxicity to *Daphnia magna*, and both acute and chronic toxicities to fathead minnows (*Pimephales promelas*) and to *Ceridaphnia dubia* (WDEQ 2003). The results varied among sites, but for the Prairie Dog Creek site, reduced (75%) survival of fathead minnows occurred only in the acute test using undiluted product water, and survival of *C. dubia* was reduced in chronic tests using water at 50% or greater concentration. *Daphnia magna* showed no reduction in survival. Chemical properties of the Prairie Dog Creek product water included: EC = 1927 µmhos/cm, HCO_3^- = 1464 mg/L, Na^+ = 508 mg/L. Another WET study is currently underway to address the effect on pallid sturgeon, fathead minnows, and white suckers of sodium bicarbonate additions to Tongue River simulation water (Skaar et al. 2004). Other studies in progress include an investigation of the water chemistry and associated biotic implications in constructed CBNG discharge ponds in Wyoming (Jackson et al. 2004), and an investigation of the effects of spreading product water at upland sites (Micale and Marrs 2004). An important consideration in applying the results from these studies to CBNG development to various locations is that product water chemistry has large site-specific differences (VanVoast 2003).

Numerous publications have described effects on aquatic and riparian systems due to increased salinity caused by factors other than CBNG development. Salinization appears to be a primary factor associated with general reductions in biodiversity and changes in species compositions in river systems of the western United States (National Research Council 2002), western Australia (Halse et al. 2003), and China (Feng et al. 2004). Decline of native riparian vegetation and replacement by salt-tolerant species has occurred in numerous watersheds in the western U.S. (Busch and Smith 1995; Vandersande 2001; National Research Council 2002). Establishment of tamarisk may be attributable to factors other than salinization (Everitt 1998), but this species thrives in highly saline environments where it may out-compete natives and lead to declines in physical stream habitat quality and macroinvertebrate productivity (Bailey et al. 2001; Vandersande 2001; National Research Council 2002). Recent research has found tamarisk to have lower tolerance to inundation than native cottonwoods and willows (Vandersande 2001), and although its presence may increase surface soil salinity, it does not necessarily establish itself by allelopathic means (Lesica and DeLuca 2004). In western Australia, soil and water salinities have risen in some drainages because of agricultural development and hydrological modifications (causing raised water tables and reduced flooding). Increasing salinity in lakes there has been associated with loss of aquatic macrophyte diversity and dominance of a few halotolerant species, followed by a prevalence of microbial mats at highest salinities (TDS >10,000 mg/L) (Davis et al. 2003). Salinized rivers hold low macroinvertebrate diversity and predominantly only highly tolerant taxa (Kay et al. 2001). One study found the abundance of aquatic macroinvertebrate species sensitive to salinity to be reduced at levels exceeding 1500 mg/L, and short pulses of high salt concentration to be more detrimental than consistent, low-level loading (Bailey and Marshall 2004). Richness and diversity of riparian vegetation, as well, appears to decline with rising soil salinity (Lymbery et al. 2003). The experience of China's Heihe basin provides an extreme example of deterioration of the aquatic environment in conjunction with salinization (Feng et al. 2004). There, salinization rapidly accelerated during the second half of the 20th century, causing drastic shifts in aquatic and upland vegetation along with massive soil erosion and sedimentation. Halophytes and xeriphytes replaced hydrophytic communities. With rising salinity, a single halotolerant fish species replaced an assemblage of several species until even that species disappeared. A disaster of such proportions is unlikely to occur in the Tongue River in the near future, but it is interesting to note that the Heihe basin experienced a ubiquitous basic pattern of ecological change characterized by the loss of biodiversity and proliferation of a small number of tolerant taxa. These studies represent a growing effort to address the effects of raised salinity; however, little information existed until recently and large gaps remain in the base of scientific knowledge (Williams 1985; James et al. 2003).

Streams of the Great Plains present harsh conditions for aquatic life. Disturbance, particularly flashy hydrographs, habitat constriction, and associated physiochemical changes, characterize these systems. The native biota has adapted to cope with extreme conditions by developing high tolerance or by using tactics such as avoidance (movement) and recolonization (Dodds et al. 2004). For example, cyprinodontids may tolerate increased salinities associated with drying pools, whereas cyprinids emigrate and return when conditions become more suitable (Ostrand and Wilde 2004). Human disturbance can have severe consequences to the biota in these systems by exacerbating the severity of stress and eliminating the opportunities to find refuge or recolonize suitable habitat (e.g., by constructing barriers). Because Montana Plains streams are inherently variable and lacking in historical data, assessments of their aquatic ecology should use a variety of criteria, for example multimetric indices (Bramblett 2003), and management should follow an adaptive management approach.

3.0 Study Area

This investigation included four sites on the main stem Tongue River and thirteen sites on ten tributary streams (Figure 3-1). Watershed area above study sites totaled 3,279 square miles, with about one-half each in Montana and Wyoming. The Northwestern Great Plains ecoregion encompasses the entire study area and is typified by semiarid sagebrush steppe with open ponderosa pine (*Pinus ponderosa)* and juniper (*Juniperus* sp.) forests at higher elevations (Woods et al. 1999). Plant species dominating the riparian zone along the Tongue River main stem include box elder (*Acer negundo),* Great Plains cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), and peachleaf willow (*Salix amygdaloides*) in the overstory, and chokecherry (*Prunus virginana)*, red-osier dogwood (*Cornus sericea*), western snowberry *(Symphoricarpos occidentalis)*, and wild rose (*Rosa* sp.) in the understory (NRCS 2002). The Fort Union and Wasatch formations dominate the basin geology (Figure 3-1). The Fort Union Formation, composed largely of marine shale, typically produces water enriched with dissolved and suspended solids. The Wasatch Formation, which overlies the Fort Union in upper portions of the basin, consists of calcareous sandstone and produces water having lower levels of dissolved solids. Surficial deposits of quaternary alluvium line the Tongue River, Otter Creek, Hanging Woman Creek, and Prairie Dog Creek valley bottoms.

States classify waters within their boundaries based on potential beneficial uses (Table 3-1). Designated beneficial uses of streams in the study area vary by stream type but include uses such as warmwater fisheries, associated aquatic life, agriculture, industry, and recreation. Other considerations in evaluating sites in the study area include watershed area and field photos (Appendix A: Reach Field Photos).

3.1 *Tongue River Main Stem*

The Tongue River originates in the Bighorn Mountains of northern Wyoming and flows about 305 miles to the Yellowstone River at Miles City. Four sites were sampled along the main stem from the confluence of Hanging Woman Creek upstream to the Montana/Wyoming state line, incorporating a watershed area of 2,533 square miles. Quaternary alluvium comprises the surficial geology along the river, while the Fort Union Formation dominates the lower watershed and the Wasatch Formation comprises higher elevation areas. The major land use in the valley bottom is agriculture, including irrigated croplands and livestock range that also extends into higher elevations.

The Tongue River Reservoir and dam impose a major influence on physical and biological characteristics both above and below the dam. Dams and their associated impoundments typically restrict or prevent movement of aquatic organisms past the dam, alter hydrological and chemical characteristics within and below impoundments, and eliminate or reduce habitat for some species while favoring others. Two sampling stations, near the confluence of Hanging Woman Creek and about 1.5 miles downstream of the dam, were located below the Tongue River Reservoir. A station just below the mouth of Badger Creek and a station at the Montana—Wyoming state line were located upstream of the reservoir. An additional location between the stations above the reservoir (near the USGS gauging station) was used for sediment sampling. The Tongue River main stem was not assessed in sampling efforts in 2002 (Confluence 2003).

Information on the status of streams includes the 303(d) list of impaired waters. The Clean Water Act mandates states to maintain this list of streams not supporting fully one or more beneficial uses. The 1996 Montana 303(d) list reported impairment of beneficial uses over the entire Montana portion of the Tongue River (MTDEQ 1996). Within the study area, flow alteration was identified as the probable cause of impairment. Impairment of agricultural, aquatic life, and coldwater fishery uses in the reach from the state line down to the Tongue River Reservoir was attributed to agriculture and natural sources. Impairment of aquatic life, and coldwater fishery uses in the reach from the dam down to Hanging Woman Creek was attributed to agriculture and flow regulation. Agriculture and municipal point sources were identified as sources of degradation to the Tongue River Reservoir, where aquatic life, coldwater fisheries, and contact recreation beneficial uses were impaired. In subsequent review for the 2002 list, the upper Tongue River was determined to support fully agricultural and industrial uses, but assessment of four of the six beneficial uses was unsuccessful because of insufficient credible data.

The Tongue River receives CBNG product water discharged directly into the river or into constructed impoundments or ephemeral channels of tributaries. A review of Montana, Wyoming, and NPDES permit records indicates at least 6 permits with 36 outfalls to the Tongue River at or above the state line sampling station, and an additional 5 permits and 27 outfalls to the river in the section below the state line station to Badger Creek.

3.2 *Badger Creek*

Badger Creek originates in Wyoming and flows into the Tongue River at the upper end of the first station upstream of the reservoir. The Wasatch Formation dominates watershed geology. Review of the Wyoming DEQ web page indicates at least 4 permits and 30 outfalls occur within the drainage. Badger Creek was not assessed in the 2002 sampling effort (Confluence 2003).

3.3 *Coal Creek*

The Coal Creek watershed drains the smallest area of any watershed in this investigation (2.49 mi^2). The Fort Union Formation comprises the geology of the entire watershed. The stream channel runs along the south edge of the East Decker Coal Mine before entering the upper Tongue River Reservoir. Coal Creek was not assessed in the 2002 sampling effort (Confluence 2003).

3.4 *Corral Creek*

Corral Creek is a small tributary of Hanging Woman Creek located near the headquarters of the Padlock Ranch. Geology consists mainly of the Fort Union Formation with the Wasatch Formation overlying at higher elevations. CBNG development has not yet occurred in the drainage but future development is likely. In summer of 2002, Corral Creek was intermittent with moderate grazing pressure, and it received a relatively low habitat score (Confluence 2003). Water samples were not remarkable relative to basin-wide reference streams, but pH and sodium adsorption ratio were high among the ten sites sampled that year (Confluence 2003). Periphyton was sparse, especially non-diatom algae, and indicated severe siltation. Macroinvertebrate samples suggested moderate impairment and no fish were captured. Corral Creek is an intermittent stream and low scores on biological assessments were likely natural and related to limited water availability.

3.5 *Hanging Woman Creek*

Hanging Woman Creek originates in Wyoming and flows for about 60 miles before its confluence with the Tongue River near Birney, Montana. The Wasatch Formation occurs in high elevation portions of the watershed; however, the Fort Union Formation dominates the majority of the watershed. No outfalls for CBNG-produced water were permitted in the Hanging Woman Creek drainage at the time of the survey, although at least two permits for CBNG discharge became effective subsequent to collection of field data. The 1996 MTDEQ 303(d) list indicated impairment of agriculture, aquatic life, and warmwater fisheries due to high concentrations of total dissolved solids, salinity, chloride, and metals from agricultural and natural sources (MTDEQ 1996). The 2002 update indicated partial support of aquatic life and warmwater uses, with degradation attributed to sedimentation (MTDEQ 2002a). In summer of 2002, Hanging Woman Creek was dry above its confluence with Corral Creek (Confluence 2003). At the sampling site, habitat was moderately impaired, including riparian degradation attributed to livestock grazing. Water quality samples revealed magnesium concentrations in the 90th percentile, relative to basin wide reference values. Sodium adsorption ratio was relatively high among the ten sites assessed in Confluence (2003). Periphyton samples indicated only minor impairment but macroinvertebrate samples suggested moderate impairment. Five fish species were present, but one species (brassy minnow) comprised 78% of all individuals and three species were non-native. Twenty-three fish species reportedly inhabit the Hanging Woman Creek watershed (USDI 2003).

3.6 *Otter Creek*

Otter Creek is the downstream-most tributary sampled and enters the Tongue River near Ashland. The sampling station incorporates the second largest watershed area in this investigation. The Fort Union Formation underlies nearly the entire watershed, with alluvial deposits along the lower stream valley. Otter Creek was not assessed in the 2002 sampling effort (Confluence 2003). The 1996 MTDEQ 303(d) list designated Otter Creek as impaired (MTDEQ 1996). Problematic levels of total dissolved solids, salinity, chlorides, suspended solids, and metals were attributed to agriculture, road construction, land development, and natural sources. CBNG development has not yet occurred in this watershed. At least twenty species of fish inhabit this watershed (USDI 2003).

3.7 *Prairie Dog Creek*

Prairie Dog Creek originates in Wyoming and joins the Tongue River just 1/2 mile from the Montana border. Prairie Dog Creek is an important conduit for irrigation water, with flows augmented by a trans-basin diversion from neighboring Piney Creek. The Wasatch Formation dominates basin geology, with quaternary alluvium along the valley bottom. Two sites were assessed in both 2002 and 2004. The upstream site was above most CBNG development (the BLM field survey suggested that some development may have occurred upstream prior to sampling in 2004), while the downstream site was near the confluence with the Tongue River. Extensive CBNG development has occurred in the lower portion of the Prairie Dog Creek. Although discharge of produced water directly into Prairie Dog Creek is prohibited, water may be stored on the surface in retention basins or released into Class 4 waters (including ephemeral tributaries) in the basin under an NPDES permit. At the time of the field survey, at least 14 permits with 118 outfalls have been permitted to ephemeral tributaries or constructed impoundments within the Prairie Dog Creek drainage.

Surveys of Prairie Dog Creek in summer of 2002 indicated relatively unimpaired physical habitat (Confluence 2003). Water samples had moderate physical and chemical characteristics at both sites, although concentrations of most constituents were higher at the lower site. Turbidity was extremely high at the upper site. Periphyton samples indicated no impairment at the upstream site and only slight impairment at the lower site, although the similarity index value between the two sites was low, suggesting a moderate amount of environmental change between these sites. Macroinvertebrate samples suggested moderate impairment with low abundances at both sites, although the relatively intolerant assemblage at the upper site suggested better water quality. Despite intact habitat and good water quality, fish sampling yielded no fish at the upper site and only five white suckers (*Catostomus commersoni*) at the lower site. Near-bankfull flows made sampling difficult with available gear at the upper sampling site; however, the causal factor or factors in the scarcity of fish at the lower site are unknown.

3.8 *Rosebud Creek*

Rosebud Creek originates on the Crow Reservation and flows into the Yellowstone River at Rosebud, MT. The Fort Union Formation dominates basin geology. Water quality is marginal for agricultural and industrial uses due to relatively high levels of dissolved solids. In summer of 2002, this section of Rosebud Creek was intermittent with standing pools but offered relatively high quality physical habitat (Confluence 2003). Water samples were high in bicarbonate and total alkalinity relative to basin-wide reference values. Periphyton analyses indicated elevated organic loading, and macroinvertebrate samples suggested moderate impairment. Three native fish species were captured in the study reach, although twenty-three fish species inhabit Rosebud Creek (USDI 2003). The relative low richness of fish at this location was likely due to its location in the watershed. Lower reaches, in closer proximity to the Yellowstone River, likely support more species.

3.9 *Spring Creek*

Spring Creek is a small, intermittent stream that originates on the Crow Reservation and flows west to its confluence with the Tongue River. The Fort Union Formation dominates the basin; however, the Wasatch Formation overlies the Fort Union in Spring Creek's headwaters. Coalbed natural gas development has not yet occurred in this area but has been proposed for the headwaters on the Crow Reservation. Groundwater from small springs and seeps augment flows, which serve as a source of domestic water for local landowners. The sampling station is located relatively high in the drainage. In summer of 2002, a habitat survey yielded relatively low scores because of marginal flow, poor pool variability, and high sedimentation (Confluence 2003). These conditions were likely natural and reflected low water availability exacerbated by drought. Water samples were relatively high in total alkalinity, bicarbonate, magnesium, and calcium, while conductivity exceeded current State of Montana standards (USDI 2003). Periphyton samples indicated heavy organic loading, elevated salinity, and overall moderate impairment, while macroinvertebrate samples indicated only slight impairment. No fish were captured, although northern leopard frogs (*Rana pipiens*) were abundant. The importance of fishless reaches to amphibians such as frogs and salamanders, notably tiger salamanders (*Ambystoma tigrinum*), is an important consideration in their management.

3.10 *Squirrel Creek*

Squirrel Creek drains about 34 square miles before its confluence with the Tongue River near Decker, Montana. The geology of the watershed consists of a nearly even mix of Wasatch and Fort Union formations. The Wasatch Formation dominates the headwaters and forms mesas confining the Squirrel Creek valley for about ¾ of its length. Two sites were assessed both in 2002 and 2004. The upstream station was located at the upper edge of CBNG development while the lower station was situated downstream of the highway bridge and below the greatest concentration of wells. CBNG development in the Squirrel Creek drainage consists of approximately 200 wells. Produced water is conveyed to the Tongue River or stored in impoundments. Direct discharge to Squirrel Creek is not permitted because the CBNG water at this location contains high levels of ammonia.

In summer of 2002, conditions differed substantially between the upper and lower reaches (Confluence 2003). The upper reach held high quality, unimpaired fish habitat with dense riparian sedges. Water samples were moderately high in bicarbonate and potassium. Periphyton samples indicated no impairment. Macroinvertebrate samples suggested slight impairment but taxa richness was quite high. Crayfish (*Oronectes* sp.) were abundant and fish sampling indicated a relatively diverse, high-density assemblage of native fishes. At the lower reach, the moderately impaired habitat appeared to be recovering from damage caused by livestock, including slumped banks, excessive siltation, and significant cover of nonnative vegetation. Water samples were very high in bicarbonate, total alkalinity, sulfate, magnesium, potassium, sodium, and calcium, and somewhat high in chloride. Sodium adsorption ratio also exceeded current Montana standards (USDI 2003). Periphyton samples indicated a marked shift towards higher salinity tolerance in comparison with the upper site, and macroinvertebrate samples revealed a decline in taxa richness, low diversity, and mild nutrient enrichment. Crayfish were rare and fish were absent at the lower site.

3.11 *Youngs Creek*

Youngs Creek begins within Montana but crosses into Wyoming, where it joins the Tongue River. The geology of this basin is similar to that of Squirrel Creek except that the extent of the Wasatch Formation is smaller. Two reaches were assessed both in 2002 and 2004; the upstream station was located above CBNG development while the downstream station was below the greatest concentration of wells. Review of NPDES permits on the Wyoming DEQ web page indicates at least 1 permit and 8 outfalls of produced water permitted within the Youngs Creek drainage.

Conditions differed between the upper and lower reaches during summer of 2002 (Confluence 2003), but not as dramatically as on Squirrel Creek. The upper reach had a higher gradient and semi-confined channel while the lower reach was narrow, deep, and flowing through an unconfined valley. Physical habitat at both sites was relatively unimpaired. Water samples tested high for potassium at the lower site, but otherwise no constituent was even moderately high in concentration at either site. Most physiochemical constituents were present in higher concentrations, though, at the lower site than at the upper site. Periphyton at the upper site indicated no impairment, whereas the lower site suffered minor impairment from organic loading, salinity, and moderate sedimentation. Macroinvertebrate samples indicated slight impairment at the upper site and moderate impairment at the lower site. A relatively diverse assemblage of native fishes was present at the upper site but no fish were captured at the lower site (although fry were observed).

Figure 3-1: Map of the study area showing sample site locations. See Table 4-1 for site number key.

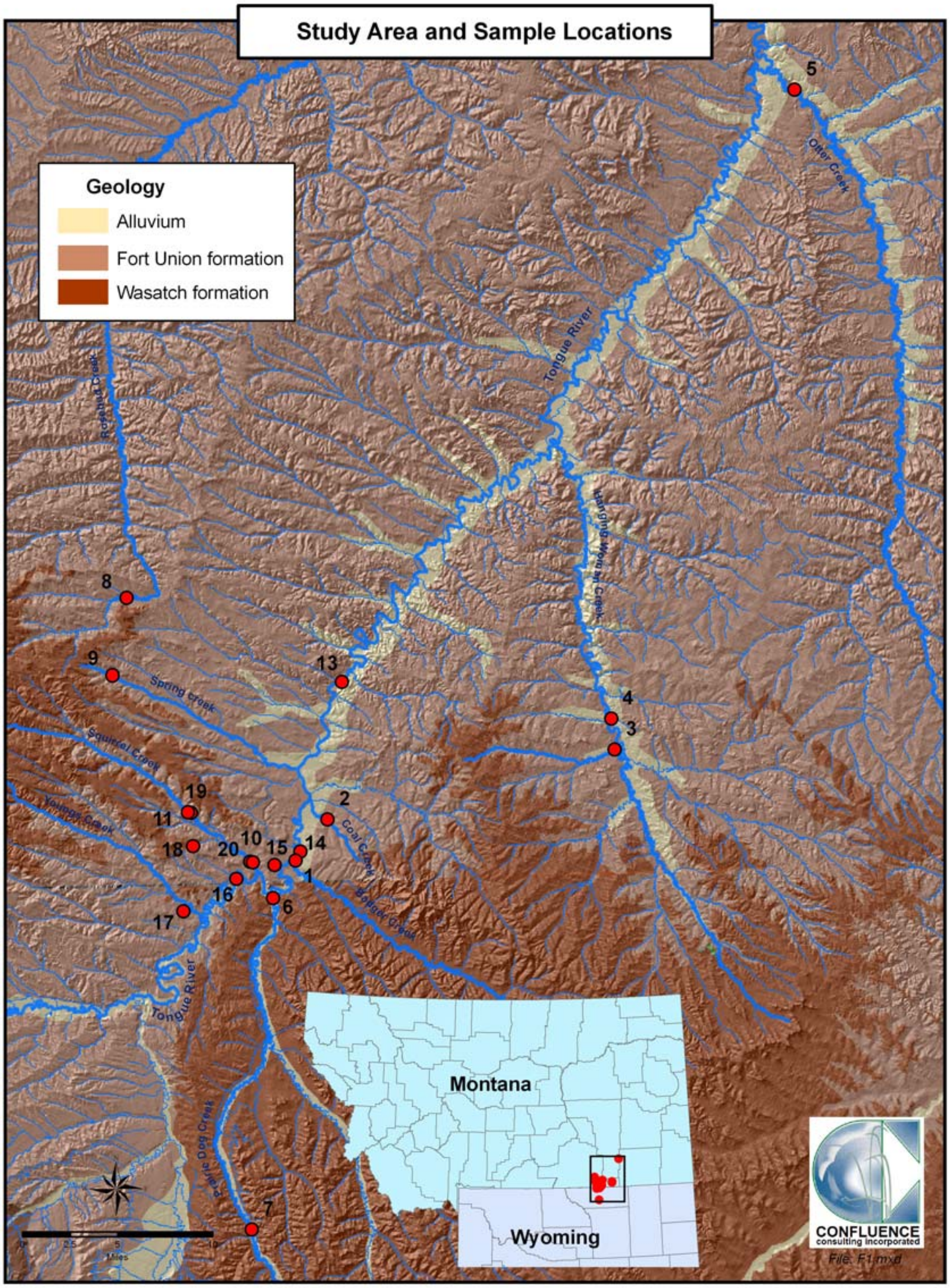

Table 3-1: Water use classifications and standards for assessed streams based on Administrative Rules of Montana and Wyoming water quality rules and regulations.

Classification (State)	Streams	Classification Standards
B2 (Montana)	Tongue River (State line to Prairie Dog Coulee)	• Suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B3 (Montana)	Tongue River (below Prairie Dog Coulee)	• Same as B2, except suitable for non-salmonid fishes rather than salmonids.
C3 (Montana)	Badger Creek Coal Creek Corral Creek Hanging Woman Creek Otter Creek Rosebud Creek Spring Creek Squirrel Creek Youngs Creek	• Suitable for bathing, swimming and recreation, growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. Naturally marginal for drinking, culinary, and food processing purposes; agriculture; and industrial water supply.
Class 2AB (Wyoming)	Prairie Dog Creek Tongue River	• “known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water I uses are otherwise attainable; • “protected for nongame fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture and scenic values”.
Class 3B (Wyoming)	Badger Creek Hanging Woman Creek Youngs Creek	• Tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. • Intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. • In general, characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length. • protected for “other aquatic life,” recreation, wildlife, agriculture, industry, and scenic value

4.0 Methods

This investigation was a collaborative project with field, analytical, and reporting components divided by the BLM, Montana Fish, Wildlife & Parks (MFWP), various analytical laboratories, HKM Engineering, and Confluence Consulting, Inc. Biological sampling and associated habitat assessments were primarily the responsibility of BLM field crews and MFWP personnel. BLM performed assessments on all tributaries and MFWP led fish sampling efforts on the main stem Tongue River and Rosebud Creek. Confluence Consulting of Bozeman, Montana collected sediment samples along the Tongue River. Analytical laboratories included Hannaea for periphyton analyses, the Utah State University / Bureau of Land Management National Aquatic Monitoring Center for macroinvertebrate analyses, and HKM Lab for water and sediment analyses. Confluence Consulting was responsible for data analysis and reporting. Selection of sampling sites followed the precedent established by Confluence (2003). Criteria included the presence of water, proximity above or below coalbed natural gas development sites, and accessibility. All ten sites used in Confluence (2003) were again sampled, and seven new sites were added (Table 4-1).

Table 4-1: Stations and dates of sampling.

Sample Station Number	Station	Latitude (N) Longitude (W) (GPS from habitat surveys)	Township, Range, Section	Habitat, field and lab physiochem., fish, periphyton (BLM)	Sediment, field physiochem. (Confluence)	Additional fish (MFWP)
1	Badger Creek (Bighorn Co., MT)	Not recorded	-	5/25/2004		
2	Coal Creek (Bighorn Co., MT)	Not recorded	-	5/25/2004		
3	Corral Creek (Bighorn Co., MT)	45 º 05’ 15.13873 106 º 28’ 00.47451	T9S,R43E,sec4	5/25/2004		
4	Hanging Woman Creek (Bighorn Co., MT)	45 º 06’ 40.27602 106 º 28’ 09.19070	T8S,R43E,sec28	6/22/2004		
5	Otter Creek near mouth (Rosebud Co., MT)	45 º 35’ 00.65809 106 º 14’ 40.32583	T3S,R44E,sec13	7/15/2004		
6	Prairie Dog Creek - lower (Sheridan Co., WY)	44 º 59’ 1.62 106 º 50’ 18.98	T58N,R83W,sec23	6/30/2004		
7	Prairie Dog Creek - upper (Sheridan Co., WY)	44 º 43’ 56.33 106 º 52’ 24.11	T55N,R83W,sec20	6/25/2004		
8	Rosebud Creek (Bighorn Co., MT)	45 º 12’ 55.65948 106 º 59’ 05.47802	T7S,R39E,sec20	5/24/2004		5/17, 5/25, 8/3/04
9	Spring Creek (Bighorn Co., MT)	45º 09’ 25.57578 107 º 00’ 09.75748	T8S,R38E,sec12	5/27/2004		
10	Squirrel Creek - lower (Bighorn Co., MT)	45º 0’ 43.69375 106 º 51’ 41.99087	T9S,R40E,sec29	5/26/2004		
11	Squirrel Creek - upper (Bighorn Co., MT)	45 º 03’ 02.58756 106 º 55’ 24.27438	T9S,R39E,sec14	5/26/2004		
12	Tongue River at Hanging Woman Creek (Rosebud Co., MT)	45 º 06’ 40.27602 106 º 28’ 09.19070	T8S,R43E,sec28	7/23/2004	9/8/2004	4-May
13	Tongue River downstream of Tongue R. Dam (Bighorn Co., MT)	45 º 08’ 47.72968 106 º 45’ 24.82143	T8S,R41E,sec7	7/28/2004	9/9/2004	4-May
14	Tongue River near Badger Cr., upstream of Tongue R. Rsvr. (Bighorn Co., MT)	45 º 01’ 06.47796 106 º 48’ 27.62463	T9S,R40E,sec27	7/27/2004	9/9/2004	4-May
15	Tongue River above rsvr. near USGS gauging stn. (Bighorn Co., MT)	45 º 00’ 32.436 106 º 50’ 08.592	T9S,R40E,sec33	Not sampled	9/9/2004	4-May
16	Tongue River at state line (Bighorn Co., MT)	44 59’ 57.54 106 º 52’ 37.83	T9S,R40E,sec31	7/26/2004	9/10/2004	4-May
17	Youngs Creek - lower (Sheridan Co., WY)	44 º 58’ 34.16 106 º 55’ 66.36	T58N,R84W,sec25	6/23/2004		
18	Youngs Creek - upper (Bighorn Co., MT)	45 º 01’ 31.72406 106 º 55’ 20.76366	T9S,R39E,sec23	6/24/2004		

4.1 *Physical and Chemical Water Quality Parameters*

Water quality was sampled on two occasions. During physical habitat assessments, BLM personnel used test kits or handheld meters and sent grab samples to HKM Laboratory for analysis of additional physicochemical properties (Table 4-2). In addition, Confluence personnel used a Horiba U10™ water quality meter to measure several parameters at five sites on the Tongue River while sampling sediments. Measurements were taken immediately upon reaching the sampling site and prior to walking through the stream. The Horiba U10™ field meter was calibrated daily prior to use.

Table 4-2: Physical and chemical water quality parameters assessed for streams in the Tongue River basin.

Parameter	Code	Method
Chloride as Cl	Cl	Laboratory analysis
Sulfate as SO_4	SO_4	Laboratory analysis
Alkalinity, Bicarbonate as HCO_3	HCO_3	Laboratory analysis
Alkalinity, Carbonate as CO_3	CO_3	Laboratory analysis
Alkalinity, Hydroxide as OH	OH	Laboratory analysis
Total Alkalinity as $CaCO_3$	$CaCO_3$	Laboratory analysis; Field test kit
Total Suspended Solids	TSS	Laboratory analysis
Phase Ratio	Phase	Laboratory analysis
Calcium as Ca	Ca	Laboratory analysis
Magnesium as Mg	Mg	Laboratory analysis
Potassium as K	K	Laboratory analysis
Sodium as Na	Na	Laboratory analysis
Sodium Adsorption Ratio	SAR	Calculated from laboratory analyses
Dissolved Oxygen	DO	Handheld meter
pH	pH	Handheld meter
Salinity	Salin.	Handheld meter
Specific conductance (µmhos/cm)	SC	Handheld meter
Turbidity (NTU)	Turb	Handheld meter
Water Temperature	T_{water}	Handheld meter

Results of water quality testing were compared with regulatory limits and with results of previous sampling at the same streams and at reference streams across the Tongue and Powder basins. Formal limits for surface water quality constituents of interest include those for specific conductivity (SC) and sodium adsorption ratio (SAR), as set by DEQ and the Northern Cheyenne Tribe (Table 4-3 USDI 2003). Dissolved oxygen (DO) limits for Montana waters include instantaneous minima of 3.0 (5.0 when early life stages of fish are present) for class B-3 and C-3 streams (MTDEQ 2002b). Based on a review of toxicity tests, the USEPA recommended that the concentration of chloride ions not exceed 860 mg/L to minimize acute effects, and 230 mg/L to minimize chronic effects on aquatic organisms (USEPA 1988), although Montana has not officially adopted these limits. Additionally, Montana statutes generally require preservation of all beneficial uses and protection of aquatic life from anthropogenic pollution, while prohibiting creation of conditions favoring nuisance species (Administrative Rules of Montana [ARM]). Water quality data from the 1970s housed in the STORET database maintained by the EPA provided the basis for evaluation of temporal trends in water quality for Squirrel Creek, Hanging Woman Creek, Youngs Creek, and upper Rosebud Creek (Table

4-4 to Table 4-7). Distribution statistics for streams in the Tongue River and Powder River basins (Confluence 2003) provided a regional reference for tributary streams in this study (Table 4-8). Klarich et al. (1980) provided additional historical data collected at Hanging Woman, Otter, and Squirrel creeks in the late 1970s. We compared results for the main stem Tongue River to historical data collected at USGS gauging stations at Birney (near the confluence with Hanging Woman Creek), the Tongue River Reservoir dam, and at the state line (Table 4-9). Conductivity values within the study reach show strong seasonal and longitudinal variation, so we stratified the data by month of collection in the effort to provide context for sample results (Table 4-9).

Table 4-3: Designated surface water limits for specific conductivity (SC) and sodium adsorption ratio (SAR) as set by MTDEQ and the Northern Cheyenne Tribe. Irrigation season specified as March 1 through October 31 (MTDEQ) and April 1 through November 15 (N. Cheyenne).

Standard	Monthly Mean SAR	Inst. Max SAR	Monthly Mean EC (µS/cm)	Inst. Max EC (µS/cm)
MT-DEQ Irrigation season - main stem	3	4.5	1000	1500
MT-DEQ Non-irrigation season - main stem	5	7.5	1500	2500
MT-DEQ All year - tributaries	3	4.5	500	500
Northern Cheyenne Irrigation season; main stem at southern boundary	--	2	1000	2000
Northern Cheyenne Non-irrigation season; main stem at southern boundary	--	2	--	2000

Table 4-4: Distribution statistics for selected water quality parameters analyzed on Squirrel Creek from 1974 through 1979 (STORET database).

Parameter	N	Min.	10th	25th	Percentile Median	75th	90th	Max.
Alkalinity, carbonate as $CaCO_3$	5	329	329	344	388	412	481	481
Calcium	5	92	92	98	104	107	121	121
Bicarbonate	5	401	401	420	473	488	586	586
Carbonate ion	5	0	0	0	0	0	7.20	7.20
Specific conductance	16	1365	1375	1852	2180	2423	2930	3400
Sulfate	5	462	462	565	640	770	918	918
Sodium	5	82	82	94	138	138	188	188
pH	16	8	8.10	8.22	8.30	8.32	8.35	8.40
Magnesium	5	102	102	115	121	161	180	180
Hardness, Ca, Mg	5	681	681	705	764	967	986	986
Chloride	5	2.90	2.90	3.40	4.50	4.80	4.90	4.90
Dissolved oxygen	13	8.38	8.80	10.33	11.72	13.30	14	14.98

Table 4-5: Distribution statistics for select water quality parameters analyzed on Youngs Creek from 1978 through 1979 (Klarich et al 1980).

			Percentile					
Parameter	**N**	**Min.**	**10th**	**25th**	**50th**	**75th**	**90th**	**Max.**
Bicarbonate	5	370	370	395	404	415	425	425
Calcium	5	62	62	66	70	80	82	82
Carbonate	5	0	0	2	4	5	7	7
Chloride	5	3	3	3	4	6	6	6
Dissolved oxygen	4	8.7	8.7	8.8	9.3	9.9	10.2	10.2
Magnesium	5	52	52	59	67	88	94	94
pH	6	8.30	8.30	8.30	8.32	8.38	8.38	8.38
Sodium	5	37	37	43	54	73	86	86
Specific conductance	6	782	782	890	1001	1215	1352	1352
Sulfate	5	141	141	181	216	314	381	381
Total dissolved solids	5	674	674	756	806	992	1069	1069

Table 4-6: Distribution statistics for select water quality parameters analyzed on upper Rosebud Creek from 1978 through 1979 (Klarich et al. 1980).

			Percentile					
Parameter	**N**	**Min.**	**10th**	**25th**	**50th**	**75th**	**90th**	**Max.**
pH	21	8.18	8.20	8.22	8.28	8.30	8.32	8.37
Specific conductance	21	721	827	865	882	900	938	950
Dissolved oxygen	17	7.6	8.4	9.0	9.3	10.0	11.9	12.6
Calcium	3	77	77	77	80	85	85	85
Magnesium	3	67	67	67	68	71	71	71
Sodium	3	20	20	20	20	22	22	22
Bicarbonate	3	438	438	438	441	447	447	447
Carbonate	3	0	0	0	0	0	0	0
Chloride	3	2	2	2	3	3	3	3
Sulfate	3	124	124	124	165	178	178	178
Total dissolved solids	3	744	744	744	777	792	792	792

We also evaluated the potential toxicity of dissolved solids to aquatic life based on toxicity of major ions to *Daphnia magna*, a crustacean, and to fathead minnows (*Pimephales promelas*) (Mount et al. 1997). Anions vary in their toxicity, with bicarbonate (HCO_3^-) being the most toxic, followed by chloride (Cl^-), and sulfate (SO_4^-). Carbonate is non-toxic. With the exception of potassium, cations are non-toxic. Comparisons of bicarbonate, chloride, and sulfate concentrations in streams to mean LC50[1] for *Daphnia magna* and fathead minnows allowed assessment of toxicity risks to aquatic life. The challenge in applying LC50s to laboratory analyses is that Mount et al. (1997) reported toxicity for the entire salt but laboratory analyses report concentrations of ionic composition. We used the proportion of the respective sodium salt comprised by the anion in describing LC50s for bicarbonate, chloride, and sulfate (Table 4-10).

Table 4-7: Distribution statistics for select water quality parameters analyzed on Hanging Woman Creek (Klarich et al 1980).

					Percentile			
Parameter	**N**	**Min.**	**10th**	**25th**	**50th**	**75th**	**90th**	**Max.**
pH	22	7.88	8.00	8.08	8.12	8.21	8.27	8.31
Specific conductance	21	3320	3590	3800	4200	4750	5910	6100
Dissolved oxygen	19	7.0	7.5	8.1	10.0	11.1	11.7	15.3
Calcium	9	120	120	168	174	238	328	328
Magnesium	9	179	179	224	238	342	645	645
Sodium	10	463	512	580	621	960	1473	1950
Bicarbonate	10	449	494	542	568	580	638	647
Carbonate	10	0	0	0	0	0	0	0
Chloride	10	13	13	13	14	15	24	30
Sulfate	10	1650	1817	2100	2308	3350	6175	6900
Dissolved solids	8	2771	2771	3605	3891	4788	7682	7682

Table 4-8: Distribution statistics for physicochemical water quality parameters sampled in streams in the Tongue and Powder River basins.

					Percentiles			
Parameter	**N**	**Min.**	**10th**	**25th**	**50th**	**75th**	**90th**	**Max.**
Alkalinity, carbonate as $CaCO_3$ (mg/L)	316	20	138	215	291	447	513	748
Bicarbonate (mg/L)	311	6	162	257	339	534	611	913
Calcium (mg/L)	299	10	36	58	77	120	166	422
Carbonate ion (mg/L)	293	0	0	0	0	4	11	103
Magnesium (mg/L)	299	2	19	42	64	137	186	496
Chloride (mg/L)	300	0	2	4	7	16	88	340
Specific conductance (µmhos/cm)	530	196	550	900	1681	2920	3692	8700
Potassium (mg/L)	119	1	4	5	9	13	19	32
Sulfate (mg/L)	347	19	116	234	507	1120	1580	5450
Sodium (mg/L)	358	6	29	58	180	398	580	1770

4.2 *Chemical Sediment Parameters*

Confluence personnel collected sediment samples at five sites on the Tongue River main stem on 9/08/2004 through 9/11/2004 (Table 4-1). All sites also served as stations for BLM aquatic habitat assessments, except for the USGS gauging station site upstream from Tongue River Reservoir. At every site, five samples were collected each from desiccating areas (exposed during base flow periods; within bankfull channel; typically vegetated) and depositional areas (subsurface but streamflow velocity nearly zero), distributed within a reach measuring ten bankfull widths in length. For each sample, we

Table 4-9: Specific conductivity (µmhos/cm) of Tongue River main stem water samples collected at USGS gauging stations prior to 2001. In each month for a given year, 0–2 samples were collected at each site.

Site	Years	Meas	May	Jun	Jul	Aug	Sep
Birney	1980 - 2000	**Max**	**1030**	**540**	**569**	**633**	**883**
		90th	852	497	459	551	762
		10th	382	254	266	380	501
		Min	245	238	229	363	497
		N	17	18	17	17	10
TR Dam	1976 - 2000	**Max**	**947**	**712**	**538**	**648**	**860**
		90th	871	529	431	578	701
		10th	359	232	255	357	523
		Min	225	208	248	315	470
		N	19	26	21	22	15
State line	1986 - 2000	**Max**	**678**	**534**	**805**	**980**	**819**
		90th	413	506	788	841	737
		10th	192	195	364	519	563
		Min	180	175	318	373	536
		N	21	21	12	12	8

Table 4-10: Mean LC50[1] (values for common ions to *Daphnia magna* and fathead minnow *Pimephales promelas* (adapted from Mount et al. 1997).

	Daphnia magna		*Fathead Minnow*		
Dissolved Constituent	**24-h**	**48-h**	**24-h**	**48-h**	**96-h**
HCO_3^-	1729	1191	3523	1816	617
Cl^-	3870	2894	5023	3949	3876
SO_4^-	6519	6422	6519	6422	6422

[1]LC50 = lethal concentration for 50% of tested organisms

collected the top ¼ inch of sediment from about 1 ft^2 of area using a plastic spoon, placed the sediment in plastic storage bags, and kept the samples on ice until arrival at the laboratory. HKM Laboratory in Butte, MT analyzed the sediment samples for the same set of physiochemical parameters as for water samples (Table 4-2).

Sediment chemistry results were evaluated by comparing constituent concentrations between desiccating and depositional sediments and among the five sampled sites along the Tongue River. Numeric standards have not been established for any of the tested parameters in river channel sediments. Acceptable SAR values have not been identified for most species, but sensitive plants typically withstand values ranging from 1.6—8.0, and extremely sensitive species may require values below 1.8 (LRES 2001). Salinity tolerances for native plant species have been summarized (LRES 2001), but conductivity was not measured as part of the analysis. To provide coarse-scale context, we compared these results to STATSGO soil sample data, which indicated that soils in the area above the reservoir exhibit maximum SAR values of 0—5, whereas soils near the sites downstream of the dam exhibit maximum SAR values of 5—10 (Tetra Tech 2003). Ideally, direct comparisons with results from previous collections would be possible, but we were unable to find historical data involving similar sediment types from the Tongue River. Considerable information is available for upland soils used in crop production, but the sediments sampled in this study were either submerged or waterlogged, lacking in soil development, and not expected to have comparable properties. Chemical characteristics of sediment reflect attributes of parent material and water chemistry, limiting the useful of comparisons with data from other basins.

4.3 *Physical Habitat*

BLM field crews assessed physical habitat using the *CBNG Aquatic Habitat Monitoring Stream/River Protocol* (Appendix B: CBNG Aquatic Habitat Monitoring Protocol & Definitions). This method involves a combination of quantitative measures and visual ratings that yield a classification of channel type (Rosgen 1996) and assessments of riparian characteristics, stream bank condition, channel morphology, substrate, and instream habitat.

4.4 *Periphyton*

BLM field crews used DEQ's standard operating procedures (Bahls 1993) for use-support assessments. Within the study reach, crewmembers picked conspicuous macroalgae (large colonial or filamentous forms) in proportion to its abundance in the reach and placed it in sample containers. Microalgae were extracted from available substrates by either squeezing moss over the container, brushing or scraping diatoms from hard substrates (rocks, logs) directly into the container, or suctioning algae from soft surfaces using a syringe. Each type of substrate (e.g., rocks) and each type of habitat (e.g., riffles) were sampled in proportion to the area covered by each substrate/habitat combination in the reach. Lugol's solution or M^3 fixative was added to preserve the samples

Dr. Loren Bahls processed and analyzed periphyton samples, using protocols described in Bahls (1993). Samples were first examined to estimate relative abundance and rank according to biovolume of diatoms and genera of soft algae. Periphyton samples were then processed using methods described in APHA (1998). A sub-sample of 300 to 400 diatom cells were counted per sample and identified to species. Taxonomic and ecological references for soft algae include Dillard (1999), Prescott (1978), Smith (1950), Whitford and Schumacher (1984), and Palmer (1969, 1977). Taxonomic and autecological references used for the diatoms include Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Patrick and Remier (1966, 1975), and Lowe (1974).

Diatom counts were used to calculate an array of diatom association metrics(Table 4-11). We applied biocriteria developed for Montana plains streams (Bahls 1993) to assess biological integrity and beneficial use support status of assessed reaches. Diatom biocriteria distinguish among four levels of stress or impairment and three levels of aquatic life use support: 1) no impairment or only minor impairment (full support); 2) moderate impairment (partial support); and 3) severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor biological integrity, respectively. The State of Wyoming has not yet developed biocriteria for periphyton. In addition to the suite of metrics required for application of MTDEQ biocriteria, we assessed other characteristics of the algal assemblage to address specific concerns. Salt tolerance of diatom species is an obvious interest in streams potentially impacted by CBNG development. Using autoecological information provided by Lowe (1974), we assessed the proportion of diatoms assigned to salt tolerance classes ranging from fresh water obligate to brackish species.

Table 4-11: Diatom association metrics used to evaluate biological integrity in Montana prairie streams: references, range of values, expected response to increasing anthropogenic perturbation or natural stress, and criteria for rating levels of biological integrity. The lowest rating for any one metric is the rating for that site.

Biological Integrity/ Impairment or Stress/ Use Support	No. of Species Counted	Diversity Index[1] (Shannon)	Pollution Index[2]	Siltation Index[3]	Disturbance Index[4]	% Dominant Species[5]	Similarity Index[6]
Excellent/ None/ Full Support	>39	>3.99	>2.25	<50.0	<25.0	<25.0	>59.9
Good/ Minor/ Full Support	30-39	3.00-3.99	1.76-2.25	50.0-69.9	25.0-49.9	25.0-49.9	40.0-59.9
Fair/ Moderate/ Partial Support	20-29	2.00-2.99	1.25-1.75	70.0-89.9	50.0-74.9	50.0-74.9	20.0-39.9
Poor/ Severe/ Nonsupport	<20	<2.00	<1.25	>89.9	>74.9	>74.9	<20.0
Range of Values	0-100+	0.00-5.00+	1.00-3.00	0.0-90.0+	0.0-100.0	~5.0-100.0	0.0-100.0
Expected Stress Response	Decrease	Decrease	Decrease	Increase	Increase	Increase	Decrease

[1] Base 2 [bits] (Weber 1973)
[2] Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[3] Sum of the percent abundances of all species in the genera Navicula, Nitzschia,and Surirella
[4] Percent abundance of Achnanthidium minutissimum (synonym: Achnanthes minutissima)
[5] Percent abundance of the species with the largest number of cells in the proportional count
[6] Percent Community Similarity (Whittaker 1952)

4.5 *Macroinvertebrates*

BLM crews sampled the macroinvertebrate assemblage at each site using qualitative and quantitative methods. The objective of quantitative invertebrate sampling was to estimate the relative abundance of invertebrates at a site. A Surber sampler (0.09 m^2; 500-micron mesh) was used to collect quantitative samples. The area within the square sampling frame was disturbed by hand and individual substrate particles within the sampling area were scrubbed, causing invertebrates and detritus to drift downstream into the net. Eight samples were collected in four different riffles and composited to form a single sample that included approximately 0.74 m^2 of the substrate at each location. The objective of qualitative efforts was to maximize the number of species collected. A kicknet (457 x 229 mm) with 500-micron mesh was used and invertebrates were hand picked from woody debris and large boulders. All major habitat types (e.g., riffles, pools, back waters, macrophyte beds) were sampled and all samples at each site were composited to form a single sample. The Utah State University / Bureau of Land Management National Aquatic Monitoring Center (BUGLAB) conducted laboratory analyses of macroinvertebrate samples as specified in Appendix D Macroinvertebrate Protocols. Proportional counts of macroinvertebrates were used to calculate a series of metrics that characterize various aspects of the community (Table 4-12). We compared metric results with criteria developed for Plains ecoregion streams in Montana (Bukantis 1998;Table 4-13) and Wyoming (Stribling et al. 2000;). We provide a ranking of sites based on scores for each metric to aid in comparing biological integrity as measured by macroinvertebrates among sites. Note, however, that the biocriteria require cautious interpretation because the collection procedure for which the criteria were developed (Bukantis 1998) differed from the procedure used in this investigation. In addition, one of the 10 component metrics of the Montana biocriteria (percent multivoltine) was omitted because voltinism was not determined during the identification phase. Therefore, we calculated the criterion, using only nine metrics and a reduced total possible score (from 30 to 27). Beneficial use support was defined as full (>75), partial (25-75), or non (<25). To provide consistency, and because Bukantis (1998) did not offer impairment rating criteria, we followed Confluence (2002) in rating the degree of impairment as none (≥ 80), slight (65-79), moderate (30-64), or severe (<30). One metric, % 10 dominant, also was omitted from the Wyoming plains streams biocriteria, but no adjustment was necessary as the final score is the average of scores for each of the ten metrics. The Wyoming biocriteria specifies rating categories as very good (>78.6), good (>57), fair (>38), poor (>18.9), and very poor (≤18.9). The BUGLAB provided a separate multimetric analysis based on 94 reference streams within the interior Columbia River basin that is inappropriate for use with Tongue River basin streams but is included for the sake of curiosity.

Table 4-12: Metrics calculated for macroinvertebrate populations sampled on streams in the Tongue River basin, June 2001. (Modified from Barbour et al 2000).

Category	Metric	Definition	Response to Stress
Abundance and composition			
	Total abundance	Estimated number per m^2 (quantitative samples) or number collected (qualitative samples)	Decrease
	Dominant family	Family having highest count of individuals	Variable
	Dominant family abundance	Count of individuals	Variable
	% Dominant family	Percent of total abundance	Decrease
	EPT	Ephemeroptera (mayflies), Plecoptera (stone flies), and Trichoptera (caddis flies)	Decrease
	Ephemeroptera taxa	Mayfly nymphs	Decrease
	Plecoptera taxa	Stonefly nymphs	Decrease
	Trichoptera taxa	Caddis fly larvae	Decrease
	Diptera	All “true” fly larvae	Increase
	Chironomidae	Midge larvae	Increase
	Odonata	Dragonflies and damselfly nymphs	Variable
	Coleoptera	Larval and adult beetles	Decrease
	Oligochaeta	Aquatic worms	Increase
	Crustacea	Crustaceans (amphipods, copepods, etc...)	Increase
	Mollusca	Mollusks (clams, snails)	Increase
Richness			
	Number of families	Count of taxa at the family level	Decrease
	Total No. taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	No. EPT taxa	Ephemeroptera (mayflies), Plecoptera (stone flies), and Trichoptera (caddis flies)	Decrease
	No. Ephemeroptera taxa	Number of mayfly taxa (usually genus or species level)	Decrease
	No. Plecoptera taxa	Number of caddis fly taxa (usually genus or species level)	Decrease
	No. Trichoptera taxa	Number of caddis fly taxa (usually genus or species level)	Decrease
	No. Diptera taxa	Number of “true” fly taxa, which includes midges	Decrease
	No. Chironomidae taxa	Number of taxa of chironomid (midge) larvae	Decrease
	No. Odonata taxa	Number of Odonata taxa including dragonflies and damselfly nymphs	Unknown
	No. Coleoptera taxa	Number of larval and adult beetle taxa	Unknown
	No. Oligochaeta taxa	Number of worm taxa	Unknown

Category	Metric	Definition	Response to Stress
(Table 4-12 continued)			
	No. Crustacea taxa	Number of crustacean taxa	Unknown
	No. Mollusca taxa	Number of mollusk taxa	Variable
Diversity Indices			
	Total taxa richness	Measures the overall variety of the macroinvertebrate assemblage	Decrease
	EPT taxa richness	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stone flies), and Trichoptera (caddis flies)	Decrease
	Shannon diversity	A measure of community structure defined by the relationship between the number of distinct taxa and their relative abundances.	Decrease
	Simpson diversity	A measure of community structure defined by the relationship between the number of distinct taxa and their relative abundances.	Increase
	Evenness	A measure of the distribution of taxa within a community.	Decrease
Biotic Indexes			
	HBI	Overall pollution tolerances of the taxa collected; originally specific to organic pollution	Increase
	USFS Community tolerance quotient	Taxa are assigned a tolerance quotient (TQ) ranging from 2 (taxa found only in high quality unpolluted water) to 108 (taxa found in severely polluted waters). CTQa = mean; CTQd = dominance weighted; values range from about 20 to 100.	Increase
	Multi-metric score	Comparison to reference sites in the interior Columbia River basin.	Decrease
Tolerance measures			
	Intolerant	Taxa richness and abundance of individuals with HBI values of 0-2	Decrease
	Tolerant	Taxa richness and abundance of individuals with HBI values of 9-10	Increase
Life cycle			
	Long-lived taxa	Number of taxa collected that typically have 2-3 year life cycles.	Decrease
Habit			
	Number of Clinger Taxa	Number of taxa of insects having fixed retreats or adaptations for attachment to surfaces in flowing water.	Decrease
Functional feeding group			
	Shredders	Consume living vascular hydrophytes and decomposing vascular plant tissue; sensitive to changes in riparian veg.; can be good indicators of toxicants that adhere to organic matter	Decrease
	Scrapers	Consume periphyton; increase with increasing abundance of diatoms and can decrease as filamentous algae, mosses, and vascular plants increase	Decrease
	Collector-filterers	Consume suspended fine particulate organic matter (FPOM); sensitive to toxicants in the water column and deposited in sediments	Variable
	Collector-gatherers	Consume deposited fine particulate organic matter; sensitive to deposited toxicants	Variable

Category	Metric	Definition	Response to Stress
(Table 4-12 continued)			
	Predators	Consume living animal tissue	Variable
	Unknown	Primary feeding mode is highly variable, parasitic, or currently unknown	Variable

Table 4-13: Criteria for metric scoring for Montana plains streams (Bukantis 1998).

Score	3 (Excellent)	2 (Good)	1 (Fair)	0 (Poor)
Taxa Richness	> 24	24-18	18-12	<12
EPT Richness	>8	6-8	3-5	<3
Biotic Index	<5	5-6	6-7	>7
% Dominant Taxon	<30	30-45	45-60	>60
% Collectors (graz. + filt.)	<60	60-80	80-95	>95
% EPT	>50	50-30	30-10	<10
Shannon Diversity	>3.0	3.0-2.4	2.4-1.8	<1.8
% Scrapers + Shredders	>30	30-15	15-3	<3
# Predator Taxa	>5	5-4	4-3	<3
% Multivoltine[1]	<40	40-60	60-80	>80

[1] Excluded because voltinism not determined at Utah BUGLAB

Table 4-14: Criteria for metric scoring for Wyoming plains streams (Stribling et al. 2000).

Metric	Scoring formula
Total taxa	100*metric / 95th%ile
Ephemeroptera taxa	100*metric / 95th%ile
Plecoptera taxa	100*metric / 95th%ile
Trichoptera taxa	100*metric / 95th%ile
% Plecoptera	100*metric / 95th%ile
% non-insects	100*(1.29 - arcsin(sqrt(metric)))/(1.29 - 5th%ile)
% 10 dominant	100*(100-metric)/(100 - 5th%ile)
BCI CTQa	100*(108 - metric)/(108 - 5th%ile)
Scraper taxa	100*metric / 95th%ile
% collector-gatherers	100*(100-metric)/(100 - 5th%ile)

4.6 *Fish*

A survey of fish presence and abundance was conducted at each site. BLM crews used seines or dip nets to capture fish during aquatic habitat assessments. MFWP conducted electrofishing surveys on the main stem Tongue River in May 2004, sampling at or near each of the stations used for aquatic habitat assessments, and conducted additional sampling on Rosebud Creek. Data from a MFWP electrofishing survey conducted downstream from the Tongue River Dam in August 1999 was also obtained for comparison. Fisheries biologists trained by Dr. Robert Bramblett (Montana State University) in prairie fish identification identified fish in the field. Total length was measured for a subset of up to 30 fish, providing information on range of lengths and presence of older fish (3 years or older as indicated by length). A representative sample of up to 10 voucher specimens was preserved in 10% buffered formalin. Joe Platz of the BLM verified voucher specimens in the lab with oversight by Dr. Bramblett.

We evaluated the results of fish surveys using an index of biological integrity developed for Montana prairie streams (Bramblett et al. 2003). This involved calculation of a series of metrics evaluating different attributes of the community (Table 4-15). Because fish taxa richness is expected to be directly proportional to watershed size (Fausch et al. 1984), all richness metrics were adjusted based on catchment area for each site (Table 4-16). These metrics allowed calculation of an overall score between 0 and 100. Bramblett et al. (2003) did not propose criteria for good, fair, and poor biological integrity for these scores. Therefore, we applied commonly used criteria where 75 to 100 indicated good biological integrity and full support of warm-water fisheries and 25 to 74% indicated fair biological integrity and partial support of warm-water fisheries.

Table 4-15: Fish metrics, metric categories, catchment adjustment equations and scoring calculation after Bramblett et al. (2003).

Metric	Catchment Adjusted Value	Score Calculation
Number of native species	AV = Metric– (-9.447+5.4628 $\times \log_{10}$ catchment area in km^2) + 13.027	(AV/18.0) × 100
Number of native families	AV = Metric – (0.0553 + 0.9907 $\times \log_{10}$ catchment area in km^2) + 4.163	(AV/5.423) × 100
Number of catostomid and ictalurid species	AV = Metric – (-7.689 + 3.2793 $\times \log_{10}$ catchment area in km^2) + 5.907	(AV/9.147) × 100
Proportion of invertivorous Cyprinids	None	100 – (P_InvCyp/72 .815) × 100
Number of benthic invertivorous species	AV = Metric – (-5.5822+2.5318 $\times \log_{10}$ catchment area in km^2) + 4.675	(AV/5.883) × 100
Proportion of litho-obligate reproductive guild individuals	None	(P_LithOb/82. 932) × 100
Proportion of tolerant reproductive guild individuals	None	100- (P_TolRep/87 .928) × 100
Proportion of native individuals	None	(P_Native/99. 965) × 100
Number of species with long-lived individuals	AV = Metric (see Table 5-36 for lengths) – (-8.655 + 3.9225 $\times \log_{10}$ catchment area in km^2) + 7.608	(AV/9.734) × 100

Table 4-16: Catchment area for sampling sites on the Tongue River and tributaries used in normalizing fish taxa richness metrics. Segment area excludes upstream stations.

Station	Catchment area (mi^2)	
	Segment	Cumulative
Badger Creek	138.59	138.59
Coal Creek	2.49	2.49
Corral Creek	26.50	26.50
Hanging Woman Creek	265.89	292.39
Otter Creek near mouth	707.93	707.93
Prairie Dog Creek - lower	292.06	360.37
Prairie Dog Creek - upper	68.31	68.31
Rosebud Creek	28.67	28.67
Spring Creek	4.20	4.20
Squirrel Creek - lower	14.91	49.26
Squirrel Creek - upper	34.35	34.35
Tongue River at Hanging Woman Creek	462.87	2542.13
Tongue River downstream of Tongue R. Dam	185.55	1786.87
Tongue River near Badger Creek.	10.91	1594.63
Tongue River at state line	973.17	1035.50
Youngs Creek - lower	39.45	62.33
Youngs Creek - upper	22.88	22.88

4.7 *Wildlife*

BLM and Confluence, Inc. personnel recorded wildlife observed during sampling. However, formal wildlife surveys were not conducted. Efforts included notation of the presence and approximate number of reptiles and amphibians as well as evidence of beaver activity.

5.0 Results

5.1 *Physical and Chemical Water Quality Parameters*

5.1.1 Tributaries

Physiochemical characteristics varied among the eleven analyzed tributary sites (Table 5-1 and Table 5-2). Badger and Coal creeks were not included because their stream channels were dry. The number of parameters for which values exceeded the 90th percentile for reference streams was 9 at lower Squirrel Creek, 8 at lower Youngs Creek, 7 at Corral Creek, 5 at Hanging Woman Creek, 3 at Spring Creek, and 2 at Otter Creek. Only one parameter exceeded the 90th percentile at lower Prairie Dog, Rosebud, upper Squirrel, and upper Youngs creeks, while upper Prairie Dog Creek produced no values exceeding even the 75th percentile.

Specific conductivity, an integrative measure of all the dissolved solids and overall salinity, exceeded the Montana limit for Tongue River tributaries (500 µmhos/cm) at all stations except upper Prairie Dog (Table 5-2). Values exceeded the highest observation for reference streams at Corral, Hanging Woman, and lower Squirrel creeks. The value of 13,500 µmhos/cm at Hanging Woman Creek greatly exceeded both the historical maximum of 7,010 µmhos/cm obtained during 1974—1987 at USGS station 6307570, and the value of 3,200 µmhos/cm measured near the mouth on 9/14/79 (Klarich et al. 1980). Conductivity at Otter Creek (2,410 µmhos/cm), though, was less than the mean value (4,207 µmhos/cm) for samples collected from April through October, 1974—1987, at a nearby USGS gauging station (6307740). Conductivity less than 500 µmhos/cm on upper Prairie Dog Creek indicated fresh waters relatively unaffected by dissolved solids.

Specific conductivity at lower Squirrel Creek exceeded historical levels. The value obtained at the lower station, downstream from the highway, (5,930 µmhos/cm) was substantially higher than values obtained for 9 samples (2,150—3,400 µmhos/cm) collected at about the same location (T 9S, R 40E, S 29, Q SW, QQ SE) during the period 7/26/79—11/06/79 (Klarich et al. 1980, Table 4-4). These also exceeded the mean value (4,900 µmhos/cm) reported for samples collected at the mouth from 1975 to 1997 (MTDEQ 2005). Conductivity at the upper station (1,510 µmhos/cm) exceeded the mean but was below the upper 75th percentile of historical values measured at the proximate USGS gauging station (6306100) during the period 10/6/75 to 6/26/85.

Concentrations of common cations (sodium, magnesium, calcium, and potassium) were generally consistent with conductivity values and Table 5-2. Values typically exceeded the 90th percentile at Corral, Hanging Woman, and lower Squirrel creeks, with sodium, potassium and magnesium exceeding the maximum observation for reference streams at Corral and Hanging Woman. Most notably, concentrations of sodium at Corral and Hanging Woman creeks exceeded those at most other sites by two orders of magnitude.

Figure 5-1: Historic and current sampling sites on Squirrel Creek.

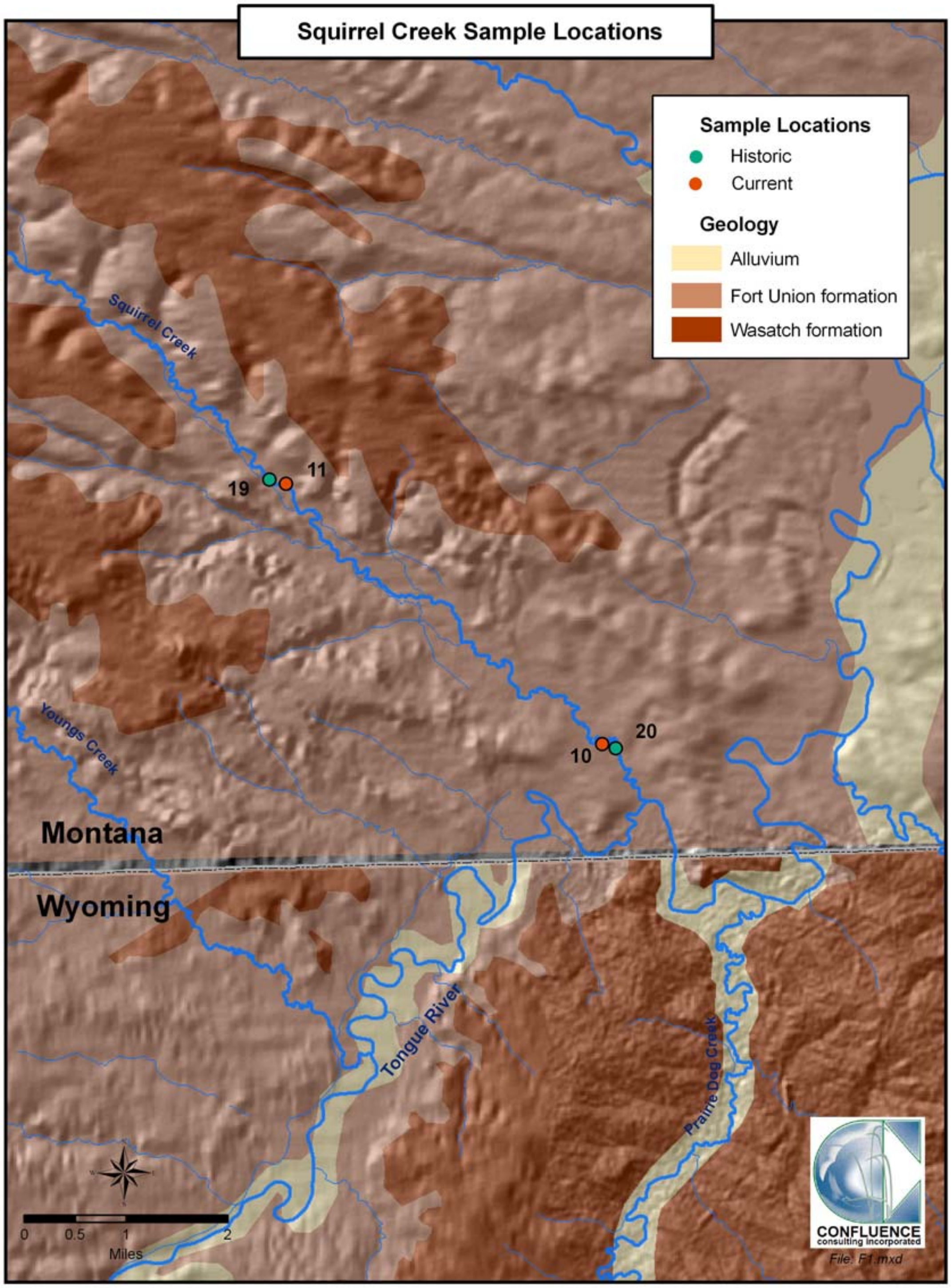

Table 5-1: Results of physiochemical measurements collected on-site during aquatic habitat inventories on Tongue River tributaries, 5/24/2004 – 7/15/2004. Underlined values exceeded 75^{th} percentile, values in Bold exceeded 90^{th} percentile, and values in Bold and Underlined exceeded maximum observation for reference streams.

Station	SC (µmhos/cm)	pH	DO (mg/L)	CaC03 (mg/L)	T_{Water} C	T_{Air} C
Corral	**13200**	8	5.8	466[1]	23	29
Hanging Woman	**13500**	8.5	12.3	210	17	26
Otter	2410	7.77	5	**523**	22	27
Prairie Dog - Lr	1600	7.9	11.9	338	18	28
Prairie Dog - Up	472	7.71	12	174	13	16
Rosebud	1480[1]	7.5	6.2	512[1]	11	12
Spring	1780	7.5	1.8	**612**	11	17
Squirrel - Lr	**5930**	8	9.2	666[1]	9	12
Squirrel - Up	1510	8	7.2	512[1]	12	21
Youngs Lr	1380	8.09	13.6	494	13	18
Youngs Up	781	7.98	12.5	415	14	12

[1] Values from lab analysis (not measured on-site) included for comparison

Concentrations of alkalinity-related constituents also varied widely but followed no apparent pattern among sites. Total alkalinity exceeded the 90^{th} percentile at three sites and the 75^{th} percentile for reference streams at six sites. Although numeric standards are unavailable, a suggested range of total alkalinity for a well-buffered system in Montana is 20-300 mg/L $CaCO_3$ (LRES 2003), which was exceeded at nine sites. Bicarbonate concentrations were highest at Spring, Squirrel, and Rosebud creeks, whereas Prairie Dog and Hanging Woman creeks had the lowest concentrations. Bicarbonate did not reach critical levels (Table 4-10) at any site, although concentrations at Spring and lower Squirrel Creek may have been close enough to the 96-hour LC_{50} for fathead minnow (a relatively insensitive species) to warrant concern (Figure 5-3). Carbonate levels were higher relative to reference streams than were bicarbonate levels and exceeded the 90^{th} percentile at 8 sites. Again, numeric standards for these constituents do not exist, but excessive levels can increase the sodium hazard (for plants and soils) above that indicated by the SAR.

Chloride ion concentrations were below levels considered to be problematic. Values at Corral and Hanging Woman creeks (37 mg/L) were the highest among assessed streams but considerably lower than the chronic limit recommended by the USEPA for protecting aquatic life (230 mg/L) and two orders of magnitude below levels determined to be toxic to diatoms or fathead minnows (see Table 4-10). Chloride concentration at Hanging Woman Creek did exceed the maximum value (32 mg/L) obtained in samples collected in April—October at a proximate USGS station (6307570) during 1974—1987.

Sodium adsorption ratio (SAR) results fell into two groups (Figure 5-4). Values for Hanging Woman, Corral, and lower Squirrel creeks easily exceeded the Montana limit for tributaries of the Tongue River (3.5), whereas results for all other sites were well below the limit. SAR values at Hanging Woman and Corral creeks were especially high, indicating potentially extreme sodium hazard, and the SAR for lower Squirrel Creek suggest moderate to high sodium hazard (Nimick 2004). The value for Hanging Woman Creek (19.9) exceeded the maximum (11.9) measured at USGS station 6307570 during 1974—1987.

Dissolved oxygen was above the Montana lower limit at all but two locations. The value at Spring Creek (1.8) was quite low, but no fish were captured in the sampled reach in 2002 or 2004, and surveys suggested that habitat for fish is otherwise limited. Because of the intermittent nature of this reach, low dissolved oxygen concentrations may reflect its potential. Often, these streams function more like linear wetlands than lotic systems and have correspondingly lower levels of dissolved oxygen. At Otter Creek, though, a value of 5.0 mg/L (equal to the 1-d minimum for periods when early life stages of fish are present) was measured and numerous fish were present, indicating that further investigation of DO levels may be warranted. Specifically, nutrient loading from agricultural or municipal sources may be contributing to eutrophication, which in turn limits dissolved oxygen due to decomposition of organic matter.

Concentrations of physiochemical parameters at tributary sites in 2004 showed variable change from levels in 2002 (Table 5-3). Parameters related to salinity generally increased from 2002 levels. Conductivity increased at all sites except Spring Creek, with extreme increases at Corral (741%) and Hanging Woman (382%), and large increases at Upper Prairie Dog (86%) and upper Youngs (59%). SAR increased at all sites except Spring and Rosebud creeks, with greatest increases at Corral (221%), Hanging Woman (205%), lower Youngs (105%), and upper Youngs (102%). Increases in SAR reflected large increases in sodium concentrations relative to the small increases in calcium concentrations. Magnesium tended to show greater proportional increases than did calcium. Changes in alkalinity concentrations were smaller in magnitude. Total alkalinity increased at all sites except Spring Creek and lower Squirrel Creek, but the difference was < 20% in all cases except upper Prairie Dog (54%), upper Youngs (40%), and lower Prairie Dog (31%). Bicarbonate, by contrast, decreased at all sites except upper Prairie Dog, with all differences less than 40%.

All physiochemical constituents increased in concentration between sites upstream of CBNG development and those downstream (410%), conductivity (239%), carbonate (225%), and potassium (118%). These differences were similar in magnitude to those measured in 2002 (Table 5-3, Table 5-4, and Table 5-5).

5.1.2 Tongue River Main Stem

Analyses of physiochemical characteristics indicated two main patterns in water quality along the main stem Tongue River (Table 5-6 to Table 5-8). First, the upstream-most site (state line) contrasted markedly with sites below. Conductivity and SAR were well below Montana limits for all samples, but concentrations increased for both parameters (conductivity 18% and SAR 59%) from the state line site to the bridge site in both July and September. Conductivity at the station below the dam, measured on 7/25/04, exceeded the 1976—2000 maximum for July and 90th percentile for August (Table 4-9). Turbidity and total suspended solids (133%), sodium (59%), carbonate (38%), and sulfate

(35%) also increased substantially below the state line site. Second, characteristics at the site below the Tongue River dam contrasted with those at upstream and downstream sites. All parameters except bicarbonate decreased relative to the next upstream site (above the reservoir), with greatest decreases for total suspended solids (86%), carbonate (45%), and conductivity (September samples 26%). Total suspended solids (200%) and carbonate (64%) showed large increases at the next downstream site.

Table 5-2: Results of laboratory analyses of physiochemical characteristics of water samples collected in 2004. <u>Underlined</u> values exceeded 75th percentile, values in Bold exceeded 90th percentile, and values in <u>Bold and Underlined</u> exceeded maximum observation for reference streams.

Station	TSS	HCO_3 (mg/L)	$C0_3$ (mg/L)	OH (mg/L)	$CaC0_3$ (mg/L)	Cl (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	SAR
Corral	12	383	**82.4**	<10	<u>466</u>	<u>37</u>	**8250**	**338**	**<u>750</u>**	**<u>32.1</u>**	**<u>2370</u>**	16.4
Hanging Woman	48	210	<10	<10	210	<u>37</u>	**7160**	50.9	**<u>589</u>**	**<u>35.5</u>**	**<u>2310</u>**	19.9
Otter	28	436	**87.2**	<10	<u>523</u>	11	774	56.1	124	<u>18.9</u>	346	36.46
Prairie Dog – Lr	33	294	**44**	<10	338	<5	661	<u>138</u>	98.8	9.7	112	1.8
Prairie Dog – Up	48	166	<10	<10	174	<5	82	47.6	24.6	3.3	13.5	0.39
Rosebud	8	489	**22.4**	<10	<u>512</u>	<5	382	<u>144</u>	116	7.9	39.3	0.591
Spring	16	**591**	**20.4**	<10	**612**	10	445	103	<u>151</u>	7.4	106	1.56
Squirrel - Lr	31	**536**	**<u>130</u>**	<10	**666**	11	**3030**	**178**	**424**	**20.7**	**816**	7.59
Squirrel - Up	<4	472	**40**	<10	<u>512</u>	<5	368	97.1	124	9.5	77.4	1.23
Youngs - Lr	16	392	**102**	<10	494	<5	320	74.9	87.7	12	132	2.5
Youngs - Up	11	333	**81.2**	<10	415	<5	53	67.7	56.8	7.8	22.6	0.49

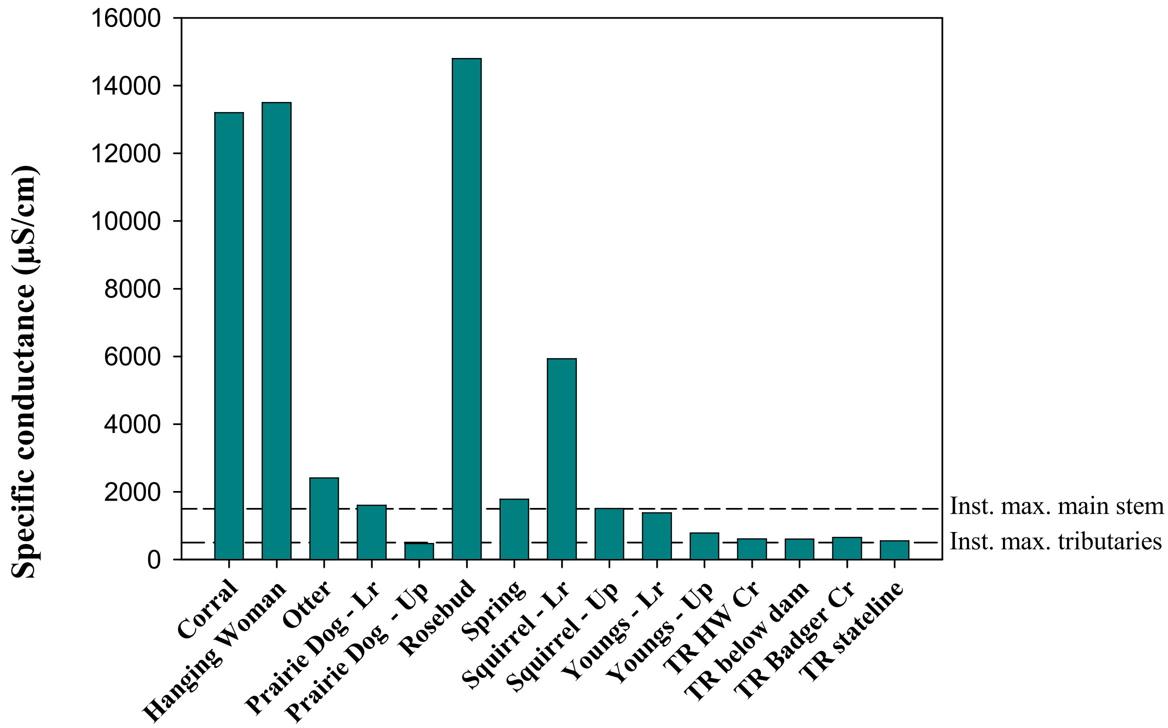

Figure 5-2 : Specific conductance at tributary and main stem stations. Reference lines (MT numeric limits) apply during irrigation season (see Table 4-3).

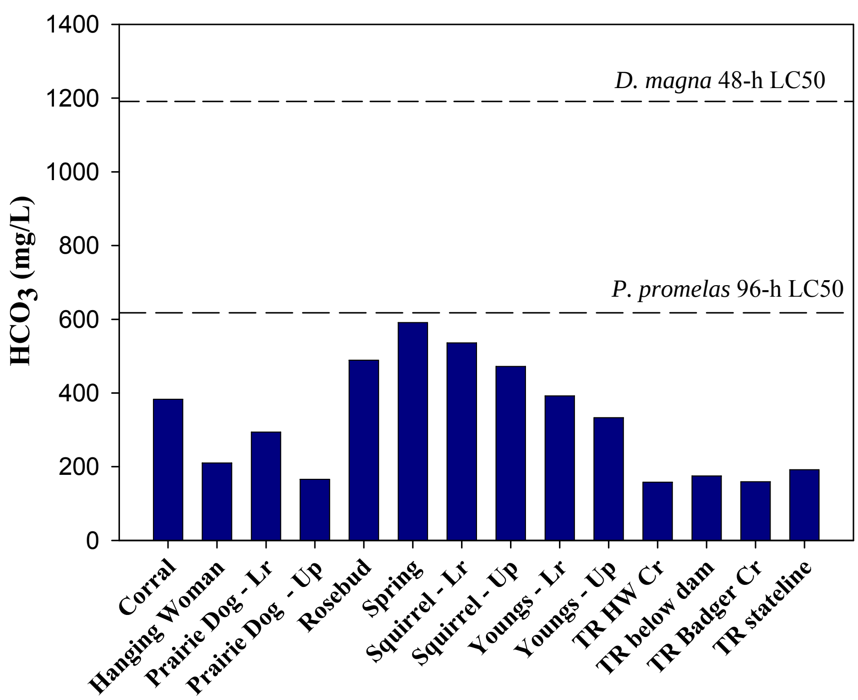

Figure 5-3: Bicarbonate ion concentrations at tributary and main stem stations. Reference lines indicate lowest levels found toxic to daphnia and fathead minnow (adapted from Mount et al. 1997).

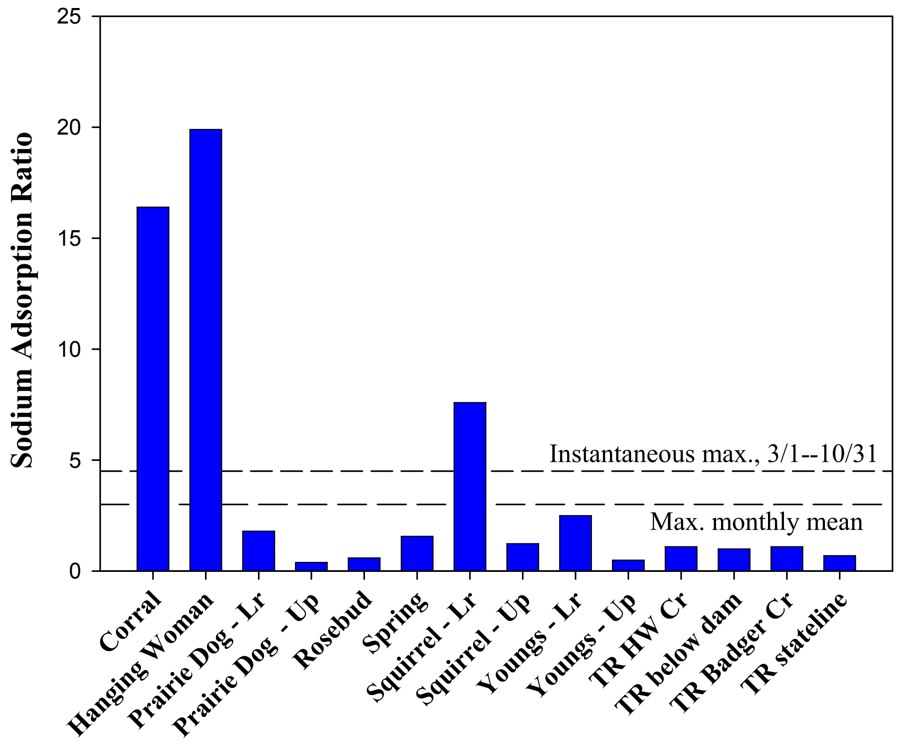

Figure 5-4: Sodium adsorption ratio (SAR) at tributary and main stem stations. Reference lines (MT numeric limits) apply both to tributaries all year and to the main stem during irrigation season (see Table 4-3)

Table 5-3: Percentage change in physiochemical characteristics of water samples collected in 2004 relative to those collected in 2002.

Station	SC (µmhos/cm)	HCO_3 (mg/L)	CaC03 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	SAR	pH	DO (mg/L)	T_{Water} C
Corral	740.8	-	-	236.4	-	445.2	1109.7	-	883.4	221.3	-16.1	-45.0	78.6
Hanging Woman	382.1	-	-	825.0	-	-55.4	191.6	-	354.7	205.3	-4.3	8.1	32.3
Otter	-	-	-	-	-	-	-	-	-		-	-	-
Prairie Dog – Lr	34.5	-7.0	30.5	25.0	66.9	27.8	54.4	7.8	53.4	32.7	-2.3	26.1	-7.9
Prairie Dog – Up	85.8	20.3	54.0	25.0	46.4	16.1	44.7	10.0	50.0	32.6	-3.5	26.3	-28.2
Rosebud	3.5	-20.5	1.6	25.0	-3.5	38.5	-14.7	12.9	-12.7	-12.3	-4.7	38.1	-40.7
Spring	-20.5	-35.2	-18.1	25.0	-35.1	-29.9	-23.7	-43.1	-27.4	-14.3	-2.2	-0.5	-36.0
Squirrel - Lr	2.4	-39.9	-8.9	-31.3	-12.2	52.1	-31.7	-50.7	-12.8	1.0	-3.5	67.6	-47.3
Squirrel - Up	4.9	-12.8	15.6	25.0	-12.4	18.4	0.0	-26.9	1.8	1.0	-2.1	-39.3	-43.1
Youngs - Lr	16.9	-22.8	18.8	-16.7	37.3	7.0	-8.6	-33.3	94.1	104.7	-4.5	91.0	-42.3
Youngs - Up	58.7	-8.0	39.7	25.0	32.5	20.9	35.2	56.0	126.0	102.0	-4.3	47.9	-36.1
Median:	25.7	-16.6	17.2	25.0	14.5	19.7	17.6	-9.6	51.7	32.6	-3.9	26.2	-36.1
Mean:	130.9	-15.7	16.6	116.3	15.0	54.1	135.7	-8.4	151.1	67.4	-4.7	22.0	-17.1

Table 5-4: Percentage difference in physiochemical characteristics of water samples collected in 2004 at stations below relative to above CBNG development.

Tributary	SC (µmhos/cm)	TSS	HCO_3 (mg/L)	C03 (mg/L)	OH (mg/L).	CaC03 (mg/L)	Cl	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	SAR	pH
Prairie Dog	239.0	-31.3	77.1	340.0	0.0	94.3	0.0	706.1	189.9	301.6	193.9	729.6	361.5	2.5
Squirrel	292.7	675.0	13.6	225.0	0.0	30.1	120.0	723.4	83.3	241.9	117.9	954.3	517.1	0.0
Youngs	76.7	45.5	17.7	25.6	0.0	19.0	0.0	503.8	10.6	54.4	53.8	484.1	410.2	1.4
Median:	239.0	45.5	17.7	225.0	0.0	30.1	0.0	706.1	83.3	241.9	117.9	729.6	410.2	1.4
Mean:	202.8	229.7	36.1	196.9	0.0	47.8	40.0	644.4	94.6	199.3	121.9	722.7	429.6	1.3

Table 5-5: Percentage difference in physiochemical characteristics of water samples collected in 2002 at stations below relative to above CBNG development (Confluence 2002).

Station	SC (µmhos/cm)	TSS	HCO_3 (mg/L)	C03 (mg/L)	OH (mg/L).	CaC03 (mg/L)	Cl-	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	SAR	pH
Prairie Dog	368.5		129.0		361.0	129.2	0.0	607.1	163.4	276.5	200.0	711.1	361.0	1.3
Squirrel	302.1		64.9		516.7	65.0	300.0	721.4	42.7	400.8	223.1	1131.6	516.7	1.5
Youngs	139.8		40.3		403.4	40.1	50.0	482.5	25.0	128.6	260.0	580.0	403.4	1.6
Mean:	302.1		64.9		403.4	65.0	50.0	607.1	42.7	276.5	223.1	711.1	403.4	1.5
Median:	270.1		78.1		427.1	78.1	116.7	603.7	77.0	268.6	227.7	807.6	427.1	1.4

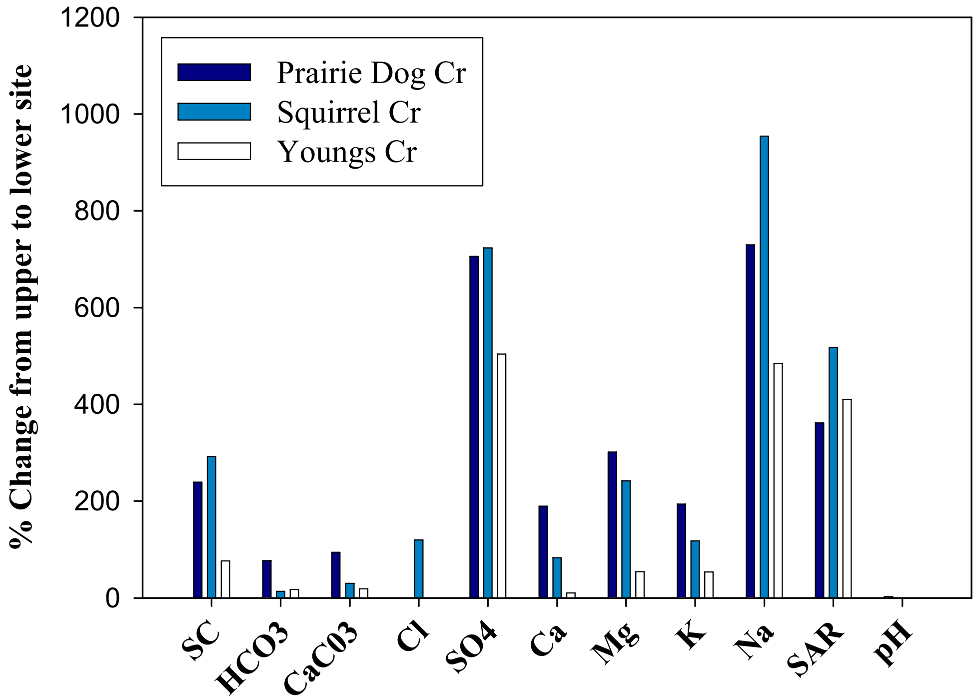

Figure 5-5: Comparison of chemical parameters at upper and lower sites on three tributary streams in 2004.

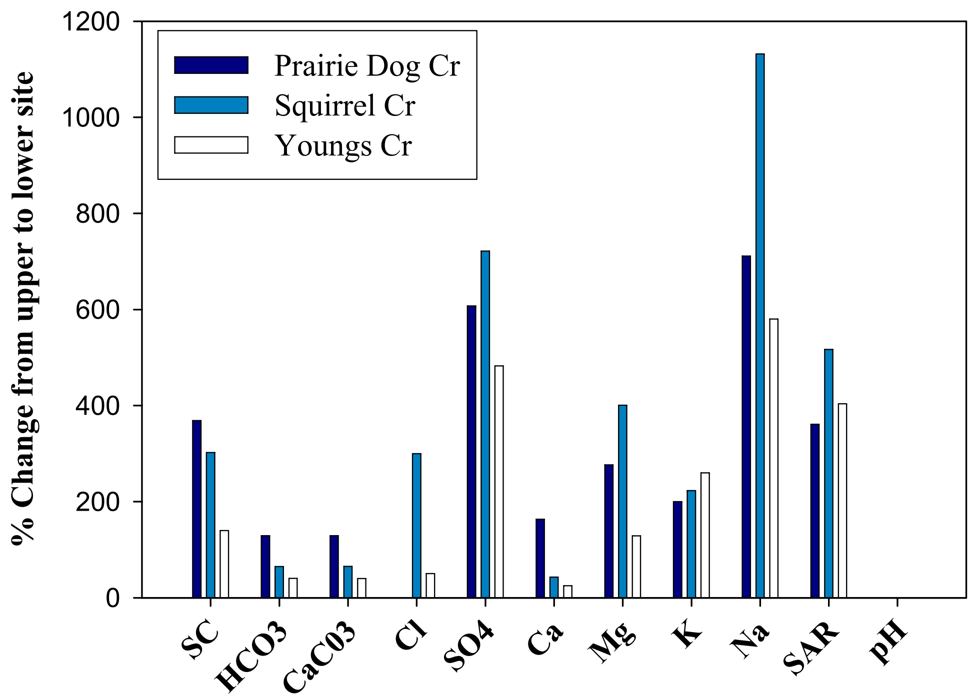

Figure 5-6: Comparison of chemical parameters at upper and lower sites on three tributary streams in 2002.

Table 5-6: Results of physiochemical measurements collected on-site on the Tongue River main stem in 2004.

Station	Date	SC (µmhos/cm)	pH	DO (mg/L)	CaC03 (mg/L)	Salinity	Turb. (NTU)	T_{Water} (°C)	T_{Air} (°C)
TR HWCr	7/23/04	606	7.0	10.8	198			20.0	15.6
TR HWCr	9/8/04	510	8.4	9.2		0.02	74	21.5	
TR below dam	7/28/04	601	7.5	9.0	200			20.0	23.9
TR below dam	9/9/04	512	8.6	9.5		0.02	111	22.2	
TR Badger Cr	7/27/04	654	8.0	9.0	203			20.0	22.8
TR Badger Cr	9/9/04	646	8.5	9.8		0.02	307	24.6	
TR USGS gauge	9/9/04	634	8.4	10.0		0.02	230	23.7	
TR state line	7/26/04	551	8.0	9.0	224			23.3	34.4
TR state line	9/10/04	534	8.2	13.7		0.02	4	19.9	

Table 5-7: Results of laboratory analyses of physiochemical characteristics of water samples collected from the Tongue River main stem in July 2004.

Station	TSS	HCO3 (mg/L)	C03 (mg/L)	OH (mg/L	CaC03 (mg/L)	Cl (mg/L)	SO4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	SAR	pH
TR HW Cr	12	158	40	5	198	3.8	125	46	33.2	4	41.6	1.1	7
TR below dam	4	175	24.4	5	200	3.5	120	49.4	31.5	3.6	38.3	1	7.5
TR Badger Cr	28	159	44	5	203	4.2	131	52	37	4	40.9	1.1	8
TR USGS gauge	-	-	-	-	-	-	-	-	-	-	-	-	-
TR state line	12	192	32	5	224	4.6	96.8	46.2	34.9	3.3	25.7	0.69	8

Table 5-8: Percentage difference in physiochemical characteristics of water samples collected in 2004 at stations on the Tongue River main stem relative to the next station upstream (listed in order progressing downstream).

Station	SC (µmhos/ cm)	TSS	HCO_3 (mg/L)	C03 (mg/L)	OH (mg/L).	CaC03 (mg/L)	Cl (mg/L)	SO_4 (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)	SAR	pH
TR state Line														
TR Badger Cr	18.7	133.3	-17.2	37.5	0.0	-9.4	-8.7	35.3	12.6	6.0	21.2	59.1	59.4	0.0
TR below Dam	-8.1	-85.7	10.1	-44.5	0.0	-1.5	-16.7	-8.4	-5.0	-14.9	-10.0	-6.4	-9.1	-6.3
TR HW Cr	0.8	200.0	-9.7	63.9	0.0	-1.0	8.6	4.2	-6.9	5.4	11.1	8.6	10.0	-6.7
Median	0.8	133.3	-9.7	37.5	0.0	-1.5	-8.7	4.2	-5.0	5.4	11.1	8.6	10.0	-6.3
Mean	3.8	82.5	-5.6	19.0	0.0	-4.0	-5.6	10.4	0.2	-1.2	7.4	20.5	20.1	-4.3

5.2 *Sediment Chemistry*

Concentrations of chemical constituents varied between sediment types (depositional and desiccating) and among stations on the main stem Tongue River (Table 5-9 and Table 5-10). Bicarbonate and total alkalinity were at higher concentrations in depositional than in desiccating sediment. Peak levels of these constituents in depositional samples occurred at the station below the dam, while conspicuously low levels in desiccating samples were found at the state line site. Carbonate and sulfate levels were highly inconsistent among sites and sediment types. The state line site produced both the greatest concentration of carbonate in depositional samples among all sites and the lowest concentration in desiccating samples. Chloride, sodium, and SAR were generally higher in desiccating than in depositional sediment. Desiccating samples showed somewhat elevated chloride at the state line but a sharp decline at the USGS gauging station. Sodium and SAR, by contrast, were lowest at the state line in both depositional and desiccating samples. Both constituents showed a distinct peak at the bridge site for desiccating samples but more uniform levels in depositional samples at all stations below the state line site. The SAR values in all samples suggested low sodium hazard, although the SAR of 3.0 for desiccating sediment at the bridge station could negatively affect highly sensitive organisms such as snowberry (*Symphoricarpos occidentalis*) and wild plum (*Prunus americana*) (Warrence et al. 2002). Calcium was generally less concentrated in desiccating samples than in depositional samples, but the level was anomalously high in desiccating sediment near the mouth of Hanging Woman Creek. Magnesium levels were consistent in depositional samples but distinctly dilute in desiccating samples from the USGS gauging station site. Potassium levels were consistent between sediment types and elevated at the station below the dam.

These results indicate three notable patterns related to sediment type and longitudinal variation along the river. First, desiccating sediment generally held lower total alkalinity but higher sodium, chloride, and sodium adsorption ratios. These results are consistent with chemical processes associated with desiccation: when sediment dries, bicarbonate combines with calcium ions to form a precipitate and leaves sodium ions, thus increasing the SAR (Warrence et al. 2002). Differing chemistry of Tongue River water at high and low flow levels may also influence the characteristics of desiccating (higher flows) and depositional (submerged when sampled) sediments. Second, the state line site produced the lowest concentrations among all sites for SAR, sodium, potassium, total alkalinity, and bicarbonate in both desiccating and depositional sediments, while carbonate in desiccating sediment was also dilute. Concentrations increased downstream coincident with entry of water from Prairie Dog and Squirrel creeks as well as active CBNG development and discharges of produced water below the state line site. Third, because of the influence of the Tongue River Reservoir, sediment chemistry below the dam differed distinctly from that at upstream sites. Concentrations of several anions and cations were elevated in depositional sediment below the dam, although this was not consistent in desiccating sediment.

Table 5-9: Physiochemical characteristics of depositional sediment sampled on the Tongue River mainstem, 9/08/2004 – 9/10/2004. Stations are in order from downstream to upstream; dashed line indicates position of dam.

Station	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	C03 (mg/L)	OH (mg/L).	CaC03 (mg/L)	Solids%	Phase ratio	Ca	Mg	K	Na	SAR
TR HW Cr	2.9	<0.5	648	<10	<10	648	63.8	0.95	97.0	71.1	9.7	59.2	1.1
TR below dam	14.8	54.6	775	35.2	<10	810	77.9	2.93	120.0	94.4	25.7	62.4	1.0
TR Badger Cr	6.8	10.7	620	36	<10	656	68.2	1.49	95.6	79.2	6.7	60.7	1.1
TR USGS gauge	6.8	3.9	566	33.6	<10	600	55.8	1.04	90.0	75.8	6.7	53.1	1.0
TR state line	6.9	55.9	498	60	<10	558	79.8	2.14	88.5	71.5	5.3	36.2	0.7

Table 5-10: Physiochemical characteristics of desiccating sediment sampled on the Tongue River mainstem, 9/08/2004 – 9/10/2004. Stations in order from downstream to upstream; dashed line indicates position of dam.

Station	Cl (mg/L)	SO_4 (mg/L)	HCO_3 (mg/L)	C03 (mg/L)	OH (mg/L).	CaC03 (mg/L)	Solids %	Phase ratio	Ca	Mg	K	Na	SAR
TR HW Cr	24.1	1000	328	33.6	<10	362	51	1	210.0	177.0	16.4	127.0	1.5
TR below dam	36.8	0.6	369	39.2	<10	408	27.7	1	90.4	127.0	80.3	114.0	1.8
TR Badger Cr	23.9	279	484	33.2	<10	517	60.3	1	55.2	89.3	15.9	156.0	3.0
TR USGS gauge	11.5	26.8	360	39.6	<10	400	79.5	1	38.2	56.8	7.5	63.5	1.5
TR state line	48.8	459	41	<10	<10	41	75.1	1	74.6	103.0	8.7	63.2	1.1

5.3 *Physical Habitat*

Six of the twelve assessed tributary sites rated as properly functioning and the remainder were at risk (Table 5-11 through Table 5-16). At all "at risk" sites, impairing factors were not within the domain of the agency land manager. Only one site, Corral Creek, showed a downward trend. Upstream channel conditions were the most frequently cited source of impairment and potentially degraded five sites. Relative influence of particular management activities varied across sites. Overall, livestock grazing was most detrimental, followed by instream structures, agriculture, roads, diversions, and mining. Urbanization and recreation have caused relatively little degradation within the study area. Riparian characteristics also varied among sites, although at most locations, vegetative cover exceeded 85%, livestock had consumed less than 25% of tree and shrub leader growth, overstory vegetation included box elder, and invasive species were present. Nine streams had Rosgen type E channels, six of which were E6 (Rosgen 1996). Most streams were somewhat incised although the incision was considered to be old at eight of eleven sites. Amounts of instream cover and large woody debris varied among sites, but silt or clay dominated the stream substrate at nine sites. Stream banks were stable or moderately stable at eight sites. Erosional inputs from surrounding hill slopes were limited.

Use of different survey protocols confounds comparisons with habitat surveys performed in 2002. Generally, though, results indicate little obvious difference between years. Presence of certain plant species was, in several instances, noted in one year but not the other. Substrate categorization as sand or silt differed at both stations on Prairie Dog Creek. An on-stream impoundment was described on upper Youngs Creek in 2002 but not in 2004.

The only station on the main stem Tongue River considered to be properly functioning was the Hanging Woman site, although two of the "at risk" stations showed an upward trend. Mining activities, CBNG discharge, and augmented flows were identified as potential sources of degradation at all sites, and upstream channel conditions affected all sites except the area below the dam. Influential land uses and structures, from most to least significant, included diversions, roads, agriculture, livestock grazing, mining, and instream structures. Riparian conditions were more similar among main stem sites than among tributary sites. Generally, vegetative cover exceeded 75%, cottonwood trees dominated the overstory, livestock consumption was less than 35 % (except at the site near the bridge above the reservoir), several invasive species were present, and native species were recruiting. Browsing livestock and wild game appeared to select for green ash. The river channel was incised at all sites, but the incision was typically old. Banks were more stable at the two stations downstream from the reservoir than at those above. Instream cover was considered adequate at all sites (and greatest at the station below the dam), gravel dominated the substrate, and few pieces of large woody debris were counted.

5.3.1 Badger Creek

Badger Creek was surveyed near its confluence with the Tongue River. No surface flow was evident and the few pools of water present appeared to be remnant from higher flows of the Tongue River. Although a full assessment was not conducted, this station was considered functioning at risk because of human activities adjacent to the stream and infestation of noxious weeds. Human disturbance included a dike that increased stream entrenchment and a hay field with insufficient riparian buffer. Among the invasive species was salt cedar, an exotic shrub that is highly tolerant of salts. Other evidence of disturbance included numerous dead cottonwood saplings and box elder. Irrigation return flows and reservoir operations were also identified as potential problems. CBNG development has occurred upstream of this site.

5.3.2 Coal Creek

Coal Creek is an ephemeral stream surveyed between the county road and the coal mine within T 9S, R 40E, S 13. No stream flow or riparian vegetation was present. The channel included a dry reservoir and some headcuts, but 90% of its channel was undefined.

5.3.3 Corral Creek

Corral Creek was surveyed near its confluence with Hanging Woman Creek. Corral Creek was the most obviously degraded of all evaluated streams. The stream was considered to be functional, but at risk and with an apparent downward trend. Intense livestock use was responsible for most of the degradation. In addition, an improperly functioning road culvert restricted flow and created an artificial pool, although water was not flowing at the time of the survey. Consumption of vegetation by livestock was more extensive than at any other site, and riparian vegetation was limited to sedges and rushes in areas of standing water. Aquatic habitat was also limited by an absence of woody debris or any other form of instream cover and by an extremely high width-to-depth ratio (34.6). The channel was determined to be Rosgen type B6c. Comparison with the survey from 2002 indicates a possible increased effect from livestock.

5.3.4 Hanging Woman Creek

Hanging Woman Creek was surveyed about two miles downstream of the confluence with Corral Creek. Hanging Woman Creek was considered to be functioning at risk, and a trend was not apparent. Potential sources of impairment included moderate livestock grazing, agricultural fields in close proximity to the stream, and instream structures (berms and dikes). The riparian zone was narrow with a limited diversity of plant species or age classes. Grasses, sedges, and forbs were the dominant vegetation with limited recruitment of shrubs and trees. Past removal of beaver dams was evident. The stream channel was Rosgen type E6 and contained an adequate amount of cover (30-50%), although no large woody debris was present and the substrate was entirely silt/clay.

5.3.5 Otter Creek

Otter Creek was surveyed above the town of Ashland, a few miles upstream from its mouth. The stream was considered to be functioning at risk but with an upward trend.

Degradation was attributable to upstream conditions, including flow augmentation and channelization. A spreader dam, impassable by fish, was present at the upstream end of the reach and more were located upstream from the assessed reach. Agricultural fields and spreader dikes were adjacent to the stream on each side, and fords crossed the stream at two locations. The stream channel contained numerous pieces of metal, wood, concrete, and old tires. Livestock use within the current riparian area appeared to be light. Russian olive has invaded the riparian zone, but the stream banks were re-vegetating and several native species were recruiting. Stream banks were moderately stable, but this Rosgen B6c channel was out of balance with its landscape setting. The channel contained less cover than desirable. This stream was relatively large in terms of bankfull width and discharge, and it had the highest sinuosity and greatest meander length of all assessed streams.

5.3.6 Prairie Dog Creek - Lower

Lower Prairie Dog Creek was surveyed about one mile upstream from its confluence with the Tongue River. This site rated within the range of proper functioning condition. Stream banks were stable and contained extensive (> 85%) deep root growth associated with dense vegetation in the riparian zone. However, the vegetation age structure lacked diversity and provided little large wood recruitment to the stream. Silt and gravel dominated the substrate of this E4 channel, although smaller amounts of sand and cobble were also present. In 2002, sand and cobble dominated the substrate; however, this was based on visual observations as opposed to quantitative pebble counts. Relative to other assessed tributaries, this stream was large in terms of bankfull depth, bankfull area, and residual pool depth, possibly reflecting the influence of flow augmentation from Piney Creek. Livestock use was light. Human-built structures in the reach included a county road bridge, irrigation pump, USGS gauging station, and residences. CBNG development has occurred near and upstream of the reach .

5.3.7 Prairie Dog Creek - Upper

The upper station on Prairie Dog Creek was located just below the WY State Highway 14 Bridge. The stream was functioning at risk largely because of upstream channel disruption by agriculture, including channel modification and irrigation withdrawals. CBNG development was another potential source of degradation. One residence was close to the stream within the assessed reach, while additional residences and a highway bridge were located just upstream of the reach. Agricultural fields bordered the stream, but the fields were fenced and the riparian zone was relatively wide. Livestock use was moderate. Lateral erosion created tall exposed banks but point bars were revegetating and some shrubs and trees had recruited. Several invasive plant species were present, although native species were also recruiting. In this survey, box elder was the dominant overstory species; however, observers in 2002 identified green ash as the dominant species. The stream contained an adequate amount of cover (30-50%) and abundant large woody debris, and the substrate was predominantly gravel. In 2002, the substrate was characterized as mostly sand; however, this was based on visual observations as opposed to quantitative pebble counts. The Rosgen channel type was E4. Compared with other assessed tributaries, upper Prairie Dog Creek was relatively large in terms of discharge, residual depth, and bankfull width and area, and it exhibited a low pool:riffle ratio.

Transwatershed flow augmentation from Piney Creek may contribute to these characteristics.

5.3.8 Rosebud Creek

Rosebud Creek was surveyed just upstream of the visitor center at Rosebud Creek State Park. Reconnaissance investigations in 2002 found no water at this site. The stream was in proper functioning condition with an upward trend. The riparian zone contained dense and diverse vegetation, effects of livestock grazing were not evident, and the only invasive species present was burdock (*Arctium* sp.). Banks were stable with dense root growth. The stream channel (Rosgen E6) contained good cover, including a moderate amount of large woody debris, and silt dominated the substrate. Rosebud Creek showed evidence of past downcutting and high sinuosity relative to other assessed streams. Above the surveyed reach, an irrigation diversion created a wetland area.

5.3.9 Spring Creek

Spring Creek was surveyed in its upper reaches and was determined to be properly functioning. The channel (Rosgen E6) was small with minimal flow, and it was dry both above and below the surveyed reach. A spring provided water near the upper end of the reach. This reach had the highest gradient (2.2%) of all assessed stream reaches. Adequate instream cover and large woody debris were present, and banks were stable with dense root growth. Silt dominated the substrate. The riparian zone supported diverse vegetation. Canada thistle was abundant in 2002 but not noted in this survey. Only light grazing occurred within the riparian zone, although hoof action was apparent within a livestock crossing. Alfalfa fields bordered the riparian zone.

5.3.10 Squirrel Creek - Lower

The lower station on Squirrel Creek was located just downstream of the highway. This reach was determined to be functional but at risk, and a trend was not apparent. Degradation was attributable to upstream CBNG development and to the highway culvert at the top of the reach. Channel conditions in the upper portion of the reach were relatively stable, but in the lower portion of the reach, the channel was out of balance with its landscape setting and the stream banks were unstable, possibly because the culvert increased water velocity. Relative to other sites, low values were obtained for width-to-depth ratio, entrenchment ratio, pool:riffle ratio, bankfull depth and width, and residual pool depth. Little instream cover and no large woody debris were present in this Rosgen E6 channel. The narrow riparian zone lacked diversity of species and ages. Grasses and rushes were dominant and few shrubs or trees were present. In 2002, Canada thistle was abundant, but it was not mentioned in this survey. Livestock grazing was light.

5.3.11 Squirrel Creek - Upper

The upper station on Squirrel Creek was located near the CX Ranch house. The stream was determined to be properly functioning. Grazing in the riparian zone was light and riparian vegetation was diverse and moderately dense. Banks were stable with dense root growth and minimal incision. The stream held good cover, although the amount of large wood was low. Silt/clay dominated the substrate of this Rosgen E6 channel. Relative to other assessed streams, upper Squirrel Creek had a high entrenchment ratio, high meander length, and low bankfull area. A ranch road crossed the stream at the downstream end of the reach. CBNG mining activity (Dry Creek POD) has occurred near this reach and downstream.

5.3.12 Youngs Creek - Lower

Lower Youngs Creek was surveyed just above the highway crossing. The stream rated as properly functioning, with an upward trend. The channel (E6) contained abundant cover and large woody debris, and the banks were stable with dense root growth. Silt/clay dominated the stream substrate. The riparian zone was wide and dense with a diversity of vegetation. Few invasive species were present and native species were recruiting. The survey in 2002 characterized the overstory as dominated by green ash, but that species was not noted in this assessment. Land management within the reach included light grazing, CBNG development approximately 150 feet uphill, and agricultural fields about 40 feet from the stream channel. A highway bridge and a stream gauge were located at the lower end of the reach, and a dilapidated wooden bridge was failing at the upper end.

5.3.13 Youngs Creek - Upper

The upper station on Youngs Creek was determined to be properly functioning with an upward trend. The channel (E6b) contained adequate cover, mainly because of an abundance of large woody debris. Although past downcutting was evident, the banks were stable with dense root growth. Relative to other assessed tributaries, gradient and the entrenchment ratio were somewhat high, while the pool:riffle ratio and residual pool depth were low. Silt and clay dominated the streambed, most likely as a consequence of basin geology. The riparian zone was relatively wide, dense, and diverse. Although invasive plants were present, recruitment of native species was excellent. Livestock grazing was light, but hoof action was evident at a few stream crossings. A culvert is located upstream of the sample reach, and a ditch parallels the stream outside of the riparian area.

5.3.14 Tongue River - Hanging Woman Creek

The Tongue River near Hanging Woman Creek was determined to be properly functioning. The river channel (Rosgen C4b) included three pocket pools and one side channel. Relative to other main stem reaches, gradient (3.1%) and water velocity (4.1 fps) were high, the pool—riffle ratio was low (0.8), and banks were moderately stable. Some lateral cutting and old incision were evident but banks were re-vegetating. The substrate was comprised mostly of gravel (61%) and cobble (33%). The riparian zone was in good condition and supported a diversity of species, although cottonwoods were not recruiting. Lack of cottonwood recruitment could result from flow regulation by the dam and resultant lack of flooding. The grazing system caused little apparent degradation. Land use upstream from the reach included CBNG development, irrigated agriculture, a bridge, and a residence. Roads within the reach caused minimal detriment.

5.3.15 Tongue River - below dam

Below the dam, the Tongue River was considered functional but at risk. The channel (Rosgen B4c) contained good cover and mostly stable banks, and it included six pocket pools and three side channels. Some lateral scour was evident on the east bank, although it appeared to be healing. Substrate consisted mostly of gravel (52%) and cobble (36%). Relative to other main stem sites, the measured values for bankfull width, bankfull area, and width-to-depth ratio were high, while flood-prone width, average riparian zone width, and entrenchment ratio were low. Aquatic vegetation was profuse within the reach and wetland vegetation (sedges and rushes) lined much of the river edge. One factor preventing the reach from attaining proper functional condition was a lack of recruitment of shrubs and trees, possibly because of flow regulation by the dam (about a mile upstream) or lack of such riparian vegetation upstream. The east bank was too steep to support much of a riparian zone. Potential for recruitment on the west bank was evidenced by the presence of a few saplings, and the survey crew recommended planting trees to speed establishment. Russian olive, a salt-tolerant invasive species, was present in this reach. Livestock grazing was light. Roads included a two-track road within 200 feet of the bank and a four-wheeler trail within 50 feet of the left bank within the reach, and a two-lane road along the east bank for over one-half mile upstream of the reach. A road ford was present at the lower end of the reach. New CBNG development had occurred at the upper end of the reach. Three dry draws were present (about 50 feet and about 250 yards from upper end, and about 250 yards from lower end).

5.3.16 Tongue River - Badger Creek

The Tongue River between Badger Creek and the bridge upstream from Tongue River Reservoir was functional, but at risk. A slow upward trend was apparent. The channel (Rosgen B4c) contained an adequate quantity of instream cover but little large woody debris. The substrate was composed of about 50% gravel, with the remainder being sand, silt/clay, and a small amount of cobble and boulder. Seven pocket pools and three side channels were located within the reach. Banks were moderately unstable and supported a lower density of root masses than at other sites. Flood-prone width was relatively narrow due to steep terrain on the east bank and a cut bank on the west. The cut bank resulted from lateral movement and some down-cutting. Downstream of the assessed reach, lateral movement had occurred and banks were exposed, but within the reach, eroded banks had begun to re-vegetate. Invasive plant species were abundant, but sedges and rushes were also established and some cottonwood recruitment had occurred. Agricultural fields bordered the riparian zone on the west side of the river, and irrigation was drawing water within the reach. Livestock grazing focused on green ash and box elder shoots on the west side of the river. CBNG development and discharge was active upstream from this reach.

5.3.17 Tongue River - state line

The Tongue River at the state line station rated as functioning at risk, but with an upward trend. The stream channel was a C4 channel type and contained adequate instream cover, side channels, pocket pools, and a relatively high count of large woody debris. Compared with other main stem sites, the channel was narrow, but flood-prone width, entrenchment ratio, residual pool depth, and pool:riffle ratio were large. In addition, the percentage of gravel comprising the stream substrate (86%) was highest at this station. Lateral channel movement and associated erosion indicated that the system was unstable, and riparian vegetation was insufficient to protect stream banks. However, banks were beginning to heal in several locations, point bars were re-vegetating, and native species were recruiting. Livestock grazing was light, but agricultural fields bordered the river. Irrigation probably occurred upstream, and a pump was observed in the river immediately above the reach. Three CBNG discharge points were present along the river, although one outfall entered the river downstream of the location where water chemistry was sampled. Flow was measured at 0.8 cfs at two outfalls and the third was not flowing. Roads were associated with the CBNG and agricultural activities, and one road crossing was located at the bottom of the reach. A two-track road paralleled the river within 50 feet of the banks.

Table 5-11: Physical habitat summary determination, with factors potentially causing impairment.

Station	Functional rating:	Trend for functional-at risk	Factors out of manager's control?	Flow regulation	Mining activities	Upstream channel conditions	Channel -ization	Road encroach-ment	Oil field water discharge	Augmen-ted flows	Other
Badger	At risk	Not apparent	Yes	X			X				Irrigation return flows
Coal	-	-	-	-	-	-	-	-	-	-	
Corral	At risk	**Downward**	Yes			X		X			Private land
Hang. Woman	At risk	Not apparent	Yes			X				X	Private land
Otter	At risk	Upward	Yes			X	X			X	
Prairie - Lr	Proper	Upward	No								
Prairie - Up	At risk	Upward	Yes	X	X	X					Private land
Rosebud	Proper	Upward	No								
Spring	Proper	Not apparent	No								
Squirrel - Lr	At risk	Not apparent	Yes			X		X	X		Culvert in road
Squirrel - Up	Proper	Not apparent	No								
Youngs - Lr	Proper	Upward	No								
Youngs - Up	Proper	Upward	No								
TR HW Cr	Proper	Upward	Yes	X	X	X			X	X	
TR below dam	At risk	Upward	Yes		X			X	X	X	
TR Badger Cr	At risk	Upward	Yes		X	X			X	X	Agriculture, grazing
TR state line	At risk	Upward	Yes		X	X		X	X	X	

Table 5-12: Relative impact of management activities. Ranking from 1 to 4, with 1 = greatest impact. Livestock use index gives number of cattle, horse, and sheep droppings (feces) counted.

Site	Instrm. structs.	Agri-culture	Recre-ation	Mining	Roads	Stream divrsn.	Urbani-zation	Livestck. grazing	Livestck. use indx.
Badger									
Coal									
Corral	2	4	4	4	2	4	4	1	233
Hanging W.	2	2	4	4	4	4	4	2	32
Otter	1	2	4	4	3	1	3	3	19
Prairie - Lr	3	3	4	3	3	3	4	2	0
Prairie - Up	3	3	4	4	3	4	4	2	28
Rosebud	4	4	4	4	3	2	4	3	0
Spring	4	2	4	4	4	4	4	2	62
Squirrel - Lr	1	4	4	1	3	4	4	3	30
Squirrel - Up	4	4	4	4	3	4	4	2	75
Youngs - Lr	3	3	4	3	3	4	4	3	32
Youngs - Up	3	4	4	4	4	3	4	3	57
Tributary median:	3	3	4	4	3	4	4	2	32
TR HW Cr	4	3	4	3	3	1	4	2.5	19
TR below dam	3	4	3	3	2	1	4	3	25
TR Badger Cr	3	2	4	2.5	3	2	4	2	20
TR state line	4	2	4	2	2	2	4	3	4
Main stem median:	3.5	2.5	4	2.75	2.5	1.5	4	2.75	19.5

Table 5-13: Hydrological and channel morphological parameters

Station	Velocity (fps)	Discharge (cfs)	Flood prone width (ft)	Gradient (%)	Valley length (ft)	Stream length (ft)	Sinuosity (KL)	Meander length (ft)	Width depth ratio	Entrenchment ratio	Pool riffle ratio	Bank full width (ft)	Bank full depth (ft)	Bank full area (ft^2)	Ave. resid. pool depth (ft)	Rosgen class
Badger	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corral	0.00	0.00	25.6	1.2	1136	1681.3	1.5	185	34.6	1.5	6.8	16.9	0.8	20.7	0.9	B6c
Hanging Woman	0.75	0.00	38	0.3	1430	2236.5	1.6	245	8.8	2.6	4.8	14.8	1.7	23.8	1.9	E6
Otter	1.47	5.19	34.6	0.9	380	2211.4	5.8	524	8.3	1.6	4.0	21.7	2.6	57.8	1.6	E6
Prairie - Lr	0.85	13.00	74.1	0.2 - 0.4	867	2012.8	2.3	175	6.3	4.5	4.6	16.4	2.6	48.8	1.8	E4
Prairie - Up	1.97	15.70	42.5	0.6	788	1563.0	2.0	128	11.7	1.8	1.7	23.6	2.0	48.6	1.7	E4
Rosebud	1.45	0.31	17.1	0.3 - 1.0	323	1440.2	4.5	185	10.2	1.2	3.5	14.7	1.4	21.6	1.0	B6c
Spring	Min	0.10	12.9	2.2	870	1544.7	1.8	134	7.1	2.2	4.7	5.8	0.8	5.7	0.4	E6
Squirrel - Lr	1.38	0.48	33.5	0.6 – 1.2	763	1565.4	2.1	169	3.5	8.8	2.0	3.8	1.1	4.0	0.5	E6
Squirrel - Up	1.03	0.66	273	0.6 – 1.2	1002	1612.7	1.6	308	7.9	31	5.9	8.8	1.1	9.7	1.0	E6
Youngs - Lr	1.00	1.10	21.5	0.5	703	1888.9	2.7	232	10.0	1.5	4.4	13.9	1.4	18.7	0.6	E6
Youngs - Up	0.96	0.89	18.5	3.7	724	1775.1	2.5	98	5.8	2.1	1.4	8.8	1.5	12.7	0.5	E6b
Tributary median:	1.02	0.66	33.5	0.9	788	1681.3	2.1	185	8.3	2.1	4.4	14.7	1.4	20.7	1.0	
TR HW Cr	4.13	462.00	221.7	3.1	1757	1961.5	1.1	-	46.6	2.0	0.8	111.8	2.4	264.7	2.4	C4b
TR below dam	2.22	464.00	292.3	0.6	2479	3230.9	1.3	-	61.4	1.9	2.1	154.1	2.5	377.0	2.3	B4c
TR Badger Cr	2.01	227.60	206.4	0.6	2937	3205.7	1.1	-	53.2	1.7	1.9	118.4	2.2	251.1	1.7	C4c
TR state line	2.62	253.00	498.1	0.7	1800	2698.0	1.5	-	42.4	5.4	3.4	92.7	2.2	206.2	3.1	C4
Main stem median:	2.42	357.50	257	0.7	2140	2951.9	1.2	-	49.9	1.95	2.0	115.1	2.3	257.9	2.3	

Table 5-14: Instream cover and channel substrate assessments.

Station	Instream cover (%)	LWD	Stream incisement	Particle counts Silt/clay	Sand	Gravel	Cobble	Boulders
Badger	-	-	-	-	-	-	-	-
Coal	-	-	-	-	-	-	-	-
Corral	< 10	29	Old/little incisement	100	0	0	0	0
Hanging Woman	30 to 50	0	Old incisement	100	0	0	0	0
Otter	10 to 30	63	Old incisement	68	6	21	5	1
Prairie - Lr	30 to 50	11	Old incisement	35	17	37	10	3
Prairie - Up	30 to 50	80	Deep incis., new fldpln. devpt.	23	17	69	2	0
Rosebud	> 50	29	Old incisement	98	2	0	0	0
Spring	30 to 50	63	Old incisement	100	0	0	0	0
Squirrel - Lr	10 to 30	0	Deep incisement	87	1	12	0	0
Squirrel - Up	> 50	14	No incisement	94	0	6	0	0
Youngs - Lr	> 50	82	Old incisement	96	0	3	1	0
Youngs - Up	30 to 50	230	Old incisement	100	0	0	0	0
Tributary median:	30 to 50	29	Old incisement	96	0	3	0	0
TR HW Cr	30 to 50	3	Old incisement	9	2	61	33	0
TR below dam	> 50	6	Old incisement	6	2	52	36	5
TR Badger Cr	30 to 50	2	Old incisement	13	17	54	9	3
TR state line	30 to 50	16	Old incisement	2	6	86	7	0
Main stem median:	30 to 50	5	Old incisement	8	4	58	21	2

Table 5-15: Stream bank cover and erosion

Station	Root masses %	Erosional deposition from surrounding slopes	Lateral cutting (% of bank)	Condition of banks
Badger	-	-	-	-
Coal	-	-	-	-
Corral	≤ 35	Some in specific limited locales	≤ 5	Banks moderately stable
Hanging Woman	65-85	Some in specific limited locales		Banks moderately stable
Otter	65-85	Some in specific limited locales	5-15	Banks moderately stable
Prairie - Lr	≥ 85	Some in specific limited locales	5-15	Banks stable
Prairie - Up	65-85	Some in specific limited locales	15-35	Banks moderately unstable
Rosebud	≥ 85	None	≤ 5	Banks stable
Spring	≥ 85	Some in specific limited locales	5-15	Banks stable
Squirrel - Lr	65-85	None	15-35	Banks moderately unstable
Squirrel - Up	≥ 85	None	≤ 5	Banks stable
Youngs - Lr	≥ 85	Some in specific limited locales	≤ 5	Banks stable
Youngs - Up	≥ 85	Some in specific limited locales	≤ 5	Banks stable
TR HW Cr	65-85	Some in specific limited locales	15-35	Banks moderately stable
TR below dam	65-85	Some in specific limited locales	5-15	Banks moderately stable
TR Badger Cr	35-64	Some in specific limited locales	15-35	Banks moderately unstable
TR state line	65-85	Some in specific limited locales	15-35	Banks moderately unstable

Table 5-16: Key for plant species abbreviations used in Table 5-17.

Native species				*Invasive species*			
Code	**Common name**	**Code**	**Common name**	**Code**	**Common name**	**Code**	**Common name**
Box	Box elder	Red	Red osier dogwood	Asp	Asparagus	Poi	Poison ivy
Cho	Chokeberry	Ros	Rose	Bur	Burdock	Rol	Russian olive
Cot	Cottonwood	Rsh	Rushes	Can	Canadian thistle	Sal	Salt cedar
Gol	Golden currant	Sag	Sage brush	Che	Cheat grass	Sti	Stick tight
Goo	Gooseberry	San	Sandbar willow	Fli	Flixweed	Swe	Sweet clover
Gra	Grasses	Sed	Sedges	Hem	Hemp dogbane	Tum	Tumbleweed
Gre	Green ash	Sno	Snowberry	Hou	Hounds tongue	Wat	Water hemlock
Pea	Peach leaf willow	Wpl	Wild plum	Koc	Kochia	Whi	Whitetop
				Lea	Leafy spurge	Wli	Wild licorice
				Mul	Mullein		

Table 5-17: Riparian zone width and vegetation cover.

Station	Width (ft)	Densiometer (median)	Veg. cover (%)	Consump. trees & shrubs by lvstck (%)	Dominant Overstory	Dominant understory	Invasive present	Non-invasive species recruiting
Badger	-	-			Cot, Box, Sal, Sed		Sal	Cot, Box[1]
Coal[2]	0	-						
Corral	3	0.00	≤ 75	**≥ 50**	Sag	Gra, Sed, Rsh	Bur	***None***
Hanging Woman	8	0.75	75-84	5-25	Box	Gra, Sed	Can, Fli, Koc	Box,Gre
Otter	20	0.88	85-94	5-25	Box	Cho, Sno	Rol, Asp	Box, Gol, Sno, Cho, Gre
Prairie - Lr	15	0.50	≥ 95	5-25	Cot, Box	Sed, San	Rol, Can, Lea, Fli, Hem	Cot, Box, San, Ros, Cho
Prairie - Up	25	0.88	85-94	30-35	Box	Cho, Sno	Lea, Can, Bur, Sti, Wat, Fli	Cho, Box, Red, Gre, Pea
Rosebud	11	1.00	≥ 95	0-5	Box, Gre	Sno, San	Bur	San, Box, Red, Sno, Ros, Gol, Rsh
Spring	10	1.63	85-94	5-25	Box	Cho, Sno	Bur	Gre, Sno, Cho, Gol, Goo, Ros, Box, Pea, San
Squirrel - Lr	6	1.00	≥ 95	0-5	*None*	Gra, Rsh	Tum, Koc, Swe	Ros, Wpl, Sno[3]
Squirrel - Up	10	0.63	85-94	0-5	Cot, Box	Gra, Sed, Rsh, Sno	Sti, Koc, Whi	
Youngs - Lr	20	2.00	≥ 95	5-25	Box	Sno	Sti, Bur	San, Ros, Box, Gol, Pea, Sno, Cho
Youngs - Up	25	4.00	≥ 95	5-25	Gre	Cho, Sno	Sti, Bur, Fli, Che[4]	*All*
Tributary median:	11	0.88	85-94	5-25				
TR HW Cr	90	0.25	75-84	5-25	Cot	Sno	Bur, Lea, Wli, Mul, Swe, Fli, Asp, Can	Gre, Sno, Cho, Gol, Goo, Ros, Box, Pea, San
TR below dam	50	0.00	85-94	5-25	Cot	Sno	Rol, Fli, Can, Swe, Wli, Bur	Cot, Pea, San, Cho, Goo, Ros
TR Badger Cr	80	0.00	75-84	25-50	Cot, Pea	Box	Can, Fli, Lea, Sal, Wli, Sti	Cot, Pea, San, Cho, Box, Ros
TR state line	90	0.13	75-84	15-20	Cot	Sno	Fli, Can, Hou, Swe, Poi, Wli	Cot, Pea, San, Gre, Cho, Sno[5]
Main stem median:	85	0.06	75-84	5-25				

[1] few alive
[2] Ephemeral stream without true riparian zone
[3] Very little
[4] Cheat grass (*Bromus tectorum*) at outer edge of riparian zone
[5] Livestock and game animals selecting green ash first

5.4 *Periphyton*

Periphyton samples varied considerably among tributary streams and among sites on a given stream (Figure 5-7 and Table 5-18, Table 5-19, Table 5-20, Table 5-21). Overall, according to the Montana plains streams biocriteria, the sites in this investigation held relatively high species richness and diversity, low percentages of dominant species and nitrogen-fixing species (*Rhopalodiales* spp.), and low values for the disturbance index. The pollution and siltation indices suggested low to moderate impairment according to the Montana plains streams biocriteria. At most of the sites that were sampled in 2002, three metrics (species richness, diversity, disturbance) indicated poorer conditions in 2004, whereas three others (pollution index, siltation index, and percent dominant species) were more variable (Table 5-22). See Appendix E Periphyton Proportional Counts for raw data.

The Tongue River sites indicated greater similarity among sites than did tributaries. Metrics included in the Montana plains streams biocriteria indicated no stress or only minor stress. These sites supported the largest diversity of non-diatom algae, suggesting environmental conditions amenable to a variety of taxa. Filamentous green algae (*Enteromorpha, Oedogonium, Rhizoclonium,* and *Spirogyra*) dominated these samples, which suggest elevated inorganic nutrients. The Tongue River sites supported the largest percentage of nitrogen-fixing diatoms (family Rhopalodiales), a clue that nitrogen is probably the limiting nutrient in the river. Freshwater diatoms dominated the samples, but percent brackish water diatoms showed a steady downstream increase in salinity. Diatom species richness and diversity values were somewhat depressed for a prairie stream but normal for a mountain stream, and the lowest diversity values were recorded below Tongue River Dam. Similarity index values between adjacent sites suggest no change to moderate change in species composition and ecological conditions between sites, and the largest change was from above to below Tongue River Reservoir.

5.4.1 Corral Creek

Samples from Corral Creek indicated stressed conditions relative to other sites. Corral Creek supported the largest percentage of brackish water diatoms (97%) of all the sites. Species that are tolerant of organic loading (*Navicula veneta* and *Nitzschia pusilla*) and elevated salinity (*Synedra famelica*) dominated the diatom assemblage. The pollution index for this site (1.43) was the lowest of all sites suggesting moderate impairment and only partial support of aquatic life uses. As the probable result of stress from elevated organic loading and/or salts, this site had the lowest diatom species richness and diversity values of all sites. *Tribonema* was the most abundant alga here, followed by the filamentous and potentially toxic cyanobacterium *Lyngbya.* Compared with results from 2002, periphyton analyses indicated improvement from moderate to minor impairment by sedimentation (33% reduction in siltation index) but a 20% increase in percent as dominant species (minor impairment).

5.4.2 Hanging Woman Creek

Periphyton samples from Hanging Woman Creek suggested relatively high stress in comparison to other sites. Hanging Woman Creek supported the third largest percentage of brackish water diatoms among tributaries of the Tongue River, slightly less than Spring Creek and Otter Creek. Richness of algal genera was high, with eight genera present, but diatom species richness was lower than optimal for a prairie stream (48 species). Diatom metrics indicate heavy organic loading that resulted in moderate impairment of aquatic life uses. The dominant diatom species in Hanging Woman Creek was *Navicula veneta*, a species that is very tolerant of organic pollution. Other tolerant species (*Nitzschia palea* and *Nitzschia pusilla*) were also common here. As with the lower site on Prairie Dog Creek, the majority of diatoms here require only low levels of dissolved oxygen. The siltation index suggests minor sedimentation for a prairie stream. Compared with results from 2002, periphyton samples indicated a 10% increase in organic pollution causing a decline to moderate impairment rating.

5.4.3 Otter Creek

Analysis of periphyton at Otter Creek indicated somewhat stressed conditions relative to other sites. Otter Creek supported the third largest percentage of brackish water diatoms and was the only site where brackish (as opposed to brackish-fresh or fresh) diatoms were in the majority. The high percentage of highly motile diatoms here resulted in the largest siltation index value of the sample set, which suggests moderate impairment from sedimentation. The pollution index value suggests minor impairment from organic loading, but some diatom taxa at this site were unclassified as to their ecological preferences. *Spirogyra* (aka "pond scum") dominated among non-diatom alga at this site. The dominant diatom species was *Nitzschia reversa*, which is a planktonic species that suggests ponding at the sample site. Diatom species richness and diversity were somewhat depressed for a prairie stream, perhaps because of ponding at the sample site, elevated salinity, or sedimentation. Periphyton samples were not collected in 2002.

5.4.4 Prairie Dog Creek - Lower

Samples from lower Prairie Dog Creek indicated low to moderate stress relative to other sites. The percentage of brackish diatoms nearly doubled between the upstream and downstream sites, but fresh water diatoms were the modal category at both sites. Besides a larger number of brackish diatoms, the lower site on Prairie Dog Creek had a significantly lower pollution index, which indicates more organic loading. The lower site was also dominated by diatoms that require only low levels of dissolved oxygen, compared to a majority that require fairly high levels at the upper site. This site supported a smaller number of non-diatom genera but a larger number of diatom species. It shared 42% of its diatom assemblage with the upper site. *Cladophora* was also abundant here, along with *Vaucheria*, which was dominant. Compared with results from 2002, periphyton metrics indicate no major changes in conditions at lower Prairie Dog Creek but greater similarity (11% increase in similarity index) between upper and lower stations.

5.4.5 Prairie Dog Creek - Upper

Periphyton samples from upper Prairie Dog Creek indicated relatively high water quality. *Cladophora*, a filamentous green alga that grows best in cool, gently flowing water rich in inorganic nutrients, dominated the upper site on Prairie Dog Creek. The small number of species (35) and the major diatom species here (*Navicula reichardtiana, Nitzschia* *dissipata, Nitzschia inconspicua*) are more typical of a mountain stream than a prairie stream. Diatom metrics at the upper site did suggest borderline moderate impairment from sedimentation but no stress from organic loading. Compared with results from 2002, periphyton analyses indicated a 105% increase in the siltation index, suggesting a decline to moderate impairment, and a 50% reduction in the number of species present, suggesting a decline to minor impairment.

5.4.6 Rosebud Creek

Periphyton samples from Rosebud Creek showed good biological integrity and provided full support of aquatic life uses. Key diatom metrics suggested only minor impairment from organic loading. The percent brackish water diatoms recorded here (48%) was the median value among sites in the sample set. Diatom species richness and diversity were normal for a prairie stream. The most abundant algae here were *Rhizoclonium*, a green filamentous alga similar to *Cladophora*, and the filamentous chrysophyte *Tribonema*. This was one of the few sites where the pollution-sensitive red alga *Audouinella* was present. The modal category for diatom motility was “not motile”. This site had the lowest percentage of motile diatoms and the smallest siltation index of all tributary sites. Compared with results from 2002, periphyton analyses indicated a 46% improvement as measured by the siltation index, suggesting no impairment.

5.4.7 Spring Creek

Periphyton samples suggested moderate stress at Spring Creek relative to other sites. Spring Creek supported the largest percentage of brackish water diatoms (83.61%) of all Tongue River tributaries. Notable here were large percentages of *Nitzschia valdecostata* and *Synedra famelica,* both brackish water diatoms. Key diatom metrics suggest moderate organic loading—*Navicula veneta* accounted for 12% of the diatom assemblage here—and minor sedimentation at this site. Most diatoms were in the “highly motile” category. Diatom diversity and species richness were slightly depressed for a prairie stream but typical for a spring creek. Diatoms and the cool water chrysophyte *Tribonema* dominated this site. Compared with results from 2002, periphyton analyses indicated declines due to siltation (22% increase in siltation index) and reduced species diversity (7% decrease in the Shannon diversity index).

5.4.8 Squirrel Creek - Lower

Periphyton samples from lower Squirrel Creek suggested moderately high stress relative to other sites. Key diatom metrics suggested minor impairment from organic loading but moderate impairment from sedimentation. The lower site on Squirrel Creek shared only about 30% of its diatom assemblage with the upper site, which suggests that there was a moderate change in ecological conditions between the two sites. Diatom species richness and diversity were somewhat lower here than they were upstream. Accompanying this moderate change in diatom flora, however, was a relatively small increase in the percentage of brackish diatoms, from about 60% at the upper site to about 75% at the lower site. Only two genera of non-diatom algae were recorded here: the pollution tolerant filamentous green *Stigeoclonium* and the cool water filamentous chrysophyte *Tribonema*. Compared with results from 2002, periphyton analyses indicated increased impairment from sedimentation (56% increase in siltation index), but improved species diversity (22% reduction in percent dominant species and 10% reduction in Shannon diversity index). Similarity between upper and lower stations changed little (4% decrease).

5.4.9 Squirrel Creek - Upper

Periphyton samples suggested moderately high stress at upper Squirrel Creek relative to other sites. Key diatom metrics were consistent with minor impairment from sedimentation and organic loading at this site. Modal categories for diatom motility ("highly motile"), dissolved oxygen demand ("low"), and saprobity ("alpha-mesosaprobous") suggest stress by sedimentation and organic loading. Upper Squirrel Creek supported more than twice the percentage of brackish water diatoms than either upper Youngs Creek or upper Prairie Dog Creek. Otherwise, this site supported a normal mix of non-diatom algae and had diatom diversity and species richness values that are typical for a prairie stream. Compared with results from 2002, periphyton analyses indicated increased impairment from sedimentation (18% increase in siltation index).

5.4.10 Youngs Creek - Lower

The site on lower Youngs Creek showed minor to moderate stress in comparison to the upper site. This site supported four more genera of non-diatom algae, including *Cladophora*, but about twenty fewer species of diatoms than the upper site. The percentage of brackish diatoms more than doubled between the two sites, but organic loading and sedimentation remained about the same. The two sites shared about one-half of their diatom assemblages, suggesting that only a minor change in environmental conditions occurred between them. Compared with results from 2002, periphyton analyses indicated reduced impairment from sedimentation (15% decline in siltation index). Similarity in conditions at upper and lower stations substantially increased in 2004 (49%).

5.4.11 Youngs Creek - Upper

Samples from the upper site on Youngs Creek indicated relatively little impairment. The chrysophyte *Vaucheria* was the dominant alga in upper Youngs Creek. *Vaucheria* prefers steady flows of cool water and is common in spring-fed streams. *Vaucheria* and *Tribonema*, another cool-water alga, were abundant at several sites. One explanation for this is that most sites were sampled early in the season (in May and June) when water temperatures were still relatively cool. Diatom metrics suggest only minor impairment from organic loading and sedimentation in upper Youngs Creek. Among tributaries of the Tongue River, this site had the second lowest percentage of brackish water diatoms. It was one of only three tributary sites to be dominated by freshwater diatoms, as opposed to brackish or brackish-fresh diatoms. This site supported the largest number of diatom species (81) and had the highest diatom species diversity (5.35) of all the sites represented in this sample set. Compared with results from 2002, periphyton analyses indicated increased impairment from sedimentation (45% increase in siltation index) and organic loading (13% decrease in pollution index).

5.4.12 Tongue River - Hanging Woman Creek

Samples from the Tongue River near Hanging Woman Creek, as with the other main stem sites, indicated good conditions relative to the tributary sites. Among main stem sites, periphyton at this station indicated higher salinity and nitrogen limitation. This site produced the highest species richness and diversity values as well as the lowest sedimentation index score.

5.4.13 Tongue River - below dam

Samples from the site below the Tongue River Dam indicated good conditions relative to the tributary sites. Compared to the other main stem sites, this site produced the fewest species, and the assemblage was more motile. Similarity index values between adjacent sites on the main stem suggested the largest change from above to below Tongue River Reservoir. Periphyton here indicated greater salinity and nitrogen limitation than at sites above the reservoir. This was the only main stem location supporting an abundance of *Vaucheria,* which prefers steady flows of cool water and is common in spring-fed streams.

5.4.14 Tongue River - Badger Creek

Periphyton samples from the Tongue River near Badger Creek indicated good conditions relative to the tributary sites. Among main stem sites, this location produced high species richness, but the high percent comprised by the dominant species led to a relatively low diversity value. This site also produced the lowest disturbance value among Tongue River sites and suggested lower levels of salinity and nitrogen limitation than at downstream sites. Similarity was greatest between this site and the state line station.

5.4.15 Tongue River - state line

Periphyton samples from the state line station indicated good conditions relative to the tributary sites. Among main stem sites, this location produced the lowest percentage of brackish and brackish-fresh taxa (10%) but a substantially higher disturbance index value. Similarity was greatest between this site and the site near Badger Creek. Samples suggested less nitrogen limitation than at sites below the dam.

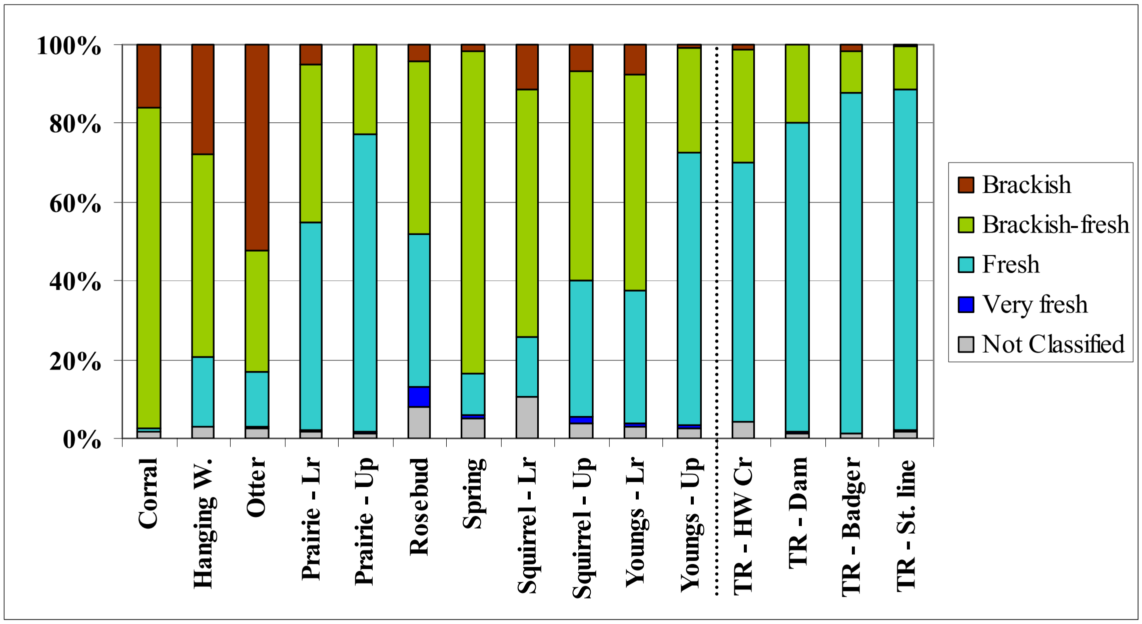

Figure 5-7: Percent diatoms in each of four salinity classes as assigned by Van Dam et al. (1994).

Table 5-18: Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples.

Taxa	Corral	HW	Otter	PD-Lr	PD-Up	Rosebud	Spring	Squirrel-Lr	Squirrel-Up	Youngs -Lr	Youngs-Up	TR-HW	TR-Dam	TR-Badger	TR-State line
Cyanophyta															
Anabaena	c/5	o/8				o/6	c/6		c/5			r/6	o/13	o/8	o/10
Calothrix													r/15	r/14	r/15
Hydrocoleum															r/12
Lyngbya	f/2	c/6													
Merismopedia															r/16
Nodularia							c/7								
Oscillatoria			c/5		f/3					o/7				c/6	c/9
Phormidium					c/4									f/5	
Pleurocapsa														r/11	
Spirulina														r/15	
Rhodophyta															
Audouinella					o/5	c/5								c/7	
Chlorophyta															
Cladophora		a/1		a/3	d/1					f/2			o/9	a/3	
Closterium									r/7			o/4	c/11	o/9	
Cosmarium														r/13	
Enteromorpha													d/1		
Hormidium							c/5								
Hydrodictyon													f/5		f/5
Microspora			f/3												a/3
Mougeotia		o/7	o/6				f/3		f/2			c/3	c/10		c/8
Oedogonium		c/5	c/4							o/6	o/4	o/5	c/7	d/1	f/6
Pediastrum													o/12		r/14
Rhizoclonium						a/1							c/8		d/1
Scenedesmus												r/7	o/14	o/10	o/11
Spirogyra	o/3	c/4	d/1						f/3	c/5	a/2	d/1	f/6	f/4	a/4

Taxa	Corral	HW	Otter	PD-Lr	PD-Up	Rosebud	Spring	Squirrel-Lr	Squirrel-Up	Youngs -Lr	Youngs-Up	TR-HW	TR-Dam	TR-Badger	TR-State line
Table 5-18 Continued															
Stigeoclonium		o/9						o/2							f/7
Table 5-18 Con't															
Zygnema													a/3		
Euglenophyta															
Euglena										r/8				r/12	r/13
Chrysophyta															
Tribonema	a/1	f/3				a/2	a/2	o/3	a/4	a/3					
Vaucheria				d/1		o/4	c/4		o/6	f/1	d/1		a/2		
Bacillariophyta	c/4	f/2	a/2	a/2	d/2	f/3	a/1	f/1	a/1	c/4	f/3	f/2	a/4	a/2	a/2
# Non-Diatom Genera	4	8	5	2	4	5	6	2	6	7	3	6	14	14	15

Table 5-19: Percent abundance of major diatom species[1] in periphyton samples.

Species or Metric	PTC[2]	Corral	HW	Otter	PD-Lr	PD-Up	Rosebud	Spring	Squirrel-Lr	Squirrel-Up	Youngs-Lr	Youngs-Up	TR-HW	TR-Dam	TR-Badger	TR-State line
Amphora inariensis	3				0.26	1.93	1.56			0.70	0.42	2.83	2.06	21.38	1.21	1.34
Cocconeis pediculus	3			0.60	0.26	1.41					12.64	0.15	20.65	3.54	1.81	1.79
Cocconeis placentula	3		5.26	1.20	1.96	2.31	0.93		0.60	4.04	4.31	10.27	7.52	12.46	3.92	2.53
Fragilaria capucina	2				0.52		6.22			2.51	0.69	0.89	10.77	0.31	0.60	
Navicula reichardtiana	2				2.09	15.68	0.62			1.11	3.33	10.86	1.18	1.54	2.41	2.08
Navicula veneta	1	21.34	24.87	6.30	0.79		6.22	12.10	17.92	4.87	8.75	2.53	1.18	0.31		0.30
Nitzschia dissipata	3				5.24	13.75	1.24	0.92		4.60	2.50	2.53	0.59	3.38	2.41	1.49
Nitzschia frustulum	2	2.74	7.37	3.90	3.80		9.33	1.53	23.49	1.39	6.94	2.08	0.44	0.92	0.60	2.08
Nitzschia inconspicua	2					10.03				0.28				5.85	0.60	0.60
Nitzschia palea	1	1.83	5.53	7.35	9.03	1.16	3.27	5.51	1.81	12.40	6.39	5.36	1.92	3.54	4.83	4.91
Nitzschia pusilla	1	18.90	1.84	0.30	0.52						1.11	2.53				
Nitzschia reversa	2			37.33												
Nitzschia valdecostata	2						0.62	19.75	0.60	0.14						
Pseudostaurosira brev.	3				0.52								4.13		31.07	15.77
Staurosira construens	3											1.04	11.21		24.28	26.93
Synedra famelica	2	29.73	2.63	0.30			7.47	25.42	4.07	11.42	0.28		0.29			
Tabularia fasciculata	2		10.00	2.10			0.62			3.76						

[1]A major diatom species accounts for 10.0% or more of the cells at one or more stations in the sample set. [2](Organic) Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive.

Table 5-20: Values of selected diatom association metrics for periphyton samples. Underlined values indicate minor stress; bold values indicate moderate stress; all other values indicate no stress and full support of aquatic life uses when compared to criteria for prairie streams in Table 4-11.

Species or Metric	Corral	HW	Otter	PD-Lr	PD-Up	Rosebud	Spring	Squirrel-Lr	Squirrel-Up	Youngs-Lr	Youngs-Up	TR-HW	TR-Dam	TR-Badger	TR-State line
Number of Species Counted	**28**	48	51	63	35	55	43	55	69	62	81	56	38	55	44
Shannon Species Diversity	3.16	4.30	3.99	5.01	4.17	4.93	3.76	4.37	4.99	4.84	5.35	4.48	4.12	3.78	3.91
Pollution Index	**1.43**	**1.64**	1.91	2.18	2.40	2.03	**1.75**	1.79	1.95	2.01	2.05	2.60	2.65	2.69	2.57
Siltation Index	63.11	68.42	**74.4**	66.75	**70.6**	38.26	59.88	**72.74**	55.85	64.58	67.56	18.14	30.77	24.43	30.06
Disturbance Index	0.00	0.00	3.00	4.58	4.50	1.40	0.61	0.15	0.14	0.28	0.30	2.65	4.77	1.36	9.97
Percent Dominant Sp.	29.73	24.87	37.33	9.29	15.68	9.33	25.42	23.49	12.40	12.64	10.86	20.65	21.38	31.07	26.93
Percent Rhopalodiales	0.00	0.00	0.00	0.13	0.00	2.64	0.31	0.90	2.09	0.69	1.04	6.19	5.23	3.17	3.57
Similarity Index[1]				42.42				29.54		47.57		33.41	26.87	69.90	

[1]Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station on the same stream.

Table 5-21: Modal categories for selected ecological attributes of diatom species in the Tongue River. Categories that represent somewhat inferior water quality when compared to the best sites in the sample set are underlined. Categories that represent significantly inferior water quality when compared to the best sites are in bold face type. Categories that represent a very significant decline in water quality compared to the best sites are underlined and in bold face.

Station	Motility[1]	pH[2]	Salinity[2]	Nitrogen Uptake[2]	Oxygen Demand[2]	Saprobity[2]	Trophic State[2]
Corral	Mod.	Alkaliphilous	Brackish-fresh	Autotroph.(high organics)	Contin. high	Oligo-saprob.	Eutraphentic
Hanging W.	Mod.	Alkaliphilous	Brackish-fresh	Autotroph.(high organics)	**Low**	**Alpha-meso-sap.**	Eutraphentic
Otter	**High**	Not classif.	**Brackish**	Not classif.	Not classif.	Not classif.	Not classif.
Prairie - Lr	**High**	Alkaliphilous	Fresh	Autotroph.(high organics)	**Low**	Beta-meso-sap.	Eutraphentic
Prairie - Up	Mod.	Alkaliphilous	Fresh	Autotroph.(high organics)	Fairly high	Beta-meso-sap.	Eutraphentic
Rosebud	Not	Alkaliphilous	Brackish-fresh	Autotroph.(high organics)	Not classif.	Beta-meso-sap.	Eutraphentic
Spring	**High**	Alkaliphilous	Brackish-fresh	Autotroph.(low organics)	Not classif.	Oligo-saprob.	Eutraphentic
Squirrel - Lr	Mod.	Alkaliphilous	Brackish-fresh	Autotroph.(high organics)	**Moderate**	Beta-meso-sap.	Eutraphentic
Squirrel - Up	**High**	Alkaliphilous	Brackish-fresh	Autotroph.(high organics)	**Low**	**Alpha-meso-sap.**	Eutraphentic
Youngs - Lr	**High**	Alkaliphilous	Brackish-fresh	Autotroph.(high organics)	**Moderate**	Beta-meso-sap.	Eutraphentic
Youngs - Up	Mod.	Alkaliphilous	Fresh	Autotroph.(high organics)	**Moderate**	**Alpha-meso-sap.**	Eutraphentic
TR HW Cr	Not	Alkaliphilous	Fresh	Autotroph.(high organics)	Fairly high	Beta-meso-sap.	Eutraphentic
TR below dam	Mod.	Alkaliphilous	Fresh	Autotroph.(high organics)	Fairly high	Beta-meso-sap.	Eutraphentic
TR Badger Cr	Not	Alkaliphilous	Fresh	Autotroph.(low organics)	Contin. high	Beta-meso-sap.	Meso-eutraph.
TR state line	Not	Alkaliphilous	Fresh	Autotroph.(low organics)	Contin. high	Beta-meso-sap.	Meso-eutraph.

[1]Dr. R. Jan Stevenson, Michigan State University, digital communication. [2]Van Dam et al. (1994).

Table 5-22: Percent change in values of diatom association metrics in 2004 relative to values for samples collected in 2002. Underlined and bold values refer to degree of stress indicated by samples collected in 2004 as presented in (underlined values indicate minor stress; bold values indicate moderate stress; all other values indicate no stress and full support of aquatic life uses when compared to criteria for prairie streams).

Station	# Spp.	Shannon Species Diversity	Pollution Index	Siltation Index	Disturb. Index	Percent Domin. Species	Similarity Index
Corral	**33.3**	-0.9	**-2.1**	-33.3	+	20.4	
Hanging Woman	-28.4	-18.4	**-9.9**	3.9	-100.0	188.5	
Prairie Dog - Lr	-13.7	-5.6	4.8	5.4	438.8	22.7	11.0
Prairie Dog - Up	-49.3	-19.8	-5.1	**104.8**	469.6	0.8	
Rosebud	-36.8	-9.4	6.8	-45.5	483.3	-13.7	
Spring	-27.1	-7.2	**19.0**	-22.2	8.9	-23.7	
Squirrel - Lr	1.9	9.8	-5.3	**55.7**	+	-22.2	-3.7
Squirrel - Up	-8.0	-1.0	-8.0	18.3	+	-29.7	
Youngs - Lr	-18.4	0.6	4.1	-15.4	+	-36.9	49.3
Youngs - Up	-5.8	-3.4	-12.8	45.4	-87.9	-21.5	

5.5 *Macroinvertebrates*

Application of the biocriteria developed for Montana Plains ecoregion streams (Bukantis 1998) indicated the full range of conditions from unimpaired and fully supporting beneficial uses to severely impaired and not supporting beneficial uses. However, most sites (10 of 11 tributary stations and 3 of 4 main stem stations) scored within the range of partial support and slight or moderate impairment. According to the biocriteria, sites included in this investigation generally supported high richness of predator taxa, high overall taxa richness, and low organic enrichment relative to other Montana Plains streams. See Appendix F: Macroinvertebrate Proportional Counts for raw data.

The Wyoming biocriteria produced lower scores at tributary locations, reflecting a relatively small contribution by the orders Ephemeroptera (mayflies), Trichoptera (caddis flies), and Plecoptera (stoneflies), with seven sites rated as poor, three as fair, and only one as good. Three of the main stem locations rated as good according to the Wyoming biocriteria, although the site below the dam rated as fair. HBI scores indicated slight to moderate organic enrichment at all sites. Dipterans (true flies), especially chironomid midges, were the most abundant taxa at most tributary sites. Few intolerant taxa showed up in samples, and EPT taxa were scarce at many sites. Plecopterans, in particular, were practically nonexistent within the study area. Functionally, collectors (especially gatherers) dominated sample compositions, whereas only Prairie Dog and upper Squirrel creeks produced scraper taxa. Although exceptions were numerous, these generalizations reflect the presence of soft substrates and low flows at many sites. The main stem Tongue River appeared to support substantially greater densities of organisms and achieved higher scores according to the Plains streams biocriteria than did most tributary streams. Tongue River samples contained a much stronger presence of ephemeropterans, trichopterans, intolerant taxa, and clinger taxa, but fewer predator taxa and a lower proportion of dipterans.

Note that the full Plains streams biocriteria could not be followed for Montana or Wyoming. One of the 10 metrics (percent 10 dominant) for the Wyoming biocriteria and one of the ten metrics (percent multivoltine) comprising the Montana biocriteria were not calculable because the required information was not determined during the identification phase. Because the absence of this single metric probably had little effect on the overall determination, we nonetheless calculated the score using only the other nine metrics and a reduced total possible for the Montana biocriteria (27 rather than 30). Further, small differences in scores may not be biologically meaningful, as variations may result from factors related to sample collection, processing, and spatiotemporal ecological variation (Bukantis 1998). To illustrate this variability, a single sample from upper Squirrel Creek in 2002 that was divided into two separately processed sample jars produced scores of 60% (moderate impairment) and 70% (slight impairment) of the total possible (Confluence 2002). The criteria do provide a useful general indication of conditions, though, and would indicate temporal trends with finer resolution if sampling and processing methods were consistent. The following interpretations refer to the results of quantitative sampling (Surber sampler in riffle habitat) unless otherwise specified.

5.5.1 Corral Creek

Scores for Corral Creek differed between the Montana and Wyoming plains streams biocriteria. Considering the relatively poor conditions indicated by water quality and physical habitat assessments, this site scored remarkably high (63%) according to the Montana biocriteria, which suggested slight impairment and partial support of beneficial uses. Corral Creek produced better scores than all other sites for the biotic index (only slight enrichment), percent collectors, and percent dominant taxa. However, this site rated as poor (30%) according to the Wyoming biocriteria. Samples produced no intolerant taxa, almost no EPT taxa or individuals, the highest proportion of tolerant individuals among all sites (19%), and the lowest overall density of animals. Diversity indices produced mixed results but operational taxon and family richness values were low. Dipterans and coleopterans (beetles) comprised most of the sample, along with a smaller number of Odonata (dragonflies and damselflies). This sample contained a relatively high proportion of predators, the dominant taxon being Dytiscidae (predacious beetles). Although qualitative sampling efforts netted a substantial number of individuals, taxa richness was lowest among sites (tied with lower Squirrel Creek), indicating environmental stress. The unexpectedly high score of quantitative samples according to the Montana biocriteria likely stems from the capture of a relatively large number of taxa relative to the very low total number of individuals (in effect, a high degree of evenness).

In comparison with the sample from 2002, the sample from 2004 produced substantially better scores overall (63% of possible, versus 37% in 2002), and for the biotic index, % collectors, and % shredders + scrapers. The absence of EPT individuals is particularly notable because the 2002 sample was dominated by the mayfly *Callibaetis* sp. Soft sediments supported abundant ostracods in both 2002 and 2004.

5.5.2 Hanging Woman

Assessment of macroinvertebrate samples indicated relatively poor conditions at Hanging Woman Creek. This site scored lowest of all sites (21 = poor condition) according to the Wyoming biocriteria and only 30% of the total possible according to the Montana biocriteria, just above the cutoff for severe impairment and non-support of beneficial uses. The low HBI score, though, indicated only slight enrichment. Although qualitative sampling produced a relatively high diversity of taxa, quantitative efforts indicated low diversity, which suggests environmental stress. *Physella* sp. snails, chironomids, and a smaller proportion of *Hyalella sp.* amphipods dominated this sample, suggesting somewhat warm and enriched conditions with organic debris. Intolerant and EPT taxa were virtually absent. A relatively low abundance but moderate richness of predators (Coleoptera and Odonata) was present.

Compared to samples collected in 2002, the samples from 2004 produced a substantially lower (better) biotic index score, a higher proportion of dominant taxa, and a lower overall Montana biocriteria score (50% of total possible in 2002). The sample from 2002 contained an abundance of *Caenis* sp. mayflies, but these were absent from the 2004 samples.

5.5.3 Otter Creek

The site on Otter Creek scored 52% of the total possible according to the Montana biocriteria, indicating partial support of beneficial uses and slight impairment, and 39% (fair) according to the Wyoming biocriteria. Based on the biocriteria, this site supports low diversity and a low percentage of scrapers but high taxa richness and predator richness. The assemblage was relatively tolerant, no intolerant taxa were collected, and the biotic index suggested moderate enrichment. The filter-feeding family Simuliidae (black flies) comprised about one-half of the sample, while most of the remainder consisted of trichopterans (Hydropsychidae) and a smaller proportion of Elmidae (riffle beetles) and amphipods (*Hyalella sp.*). This site was not sampled in 2002.

5.5.4 Prairie Dog Creek - Lower

Macroinvertebrate assemblages in Prairie Dog Creek indicated somewhat higher quality habitat than most sites. The two stations produced the highest overall taxa richness, EPT richness, and EPT abundance of all tributary sites. Prairie Dog Creek was the only tributary having no taxa categorized as tolerant and one of only two streams supporting intolerant taxa. The site on lower Prairie Dog Creek scored highest (78%) among all tributaries according to the Montana plains streams criteria, indicating slight impairment and partial support of beneficial uses, and fair (48%) according to the Wyoming biocriteria. Overall taxa richness as well as richness of EPT taxa, long-lived taxa, intolerant taxa, and clinger taxa all exceeded values obtained at most of the other tributaries. Presence of clinger and scraper taxa reflected the relatively low level of fine sediment in the stream substrate. This site held the greatest overall abundance of animals and the second highest EPT abundance. Thirty-five percent of the quantitative sample consisted of Hydropsychidae caddis fly larvae with the remainder comprised mainly of chironomids, elmids, and *Tricorythodes* spp. mayflies. Although ephemeropterans constituted a much smaller proportion of the sample than at the upper site, the density of individuals was actually higher at this site. The number of Trombidiformes mites collected in Surber samples was highest among all sites (323/m^2). The biotic index suggested moderate enrichment.

Compared with results from 2002, macroinvertebrate samples collected in 2004 produced an improvement in rating from moderate to slight impairment, corresponding to an increase in score from 50% to 74% of the total possible according to the Montana biocriteria. Metrics that indicated substantially better conditions in 2004 included the biotic index, EPT richness, and % EPT. Sampling appeared to be considerably less effective in capturing macroinvertebrates in 2002, possibly because of high flow conditions during the site visit.

5.5.5 Prairie Dog Creek - Upper

The site at upper Prairie Dog Creek scored 67% of the total possible according to the Montana plains streams biocriteria, indicating slight impairment and partial support of beneficial uses. This site scored higher than all other tributary sites (and was the only one rated as good (all others were fair or poor) according to the Wyoming biocriteria. This site produced the highest values among all tributary sites for taxa richness, EPT richness, %EPT, clinger taxa, long-lived taxa, and both abundance and richness of intolerant taxa. Only upper Squirrel Creek produced more scraper taxa. Ephemeropterans comprised 62% (Baetidae 55%) of the macroinvertebrate assemblage, and trichopterans (predominantly *Brachycentrus occidentalis*) an additional 23%. The biotic index indicated only slight enrichment. Hanging Woman Creek produced one plecopteran in the qualitative sample. No other site produced plecopterans and, interestingly, this was the only site that met biological integrity goals according to the BUGLAB Interior Columbia Basin criteria.

Compared with sampling conducted in 2002, the samples collected in 2004 produced a similar overall score according to the Montana biocriteria. Metrics indicating substantial improvements included overall taxa richness, EPT richness, and # of predator taxa. Scores declined for % dominant taxon and Shannon Diversity Index.

5.5.6 Rosebud Creek

The site on Rosebud Creek scored 56% of the total possible according to the Montana biocriteria, indicating moderate impairment and partial beneficial use support, and 34% poor) according to the Wyoming biocriteria. The biotic index suggested moderate organic enrichment. Notable at this site were the strong presence of predators (12 taxa, 43% of total abundance) and low proportion of collectors (57%). Although the Plains streams biocriteria indicated a relatively high richness of taxa, the overall score was limited by low values for diversity, scraper abundance, and EPT richness and abundance. Dipterans, primarily chironomids, ceratopogonids, and a smaller proportion of simuliids, dominated the assemblage (90%). Coleopterans and fingernail clams each comprised nearly one-half of the remaining portion. An abundance of crayfish was noted during the fish survey.

The sample from 2004 scored somewhat (40%) higher than the sample from 2002 according to the Montana biocriteria, although the ultimate impairment rating and use support were the same. Improved metric results for the biotic index and % collectors contributed to the better score. In 2002, tubificid worms dominated the sample, whereas quantitative samples in 2004 produced few annelids but qualitative sampling produced numerous Branchiobdellidae worms.

5.5.7 Spring Creek

The site on Spring Creek scored 63% of the total possible according to the Montana biocriteria, indicating slight impairment and partial support of beneficial uses, and 32% (poor) according to the Wyoming biocriteria. Most metric scores fell near the median for the set of tributary sites. Dipterans, primarily chironomids, comprised 54% of the total abundance, followed by trichopterans (Limnephilidae; 21%), amphipods (*Hyalella sp.* 9%), and fingernail clams (Pisidiidae; 5%). Macroinvertebrate density was lower than at all sites except Corral Creek. This site produced a relatively high percentage of individuals belonging to tolerant taxa (9%), although the biotic index suggested only slight organic enrichment.

The overall score and rating according to the Montana biocriteria differed little from those obtained in 2002 (67% of total possible). The biotic index score improved but diversity decreased in 2004. Chironomid midges dominated the insect assemblage in both years (different genera, though). Samples collected in 2004 suggested a substantially reduced abundance of nematodes and Physidae snails, whereas trichopterans and fingernail clams were absent from the 2002 sample.

5.5.8 Squirrel Creek - Lower

Assessment of macroinvertebrate samples indicated poor conditions at lower Squirrel Creek. This site scored only 22% of the total possible according to the Montana biocriteria, the lowest of any site, indicating severe impairment and non-support of beneficial uses, and 31% (poor) according to the Wyoming biocriteria. Dipterans, primarily chironomids and a much smaller proportion of Ceratopogonidae (no-see-ums), comprised 98% of the quantitative sample. Taxa richness, diversity, number of long-lived taxa, and EPT presence were very low at this site, indicating a high degree of environmental stress. Qualitative sampling turned up only 19 OTUs and 12 families, the lowest values of any site.

This sample scored considerably lower (22% of the total possible) according to the Montana biocriteria than the sample from 2002 (57%), which produced a rating of moderate impairment and partial support. Although the biotic index suggested some reduction in organic enrichment, the metrics of % collectors, % dominant taxon, and % shredders + scrapers showed large declines in 2004. This owes largely to the exceptional quantity of chironomids sampled in 2004. Dipterans dominated in abundance in both years, but they comprised only about 36% of the sample in 2002. *Hyalella* sp. dominated the sample in 2002 (24%), but none were collected in quantitative or qualitative sampling in 2004. Ephemeropterans also disappeared from the assemblage in 2004, although only

10 *Caenis* sp. individuals were captured in 2002. Crayfish were rare at this site in 2004 and 2002.

Klarich et al. (1980) reported the results of nine macroinvertebrate collections performed using Surber samplers in 1978 and 1979 near the highway bridge (T 9S, R 40E, S 29 SW). Abundances varied widely among samples, but hydropsychid caddis (mean 1935/m^2) and chironomid midges (mean 1391/m^2) dominated all samples. These results provide dramatic contrast to samples collected in 2002 and 2004 in which hydropsychids were absent and few trichopterans present.

5.5.9 Squirrel Creek - Upper

In contrast to the lower site, the site at upper Squirrel Creek scored 67% of the total possible according to the Montana biocriteria, indicating slight impairment and partial support of beneficial uses. This site scored 43% (fair) according to the Wyoming biocriteria, third highest among tributary sites. This site supported a relatively high degree of taxa richness, including six EPT taxa that comprised 18% of the total abundance, as well as the highest richness of scraper, clinger, and long-lived taxa of any tributary station. A relatively high number of tolerant individuals representing three taxa turned up in the sample. Dipterans comprised 64% of the sample and primarily included chironomids, ceratopogonids, and simuliids. Baetis mayflies comprised 17% of the sample, while *Hyalella sp.* comprised 7%, coleopterans 6%, and mollusks 4%. The upper site on Squirrel Creek produced an abundance of EPT invertebrates nearly an order of magnitude higher than the lower site, as well as twice the number of families and operational taxa. The lower site supported twice the total abundance of organisms, but this difference was primarily made up of chironomids.

Samples from 2002 and 2004 indicated produced roughly similar assessments according to the Montana biocriteria. In 2002 the two samples scored 60% and 70% of the total possible, bracketing the 2004 score of 67%. The most notable difference in assemblage was the absence in 2004 of tubificid worms, which were the dominant taxon in 2002. Crayfish (*Oronectes* sp.) were abundant in 2004 and 2002, in sharp contrast to the lower site.

5.5.10 Youngs Creek - Lower

The site on lower Youngs Creek scored 67% of the maximum possible according to the Montana biocriteria, indicating slight impairment and partial support of beneficial uses, but only 31% (poor) according to the Wyoming biocriteria. This site produced the highest diversity values of any site. The biotic index suggested moderate enrichment, although the score was relatively good for Montana plains streams, and 18% of the sample consisted of tolerant individuals. Dipterans (primarily chironomids and simuliids) comprised 25% of the total abundance, with slightly lesser numbers of ephemeropterans (23%, mainly *Baetis* spp.), crustaceans (21%, mostly *Hyalella*), and mollusks (18%, equal proportions Physidae snails and Pisiidae clams). Coleoptera beetles (primarily Elmidae) also turned up in fair quantities (9%). High proportional abundances of gatherers and non-insects relative to other tributary sites produced the low Wyoming biocriteria score. Three crayfish were captured during the fish survey.

This sample scored considerably higher according to the Montana biocriteria than did the sample from 2002 (43%). Scores improved in 2004 for all of the included Montana biocriteria metrics except for Shannon diversity index (no change) and % shredders and scrapers (decline). The most obvious difference in sample composition between years was that the 2002 sample contained <1% Ephemeroptera, whereas *Baetis* spp. mayflies were the dominant OTU in 2004.

5.5.11 Youngs Creek - Upper

The macroinvertebrate assemblage sampled at this station scored 59% of the total possible according to the Montana biocriteria, indicating moderate impairment and partial support of beneficial uses, and only 32% (poor) according to the Wyoming biocriteria. This was one of only three sites at which at least one intolerant taxon was collected, while tolerant individuals comprised <1% of the sample and the biotic index suggested only slight impairment. Dipterans (about 80% chironomids, 20% simuliids) and mollusks (Physidae snails and Pisiidae clams) each made up 37% of the assemblage, the remainder consisting primarily of coleopterans (Elmidae), ephemeropterans (Baetidae), and trichopterans (Hydropsychidae, Brachycentridae). The number of Trombidiformes mites collected in Surber samplers was quite high (122/m^2). The high percentage of non-insects relative to other tributary sites contributed to the low Wyoming biocriteria score. Crayfish were abundant during the fish survey, in contrast to the lower site.

The score and assessed condition according to the Montana biocriteria based on this sample were similar to those obtained in 2002. Assemblage diversity was lower but the biotic index suggested substantially less organic enrichment in 2004.

5.5.12 Tongue River - Hanging Woman Creek

The sample from the Tongue River near Hanging Woman Creek scored 85% of the total possible according to the Montana biocriteria, the highest among all sites, indicating no impairment and full support of beneficial uses. A score of 58% according to the Wyoming biocriteria suggested good conditions. This site exhibited the greatest total number of taxa, number of Ephemeroptera taxa, and percentage of scrapers, as well as the lowest percentage dominant taxon of any site. Among the four main stem sites, this location produced the lowest density of macroinvertebrates, but the greatest diversity, predator abundance and predator richness. The sample composition included 6% intolerant but also 4% tolerant individuals and the HBI score suggested only slight impairment. Other metrics indicating high quality included a low percentage of collectors and a high number of clinger taxa. Ephemeropterans (including small numbers of intolerant Polymitarcyidae), and elmid beetles each comprised 31% of the sample, while trichopterans comprised 11%. The more tolerant chironomids (12%), mollusks (mainly snails; 6%), and crustaceans (mainly *Hyalella sp.*; 5%) made up a smaller portion of the assemblage. One plecopteran was found in the qualitative sample.

5.5.13 Tongue River - below dam

The site downstream of the dam scored 74% of the total possible according to the Montana biocriteria, indicating slight impairment and partial support of beneficial uses.

The score of 43% according to the Wyoming biocriteria indicated only fair conditions, in contrast to the other main stem sites, which all scored in the range of good conditions. Although high for Montana plains streams, total taxa richness and EPT richness were low in comparison to the other main stem sites. This site also produced fewer clinger taxa and intolerant taxa than other main stem locations, a higher overall tolerance score (HBI and CTQa), and only two long-lived taxa. However, the sample contained no tolerant taxa and a large percentage of predators (12%). Four orders (Diptera, Ephemeroptera, Mollusca, and Trichoptera) each constituted 21-23% of the sample, corresponding to high evenness (0.72). Physidae snails, the dominant family, were much more abundant than at other main stem sites and, together with abundant *Tricorythodes* mayflies, suggested relatively warm temperatures.

5.5.14 Tongue River - Badger Creek

Samples from the site on the Tongue River near Badger Creek scored 78% of the total possible according to the Montana biocriteria, indicating slight impairment and partial support of beneficial uses, and 60% (good) according to the Wyoming biocriteria. Metric results indicating good biotic conditions included high values for total taxa richness, EPT richness, and percentage of EPT (73% of the sample). Despite the high percentage of EPT, the biotic index scored higher than at the other main stem sites and suggested moderate organic enrichment. This site produced a high abundance of macroinvertebrates, and the sample was dominated by Ephemeroptera (50%; primarily Baetidae and *Tricorythodes* sp.), Tricoptera (23%; predominantly hydropsychids, hydroptilids also abundant), and Diptera (21%; mainly chironomids). Elmid beetles were abundant, although they comprised only 4% of the sample due to the high density of other taxa. Non-insect taxa were scarce, in contrast to the sites below Tongue River Reservoir. Amphipods were not reported.

5.5.15 Tongue River - state line

The state line site scored 67% of the total possible according to the Montana biocriteria, indicating slight impairment and partial support of beneficial uses, and 60% (good) according to the Wyoming biocriteria. This site supported the highest percentage EPT (79%) among main stem sites and the greatest richness of scraper taxa (4) among all sites, indicating good water quality and limited sedimentation. Only two predator taxa comprising 2% of the total abundance were collected, representing a limitation on functional diversity. Ephemeropterans dominated in abundance (60%), and most of the remainder consisted of tricopterans (20%) and elmid beetles (15%). Dipterans (3%) and non-insect taxa made up a small portion of the assemblage, suggesting good water quality. *Hyalella sp.* and Physidae snails were present in low densities, but their abundance in kicknet samples suggests widespread occurrence. Additional evidence of high quality conditions comes from qualitative samples, which produced the highest values among sites for richness of operational taxa and long-lived taxa. An abundance of crayfish was noted during the fish survey at this site but not at the other main stem sites.

Table 5-23: Montana plains streams (Bukantis 1998) metric values and scores (in parentheses) based on quantitative macroinvertebrate sampling efforts. Scores range from 0 (poor) to 3 (excellent). Values rated as excellent given in bold. One of the metrics (% multivoltine) could not be included.

Station	Taxa Richness	EPT Richness	Biotic Index	% Dominant Taxon	% Collectors (g+ff)	% EPT	Shannon Diversity	% Scrapers + Shredders	# Predator Taxa	% Possible score	Impairment rating	Beneficial use support
Corral	17 (1)	0 (0)	**2.3 (3)**	**19.3 (3)**	**37 (3)**	0 (0)	2.51 (2)	15 (2)	**7 (3)**	63	Slight	Partial
Hanging Woman	20 (2)	0 (0)	**2.8 (3)**	51.9 (1)	96 (0)	0 (0)	1.36 (0)	1 (0)	5 (2)	30	Moderate	Partial
Otter	**27 (3)**	8 (2)	5.1 (2)	52.4 (1)	92 (1)	37 (2)	1.47 (0)	0 (0)	**7 (3)**	52	Moderate	Partial
Prairie – Lr	**32 (3)**	**11 (3)**	**4.4 (3)**	**22.5 (3)**	78 (2)	47 (2)	2.43 (2)	1 (0)	**7 (3)**	78	Slight	Partial
Prairie – Up	**33 (3)**	**18 (3)**	**3.4 (3)**	45.2 (1)	90 (1)	**84 (3)**	2.05 (1)	1 (0)	**6 (3)**	67	Slight	Partial
Rosebud	**26 (3)**	3 (1)	5.5 (2)	33.3 (2)	**57 (3)**	1 (0)	1.93 (1)	1 (0)	**12 (3)**	56	Moderate	Partial
Spring	**25 (3)**	3 (1)	**4.6 (3)**	45.0 (1)	64 (2)	20 (1)	1.98 (1)	22 (2)	**8 (3)**	63	Slight	Partial
Squirrel - Lr	15 (1)	2 (0)	5.9 (2)	62.2 (0)	92 (1)	0 (0)	0.96 (0)	1 (0)	5 (2)	22	Severe	Non
Squirrel - Up	**30 (3)**	6 (2)	5.3 (2)	**27.7 (3)**	72 (2)	18 (1)	2.18 (1)	4 (1)	**7 (3)**	67	Slight	Partial
Youngs - Lr	**26 (3)**	4 (1)	**4.2 (3)**	**21.4 (3)**	77 (2)	24 (1)	2.51 (2)	1 (0)	**8 (3)**	67	Slight	Partial
Youngs - Up	**27 (3)**	5 (1)	**3.1 (3)**	**19.2 (3)**	83 (1)	13 (1)	2.39 (1)	0 (0)	**6 (3)**	59	Moderate	Partial
Tributary median:	**26 (3)**	4 (1)	**4.4 (3)**	33.3 (2)	78 (2)	18 (1)	2.05 (1)	1 (0)	**7 (3)**	63	Moderate	Partial
TR HW Cr	**41 (3)**	**19 (3)**	**3.9 (3)**	**15.3 (3)**	**55 (3)**	41 (2)	**3.02 (3)**	5 (1)	**6 (3)**	85	None	Full
TR below dam	**25 (3)**	**10 (3)**	**3.2 (3)**	**21.8 (3)**	77 (2)	43 (2)	2.51 (2)	9 (1)	3 (1)	74	Slight	Partial
TR Badger Cr	**37 (3)**	**22 (3)**	**4.3 (3)**	**20.2 (3)**	88 (1)	**73 (3)**	2.69 (2)	4 (1)	4 (2)	78	Slight	Partial
TR state line	**29 (3)**	**17 (3)**	**4 (3)**	33.2 (2)	77 (2)	**79 (3)**	2.33 (1)	6 (1)	2 (0)	67	Slight	Partial
Main stem median:	**33 (3)**	**18 (3)**	**3.95 (3)**	**21.0 (3)**	77 (2)	**58 (3)**	2.60 (2)	5.5 (1)	3.5 (1)	76	Slight	Partial

Table 5-24: Wyoming plains streams metric scores (Stribling et al. 2000). Rating criteria: 100—78.7 = very good; 78.6—58 = good; 57—39 = fair; 38—19 = poor; 0—18.9 = very poor. One of the metrics (% 10 dominant) could not be included. Scores rated as very good are listed in bold.

Metric	Total taxa	Ephemeroptera taxa	Plecoptera taxa	Trichoptera taxa	% Plecoptera	% non-insects	BCI CTQa	Scraper taxa	% collector-gatherers	Index score	Sample rating
Corral	39	0	0	0	0	**100**	50	0	**86**	30	poor
Hanging Woman	45	0	0	0	0	38	35	0	66	21	poor
Otter	61	29	0	60	0	**100**	20	0	**81**	39	fair
Prairie - Lr	73	57	0	70	0	**94**	38	14	**83**	48	fair
Prairie - Up	75	**100**	33	**80**	7	**100**	73	43	70	65	good
Rosebud	59	0	0	30	0	**90**	41	0	**83**	34	poor
Spring	57	0	0	30	0	75	38	0	**87**	32	poor
Squirrel - Lr	34	0	0	20	0	**100**	35	0	**88**	31	poor
Squirrel - Up	68	29	0	40	0	**80**	38	43	**88**	43	fair
Youngs - Lr	59	29	0	20	0	51	38	0	78	31	poor
Youngs - Up	61	14	0	40	0	53	32	0	**89**	32	poor
Tributary median:	59	14	0	30	0	**90**	38	0	**83**	35	poor
TR HW Cr	**93**	**100**	0	70	0	**80**	70	43	67	58	good
TR below dam	57	71	0	50	0	67	38	29	72	43	fair
TR Badger Cr	**84**	**100**	0	**100**	0	**100**	76	43	75	64	good
TR state line	66	**100**	0	60	0	**100**	**79**	57	75	60	good
Mainstem median:	75	**100**	0	65	0	**93**	73	43	73	58	good

Table 5-25: Macroinvertebrate taxa composition based on quantitative samples.

Stream	% Ephemer-optera	% Plecop-tera	% Trichop-tera	% Coleop-tera	% Megalop-tera	% Diptera	% Chirono-midae	% Crustacea	% Oligo-chaeta	% Mollusca	% Other
Corral	0	0	0	47	0	48	9	0	0	0	4
Hanging Woman	0	0	0	2	0	42	38	3	0	52	1
Otter	0	0	37	7	0	54	2	1	0	0	1
Prairie - Lr	10	0	38	16	0	32	28	0	0	3	2
Prairie - Up	62	0	23	4	0	8	7	0	0	0	3
Rosebud	0	0	1	4	0	90	40	0	0	4	0
Spring	0	0	21	6	0	54	49	9	0	5	5
Squirrel - Lr	0	0	1	0	0	98	91	0	0	0	0
Squirrel - Up	17	0	2	6	0	64	29	7	0	4	0
Youngs - Lr	23	0	2	9	0	25	12	22	0	18	2
Youngs - Up	8	0	6	10	0	37	27	1	0	37	2
Tributary median:	0	0	2	6	0	48	28	1	0	4	1.55
TR HW Cr	31	0	11	31	0	13	12	5	0	6	3
TR below dam	22	0	21	2	0	23	15	0	0	22	10
TR Badger Cr	50	0	23	4	0	21	17	0	0	0	1
TR state line	60	0	20	15	0	3	3	0	0	0	2
Main stem median:	40.25	0.00	20.52	9.67	0.00	17.08	13.23	0.22	0.00	3.29	2.01

Table 5-26: Abundance data for quantitative samples. Taxa richness data are the number per sample.

Station ID	Total abundance (estim. #/m^2)	EPT abundance (estim. #/m^2)	Number of families	Dominant family	Dominant family abundance	% contribution dominant family
Corral	114	0	11	Dytiscidae	24	21.05
Hanging Woman	3144	0	15	Physidae	1632	51.91
Otter	9672	3625	15	Simuliidae	5070	52.42
Prairie - Lr	21181	10022	16	Hydropsychidae	7452	35.18
Prairie - Up	2188	1850	13	Baetidae	1206	55.12
Rosebud	5633	60	16	Chironomidae	2222	39.45
Spring	342	69	15	Chironomidae	164	47.95
Squirrel - Lr	8605	51	10	Chironomidae	7869	91.45
Squirrel - Up	3496	663	21	Chironomidae	1018	29.12
Youngs - Lr	2058	504	16	Baetidae	440	21.38
Youngs - Up	7125	935	14	Chironomidae	1921	26.96
Tributary median:	3496	504	15		1632	39.45
TR HW Cr	1631	681	24	Elmidae	507	31.09
TR below dam	6770	2931	15	Physidae	1473	21.76
TR Badger Cr	13978	10254	17	Baetidae	4452	31.85
TR state line	15761	12548	17	Leptohyphidae	5237	33.23
Main stem median:	10374	6592.5	17		2962.5	31.47

Table 5-27: Diversity indices calculated using quantitative samples.

Station ID	Total taxa richness	EPT taxa richness	Shannon diversity	Simpson diversity	Evenness
Corral	17	0	2.511	0.095	0.85
Hanging Woman	20	0	1.36	0.368	0.59
Otter	27	8	1.471	0.348	0.56
Prairie - Lr	32	11	2.439	0.127	0.66
Prairie - Up	33	18	2.056	0.245	0.45
Rosebud	26	3	1.932	0.214	0.62
Spring	25	3	1.983	0.252	0.47
Squirrel - Lr	15	2	0.961	0.477	0.68
Squirrel - Up	30	6	2.183	0.164	0.65
Youngs - Lr	26	4	2.514	0.115	0.68
Youngs - Up	27	5	2.394	0.118	0.75
Tributary median:	26	4	2.056	0.214	0.65
TR HW Cr	41	19	3.028	0.068	0.69
TR below dam	25	10	2.512	0.109	0.72
TR Badger Cr	37	22	2.69	0.1	0.65
TR state line	29	17	2.334	0.162	0.56
Main stem median:	33	18	2.601	0.1045	0.67

Table 5-28: Tolerance-based indices calculated using quantitative sample data.

Station	HBI	Indication	CTQa	CTQd	Multi-metric score (Columbia Basin)	Indication
Corral	2.3	Slight organic enrichment	91	93	42.03	Not meeting
Hanging Woman	2.8	Slight organic enrichment	96	99	29	Not meeting
Otter	5.1	Moderate organic enrichment	101	103	12.22	Not meeting
Prairie - Lr	4.4	Moderate organic enrichment	95	99	35.53	Not meeting
Prairie - Up	3.4	Slight organic enrichment	83	83	51.99	Meeting
Rosebud	5.5	Moderate organic enrichment	94	95	31.32	Not meeting
Spring	4.6	Moderate organic enrichment	95	98	33.14	Not meeting
Squirrel - Lr	5.9	Moderate organic enrichment	96	101	24.3	Not meeting
Squirrel - Up	5.3	Moderate organic enrichment	95	96	26.52	Not meeting
Youngs - Lr	4.2	Moderate organic enrichment	95	98	35.04	Not meeting
Youngs - Up	3.1	Slight organic enrichment	97	98	27.25	Not meeting
Tributary median:	4.4	Moderate organic enrichment	95	98	31.32	Not meeting
TR HW Cr	3.9	Slight organic enrichment	84	86	42.98	Not meeting
TR below dam	3.2	Slight organic enrichment	95	97	39.98	Not meeting
TR Badger Cr	4.3	Moderate organic enrichment	82	84	44.81	Not meeting
TR state line	4	Slight organic enrichment	81	83	38.45	Not meeting
Main stem median:	3.95	Slight organic enrichment	83	85	41.48	Not meeting

Table 5-29: Taxa richness and relative abundance values with respect to tolerance or intolerance to pollution. Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are those taxa given a HBI score of 8, 9, or 10. Data are presented as the estimated number per square meter.

	Intolerant				Tolerant			
	Richness		Abundance		Richness		Abundance	
Station ID	#	%	#	%	#	%	#	%
Corral	0	0	0	0	1	6	22	19
Hanging Woman	0	0	0	0	1	5	108	3
Otter	0	0	0	0	2	7	60	1
Prairie - Lr	4	13	196	1	0	0	0	0
Prairie - Up	9	27	503	23	0	0	0	0
Rosebud	0	0	0	0	2	8	53	1
Spring	0	0	0	0	1	4	31	9
Squirrel - Lr	0	0	0	0	1	7	1	0
Squirrel - Up	0	0	0	0	3	10	281	8
Youngs - Lr	0	0	0	0	1	4	375	18
Youngs - Up	1	4	122	2	2	7	24	0
Tributary median:	0	0	0	0	1	6	31	1
TR HW Cr	4	10	96	6	1	2	62	4
TR below dam	1	4	32	0	0	0	0	0
TR Badger Cr	4	11	194	1	0	0	0	0
TR state line	3	10	282	2	1	3	43	0
Main stem median:	3.5	10	145	1.5	0.5	1	21.5	0

Table 5-30: Taxa richness by functional feeding group, based on quantitative samples.

	Shredders		Scrapers		Collector-filterers		Collector-gatherers		Predators		Unknown	
Station ID	#	%	#	%	#	%	#	%	#	%	#	%
Corral	4	24	0	0	1	6	5	29	7	41	0	0
Hanging Woman	3	15	0	0	1	5	9	45	5	25	2	10
Otter	3	11	0	0	4	15	9	33	7	26	4	15
Prairie - Lr	2	6	1	3	8	25	10	31	7	22	4	13
Prairie - Up	2	6	3	9	3	9	14	42	6	18	5	15
Rosebud	2	8	0	0	2	8	8	31	12	46	2	8
Spring	4	16	0	0	2	8	7	28	8	32	4	16
Squirrel - Lr	4	27	0	0	1	7	4	27	5	33	1	7
Squirrel - Up	4	13	3	10	3	10	8	27	7	23	5	17
Youngs - Lr	2	8	0	0	5	19	9	35	8	31	2	8
Youngs - Up	1	4	0	0	8	30	7	26	6	22	5	19
Tributary median:	3	11	0	0	3	9	8	31	7	26	4	13
TR HW Cr	1	2	3	7	7	17	18	44	6	15	6	15
TR below dam	3	12	2	8	5	20	10	40	3	12	2	8
TR Badger Cr	2	5	3	8	9	24	14	38	4	11	5	14
TR state line	1	3	4	14	6	21	11	38	2	7	5	17
Main stem median:	1.5	4	3	8	6.5	20.5	12.5	39	3.5	11.5	5	14.5

Table 5-31: Invertebrate abundance (estimated number per m^2) by functional feeding group, based on quantitative samples.

	Shredders		Scrapers		Collector-filterers		Collector-gatherers		Predators		Unknown	
Station ID	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
Corral	17	15	0	0	11	10	31	27	56	49	0	0
Hanging Woman	33	1	0	0	22	1	2989	95	89	3	11	0
Otter	44	0	0	0	8629	89	254	3	109	1	636	7
Prairie - Lr	303	1	1	0	8015	38	8403	40	1428	7	3029	14
Prairie - Up	8	0	14	1	467	21	1518	69	103	5	78	4
Rosebud	49	1	0	0	924	16	2284	41	2349	42	28	0
Spring	76	22	0	0	19	6	199	58	38	11	10	3
Squirrel - Lr	68	1	0	0	14	0	7913	92	595	7	14	0
Squirrel - Up	122	3	22	1	546	16	1954	56	768	22	83	2
Youngs - Lr	15	1	0	0	421	20	1181	57	292	14	150	7
Youngs - Up	1	0	0	0	2271	32	3667	51	431	6	756	11
Tributary median:	44	1	0	0	467	16	1954	56	292	7	78	3
TR HW Cr	5	0	75	5	196	12	708	43	135	8	514	32
TR below dam	507	7	118	2	1476	22	3724	55	827	12	118	2
TR Badger Cr	344	2	301	2	3461	25	8840	63	473	3	559	4
TR state line	108	1	860	5	2966	19	9091	58	366	2	2370	15
Main stem median:	226	1.5	209.5	3.5	2221	20.5	6282	56.5	419.5	5.5	536.5	9.5

Table 5-32: The 10 metrics thought to be most responsive to human-induced disturbance (Karr and Chu 1998).

Station ID	Total taxa richness	Ephemer-optera taxa	Plecop-tera taxa	Trichop-tera taxa	Long-lived taxa	Intolerant taxa	% Tolerant individ.	Clinger taxa	% Domi-nant taxon	% Predators
Corral	17	0	0	0	7	0	19.3	0	19.3	49.1
Hanging Woman	20	0	0	0	4	0	3.4	1	51.9	2.8
Otter	27	2	0	6	6	0	0.6	12	52.4	1.1
Prairie - Lr	32	4	0	7	7	4	0	11	22.5	6.7
Prairie - Up	33	9	1	8	10	9	0	17	45.2	4.7
Rosebud	26	0	0	3	5	0	0.9	2	33.3	41.7
Spring	25	0	0	3	5	0	9.1	3	45	11.1
Squirrel - Lr	15	0	0	2	2	0	0	1	62.2	6.9
Squirrel - Up	30	2	0	4	10	0	8	9	27.7	22
Youngs - Lr	26	2	0	2	5	0	18.2	5	21.4	14.2
Youngs - Up	27	1	0	4	8	1	0.3	9	19.2	6
Tributary median:	26	1	0	3	6	0	0.9	5	33.3	6.9
TR HW Cr	41	12	0	7	7	4	3.8	15	15.3	8.3
TR below dam	25	5	0	5	2	1	0	9	21.8	12.2
TR Badger Cr	37	12	0	10	4	4	0	17	20.2	3.4
TR state line	29	11	0	6	5	3	0.3	15	33.2	2.3
Main stem median:	33	11.5	0	6.5	4.5	3.5	0.15	15	21	5.85

Table 5-33: Taxa richness for qualitative samples.

Station	% Sample ID'd	# Organisms ID'd	Total OTU richness	# Families	# Genera	# EPT taxa	Clinger taxa	Long-lived taxa (>2 yrs)
Corral	75.00	668	19	12	19	1	0	5
Hanging Woman	25.00	617	30	21	30	1	1	9
Otter	37.50	818	31	20	31	5	9	8
Prairie - Lr	25.00	929	38	24	38	10	9	9
Prairie - Up	18.75	739	48	21	46	20	17	13
Rosebud	100.00	229	25	17	25	5	2	3
Spring	100.00	359	31	18	31	3	1	9
Squirrel - Lr	25.00	946	19	12	19	2	2	6
Squirrel - Up	21.88	637	32	19	32	4	2	7
Youngs - Lr	43.75	917	35	20	34	6	5	9
Youngs - Up	50.00	630	28	21	27	7	6	9
Tributary median:	37.50	668	31	20	31	5	2	9
TR HW Cr	6.25	684	47	24	45	22	16	8
TR below dam	15.73	708	36	28	36	9	7	9
TR Badger Cr	9.37	759	30	14	29	15	12	4
TR state line	18.75	786	52	29	51	18	16	13
Main stem median:	12.55	733.5	41.5	26	40.5	16.5	14	8.5

Table 5-34: Functional feeding group taxa richness for qualitative samples.

Station	Shredder	Scraper	Collecter - filterer	Collecter - gatherer	Predator	Unknown
Corral	4	0	1	4	8	2
Hanging Woman	6	0	1	9	13	1
Otter	3	0	3	7	15	3
Prairie - Lr	6	1	7	11	8	5
Prairie - Up	5	3	5	17	10	8
Rosebud	2	0	3	11	8	1
Spring	6	0	3	10	10	2
Squirrel - Lr	3	0	2	5	8	1
Squirrel - Up	4	1	2	10	11	4
Youngs - Lr	2	0	6	12	12	3
Youngs - Up	2	1	3	10	9	3
Tributary median:	4	0	3	10	10	3
TR HW Cr	5	6	4	16	8	8
TR below dam	3	1	3	15	11	3
TR Badger Cr	3	2	5	10	5	5
TR state line	5	1	6	18	15	7
Main stem median:	4	1.5	4.5	15.5	9.5	6

Table 5-35: Taxa richness for qualitative samples.

Station	Ephemer-optera	Plecop-tera	Trichop-tera	Coleop-tera	Megalop-tera	Diptera	Chiro-nomidae	Crusta-cea	Oligo-chaeta	Mollusca	Other
Corral	0	0	1	6	0	8	3	0	0	0	3
Hanging Woman	1	0	0	7	0	9	4	1	1	1	6
Otter	2	0	3	5	1	4	3	1	0	2	8
Prairie - Lr	5	0	5	5	1	9	4	1	1	4	5
Prairie - Up	11	1	8	10	0	8	4	1	1	2	4
Rosebud	1	0	4	2	0	9	4	1	1	3	1
Spring	0	0	3	9	0	10	4	1	1	3	2
Squirrel - Lr	0	0	2	5	0	9	4	0	0	1	1
Squirrel - Up	2	0	2	5	0	10	4	1	0	3	6
Youngs - Lr	4	0	2	5	0	10	4	2	1	4	4
Youngs - Up	5	0	2	6	1	6	3	1	1	2	2
Tributary median:	2	0	2	5	0	9	4	1	1	2	4
TR HW Cr	14	0	8	7	0	6	2	1	0	2	6
TR below dam	7	0	2	5	0	7	3	3	0	4	5
TR Badger Cr	7	0	8	4	0	6	3	0	0	1	4
TR state line	11	1	6	9	0	6	3	1	0	5	10
Main stem median:	9	0	7	6	0	6	3	1	0	3	5.5

5.6 *Fish*

Capture efforts using seines and dip nets produced 15 fish species in tributary streams. At each tributary location, up to 5 species and 691 total individuals were captured (Table 5-36). Sampling most commonly (seven events) produced 20—100 individuals, although three events produced 400—691 individuals, and two stations produced only 4 or 5 individuals. Badger, Coal, Corral, and Spring creeks contained no fish (although two dead common carp were found in the Badger Creek channel at the confluence with the Tongue River). The fish assemblage at four sites included five species, whereas fewer sites held four species (2 sites), three species (3), two species (1), or one species (2). The species captured showed a range of tolerance to disturbance, trophic guild composition, reproductive strategies, and size potential (Table 5-37). Fathead minnows were the most widespread, found at six sites, and their overall abundance (1417) was one to two orders of magnitude greater than that of any of the other species. Lake chub (143) and longnose dace (170) both occurred at five sites and comprised the next most-abundant group along with sand shiners (165), which occurred only at Otter Creek. The remaining 11 species occurred at 1 to 3 sites and their total abundances ranged from 1 to 66. Only one each of black bullhead, brown trout, and shorthead redhorse was captured. Final IBI scores ranged up to 91, although only one site scored greater than 75 and indicated full support of warmwater fisheries (Table 5-38). Seven sites scored between 40 and 75 and suggested partial support, although three of these sites scored only marginally below the cutoff for full support (71 to 75). Two sites that produced 1 to 5 fish (lower Squirrel Creek and the Rosebud Creek event in May at the state park) automatically received a total IBI score of 10, indicating non-support of warmwater fisheries.

Presence and abundance of fish species in 2004 compared to 2002 varied among the ten tributary sites that were sampled in both years. Generally, more species were captured in 2004 than in 2002, although the number caught declined in 8 of 13 instances where a species was captured at a station in both years (Table 5-39). Capture efforts in 2004 produced fish at three stations where no fish were captured in 2002 (upper Prairie Dog, Rosebud, and lower Squirrel). Note, though, that the exact reach sampled and effort expended were not always identical in both years. Considerable intra-annual spatial and temporal variability in habitat availability and fish presence may occur at a tributary reach, as indicated by results for Rosebud Creek in 2004. A single species (fathead minnow) was captured at the state park site, ranging in abundance from 5 in May to 400 in August, whereas four species (691 individuals) were captured in a reach just upstream in May but only three species (43 individuals) at the same site in August. At the five tributary sites where fish were captured in both years, final IBI scores from 2004 were within 10 points of the 2002 score for three sites, 21 points lower in 2004 at upper Youngs Creek, and substantially higher at lower Prairie Dog Creek where the 2002 score was limited by capture of <10 fish

Results for the Tongue River main stem differed between sampling methods (Table 5-40). The large size of the river rendered seining ineffective for capturing all species and size classes and for providing reasonable assessments of relative abundance.

Nonetheless, seining produced eight or nine species at each site except below the dam, where only two species were captured. Electrofishing through three extended river reaches produced 19 species, including 11-14 species per reach and 9 species that occurred at all three reaches. However, small fishes in marginal or off-channel habitats (e.g. longnose dace) were likely underrepresented in the electrofishing catch, and the technique itself may present low capture efficiency with some portions of the fish assemblage on the Tongue River (Backes 2000). Sampling efforts in the main stem produced 12 species not collected in tributaries, whereas 7 species were captured in tributaries but not the main stem. Relative abundances and mean body lengths varied among reaches (Figure 5-8 and Figure 5-9). Although the assemblage included a greater number of native species in each main stem reach than in tributaries, the percentage of native individuals was typically lower (63 to 82%) than in tributaries (59 to 100%, median = 100%) (Table 5-41). Moderately tolerant individuals dominated the main stem reaches (48 to 80%), with tolerant (20 to 36%) and intolerant species (0 to16%) comprising smaller portions of the assemblage, although capture bias favoring larger individuals could have affected these results. Because the Tongue River supported an expanded array of fish species and was substantially larger than the small streams for which the Montana IBI was developed, and because of the differences in sampling methodology and gear selectivity, we did not apply the Montana IBI to the Tongue River data.

5.6.1 Hanging Woman Creek

The site on Hanging Woman Creek scored relatively low (53) among tributary sites according to the Montana IBI, but still within the range of moderate impairment and partial support of warmwater fisheries. The fish assemblage consisted of the same five species as in 2002, although efforts in 2004 produced substantially lower numbers of brassy minnows, common carp, and green sunfish. The catch in both years also included fewer than five white suckers and a single black bullhead. This site produced the only black bullhead and all but one of the brassy minnows captured at all tributary sites. All species captured were tolerant except brassy minnows, a moderately tolerant species. The final IBI score declined slightly in 2004 from its value in 2002 (59). Seining was conducted at about the same location in both years, approximately 1/3 mile downstream of the reach surveyed for habitat in 2004, which was avoided because of excessive algae and aquatic vegetation growth. Two large pools (length = 100—150’, width = 30—40’, depth = 5’) having almost no flow were seined. These pools contained somewhat harder substrate than in the sample reach.

5.6.2 Otter Creek

The site on Otter Creek scored lowest (42) among any site producing greater than ten fish, but still within the range of moderate impairment and partial support. The assemblage included five species. Fathead minnows dominated the catch and were the sole native species. An abundance of sand shiners (including some individuals age-3 or older) and common carp were present, in addition to a few pumpkinseed and a green sunfish. The absence of invertivorous cyprinids, benthic invertivores, and native catostomids all contributed to the relatively low final IBI score. The landowner at this site indicated that smallmouth bass were formerly common but no longer present (period not reported), perhaps indicative of a recent decline in habitat quality. The seined reach began about 50 meters upstream of cross-section 1 and ended 50 meters upstream of cross-section 6.

5.6.3 Prairie Dog Creek - Lower

Lower Prairie Dog Creek received an IBI score of 63, suggesting moderate impairment and partial support of warmwater fisheries. This site produced a low number of fish (20), of which 16 were white suckers. Two of the four species were native. Metric results indicating good conditions (good water quality, low level of sedimentation, high permanence of suitable habitat) included an absence of tolerant individuals, the highest percentages among sites of invertivorous cyprinids and litho-obligate reproductive guild individuals, and presence of two native species that had long-lived (≥ age-3) individuals. Seining in 2002 produced only five white suckers (IBI = 10), probably because augmented flows limited capture efficiency. Seining was conducted in 2004 from cross-sections 1 to 6.

5.6.4 Prairie Dog Creek - Upper

The site on upper Prairie Dog Creek received the highest IBI score of all sites (91). The catch consisted of 51 longnose dace and 18 mountain suckers, both species native and including long-lived individuals (≥ age-3). A single brown trout was also captured, which was fitting given the resemblance of this reach to a trout stream. No other site produced mountain suckers or salmonids. This assemblage suggested high quality habitat unaffected by catastrophic disturbance. Surprisingly, seining conducted in 2002 produced no fish, probably because augmented bankfull flows limited capture probability. Highly complex habitat reduced the effectiveness of seining at this location in 2004. The BLM crew seined from cross-section 4 to cross-section 10.

5.6.5 Rosebud Creek

Four surveys at two locations on Rosebud Creek yielded widely varying results. Final IBI scores ranged from 10 to 71, the site at the state park scoring lower than the site just upstream. At the state park location, the channel held two beaver dams and some deep areas during the sampling event on May 17 but only five fathead minnows were dip-netted. During the August event, two small holes contained nearly all of the remaining water and about 400 very small, young of the year fathead minnows. The assemblage at the upstream reach was more diverse, reflecting the greater availability of perennial habitat. Although the number of species and their abundances declined between May and August samples, the final IBI scores (70 in May and 71 in August) changed little and fell marginally below the cutoff for full support of warmwater fisheries. All four species were native but none included long-lived individuals. The sampled portion of Rosebud Creek probably experiences periodic severe stress (e.g. goes dry) preventing the maintenance of a diverse age structure. High, but variable, species abundances may indicate proximity to spawning areas or seasonal importance. The presence of longnose dace, an intolerant species, in May suggests the existence of unimpaired conditions in the vicinity. Seining conducted about a mile downstream of the state park in 2002 produced only 7 fathead minnow, 11 lake chub, and 1 white sucker, a composition similar to that captured at the site upstream from the state park in August 2004.

5.6.6 Squirrel Creek - Lower

The site at lower Squirrel Creek produced one lake chub and three fathead minnows, leading to an IBI score of 10 and designation as not supporting warmwater fisheries. Potential explanations for the depauperate assemblage in comparison to the upper site include changes in water quality (water chemistry results indicated high concentrations of dissolved solids) or drying during the late summer. The BLM crew used dip nets to sample about 300 meters of stream. Seining efforts at this site in 2002 failed to produce any fish.

5.6.7 Squirrel Creek - Upper

The fish assemblage at upper Squirrel Creek received an IBI score (74) marginally below the cutoff for full support of warmwater fisheries. This site supported a relatively intolerant assemblage of five native species. Fathead minnows, longnose dace, and lake chubs dominated the sample, although two creek chubs and a brassy minnow (both species found in only one other tributary) were also present. The IBI score declined from its value in 2002 (83). In 2002, lake chubs were dominant and the sample included three white suckers, no brassy minnows, and fewer fathead minnows and creek chubs. The 2004 sample included no long-lived individuals, whereas long-lived creek chubs were captured in 2002. In 2004, the BLM crew used dip nets to sample a reach extending from the ford upstream approximately 300 meters, but suggested that electrofishing might be a better method for the habitat. The difference in sampling gear, seining in 2002 and dipnetting in 2004, confounds meaningful comparisons of fish sampling results.

5.6.8 Youngs Creek - Lower

The lower site on Youngs Creek scored 62 according to the Montana IBI, suggesting partial support of warmwater fisheries. The catch consisted of 21 fathead minnows, 7 longnose dace, and 2 lake chubs, all native species but none including long-lived individuals. This sample showed improvement from seining efforts in 2002, during which the crew observed some fry but caught no fish. In 2004, the BLM crew dip-netted from the downstream end of the study reach to labeled cross-section 5 (actually cross-section 1 to cross-section 7).

5.6.9 Youngs Creek - Upper

The site on upper Youngs Creek received an IBI score of 74, marginally below the cutoff for full support of warmwater fisheries. Although dip-netting produced five species, all native, 42 of the 56 individuals were fathead minnows. However, the crew noted that fish utilized the large woody material and aquatic vegetation, and several observed fish escaped capture. Presence of creek chubs and white suckers, both litho-obligates for spawning, suggested low levels of sedimentation. Long-lived fathead minnows and longnose suckers indicated relatively stable habitat conditions. Despite these indications of high quality, the IBI score in 2004 declined substantially from that in 2002 (95). In 2002, longnose dace, an intolerant species, dominated the assemblage and mountain suckers were third most abundant. The catch in 2002 included a brook trout but no creek chubs or white suckers, and fewer fathead minnows, all of which contributed to high IBI scores. In addition, three species in 2002 included long-lived individuals (versus two in

2004). The sampled reach in 2004 extended from cross-sections 1 to 5 (upstream end to station 5).

Differences in sampling methodology may be attributable for the disparities in the fish results between years. Woody draws present a challenge to sample as dense shrubs often obscure the channel and complex woody debris limits the ability to drag seines. The 2002 effort employed seines with "fish drives", which involved driving fish downstream into the seine by kicking and otherwise disturbing the water though complex habitat. In contrast, field crews in 2004 used dip nets to sample this habitat. Different susceptibility to capture between these methods may account for the inter-year variability.

5.6.10 Tongue River - Hanging Woman Creek

Electrofishing through a 4.8-mile reach ending approximately two miles upstream (RM 161.5 to 156.7) of the station near Hanging Woman Creek produced the most individuals (873) but the fewest species (11) of the three reaches. Low diversity scores resulted from the lower species count combined with high abundance (about one-half of the total sample) of shorthead redhorse suckers. This reach produced the highest proportions of native species, native individuals, and moderately tolerant individuals. Channel catfish were considerably more abundant here than in the other reaches. The absence of salmonids and dominance of warmwater species indicated that thermal influence from the Tongue River Dam was minimal this far downstream. Seining in backwater areas, pools, and a side channel produced eight species, although small white suckers constituted 58 of the 69 total individuals. However, the BLM crew considered seining ineffective for collecting a representative sample of the assemblage.

5.6.11 Tongue River - below dam

Electrofishing through the 3.4-mile reach below the dam produced a lower total catch (381 individuals) than in other reaches but a greater count of species (14) than in the reach farther downstream. Mean length exceeded that at the other reaches for most species, potentially indicating a greater availability of deep cover, higher growth rates, or less spawning, marginal, or off-channel rearing habitat (fewer small individuals). This was the only reach at which salmonids (corresponding to reservoir operations) and pumpkinseed were electrofished, although pumpkinseeds turned up in seine hauls at the stations near Hanging Woman and Badger creeks. The assemblage here included substantially higher proportions of intolerant species and individuals than the other two reaches, but also the highest proportion of tolerant individuals. In addition, this sample produced the highest diversity values. Seining in side channels and backwaters was ineffective, producing only seven smallmouth bass and three white suckers. Potential reasons for this included fast current, low cyprinid abundance, copious amounts of aquatic vegetation, and relatively evasive species or size classes.

MFWP also electrofished this reach in early August of 2003 and 1999 (Figure 5-10 and Figure 5-11), although only a subset of non-salmonid species was collected in 1999. These data suggest reduced relative abundance of shorthead redhorse suckers, smallmouth bass, channel catfish, common carp, and river carpsuckers in 2004 compared to 2002. Mean length changed little for seven species, increased in 2004 for common carp and white suckers, and decreased in 2004 for brown trout and rainbow trout. However, variability in abundance could have been related to sampling in different seasons. Species composition was similar between 2003 and 2004 except for the occurrence of one individual each of pumpkinseed and yellow bullhead in 2004, and of walleye, black crappie, and green sunfish in 2003. The 1999 survey produced four species not captured in 2004 (black crappie, white crappie, walleye, and yellow perch). Substantially more smallmouth bass were captured in 1999 (105) and in 2003 (140) than in 2004 (27), although the 1999 data was not standardized by time or effort.

5.6.12 Tongue River - state line and Badger Creek

Electrofishing at the reach extending from the state line downstream six miles produced 452 individuals and 14 species. Moderately tolerant species and individuals dominated the assemblage. This sample produced median diversity scores and a similar percentage of native individuals to the reach below the dam. This reach produced the only sauger, walleye, white crappie, black crappie, and spottail shiners among the three reaches in 2004, potentially indicating upstream dispersion from the reservoir. The sample also indicated higher relative abundance of smallmouth bass than in downstream reaches. No river carpsuckers or yellow bullhead, and relatively few channel catfish were captured, which may reflect the blockage of upstream migration by the dam. BLM crews conducted seining efforts in backwater areas and pools at the Badger Creek and state line sites but found seining to be ineffective for adequately sampling the assemblage.

Table 5-36: Numbers of fish captured in Tongue River tributaries in 2004. Bold values signify presence of long-lived individuals (≥ age-3). Asterisk indicates native species.

Family/ Species	Hanging Woman	Otter	Upper Prairie Dog	Lower Prairie Dog	Rosebud State Park May	Rosebud State Park August	Upper Rosebud May	Upper Rosebud August	Lower Squirrel	Upper Squirrel	Upper Youngs	Lower Youngs
Catostomidae												
Mountain sucker*			**18**									
Shorthead redhorse*				1								
White sucker*	**2**			**16**			43	3			2	
Cyprinidae												
Brassy minnow*	52									1		
Common carp	7	32		1								
Creek chub*										2	3	
Fathead minnow*		405			5	400	471	22	3	48	**42**	21
Lake chub*							106	18	1	14	2	2
Longnose dace*			**51**				71			34	**7**	7
Sand shiner*		**165**										
Salmonidae												
Brown trout			1									
Centrarchidae												
Green sunfish	**30**	1										
Pumpkinseed		6										
Smallmouth bass				**2**								
Ictaluridae												
Black bullhead	**1**											
TOTAL:	92	609	70	20	5	400	691	43	4	99	56	30

Table 5-37: Fish species captured at Tongue River tributary sites and classification of biological attributes used in metric calculations.

Species	Scientific Name	Trophic[1]	Feeding Habitat[2]	Litho-obligate Reproductive Guild[3]	Tolerant Reproductive Strategist[4]	General Tolerance[5]	Origin[6]	Total Length at 3 years
Catostomidae								
Mountain Sucker	*Catostomus platyrhynchus*	HB	BE	LO		MOD	N	102
Shorthead redhorse	*Moxostoma macrolepidotum*	IN	BE	LO		MOD	N	254
White sucker	*Castostomus commersoni*	OM	BE	LO		TOL	N	229
Cyprinidae								
Brassy min	*Hybognathus hankinsoni*	HB	BE			MOD	N	81
Common carp	*Cyprinus carpio*	OM	BE			TOL	I	381
Creek chub	*Semotilus atromaculatus*	IC	GE	LO		MOD	N	114
Fathead minnow	*Pimephales promelas*	OM	GE		TR	TOL	N	76
Lake chub	*Couesius plumbeus*	IN	WC			MOD	N	140
Longnose dace	*Rhinichthys cataractae*	IN	BE	LO		INT	N	71
Sand shiner	*Notropis ludibundus*	OM	GE	LO		MOD	N	61
Salmonidae								
Brown trout	*Salmo trutta*	P	WC	LO		MOD	I	254

[1] CA = Carnivore (> 90% fish or other vertebrates); HB = herbivore (> 90% plants or detritus); IC = invertivore/carnivore (>25% both invertebrates and vertebrates); IN = invertivore); OM = omnivore (25-90% plants or detritus)
[2] = benthic; Ge = generalist; WC = water column: Starrett (1950); Brown (1971); Scott and Crossman (1973); Copes (1975); Becker (1983)
[3] Scott and Crossman (1973); Pflieger (1997); Goldstein and Simon (1998); Halliwell et al. (1999); Barbour et al. (1999)
[4] Tolerant reproductive strategists are not litho-obligates, and use parental care of the spawning site: Scott and Crossman (1973); Becker (1983); Cross and Collins (1995); Pflieger (1997); Simon (1998)
[5] INT = intolerant; MOD = moderately tolerant: TOL = tolerant; Barbour et al. (1999); Cross (1967); Pflieger (1997)
[6] N = native; I – introduced; Brown (1971); Holton and Johnson (2003)
[7] Approximate total lengths at age 3 from Brown (1971)

Species	Scientific Name	Trophic [1]	Feeding Habitat [2]	Litho-obligate Reproductive Guild [3]	Tolerant Reproductive Strategist [4]	General Tolerance [5]	Origin [6]	Total Length at 3 years
Table 5-37 Continued								
Centrarchidae								
Green Sunfish	*Lepomis cyanellus*	IC	GE		TR	TOL	I	102
Pumpkinseed	*Lepomis gibbosus*	IC	GE	LO		MOD	I	89
Smallmouth bass	*Micopterus dolomieui*	IC	GE		TR	MOD	I	154
Ictaluridae								
Black bullhead	*Ameiurus melas*	IC	BE		TR	TOL	I	152

Table 5-38 : Index of Biological Integrity scores for tributary stations in 2002 and 2004.

Station	IBI Score 2002	IBI Score 2004
Badger Creek	Not sampled	0
Coal Creek	Not sampled	0
Corral Creek	0	0
Hanging Woman Creek	59	53
Otter Creek near mouth	Not sampled	43
Prairie Dog Creek - lower	10[1]	63
Prairie Dog Creek - upper	0	91
Rosebud Creek - SP May	Not Sampled	10[1]
Rosebud Creek - SP Aug	73	57
Rosebud Creek - UpSP May	Not sampled	70
Rosebud Creek - UpSP Aug	Not sampled	71
Spring Creek	0	0
Squirrel Creek - lower	0	10[1]
Squirrel Creek - upper	83	74
Youngs Creek - lower	0	62
Youngs Creek - upper	95	74

Table 5-39 : Change in fish species presence and abundance (% increase or decrease) at tributary sites in 2004 relative to 2002. Plus sign signifies species captured in 2004 but not in 2002. Minus sign (without number) signifies species present in 2002 but not in 2004. "P" signifies species present in both years in Rosebud Creek, but percent change not calculated because of variability among four sampling events at this stream in 2004. Asterisk indicates native species.

Family/Species	Hanging Woman	Prairie Dog - Lr	Prairie Dog -Up	Rosebud	Squirrel - Lr	Squirrel - Up	Youngs - Lr	Youngs - Up
Catostomidae								
Mountain sucker*			+					-
Shorthead redhorse*		+						
White sucker*	-50	220		P		-		+
Cyprinidae								
Brassy minnow*	-86					+		
Common carp	-77	+						
Creek chub*						-89		+
Fathead minnow*				P	+	167	+	950
Lake chub*				P	+	-72	+	-78
Longnose dace*			+	+		580	+	-74
Salmonidae								
Brook trout			+					-
Centrarchidae								
Green sunfish	-57							
Smallmouth bass		+						
Ictaluridae								
Black bullhead	0							
Total:	-81	300	+		+	5	+	17

Table 5-40 : Number of each fish species captured in the main stem Tongue River in 2004. Electrofishing data courtesy of MFWP. Asterisk indicates native species.

Family/Species	Seine Hanging W.	TR Dam	Badger	State Line	Electrofishing (boat) Birney Up 5.2 mi.	TR Dam Dn 3.4 mi.	State Line Dn 6.0 mi.
Catostomidae							
Longnose sucker*					4	12	3
River carpsucker*					60	25	
Shrthd redhorse*	1				432	96	167
White sucker*	58	3	51	7	93	94	100
Cyprinidae							
Common carp	2		15	5	79	28	42
Longnose dace*	2			1			
Spottail Shiner			9	5			4
Salmonidae							
Brown trout						2	
Rainbow trout						58	
Centrarchidae							
Black Crappie			11	7			1
Pumpkinseed	1		5			1	
Rock bass	2		5	13	39	1	36
SMB	2	7	2	11	37	27	74
White crappie							2
Ictaluridae							
Black bullhead	1		4		1	15	9
Channel catfish*					124	20	4
Stonecat*			1	2	3	1	1
Yellow bullhead					1	1	
Percidae							
Sauger*							8
Walleye							1
TOTAL:	69	10	103	51	873	381	452

Table 5-41 : Metric values for Tongue River electrofishing data.

Metric	Birney - up 5.2 mi.	Dam - down 3.4 mi.	State line - down 6.0 mi.
% Tolerant species	27	21	21
% Tolerant individuals	20	36	33
% Moderate species	64	57	71
% Moderate individuals	80	48	66
% Intolerant species	9	21	7
% Intolerant individuals	0	16	0
% Native species	55	43	43
% Native individuals	82	65	63
% Dominant species	49	25	37
Shannon Diversity	1.60	2.02	1.75

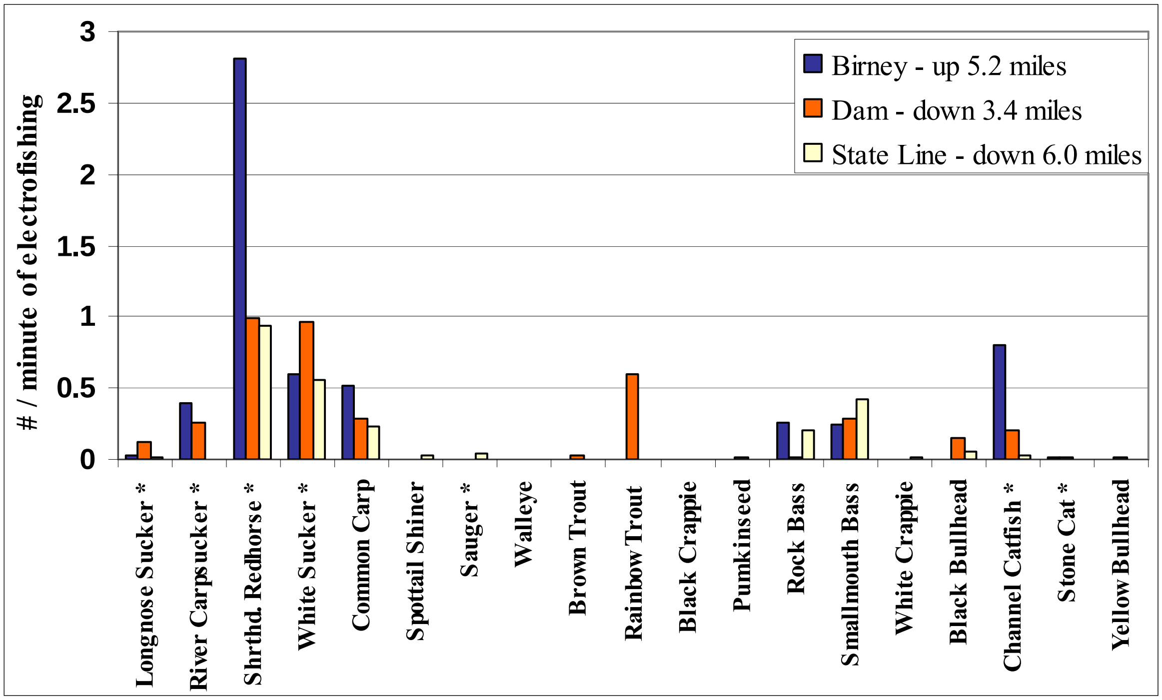

Figure 5-8 : Relative abundance of fish species captured by electrofishing on the Tongue River in 2004. Asterisk indicates native species.

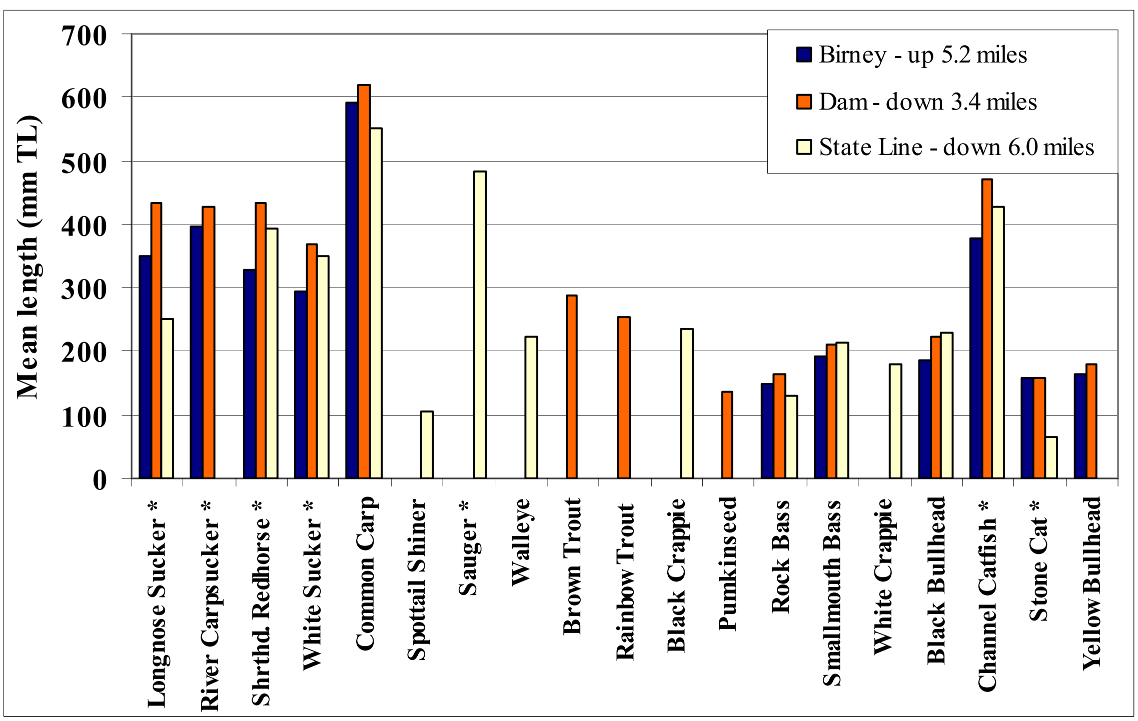

Figure 5-9 : Mean length of fish species captured by electrofishing on the Tongue River in 2004. Asterisk indicates native species.

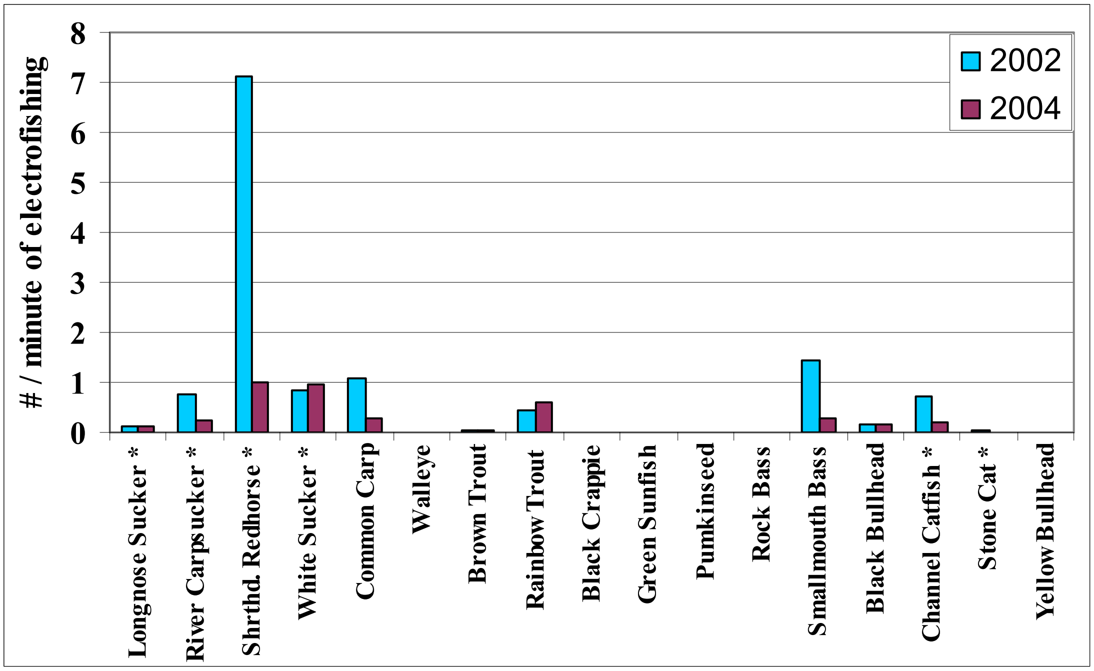

Figure 5-10 : Relative abundance of fish species captured by electrofishing in the reach below the dam on the Tongue River in 2002 and 2004. Asterisk indicates native species.

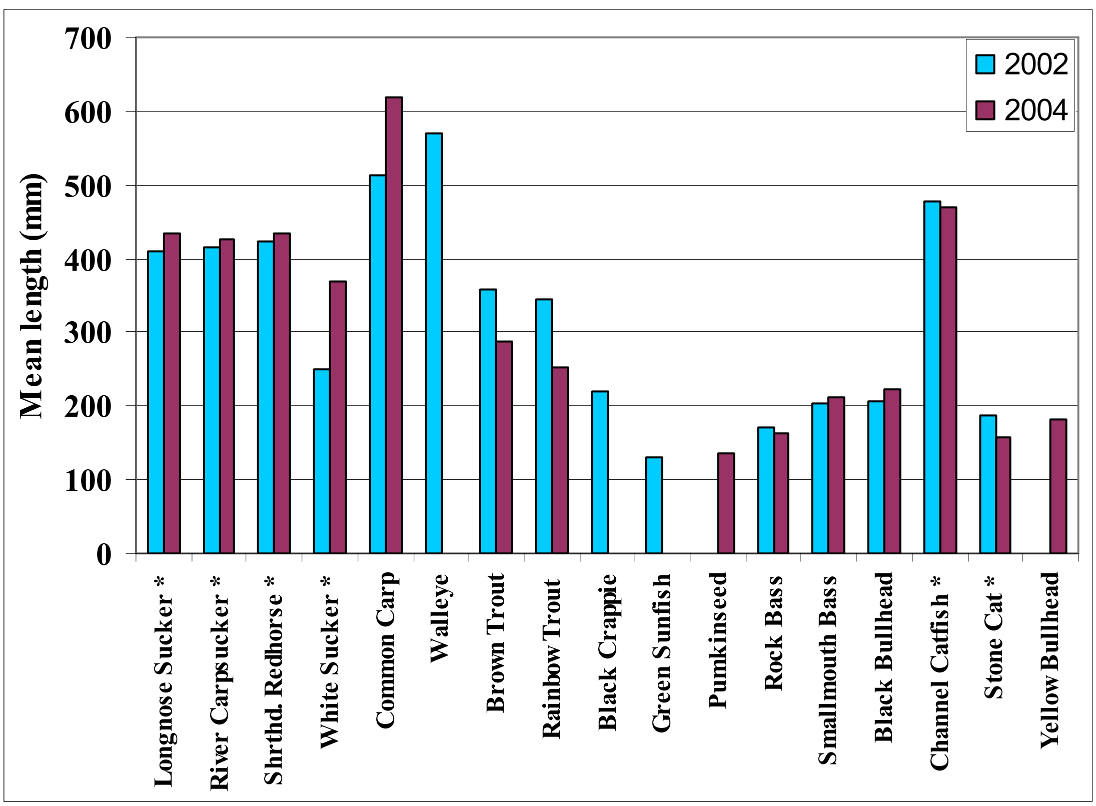

Figure 5-11 : Mean length of fish species captured by electrofishing in the reach below the dam on the Tongue River in 2002 and 2004. Asterisk indicates native species.

5.7 *Wildlife*

The BLM crew noted the presence of a variety of species encountered during habitat evaluations. Because no formal wildlife surveys were conducted, these data are suitable mainly for indicating presence of observed species and potentially for detecting future declines. The lack of an observation cannot be taken to indicate absence of a species or even low abundance.

Table 5-42: Reptiles and amphibians observed on assessed sites.

	Amphibians			Reptiles			
Site	**Northern leopard frog (*Rana pipiens*)**	**Western chorus frog (*Pseudacris triseriata*)**	**Woodhouse toad (*Bufo woodhousii*)**	**Western rattlesnake (*Crotalus viridis*)**	**Gopher snake (*Pituophis catenifer*)**	**Plains garter snake (*Thamnophis radix*)**	**Snapping turtle (*Chelydra serpentine*)**
Badger	1						
Coal							
Corral	Abundant						
Hanging Woman	3	Tadpoles	1				
Otter	1						1
Prairie - Lr					1		
Prairie - Up					1		
Rosebud	30						
Spring							
Squirrel - Lr	1				1		
Squirrel - Up	1		1		1		
Youngs - Lr	8						1
Youngs - Up	3						
TR - Hanging W.	13	2					
TR - below dam	10	9		1			
TR - Badger	33	6		3	1		
TR - state line	13				1	1	

Table 5-43: Mammals and birds observed on assessed sites.

Site	Mammals			Birds			
	Beaver active?	Field mice	Muskrat	Bald eagle	Great blue heron	Waterfowl	Songbirds
Badger	No						
Coal	No						
Corral	No						
Hanging Woman						2	
Otter	No						
Prairie - Lr	No					1	
Prairie - Up	No						
Rosebud	Yes						Abundant
Spring							
Squirrel - Lr	No	Abundant	1		1		
Squirrel - Up	Yes				1		
Youngs - Lr	No						
Youngs - Up	No						
TR - Hanging W.	Yes						
TR - below dam	No			1	2		
TR - Badger	Yes			1	2		
TR - state line	Yes		1		2	1	

6.0 Discussion

Two groups of tributary sites emerged from assessments of biological, chemical, and physical characteristics. Corral, Hanging Woman, Otter, and lower Squirrel creeks all exhibited overall poorer condition than the other locations, despite a few higher scores (e.g., moderately high scores for Corral Creek macroinvertebrates, Hanging Woman Creek fish). The other seven tributary sites and four main stem sites produced considerably better ratings across the suite of investigated characteristics. However, inherent differences between the tributaries and the larger, lower-order main stem suggest that the main stem should be evaluated according to separate criteria from those applied to the tributaries. The condition of the Tongue River was not compared to metric standards derived using rivers of comparable size because such standards have not been developed. Comparisons between tributary and main stem sites do offer perspective, and comparisons among main stem sites have utility in assessments of longitudinal differences.

Water quantity and quality present obvious limitations to aquatic life in Tongue River tributaries. Intermittency, a defining characteristic of many prairie streams (Dodds et al. 2004) affects a high proportion of stream channels throughout the study area, and was particularly evident at the sites on Badger, Coal, Corral, Rosebud, and Spring creeks. Such conditions limit the overall abundance of aquatic organisms and favor greater proportions of species (e.g., fathead minnows, motile periphyton, crustaceans, and certain dipterans) more tolerant of habitat constriction or temporary drying. However, springs or seeps may create patches of persistent habitat, as appeared to be the case at Spring Creek. These provide refugia for aquatic organisms during intermittency and may provide important habitat for amphibians. In part, these observations reflect the position of a station within its catchment (e.g., Rosebud and Spring stations situated near headwaters) and within the basin (e.g., Badger and Coal creeks situated on east side of the Tongue River). The substantial variation in water quality also coincides with geographic variation in soil chemistry and geology. Samples from Corral, Hanging Woman, and lower Squirrel creeks in particular contained levels of salt ions high enough to exclude various forms of biota, and these sites fall within a portion of the basin having soils characterized by relatively high clay content (60-70%), low infiltration rates, and high salinity (maximum soil conductivities exceeding 10,000 µmhos/cm) (Tetra Tech 2003). Streams within the study area appear to contain naturally high concentrations of salt ions, and it is noteworthy that conductivity at all except one tributary site exceeded the Montana standards for Tongue River tributaries. Although critical bicarbonate levels have not been defined for most organisms, values at some sites (e.g., Spring, Squirrel, and Rosebud creeks) were close enough to the 96-hour LC50 value for fathead minnows to potentially exclude or stress more sensitive taxa, especially considering that analyses from 2002 indicated even higher concentrations at most sites.

Comparisons of results from assessments in 2002 and 2004 indicated no consistent trend across sites and investigated characteristics. Water chemistry analyses from 2004 showed higher salinity levels (although the results for specific ions varied) but lower bicarbonate concentrations at all but one site. Periphyton samples generally suggested declines according to taxa richness, diversity, and disturbance; however, results of pollution, siltation, and percent dominant species metrics were inconsistent. Fish species richness and total abundance were greater in 2004 at every site except Hanging Woman Creek, but Montana IBI scores showed considerable variation. Changes in status suggested by physical habitat and macroinvertebrate assemblages could not be finely resolved because survey protocols differed between years. Coarse-scale comparisons in these characteristics revealed no trends. Assessments of characteristics at Corral, Hanging Woman, and lower Squirrel creeks typically indicated either declines or only marginal improvements in conditions.

Several factors confound the identification of effects of CBNG development on aquatic ecology. Analysis of data from sites without CBNG activity indicates substantial interannual variability at study sites. Hydrology, geology, and soils exhibit natural variation across the study area that can be expected to effect large differences in biota. On a smaller geographical scale, natural longitudinal variation may obscure changes caused by CBNG development between upper and lower sites on a given stream. The relatively low drainage density in this semi-arid environment limits the opportunity to establish control systems having upper and lower stations both unaffected by CBNG development, and historical data for study streams is scant. Augmentation of flows in Prairie Dog Creek with water from Piney Creek presents another complicating factor at that location. Information regarding the actual quantity and fate of produced water would facilitate assessment of the effects of development, but such data are currently indirect or extremely coarse in scale (e.g. numbers of permitted wells or outfalls), or else unavailable.

Despite the high level of noise, the data collected to date provide reason for some concern. Sites below CBNG development do exhibit elevated concentrations of salt ions and distinct differences in biota from upper sites, although sources of salt loading are unknown. Further, conductivities at lower Squirrel Creek (downstream of significant CBNG development) easily exceeded the historical maximum. As previously mentioned, the specific relationship between climatic conditions, watershed hydrology, and water chemistry has not been established, but any increase in shallow groundwater discharge (particularly at Corral, middle Hanging Woman, and the lower reaches of Squirrel Creek) may raise concentrations of certain constituents to levels causing greater impairment of beneficial uses.

Evaluation of the ionic composition of the salt crust along the Tongue River was a sub-component of this investigation and a pilot study of a poorly understood aspect of prairie stream ecology. Salt crusts are a natural phenomenon along many prairie streams and reflect their tendency towards relatively high levels of dissolved solids. Nevertheless, human activities can increase salinization in streams resulting in greater accumulations of salts within the bankfull channel and on the floodplain. Although investigations on the effects of these salts are lacking, incidental information suggests that these can contribute to water quality impairment. For example, in Sage Creek, a stream affected by saline seep in Toole and Liberty counties in north central Montana, dissolution and mobilization of the anthropogenically enhanced salt crust renders spring flows unsuitable for irrigation. This represents a substantial hardship to agricultural producers who rely on spring runoff in this dry country. Presumably, the spring pulse of salty flows may be harmful to fish communities, especially the early life history stages that are present in spring.

The influence of salt deposition on riparian vegetation is another concern for which little is known. Salt crusts may restrict the emergence of seedlings and affect the exchange of water and gasses between the soil and air. High SAR values may impair soil development, and high levels of salt ions have toxic effects on plants. Increases in salinity would be expected to have consequences to the present biota, as freshwater organisms from microbes to fishes range in their tolerances to salinity, even within genera. Observations from other drainages in the western U.S. and elsewhere indicate the potential for ecological changes at least partially attributable to increased salinity. Concentrations and biotic responses will depend on factors such as durability and persistence of crusts, and the complexity of floodplain geohydrology.

7.0 Recommendations

The results of this study provide a valuable baseline and allow some inference on potential influences of CBNG development on streams in a region with significant energy resources. Recommendations developed from study results involve additional investigation of longitudinal dynamics along streams, stream specific concerns, and identification of sensitive resources in need of extra consideration. Moreover, identification of prairie streams and more specifically, streams in the Tongue and Powder River drainages as priorities for conservation actions by Montana Fish, Wildlife, & Parks (MFWP 2005) emphasizes the need to collect additional data in the management of these systems, particularly concerning the influence of CBNG development.

Disparities between the chemical and biological results above and below CBNG development on Youngs Creek, Prairie Dog Creek, and Squirrel Creek suggests salt loading has a negative effect on biological integrity in these streams; however, the available data do not distinguish between natural loading and anthropogenic sources. Moreover, each case presents a different scenario in terms of wastewater management and other logistic concerns. Therefore, we recommend stream specific investigations to add to the understanding of the spatial and temporal variability in water quality and biological integrity.

The increase in dissolved solids along the length of Squirrel Creek is a considerable concern as it occurs concomitantly with a marked decline in biological integrity ratings compared to the upstream site. Examination of groundwater data (Groundwater Information Center [GWIC] database [http://mbmggwic.mtech.edu/]) in the vicinity suggests salty groundwater inflows in gaining reaches may be responsible for these conditions. On the other hand, water quality data collected in the 1970s showed considerably lower concentrations of salts near the lower sampling site. Investigation of salt concentrations, or simply specific conductance, along the longitudinal gradient of this stream would assist in identification of zones or sources of salt loading. Consideration of climatic trends in this analysis would shed light on the role of the ongoing drought on recent water quality. Together, these analyses would shed light on potential spatial and temporal trends associated with climate and geology that would prove useful in the sustainable development of CBNG.

Another recommendation with regard to Squirrel Creek and other streams assessed in the 1970s is to update both periphyton and macroinvertebrate data collected by Klarich et al. (1980). These investigations predated many of the metrics now used in evaluating biological integrity, which sorely limits potential applications. Moreover, scientific names for many of these organisms have changed making the available data difficult to interpret. The original diatom slides still exist making proportional counts and metric calculation possible (Dr. Loren Bahls, personal communication). Similarly, updating macroinvertebrate data (Klarich et al. 1980) will allow calculation of the currently used metrics. Combined, these actions would add significantly to our understanding of the temporal trends in Squirrel Creek and other streams, which include Rosebud Creek, Hanging Woman Creek, Youngs Creek, and Prairie Dog Creek.

Prairie Dog Creek provides another opportunity to evaluate stream integrity above and below CBNG development. As discussed in the previous report (Confluence 2003), the interbasin transfer of water to supply irrigators confounds the ability to evaluate the influence of a high level of CBNG development on water quality during the irrigation season. These augmented flows overwhelm water contributed from the Prairie Dog Creek basin and potentially mask contributions from CBNG wastewater disposal during the summer months. Water quality and biological integrity during the non-irrigation season remains unknown. Repeating these investigations following cessation of flow transfer would allow evaluation of a stream with a considerable degree of CBNG development. Moreover, this effort may shed light on the cause for the low scores on the fish IBI at the lower site despite adequate flows of clean water and relatively high scoring habitat conditions. As with Squirrel Creek, investigation of specific conductance along the length of Prairie Dog Creek would be useful in identifying sources of salt loading along the river continuum.

With relatively few permitted outfalls, only eight, Youngs Creek provides an opportunity for a relatively simple investigation of the influence of CBNG wastewater management on stream integrity. Evaluation of biological and chemical parameters above and below these outfalls would potentially provide significant information to guide sustainable wastewater management strategies.

Youngs Creek also represents one of the few fisheries investigations in woody draws in the region. Woody draws provide substantial habitat for a diversity of plant and animal species and are hot spots for biodiversity in the Northern Great Plains ecoregion. Fisheries data for Youngs Creek suggests that when flows are adequate, these streams have the potential to support a diverse, native assemblage of fishes. Identification and assessment of fish-bearing woody draws across the Tongue and Powder River watersheds would augment our understanding of these communities and facilitate their conservation.

Reptiles and amphibians represent other beneficial uses of prairie streams that may be vulnerable to disturbance associated with CBNG development. Amphibians rely on water for reproduction and alterations in water quality may influence development of eggs and larvae. Similarly, snapping turtles, painted turtles (*Chrysemys picta*), and spiny softshells (*Trionyx spiniferus*) are aquatic species that rely on fish and invertebrates as a forage base. Additional information on their distribution and status would aid in their conservation.

Investigation of seasonal influences of fish use of tributaries is another factor shaping their ecology that is poorly understood. Fishes often use a variety of habitats, depending on season and life history stage. Investigations into habitat use and movements of fishes in the Tongue and Powder River watersheds would shed light on the roles of the main stem and tributaries in supporting these diverse fisheries.

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Appendix A: Reach Field Photos

Badger Creek looking downstream

Badger Creek looking upstream

Coal Creek

Coal Creek looking upstream

Corral Creek looking downstream

Corral Creek looking upstream

Hanging Woman Creek upward trend

Hanging Woman Creek center looking upstream

Otter Creek spreader dam


Otter Creek looking downstream


Lower Prairie Dog Creek looking upstream


Lower Prairie Dog Creek looking downstream

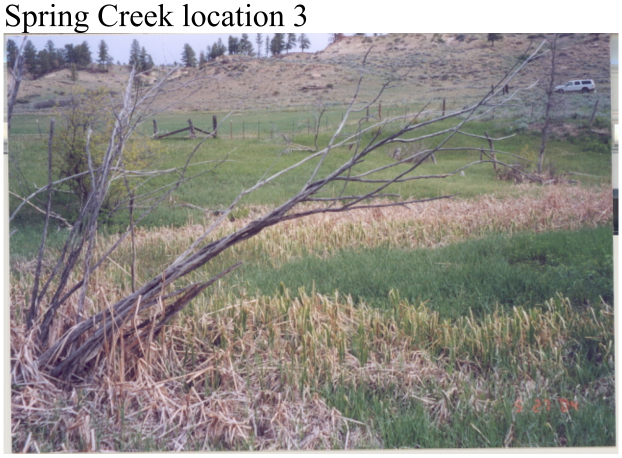

Upper Prairie Dog Creek looking downstream


Upper Prairie Dog Creek cutbank


Rosebud Creek looking upstream

Rosebud Creek looking downstream

Spring Creek location 3



Spring Creek downstream end

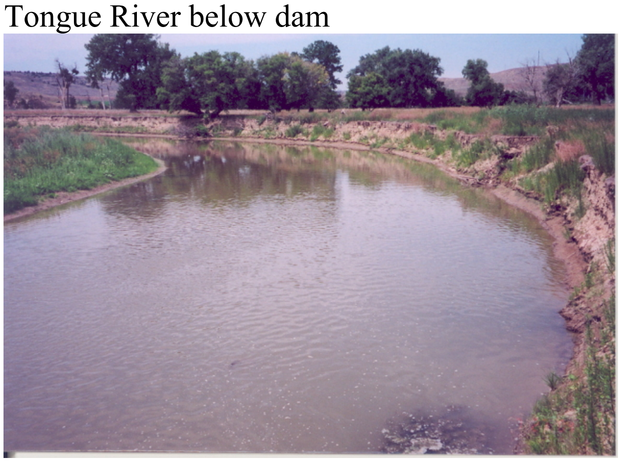
Lower Squirrel Creek location 1

Lower Squirrel Creek looking upstream

Upper Squirrel Creek location 3

Upper Squirrel Creek location 4

Tongue River below dam



Tongue River near Bridge


Tongue River at Hanging Woman Creek


Tongue River at state line


Lower Youngs Creek looking upstream

Lower Youngs Creek stock crossing

Upper Youngs Creek riparian area

Upper Youngs Creek looking upstream

Appendix B: CBNG Aquatic Habitat Monitoring Protocol & Definitions

Header Information

Stream/Site Name: Record the full name of the stream. Include the river or creek designation. Write down the state and county. Assign a unique site ID number to each site sampled.
Samplers/Organization: Record the names of the people collecting data at that site. Record the name of the company or government organization (with district) that the work is being conducted for.
Date: Record as day, month, year. (e.g. 04 July 1998)
Weather: Describe the weather (i.e. – partly cloudy, drizzle, etc.)
Location: Record the Township, Range, and Section.
Location in the Section: Record the location in the Section (i.e. SW of SE)
GPS coordinates (decimal degrees): Record Latitude, Longitude, and elevation.
Landownership: Circle y or n to verify if the land is publicly owned. If not, please provide landowner contact information:

The information on the CBNG Aquatic Habitat Monitoring Stream/River Survey Form should be taken within a stream segment that is equal to two meander lengths, 20 bankfull channel widths, or 500 m, which ever is greater (for larger rivers, such as the Tongue and Powder Rivers, stream segment length may be adjusted to achieve credible results). Establish the beginning and end of the stream segment and complete the form. The following text involves definitions and protocol for the parameters on the survey form.

General Sight Overview

Comments:

Use this space to elaborate on any of the attributes below. Note apparent watershed problems, special features or habitats, management problems, beaver activity, tributary information, natural features, prominent geology, biological information, etc.

Photos:

Include at least two photos from the center of the stream segment (one downstream and one upstream).

Management Activities:

Rank all of the management activities, as described on the data form that occur along the stream segment according to their relative impact on the stream system. A ranking of 1 represents the most significant impact. A ranking of 4 indicates no impact. Describe the impact in the comments.

Livestock Use Index:

We calculate a livestock use index by counting the number of cow and sheep droppings (feces) observed along two 75m, zigzag transects, 1 located on each side of the stream. Start each transect at the lower end of the study area. Each transect should zigzag 3 times over the 75m total length. Start at the streams' edge and locate a landmark ~ 25m away and angling at ~ 30-45o away from the stream. Walk directly toward the landmark and count all cattle and sheep droppings within 1m on either side of you (i.e., a 2m wide band). Keep counts for cattle and sheep separate. Keep counts of >new= and >old= droppings separate as well. New droppings cannot be turned over intact with a stick; old droppings can. Use a 25m tape or string to locate the end of the first 25m part of the transect. After completing the first 25m of the transect, locate another landmark ~ 25 meter away back toward the stream channel. Count droppings along this transect. The 3rd portion of the transect should angle away from the stream again. Repeat this procedure on the other side of the stream.

Riparian Assessment

Riparian Vegetative Zone Width:

Take a measurement of the representative riparian zone width within the reach. This area is defined from the bankfull mark to the point where there is a distinctive change in upland vegetation or hillslope. If there is no clear transition, consider the area within 10 - 15 m of the bank when answering riparian related questions.

Dominant Overstory: Enter the dominant overstory species of vegetation (should be a woody shrub species unless none are present) growing in the riparian zone. The task is to define from an overhead (i.e., bird's-eye) view which species occupies the most overstory area within the riparian zone along both banks of the measured habitat. It is the average of both bank's condition.

Dominant Understory: Enter the dominant understory species of vegetation (should be a woody shrub species unless none are present) growing in the riparian zone. The task is to define the dominant understory vegetation (based on percent area covered) on the site. This should be a woody shrub species unless none are present. A grass/forb/sedge delineation should not be used if a large number of understory woody shrub species are present, even though it may constitute a higher percentage of the riparian area.

Invasive plants: Indicate whether noxious weeds or other nonnative plant species are present on site. List these species.

Non-invasive plants: Indicate whether there is recruitment of all age classes of native plant species on site (i.e. Are there cottonwood saplings intermixed with older age classes?)

Densiometer:

Take four densiometer readings from the center of each of the four habitat units sampled for invertebrates. Readings should be taken facing upstream, downstream, bank left, and bank right. For each reading, place the densiometer near the surface of the stream and level it before taking a reading. Estimate shading by assigning 0 -4 points to each square on the densiometer grid and summing across grid squares. Points are assigned based on the percent of each square containing a shade object: 0 for no objects, 1 for 25% cover, 2 for 50% cover, 3 for 75% cover, and 4 for 100% cover.

Vegetative Cover: Estimate the % of the floodplain covered by mature perennial plants (tress, shrubs, or grass).

4 = > 95%
3 = 85 - 95%
2 = 75 - 85%.
1 = < 75%

Consumption of trees & shrubs by livestock (leader growth):

4 = 0 - 5%
3 = 5 - 25%
2 = 25 - 50%
1 = > 50%

Stream Banks

Percent of streambank with deep, binding root mass:

4 = > 85% of the bank with deep, binding root mass.
3 = 65 - 85% of the bank with deep, binding root mass.
2 = 35 - 64% of the bank with deep, binding root mass.
1 = < 35% of the bank with deep, binding root mass.

Erosional deposition into stream from surrounding hillslopes - Scan the hillsides on both sides of the stream for evidence of active erosion:

4 = No erosional deposition is apparent.
3 = Some signs of erosional deposition are apparent, but these areas are confined to specific, limited locales along the stream (e.g., gulleys, washes, slumps, roads).
2 = Obvious signs of erosional deposition from the hillslopes are apparent.
1 = Mass wasting is evident on hillslopes. Stream deposition is significant enough to cause obvious changes in stream flow (e.g., debris avalanche, torrent tracks).

Percent of stream with active lateral cutting:

4 = 5% or less of the streambank shows active lateral cutting.
3 = 5 - 15% of the streambank shows active lateral cutting.
2 = 15 - 35% of the streambank shows active lateral cutting.
1 = > 35% of the streambank shows active lateral cutting.

Condition of Stream Banks (Check the most appropriate statement)

__ Stream banks stable; no evidence of erosion or bank failure
___ Banks moderately stable; infrequent or small areas of erosion mostly healed over.
___ Banks moderately unstable; up to 60% of banks in the reach have areas of erosion.
___ Banks unstable, many eroded areas. "Raw" areas frequent along straight sections, bends and side slopes. 60-100% of stream banks have erosional scars.

Water Chemistry

Conductivity: Turn on the conductivity meter and place the probe into the main flow. When the reading stabilizes, record the conductivity as micro-Siemens per cm.
P Alkalinity: Use the test kit to determine the alkalinity of the water. Record the value as ppm of $CaCO_3$.
Total Alkalinity: Use the test kit to determine the total alkalinity of the water. Record the value as ppm of $CaCO_3$.
pH: Use a test kit or meter to determine pH and record the value.
Dissolved Oxygen (DO): Use a test kit or meter to determine DO and record the value.
Turbidity (NTU's): Use a test kit or meter to determine turbidity and record the value.
Air Temperature: Place or hold the thermometer away from the direct sunlight and materials that conduct heat (metal, etc.) for 30 seconds. Read and record the temperature.
Water Temperature: Place the thermometer into the main flow. After 1 minute, read and record the temperature.

Channel Morphology

Bankfull: A term used to describe streamflow which occurs on average once every 1.5 years. Flows of this magnitude transport the most sediment over time. Bankfull flows are the discharge for maintaining the present channel shape. In channel types possessing a well-developed floodplain (i.e. Rosgen streamtype C), Bankfull is the stage or streamflow that just overtops the channel's banks and begins to inundate the floodplain (Stream Inventory Handbook 1999)

Bankfull Indicators: The channel attributes created during bankfull flow and visible during low flow conditions. The best indicator of bankfull flow is the deposits of streambed material which remain after a bankfull event. The top of these depositional features closely approximates the height of bankfull flow. Other indicators of bankfull are the lower limit of perennial vegetation, a change in streambanks' slope, a change in the particle size of the streambank, undercut banks and the presence of stain lines or the lower extent of lichen colonization on the banks (Stream Inventory Handbook 1999).

Bankfull Stage: The water level elevation during a bankfull discharge. This elevation leaves a signature on the channel in the form of depositional areas and distinct streambank slopes. The line of permanent vegetation along a stream is often a close approximation of the bankfull stage (Stream and Inventory Handbook 1999).

Bankfull Width: This is the measured width (perpendicular crossection) of the stream at bankfull stage. Use bankfull indicators to determine where the bankfull stage is located. Complete ten cross-sections within the study stream segment.

Bankfull Depth: This is the mean depth of at bankfull stage taken every foot across the crossection from the bankfull stage. Complete ten crossections within the study segment.

Bankfull Area: The bankfull area is the bankfull width times the mean bankfull depth (bankfull width x mean bankfull depth.

Water velocity: Use a velocity meter or measure and mark off ten feet of stream and time how long it takes an orange to float through the ten feet of the stream. Divide ten feet by the number of seconds it takes the orange to float through the area. This number would result in water velocity (feet per second).

Calculated Discharge: Discharge is equal to the water velocity multiplied by the cross-sectional area.
Width of flood prone area: The flood prone area is equal to the measured width at two times the maximum bankfull depth (Rosgen 1996) (2 x maximum Bankfull depth)

Stream Slope: This is equal to the vertical distance divided by the linear distance.

Valley Slope: This is equal to the vertical distance divided by the linear distance from the headwaters to the mouth.

Valley Length: This is the length of a linear straight line from the beginning point of your stream segment to the ending point of your stream segment.

Stream Length: Length of the stream segment surveyed following the channel thalweg.

Sinuosity from Length: Channel sinuosity is the ratio of stream channel length to valley length (Rosgen 1996) (stream length divided by valley distance).

Meander Length: It is the length of the stream in each meander in your stream segment. This is measured by following the channel thalweg.

Width of stream belt: This is equal to the average width of the meanders within the stream segment.

Width/depth ratio: The width/depth ratio is the ratio of the bankfull surface width to the mean depth of the bankfull channel (Rosgen 1996) (bankfull width divided by the mean bankfull depth).

Entrenchment ratio: The entrenchment ratio is the ratio of the width of the flood-prone area to the surface width of the bankfull channel. The flood prone width is measured at the elevation that corresponds to twice the maximum depth of the bankfull channel as taken from the established bankfull stage (flood-prone area width divided by the bankfull channel width) (Rosgen 1996).

Pool (or Glide)/Riffle Ratio: Count and estimate the wetted length, width and average depth of each habitat unit (pool (or glide)/riffle) within the study reach (500m to 1000m).

A pool is defined as a portion of the stream which usually has reduced surface turbulence and has an average depth greater than riffles when viewed during low flow conditions. A pool may at times contain substantial surface turbulence at the upstream end, but always has a hydraulic control present across the full width of the channel at the downstream end.

A riffle is a portion of stream with increased water velocity. Streamflow during low flow discharge is intercepted partially or completely by submerged obstructions to produce relatively high surface turbulence. Stream channel gradient is greater in riffles than in pools. Riffles are an inclusive term for low gradient riffles, moderate gradient rapids, and high gradient cascades.

Residual Pool Depth: Within each pool habitat unit, measure the maximum pool depth and the depth at pool tail crest. Subtract the maximum pool depth from the depth at the pool tail crest. Record these numbers on the data sheet.

The pool tail crest is the maximum depth measured at the hydraulic control of a pool.

Substrate and Instream Habitat

Instream cover within study reach (check the most appropriate statement):

__ Greater than 50% mix of boulder, cobble, submerged logs, undercut banks or other stable habitat. Good habitat
___ 30 to 50% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat. Adequate habitat.
___ 10 to 30% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat. Less than desirable habitat.
___ Less than 10% mix of boulder, cobble, submerged logs, undercut banks, or other stable habitat. Habitat is lacking.

Large Woody Debris:

Count all pieces of LWD in the study reach (500m to 1000m) equivalent to a minimum of 6 inches in diameter (or larger) and a minimum of 10 feet in length (or larger) within the bankfull channel.

Stream Incisement:

4 = No incisement.
3 = Old incisement.
2 = Deep incisement with new floodplain development.
1 = Deep incisement with active downcutting.

Pebble Counts:

(1) Locate a Reach for sampling through two meander wave-lengths or cycles of a channel reach that is approximately 20 to 30 “channel widths” in length.

(2) Determine the percentage of the reach configured as riffles and pools (this should have been completed in your pool/riffle ratio.

(3) Adjust the pebble-count transects of sampling locations so that riffles and pools are sampled on a proportional basis, where the percentage of samples taken in riffles is equal to the percentage of channel reach length.

(4) A total of ten transects with 10 samples at each transect needs to be taken (100 samples altogether).

(5) Always begin a transect at the edge of the bankfull channel and end each transect at the opposite edge of the bankfull channel.

(6) For pebble counting accuracy, use a tape line with equally spaced intervals to assist in determining an appropriate location for selecting in-channel particles for measurements. These measurements should be taken at each interval without looking at the substrate.

(7) Refer to Figure.
Mannings Roughness Coefficient:

$$U = \frac{1.49(R)2/3(S)1/2}{n}$$

U = mean velocity
R = Hydraulic radius (cross-sectional area/wetted perimeter)
S = Slope of stream
n = Manning's Roughness Coefficient.

Appendix C: Periphyton Methods and Quality Assurance

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Station and sample attribute data are recorded in the Montana Diatom Database (MS Access 2000) and each sample is assigned a unique number, e.g., 2684-01. The first part of this number (2684) designates the sampling site (Indian Creek) and the second part (01) designates the number of periphyton samples that have been collected at this site for which data have been entered into the Montana Diatom Database.

Samples are examined to estimate the relative abundance and rank by biovolume of diatoms and genera of soft (non-diatom) algae according to the method described in Bahls (1993). Soft algae are identified using Smith (1950), Prescott (1962, 1978), John et al. (2002), and Wehr and Sheath (2003). These books also serve as references on the ecology of the soft algae, along with Palmer (1969, 1977). Sample observations (e.g., "silty", "contains moss", etc.) and the relative abundance and rank according to biovolume of diatoms and genera of soft (non-diatom) algae are recorded in a lab notebook along with information on the sample label.

After the identification of soft algae, a portion of the raw sample is used to make duplicate diatom slides. The diatom subsample is cleaned of organic matter using sulfuric acid, potassium dichromate, and hydrogen peroxide. Then permanent diatom slides are prepared using Naphrax, a high refractive index mounting medium, following *Standard Methods for the Examination of Water and Wastewater* (APHA 1998). Generally, 300-400 diatom cells (600-800 valves) are counted at random and identified to species. The following are the main taxonomic references currently used for the diatoms: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Lange-Bertalot 2001; Krammer 1997a, 1997b, 2002. A more complete list of taxonomic references will be made available on request.

Diatom naming conventions follow those adopted by the Academy of Natural Sciences (Philadelphia) for USGS NAWQA samples (Morales and Potapova 2000) as updated in 2003 (Dr. Eduardo Morales, ANSP, digital communication). The slide used for the diatom proportional count will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slide will be retained by *Hannaea* in Helena.

Diatom proportional counts are entered into the Montana Diatom Database. Using customized software, the diatom counts are used to generate an array of 65 diatom association metrics and ecological attributes. A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999). Diatoms are particularly useful in generating metrics because there is a wealth of information available in the literature regarding the pollution tolerances and water quality preferences of common diatom species. The following are the main ecological references for the diatoms: Lowe 1974, Beaver 1981, Lange-Bertalot 1996, Van Dam et al. 1994. The taxonomic references cited below also contain a wealth of ecological and geographical information about diatom species.

Values for selected metrics are compared to biocriteria (numeric thresholds) developed for streams in the Rocky Mountains or Great Plains ecoregions (USEPA 2000). These biocriteria are based on metric values measured in least-impaired reference streams (Bahls et al. 1992) and metric values measured in streams that are known to be impaired by various sources and causes of pollution (Bahls 1993). A similarity index (Whittaker 1952) is calculated to judge the amount of floristic change (and possible impairment or recovery) that occurs between adjacent sites sampled on the same stream on the same date.

Diatom biocriteria distinguish among four levels of stress or impairment and three levels of aquatic life use support: (1) no impairment or only minor impairment (full support); (2) moderate impairment (partial support); and (3) severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor biological integrity, respectively. In cold, high-gradient mountain streams, natural stressors will often mimic the effects of man-caused impairment on some metric values.

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Appendix D. Macroinvertebrate Protocols

The general procedures followed for processing invertebrate samples were similar to those recommended by the United States Geological Survey (Cuffney et al. 1993) and are described in greater detail and rationalized in Vinson and Hawkins (1996). Methods for individual samples are presented in Table 3. Samples were sub-sampled if the sample appeared to contain more than 600 organisms. Samples were sub-sampled if more than about 600 organisms appeared to be present. Sub-samples were created by pouring the sample into a 250-micron sieve, floating this material by placing the sieve within an enamel pan partially filled with water, and leveling the material within the sieve. The sieve was then removed from the water pan and the material within the sieve was divided into equal parts. One side was randomly chosen to be processed and the other set aside. This process was repeated until approximately 600 organisms remained in one-half of the sieve. This material was then placed into a Petri dish and all organisms were removed under a dissecting microscope at 10-30 power. The organisms in the sub-sample were separated by Order, then the entire sample was spread throughout a large white enamel pan and searched for 10 minutes to remove any taxa that might not have been picked up during the initial sample sorting process (a "big/rare" search). These rarer bugs were placed into a separate vial and tracked separately from the bugs removed during the sub-sampling process. All organisms removed during the sorting process were then identified to species. Once the data had been entered into a computer and checked, the unsorted portion of the sample was discarded. All identified invertebrates in each sample were combined into a single museum-grade glass vial with a polypropylene lid and liner. Internal sample labels were penciled on waterproof paper, and included the sampling location, sampling date, and laboratory processing information. Vials were filled with 70% ethanol. Each vial was labeled with a unique catalog number and retained in the Utah State University / Bureau of Land Management National Aquatic Monitoring Center collection.

Laboratory sample processing information. The percentage of each sample processed and the total number of invertebrates identified for each sample are reported.

Sample ID	Station ID	Sampling date	% of sample processed	Invertebrates identified
124092	TONGUE-01	7/23/2004	53	662
124094	TONGUE-02	7/28/2004	13	641
124096	TONGUE-03	7/27/2004	6	665
124098	TONGUE-04	7/26/2004	6	761
124100	OTTERC-01	7/15/2004	13	987
124168	YOUNGSC-01	6/24/2004	13	664
124170	YOUNGSC-02	6/23/2004	56	858
124172	PRAIRIE-01	6/25/2004	50	825
124174	HANGING-01	6/22/2004	25	575
124176	SPRING-01	5/27/2004	100	246
124178	SQUIRREL01	5/26/2004	25	636
124180	SQUIRREL02	5/26/2004	9	618
124182	ROSEBUD-01	5/24/2004	16	639
124184	CORRALC-01	5/25/2004	100	82
124186	PRAIRIE-02	6/30/2004	7	1147

Appendix E: Periphyton Proportional Counts

Diatom association metrics used by the State of Montana to evaluate biological integrity in **prairie** streams: references, range of values, expected response to increasing impairment or natural stress, and criteria for rating levels of biological integrity. The lowest rating for any one metric is the rating for that site.

Biological Integrity/ Impairment or Stress/ Use Support	No. of Species Counted[1]	Diversity Index[2] (Shannon)	Pollution Index[3]	Siltation Index[4]	Disturbance Index[5]	% Dominant Species[6]	Similarity Index[7]
Excellent/None Full Support	>39	>3.99	>2.25	<50.0	<25.0	<25.0	>59.9
Good/Minor Full Support	30-39	3.00-3.99	1.76-2.25	50.0-69.9	25.0-49.9	25.0-49.9	40.0-59.9
Fair/Moderate Partial Support	20-29	2.00-2.99	1.25-1.75	70.0-89.9	50.0-74.9	50.0-74.9	20.0-39.9
Poor/Severe Nonsupport	<20	<2.00	<1.25	>89.9	>74.9	>74.9	<20.0
References	Bahls 1979 Bahls 1993	Bahls 1979	Bahls 1993	Bahls 1993	Barbour et al. 1999	Barbour et al. 1999	Whittaker 1952
Range of Values	0-100+	0.00-5.00+	1.00-3.00	0.0-90.0+	0.0-100.0	~5.0-100.0	0.0-100.0
Expected Response	Decrease	Decrease	Decrease	Increase	Increase	Increase	Decrease

[1]Based on a proportional count of 400 cells (800 valves)
[2]Base 2 [bits] (Weber 1973)
[3]Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[4]Sum of the percent abundances of all species in the genera *Navicula, Nitzschia,* and *Surirella*
[5]Percent abundance of *Achnanthidium minutissimum* (synonym: *Achnanthes minutissima*)
[6]Percent abundance of the species with the largest number of cells in the proportional count
[7]Percent Community Similarity (Whittaker 1952)

Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from the Tongue River and tributaries, Corral Creek, and Rosebud Creek in 2004: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

Taxa	Site														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cyanophyta															
Anabaena				o/8	c/6	c/5		o/6	c/5		r/6	o/13	o/8	o/10	
Calothrix												r/15	r/14	r/15	
Hydrocoleum														r/12	
Lyngbya				c/6					f/2						
Merismopedia														r/16	
Nodularia					c/7										
Oscillatoria		o/7	f/3										c/6	c/9	c/5
Phormidium			c/4										f/5		
Pleurocapsa													r/11		
Spirulina													r/15		
Rhodophyta															
Audouinella			o/5					c/5					c/7		
Chlorophyta															
Cladophora		f/2	d/1	a/1						a/3		o/9	a/3		
Closterium						r/7					o/4	c/11	o/9		
Cosmarium													r/13		
Enteromorpha												d/1			
Hormidium					c/5										
Hydrodictyon												f/5		f/5	
Microspora														a/3	f/3
Mougeotia				o/7	f/3	f/2					c/3	c/10		c/8	o/6
Oedogonium	o/4	o/6		c/5							o/5	c/7	d/1	f/6	c/4

Pediastrum												o/12		r/14	
Rhizoclonium								a/1				c/8		d/1	
Scenedesmus											r/7	o/14	o/10	o/11	
Spirogyra	a/2	c/5		c/4		f/3			o/3		d/1	f/6	f/4	a/4	d/1
Stigeoclonium				o/9			o/2							f/7	
Zygnema												a/3			
Euglenophyta															
Euglena		r/8											r/12	r/13	
Chrysophyta															
Tribonema		a/3		f/3	a/2	a/4	o/3	a/2	a/1						
Vaucheria	d/1	f/1			c/4	o/6		o/4		d/1		a/2			
Bacillariophyta	f/3	c/4	d/2	f/2	a/1	a/1	f/1	f/3	c/4	a/2	f/2	a/4	a/2	a/2	a/2
No. Non-Diatom Genera	3	7	4	8	6	6	2	5	4	2	6	14	14	15	5

Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from the Tongue River and tributaries, Corral Creek, and Rosebud Creek in 2004. Underlined values indicate minor stress; **bold values** indicate moderate stress; **underlined and bold** values indicate severe stress; all other values indicate no stress and full support of aquatic life uses when compared to criteria for prairie streams in Table 2.

Species/Metric	PTC[2]	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Amphora inariensis	3	2.83	0.42	1.93			0.70		1.56		0.26	2.06	21.38	1.21	1.34	
Cocconeis pediculus	3	0.15	12.64	1.41							0.26	20.65	3.54	1.81	1.79	0.60
Cocconeis placentula	3	10.27	4.31	2.31	5.26		4.04	0.60	0.93		1.96	7.52	12.46	3.92	2.53	1.20
Fragilaria capucina	2	0.89	0.69				2.51		6.22		0.52	10.77	0.31	0.60		
Navicula reichardtiana	2	10.86	3.33	15.68			1.11		0.62		2.09	1.18	1.54	2.41	2.08	
Navicula veneta	1	2.53	8.75		24.87	12.10	4.87	17.92	6.22	21.34	0.79	1.18	0.31		0.30	6.30
Nitzschia dissipata	3	2.53	2.50	13.75		0.92	4.60		1.24		5.24	0.59	3.38	2.41	1.49	
Nitzschia frustulum	2	2.08	6.94		7.37	1.53	1.39	23.49	9.33	2.74	3.80	0.44	0.92	0.60	2.08	3.90
Nitzschia inconspicua	2			10.03			0.28						5.85	0.60	0.60	
Nitzschia palea	1	5.36	6.39	1.16	5.53	5.51	12.40	1.81	3.27	1.83	9.03	1.92	3.54	4.83	4.91	7.35
Nitzschia pusilla	1	2.53	1.11		1.84					18.90	0.52					0.30
Nitzschia reversa	2															37.33
Nitzschia valdecostata	2					19.75	0.14	0.60	0.62							
Pseudostaurosira brevistriata	3										0.52	4.13		31.07	15.77	
Staurosira construens	3	1.04										11.21		24.28	26.93	
Synedra famelica	2		0.28		2.63	25.42	11.42	4.07	7.47	29.73		0.29				0.30
Tabularia fasciculata	2				10.00		3.76		0.62							2.10
Number of Species Counted		81	62	35	48	43	69	55	55	**28**	63	56	38	55	44	51
Shannon Species Diversity		5.35	4.84	4.17	4.30	3.76	4.99	4.37	4.93	3.16	5.01	4.48	4.12	3.78	3.91	3.99
Pollution Index		2.05	2.01	2.40	**1.64**	**1.75**	1.95	1.79	2.03	**1.43**	2.18	2.60	2.65	2.69	2.57	1.91
Siltation Index		67.56	64.58	**70.57**	68.42	59.88	55.85	**72.74**	38.26	63.11	66.75	18.14	30.77	24.43	30.06	**74.36**
Disturbance Index		0.30	0.28	4.50	0.00	0.61	0.14	0.15	1.40	0.00	4.58	2.65	4.77	1.36	9.97	3.00
Percent Dominant Species		10.86	12.64	15.68	24.87	25.42	12.40	23.49	9.33	29.73	9.29	20.65	21.38	31.07	26.93	37.33
Percent Rhopalodiales		1.04	0.69	0.00	0.00	0.31	2.09	0.90	2.64	0.00	0.13	6.19	5.23	3.17	3.57	0.00
Similarity Index[3]			47.57					29.54			42.42	33.41	26.87	69.90		

[1]A major diatom species accounts for 10.0% or more of the cells at one or more stations in the sample set.
[2](Organic) Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive.
[3]Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station on the same stream.

Modal categories for selected ecological attributes of diatom species in the Tongue River, tributaries of the Tongue River, Corral Creek, and Rosebud Creek. Categories that represent somewhat inferior water quality when compared to the best sites in the sample set are underlined. Categories that represent significantly inferior water quality when compared to the best sites are in **bold face type**. Categories that represent a very significant decline in water quality compared to the best sites are **underlined and in bold face**.

Ecological Attribute	Site Number 1	2	3	4	5	6	7	8
Motility[1]	moderately motile	**highly motile**	moderately motile	moderately motile	**highly motile**	**highly motile**	moderately motile	not motile
pH[2]	alkaliphilous	alkaliphilous	alkaliphilous	alkaliphilous	alkaliphilous	alkaliphilous	alkaliphilous	alkaliphilous
Salinity[2]	fresh	brackish-fresh	fresh	brackish-fresh	brackish-fresh	brackish-fresh	brackish-fresh	brackish-fresh
Nitrogen Uptake[2]	autotrophs (high organics)	autotrophs (high organics)	autotrophs (high organics)	autotrophs (high organics)	autotrophs (low organics)	autotrophs (high organics)	autotrophs (high organics)	autotrophs (high organics)
Oxygen Demand[2]	**moderate**	**moderate**	fairly high	**low**	not classified	**low**	**moderate**	not classified
Saprobity[2]	**alpha-meso-saprobous**	beta-meso-saprobous	beta-meso-saprobous	**alpha-meso-saprobous**	oligo-saprobous	**alpha-meso-saprobous**	beta-meso-saprobous	beta-meso-saprobous
Trophic State[2]	eutraphentic	eutraphentic	eutraphentic	eutraphentic	eutraphentic	eutraphentic	eutraphentic	eutraphentic

[1]Dr. R. Jan Stevenson, Michigan State University, digital communication.

[2]Van Dam et al. 1994

Appendix F: Macroinvertebrate Proportional Counts

List of all taxa collected in 40 samples. Count is the total number of individuals identified and retained.

Taxon	Count
Annelida	
Clitellata	
Arhynchobdellida	
Erpobdellidae	8
Dina parva	1
Erpobdella punctata	2
Branchiobdellida	
Branchiobdellidae	126
Rhynchobdellida	
Glossiphoniidae	
Glossiphonia complanata	7
Theromyzon rude	1
Oligochaeta	116
Arthropoda	
Arachnida	
Trombidiformes	203
Entognatha	
Collembola	38
Insecta	
Coleoptera	
Curculionidae	26
Dryopidae	
Helichus	2
Dytiscidae	125
Agabus	57
Hygrotus	12
Laccophilus	1
Laccophilus maculosus	1
Oreodytes	1
Stictotarsus	1
Tribe bidessini	12
Elmidae	35
Dubiraphia	316
Dubiraphia vittata	85
Microcylloepus pusillus	403
Optioservus	5
Optioservus quadrimaculatus	1
Ordobrevia nubifera	111
Stenelmis calida	102
Zaitzevia parvula	3
Gyrinidae	
Gyrinus	4
Haliplidae	1
Brychius	2
Haliplus	18
Peltodytes	2
Helophoridae	
Helophorus	58
Hydraenidae	

Taxonomic list, continued.

Taxon	Count
Ochthebius	8
Hydrophilidae	30
Berosus	33
Enochrus	5
Hydrobius	5
Paracymus	14
Tropisternus	1
Diptera	30
Ceratopogonidae	440
Bezzia	4
Probezzia	258
Chaoboridae	10
Chaoborus	11
Chironomidae	282
Chironominae	1968
Orthocladiinae	2254
Tanypodinae	552
Culicidae	43
Anopheles	1
Culex	1
Dixidae	
Dixa	3
Dixella	2
Dolichopodidae	3
Ephydridae	31
Psychodidae	
Pericoma	6
Psychoda	1
Sciomyzidae	5
Simuliidae	11
Simulium	1450
Stratiomyidae	
Caloparyphus	49
Nemotelus	2
Odontomyia	3
Stratiomys	16
Tabanidae	10
Chrysops	8
Tabanus	3
Tipulidae	8
Dicranota	10
Holorusia	6
Tipula	2
Ephemeroptera	7
Baetidae	350
Acentrella	168
Baetis	1925
Callibaetis	58
Camelobaetidius similis	3
Centroptilum	47
Diphetor hageni	5
Fallceon quilleri	252
Plauditus	146

Taxonomic list, continued.

Taxon	Count
Plauditus punctiventris	2
Pseudocloeon	17
Caenidae	
Caenis	879
Ephemerellidae	13
Ephemerella	5
Ephemerella aurivillii	32
Ephemeridae	
Ephemera	1
Heptageniidae	53
Rhithrogena	3
Stenonema	1
Leptohyphidae	3
Asioplax	6
Tricorythodes	1296
Leptophlebiidae	77
Choroterpes	6
Neochoroterpes	1
Traverella	1
Polymitarcyidae	
Ephoron	9
Hemiptera	1
Heteroptera	1
Corixidae	274
Hesperocorixa	1
Sigara	224
Trichocorixa	28
Gerridae	102
Aquarius	21
Gerris	1
Metrobates	1
Naucoridae	
Ambrysus	127
Notonectidae	3
Notonecta	115
Saldidae	2
Veliidae	
Rhagovelia	2
Lepidoptera	
Pyralidae	
Petrophila	15
Megaloptera	
Sialidae	
Sialis	6
Odonata	2
Aeshnidae	9
Aeshna	5
Anax junius	2
Calopterygidae	
Hetaerina americana	7
Coenagrionidae	276
Amphiagrion abbreviatum	1
Argia	5

Taxonomic list, continued.

Taxon	Count

Argia emma	2
Enallagma	1
Ischnura	3
Gomphidae	26
Ophiogomphus	18
Lestidae	
Lestes	167
Libellulidae	13
Plecoptera	
Perlidae	
Acroneuria	1
Pteronarcyidae	
Pteronarcella badia	3
Trichoptera	7
Brachycentridae	
Brachycentrus	1
Brachycentrus occidentalis	302
Glossosomatidae	1
Helicopsychidae	
Helicopsyche borealis	1
Hydropsychidae	419
Cheumatopsyche	490
Hydropsyche	646
Hydroptilidae	111
Hydroptila	39
Ithytrichia clavata	1
Mayatrichia	1
Lepidostomatidae	
Lepidostoma	1
Leptoceridae	18
Nectopsyche	34
Oecetis	17
Triaenodes	1
Ylodes	5
Limnephilidae	21
Grammotaulius	7
Limnephilus	167
Onocosmoecus unicolor	1
Philopotamidae	2
Chimarra	49
Polycentropodidae	
Neureclipsis bimaculata	1
Polycentropus	18
Psychomyiidae	1
Psychomyia	11
Rhyacophilidae	
Rhyacophila sibirica group a	1
Malacostraca	
Amphipoda	
Gammaridae	
Gammarus lacustris	10
Hyalellidae	
Hyalella azteca	1397

Taxonomic list, continued.

Taxon	Count
Decapoda	

Cambaridae	61
Orconectes	1
Orconectes virilis	2
Maxillopoda, subclass copepoda	11
Ostracoda	441
Chordata	
Actinopterygii	576
Amphibia	
Anura	15
Bufonidae	1
Mollusca	
Bivalvia	4
Veneroida	
Pisidiidae	24
Pisidium	418
Sphaerium	60
Gastropoda	
Basommatophora	
Ancylidae	
Ferrissia rivularis	1
Lymnaeidae	112
Stagnicola	31
Physidae	
Physella	1998
Planorbidae	80
Gyraulus	20
Helisoma anceps	4
Nemata	2
Platyhelminthes	
Turbellaria	2
	---------
189 Taxa	23942 individuals

Methods and results for 2 aquatic macroinvertebrate samples taken at station
CORRALC-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 750

Sample results

Total OTU taxa richness:	24	EPT OTU taxa richness:	1
Total abundance:	750	EPT abundance:	9
Number of unique Orders:	6	Number of unique families:	13
Dominant family: Several		Contribution of dominant family:	49.2%
Number of long-lived taxa:	8	Number of clinger taxa:	0
Shannon:	2.066	Evenness:	0.449

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	24	12	750
Insects:	22	12	394
Coleoptera:	9	7	111
Diptera:	10	3	198
Ephemeroptera:	0	0	0
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	1	1	75
Plecoptera:	0	0	0
Trichoptera:	1	0	9
Annelida:	0	0	0
Crustacea:	0	0	0
Mollusca:	0	0	0

Functional feeding groups:	OTU's	Abundance
Shredders:	5	65
Scrapers:	0	0
Collector-gatherers:	7	149
Collector-filterers:	1	26
Predators:	9	148

Biotic Indices

Hilsenhoff Biotic Condition Index: 1.79
Area sampled does not appear to be organically enriched.
USFS Community Tolerance Quotient (CTQd): 85

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	2	8.3%	Tolerant taxa abundance:	98	13.1%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
HANGING-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1192

Sample results

Total OTU taxa richness:	37	EPT OTU taxa richness:	1
Total abundance:	1192	EPT abundance:	3
Number of unique Orders:	8	Number of unique families:	24
Dominant family: Physidae		Contribution of dominant family:	36.8%
Number of long-lived taxa:	10	Number of clinger taxa:	0
Shannon:	2.021	Evenness:	0.586

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	37	19	1192
Insects:	33	17	557
Coleoptera:	8	5	30
Diptera:	14	6	391
Ephemeroptera:	1	1	3
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	4	2	59
Plecoptera:	0	0	0
Trichoptera:	0	0	0
Annelida:	1	0	6
Crustacea:	1	1	187
Mollusca:	1	1	439

Functional feeding groups:	OTU's	Abundance
Shredders:	6	23
Scrapers:	0	0
Collector-gatherers:	12	992
Collector-filterers:	2	5
Predators:	14	169

Biotic Indices

Hilsenhoff Biotic Condition Index: 3.86

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 100

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	5	13.5%	Tolerant taxa abundance:	378	31.7%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
OTTERC-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1805

Sample results

Total OTU taxa richness:	41	EPT OTU taxa richness:	9
Total abundance:	1805	EPT abundance:	457
Number of unique Orders:	12	Number of unique families:	22
Dominant family: Simuliidae		Contribution of dominant family:	48.4%
Number of long-lived taxa:	12	Number of clinger taxa:	0
Shannon:	1.903	Evenness:	0.455

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	41	22	1805
Insects:	34	20	1607
Coleoptera:	8	5	76
Diptera:	5	1	911
Ephemeroptera:	3	3	8
Hemiptera:	0	0	0
Megaloptera:	1	1	2
Odonata:	5	2	13
Plecoptera:	0	0	0
Trichoptera:	6	4	449
Annelida:	1	0	2
Crustacea:	1	1	163
Mollusca:	2	1	26

Functional feeding groups:	OTU's	Abundance
Shredders:	5	116
Scrapers:	0	0
Collector-gatherers:	11	225
Collector-filterers:	4	1316
Predators:	16	76

Biotic Indices

Hilsenhoff Biotic Condition Index: 4.99

Area sampled appears to be organically enriched.

USFS Community Tolerance Quotient (CTQd): 101

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	5	12.2%	Tolerant taxa abundance:	176	9.8%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
PRAIRIE-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1564

Sample results

Total OTU taxa richness:	51	EPT OTU taxa richness:	22
Total abundance:	1564	EPT abundance:	1258
Number of unique Orders:	12	Number of unique families:	22
Dominant family: Baetidae		Contribution of dominant family:	48.5%
Number of long-lived taxa:	13	Number of clinger taxa:	0
Shannon:	2.472	Evenness:	0.436

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	51	26	1564
Insects:	44	24	1503
Coleoptera:	10	7	51
Diptera:	9	2	162
Ephemeroptera:	11	6	884
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	2	1	30
Plecoptera:	1	1	3
Trichoptera:	10	6	371
Annelida:	1	0	4
Crustacea:	1	1	1
Mollusca:	2	1	3

Functional feeding groups:	OTU's	Abundance
Shredders:	5	16
Scrapers:	3	50
Collector-gatherers:	19	1028
Collector-filterers:	5	329
Predators:	11	95

Biotic Indices

Hilsenhoff Biotic Condition Index: 3.30

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 77

Intolerant taxa:	9	17.6%	Intolerant taxa abundance:	356	22.8%
Tolerant taxa:	2	3.9%	Tolerant taxa abundance:	41	2.6%

Methods and results for 2 aquatic macroinvertebrate samples taken at station PRAIRIE-02 between 28 October 1999 and 25 April 2005. Abundance data are presented as the number individuals collected. Taxa richness and relative abundance by tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI). Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera + Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 2076

Sample results

Total OTU taxa richness:	50	EPT OTU taxa richness:	14
Total abundance:	2076	EPT abundance:	711
Number of unique Orders:	12	Number of unique families:	27
Dominant family: Chironomidae		Contribution of dominant family:	30.3%
Number of long-lived taxa:	13	Number of clinger taxa:	0
Shannon:	2.831	Evenness:	0.647

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	50	26	2076
Insects:	41	22	1727
Coleoptera:	7	6	258
Diptera:	10	2	711
Ephemeroptera:	6	3	189
Hemiptera:	0	0	0
Megaloptera:	1	1	3
Odonata:	4	2	13
Plecoptera:	0	0	0
Trichoptera:	8	5	522
Annelida:	1	0	92
Crustacea:	1	1	1
Mollusca:	6	3	235

Functional feeding groups:	OTU's	Abundance
Shredders:	7	64
Scrapers:	2	4
Collector-gatherers:	13	1090
Collector-filterers:	10	545
Predators:	11	132

Biotic Indices

Hilsenhoff Biotic Condition Index: 3.62

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 99

Intolerant taxa:	4	8.0%	Intolerant taxa abundance:	36	1.7%
Tolerant taxa:	2	4.0%	Tolerant taxa abundance:	69	3.3%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
ROSEBUD-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 868

Sample results

Total OTU taxa richness:	36	EPT OTU taxa richness:	5
Total abundance:	868	EPT abundance:	47
Number of unique Orders:	12	Number of unique families:	24
Dominant family: Chironomidae		Contribution of dominant family:	29.8%
Number of long-lived taxa:	6	Number of clinger taxa:	0
Shannon:	2.375	Evenness:	0.614

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	36	18	868
Insects:	28	14	684
Coleoptera:	3	1	33
Diptera:	16	7	591
Ephemeroptera:	1	1	1
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	3	1	12
Plecoptera:	0	0	0
Trichoptera:	4	3	46
Annelida:	3	1	129
Crustacea:	1	1	6
Mollusca:	3	2	48

Functional feeding groups:	OTU's	Abundance
Shredders:	3	29
Scrapers:	0	0
Collector-gatherers:	13	414
Collector-filterers:	3	118
Predators:	15	298

Biotic Indices

Hilsenhoff Biotic Condition Index: 4.62

Area sampled appears to be organically enriched.

USFS Community Tolerance Quotient (CTQd): 99

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	4	11.1%	Tolerant taxa abundance:	91	10.5%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
SPRING-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 605

Sample results

Total OTU taxa richness:	36	EPT OTU taxa richness:	4
Total abundance:	605	EPT abundance:	129
Number of unique Orders:	10	Number of unique families:	22
Dominant family: Chironomidae		Contribution of dominant family:	24.6%
Number of long-lived taxa:	9	Number of clinger taxa:	0
Shannon:	2.384	Evenness:	0.579

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	36	20	605
Insects:	28	16	374
Coleoptera:	10	7	48
Diptera:	12	5	192
Ephemeroptera:	0	0	0
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	1	0	3
Plecoptera:	0	0	0
Trichoptera:	4	3	129
Annelida:	2	1	7
Crustacea:	1	1	54
Mollusca:	3	2	145

Functional feeding groups:	OTU's	Abundance
Shredders:	6	138
Scrapers:	0	0
Collector-gatherers:	10	215
Collector-filterers:	4	156
Predators:	12	79

Biotic Indices

Hilsenhoff Biotic Condition Index: 3.32

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 96

Intolerant taxa:	1	2.8%	Intolerant taxa abundance:	1	0.2%
Tolerant taxa:	3	8.3%	Tolerant taxa abundance:	68	11.2%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
SQUIRREL01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1273

Sample results

Total OTU taxa richness:	44	EPT OTU taxa richness:	7
Total abundance:	1273	EPT abundance:	184
Number of unique Orders:	11	Number of unique families:	26
Dominant family: Chironomidae		Contribution of dominant family:	40.1%
Number of long-lived taxa:	14	Number of clinger taxa:	0
Shannon:	2.632	Evenness:	0.586

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	44	21	1273
Insects:	35	18	1018
Coleoptera:	11	8	62
Diptera:	11	4	757
Ephemeroptera:	3	2	168
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	4	2	11
Plecoptera:	0	0	0
Trichoptera:	4	2	16
Annelida:	0	0	0
Crustacea:	1	1	71
Mollusca:	4	2	59

Functional feeding groups:	OTU's	Abundance
Shredders:	5	33
Scrapers:	3	7
Collector-gatherers:	13	761
Collector-filterers:	3	107
Predators:	12	243

Biotic Indices

Hilsenhoff Biotic Condition Index: 4.84
Area sampled appears to be organically enriched.
USFS Community Tolerance Quotient (CTQd): 91

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	5	11.4%	Tolerant taxa abundance:	189	14.8%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
SQUIRREL02 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1564

Sample results

Total OTU taxa richness:	26	EPT OTU taxa richness:	2
Total abundance:	1564	EPT abundance:	29
Number of unique Orders:	7	Number of unique families:	16
Dominant family: Chironomidae		Contribution of dominant family:	80.2%
Number of long-lived taxa:	7	Number of clinger taxa:	0
Shannon:	1.336	Evenness:	0.458

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	26	14	1564
Insects:	24	13	1505
Coleoptera:	6	4	33
Diptera:	13	6	1411
Ephemeroptera:	0	0	0
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	2	2	29
Plecoptera:	0	0	0
Trichoptera:	2	1	29
Annelida:	0	0	0
Crustacea:	0	0	0
Mollusca:	1	1	58

Functional feeding groups:	OTU's	Abundance
Shredders:	5	33
Scrapers:	0	0
Collector-gatherers:	6	1302
Collector-filterers:	2	7
Predators:	11	218

Biotic Indices

Hilsenhoff Biotic Condition Index: 6.92

Area sampled appears to be organically enriched.

USFS Community Tolerance Quotient (CTQd): 102

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	3	11.5%	Tolerant taxa abundance:	1025	65.5%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
TONGUE-01 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1448

Sample results

Total OTU taxa richness:	67	EPT OTU taxa richness:	24
Total abundance:	1448	EPT abundance:	405
Number of unique Orders:	12	Number of unique families:	37
Dominant family: Elmidae		Contribution of dominant family:	17.7%
Number of long-lived taxa:	17	Number of clinger taxa:	0
Shannon:	3.312	Evenness:	0.710

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	67	44	1448
Insects:	56	37	942
Coleoptera:	11	8	264
Diptera:	8	3	156
Ephemeroptera:	14	10	281
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	4	3	17
Plecoptera:	1	1	1
Trichoptera:	9	6	123
Annelida:	1	1	1
Crustacea:	2	2	131
Mollusca:	6	4	369

Functional feeding groups:	OTU's	Abundance
Shredders:	6	67
Scrapers:	3	38
Collector-gatherers:	22	817
Collector-filterers:	8	144
Predators:	18	114

Biotic Indices

Hilsenhoff Biotic Condition Index: 2.95

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 91

Intolerant taxa:	8	11.9%	Intolerant taxa abundance:	55	3.8%
Tolerant taxa:	3	4.5%	Tolerant taxa abundance:	186	12.8%

Methods and results for 2 aquatic macroinvertebrate samples taken at station TONGUE-02 between 28 October 1999 and 25 April 2005. Abundance data are presented as the number individuals collected. Taxa richness and relative abundance by tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI). Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera + Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1349

Sample results

Total OTU taxa richness:	44	EPT OTU taxa richness:	13
Total abundance:	1349	EPT abundance:	635
Number of unique Orders:	12	Number of unique families:	30
Dominant family: Leptohyphidae		Contribution of dominant family:	26.9%
Number of long-lived taxa:	10	Number of clinger taxa:	0
Shannon:	2.544	Evenness:	0.524

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	44	26	1349
Insects:	35	20	945
Coleoptera:	6	6	20
Diptera:	8	3	198
Ephemeroptera:	8	5	485
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	3	0	9
Plecoptera:	0	0	0
Trichoptera:	5	3	150
Annelida:	1	0	1
Crustacea:	3	3	23
Mollusca:	4	3	318

Functional feeding groups:	OTU's	Abundance
Shredders:	5	63
Scrapers:	2	32
Collector-gatherers:	17	905
Collector-filterers:	5	154
Predators:	11	178

Biotic Indices

Hilsenhoff Biotic Condition Index: 1.97
Area sampled does not appear to be organically enriched.
USFS Community Tolerance Quotient (CTQd): 96

Intolerant taxa:	2	4.5%	Intolerant taxa abundance:	5	0.4%
Tolerant taxa:	4	9.1%	Tolerant taxa abundance:	57	4.2%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
TONGUE-03 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1424

Sample results

Total OTU taxa richness:	45	EPT OTU taxa richness:	24
Total abundance:	1424	EPT abundance:	1106
Number of unique Orders:	9	Number of unique families:	20
Dominant family: Baetidae		Contribution of dominant family:	40.0%
Number of long-lived taxa:	6	Number of clinger taxa:	0
Shannon:	2.679	Evenness:	0.599

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	45	26	1424
Insects:	42	24	1405
Coleoptera:	6	4	47
Diptera:	7	2	211
Ephemeroptera:	12	8	880
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	0	0	0
Plecoptera:	0	0	0
Trichoptera:	12	7	226
Annelida:	0	0	0
Crustacea:	0	0	0
Mollusca:	2	2	13

Functional feeding groups:	OTU's	Abundance
Shredders:	4	71
Scrapers:	4	32
Collector-gatherers:	15	987
Collector-filterers:	9	250
Predators:	6	38

Biotic Indices

Hilsenhoff Biotic Condition Index: 3.38
Area sampled appears to be slightly organically enriched.
USFS Community Tolerance Quotient (CTQd): 90

Intolerant taxa:	4	8.9%	Intolerant taxa abundance:	17	1.2%
Tolerant taxa:	1	2.2%	Tolerant taxa abundance:	76	5.3%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
TONGUE-04 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1445

Sample results

Total OTU taxa richness:	53	EPT OTU taxa richness:	25
Total abundance:	1445	EPT abundance:	963
Number of unique Orders:	12	Number of unique families:	27
Dominant family: Leptohyphidae		Contribution of dominant family:	24.3%
Number of long-lived taxa:	9	Number of clinger taxa:	0
Shannon:	2.861	Evenness:	0.549

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	53	32	1445
Insects:	47	28	1298
Coleoptera:	8	4	157
Diptera:	6	2	90
Ephemeroptera:	16	12	728
Hemiptera:	1	0	1
Megaloptera:	0	0	0
Odonata:	2	0	43
Plecoptera:	0	0	0
Trichoptera:	9	7	235
Annelida:	0	0	0
Crustacea:	1	1	69
Mollusca:	4	3	67

Functional feeding groups:	OTU's	Abundance
Shredders:	5	54
Scrapers:	7	66
Collector-gatherers:	18	874
Collector-filterers:	6	213
Predators:	8	83

Biotic Indices

Hilsenhoff Biotic Condition Index: 3.11

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 88

Intolerant taxa:	5	9.4%	Intolerant taxa abundance:	25	1.7%
Tolerant taxa:	3	5.7%	Tolerant taxa abundance:	116	8.0%

Methods and results for 2 aquatic macroinvertebrate samples taken at station YOUNGSC-01 between 28 October 1999 and 25 April 2005. Abundance data are presented as the number individuals collected. Taxa richness and relative abundance by tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI). Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera + Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1294

Sample results

Total OTU taxa richness:	38	EPT OTU taxa richness:	10
Total abundance:	1294	EPT abundance:	251
Number of unique Orders:	11	Number of unique families:	23
Dominant family: Physidae		Contribution of dominant family:	30.0%
Number of long-lived taxa:	10	Number of clinger taxa:	0
Shannon:	2.324	Evenness:	0.612

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	38	23	1294
Insects:	31	19	751
Coleoptera:	6	4	114
Diptera:	10	4	361
Ephemeroptera:	5	4	204
Hemiptera:	0	0	0
Megaloptera:	1	1	1
Odonata:	3	2	8
Plecoptera:	0	0	0
Trichoptera:	5	4	47
Annelida:	1	0	1
Crustacea:	1	0	12
Mollusca:	4	4	516

Functional feeding groups:	OTU's	Abundance
Shredders:	3	3
Scrapers:	1	3
Collector-gatherers:	11	855
Collector-filterers:	8	247
Predators:	10	75

Biotic Indices

Hilsenhoff Biotic Condition Index: 2.91

Area sampled appears to be slightly organically enriched.

USFS Community Tolerance Quotient (CTQd): 96

Intolerant taxa:	2	5.3%	Intolerant taxa abundance:	14	1.1%
Tolerant taxa:	3	7.9%	Tolerant taxa abundance:	98	7.6%

Methods and results for 2 aquatic macroinvertebrate samples taken at station
YOUNGSC-02 between 28 October 1999 and 25 April 2005. Abundance data are presented
as the number individuals collected. Taxa richness and relative abundance by
tolerance and intolerance to pollution based on Hilsenhoff Biotic Index (HBI).
Intolerant taxa are those taxa given a HBI score of 0, 1, or 2. Tolerant taxa are
those taxa given a HBI score of 8, 9, or 10. ***.* = <0.1%. EPT = Ephemeroptera +
Plecoptera + Trichoptera. OTU = operational taxonomic unit.

Field and laboratory methods

Area sampled (square meters): Unknown Invertebrates identified: 1775

Sample results

Total OTU taxa richness:	38	EPT OTU taxa richness:	6
Total abundance:	1775	EPT abundance:	483
Number of unique Orders:	11	Number of unique families:	21
Dominant family: Baetidae		Contribution of dominant family:	25.0%
Number of long-lived taxa:	9	Number of clinger taxa:	0
Shannon:	2.542	Evenness:	0.602

Richness and abundances for taxonomic groups

	OTU's	Genera	Abundance
All taxa groups:	38	14	1775
Insects:	29	10	1093
Coleoptera:	6	3	110
Diptera:	11	3	410
Ephemeroptera:	4	2	464
Hemiptera:	0	0	0
Megaloptera:	0	0	0
Odonata:	3	0	5
Plecoptera:	0	0	0
Trichoptera:	2	1	19
Annelida:	1	0	5
Crustacea:	2	1	388
Mollusca:	5	3	282

Functional feeding groups:	OTU's	Abundance
Shredders:	3	55
Scrapers:	0	0
Collector-gatherers:	12	1108
Collector-filterers:	7	294
Predators:	13	238

Biotic Indices

Hilsenhoff Biotic Condition Index: 4.25
Area sampled appears to be organically enriched.
USFS Community Tolerance Quotient (CTQd): 98

Intolerant taxa:	0	0.0%	Intolerant taxa abundance:	0	0.0%
Tolerant taxa:	3	7.9%	Tolerant taxa abundance:	367	20.7%

Taxonomic list and abundances of aquatic invertebrates collected 23 July 2004 at station TONGUE-01, Tongue River near Hanging Woman Creek, Rosebud County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124091. The percentage of the sample that was identified and retained was 19% of the collected sample. A total of 786 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	11	
Class: Insecta					
Coleoptera	Dytiscidae	Hygrotus	adult	5	
Coleoptera	Elmidae		larvae	5	I
Coleoptera	Elmidae	Dubiraphia	larvae	5	
Coleoptera	Elmidae	Dubiraphia vittata	adult	11	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	48	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	123	
Coleoptera	Elmidae	Stenelmis calida	adult	5	
Coleoptera	Elmidae	Stenelmis calida	larvae	76	
Coleoptera	Haliplidae	Haliplus	adult	5	
Coleoptera	Hydrophilidae		larvae	16	I
Coleoptera	Hydrophilidae	Berosus	larvae	5	
Diptera	Ceratopogonidae		pupae	5	
Diptera	Chironomidae	Chironominae	larvae	149	
Diptera	Chironomidae	Orthocladiinae	larvae	59	
Diptera	Chironomidae	Tanypodinae	larvae	69	
Diptera	Culicidae	Anopheles	larvae	5	
Diptera	Simuliidae	Simulium	larvae	101	
Ephemeroptera			larvae	32	D
Ephemeroptera	Baetidae		larvae	75	I,D
Ephemeroptera	Baetidae	Acentrella	larvae	16	
Ephemeroptera	Baetidae	Baetis	larvae	37	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	85	
Ephemeroptera	Baetidae	Plauditus	larvae	43	
Ephemeroptera	Heptageniidae	Rhithrogena	larvae	5	
Ephemeroptera	Leptohyphidae	Asioplax	larvae	5	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	64	
Ephemeroptera	Leptophlebiidae		larvae	59	D
Ephemeroptera	Leptophlebiidae	Choroterpes	larvae	5	
Heteroptera	Corixidae		larvae	283	I
Heteroptera	Corixidae	Sigara	adult	29	
Heteroptera	Corixidae	Trichocorixa	adult	21	
Heteroptera	Gerridae		larvae	5	
Heteroptera	Gerridae	Metrobates	adult	5	
Heteroptera	Naucoridae	Ambrysus	exuvia	21	
Heteroptera	Naucoridae	Ambrysus	larvae	25	
Heteroptera	Notonectidae		larvae	11	I
Heteroptera	Notonectidae	Notonecta	adult	6	
Heteroptera	Veliidae	Rhagovelia	adult	5	
Heteroptera	Veliidae	Rhagovelia	larvae	5	
Odonata	Aeshnidae	Anax junius	larvae	2	
Odonata	Coenagrionidae		larvae	59	I
Odonata	Gomphidae	Ophiogomphus	larvae	6	I
Plecoptera	Perlidae	Acroneuria	larvae	1	
Trichoptera	Hydropsychidae		larvae	11	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	16	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124091.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Notes				
Trichoptera	Hydropsychidae	Hydropsyche	larvae	88
Trichoptera	Hydroptilidae	Hydroptila	larvae	16
Trichoptera	Philopotamidae	Chimarra	larvae	87
Trichoptera	Rhyacophilidae	Rhyacophila sibirica group a	larvae	5
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	adult	506
Phylum: Mollusca				
Class: Gastropoda				
Basommatophora	Lymnaeidae		adult	437
I				
Basommatophora	Lymnaeidae	Stagnicola	adult	131
Basommatophora	Physidae	Physella	adult	631
Basommatophora	Planorbidae		adult	400
I				
Basommatophora	Planorbidae	Gyraulus	adult	85

Total: 52 taxa				4032
individuals				

Taxonomic list and abundances of aquatic invertebrates collected 23 July 2004 at station TONGUE-01, Tongue River near Hanging Woman Creek, Rosebud County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124092. The percentage of the sample that was identified and retained was 53% of the collected sample. A total of 662 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Clitellata					
Rhynchobdellida	Glossiphoniidae	Theromyzon rude	adult	3	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	3	
Class: Insecta					
Coleoptera	Dryopidae	Helichus	adult	3	
Coleoptera	Elmidae	Dubiraphia	larvae	37	
Coleoptera	Elmidae	Dubiraphia vittata	adult	56	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	28	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	223	
Coleoptera	Elmidae	Ordobrevia nubifera	adult	17	
Coleoptera	Elmidae	Ordobrevia nubifera	larvae	147	
Diptera	Ceratopogonidae	Probezzia	larvae	3	
Diptera	Chironomidae		pupae	3	
Diptera	Chironomidae	Chironominae	larvae	58	
Diptera	Chironomidae	Orthocladiinae	larvae	40	
Diptera	Chironomidae	Tanypodinae	larvae	89	
Diptera	Simuliidae	Simulium	larvae	18	
Ephemeroptera	Baetidae		larvae	9	D
Ephemeroptera	Baetidae	Acentrella	larvae	28	
Ephemeroptera	Baetidae	Baetis	larvae	17	
Ephemeroptera	Baetidae	Camelobaetidius similis	larvae	5	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	76	
Ephemeroptera	Baetidae	Plauditus	larvae	70	
Ephemeroptera	Heptageniidae		larvae	3	I
Ephemeroptera	Heptageniidae	Rhithrogena	larvae	5	
Ephemeroptera	Leptohyphidae	Asioplax	larvae	10	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	187	
Ephemeroptera	Leptophlebiidae		larvae	79	I,D
Ephemeroptera	Polymitarcyidae	Ephoron	larvae	10	
Heteroptera	Naucoridae	Ambrysus	larvae	33	
Odonata	Calopterygidae	Hetaerina americana	larvae	5	
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	5	
Trichoptera	Glossosomatidae		larvae	3	U
Trichoptera	Hydropsychidae		larvae	15	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	15	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	96	
Trichoptera	Hydroptilidae		larvae	5	I
Trichoptera	Philopotamidae	Chimarra	larvae	44	
Class: Malacostraca					
Amphipoda	Gammaridae	Gammarus lacustris	adult	18	
Amphipoda	Hyalellidae	Hyalella azteca	adult	62	
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	3	
Class: Gastropoda					
Basommatophora	Lymnaeidae		adult	15	U
Basommatophora	Physidae	Physella	adult	73	
Basommatophora	Planorbidae		adult	13	U

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124092.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Notes				
Phylum: Platyhelminthes				
Class: Turbellaria			adult	5

Total: 41 taxa				1631
individuals				

Taxonomic list and abundances of aquatic invertebrates collected 28 July 2004 at station TONGUE-02, Tongue River below dam, Bighorn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124093. The percentage of the sample that was identified and retained was 16% of the collected sample. A total of 708 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	153	
Class: Insecta					
Coleoptera	Dytiscidae	Tribe Bidessini	adult	13	U
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	25	
Coleoptera	Elmidae	Ordobrevia nubifera	larvae	1	
Coleoptera	Haliplidae	Haliplus	adult	6	
Coleoptera	Hydrophilidae	Paracymus	adult	6	
Diptera	Ceratopogonidae		larvae	13	I
Diptera	Ceratopogonidae	Probezzia	larvae	6	
Diptera	Chironomidae	Chironominae	larvae	32	
Diptera	Chironomidae	Orthocladiinae	larvae	83	
Diptera	Chironomidae	Tanypodinae	larvae	38	
Diptera	Ephydridae		pupae	51	
Diptera	Ephydridae		larvae	64	
Diptera	Simuliidae	Simulium	larvae	52	
Ephemeroptera	Baetidae		larvae	13	D
Ephemeroptera	Baetidae	Baetis	larvae	290	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	45	
Ephemeroptera	Baetidae	Plauditus	larvae	134	
Ephemeroptera	Ephemerellidae		larvae	6	D
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	1607	
Ephemeroptera	Leptophlebiidae		larvae	6	D
Heteroptera	Corixidae		adult	6	D
Heteroptera	Corixidae		larvae	6	I
Heteroptera	Gerridae		larvae	57	I
Heteroptera	Naucoridae	Ambrysus	adult	4	
Heteroptera	Naucoridae	Ambrysus	larvae	104	
Heteroptera	Notonectidae	Notonecta	larvae	20	I
Odonata	Aeshnidae		larvae	1	I
Odonata	Coenagrionidae		larvae	39	I
Odonata	Libellulidae		larvae	1	U
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	19	
Trichoptera	Hydroptilidae	Hydroptila	larvae	76	
Class: Malacostraca					
Amphipoda	Gammaridae	Gammarus lacustris	adult	7	
Amphipoda	Hyalellidae	Hyalella azteca	adult	114	
Decapoda	Cambaridae	Orconectes virilis	adult	2	
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	19	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124093.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Class: Gastropoda					
	Basommatophora	Lymnaeidae		adult	38
U	Basommatophora	Physidae	Physella	adult	1062
	Basommatophora	Planorbidae	Gyraulus	adult	19

Total: 36 taxa					4238
individuals					

Taxonomic list and abundances of aquatic invertebrates collected 28 July 2004 at station TONGUE-02, Tongue River below dam, Bighorn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124094. The percentage of the sample that was identified and retained was 13% of the collected sample. A total of 641 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	11	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	409	
Class: Insecta					
Coleoptera	Elmidae	Dubiraphia	larvae	11	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	108	
Diptera	Chironomidae	Chironominae	larvae	280	
Diptera	Chironomidae	Orthocladiinae	larvae	462	
Diptera	Chironomidae	Tanypodinae	larvae	258	
Diptera	Simuliidae	Simulium	larvae	538	
Diptera	Tipulidae	Tipula	larvae	1	
Ephemeroptera	Baetidae	Baetis	larvae	333	
Ephemeroptera	Baetidae	Diphetor hageni	larvae	54	
Ephemeroptera	Baetidae	Plauditus	larvae	22	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	1058	
Ephemeroptera	Leptophlebiidae		larvae	32	D
Heteroptera	Naucoridae	Ambrysus	larvae	126	I
Heteroptera	Naucoridae	Ambrysus	adult	34	
Lepidoptera	Pyralidae	Petrophila	adult	97	
Trichoptera	Hydropsychidae		larvae	194	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	712	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	22	
Trichoptera	Hydroptilidae		larvae	430	I,U
Trichoptera	Hydroptilidae	Hydroptila	larvae	75	
Class: Malacostraca					
Amphipoda	Gammaridae	Gammarus lacustris	adult	11	
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	11	
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	1473	
Basommatophora	Planorbidae	Gyraulus	adult	11	

Total: 25 taxa				6770 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 27 July 2004 at station TONGUE-03, Tongue River near bridge, Bighorn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124095. The percentage of the sample that was identified and retained was 9% of the collected sample. A total of 759 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	21	
Class: Insecta					
Coleoptera	Elmidae	Dubiraphia	larvae	117	
Coleoptera	Elmidae	Dubiraphia vittata	adult	11	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	32	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	11	
Coleoptera	Elmidae	Ordobrevia nubifera	larvae	32	
Diptera			larvae	11	U
Diptera	Ceratopogonidae	Probezzia	larvae	11	
Diptera	Chironomidae	Chironominae	larvae	267	
Diptera	Chironomidae	Orthocladiinae	larvae	21	
Diptera	Chironomidae	Tanypodinae	larvae	107	
Diptera	Simuliidae	Simulium	larvae	353	
Ephemeroptera	Baetidae		larvae	1046	I,D
Ephemeroptera	Baetidae	Acentrella	larvae	245	
Ephemeroptera	Baetidae	Baetis	larvae	1686	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	715	
Ephemeroptera	Baetidae	Plauditus	larvae	181	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	1954	
Ephemeroptera	Leptophlebiidae		larvae	47	D
Heteroptera	Corixidae		adult	43	U
Heteroptera	Corixidae		larvae	288	I
Heteroptera	Corixidae	Sigara	adult	64	
Heteroptera	Naucoridae	Ambrysus	adult	12	
Trichoptera	Hydropsychidae		larvae	96	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	11	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	193	
Trichoptera	Hydroptilidae		larvae	192	
Trichoptera	Hydroptilidae	Ithytrichia clavata	larvae	11	
Trichoptera	Leptoceridae		larvae	11	I
Trichoptera	Leptoceridae	Oecetis	larvae	11	
Trichoptera	Philopotamidae	Chimarra	larvae	12	
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	96	

Total: 30 taxa				7907 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 27 July 2004 at station TONGUE-03, Tongue River near bridge, Bighorn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124096. The percentage of the sample that was identified and retained was 6% of the collected sample. A total of 665 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	86	
Class: Insecta					
Coleoptera	Elmidae		larvae	86	I
Coleoptera	Elmidae	Dubiraphia	larvae	129	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	215	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	65	
Coleoptera	Elmidae	Stenelmis calida	larvae	108	
Diptera			larvae	22	U
Diptera	Chironomidae		pupae	108	
Diptera	Chironomidae	Chironominae	larvae	1097	
Diptera	Chironomidae	Orthocladiinae	larvae	860	
Diptera	Chironomidae	Tanypodinae	larvae	344	
Diptera	Simuliidae	Simulium	larvae	538	
Ephemeroptera	Baetidae		larvae	667	I
Ephemeroptera	Baetidae	Acentrella	larvae	108	
Ephemeroptera	Baetidae	Baetis	larvae	2817	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	624	
Ephemeroptera	Baetidae	Plauditus	larvae	237	
Ephemeroptera	Heptageniidae		larvae	43	I
Ephemeroptera	Leptohyphidae		adult	43	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	2238	
Ephemeroptera	Leptophlebiidae		larvae	129	I,D
Ephemeroptera	Leptophlebiidae	Choroterpes	larvae	22	
Ephemeroptera	Leptophlebiidae	Traverella	larvae	22	
Ephemeroptera	Polymitarcyidae	Ephoron	larvae	22	
Heteroptera	Saldidae		adult	22	U
Lepidoptera	Pyralidae	Petrophila	larvae	22	
Trichoptera			pupae	22	
Trichoptera	Hydropsychidae		larvae	817	I
Trichoptera	Hydropsychidae		larvae	22	
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	387	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	1519	
Trichoptera	Hydroptilidae		pupae	22	
Trichoptera	Hydroptilidae	Hydroptila	larvae	323	
Trichoptera	Leptoceridae	Oecetis	larvae	22	
Trichoptera	Philopotamidae		larvae	43	I
Trichoptera	Philopotamidae	Chimarra	larvae	89	
Trichoptera	Polycentropodidae	Neureclipsis bimaculata	larvae	22	R1
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Sphaerium	adult	4	
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	22	

Total: 37 taxa				13978	individuals

Taxonomic list and abundances of aquatic invertebrates collected 26 July 2004 at station TONGUE-04, Tongue River at State Line, Bighorn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124097. The percentage of the sample that was identified and retained was 6% of the collected sample. A total of 684 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	48	
Class: Insecta					
Coleoptera	Curculionidae		adult	16	
Coleoptera	Elmidae		larvae	32	I
Coleoptera	Elmidae	Dubiraphia	larvae	288	
Coleoptera	Elmidae	Dubiraphia vittata	adult	96	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	128	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	16	
Coleoptera	Elmidae	Stenelmis calida	larvae	80	
Coleoptera	Hydrophilidae		larvae	48	I
Diptera			larvae	16	U
Diptera	Ceratopogonidae	Probezzia	larvae	16	
Diptera	Chironomidae	Chironominae	larvae	80	
Diptera	Chironomidae	Orthocladiinae	larvae	768	
Diptera	Sciomyzidae		larvae	16	
Diptera	Simuliidae	Simulium	larvae	144	
Ephemeroptera	Baetidae		larvae	128	I,D
Ephemeroptera	Baetidae	Acentrella	larvae	80	
Ephemeroptera	Baetidae	Baetis	larvae	1073	
Ephemeroptera	Baetidae	Camelobaetidius similis	larvae	16	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	1025	
Ephemeroptera	Baetidae	Plauditus	larvae	256	U
Ephemeroptera	Baetidae	Plauditus punctiventris	larvae	32	
Ephemeroptera	Heptageniidae		larvae	80	D
Ephemeroptera	Leptohyphidae	Asioplax	larvae	16	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	1569	
Ephemeroptera	Leptophlebiidae		larvae	49	D
Ephemeroptera	Leptophlebiidae	Choroterpes	larvae	48	
Ephemeroptera	Leptophlebiidae	Neochoroterpes	larvae	16	
Ephemeroptera	Polymitarcyidae	Ephoron	larvae	16	
Hemiptera			larvae	16	I
Heteroptera	Corixidae		larvae	320	
Heteroptera	Corixidae		adult	32	U
Heteroptera	Corixidae	Sigara	adult	96	
Heteroptera	Corixidae	Trichocorixa	adult	176	
Heteroptera	Notonectidae		larvae	1	I
Lepidoptera	Pyralidae	Petrophila	larvae	16	
Odonata	Coenagrionidae		larvae	567	U,D
Odonata	Gomphidae		larvae	1	I
Trichoptera	Helicopsychidae	Helicopsyche borealis	larvae	16	
Trichoptera	Hydropsychidae		larvae	80	
Trichoptera	Hydropsychidae		pupae	16	
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	64	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	642	
Trichoptera	Hydroptilidae		larvae	160	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124097.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Notes				
Trichoptera	Hydroptilidae	Mayatrichia	larvae	16
Trichoptera	Leptoceridae	Nectopsyche	larvae	160
Trichoptera	Leptoceridae	Oecetis	larvae	64
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	adult	1057
Phylum: Mollusca				
Class: Gastropoda				
Basommatophora	Lymnaeidae	Stagnicola	adult	64
Basommatophora	Physidae	Physella	adult	884

Total: 47 taxa				10644
individuals				

Taxonomic list and abundances of aquatic invertebrates collected 26 July 2004 at station TONGUE-04, Tongue River at State Line, Bighorn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124098. The percentage of the sample that was identified and retained was 6% of the collected sample. A total of 761 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Arthropoda				
	Class: Arachnida				
	Trombidiformes			adult	172
	Class: Insecta				
	Coleoptera	Elmidae	Dubiraphia	larvae	323
	Coleoptera	Elmidae	Dubiraphia vittata	adult	43
	Coleoptera	Elmidae	Microcylloepus pusillus	adult	151
	Coleoptera	Elmidae	Microcylloepus pusillus	larvae	1226
	Coleoptera	Elmidae	Ordobrevia nubifera	larvae	520
	Coleoptera	Elmidae	Stenelmis calida	adult	108
	Diptera	Chironomidae	Orthocladiinae	larvae	409
	Diptera	Simuliidae	Simulium	larvae	129
	Ephemeroptera	Baetidae	Acentrella	larvae	172
	Ephemeroptera	Baetidae	Baetis	larvae	2454
	Ephemeroptera	Baetidae	Fallceon quilleri	larvae	452
	Ephemeroptera	Baetidae	Plauditus	larvae	753
	Ephemeroptera	Ephemeridae	Ephemera	larvae	22
D	Ephemeroptera	Heptageniidae		larvae	22
	Ephemeroptera	Heptageniidae	Stenonema	larvae	22
	Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	5237
D	Ephemeroptera	Leptophlebiidae		larvae	237
	Ephemeroptera	Leptophlebiidae	Choroterpes	larvae	22
	Ephemeroptera	Polymitarcyidae	Ephoron	larvae	24
	Lepidoptera	Pyralidae	Petrophila	larvae	65
I	Trichoptera	Hydropsychidae		larvae	430
	Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	603
	Trichoptera	Hydropsychidae	Hydropsyche	larvae	1692
I	Trichoptera	Hydroptilidae		larvae	108
	Trichoptera	Leptoceridae	Oecetis	larvae	194
	Trichoptera	Philopotamidae	Chimarra	larvae	108
	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	43
	Phylum: Mollusca				
	Class: Bivalvia				
	Veneroida	Pisidiidae	Sphaerium	adult	4
	Class: Gastropoda				
	Basommatophora	Lymnaeidae		adult	22

	Total: 29 taxa				15761 individuals

Taxonomic list and abundances of aquatic invertebrates collected 15 July 2004 at station OTTERC-01, Otter Creek, Rosebud County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124099. The percentage of the sample that was identified and retained was 38% of the collected sample. A total of 818 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Clitellata					
Arhynchobdellida	Erpobdellidae		adult	3	U
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	3	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	3	I
Coleoptera	Elmidae	Dubiraphia vittata	adult	3	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	3	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	21	
Coleoptera	Elmidae	Ordobrevia nubifera	larvae	5	
Coleoptera	Helophoridae	Helophorus	adult	3	
Diptera	Chironomidae		pupae	24	
Diptera	Chironomidae	Chironominae	larvae	5	
Diptera	Chironomidae	Tanypodinae	larvae	19	
Diptera	Simuliidae	Simulium	larvae	1022	
Ephemeroptera	Baetidae	Callibaetis	larvae	12	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	3	
Heteroptera	Corixidae		larvae	109	I
Heteroptera	Corixidae		adult	46	U
Heteroptera	Corixidae	Sigara	adult	124	
Heteroptera	Corixidae	Trichocorixa	adult	5	
Heteroptera	Gerridae		larvae	5	I
Heteroptera	Gerridae	Aquarius	adult	3	
Heteroptera	Naucoridae	Ambrysus	larvae	53	
Heteroptera	Naucoridae	Ambrysus	adult	2	
Megaloptera	Sialidae	Sialis	larvae	3	U
Odonata	Aeshnidae		larvae	1	I
Odonata	Calopterygidae	Hetaerina americana	larvae	7	
Odonata	Coenagrionidae		larvae	13	I
Odonata	Coenagrionidae	Argia	larvae	1	D
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	127	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	14	
Trichoptera	Polycentropodidae	Polycentropus	larvae	5	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	397	
Phylum: Chordata					
Class: Actinopterygii			larvae	7	U
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Lymnaeidae		adult	3	U
Basommatophora	Physidae	Physella	adult	64	

Total: 31 taxa				2118 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 15 July 2004 at station OTTERC-01, Otter Creek, Rosebud County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124100. The percentage of the sample that was identified and retained was 13% of the collected sample. A total of 987 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Clitellata					
Arhynchobdellida	Erpobdellidae		adult	1	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	11	
Class: Entognatha					
Collembola			adult	11	
Class: Insecta					
Coleoptera	Elmidae		exuvia	22	
Coleoptera	Elmidae	Dubiraphia	larvae	54	
Coleoptera	Elmidae	Dubiraphia vittata	adult	11	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	54	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	356	
Coleoptera	Elmidae	Stenelmis calida	adult	11	
Coleoptera	Elmidae	Stenelmis calida	larvae	151	
Diptera	Chironomidae		pupae	32	
Diptera	Chironomidae	Chironominae	larvae	32	
Diptera	Chironomidae	Orthocladiinae	larvae	67	
Diptera	Chironomidae	Tanypodinae	larvae	44	
Diptera	Simuliidae	Simulium	larvae	5070	
Ephemeroptera	Caenidae	Caenis	larvae	11	U
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	11	
Heteroptera	Corixidae		adult	11	G
Heteroptera	Naucoridae	Ambrysus	larvae	36	
Heteroptera	Naucoridae	Ambrysus	adult	1	
Megaloptera	Sialidae	Sialis	larvae	1	U
Odonata	Coenagrionidae	Argia emma	larvae	3	
Trichoptera	Hydropsychidae		larvae	1056	I
Trichoptera	Hydropsychidae		pupae	1	
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	2352	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	149	
Trichoptera	Hydroptilidae		larvae	22	I
Trichoptera	Hydroptilidae	Hydroptila	larvae	12	
Trichoptera	Polycentropodidae	Polycentropus	larvae	11	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	58	
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	11	
Total: 27 taxa				9672 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 21 July 2004 at station CEDARC-01, Cedar Creek, Dawson County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124101. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 326 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	1	
Class: Insecta					
Coleoptera	Curculionidae		adult	13	
Coleoptera	Dytiscidae		larvae	1	I
Coleoptera	Dytiscidae	Tribe Bidessini	adult	3	U
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	1	
Coleoptera	Elmidae	Stenelmis calida	adult	1	
Coleoptera	Haliplidae	Haliplus	adult	1	
Coleoptera	Helophoridae	Helophorus	adult	2	
Coleoptera	Hydrophilidae	Berosus	adult	1	
Diptera			pupae	1	U
Diptera	Ceratopogonidae		larvae	1	I
Diptera	Chironomidae	Chironominae	larvae	75	
Diptera	Chironomidae	Orthocladiinae	larvae	33	
Diptera	Chironomidae	Tanypodinae	larvae	3	
Diptera	Culicidae		larvae	2	I,U
Ephemeroptera	Baetidae		larvae	7	I
Ephemeroptera	Baetidae	Callibaetis	larvae	1	
Ephemeroptera	Baetidae	Pseudocloeon	larvae	12	
Ephemeroptera	Caenidae	Caenis	larvae	3	
Heteroptera	Corixidae		larvae	1	I
Heteroptera	Corixidae	Hesperocorixa	adult	1	
Heteroptera	Corixidae	Sigara	adult	45	
Heteroptera	Gerridae		larvae	1	I
Heteroptera	Gerridae	Aquarius	adult	5	
Heteroptera	Notonectidae	Notonecta	adult	1	
Odonata	Coenagrionidae		larvae	58	I,U,D
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	1	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	12	
Phylum: Chordata					
Class: Actinopterygii			adulte	14	U
Class: Amphibia					
Anura	Bufonidae		larvae	1	U
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	14	

Total: 31 taxa				326	

individuals

Taxonomic list and abundances of aquatic invertebrates collected 21 July 2004 at station CEDARC-01, Cedar Creek, Dawson County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124102. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 165 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Dytiscidae		adult	1	U
Coleoptera	Dytiscidae	Agabus	adult	1	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	1	
Coleoptera	Helophoridae	Helophorus	adult	1	
Coleoptera	Hydraenidae	Ochthebius	adult	4	
Diptera	Ceratopogonidae		larvae	3	
Diptera	Ceratopogonidae	Probezzia	larvae	7	
Diptera	Chironomidae	Chironominae	larvae	11	
Diptera	Chironomidae	Orthocladiinae	larvae	67	
Diptera	Chironomidae	Tanypodinae	larvae	15	
Diptera	Tabanidae		larvae	1	I
Ephemeroptera	Baetidae		larvae	9	U
Ephemeroptera	Caenidae	Caenis	larvae	31	
Heteroptera	Corixidae		adult	4	U
Heteroptera	Corixidae	Sigara	adult	5	
Heteroptera	Corixidae	Trichocorixa	adult	1	
Odonata	Coenagrionidae		larvae	3	I
Odonata	Libellulidae		larvae	1	I
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	4	
Phylum: Chordata					
Class: Actinopterygii			eggvae	22	
Class: Amphibia					
Anura			adult	3	U
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	3	
Total: 22 taxa				222 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 20 July 2004 at station CEDARC-02, Cedar Creek, Dawson County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124103. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 223 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	1	
Class: Insecta					
Coleoptera	Gyrinidae	Gyrinus	adult	1	
Coleoptera	Haliplidae	Haliplus	adult	4	
Diptera	Chironomidae	Chironominae	larvae	1	
Diptera	Chironomidae	Orthocladiinae	larvae	27	
Ephemeroptera	Baetidae		larvae	3	I
Ephemeroptera	Baetidae	Pseudocloeon	larvae	4	
Ephemeroptera	Caenidae	Caenis	larvae	4	
Heteroptera	Corixidae		adult	5	U
Heteroptera	Corixidae		larvae	1	I
Heteroptera	Corixidae	Sigara	adult	46	
Heteroptera	Corixidae	Trichocorixa	adult	2	
Odonata	Aeshnidae	Aeshna	larvae	1	U
Odonata	Coenagrionidae		larvae	59	I,U
Odonata	Lestidae	Lestes	larvae	1	U
Odonata	Libellulidae		larvae	1	I
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	35	
Phylum: Chordata					
Class: Actinopterygii			adult	7	U
Class: Amphibia					
Anura			larvae	6	U,D
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	14	

Total: 19 taxa				223 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 20 July 2004 at station CEDARC-02, Cedar Creek, Dawson County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124104. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 70 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Dytiscidae		larvae	1	U
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	1	
Coleoptera	Helophoridae	Helophorus	adult	1	
Coleoptera	Hydraenidae	Ochthebius	adult	1	
Coleoptera	Hydrophilidae	Berosus	adult	3	
Diptera	Chironomidae		pupae	1	
Diptera	Chironomidae	Chironominae	larvae	8	
Diptera	Chironomidae	Orthocladiinae	larvae	3	
Diptera	Chironomidae	Tanypodinae	larvae	5	
Diptera	Simuliidae	Simulium	larvae	1	
Ephemeroptera	Caenidae	Caenis	larvae	36	
Heteroptera	Corixidae	Trichocorixa	adult	1	
Odonata	Coenagrionidae		larvae	1	I
Odonata	Libellulidae		larvae	1	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	1	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	9	
Phylum: Chordata					
Class: Actinopterygii			adult	5	U
Class: Amphibia					
Anura			larvae	9	U,D
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	1	

Total: 19 taxa				94	

individuals

Taxonomic list and abundances of aquatic invertebrates collected 25 August 2004 at station CEDARC-03, Cedar Creek, Dawson County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124105. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 702 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Clitellata					
Arhynchobdellida	Erpobdellidae		adult	6	U
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Curculionidae		adult	1	
Coleoptera	Dytiscidae	Laccophilus maculosus	adult	1	
Coleoptera	Dytiscidae	Tribe Bidessini	adult	1	U
Diptera	Ceratopogonidae	Probezzia	larvae	2	
Diptera	Chaoboridae		pupae	10	
Diptera	Chaoboridae	Chaoborus	larvae	11	
Diptera	Chironomidae		pupae	1	
Diptera	Chironomidae	Chironominae	larvae	19	
Diptera	Chironomidae	Orthocladiinae	larvae	14	
Diptera	Chironomidae	Tanypodinae	larvae	72	
Ephemeroptera	Baetidae	Callibaetis	larvae	10	
Ephemeroptera	Caenidae	Caenis	larvae	71	
Heteroptera	Corixidae		adult	1	U
Heteroptera	Corixidae	Sigara	adult	13	
Heteroptera	Corixidae	Trichocorixa	adult	2	
Heteroptera	Gerridae		larvae	8	I
Heteroptera	Gerridae	Aquarius	adult	5	
Heteroptera	Notonectidae	Notonecta	adult	2	
Odonata	Aeshnidae	Aeshna	larvae	2	I
Odonata	Coenagrionidae		larvae	23	I,D
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	134	
Phylum: Chordata					
Class: Actinopterygii			adult	238	U
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	55	

Total: 24 taxa				702	

individuals

Taxonomic list and abundances of aquatic invertebrates collected 25 August 2004 at station CEDARC-03, Cedar Creek, Dawson County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124106. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 409 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Clitellata					
Arhynchobdellida	Erpobdellidae	Dina parva	adult	1	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	3	
Class: Insecta					
Coleoptera	Haliplidae	Haliplus	adult	1	
Coleoptera	Haliplidae	Peltodytes	larvae	1	
Coleoptera	Helophoridae	Helophorus	adult	1	
Coleoptera	Hydraenidae	Ochthebius	adult	1	
Diptera	Chironomidae	Chironominae	larvae	23	
Diptera	Chironomidae	Orthocladiinae	larvae	20	
Diptera	Chironomidae	Tanypodinae	larvae	16	
Ephemeroptera	Baetidae		larvae	15	U
Ephemeroptera	Caenidae	Caenis	larvae	284	
Heteroptera	Corixidae		larvae	3	I
Heteroptera	Corixidae	Sigara	adult	1	
Heteroptera	Gerridae		larvae	4	I
Odonata	Coenagrionidae		larvae	22	I,D
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	69	
Phylum: Chordata					
Class: Actinopterygii			adult	40	U
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	44	
Total: 18 taxa				550 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 18 August 2004 at station CEDARC-04, Cedar Creek, Dawson County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124107. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 405 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Annelida				
	Class: Clitellata				
	Arhynchobdellida	Erpobdellidae	Erpobdella punctata	adult	1
	Phylum: Arthropoda				
	Class: Arachnida				
	Trombidiformes			adult	4
	Class: Insecta				
	Coleoptera	Curculionidae		adult	2
	Coleoptera	Hydrophilidae	Paracymus	adult	1
	Diptera	Chironomidae		pupae	2
	Diptera	Chironomidae	Chironominae	larvae	13
	Diptera	Chironomidae	Tanypodinae	larvae	12
	Diptera	Tabanidae		larvae	1
I	Ephemeroptera	Baetidae		larvae	3
D	Ephemeroptera	Caenidae	Caenis	exuvia	1
	Ephemeroptera	Caenidae	Caenis	larvae	37
I,U	Heteroptera	Corixidae		adult	2
U	Heteroptera	Corixidae	Sigara	adult	8
	Heteroptera	Corixidae	Trichocorixa	adult	1
	Heteroptera	Gerridae		larvae	6
I	Heteroptera	Gerridae	Aquarius	adult	5
	Heteroptera	Notonectidae	Notonecta	adult	41
	Odonata	Coenagrionidae		larvae	11
U,I,D	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	41
	Phylum: Chordata				
	Class: Actinopterygii			adult	185
I,U	Phylum: Mollusca				
	Class: Gastropoda				
	Basommatophora	Physidae	Physella	adult	28

	Total: 20 taxa				405
individuals					

Taxonomic list and abundances of aquatic invertebrates collected 18 August 2004 at station CEDARC-04, Cedar Creek, Dawson County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124108. The percentage of the sample that was identified and retained was 63% of the collected sample. A total of 673 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum:			adult	2	
Phylum: Annelida					
Class: Clitellata					
Arhynchobdellida	Erpobdellidae	Erpobdella punctata	adult	1	
Class: Oligochaeta			adult	2	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	4	
Class: Insecta					
Coleoptera	Dytiscidae	Oreodytes	larvae	2	
Diptera	Ceratopogonidae	Probezzia	larvae	4	
Diptera	Chironomidae		pupae	22	
Diptera	Chironomidae	Chironominae	larvae	47	
Diptera	Chironomidae	Orthocladiinae	larvae	17	
Diptera	Chironomidae	Tanypodinae	larvae	141	
Ephemeroptera	Baetidae		larvae	6	I
Ephemeroptera	Baetidae	Baetis	larvae	2	
Ephemeroptera	Baetidae	Callibaetis	larvae	84	
Ephemeroptera	Caenidae	Caenis	exuvia	30	
Ephemeroptera	Caenidae	Caenis	larvae	829	
Heteroptera	Corixidae		adult	4	U
Heteroptera	Corixidae		larvae	4	
Heteroptera	Corixidae	Sigara	adult	25	
Heteroptera	Gerridae		larvae	2	
Heteroptera	Notonectidae	Notonecta	adult	17	
Odonata	Aeshnidae	Aeshna	larvae	2	U
Odonata	Coenagrionidae		larvae	47	I,D
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	97	
Phylum: Chordata					
Class: Actinopterygii			adult	6	I
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	38	

Total: 23 taxa				1438	individuals

Taxonomic list and abundances of aquatic invertebrates collected 22 July 2004 at station CEDARC-05, Cedar Creek, Dawson County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124109. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 383 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	2	
Phylum: Arthropoda					
Class: Entognatha					
Collembola			adult	15	
Class: Insecta					
Coleoptera	Curculionidae		adult	1	
Coleoptera	Dytiscidae		larvae	2	I
Coleoptera	Dytiscidae	Tribe Bidessini	adult	3	
Coleoptera	Elmidae		larvae	1	D
Coleoptera	Haliplidae	Haliplus	adult	1	
Coleoptera	Haliplidae	Peltodytes	adult	1	
Coleoptera	Hydraenidae	Ochthebius	adult	1	
Diptera	Ceratopogonidae		pupae	1	
Diptera	Chironomidae		pupae	23	
Diptera	Chironomidae	Chironominae	larvae	47	
Diptera	Chironomidae	Orthocladiinae	larvae	32	
Diptera	Chironomidae	Tanypodinae	larvae	4	
Diptera	Simuliidae	Simulium	larvae	4	
Ephemeroptera	Baetidae		larvae	103	D
Ephemeroptera	Baetidae	Pseudocloeon	larvae	1	
Ephemeroptera	Caenidae	Caenis	exuvia	1	
Ephemeroptera	Caenidae	Caenis	larvae	43	
Heteroptera	Corixidae		adult	2	U
Heteroptera	Corixidae		larvae	3	I
Heteroptera	Corixidae	Sigara	adult	11	
Heteroptera	Corixidae	Trichocorixa	adult	2	
Heteroptera	Gerridae		larvae	12	I
Heteroptera	Gerridae	Aquarius	adult	1	
Heteroptera	Notonectidae	Notonecta	adult	1	
Heteroptera	Saldidae		larvae	1	U
Odonata	Aeshnidae	Aeshna	larvae	1	I
Odonata	Coenagrionidae		larvae	8	I
Odonata	Lestidae	Lestes	larvae	1	D
Trichoptera	Lepidostomatidae	Lepidostoma	larvae	1	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	19	
Phylum: Chordata					
Class: Actinopterygii			adult	27	I
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	7	
Total: 32 taxa				------ 383 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 22 July 2004 at station CEDARC-05, Cedar Creek, Dawson County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124110. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 154 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Annelida				
	Class: Oligochaeta			adult	1
	Phylum: Arthropoda				
	Class: Insecta				
	Coleoptera	Curculionidae		adult	1
	Coleoptera	Dytiscidae	Tribe Bidessini	adult	4
U	Diptera			pupae	1
U	Diptera	Ceratopogonidae		larvae	3
I	Diptera	Ceratopogonidae	Probezzia	larvae	5
	Diptera	Chironomidae		pupae	5
	Diptera	Chironomidae	Chironominae	larvae	27
	Diptera	Chironomidae	Orthocladiinae	larvae	43
	Diptera	Chironomidae	Tanypodinae	larvae	17
	Diptera	Simuliidae	Simulium	larvae	4
	Ephemeroptera	Baetidae	Baetis	larvae	13
	Ephemeroptera	Caenidae	Caenis	larvae	47
	Heteroptera	Corixidae		larvae	4
I	Heteroptera	Corixidae	Sigara	adult	3
	Heteroptera	Corixidae	Trichocorixa	adult	3
	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	23
	Phylum: Mollusca				
	Class: Gastropoda				
	Basommatophora	Physidae	Physella	adult	1

	Total: 18 taxa				207 individuals

Taxonomic list and abundances of aquatic invertebrates collected 24 June 2004 at station YOUNGSC-01, Youngs Creek - Upper, Bighorn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124167. The percentage of the sample that was identified and retained was 50% of the collected sample. A total of 630 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	1	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	6	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	4	I
Coleoptera	Elmidae	Dubiraphia	larvae	63	
Coleoptera	Elmidae	Dubiraphia vittata	adult	18	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	4	
Coleoptera	Gyrinidae	Gyrinus	adult	2	
Coleoptera	Helophoridae	Helophorus	adult	2	
Diptera	Chironomidae	Chironominae	larvae	41	
Diptera	Chironomidae	Orthocladiinae	larvae	144	
Diptera	Chironomidae	Tanypodinae	larvae	2	
Diptera	Dixidae	Dixa	larvae	2	
Diptera	Simuliidae	Simulium	larvae	36	
Diptera	Tipulidae	Dicranota	larvae	2	
Ephemeroptera	Baetidae	Baetis	larvae	292	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	4	
Ephemeroptera	Caenidae	Caenis	larvae	2	
Ephemeroptera	Heptageniidae		larvae	6	D
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	2	
Heteroptera	Gerridae		larvae	30	I
Megaloptera	Sialidae	Sialis	larvae	2	U
Odonata	Coenagrionidae		larvae	6	I
Odonata	Gomphidae	Ophiogomphus	larvae	2	I
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	4	
Trichoptera	Limnephilidae	Onocosmoecus unicolor	larvae	1	
Class: Malacostraca					
Decapoda	Cambaridae		adult	10	I
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	26	
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	528	
Total: 28 taxa				1242 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 24 June 2004 at station YOUNGSC-01, Youngs Creek - Upper, Bighorn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124168. The percentage of the sample that was identified and retained was 13% of the collected sample. A total of 664 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	122	
Class: Insecta					
Coleoptera	Elmidae	Dubiraphia	larvae	656	
Coleoptera	Elmidae	Dubiraphia vittata	adult	56	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	22	
Coleoptera	Gyrinidae	Gyrinus	larvae	1	
Diptera			larvae	11	I
Diptera	Chironomidae		pupae	13	
Diptera	Chironomidae	Chironominae	larvae	758	
Diptera	Chironomidae	Orthocladiinae	larvae	926	
Diptera	Chironomidae	Tanypodinae	larvae	224	
Diptera	Dixidae	Dixa	larvae	11	
Diptera	Simuliidae		pupae	67	
Diptera	Simuliidae	Simulium	larvae	556	
Diptera	Tipulidae	Dicranota	larvae	60	
Diptera	Tipulidae	Tipula	larvae	1	
Ephemeroptera	Baetidae	Baetis	larvae	533	
Odonata	Coenagrionidae		larvae	1	U
Odonata	Coenagrionidae	Argia	larvae	22	I
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	122	
Trichoptera	Hydropsychidae		larvae	144	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	133	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	1	
Class: Malacostraca					
Decapoda	Cambaridae		adult	57	I
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	1235	
Veneroida	Pisidiidae	Sphaerium	adult	13	
Class: Gastropoda					
Basommatophora	Ancylidae	Ferrissia rivularis	adult	11	
Basommatophora	Physidae	Physella	adult	1368	
Total: 27 taxa				7125 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 23 June 2004 at station YOUNGSC-02, Youngs Creek - Lower, Sheridan County, Wyoming. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124169. The percentage of the sample that was identified and retained was 44% of the collected sample. A total of 917 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	5	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	7	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	7	I
Coleoptera	Dytiscidae		adult	2	U
Coleoptera	Dytiscidae	Agabus	larvae	9	
Coleoptera	Elmidae	Dubiraphia	larvae	37	
Coleoptera	Elmidae	Dubiraphia vittata	adult	5	
Coleoptera	Hydrophilidae		larvae	7	I
Diptera	Ceratopogonidae		pupae	53	
Diptera	Ceratopogonidae	Probezzia	larvae	2	
Diptera	Chironomidae		pupae	18	
Diptera	Chironomidae	Chironominae	larvae	48	
Diptera	Chironomidae	Orthocladiinae	larvae	62	
Diptera	Chironomidae	Tanypodinae	larvae	103	
Diptera	Ephydridae		larvae	2	
Diptera	Simuliidae		pupae	2	
Diptera	Simuliidae	Simulium	larvae	167	
Diptera	Tipulidae		pupae	2	
Ephemeroptera			adult	2	D
Ephemeroptera	Baetidae		larvae	16	D
Ephemeroptera	Baetidae	Baetis	larvae	580	
Ephemeroptera	Caenidae	Caenis	larvae	16	
Ephemeroptera	Caenidae	Caenis	exuvia	7	
Heteroptera	Corixidae		adult	7	U
Heteroptera	Corixidae		larvae	98	
Heteroptera	Gerridae		exuvia	2	
Heteroptera	Gerridae		larvae	57	I
Heteroptera	Gerridae	Aquarius	adult	2	
Odonata			larvae	5	D
Odonata	Aeshnidae		larvae	2	I
Odonata	Coenagrionidae		larvae	5	D
Trichoptera	Hydropsychidae		larvae	5	I
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	2	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	405	
Decapoda	Cambaridae		adult	33	I
Phylum: Mollusca					
Class: Bivalvia			adult	5	U
Veneroida	Pisidiidae	Pisidium	adult	96	
Class: Gastropoda					

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124169.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Basommatophora	Lymnaeidae		adult	11	I,U
Basommatophora	Physidae	Physella	adult	187	
Total: 35 taxa				------ 2081	

individuals

Taxonomic list and abundances of aquatic invertebrates collected 23 June 2004 at station YOUNGSC-02, Youngs Creek - Lower, Sheridan County, Wyoming. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124170. The percentage of the sample that was identified and retained was 56% of the collected sample. A total of 858 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Annelida				
	Class: Oligochaeta			adult	6
	Phylum: Arthropoda				
	Class: Arachnida				
	Trombidiformes			adult	10
	Class: Insecta				
I	Coleoptera	Dytiscidae		larvae	10
	Coleoptera	Dytiscidae	Agabus	larvae	32
	Coleoptera	Elmidae	Dubiraphia	larvae	103
	Coleoptera	Elmidae	Dubiraphia vittata	adult	47
	Coleoptera	Helophoridae	Helophorus	adult	2
U	Diptera	Ceratopogonidae		larvae	15
	Diptera	Ceratopogonidae	Probezzia	larvae	47
	Diptera	Chironomidae		pupae	17
	Diptera	Chironomidae	Chironominae	larvae	12
	Diptera	Chironomidae	Orthocladiinae	larvae	62
	Diptera	Chironomidae	Tanypodinae	larvae	164
	Diptera	Simuliidae	Simulium	larvae	190
	Diptera	Tipulidae	Dicranota	larvae	2
	Ephemeroptera	Baetidae	Baetis	larvae	440
I,U	Ephemeroptera	Caenidae	Caenis	larvae	25
U	Heteroptera	Corixidae		adult	12
I	Heteroptera	Gerridae		larvae	12
I	Trichoptera	Hydropsychidae		larvae	17
	Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	21
	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	375
I	Decapoda	Cambaridae		adult	71
	Phylum: Mollusca				
	Class: Bivalvia				
	Veneroida	Pisidiidae	Pisidium	adult	179
	Veneroida	Pisidiidae	Sphaerium	adult	13
	Class: Gastropoda				
	Basommatophora	Physidae	Physella	adult	173

	Total: 26 taxa				2058 individuals

Taxonomic list and abundances of aquatic invertebrates collected 25 June 2004 at station PRAIRIE-01, Prairie Dog Creek - Upper, Sheridan County, Wyoming. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124171. The percentage of the sample that was identified and retained was 19% of the collected sample. A total of 739 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	16	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	48	
Class: Entognatha					
Collembola			adult	5	
Class: Insecta					
Coleoptera	Curculionidae		adult	5	
Coleoptera	Elmidae	Dubiraphia	larvae	21	
Coleoptera	Elmidae	Dubiraphia vittata	adult	17	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	16	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	5	
Coleoptera	Elmidae	Optioservus	larvae	11	
Coleoptera	Elmidae	Stenelmis calida	larvae	5	
Coleoptera	Elmidae	Zaitzevia parvula	larvae	5	
Coleoptera	Gyrinidae	Gyrinus	adult	5	
Coleoptera	Hydrophilidae		larvae	11	I
Coleoptera	Hydrophilidae	Paracymus	adult	5	
Diptera			larvae	5	I
Diptera	Ceratopogonidae		pupae	5	
Diptera	Chironomidae		pupae	123	
Diptera	Chironomidae	Chironominae	larvae	156	
Diptera	Chironomidae	Orthocladiinae	larvae	225	
Diptera	Chironomidae	Tanypodinae	larvae	5	
Diptera	Simuliidae	Simulium	larvae	5	
Diptera	Tipulidae		pupae	5	
Ephemeroptera	Baetidae		larvae	69	I,D
Ephemeroptera	Baetidae	Acentrella	larvae	240	
Ephemeroptera	Baetidae	Baetis	larvae	1101	
Ephemeroptera	Baetidae	Centroptilum	larvae	245	
Ephemeroptera	Baetidae	Plauditus	larvae	32	
Ephemeroptera	Ephemerellidae		larvae	43	I,D
Ephemeroptera	Ephemerellidae	Ephemerella	larvae	5	U
Ephemeroptera	Ephemerellidae	Ephemerella aurivillii	larvae	22	
Ephemeroptera	Heptageniidae		larvae	193	D
Ephemeroptera	Leptohyphidae		adult	5	
Ephemeroptera	Leptohyphidae	Tricorythodes	exuvia	21	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	101	
Heteroptera	Naucoridae	Ambrysus	larvae	1	
Heteroptera	Naucoridae	Ambrysus	adult	1	
Odonata	Gomphidae		larvae	21	I
Odonata	Gomphidae	Ophiogomphus	larvae	31	U

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124171.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Plecoptera	Pteronarcyidae	Pteronarcella badia	larvae	5	
Trichoptera			pupae	6	D
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	598	
Trichoptera	Hydropsychidae		adult	5	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	37	
Trichoptera	Leptoceridae		larvae	85	I
Trichoptera	Leptoceridae	Nectopsyche	larvae	27	
Trichoptera	Leptoceridae	Oecetis	larvae	5	
Trichoptera	Leptoceridae	Ylodes	larvae	27	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	5	
Phylum: Chordata					
Class: Actinopterygii			adult	99	I
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	5	
Class: Gastropoda					
Basommatophora	Lymnaeidae		adult	11	I

Total: 48 taxa				3755	individuals

Taxonomic list and abundances of aquatic invertebrates collected 25 June 2004 at station PRAIRIE-01, Prairie Dog Creek - Upper, Sheridan County, Wyoming. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124172. The percentage of the sample that was identified and retained was 50% of the collected sample. A total of 825 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	1	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	60	
Class: Insecta					
Coleoptera	Elmidae	Dubiraphia	larvae	3	
Coleoptera	Elmidae	Dubiraphia vittata	adult	3	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	31	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	33	
Coleoptera	Elmidae	Optioservus	larvae	6	
Coleoptera	Elmidae	Stenelmis calida	larvae	3	
Coleoptera	Elmidae	Zaitzevia parvula	adult	3	
Coleoptera	Elmidae	Zaitzevia parvula	larvae	3	
Diptera	Ceratopogonidae	Probezzia	larvae	6	
Diptera	Chironomidae		pupae	39	
Diptera	Chironomidae	Chironominae	larvae	25	
Diptera	Chironomidae	Orthocladiinae	larvae	89	
Diptera	Chironomidae	Tanypodinae	larvae	6	
Ephemeroptera	Baetidae		larvae	25	I,D
Ephemeroptera	Baetidae	Acentrella	larvae	185	
Ephemeroptera	Baetidae	Baetis	larvae	990	
Ephemeroptera	Baetidae	Plauditus	larvae	6	
Ephemeroptera	Ephemerellidae		larvae	10	D
Ephemeroptera	Ephemerellidae	Ephemerella	larvae	11	U
Ephemeroptera	Ephemerellidae	Ephemerella aurivillii	larvae	71	
Ephemeroptera	Heptageniidae		larvae	3	D
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	38	
Odonata	Gomphidae		larvae	26	I
Odonata	Gomphidae	Ophiogomphus	larvae	3	U
Plecoptera	Pteronarcyidae	Pteronarcella badia	larvae	6	
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	344	
Trichoptera	Hydropsychidae		pupae	1	
Trichoptera	Hydropsychidae		larvae	8	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	113	
Trichoptera	Leptoceridae		larvae	3	I
Trichoptera	Leptoceridae	Nectopsyche	larvae	3	
Trichoptera	Leptoceridae	Oecetis	larvae	3	
Trichoptera	Psychomyiidae		larvae	3	D
Trichoptera	Psychomyiidae	Psychomyia	larvae	29	
Total: 33 taxa				2188 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 22 June 2004 at station HANGING-01, Hanging Woman Creek, Big Horn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124173. The percentage of the sample that was identified and retained was 25% of the collected sample. A total of 617 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	16	
Phylum: Arthropoda					
Class: Entognatha					
Collembola			adult	12	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	36	I,U
Coleoptera	Haliplidae		larvae	4	I
Coleoptera	Haliplidae	Haliplus	larvae	4	
Coleoptera	Haliplidae	Haliplus	adult	16	
Coleoptera	Helophoridae	Helophorus	adult	4	
Coleoptera	Hydraenidae	Ochthebius	adult	4	
Coleoptera	Hydrophilidae		larvae	4	I
Coleoptera	Hydrophilidae	Berosus	larvae	4	
Diptera	Ceratopogonidae		pupae	4	
Diptera	Ceratopogonidae		larvae	28	U
Diptera	Chironomidae		pupae	16	
Diptera	Chironomidae	Chironominae	larvae	340	
Diptera	Chironomidae	Orthocladiinae	larvae	144	
Diptera	Chironomidae	Tanypodinae	larvae	20	
Diptera	Culicidae	Culex	larvae	4	
Diptera	Ephydridae		larvae	16	
Diptera	Sciomyzidae		larvae	13	
Diptera	Tabanidae	Chrysops	larvae	17	
Ephemeroptera	Baetidae	Callibaetis	larvae	12	
Heteroptera	Corixidae		larvae	28	I
Heteroptera	Corixidae	Sigara	adult	8	
Heteroptera	Gerridae		larvae	20	I
Heteroptera	Gerridae	Gerris	adult	4	
Heteroptera	Notonectidae	Notonecta	larvae	180	
Heteroptera	Notonectidae	Notonecta	exuvia	16	
Heteroptera	Notonectidae	Notonecta	adult	1	
Odonata	Aeshnidae		larvae	4	I
Odonata	Coenagrionidae	Enallagma	adult	4	
Odonata	Lestidae	Lestes	larvae	200	U
Odonata	Libellulidae		larvae	4	I
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	658	
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	569	too many snails

Total: 30 taxa				2414	individuals

Taxonomic list and abundances of aquatic invertebrates collected 22 June 2004 at station HANGING-01, Hanging Woman Creek, Big Horn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124174. The percentage of the sample that was identified and retained was 25% of the collected sample. A total of 575 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Annelida				
	Class: Oligochaeta			adult	3
	Phylum: Arthropoda				
	Class: Insecta				
U	Coleoptera	Dytiscidae		larvae	11
	Coleoptera	Haliplidae	Haliplus	larvae	6
	Coleoptera	Helophoridae	Helophorus	adult	11
I	Coleoptera	Hydrophilidae		larvae	28
	Coleoptera	Hydrophilidae	Paracymus	adult	6
U	Diptera	Ceratopogonidae		larvae	22
	Diptera	Chironomidae	Chironominae	larvae	263
	Diptera	Chironomidae	Orthocladiinae	larvae	944
	Diptera	Dixidae	Dixella	larvae	6
	Diptera	Ephydridae		larvae	22
	Diptera	Simuliidae	Simulium	larvae	22
	Diptera	Stratiomyidae	Nemotelus	larvae	6
	Diptera	Stratiomyidae	Stratiomys	larvae	6
I	Diptera	Tabanidae		larvae	21
I	Heteroptera			larvae	6
I	Heteroptera	Corixidae		larvae	17
I	Heteroptera	Notonectidae	Notonecta	larvae	7
	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	108
	Phylum: Mollusca				
	Class: Gastropoda				
	Basommatophora	Physidae	Physella	adult	1632

	Total: 20 taxa				3144 individuals

Taxonomic list and abundances of aquatic invertebrates collected 27 May 2004 at station SPRING-01, Spring Creek, Big Horn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124175. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 359 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Annelida				
	Class: Clitellata				
	Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	adult	1
	Class: Oligochaeta			adult	1
	Phylum: Arthropoda				
	Class: Arachnida				
	Trombidiformes			adult	12
	Class: Insecta				
	Coleoptera	Curculionidae		adult	1
	Coleoptera	Dytiscidae		larvae	10
I	Coleoptera	Dytiscidae	Agabus	adult	1
	Coleoptera	Dytiscidae	Agabus	larvae	5
	Coleoptera	Helophoridae	Helophorus	adult	1
	Coleoptera	Hydrophilidae		larvae	3
I	Coleoptera	Hydrophilidae	Berosus	adult	2
	Coleoptera	Hydrophilidae	Enochrus	adult	1
	Coleoptera	Hydrophilidae	Hydrobius	adult	3
	Coleoptera	Hydrophilidae	Paracymus	adult	7
	Diptera	Ceratopogonidae		pupae	1
	Diptera	Ceratopogonidae	Probezzia	larvae	12
	Diptera	Chironomidae		pupae	3
	Diptera	Chironomidae	Chironominae	larvae	8
	Diptera	Chironomidae	Orthocladiinae	larvae	18
	Diptera	Chironomidae	Tanypodinae	larvae	2
	Diptera	Culicidae		larvae	4
U	Diptera	Culicidae		pupae	10
	Diptera	Stratiomyidae	Caloparyphus	larvae	3
	Diptera	Stratiomyidae	Stratiomys	larvae	1
	Diptera	Tipulidae	Holorusia	larvae	1
R1	Heteroptera	Gerridae	Aquarius	adult	2
	Odonata	Libellulidae		larvae	3
I	Trichoptera	Brachycentridae	Brachycentrus	larvae	1
I	Trichoptera	Limnephilidae		larvae	5
I	Trichoptera	Limnephilidae	Limnephilus	larvae	73
	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	32
	Phylum: Mollusca				
	Class: Bivalvia				
	Veneroida	Pisidiidae	Pisidium	adult	127
	Class: Gastropoda				
	Basommatophora	Lymnaeidae		adult	1
I	Basommatophora	Physidae	Physella	adult	4
	Total: 31 taxa individuals				359

Taxonomic list and abundances of aquatic invertebrates collected 27 May 2004 at station SPRING-01, Spring Creek, Big Horn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124176. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 246 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Clitellata					
Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	adult	7	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	15	
Class: Insecta					
Coleoptera	Dytiscidae	Agabus	larvae	3	
Coleoptera	Helophoridae	Helophorus	adult	4	
Coleoptera	Hydraenidae	Ochthebius	adult	1	
Coleoptera	Hydrophilidae		larvae	3	I
Coleoptera	Hydrophilidae	Enochrus	adult	3	
Coleoptera	Hydrophilidae	Hydrobius	adult	1	
Coleoptera	Hydrophilidae	Paracymus	adult	4	
Diptera	Ceratopogonidae	Probezzia	larvae	3	
Diptera	Chironomidae		pupae	3	
Diptera	Chironomidae	Chironominae	larvae	4	
Diptera	Chironomidae	Orthocladiinae	larvae	154	
Diptera	Chironomidae	Tanypodinae	larvae	3	
Diptera	Simuliidae	Simulium	larvae	1	
Diptera	Stratiomyidae	Caloparyphus	larvae	1	
Diptera	Stratiomyidae	Stratiomys	larvae	3	
Diptera	Tabanidae		larvae	3	I
Diptera	Tipulidae	Holorusia	larvae	4	
Trichoptera	Limnephilidae		larvae	3	I
Trichoptera	Limnephilidae	Limnephilus	larvae	65	
Trichoptera	Polycentropodidae	Polycentropus	larvae	1	
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	31	
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	18	
Phylum: Nemata			adult	3	

Total: 25 taxa				342 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 May 2004 at station SQUIRREL01, Squirrel Creek - Upper, Big Horn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124177. The percentage of the sample that was identified and retained was 22% of the collected sample. A total of 637 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	14	
Class: Entognatha					
Collembola			adult	78	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	69	I
Coleoptera	Dytiscidae	Agabus	larvae	9	
Coleoptera	Dytiscidae	Stictotarsus	adult	5	
Coleoptera	Elmidae	Dubiraphia	larvae	9	
Coleoptera	Helophoridae	Helophorus	adult	18	
Diptera			pupae	9	U
Diptera	Ceratopogonidae		larvae	37	I
Diptera	Ceratopogonidae	Probezzia	larvae	64	
Diptera	Chironomidae		pupae	55	
Diptera	Chironomidae	Chironominae	larvae	466	
Diptera	Chironomidae	Orthocladiinae	larvae	745	
Diptera	Chironomidae	Tanypodinae	larvae	214	
Diptera	Dixidae	Dixa	larvae	5	
Diptera	Ephydridae		larvae	5	U
Diptera	Simuliidae	Simulium	larvae	10	I
Ephemeroptera	Baetidae		larvae	101	U,D
Ephemeroptera	Baetidae	Baetis	larvae	151	
Heteroptera	Corixidae		adult	5	U
Heteroptera	Corixidae		larvae	5	I
Heteroptera	Gerridae		larvae	9	I
Odonata	Aeshnidae		larvae	18	I
Odonata	Coenagrionidae		larvae	9	I
Odonata	Coenagrionidae	Ischnura	larvae	10	U
Trichoptera	Hydroptilidae		larvae	14	I,U
Trichoptera	Limnephilidae		larvae	9	I
Class: Malacostraca					
Amphipoda	Hyalellidae	Hyalella azteca	adult	85	
Class: Maxillopoda, subclass copepoda			adult	50	Spilled & lost
Class: Ostracoda			adult	420	Spilled & lost
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae		adult	23	U

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124177.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Notes				
Class: Gastropoda				
Basommatophora	Physidae	Physella	adult	111
Basommatophora	Planorbidae	Helisoma anceps	adult	3

Total: 32 taxa				2833
individuals				

Taxonomic list and abundances of aquatic invertebrates collected 26 May 2004 at station SQUIRREL01, Squirrel Creek - Upper, Big Horn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124178. The percentage of the sample that was identified and retained was 25% of the collected sample. A total of 636 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Notes				
Phylum: Arthropoda				
Class: Arachnida				
Trombidiformes			adult	11
Class: Insecta				
Coleoptera	Dryopidae	Helichus	adult	6
Coleoptera	Dytiscidae		adult	6
U				
Coleoptera	Dytiscidae	Agabus	larvae	17
Coleoptera	Dytiscidae	Agabus	adult	11
Coleoptera	Elmidae	Dubiraphia	larvae	11
Coleoptera	Elmidae	Dubiraphia vittata	adult	56
Coleoptera	Elmidae	Optioservus	larvae	6
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	6
Coleoptera	Haliplidae	Brychius	adult	11
Coleoptera	Helophoridae	Helophorus	adult	78
Coleoptera	Hydrophilidae	Hydrobius	adult	6
Diptera	Ceratopogonidae		larvae	67
I				
Diptera	Ceratopogonidae	Probezzia	larvae	644
Diptera	Chironomidae	Chironominae	larvae	50
Diptera	Chironomidae	Orthocladiinae	larvae	967
Diptera	Chironomidae	Tanypodinae	larvae	1
Diptera	Psychodidae	Pericoma	larvae	33
Diptera	Simuliidae	Simulium	larvae	461
Ephemeroptera	Baetidae	Baetis	larvae	600
Ephemeroptera	Caenidae	Caenis	larvae	6
Odonata	Coenagrionidae	Argia	larvae	11
D				
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	13
Trichoptera	Hydroptilidae		larvae	17
U				
Trichoptera	Limnephilidae		larvae	17
I				
Trichoptera	Limnephilidae	Limnephilus	larvae	11
Class: Malacostraca				
Amphipoda	Hyalellidae	Hyalella azteca	adult	236
Phylum: Mollusca				
Class: Bivalvia				
Veneroida	Pisidiidae		adult	72
U				
Class: Gastropoda				
Basommatophora	Lymnaeidae		adult	6
U				
Basommatophora	Physidae	Physella	adult	57
Basommatophora	Planorbidae	Helisoma anceps	adult	6

Total: 30 taxa				3496
individuals				

Taxonomic list and abundances of aquatic invertebrates collected 26 May 2004 at station SQUIRREL02, Squirrel Creek - Lower, Big Horn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124179. The percentage of the sample that was identified and retained was 25% of the collected sample. A total of 946 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Insecta					
Coleoptera	Dytiscidae		larvae	65	I
Coleoptera	Dytiscidae	Agabus	larvae	29	
Coleoptera	Elmidae	Dubiraphia	larvae	12	
Coleoptera	Haliplidae	Haliplus	larvae	4	
Coleoptera	Hydrophilidae		larvae	4	I
Diptera	Ceratopogonidae		larvae	32	
Diptera	Ceratopogonidae		larvae	369	I,U
Diptera	Ceratopogonidae	Probezzia	larvae	8	
Diptera	Chironomidae		pupae	44	
Diptera	Chironomidae	Chironominae	larvae	2446	
Diptera	Chironomidae	Orthocladiinae	larvae	229	
Diptera	Chironomidae	Tanypodinae	larvae	48	
Diptera	Dixidae	Dixella	larvae	4	
Diptera	Simuliidae		pupae	12	
Diptera	Simuliidae	Simulium	larvae	12	
Heteroptera	Gerridae		larvae	12	I
Odonata	Lestidae	Lestes	larvae	106	I
Trichoptera	Limnephilidae		larvae	8	I
Trichoptera	Limnephilidae	Limnephilus	larvae	60	
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	157	
Total: 19 taxa				------ 3661 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 26 May 2004 at station SQUIRREL02, Squirrel Creek - Lower, Big Horn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.744 square meters. The sample identification number is 124180. The percentage of the sample that was identified and retained was 9% of the collected sample. A total of 618 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Entognatha					
Collembola			adult	14	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	29	I
Coleoptera	Helophoridae	Helophorus	adult	14	
Diptera			larvae	14	U
Diptera	Ceratopogonidae		larvae	545	U
Diptera	Chironomidae	Chironominae	larvae	5356	
Diptera	Chironomidae	Orthocladiinae	larvae	2513	
Diptera	Simuliidae	Simulium	larvae	14	
Diptera	Tabanidae	Chrysops	larvae	17	
Diptera	Tabanidae	Tabanus	larvae	3	
Diptera	Tipulidae	Holorusia	larvae	3	
Odonata	Coenagrionidae	Amphiagrion abbreviatum	larvae	1	
Trichoptera	Limnephilidae		pupae	1	
Trichoptera	Limnephilidae	Limnephilus	larvae	50	
Phylum: Mollusca					
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	30	

Total: 15 taxa				8605 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 24 May 2004 at station ROSEBUD-01, Rosebud Creek, Bighorn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124181. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 229 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Notes	Order	Family	Subfamily/Genus/species	Life Stage	Abundance
	Phylum: Annelida				
	Class: Clitellata				
R20	Branchiobdellida	Branchiobdellidae		adult	126
	Rhynchobdellida	Glossiphoniidae	Glossiphonia complanata	adult	1
	Class: Oligochaeta			adult	1
	Phylum: Arthropoda				
	Class: Insecta				
I	Coleoptera	Dytiscidae		larvae	4
	Coleoptera	Dytiscidae	Agabus	adult	2
	Coleoptera	Dytiscidae	Agabus	larvae	3
	Diptera	Ceratopogonidae		pupae	4
D	Diptera	Ceratopogonidae		larvae	1
	Diptera	Chironomidae		pupae	2
	Diptera	Chironomidae	Chironominae	larvae	1
	Diptera	Chironomidae	Orthocladiinae	larvae	5
	Diptera	Chironomidae	Tanypodinae	larvae	1
	Diptera	Culicidae		pupae	1
	Diptera	Simuliidae	Simulium	larvae	6
	Diptera	Stratiomyidae	Nemotelus	larvae	1
	Diptera	Stratiomyidae	Stratiomys	larvae	1
	Ephemeroptera	Baetidae	Centroptilum	larvae	1
	Heteroptera	Gerridae	Aquarius	adult	1
I,D	Odonata	Lestidae	Lestes	larvae	6
I	Trichoptera	Limnephilidae		larvae	6
	Trichoptera	Limnephilidae	Grammotaulius	larvae	5
	Trichoptera	Limnephilidae	Limnephilus	larvae	15
	Trichoptera	Polycentropodidae	Polycentropus	larvae	9
	Class: Malacostraca				
	Amphipoda	Hyalellidae	Hyalella azteca	adult	6
	Phylum: Mollusca				
	Class: Bivalvia				
	Veneroida	Pisidiidae	Pisidium	adult	7
	Class: Gastropoda				
I	Basommatophora	Lymnaeidae		adult	3
	Basommatophora	Physidae	Physella	adult	10
	Total: 25 taxa				229 individuals

Taxonomic list and abundances of aquatic invertebrates collected 24 May 2004 at station ROSEBUD-01, Rosebud Creek, Bighorn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124182. The percentage of the sample that was identified and retained was 16% of the collected sample. A total of 639 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	9	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	9	
Class: Insecta					
Coleoptera	Dytiscidae		larvae	89	I
Coleoptera	Dytiscidae		exuvia	9	
Coleoptera	Dytiscidae	Agabus	larvae	53	
Coleoptera	Hydrophilidae		larvae	62	I
Diptera			larvae	18	I
Diptera	Ceratopogonidae		pupae	27	
Diptera	Ceratopogonidae		larvae	1848	
Diptera	Ceratopogonidae	Bezzia	larvae	36	
Diptera	Ceratopogonidae	Probezzia	larvae	107	
Diptera	Chironomidae		pupae	44	
Diptera	Chironomidae	Chironominae	larvae	649	
Diptera	Chironomidae	Orthocladiinae	larvae	1511	
Diptera	Chironomidae	Tanypodinae	larvae	18	
Diptera	Ephydridae		larvae	27	I
Diptera	Psychodidae	Psychoda	larvae	9	
Diptera	Simuliidae	Simulium	larvae	711	
Diptera	Tabanidae	Tabanus	larvae	1	
Diptera	Tipulidae		larvae	36	I
Odonata	Aeshnidae		larvae	9	I
Odonata	Libellulidae		larvae	44	I
Trichoptera	Limnephilidae	Grammotaulius	larvae	10	
Trichoptera	Limnephilidae	Limnephilus	larvae	13	
Trichoptera	Polycentropodidae	Polycentropus	larvae	37	
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae	Pisidium	adult	213	
Class: Gastropoda					
Basommatophora	Lymnaeidae		adult	18	I
Basommatophora	Physidae	Physella	adult	18	
Total: 26 taxa				5633	individuals

Taxonomic list and abundances of aquatic invertebrates collected 25 May 2004 at station CORRALC-01, Corral Creek, Big Horn County, Montana. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124183. The percentage of the sample that was identified and retained was 75% of the collected sample. A total of 668 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	5	
Class: Insecta					
Coleoptera	Curculionidae		adult	5	
Coleoptera	Dytiscidae		adult	1	
Coleoptera	Dytiscidae		larvae	34	I,U
Coleoptera	Dytiscidae	Hygrotus	adult	11	
Coleoptera	Helophoridae	Helophorus	larvae	17	
Coleoptera	Helophoridae	Helophorus	adult	6	
Coleoptera	Hydrophilidae	Berosus	larvae	16	
Coleoptera	Hydrophilidae	Berosus	adult	12	
Coleoptera	Hydrophilidae	Tropisternus	adult	1	
Diptera			pupae	17	U
Diptera	Ceratopogonidae		larvae	9	I
Diptera	Chironomidae		pupae	1	
Diptera	Chironomidae	Chironominae	larvae	31	
Diptera	Chironomidae	Orthocladiinae	larvae	77	
Diptera	Culicidae		larvae	18	I,D
Diptera	Culicidae		pupae	5	
Diptera	Dolichopodidae		larvae	1	
Diptera	Stratiomyidae	Caloparyphus	larvae	58	
Heteroptera	Notonectidae	Notonecta	adult	1	
Odonata	Lestidae	Lestes	larvae	77	I,D
Trichoptera	Hydroptilidae		larvae	12	I
Class: Ostracoda			adult	465	

Total: 19 taxa				885	individuals

Taxonomic list and abundances of aquatic invertebrates collected 25 May 2004 at station CORRALC-01, Corral Creek, Big Horn County, Montana. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124184. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 82 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I – immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U – indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	4	
Class: Insecta					
Coleoptera	Curculionidae		adult	1	
Coleoptera	Dytiscidae		larvae	15	I
Coleoptera	Dytiscidae	Agabus	adult	1	
Coleoptera	Dytiscidae	Agabus	larvae	3	
Coleoptera	Dytiscidae	Hygrotus	adult	4	
Coleoptera	Haliplidae	Haliplus	adult	1	
Coleoptera	Helophoridae	Helophorus	adult	8	
Coleoptera	Hydrophilidae	Berosus	adult	6	
Coleoptera	Hydrophilidae	Enochrus	adult	3	
Diptera	Ceratopogonidae		larvae	1	I
Diptera	Ceratopogonidae		pupae	1	
Diptera	Chironomidae		pupae	1	
Diptera	Chironomidae	Orthocladiinae	larvae	7	
Diptera	Culicidae		larvae	1	U
Diptera	Culicidae		pupae	10	
Diptera	Dolichopodidae		larvae	3	
Diptera	Stratiomyidae	Odontomyia	larvae	4	
Diptera	Stratiomyidae	Stratiomys	larvae	15	
Odonata	Lestidae	Lestes	larvae	22	U
Total: 17 taxa				114 individuals	

Taxonomic list and abundances of aquatic invertebrates collected 30 June 2004 at station PRAIRIE-02, Prairie Dog Creek - Lower, Sheridan County, Wyoming. The sample was collected from multiple habitats using a Kick net. The total area sampled was unspecified. The sample identification number is 124185. The percentage of the sample that was identified and retained was 25% of the collected sample. A total of 929 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals collected in the entire sample. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	352	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	20	
Class: Insecta					
Coleoptera	Dytiscidae	Laccophilus	adult	4	U
Coleoptera	Elmidae	Dubiraphia	adult	48	U
Coleoptera	Elmidae	Dubiraphia	larvae	172	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	80	
Coleoptera	Elmidae	Ordobrevia nubifera	larvae	33	
Coleoptera	Haliplidae	Haliplus	adult	4	
Diptera			pupae	17	U
Diptera	Ceratopogonidae	Probezzia	larvae	92	
Diptera	Chironomidae		pupae	408	
Diptera	Chironomidae	Chironominae	larvae	204	
Diptera	Chironomidae	Orthocladiinae	larvae	696	
Diptera	Chironomidae	Tanypodinae	larvae	52	
Diptera	Simuliidae		pupae	4	
Diptera	Simuliidae	Simulium	larvae	29	
Diptera	Tipulidae		larvae	8	I
Ephemeroptera	Baetidae		larvae	4	D
Ephemeroptera	Baetidae	Baetis	larvae	4	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	52	
Ephemeroptera	Heptageniidae		larvae	12	D
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	265	
Heteroptera	Corixidae		larvae	56	I
Heteroptera	Corixidae	Sigara	adult	37	
Heteroptera	Gerridae		larvae	8	I
Heteroptera	Naucoridae	Ambrysus	adult	8	
Megaloptera	Sialidae	Sialis	larvae	12	U
Odonata	Calopterygidae	Hetaerina americana	larvae	4	
Odonata	Coenagrionidae		larvae	8	I,D
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	9	
Trichoptera	Hydropsychidae		larvae	88	I
Trichoptera	Hydropsychidae	Hydropsyche	larvae	82	
Trichoptera	Hydroptilidae		larvae	16	U
Trichoptera	Leptoceridae	Nectopsyche	larvae	60	
Class: Malacostraca					
Decapoda	Cambaridae	Orconectes	adult	1	U
Phylum: Mollusca					
Class: Bivalvia					
Veneroida	Pisidiidae		adult	24	U
Veneroida	Pisidiidae	Sphaerium	adult	16	

Continuation of the taxonomic list and abundances of aquatic invertebrates for sample number 124185.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance
Notes				
Class: Gastropoda				
Basommatophora	Lymnaeidae		adult	8
U				
Basommatophora	Physidae	Physella	adult	566

Total: 38 taxa				3563
individuals				

Taxonomic list and abundances of aquatic invertebrates collected 30 June 2004 at station PRAIRIE-02, Prairie Dog Creek - Lower, Sheridan County, Wyoming. The sample was collected from riffle habitat using a Surber sampler. The total area sampled was 0.720 square meters. The sample identification number is 124186. The percentage of the sample that was identified and retained was 7% of the collected sample. A total of 1147 individuals were removed, identified and retained. Abundance data are presented as the estimated number of individuals per square meter. Notes - identification to genus or species was not supported because: I - immature organisms, D - damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/species	Life Stage	Abundance	Notes
Phylum: Annelida					
Class: Oligochaeta			adult	40	
Phylum: Arthropoda					
Class: Arachnida					
Trombidiformes			adult	323	
Class: Insecta					
Coleoptera	Elmidae		larvae	486	I
Coleoptera	Elmidae	Dubiraphia	larvae	565	
Coleoptera	Elmidae	Microcylloepus pusillus	larvae	1191	
Coleoptera	Elmidae	Microcylloepus pusillus	adult	141	
Coleoptera	Elmidae	Stenelmis calida	adult	61	
Coleoptera	Elmidae	Stenelmis calida	larvae	1009	
Diptera	Ceratopogonidae		larvae	81	D
Diptera	Ceratopogonidae	Probezzia	larvae	767	
Diptera	Chironomidae		pupae	525	
Diptera	Chironomidae	Chironominae	larvae	323	
Diptera	Chironomidae	Orthocladiinae	larvae	4764	
Diptera	Chironomidae	Tanypodinae	larvae	222	
Diptera	Simuliidae	Simulium	larvae	20	
Ephemeroptera	Baetidae	Baetis	larvae	40	
Ephemeroptera	Baetidae	Fallceon quilleri	larvae	40	
Ephemeroptera	Leptohyphidae	Tricorythodes	larvae	1961	
Ephemeroptera	Leptophlebiidae		larvae	1	D
Heteroptera	Naucoridae	Ambrysus	adult	3	
Lepidoptera	Pyralidae	Petrophila	larvae	1	
Odonata	Gomphidae		larvae	27	I
Odonata	Gomphidae	Ophiogomphus	larvae	6	U
Trichoptera			pupae	62	U
Trichoptera	Brachycentridae	Brachycentrus occidentalis	larvae	162	
Trichoptera	Hydropsychidae		larvae	3318	I,D
Trichoptera	Hydropsychidae	Cheumatopsyche	larvae	304	
Trichoptera	Hydropsychidae	Hydropsyche	larvae	3831	
Trichoptera	Hydroptilidae		larvae	283	I,U
Trichoptera	Leptoceridae	Triaenodes	larvae	20	
Phylum: Mollusca					
Class: Bivalvia			adult	40	I
Veneroida	Pisidiidae	Pisidium	adult	20	
Veneroida	Pisidiidae	Sphaerium	adult	320	
Class: Gastropoda					
Basommatophora	Physidae	Physella	adult	182	

Total: 32 taxa					