CLARK FORK RIVER BIOMONITORING
MACROINVERTEBRATE COMMUNITY ASSESSMENTS, 2006

prepared for
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SUMMARY

The United States Environmental Protection Agency (USEPA) reestablished a macroinvertebrate-based biological monitoring program in portions of the Clark Fork River Basin during 2006. Monitoring was concentrated at sites from the Warm Springs Ponds to Deer Lodge and above and below Milltown Dam. There are ongoing or planned remedial actions in these stream reaches. In addition to providing current assessments of ecological condition, these data will revive a long-term database (1986-2003) used to evaluate water quality trends and the effectiveness of remedial actions. The 2006 data updates this baseline for 11 key sites in the Clark Fork River Basin.

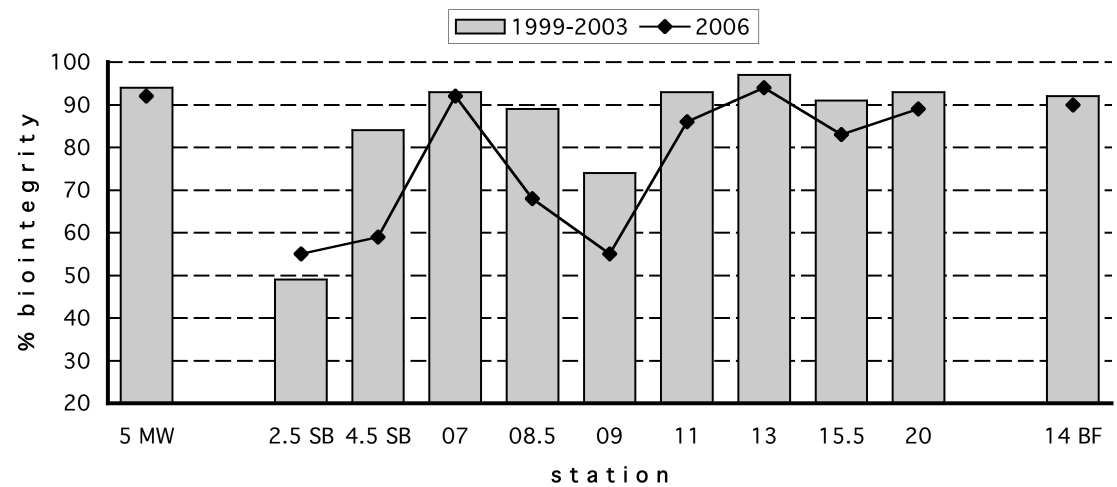
This analysis was developed specifically for the Clark Fork River drainage and compares each station to a fixed reference condition. Ten measures of macroinvertebrate community structure and composition are integrated into a single index of biological integrity. Results are presented on a scale of 0 to 100% with values greater than 90% indicating nonimpairment. In addition, metric subsets estimate the relative severity of metals and nutrient-organic pollution.

2006 macroinvertebrate-based bioassessments indicated significant biological impairment at 7 of the 11 Clark Fork River Basin sites. The Mill-Willow Bypass, the Clark Fork below Warm Springs Creek and at Turah, and the lower Blackfoot River were nonimpaired. Metals pollution was indicated at 4 sites: Silver Bow Creek above and below the Warm Springs Ponds and in the Clark Fork River at Sager Lane and Deer Lodge. Nutrient/organic pollution was indicated at these four sites and at Clark Fork stations above and below Missoula. Drought related stresses, such as higher water temperatures and increased fine sediment, contributed to biological impairment at each of these sites.

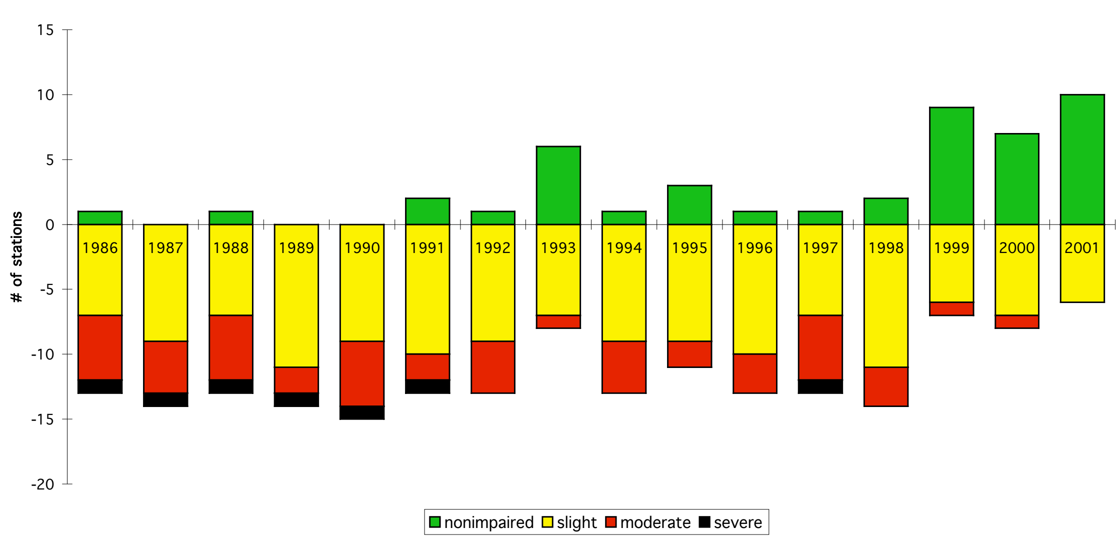
Rigorous analysis of temporal trends was precluded by the 2 to 4 year gap in the data. Most 2006 assessment scores were within the recent historic ranges for individual stations. However, biointegrity was substantially lower in 2006 at Silver Bow Creek below the Warm Springs Ponds and in the Clark Fork River at Sager Lane and Deer Lodge (stations 04.5, 08.5 and 09; Summary Figure 1).

Biological integrity has improved in much of the Clark Fork River basin during the past 20 years (Summary Figure 2) in response to the removal and containment of mining-related metals contamination and improved water quality. Nevertheless, the ecological health of much of the river remains impaired by contaminants and other environmental stresses. A comprehensive biomonitoring program is needed to guide and evaluate future environmental cleanup activities.

Summary Figure 1. macroinvertebrate community biointegrity at 11 stations in the Clark Fork River Basin during August (1999-2003 and 2006).



Summary Figure 2. Biointegrity impairment classifications for Clark Fork River stations from the Warm Springs Ponds to the Flathead River, 1986 through 2001 (14 to 16 stations per year).



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1. INTRODUCTION

The United States Environmental Protection Agency (USEPA) reestablished a macroinvertebrate-based biological monitoring program in portions of the Clark Fork River Basin during 2006. Monitoring was limited to stream reaches in the upper Clark Fork and near Milltown Dam where remedial activities are ongoing or planned. In addition to providing current assessments of ecological condition, these data will revive a long-term database used to evaluate biological trends and the effectiveness of remedial activities. The Montana Department of Environmental Quality (MDEQ) conducted annual macroinvertebrate surveys in the Clark Fork River Basin from 1986 through 2003 (McGuire 1987, 1989a, 1989b, 1993, 1995, 1997-2004; McGuire and Ingman 1996). Macroinvertebrates were collected from up to 28 stations along a 300-mile reach from Silver Bow Creek to Thompson Falls Reservoir through 2001. Sampling was conducted at 12 sites in 2002 and 2003. Samples were collected in 2004 but were not analyzed. No monitoring was done in 2005. The 2006 data reinstates and updates this baseline for 11 key sites in the Clark Fork River Basin.

2. STUDY AREA

The upper Clark Fork River Basin in western Montana contains four contiguous Superfund Sites. These sites encompass more than 140 miles of stream, including the Clark Fork River from Warm Springs to Milltown Dam and all of Silver Bow Creek (Figure 1). The MDEQ biomonitoring program included data from 35 locations in the Clark Fork River Basin (Table 1). During 2006, we revisited and sampled 11 of these sites. We concentrated on stream reaches with known water quality issues and upcoming remedial activities.

Insert new map

Table 1. MDEQ Clark Fork Basin biomonitoring sites (sites in bold were sampled in 2006).

station	name	period of record
SF-1	Blacktail Creek above Grove Gulch	1993 - 2001
00	Silver Bow Creek above Butte WWTP	1987 - 2001
01	Silver Bow Creek at Rocker	1986 - 2001
02	Silver Bow Creek near Ramsay	1986 - 1992
02.5	**Silver Bow Creek at Opportunity**	1993 - 2003, **2006**
03	Silver Bow Creek above Warm Springs Ponds	1986 - 1992
04	Warm Springs Pond #2 discharge	1986 - 1991
04.5	**Silver Bow Creek below Warm Springs Ponds**	1993 - 2003, **2006**
05	**Mill-Willow Creeks Bypass**	1986 - 1991, 1999 - 2001, **2006**
06	Warm Springs Creek near mouth	1986 - 2001
07	**Clark Fork River below Warm Springs Creek**	1986 - 2003, **2006**
08	Clark Fork River near Dempsey	1986 - 1992, 1998 - 2001,
08.5	**Clark Fork River at Sager Lane**	1990 - 1992, 1998 - 2001, **2006**
09	**Clark Fork River at Deer Lodge**	1986 - 2003, **2006**
10	Clark Fork River above Little Blackfoot River	1986 - 2003
10.2	Little Blackfoot River near mouth	1993 - 2001
11	**Clark Fork River at Gold Creek Bridge**	1986 - 2001 **2006**
11.5	Flint Creek at New Chicago	1993 - 2001
11.7	Clark Fork River at Bearmouth	1993 - 2001
12	Clark Fork River at Bonita	1986 - 2003
12.5	Rock Creek near Clinton	1993 - 2001
13	**Clark Fork River at Turah**	1986 - 2003, **2006**
14	Blackfoot River near mouth	1986 - 2001
15	Clark Fork River below Milltown Dam	1986 - 1988
15.5	**Clark Fork River at ShuRon FA**	1989 - 2003, **2006**
16	Clark Fork River above Missoula WWTP	1986 - 1988
18	Clark Fork River at Shuffield's	1986 - 2003
19	Bitterroot River near mouth	1986 - 2003
20	Clark Fork River at Harper Bridge	1986 - 2003
20^	**Clark Fork River at Kona Rd F.A.**	**2006**
22	Clark Fork River at Huson	1986 - 2003
23	Clark Fork River near Alberton	1986 - 1992
24	Clark Fork River at Superior	1986 - 2001
25	Clark Fork River above Flathead River	1986 - 2001
26	Flathead River near mouth	1986 - 1988
27	Clark Fork River above Thompson Falls Reservoir	1987 - 2001

Samples were collected at 28 sites during 2004, but were not analyzed. No biomonitoring was conducted during 2005.

2006 sampling sites:

- Warm Springs Ponds and Mill/Willow Bypass
  - Silver Bow Creek at Opportunity (CFR 0.2.5),
  - Silver Bow Creek below the pond 2 discharge (CFR 04.5)
  - Mill-Willow Bypass above pond 2 discharge (CFR 05)
- Upper Clark Fork River
  - Clark Fork below Warm Springs Creek (CFR 07)
  - Clark Fork at Sager Lane (CFR 08.5)
  - Clark Fork at Deer Lodge (CFR 09)
  - Clark Fork at Gold Creek Bridge (CFR 11)
- Milltown Dam area
  - Clark Fork at Turah fishing access (CFR13)
  - Blackfoot River at USGS gage above Bonner (CFR14)
  - Clark Fork River above Missoula (CFR 15.5)
  - Clark Fork River below Missoula (CFR 20.1)

3. METHODS

3.1 Field Work

Sampling methods are described in the MDEQ Field Procedures Manual (1996) and have been consistent since 1986. Benthic macroinvertebrates were collected with modified Hess samplers (0.1 sq. meter diameter, 1000 micron mesh netting). Four replicate samples were obtained from each station. At each site, samples were obtained from the least embedded, most heterogeneous cobble substrates available. Scott Brown (EPA), Kris Knutson (EPA), and Bill Olsen (USFWS) assisted Dan McGuire with fieldwork during the 2nd week of August, 2006.

3.2 Laboratory Analysis

Laboratory processing was consistent with that used in previous years. Samples were rinsed in a U.S. Standard #30 sieve to remove the preservative. A small portion of the sample was placed in a white pan divided into ten equal areas by a grid. All macroinvertebrates were removed and sorted to order. This process was repeated until the entire sample was processed. If the sample clearly contained more than 1000 organisms, subsampling was used to estimate densities of selected abundant taxa (e.g. blackflies or hydropsychids). Samples were processed as usual except that selected taxa were removed from only two randomly selected grids. The number in the subsample was multiplied by five to provide estimated density per 0.1 m^2 Hess sample. Organisms were identified to the lowest level practical, usually genus or species, and enumerated.

3.3 Data Analysis

The analysis was specifically designed to evaluate water quality in the Clark Fork River Basin (McGuire 1993). The analysis incorporates 10 metrics (Table 2) into a single index of biological integrity. The metrics used in the analysis exhibit predicable responses to environmental stress and were the most suitable to the broad range of habitats within the study area. Each metric measured a different aspect of community composition, structure, or function. Since biological communities integrate the effects of all environmental stresses, this analysis provided a reliable evaluation of cumulative impacts from metals, nutrients, and streamflow alteration.

To evaluate stream health, each metric was assigned a score (0 to 6) based on its comparability to a reference value. Scores for all metrics were totaled and the sum, expressed as a percentage of the maximum possible score, was used as an estimate of biological integrity. The resulting summary score provides a reliable and easily understandable estimate of ecological health.

Metric scoring criteria reflect the range of values in the Clark Fork River Basin from 1986 through 1990. Data from the first three years (1986-1988) of the Clark Fork River Basin study and two years of data (1988-1989) from the Blackfoot River were used to establish metric scoring criteria. For each metric, statistically significant differences among stations were identified by one-way analysis of variance (McGuire 1987, 1989a, 1989b, 1990a, 1990b, Ingman et al. 1989, and unpublished data). Scoring criteria endpoints were defined by statistically distinct groups of stations with the highest and lowest scores. Nonimpaired endpoints were based on stations with the best metric scores and were generally established as the mean minus one standard deviation. On the lower end of the scale, endpoints were generally based on average values of the most severely impaired station(s).

Scoring criteria for some metrics were adjusted to improve the reliability of the assessment. The inclusion of Silver Bow Creek data resulted in wide scoring ranges for most metrics and, consequently, some statistical differences in metric values were not reflected in the scoring criteria. The lower end of the scoring criteria for taxa richness was truncated to provide better discrimination of slight impacts in the Clark Fork River at the expense of detecting slight improvements in Silver Bow Creek. Scoring criteria for percent filterers, Baetidae to Ephemeroptera, Hydropsychinae to Trichoptera, and EPT to EPTC ratio metrics were relaxed to improve the reliability of these metrics over the wide geographic area.

In general, biological integrity in the Clark Fork Basin can be categorized as nonimpaired (90 to 100%), slightly impaired (70 to 90%), moderately impaired (50 to 70%), or severely impaired (<50%). These impairment classifications were less rigorous than statistical differences in the 1986 through 1988 Clark Fork River Basin data. Except for borderline values, scores in different narrative categories are considered significantly different from one another.

Macroinvertebrate assemblages exhibit predictable responses to different types of environmental stress; consequently, the sensitivity of individual metrics varies with the type of pollution. Some parameters are useful as estimators of metals pollution while others are more sensitive to organic/nutrient enrichment, excessive sediment deposition, or partial dewatering. Both metals and nutrient pollution are known to degrade water quality and impact aquatic life in the Clark Fork Basin (Ingman and Kerr 1990, McGuire 1990). Therefore, subsets of metrics considered sensitive to these forms of pollution were used to estimate the relative severity of each pollutant (Table 2).

Impacts attributable to metals and nutrient/organic pollutants were estimated by the sum of scores for metrics in each subset, expressed as a percentage of the maximum possible score (usually 18). A specific type of pollution was indicated when the score of one set of metrics was substantially lower than the other. To facilitate interpretation, impacts attributable to these pollutants were categorized as slight (~60 to 80%), moderate (~40 to 60%) or severe (< 40%). The more conservative classification scheme for these metric subsets reflects the limitations of an assessment based on only three metrics. Metrics comprising the nutrient/organic subset were community density, biotic index, and the percent relative abundance of filter-feeding macroinvertebrates. The subset used to estimate metals pollution consisted of community density, EPT richness, and metals tolerance index.

Impairment classifications accurately reflect statistical differences in the 1986 through 1988 Clark Fork River Basin data. Except for borderline values, scores in different narrative categories were considered significantly different from one another. These assessments must be interpreted cautiously. Metrics are not direct measurements of toxicity of nutrient concentration. While they may be strongly correlated with a particular stressor (ISSI 1999), each metric is also influenced to a greater or lesser degree by other environmental factors. Metrics and the rationale for their use are described as follows.

Macroinvertebrate Density

Total macroinvertebrate density is an important feature of community structure and, when carefully interpreted, can be a useful indicator of several different environmental conditions. Unusually high or low macroinvertebrate densities are considered indicative of environmental perturbation. Macroinvertebrate density tends to increase in response to organic and/or nutrient enrichment, and the magnitude of the increase reflects the degree of the pollution. Conversely, macroinvertebrate density may be reduced by toxic substances, by severe habitat degradation, or by extensive scouring.

Low macroinvertebrate densities were used as an index of metals pollution in the upper Clark Fork River Basin. Specifically, this metric was included to document toxic impacts and provide a measure of biological improvement in Silver Bow Creek. Historically, macroinvertebrates have been absent from or present at very low densities in Silver Bow Creek and the Mill-Willow Bypass (Spindler 1959, Multitech and OEA Research 1986, McGuire 1990b). Increased macroinvertebrate abundance at these sites can be considered a clear indication of reduced toxicity. This metric typically provides little information regarding environmental health in the remainder of the study area.

High macroinvertebrate standing crops were included as a metric to assess nutrient and organic loading in the Clark Fork River. Densities greater than 2,000 per sample (0.1 m^2) were attributed to organic pollution and/or enhanced primary production caused by nutrient enrichment. Given that the threshold value is 2,000 organisms per sample, it is not considered a sensitive measure of organic loading in more oligotrophic tributaries. Because toxic conditions can preclude high macroinvertebrate densities (McGuire 1990b), this metric was not used to evaluate organic/nutrient pollution when density was less than 550 organisms per sample. Densities between 550 and 2,000 organisms per sample received maximum scores for both metrics.

Taxa Richness

Taxa richness, or the number of macroinvertebrate taxa per Hess sample, was probably the single best measure of environmental condition in the Clark Fork River drainage. It is a reliable measure of biological integrity because the loss of the most sensitive species to any stress affects the index. The range for scoring this metric was 14 to 40 taxa per sample. This truncated scoring range maximizes the sensitivity of this metric to small reductions in taxa richness. Mean taxa richness in the lower Blackfoot River during 1988 and 1989 was 41 (Ingman et al 1990 and McGuire 1990a).

Shannon Diversity

Shannon diversity has long been used as an index of environmental condition (Weber 1973) and is a reliable measure of combined environmental stress in the Clark Fork drainage. This index has two components and is influenced by taxa richness and the distribution of individuals among taxa (evenness). Reference stations had an average Shannon diversity value of 3.7 with a standard deviation of 0.4. For this analysis, values greater than 3.3 were considered nonimpaired.

EPT to Chironomidae Ratio (EPT/EPTC)

This metric, originally developed by the EPA (Plafkin et al. 1989), is based on relative abundance of indicator groups. Most Ephemeroptera, Plecoptera, and Trichoptera are considered sensitive to environmental stresses while Chironomidae, as a group, are more tolerant. In the form (E+P+T) divided by (E+P+T+C), this metric ranges from 0 to 1.

An even distribution of individuals among the four groups reflects good biotic condition while a disproportionate number of chironomids indicates environmental stress. For the Clark Fork analysis, values <0.55 indicate impairment. Using this scale, the EPT/EPTC metric reliably identifies severe biological impairment but does not consistently separate slight, moderate and nonimpaired sites. In some cases, large populations of relatively tolerant EPT taxa (e.g. Baetidae, *Tricorythodes* or hydropsychids) result in high EPT/EPTC values. The percentage Baetidae of Ephemeroptera and percentage Hydropsychinae of Trichoptera metrics are included to identify slight to moderate impairment missed by the EPT/EPTC metric.

Percent Baetidae of Ephemeroptera

Members of the family Baetidae are among the most pollution-tolerant mayflies (Hubbard and Peters 1978). Slight to moderate environmental stress is indicated when baetids comprise most of the mayfly fauna. This metric ranges from 0 to 1 with high values (>0.85) indicating biological impairment. This metric received a default value of 1 when no mayflies were collected.

Percent Hydropsychinae of Trichoptera

The subfamily Hydropsychinae is, in general, more tolerant of pollution than most other caddisflies (Harris and Lawrence 1978). Environmental stress is indicated when most of the caddisflies in a sample are *Hydropsyche* and *Cheumatopsyche*. This metric is analogous to the Baetidae/Ephemeroptera metric and ranges from 0 to 1 with high values (>0.85) indicating biological impairment. When no caddisflies were collected, this metric received a default value of 1.

Biotic Index

The biotic index is based on the indicator organism approach to water quality assessment and was developed to measure organic pollution. The index is calculated: SUM ($\%RA_i * t_i$), where $\%RA_i$ is the percent relative abundance of each taxon and t_i is the tolerance value of the taxon. This index is on a scale of 0 to 10 with higher values indicating more polluted conditions. Tolerance values used in this study (Appendix A) were taken from Hilsenhoff (1987) and McGuire (1992).

Percent Relative Abundance of Filter Feeders

The relative abundance of functional feeding groups can provide useful insights into energy transfer, food resources and organic loading in aquatic ecosystems. Filter feeding insects typically comprise a major component of the summer macroinvertebrate fauna in Montana rivers. Relative abundance greater than 50 percent indicate high seston (suspended organics) concentrations that are usually associated with organic/nutrient enrichment, extensive filamentous algae growth, or lake outflows. This metric is used as a measure of organic pollution in the Clark Fork River Basin. Functional classifications were based on Merritt and Cummins (1984).

EPT Richness

This metric summarizes species richness of Ephemeroptera, Plecoptera, and Trichoptera and was used as an indicator of metals pollution. The majority of mayfly, stonefly and caddisfly species are highly sensitive to pollution. With a few exceptions, species in these groups are among the first to be eliminated by metals toxicity (Wiederholm 1984, Clements 1991). EPT richness averaged 21 among Blackfoot River reference stations. The scoring criteria reflect the wide range of values found within the study area. While minimizing influences of pollutants other than toxins, the wide range reduces the sensitivity of this metric to subtle changes.

Metal Tolerance Index (MTI)

This metric quantifies changes in community composition attributable to metals pollution in the Clark Fork River Basin. The format and calculation are based on Hilsenhoff's biotic index, with tolerance values assigned to each taxon based on sensitivity to metals rather than organics. The index is calculated: SUM ($\%RA_i * t_i$), where $\%RA_i$ is the percent relative abundance of each taxon and t_i is the tolerance value of the taxon. The theoretical scale of the index is 0 to 10 with higher values indicating communities more tolerant of metals pollution. MTI values for communities dominated by species intolerant of metals are less than 4 (i.e. Blackfoot River) while values for communities composed of only the most metals-tolerant species approach 10 (i.e. Silver Bow Creek). Small, but statistically significant differences in metric values are not reflected in assessment scores due to the wide criteria range necessitated by the inclusion of Silver Bow Creek data.

Metals tolerance values (Appendix A) for most taxa were developed from the 1987 and 1988 Clark Fork River Basin water quality report (Ingman and Kerr 1989) and co-located macroinvertebrate data (McGuire 1987 and 1989a). Ingman and Kerr (1989) quantified metals pollution severity for each station based on the frequency and magnitude of measured copper, zinc, cadmium, and lead concentrations exceeding EPA chronic or acute criteria for the protection of aquatic life. Stations were ranked by metals pollution severity. Macroinvertebrate taxa were ranked according to their relative abundance and distributions along this gradient. Abundant taxa (comprising at least five percent of the fauna at any station) were assigned a rank corresponding to the station where they attained their maximum relative abundance. For less abundant taxa, ranks corresponded to the midpoint of their distribution within the study area. Ranks were transformed to a scale of 0 to 10, rounded to the nearest integer, and used as metals tolerance values. Some tolerance values, particularly for infrequently collected taxa, were modified based on the author's interpretation of pertinent literature (Clements 1991, Clements et al. 1988, Rolin 1988, Wiederholm 1984, Winner et al. 1980, Yasuno et al. 1985, Lynch et al. 1988, Leland et al. 1989).

Table 2

4. RESULTS AND DISCUSSION

Appendix A contains tolerance values for 227 macroinvertebrate taxa encountered within the Clark Fork Basin since 1986. Identifications, organism counts, metric values, and summary statistics for 2006 are presented in Appendix B. For each station, mean metric values, metric scores, and percent biological integrity were calculated for each year that data were available (Appendix C).

4.1. Stream discharge

Stream flows were low throughout the basin again in 2006. Mean annual discharge has been below average each year since 2000 (Table 3). The extended drought has had a profound influence on the aquatic ecosystem. The cumulative impacts of reduced sediment scour and transport, increased nutrient retention, and altered thermal regime are reflected in the composition and structure of macroinvertebrate assemblages. These impacts are more severe below the Warm Springs Ponds and in the lower Deer Lodge Valley than in other stream reaches. Retention time in the Warm Springs Ponds is increased during periods of low stream flow. Augmented summer flows in Warm Springs Creek help to attenuate drought-related impacts in the Clark Fork River for a short distance downstream. However, extensive irrigation withdrawals accentuate sediment, nutrient, and thermal impacts in the remainder of the Deer Lodge Valley.

4.2 Community Biointegrity during 2006

The overall effect of water quality on macroinvertebrate assemblages was estimated from the composite score of 10 metrics (Table 2). For discussion purposes, bioassessment scores are categorized as nonimpaired (90 to 100%), slightly impaired (70 to 89%), moderately impaired (50 to 69%), or severely impaired (<50%).

During 2006, biointegrity was nonimpaired at 4 monitoring sites, slightly impaired at 3 sites, and moderately impaired at 4 sites (Figure 2). Bioassessment scores (Table 3) ranged from 94% to 55%. Biological integrity was nonimpaired in the Mill-Willow Bypass (station 5), the lower Blackfoot River (station 14), and the Clark Fork below Warm Springs Creek (station 07) and at Turah (station 13). Biointegrity was slightly impaired in the Clark Fork River at

Gold Creek Bridge, and at sites above and below Missoula (stations 11, 15.5 and 20, respectively). Both Silver Bow Creek sites (02.5 and 04.5) and the Clark Fork at Sager Lane and Deer Lodge (stations 08.5 and 09) were considered moderately impaired.

Metals pollution was indicated at 4 stations in 2006 (Table 3). Composite scores for metals-sensitive metrics ranged from 61% to 94%. This assessment indicated slight biological impairment by metals in Silver Bow Creek at Opportunity (station 02.5) and below the Warm Springs Ponds (station 04.5) and in the upper Clark Fork River at Sager Lane (station 08.5) and at Deer Lodge (station 09).

Nutrient/organic pollution was indicated at 6 sites during 2006 (Table 3). Scores for the metrics most responsive of these pollutants ranged from 56 to 100%. Moderate impairment was indicated in the Clark Fork River at Deer Lodge (station 09). Slight nutrient/organic pollution was indicated at both Silver Bow Creek sites (stations 02.5 and 04.5), in the upper Clark Fork River at Sager Lane (station 08.5), and at both Clark Fork River stations below Milltown Dam (stations 15.5 and 20).

4.3 Longitudinal Trends

With the exception of the Clark Fork River between Warm Springs and Deer Lodge (stations 07, 08.5 and 09), the limited monitoring in 2006 offered little insight about longitudinal trends in water quality. Biological integrity was nonimpaired below Warm Springs but declined to moderately impaired at Sager Lane and Deer Lodge. Both the metals and nutrient/organic metric sets indicated gradients of increasing stress through this stream reach (Figure 2). At a larger scale, the stations at Deer Lodge, Gold Creek Bridge and Turah (stations 09, 11, and 13, respectively) exhibited the historic pattern of increasing biological integrity from upstream to downstream in the upper Clark Fork River.

4.4 Long-term Monitoring

Most 2006 assessment scores were within the recent historic ranges for individual stations (Tables 4-6). However, biointegrity was substantially lower in 2006 at Silver Bow Creek below the Warm Springs Ponds and in the Clark Fork River at Sager Lane and Deer Lodge (stations 08.5 and 09, respectively: Summary Figure 2).

Rigorous analysis of temporal trends was precluded by the 2 to 4 year gap in the data set.

4.5 Site-Specific Assessments

Mill-Willow Creeks Bypass (station 05)

The Mill-Willow Bypass supports a diverse macroinvertebrate assemblage and has been classified as nonimpaired on each date sampled since 1999. The biointegrity estimate for 2006 was 92%.

From 1986 through 1992, metals impacts were evident and the stream was moderately impaired (Figure 3). In 2006, we collected an average of 42 taxa per Hess sample, more than double the number collected prior to restoration (Appendix C-2). The metals tolerance index declined from an average of 5.6 prior to 1992 to 4.4 since 1999.

Silver Bow Creek at Opportunity (station 02.5)

Silver Bow Creek at Opportunity was moderately impaired in 2006. Biological integrity was estimated at 55%; with both metals (61%) and nutrient/organic pollution (67%) indicated as stressors. Metals impacts appeared to be less severe than in previous years (Figure 4). From 1986 through 2003, biointegrity averaged 45% and the score for the metals-sensitive subset was 33%. These results reflect a recent shift in macroinvertebrate community structure and composition. Community density, taxa richness, and EPT richness were well above average in 2006 (Appendix C-1). Hydropsychid caddisflies, rather than midges, were the most abundant macroinvertebrates collected.

Silver Bow Creek below the Warm Springs Ponds (station 04.5)

Silver Bow Creek below the Warm Springs Ponds was classified as moderately impaired (59%) in 2006. This was a significant decline compared to recent years (Figure 5). From 1999 through 2003, biointegrity averaged 84% with nutrient and organic loading from the pond outflow identified as the principal factor limiting biological integrity. Significant metals pollution was not detected from 2000 to 2003.

Although both nutrient/organic (72%) and metals pollution (72%) were indicated as slight stressors in 2006, neither metric subset gave a strong signal corresponding to the degree of impairment indicated by the overall assessment. It is therefore likely that additional environmental stresses were present. Drought-related impacts, including elevated summer water temperatures and possibly altered water chemistry were probable causes of increased biological impairment.

Community composition was markedly different than in the past. The caddisfly *Cheumatopsyche*, adult elmid beetles, and flatworms, minor components of the community in past years, were the most abundant macroinvertebrates in 2006. This shift in community composition is characteristic of higher water temperature.

Water chemistry in the Warm Springs Ponds may have shifted due to increased retention time during periods of low stream flow. As a consequence, lower metric scores may also reflect recent episodes of low dissolved oxygen and /or elevated concentrations of ammonia and arsenic. Only one species of mayfly (*Baetis tricaudatus*) and no stoneflies were collected at this site in 2006. Reduced macroinvertebrate density, diversity and taxa richness were also consistent with increased toxicity.

Clark Fork River below Warm Springs Creek (station 07)

Biointegrity was nonimpaired (92%) at this site in 2006. From 1986 through 1992, this site was moderately impaired and had the lowest biointegrity (60%) in the Clark Fork River (Table 4). Biointegrity was slightly impaired from 1993 through 1996, but has been classified as nonimpaired on the last 6 dates sampled (Figure 6). Drought-related impacts appeared to be ameliorated by augmented streamflow from Warm Springs Creek.

Clark Fork River at Sager Lane (station 08.5)

The 2006 assessment indicates a significant decline in biointegrity in the Clark Fork at Sager Lane since last sampled. This site was previously sampled on 7 dates (1990-1992 and 1999-2001). During those years, biointegrity was consistently high (88 to 91%) and significant impairment was not evident (Figure 7). However, biological integrity (68%) was moderately impaired at Sager Lane in 2006. Slight environmental stress from both nutrient/organic

(67%) and metals (78%) was indicated. However, drought-induced stresses, particularly increased fine sediments and elevated temperature, probably contributed to lower biointegrity.

Clark Fork River at Deer Lodge (station 09)

The Clark Fork River at Deer Lodge was moderately impaired in 2006. Biointegrity was estimated at 55%. Slight metals pollution (72%) and moderate nutrient/organic pollution (56%) were indicated.

Since 1986, this site has been classified as moderately impaired on 13 dates and slightly impaired on 6 dates (Figure 8). The Deer Lodge site has had the lowest average biointegrity (65%) in the Clark Fork River since 1993. Slight metals pollution has been indicated on 14 occasions. However, nutrient/organic pollution, accentuated by low stream flow, appeared to be the most important limiting factor at this site.

Clark Fork River at Gold Creek Bridge (station 11)

Biological integrity was classified as slightly impaired (86%) at the Gold Creek Bridge site in 2001. Neither metals (83%) nor nutrients (89%) were indicated as significant stressors. These results are consistent with previous assessments of this site, which was last sampled in 2001 (Figure 9). Since 1986, biointegrity has averaged 85% while the mean metals and nutrient/organic subset scores have been 83 and 80%, respectively. This site was classified as impaired on 13 occasions. Nutrient/organic pollution was indicated on 7 dates. Metals pollution has been indicated on 5 dates, but only once (1997) since 1993. This stream reach appears susceptible to excessive sand deposition, and slight reductions in biointegrity scores may reflect unstable habitat conditions (McGuire 1989b). Diminished habitat quality associated with low stream flow was the likely cause of slight biological impairment in this reach during 2006.

Clark Fork River at Turah (station 13)

The Turah fishing access is the nearest upstream monitoring station on the Clark Fork River above Milltown Dam. As such, it will provide an important reference site for downstream remedial activities.

Biointegrity was nonimpaired (94%) at Turah in 2006. With the exception of 1997, when slight metals impacts were detected, this site has been nonimpaired on each date monitored since 1992 (Figure 10). Slight metals pollution was indicated at this site in 1986, 1990, and 1997 while nutrient and organic pollution was indicated in 1987, 1988, 1990 and 1992. This site has the highest average biointegrity in the Clark Fork River (90%) and, based on long-term mean biointegrity values, is the only mainstem site classified as nonimpaired.

Blackfoot River near mouth (station 14)

The lower Blackfoot River was nonimpaired in 2006. Biointegrity was estimated at 90%, which was typical. Biointegrity averaged 90% at this site from 1986 through 2001 (Figure 11). Slight impairment was detected from 1986 through 1989 and was attributed to reduced sediment transport and higher temperatures during a drought. High flows during 1997 also resulted in a slightly lower biointegrity score (83%). The macroinvertebrate assemblage in the lower Blackfoot River is considerably different from that in the Clark Fork River. The Blackfoot community is characterized by high diversity but relatively low density.

Clark Fork River above Missoula (station 15.5)

This site, upstream from the ShuRon Fishing Access in East Missoula, was included in the 2006 monitoring program because it is the nearest monitoring station below Milltown Dam.

In 2006, macroinvertebrate community biointegrity was estimated at 83% at this site. Slight impacts from nutrient/organic pollution (72%) were indicated. These results were consistent with previous assessments at this site (Figure 12). Metals pollution has not been indicated at this site since 1990 although slight to moderate nutrient-organic pollution was usually evident (Appendix C-10).

Clark Fork River below Missoula (station 20^)

The monitoring station below Missoula and the Bitterroot River was moved to the Kona Road Fishing Access in 2006 because of access restrictions at the old Harper's Bridge site. The new location is approximately 2 miles upstream from Harper's Bridge. This location will be used to evaluate the extent of downstream impacts, if any, associated with the Milltown Dam remediation project.

Biological integrity was slightly impaired (89%) at the Kona Road site during 2006. Metric subsets indicated slight nutrient/organic pollution (78%) but no metals pollution (89%). Results were similar to those for the last 5 years of monitoring at Harper's Bridge (Figure 13).

Table 3. Mean annual stream discharge (cfs) at selected sites in the upper Clark Fork Basin. Water years 1979 -2006.

year	Silver Bow at Warm Springs USGS 12323750	Clark Fork at Deer Lodge USGS 12324200	Clark Fork above Missoula USGS 12340500
1986		273	2927
1987		197	1692
1988		155	**1544**
1989		184	2689
1990		183	2870
1991		185	2666
1992		**131**	1614
1993		248	2417
1994	77	207	2078
1995	124	274	2577
1996	133	327	4381
1997	**184**	**465**	**4700**
1998	103	309	3085
1999	88	252	3015
2000	43	156	1996
2001	44	151	1785
2002	49	161	2424
2003	73	211	2552
2004	**41**	145	2039
2005	64	197	2265
2006	71	195	2485
Mean	84	219	2562

min and max in bold

Table 4. Macroinvertebrate community biointegrity estimates for Clark Fork River Basin stations during August, 2006.

Station		% Biointegrity		
		overall	metals subset	organic subset
Mill-Willow Bypass				
05		92	89	83
Silver Bow Creek				
02.5	(above WSP)	55 **	61 *	67 *
04.5	(below WSP)	59 **	72 *	72 *
Upper Clark Fork River				
07		92	83	89
08.5		68 **	78 *	67 *
09		55 **	72 *	56 **
11		86 *	83	89
Above Milltown Reservoir				
13	(Clark Fork)	94	94	89
14	(Blackfoot)	90	78	100
Below Milltown Reservoir				
15.5		83 *	94	72 *
20		89 *	89	78 *

Classification : slightly impaired *, moderately impaired **, severely impaired ***.

Table 5. Mean annual macroinvertebrate biointegrity (%) at Clark Fork River Basin monitoring stations during August, 1986-2003, and 2006.

station	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	**2006**	Mean
Silver Bow Creek																				
02.5	38	40	35	50	43	43	43	47	55	43	50	38	45	50	52	57	40	44	**55**	46
04.5	45	44	44	47	41	45		71	70	59	62	58	61	83	88	88	74	86	**59**	63
Mill-Willow Bypass																				
05	58	61	67	61		43								97	94	91			**92**	74
Upper Clark Fork River																				
07	59	64	53	59	55	65	65	83	82	88	77	94	86	94	92	94	92	95	**92**	78
08.5					89	88	89						91	89	91	88			**68**	87
09	52	65	62	73	61	83	55	86	53	58	55	55	55	68	79	86	82	53	**55**	65
11	86	80	85	88	63	89	85	94	94	86	78	62	86	88	95	95			**86**	85
Above Milltown Reservoir																				
13	88	80	76	88	86	92	83	95	89	94	94	82	91	98	94	97	97	97	**94**	90
14	82	83	90	85	92	88	89	90	95	97	92	83	95	92	92	91			**90**	90
Below Milltown Reservoir																				
15.5	76	88	86	77	68	79	80	90	82	83	85	71	82	95	91	88	91	89	**83**	83
20	71	77	61	79	73	79	76	61	79	82	76	83	76	92	95	95	92	89	**89**	80
All stations	66	68	66	71	67	72	74	80	78	77	74	70	77	86	88	88	81	79	**78**	76

Table 6. Mean annual macroinvertebrate biointegrity (%) as measured by metrics* sensitive to nutrient/organic pollution at Clark Fork River Basin stations - August, 1986-2003, and 2006.

station	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2006	Mean
Silver Bow Creek																				
02.5	83	83	33	100	83	75	42	92	61	92	75	92	92	100	67	83	67	56	**67**	76
04.5	50	56	44	39	39	56		83	72	56	50	33	33	78	72	72	72	83	**72**	59
Mill-Willow Bypass																				
05	58	61	78	56		42								100	89	78			**83**	72
Clark Fork RIver																				
07	72	72	50	78	56	72	83	83	83	83	67	89	67	89	83	83	83	89	**89**	77
08.5					89	89	83						89	83	78	83			**67**	83
09	56	67	50	61	44	83	50	89	50	50	39	50	44	44	61	78	83	22	**56**	57
11	89	72	92	89	42	89	78	94	89	83	67	42	78	83	89	94			**89**	80
13	89	67	44	89	83	83	67	92	89	89	83	92	89	94	83	94	94	94	**89**	84
15.5	72	75	81	58	42	78	83	100	78	67	72	61	67	100	89	83	78	83	**72**	76
20	67	67	39	78	67	72	61	33	67	67	61	67	61	92	89	94	92	78	**78**	70
Blackfoot River																				
14	100	83	83	100	100	100	94	92	92	100	92	67	92	100	94	100			**100**	93
All stations	74	70	59	75	65	76	71	84	76	76	67	66	71	88	81	86	81	72	**78**	75

* metric subset: biotic index, % filterers and community density.

Table 7. Mean annual macroinvertebrate biointegrity (%) as measured by metrics* sensitive to metals pollution at Clark Fork River Basin stations - August, 1986-2003, and 2006.

station	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	**2006**	Mean
Silver Bow Creek																				
02.5	22	17	44	28	22	28	50	33	56	22	44	22	28	22	44	33	33	56	**61**	35
04.5	61	61	61	67	67	61		72	72	61	72	72	72	78	89	83	83	89	**72**	72
Mill-Willow Bypass																				
05	61	72	67	72		50								94	89	89			**89**	76
Clark Fork River																				
07	72	72	78	72	72	72	72	83	83	78	83	89	94	89	89	94	89	94	**83**	82
08.5					83	83	83						83	83	89	83			**78**	83
09	78	78	72	83	72	83	72	78	72	72	78	67	78	78	83	78	83	83	**72**	77
11	83	78	78	89	67	83	78	89	94	83	83	67	89	83	94	89			**83**	83
13	78	89	94	83	78	89	94	94	89	89	94	61	94	100	94	94	94	94	**94**	89
15.5	83	92	92	72	78	83	83	83	89	94	94	83	94	89	94	89	89	89	**94**	88
20	83	83	78	78	78	83	83	89	83	89	89	78	94	83	94	89	89	94	**89**	86
Blackfoot River																				
14	61	83	83	67	83	72	100	83	94	94	83	78	94	78	100	94			**78**	84
All stations	68	73	75	71	70	72	79	78	81	76	80	69	82	80	87	83	80	86	**81**	75

* metric subset: metals tolerance index, EPT richness and community density.

Figure 3. Macroinvertebrate community biointegrity in the Mill-Willow Bypass (station 05) 1986-2006.

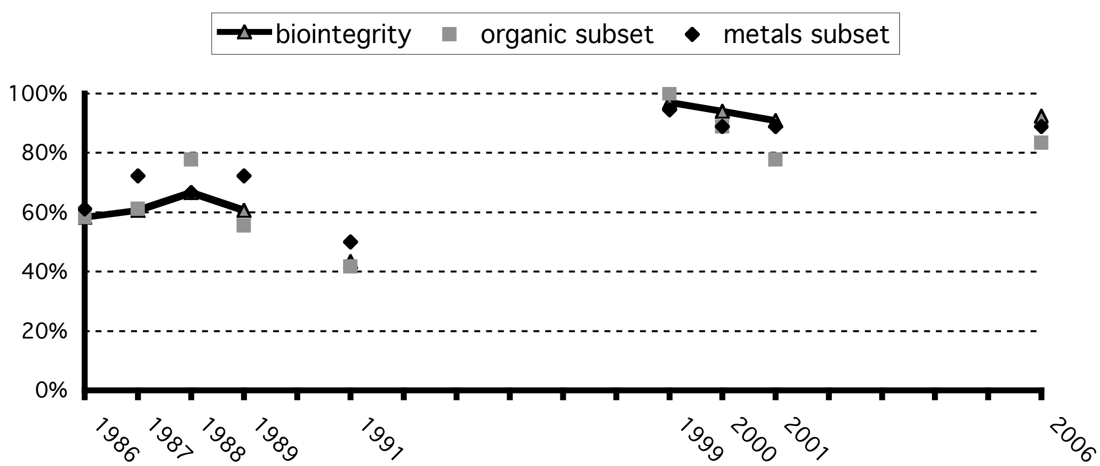


Figure 4. Macroinvertebrate community biointegrity in Silver Bow Creek at Opportunity (station 02.5) 1986-2006.

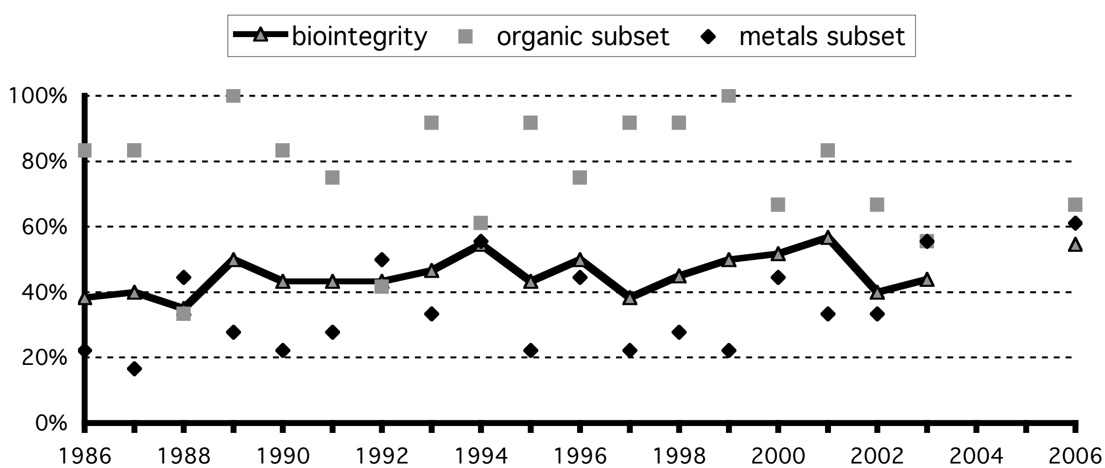


Figure 5. Macroinvertebrate community biointegrity in Silver Bow Creek below the Warm Springs Ponds (station 04.5) 1986-2006.

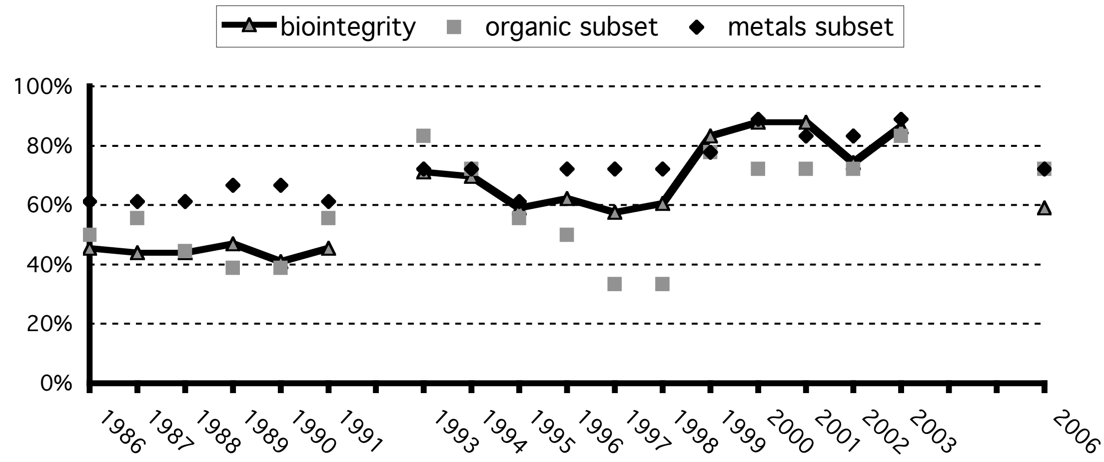


Figure 6. Macroinvertebrate community biointegrity in the Clark Fork below Warm Springs Creek (station 7) 1986-2006.

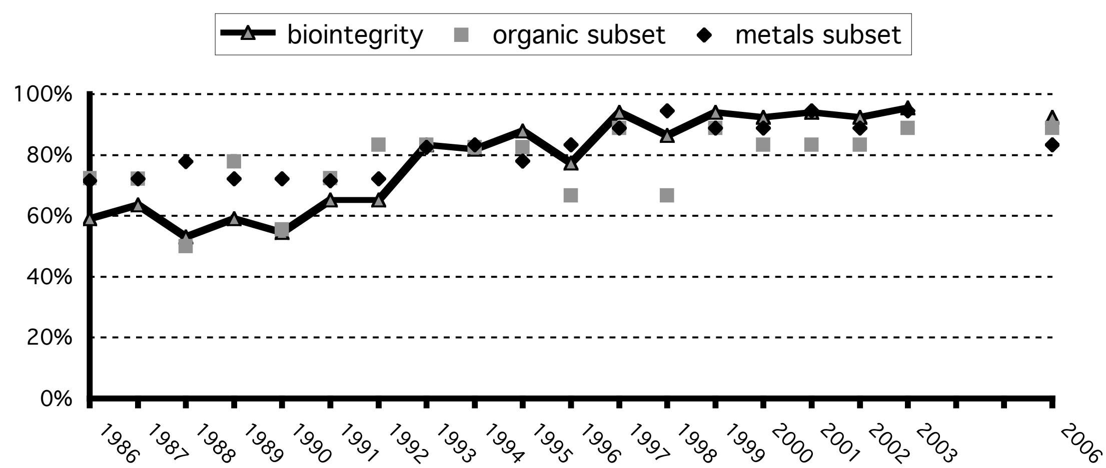


Figure 7. Macroinvertebrate community biointegrity in the Clark Fork at Sagger Lane (station 08.5) 1990-2006.

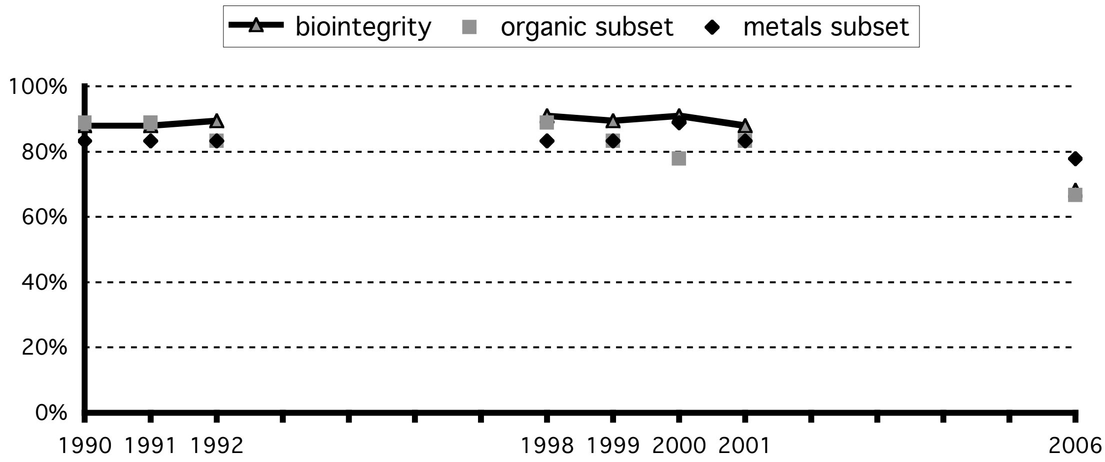


Figure 8. Macroinvertebrate community biointegrity the Clark Fork at Deer Lodge (station 09) 1986-2006.

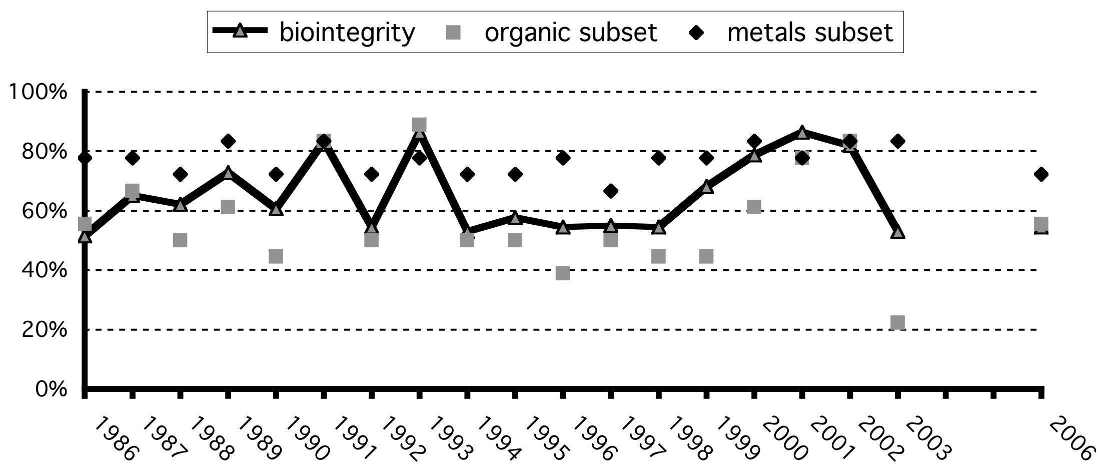


Figure 9. Macroinvertebrate community biointegrity in the Clark Fork at Gold Creek Bridge (station 11) 1986-2006.

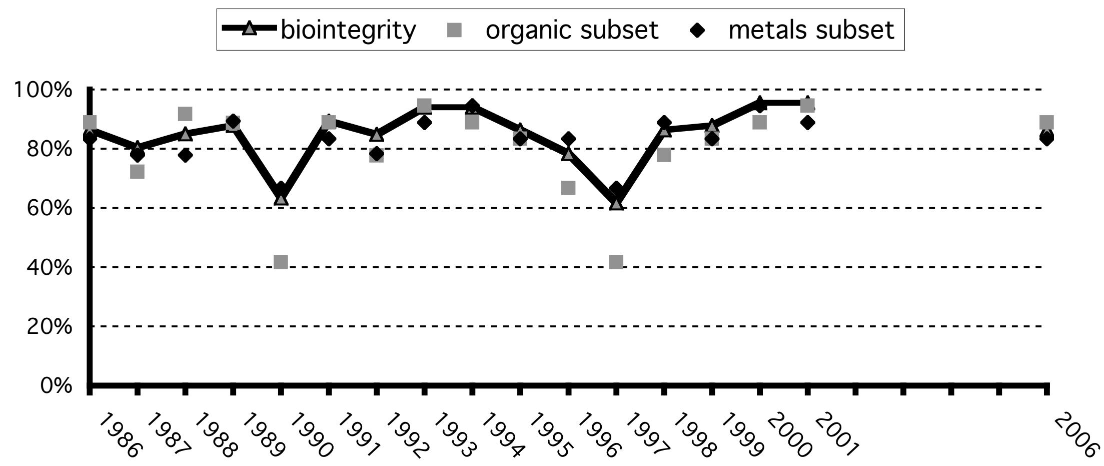


Figure 10. Macroinvertebrate community biointegrity in the Clark Fork at Turah (station 13) 1986-2006.

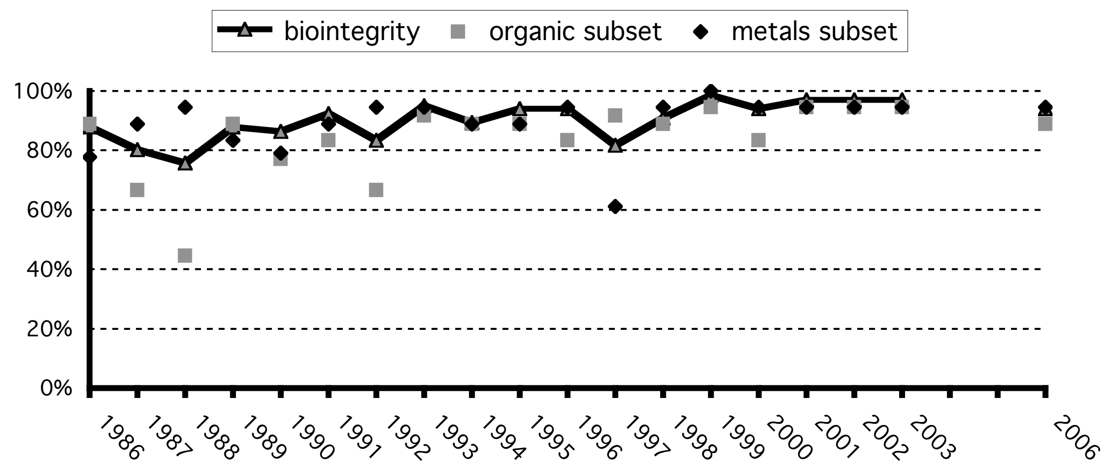


Figure 11. Macroinvertebrate community biointegrity in the Blackfoot River at USGS gage# (station 14) 1986-2006.

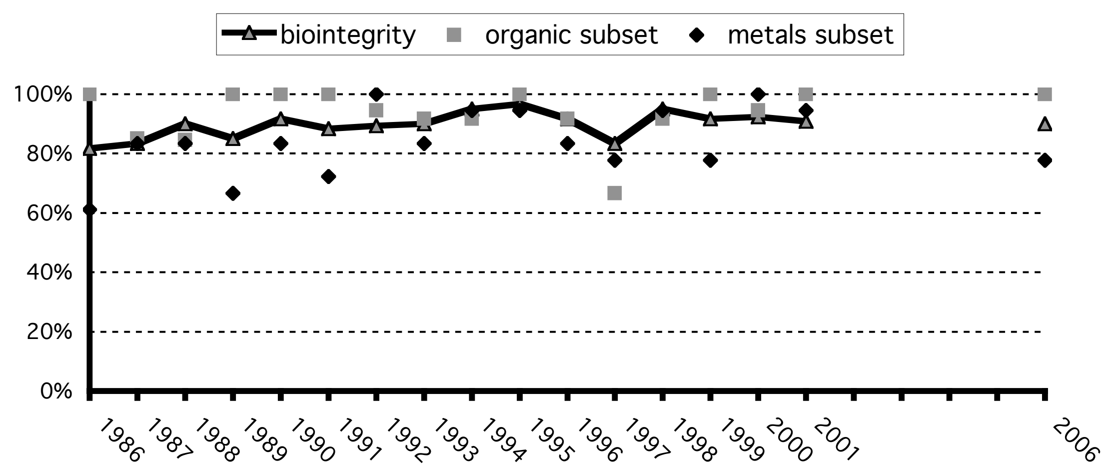


Figure 12. Macroinvertebrate community biointegrity in the Clark Fork above Missoula (station 15.5) 1989-2006.

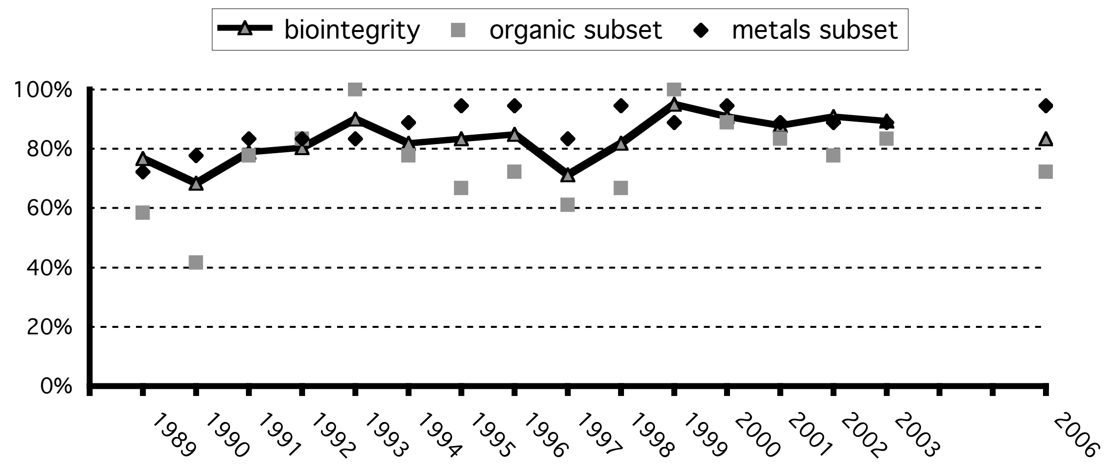
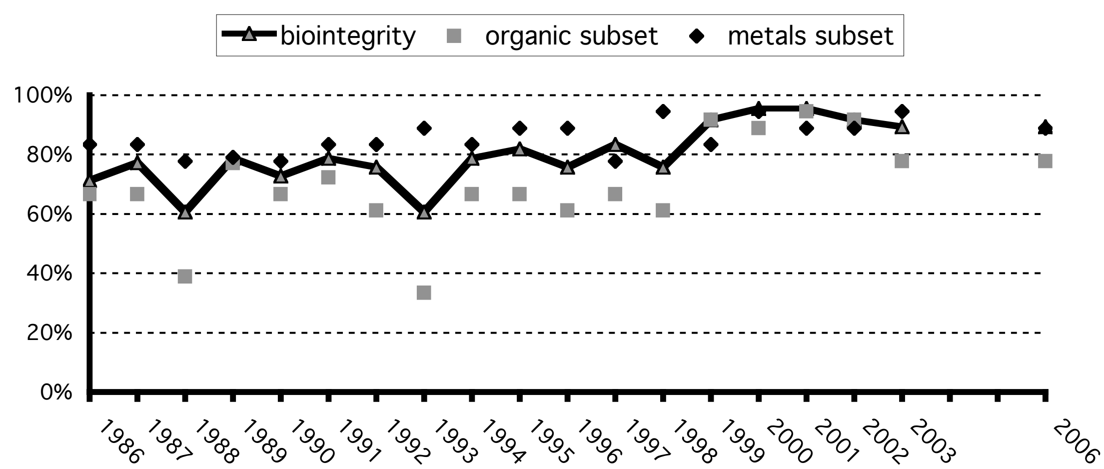


Figure 13. Macroinvertebrate community biointegrity in the Clark Fork below Missoula (station 20) 1986-2006.



5. CONCLUSIONS

1. Macroinvertebrate-based bioassessments indicated significant biological impairment at 7 of the 11 Clark Fork River Basin sites monitored during 2006. Biointegrity was moderately impaired in Silver Bow Creek at Opportunity and below the Warm Springs Ponds, and in the upper Clark Fork River at Sager Lane and Deer Lodge. Biointegrity was slightly impaired in the Clark Fork River at the Gold Creek Bridge, and at sites above and below Missoula. The Mill-Willow Bypass, lower Blackfoot River and the Clark Fork below Warm Springs Creek and at Turah were nonimpaired.

2. Nutrient/organic pollution was indicated at 6 sites. Moderate impacts were evident in the Clark Fork River at Deer Lodge. Nutrient/organic pollution caused slight biological impairment in the Clark Fork above and below Missoula and contributed to impacts in Silver Bow Creek and in the Clark Fork at Sager Lane.

3. Metals pollution was indicated at both sites on Silver Bow Creek and in the upper Clark Fork River at Sager Lane and Deer Lodge. Impacts from metals were classified as slight at each station.

4. Drought-related stresses were evident throughout the study area during 2006. Impacts were most apparent in Silver Bow below the Warm Springs Ponds and in the Clark Fork at Sager Lane and Deer Lodge. Reduced stream discharge stressed aquatic communities via higher water temperatures, habitat alteration due to reduced sediment scour and increased aquatic vegetation cover, and altered water chemistry.

5. Biological integrity was nonimpaired in the Clark Fork below Warm Springs Creek but was moderately impaired at Sager Lane and Deer Lodge. Both the metals and nutrient/organic metric sets indicated gradients of increasing stress through this stream reach.

6. Rigorous analysis of temporal trends was precluded by the 2 to 4 year gap in the data. Most 2006 assessment scores were within the recent historic ranges for individual stations. However, biointegrity was substantially lower in 2006 at Silver Bow Creek below the Warm Springs Ponds and in the Clark Fork River at Sager Lane and Deer Lodge.

6. RECOMMENDATIONS

1. Biological monitoring should be conducted annually at Clark Fork River Basin sites where remedial activities are ongoing or planned.

2. Based on the 2006 results, analysis and interpretation of archived 2004 samples from selected sites in the upper basin seems warranted. Recommended sites include Silver Bow Creek below the Warm Springs Ponds and 3 Clark Fork River sites from Warm Springs to Deer Lodge (stations 04.5, 07, 08.5 and 09).

3. At least one additional site in the Deer Lodge Valley should be monitored in the future. The Clark Fork River at Beck Hill Fishing Access (station 10) would provide a measure of cumulative affects of remediation in the upper Clark Fork. Additional sites may be useful as remediation continues.

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