INVERTEBRATE AND PERIPHYTON ASSESSMENT METHODS FOR MONTANA STREAMS: A STUDY OF SITE RANKING, VARIABILITY, AND METHOD AGREEMENT IN THE STATEWIDE MONITORING NETWORK

2001-2005

A report to

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TABLE OF CONTENTS

Summary 3

Introduction 4

Purpose and scope 4

Description of the study area 5

Methods 6

Sample processing and analysis 6

Data analysis and bioassessment 6

Results 7

1. Bioassessment and site rankings 7

Historic MMI site rankings and classifications 7

MMI site rankings and classifications 8

RIVPACS site rankings and classifications 8

2. Variability of bioassessment scores 8

Spatial variability 9

Temporal variability 9

3. Agreement between bioassessment methods 22

Discussion 26

Alternative interpretations 26

Issues accounting for poor agreement 28

Recommendations for improving biocriteria 33

References 38

Appendices

1. Revised MMI and RIVPACS metrics, scoring and results. 42

2. Site impairment, estimated degree of impairment and probable causes. 54

3. Classification results for all assessment methods. 57

4. Error matrices used to derive Kappa coefficients. 60

SUMMARY

Aquatic invertebrate samples, periphyton (diatom) samples, and habitat assessment data were collected at 46 fixed stations from 2001 to 2005. Stations were part of the Montana Statewide monitoring network. Sampling procedures, sample processing and analysis, and habitat evaluation were conducted according to Montana Department of Environmental Quality (MDEQ) standard operating procedures (Bukantis 1998) which were current in those years. Taxonomic data were used to obtain impairment classifications for each site in each sampled year using 5 different assessment methods: 3 metric-based bioassessment tools, a predictive model, and a discriminant function analysis. The metric-based tools were 1) invertebrate multimetric indices (Historic MMI: Bollman 1998, Bukantis 1998, and Bramblett 2003) and 2) diatom multimetric indices (Diatom MMI: Bahls 1993) that were included in past MDEQ operating procedures for biologic assessment and 3) newly developed invertebrate indices (MMI: Jessup et al. 2006) recently adopted as standard procedure by MDEQ. The predictive model is based on comparisons between observed and expected invertebrate assemblages (RIVPACS: Hawkins 2005) and has also been adopted for use by MDEQ. A discriminant function analysis based on the incidence of specific diatom taxa (Increaser Taxa: Teply and Bahls 2005) was the fifth tool applied in this study; among the assessment tools examined, it is the only one which has not been adopted by MDEQ either in the past or for current use.

Sites were ranked within major basins and ecoregions using mean bioassessment scores for all 3 invertebrate assessment tools over all years. The ranges of numeric scores of the invertebrate indices were compared; spatial variation in scores over site classes, ecoregions, and major watersheds was examined, and temporal variation in scores within each ecoregion and major watershed were described. For within-watershed comparisons, standardized scores from all 3 indices could be compared, but for within-ecoregion or within-site class comparisons, the different stratification methods limited the comparisons.

Statistical analyses were performed comparing the results of all assessments; specifically, these analyses were directed at finding out how often invertebrate and diatom assessments of impairment agree, overall as well as within ecoregions and site classes. These analyses also sought to elucidate whether any patterns could be distinguished to help explain why disagreements occurred.

INTRODUCTION

In 2001, the Montana Department of Environmental Quality (MDEQ) began annual collections of benthic macroinvertebrate and periphyton samples from a network of sites established for a statewide water quality monitoring program. The program seeks to document water quality and aquatic habitat conditions in the 3 major river basins in Montana by periodically sampling water chemistry, benthic macroinvertebrates, and periphyton, and evaluating habitat characteristics and physical properties at 46 sites on the tributaries of the major rivers. Other project goals are to track annual variation in water quality, identify instances where water quality standards are exceeded, and establish a reference database for detecting long-term trends in water quality. This report summarizes and analyzes bioassessment results from data collected over 5 years (2001-2005) using historic methods for macroinvertebrates and diatoms, and compares the performance and assesses the comparability of results of these methods with newly-developed assessment methods (MMI and RIVPACS) developed for MDEQ (Hawkins 2005, Jessup et al. 2006).

Purpose and Scope

In this report, the biologic conditions of Statewide monitoring sites in Montana, as suggested by faunal characteristics of benthic invertebrate assemblages collected over 5 years, are ranked and described. An earlier report (Bollman 2006) translated these faunal characteristics into multimetric indices used historically by MDEQ (Historic MMI: Bukantis 1998, Bollman 1998, and Bramblett et al. 2003), and offered interpretations of metric performance and taxonomic composition of assemblages which were suggestive of probable stressors at each site. This report restates those results and compares assessment results from those methods with results of the newly-developed RIVPACS and MMI (Jessup et al. 2006) methods.

A further purpose of this report is to give a descriptive analysis of the spatial and temporal variation of Historic MMI, MMI, and RIVPACS results for the Statewide monitoring sites over the years of study. Finally, assessment results of the 3 benthic invertebrate models with assessments based on periphyton (diatom) biocriteria where diatom-based assessments were available are compared. Two diatom methods were employed: the first, the diatom MMI (Bahls 1993) translated characteristics of diatom assemblages into multimetric indices, and has been employed in biological assessments made by MDEQ. The second method (Increaser Taxa) discriminates impairment classifications based on suites of increaser taxa (Teply and Bahls 2005). Impairment classifications of the Statewide monitoring sites were provided by MDEQ, and

classifications resulting from benthic invertebrate and diatom methods were compared to these.

Description of Study Area

Statewide monitoring sites considered in this report lie in 3 major river basins: the Missouri, the Yellowstone, and the Columbia River basins. (Neither the St. Mary River basin nor the Little Missouri River basin were represented by any sites in the Statewide monitoring network.) Tributaries of the Columbia River flow west of the Continental Divide to the Pacific Ocean. East of the Continental Divide, the Yellowstone and Missouri Rivers and their tributaries drain the State's waters toward the Mississippi River and on to the Gulf of Mexico. In this report, sites are stratified by the 3 major basins and by ecoregions (for the Historic MMI) and by site classes (for MMI and RIVPACS). Tables 1, 2, and 3 indicate the river basin, ecoregion, or site class for each site.

METHODS

Sample Collection, Processing, and Analysis

Aquatic invertebrate samples were collected by MDEQ representatives, and samples were analyzed using then-current standard operating procedures (Bukantis 1998) by Rhithron Associates, Inc. More than 200 samples were collected from 2001 through 2005; this report analyzes data from 199 samples taken at 46 sites. Not all sites were visited in each year; sampling episodes at individual sites ranged from a single visit to 5 visits. Replicate samples were taken at 4 sites in 2005. Habitat assessments, including ratings of quality or integrity of various habitat features, were conducted at every visit. Diatom samples were collected, processed and analyzed according to MDEQ methods (Bahls 1993).

Data Analysis and Bioassessment

Bioassessment scores and impairment classifications for each site were derived based on benthic invertebrate methods as follows:

Historic MMI – Bramblett et al. (2003); Bollman (1998); Bukantis (1998)

MMI – Jessup et al. (2006)

RIVPACS – Hawkins (2005).

When the MMI and RIVPACS methods were used, the degree of impairment was determined by criteria set out in Feldman 2006. Sites were stratified by ecoregion for Historic MMI results, and by site classes for MMI and RIVPACS results, and were grouped by major watershed. Within each stratum, sites were ranked based on

assessment scores averaged over the 5 years of the study. Historic MMI data was retrieved from the Rhithron Associates, Inc. database. New MMI metric results and scores were provided by MDEQ (Appendix 1).

Impairment classifications based on diatom methods were derived using the following methods:

Diatom MMI – Bahls (1993)

Increaser Taxa – Teply and Bahls (2005).

Impairment classifications determined by these methods are not equivalent to the results of Aquatic Life Beneficial Use Support (ALU) determinations. ALU determinations are based on processes and methods which consider all of the biological, physical, and chemical data collected from a stream reach. The results considered in the current study evaluate only the biological data collected from one location in each stream reach.

RESULTS

1. Bioassessments and site rankings

A series of tables summarize bioassessment results and rank the Statewide monitoring network sites by average score over all years of data. Sites are ranked in each ecoregion or site class within each major river basin. Tables 1, 2, and 3 correspond to the Historic MMI, MMI, and RIVPACS methods respectively. Site rankings differed considerably among bioassessment methods.

Historic MMI site rankings and classifications

The Historic MMI utilized a site classification based on 1998 ecoregions, thus its bioassessment rankings are not uniformly comparable to those of either the MMI or RIVPACS tools. Table 1 summarizes the impairment classifications, average site scores, and other summary statistics for Statewide monitoring sites when the Historic MMI was used. Six of the 46 sites (13.0%) were classified as "good" or non-impaired. All of these sites were located in the Plains ecoregions and were evaluated with the index developed by Bramblett et al. (2003). All other sites, evaluated with indices developed by Bollman (1998) or Bukantis (1998) were classified as having some degree of impairment. Table 1 also includes results from an alternate assessment of Mountain ecoregion sites within the Columbia River basin: application of the 2 indices for Mountain region sites resulted in different impairment classifications for 5 of the 7 sites.

Bioassessment scores for sample replicates, which were collected at 4 sites in 2005, resulted in equivalent impairment classifications for each replicate pair, however, scores differed by 11% for Shields River near mouth, and by 6% for Clark Fork River at

Turah. Replicate scores were identical for Sun River at Sun River. All 3 sites were assessed using the MVFP index.

MMI site rankings and classifications

Table 2 summarizes the impairment classifications, average site scores, and other summary statistics for Statewide monitoring sites when the MMI was used. Thirty-three of the 46 sites, or 71.7% of Statewide monitoring sites were classified as non-impaired when the MMI criteria were used.

All Low Valley sites were rated as non-impaired. Classifications for Plains sites ranged from non-impaired to severely impaired. Mountain sites were either non-impaired or moderately impaired.

MMI scores for replicated samples resulted in identical impairment classifications within each pair. Scores differed by 0.98 for Big Hole River near Wise River, by 3.11 for Clark Fork River at Turah, 3.38 for Shields River near Livingston, and 10.84 for Sun River at Sun River.

RIVPACS site rankings and classifications

Table 3 summarizes the impairment classifications, average site scores, and other summary statistics for Statewide monitoring sites when the RIVPACS assessment model was used. Twenty-six of 45 sites, or 57.8% of Statewide monitoring sites were classified as non-impaired when the RIVPACS criteria were used.

The RIVPACS model gave the same impairment classifications to 3 pairs out of the 4 replicated samples. Clark Fork River at Turah yielded scores of 1.00 (non-impaired) and 0.71 (moderately impaired). Scores for Shields River near Livingston and Sun River at Sun River differed by 0.13 and 0.25 respectively. Replicate scores were identical for Big Hole River at Wise River.

2. Variability

Bioassessment scores for each method varied within site classes among the major watersheds as well as among years for each individual site. This variability is illustrated in a series of graphs, Figures 1, 2, and 3, which plot individual sample scores, with sites stratified by watershed and then by site classes (MMI and RIVPACS) or ecoregion (Historic MMI).

Spatial variability

When Low Valley samples were evaluated with the MMI, 66 of 70 total samples (94%) scored above the threshold for impairment. In contrast, the Historic MMI scored 63 of 64 (98%) Low Valley samples below the threshold for impairment, when only those MVFP sites classified as Low Valley sites were included. RIVPACS treads an intermediate ground: 50 of 70 (71%) Low Valley samples scored above the impairment threshold. Distributions of scores suggest that, among Low Valley sites, the Historic MMI tended to score Columbia River basin samples higher than samples from sites in the Missouri or Yellowstone River basins. The RIVPACS model appears to have the opposite trend; Columbia basin samples, with the exception of those from Little Blackfoot River at Garrison, yielded lower scores than most other samples in the other 2 basins, while all Missouri River basin samples achieved high RIVPACS scores.

Within the Mountain site class, the MMI scored 15 of 51 (29%) of samples above the threshold for impairment, while RIVPACS scored a non-impairment classification for more than twice that number (33 of 51 or 65%). The Northern Rockies ecoregion defined the montane sites for the Historic MMI, but if Mountain site classes are considered, the Historic MMI (MVFP index) rated only one sample (2%) above the threshold for impairment.

The MMI rated 49 of 76 (64%) Plains site class samples above the threshold for impairment; 29 of these samples (38%) had RIVPACS scores indicating non-impairment. For sites in the Plains ecoregion, the Historic MMI scored 26 of 61 (43%) samples above the impairment threshold.

Temporal variability

The plots in Figures 1, 2, and 3 suggest that, for Low Valley and Mountain site class samples, MMI results are the least variable between years. Differences between minimum score and maximum score obtained in the 5 years of study ranged from 1.93 at Big Horn River near Hardin to 82.91 at Clark Fork River at Turah, and averaged 25.02. Differences between minimum and maximum RIVPACS scores ranged from 0.12 at Milk River at Nashua and Milk River at Saco to 1.51 at Sun River at Sun River.

Figure 4 illustrates mean values of standardized mean scores for all sites using the 3 assessment methods in each of the 5 years of the study. Of the 3 methods, the mean value for the Historic MMI remains the most stable for the entire dataset over the period of study. Both the MMI and RIVPACS scores dip sharply in 2002, while the mean value for the Historic MMI fell slightly in that year. Figure 5 shows plots of mean MMI and RIVPACS scores by year with samples grouped by site class, and Figure 6 shows mean scores for all 3 methods with samples grouped by watershed. In all site classes

and in the Yellowstone River drainage, RIVPACS scores appear to be the most stable year-to-year. In the Missouri River drainage, mean MMI scores appear to vary the most over the years of study, while this method seems to have produced the most stable mean scores in the Columbia drainage.

Table 1. Historic MMI results: Mean value of total bioassessment score over all study years, rank within each watershed/region combination, and comparison with reference condition for each site.

Rank	Site	Historic MMI result (mean score)	Index used[3]	Number of samples	Mean score	Median score	Min score	Max score	Mean habitat score
Missouri River Basin									
MVFP									
1	BIG HOLE RIVER NEAR WISE RIVER	Slight Impairment	A	3	0.61	0.67	0.50	0.67	0.79
2	DEARBORN RIVER NEAR CRAIG	Slight Impairment	A	5	0.59	0.50	0.44	0.83	0.76
3	BIG HOLE RIVER NEAR TWIN BRIDGES	Moderate Impairment	A	3	0.52	0.50	0.50	0.56	0.64
4	SMITH RIVER AT EDEN BRIDGE	Moderate Impairment	A	4	0.50	0.50	0.39	0.61	0.74
5	PRICKLY PEAR CREEK NEAR CLANCY	Moderate Impairment	A	5	0.50	0.50	0.39	0.61	0.64
6	MADISON RIVER NEAR THREE FORKS	Moderate Impairment	A	3	0.50	0.50	0.50	0.50	0.79
7	GALLATIN RIVER NEAR THREE FORKS	Moderate Impairment	A	4	0.43	0.42	0.39	0.50	0.63
8	JEFFERSON RIVER NEAR THREE FORKS	Moderate Impairment	A	5	0.41	0.44	0.28	0.50	0.63
9	GALLATIN RIVER AT LOGAN	Moderate Impairment	A	1	0.39	0.39	0.39	0.39	0.62
10	SUN RIVER AT SUN RIVER	Moderate Impairment	A	6	0.39	0.36	0.33	0.50	0.65
11	BEAVERHEAD RIVER AT TWIN BRIDGES	Moderate Impairment	A	5	0.36	0.33	0.28	0.44	0.61
12	BEAVERHEAD RIVER NEAR DILLON	Moderate Impairment	A	4	0.35	0.33	0.28	0.44	0.72
PLAINS									
1	JUDITH RIVER NEAR MOUTH	Good	B	5	0.70	0.71	0.65	0.74	0.76
2	TETON RIVER NEAR LOMA	Good	B	5	0.61	0.56	0.49	0.77	0.58
3	MUSSELSHELL RIVER ABOVE HARLOWTON	Good	B	4	0.56	0.55	0.50	0.64	0.63
4	MILK RIVER NEAR SACO	Good	B	2	0.55	0.55	0.55	0.56	0.71
5	POPLAR RIVER NEAR SCOBEY	Fair	B	5	0.47	0.46	0.39	0.56	0.68
6	MILK RIVER AT NASHUA	Poor	B	3	0.39	0.49	0.14	0.54	0.55
7	MUSSELSHELL RIVER AT MOSBY	Poor	B	5	0.35	0.36	0.14	0.60	0.49
8	BIG MUDDY CREEK NEAR CULBERTSON	Very Poor	B	1	0.23	0.23	0.23	0.23	0.64
Yellowstone River Basin									
MVFP									
1	BOULDER RIVER NEAR MOUTH	Slight Impairment	A	5	0.63	0.67	0.56	0.67	0.76
2	STILLWATER RIVER NEAR ABSAROKEE	Moderate Impairment	A	5	0.52	0.56	0.44	0.61	0.81
3	SHIELDS RIVER NEAR MOUTH	Moderate Impairment	A	6	0.48	0.50	0.28	0.61	0.71
4	CLARKS FORK RIVER AT EDGAR	Moderate Impairment	A	5	0.48	0.50	0.39	0.56	0.59
5	TONGUE RIVER NEAR STATELINE	Moderate Impairment	A	1	0.33	0.33	0.33	0.33	0.58
PLAINS									
1	TONGUE RIVER NEAR BRANDENBERG	Good	B	4	0.69	0.71	0.57	0.75	0.60
2	POWDER RIVER NEAR MOORHEAD	Good	B	4	0.57	0.58	0.46	0.65	0.53
3	BIG HORN RIVER AT MOUTH	Fair	B	5	0.41	0.38	0.15	0.65	0.64
4	TONGUE RIVER AT MILES CITY	Fair	B	5	0.40	0.40	0.13	0.68	0.46
5	POWDER RIVER NEAR LOCATE	Poor	B	5	0.35	0.37	0.23	0.46	0.46
6	ROSEBUD CREEK NEAR ROSEBUD	Poor	B	5	0.26	0.16	0.10	0.60	0.38
7	BIG HORN RIVER NEAR HARDIN	Very Poor	B	3	0.14	0.12	0.11	0.19	0.71

Table 1. ***(continued)*** Historic MMI results: Mean value of total bioassessment score over all study years, rank within each watershed/region combination, and comparison with reference condition for each site.

Rank	Site	Historic MMI result (mean score)	Index used[3]	Number of samples	Mean score	Median score	Min score	Max score	Mean habitat score
Columbia River Basin									
MVFP									
1	BITTERROOT RIVER NEAR DARBY	Slight Impairment	A	3	0.67	0.67	0.61	0.72	0.70
2	ROCK CREEK NEAR CLINTON	Slight Impairment	A	5	0.66	0.67	0.50	0.78	0.82
3	BLACKFOOT RIVER NEAR MOUTH	Slight Impairment	A	5	0.62	0.67	0.50	0.67	0.79
4	LITTLE BLACKFOOT RIVER AT GARRISON	Slight Impairment	A	5	0.62	0.61	0.50	0.83	0.77
5	CLARK FORK RIVER AT TURAH	Slight Impairment	A	6	0.60	0.58	0.50	0.72	0.75
6	BITTERROOT RIVER NEAR MOUTH	Moderate Impairment	A	5	0.49	0.50	0.44	0.56	0.73
7	WHITEFISH RIVER NEAR KALISPELL	Moderate Impairment	A	5	0.46	0.44	0.33	0.61	0.74
MOUNTAINS (MDEQ index)									
1	FISHER RIVER NEAR MOUTH	Slight Impairment	C	5	0.55	0.52	0.38	0.81	0.76
2	SF FLATHEAD RIVER AT SPOTTED BEAR	Moderate Impairment	C	4	0.44	0.40	0.33	0.62	0.88
3	CLARK FORK RIVER AT ST. REGIS	Moderate Impairment	C	5	0.41	0.38	0.29	0.52	0.77
4	NF FLATHEAD RIVER NEAR COLUMBIA FALLS	Moderate Impairment	C	5	0.39	0.33	0.24	0.57	0.90
5	YAAK RIVER AT MOUTH	Moderate Impairment	C	5	0.39	0.48	0.10	0.48	0.84
6	SWAN RIVER NEAR BIGFORK	Moderate Impairment	C	5	0.30	0.24	0.19	0.48	0.87
7	MF FLATHEAD RIVER NEAR WEST GLACIER	Moderate Impairment	C	5	0.28	0.14	0.10	0.57	0.85
MOUNTAINS (MVFP index)									
1	NF FLATHEAD RIVER NEAR COLUMBIA FALLS	Slight Impairment	A	5	0.76	0.78	0.72	0.78	0.90
2	SF FLATHEAD RIVER AT SPOTTED BEAR	Slight Impairment	A	4	0.72	0.75	0.61	0.78	0.88
3	FISHER RIVER NEAR MOUTH	Slight Impairment	A	5	0.68	0.67	0.61	0.72	0.76
4	SWAN RIVER NEAR BIGFORK	Slight Impairment	A	5	0.62	0.67	0.39	0.78	0.87
5	MF FLATHEAD RIVER NEAR WEST GLACIER	Slight Impairment	A	5	0.59	0.61	0.50	0.67	0.85
6	YAAK RIVER AT MOUTH	Slight Impairment	A	5	0.58	0.56	0.50	0.72	0.84
7	CLARK FORK RIVER AT ST.REGIS	Moderate Impairment	A	5	0.40	0.39	0.33	0.50	0.77

* Bioassessment indices used: A = Bollman 1998, Bukantis 1998; B = Bramblett et al. 2003; C = Bukantis 1998.

Table 2. MMI results: Mean value of total bioassessment score over all study years, rank within each watershed/region combination, and comparison with reference condition for each site.

Rank	Site	MMI Model result (mean score)	Number of samples	Mean score	Median score	Min score	Max score	Mean habitat score
Missouri River								
Low Valley Site Class								
1	BIG HOLE NEAR TWIN BRIDGES	Non-impaired	3	79.0	77.2	75.1	84.8	0.64
2	GALLATIN RIVER @ LOGAN	Non-impaired	1	72.9	72.9	72.9	72.9	0.62
3	GALLATIN RIVER NEAR THREE FORKS	Non-impaired	4	59.9	61.5	50.3	66.3	0.63
4	MADISON RIVER NEAR THREE FORKS	Non-impaired	3	59.6	58.4	57.6	62.8	0.79
5	JEFFERSON RIVER NEAR THREE FORKS	Non-impaired	5	58.7	61.3	42.9	66.8	0.63
6	BEAVERHEAD RIVER @ TWIN BRIDGES	Non-impaired	5	57.5	58.5	52.0	59.7	0.61
7	PRICKLY PEAR CREEK NEAR CLANCY	Non-impaired	5	54.8	53.3	48.5	65.5	0.64
8	BEAVERHEAD RIVER NEAR DILLON	Non-impaired	4	51.7	53.5	38.7	61.0	0.72
Mountain Site Class								
1	DEARBORN RIVER @ CRAIG	Non-impaired	5	65.3	67.3	59.9	70.9	0.76
2	BIG HOLE RIVER NEAR WISE RIVER	Non-impaired	3	56.3	54.4	53.5	61.1	0.79
Plains Site Class								
1	MUSSELSHELL RIVER NEAR MOSBY	Non-impaired	5	57.6	58.7	36.2	75.8	0.49
2	POPLAR RIVER NEAR SCOBY	Non-impaired	5	55.5	56.2	44.6	63.0	0.68
3	TETON RIVER NEAR LOMA	Non-impaired	5	52.1	45.5	37.7	71.1	0.58
4	SMITH RIVER @ EDEN BRIDGE	Non-impaired	4	49.0	50.2	31.5	64.1	0.74
5	SUN RIVER @ SUN RIVER	Non-impaired	5	46.8	44.3	36.4	61.4	0.65
6	MUSSELSHELL RIVER @ HARLOTOWN	Non-impaired	4	37.3	37.9	27.3	46.3	0.63
7	JUDITH RIVER NEAR MOUTH	Moderately Impaired	5	34.8	28.1	20.2	49.6	0.76
8	MILK RIVER @ SACO	Moderately Impaired	2	30.5	30.5	27.3	33.7	0.71
9	BIG MUDDY CREEK NEAR CULBERTSON	Severely Impaired	1	27.6	27.6	27.6	27.6	0.64
10	MILK RIVER @ NASHUA	Severely Impaired	3	25.6	22.2	16.9	37.8	0.55
Yellowstone River								
Low Valley Site Class								
1	BOULDER RIVER @ BIG TIMBER	Non-impaired	5	67.0	70.5	51.8	77.1	0.76
2	CLARKS FORK @ EDGAR	Non-impaired	5	65.2	68.8	51.6	75.5	0.59
3	STILLWATER RIVER NEAR ABSAROKEE	Non-impaired	5	61.1	58.7	49.9	71.7	0.81
Plains Site Class								
1	ROSEBUD CR @ ROSEBUD	Non-impaired	5	55.2	60.6	31.4	70.0	0.38
2	TONGUE RIVER NEAR STATE LINE	Non-impaired	1	53.8	53.8	53.8	53.8	0.58
3	SHIELDS RIVER NEAR LIVINGSTON	Non-impaired	5	49.3	46.0	43.8	60.2	0.71
4	BIGHORN RIVER @ BIGHORN	Non-impaired	5	48.3	47.4	33.9	63.9	0.64
5	TONGUE RIVER NEAR BRANDENBURG	Non-impaired	4	45.5	45.4	37.4	53.9	0.60
6	POWDER RIVER NEAR MOORHEAD	Non-impaired	4	41.5	40.9	34.8	49.4	0.53
7	BIG HORN RIVER NEAR HARDIN	Moderately Impaired	3	33.2	32.7	32.4	34.4	0.71
8	TONGUE R @ MILES CITY	Moderately Impaired	5	31.4	32.5	25.1	39.9	0.46
9	POWDER RIVER NEAR LOCATE	Moderately Impaired	5	29.2	25.7	5.2	45.1	0.46

Table 2. ***(continued)*** MMI results: Mean value of total bioassessment score over all study years, rank within each watershed/region combination, and comparison with reference condition for each site.

Rank	Site	MMI Model result (mean score)	Number of samples	Mean score	Median score	Min score	Max score	Mean habitat score
Columbia River								
Low Valley Site Class								
1	BLACKFOOT R NEAR MOUTH	Non-impaired	5	70.3	63.2	62.1	82.1	0.79
2	ROCK CREEK NEAR CLINTON	Non-impaired	5	69.2	69.8	47.0	81.0	0.82
3	CLARK FORK RIVER @ ST REGIS	Non-impaired	5	64.7	68.4	50.3	77.1	0.77
4	LITTLE BLACKFOOT R @ GARRISON	Non-impaired	5	60.7	59.5	57.5	66.3	0.77
5	CLARK FORK RIVER @ TURAH	Non-impaired	5	60.4	63.0	47.0	71.6	0.75
Mountain Site Class								
1	BITTERROOT RIVER NEAR DARBY	Non-impaired	3	67.8	70.3	62.6	70.5	0.70
2	NFK FLATHEAD NEAR COLUMBIA FALLS	Non-impaired	5	64.3	61.4	56.0	79.5	0.90
3	S FK FLATHEAD RIVER @ SPOTTED BEAR	Non-impaired	4	63.8	64.7	49.4	76.4	0.88
4	FISHER RIVER NEAR MOUTH	Moderately Impaired	5	61.5	62.4	54.2	71.4	0.76
5	M FK FLATHEAD R NEAR W GLACIER	Moderately Impaired	5	58.8	54.8	49.7	73.1	0.85
6	BITTERROOT R NEAR MOUTH	Moderately Impaired	5	57.2	56.7	52.8	62.4	0.73
7	YAAK RIVER NEAR TROY	Moderately Impaired	5	56.8	57.3	45.7	67.6	0.84
8	WHITEFISH RIVER NEAR KALISPELL	Moderately Impaired	5	56.3	56.8	44.8	65.5	0.74
9	SWAN RIVER NEAR BIGFORK	Moderately Impaired	5	41.1	44.5	29.2	47.2	0.87

Table 3. RIVPACS results: Mean value of RIVPACS score over all study years, rank within each watershed/site class combination, and impairment classification based on mean score for each site.

Rank	Site	RIVPACS Model result (mean score)	Number of samples	Mean score	Median score	Min score	Max score	Mean habitat score
Missouri River								
Low Valley Site Class								
1	BEAVERHEAD RIVER @ TWIN BRIDGES	Non-impaired	5	1.21	1.26	1.13	1.26	0.61
2	MADISON RIVER NEAR THREE FORKS	Non-impaired	3	1.19	1.28	1.02	1.28	0.79
3	BEAVERHEAD RIVER NEAR DILLON	Non-impaired	4	1.17	1.20	1.01	1.27	0.72
4	BIG HOLE NEAR TWIN BRIDGES	Non-impaired	3	1.09	1.01	1.01	1.26	0.64
5	GALLATIN RIVER NEAR THREE FORKS	Non-impaired	4	1.07	1.13	0.88	1.13	0.63
6	JEFFERSON RIVER NEAR THREE FORKS	Non-impaired	5	1.03	1.01	1.01	1.13	0.63
7	PRICKLY PEAR CREEK NEAR CLANCY	Impaired	5	0.73	0.76	0.50	0.88	0.64
Mountain Site Class								
1	BIG HOLE RIVER NEAR WISE RIVER	Non-impaired	3	0.88	0.57	0.46	1.61	0.79
2	DEARBORN RIVER @ CRAIG	Non-impaired	5	0.83	0.88	0.50	1.01	0.76
Plains Site Class								
1	SUN RIVER @ SUN RIVER	Non-impaired	5	1.26	1.13	0.76	2.27	0.65
2	MUSSELSHELL RIVER @ HARLOTOWN	Non-impaired	4	1.08	1.08	0.89	1.27	0.63
3	SMITH RIVER @ EDEN BRIDGE	Non-impaired	4	1.07	1.07	0.88	1.26	0.74
4	POPLAR RIVER NEAR SCOBY	Non-impaired	5	1.02	1.12	0.74	1.12	0.68
5	MUSSELSHELL RIVER NEAR MOSBY	Impaired	5	0.70	0.75	0.12	1.00	0.49
6	TETON RIVER NEAR LOMA	Impaired	5	0.62	0.59	0.29	1.03	0.58
7	BIG MUDDY CREEK NEAR CULBERTSON	Impaired	1	0.37	0.37	0.37	0.37	0.64
8	MILK RIVER @ NASHUA	Impaired	3	0.33	0.37	0.25	0.37	0.55
9	MILK RIVER @ SACO	Impaired	2	0.31	0.31	0.25	0.37	0.71
10	JUDITH RIVER NEAR MOUTH	Impaired	5	0.27	0.30	0.00	0.45	0.76
Yellowstone River								
Low Valley Site Class								
1	BOULDER RIVER @ BIG TIMBER	Non-impaired	5	1.03	1.01	0.88	1.26	0.76
2	STILLWATER RIVER NEAR ABSAROKEE	Non-impaired	5	0.99	0.89	0.63	1.27	0.81
3	CLARKS FORK OF YELLOWSTONE @ EDGAR	Non-impaired	5	0.96	0.98	0.70	1.26	0.59
Plains Site Class								
1	SHIELDS RIVER NEAR LIVINGSTON	Non-impaired	5	1.38	1.13	1.01	2.39	0.71
2	ROSEBUD CR @ ROSEBUD	Impaired	5	0.72	0.87	0.12	1.12	0.38
3	BIG HORN RIVER NEAR HARDIN	Impaired	3	0.59	0.63	0.51	0.63	0.71
4	BIG HORN RIVER @ MOUTH	Impaired	5	0.57	0.62	0.25	0.75	0.64
5	TONGUE RIVER NEAR STATE LINE	Impaired	1	0.39	0.39	0.39	0.39	0.58
6	TONGUE R @ MILES CITY	Impaired	5	0.32	0.25	0.12	0.74	0.46
7	POWDER RIVER NEAR MOORHEAD	Impaired	4	0.25	0.25	0.00	0.50	0.53
8	TONGUE RIVER NEAR BRANDENBURG	Impaired	4	0.25	0.25	0.12	0.37	0.60
9	POWDER RIVER NEAR LOCATE	Impaired	5	0.15	0.12	0.00	0.25	0.46

Table 3. ***(continued)*** RIVPACS results: Mean value of RIVPACS score over all study years, rank within each watershed/site class combination, and impairment classification based on mean score for each site.

Rank	Site	RIVPACS Model result (mean score)	Number of samples	Mean score	Median score	Min score	Max score	Mean habitat score
Columbia River								
Low Valley Site Class								
1	LITTLE BLACKFOOT R @ GARRISON	Non-impaired	5	1.11	1.00	1.00	1.29	0.77
2	CLARK FORK RIVER @ TURAH	Non-impaired	5	0.94	0.71	0.71	1.71	0.75
3	CLARK FORK RIVER @ ST REGIS	Non-impaired	5	0.88	0.88	0.75	1.01	0.77
4	ROCK CREEK NEAR CLINTON	Impaired	5	0.79	0.79	0.57	1.02	0.82
5	BLACKFOOT R NEAR MOUTH	Impaired	5	0.65	0.67	0.56	0.78	0.79
Mountain Site Class								
1	WHITEFISH RIVER NEAR KALISPELL	Non-impaired	5	1.06	1.14	0.86	1.28	0.74
2	BITTERROOT RIVER NEAR DARBY	Non-impaired	3	1.01	1.01	0.89	1.14	0.70
3	FISHER RIVER NEAR MOUTH	Non-impaired	5	0.99	1.01	0.76	1.14	0.76
4	SWAN RIVER NEAR BIGFORK	Non-impaired	5	0.98	1.04	0.74	1.19	0.87
5	YAAK RIVER AT MOUTH	Non-impaired	5	0.91	0.89	0.76	1.01	0.84
6	BITTERROOT R NEAR MOUTH	Non-impaired	5	0.90	0.96	0.82	0.96	0.73
7	N FK FLATHEAD R NEAR COLUMBIA FALLS	Non-impaired	5	0.81	0.75	0.45	1.35	0.90
8	M FK FLATHEAD R NEAR W GLACIER	Impaired	5	0.69	0.75	0.45	0.89	0.85
9	S FK FLATHEAD RIVER @ SPOTTED BEAR	Impaired	4	0.62	0.62	0.53	0.70	0.88

Figure 1. Variation in RIVPACS (O/E) scores for Statewide monitoring network sites, 2001 – 2005. Sites sampled in a single year are not included. The impairment threshold for the RIVPACS model is 0.8 in all site classes.

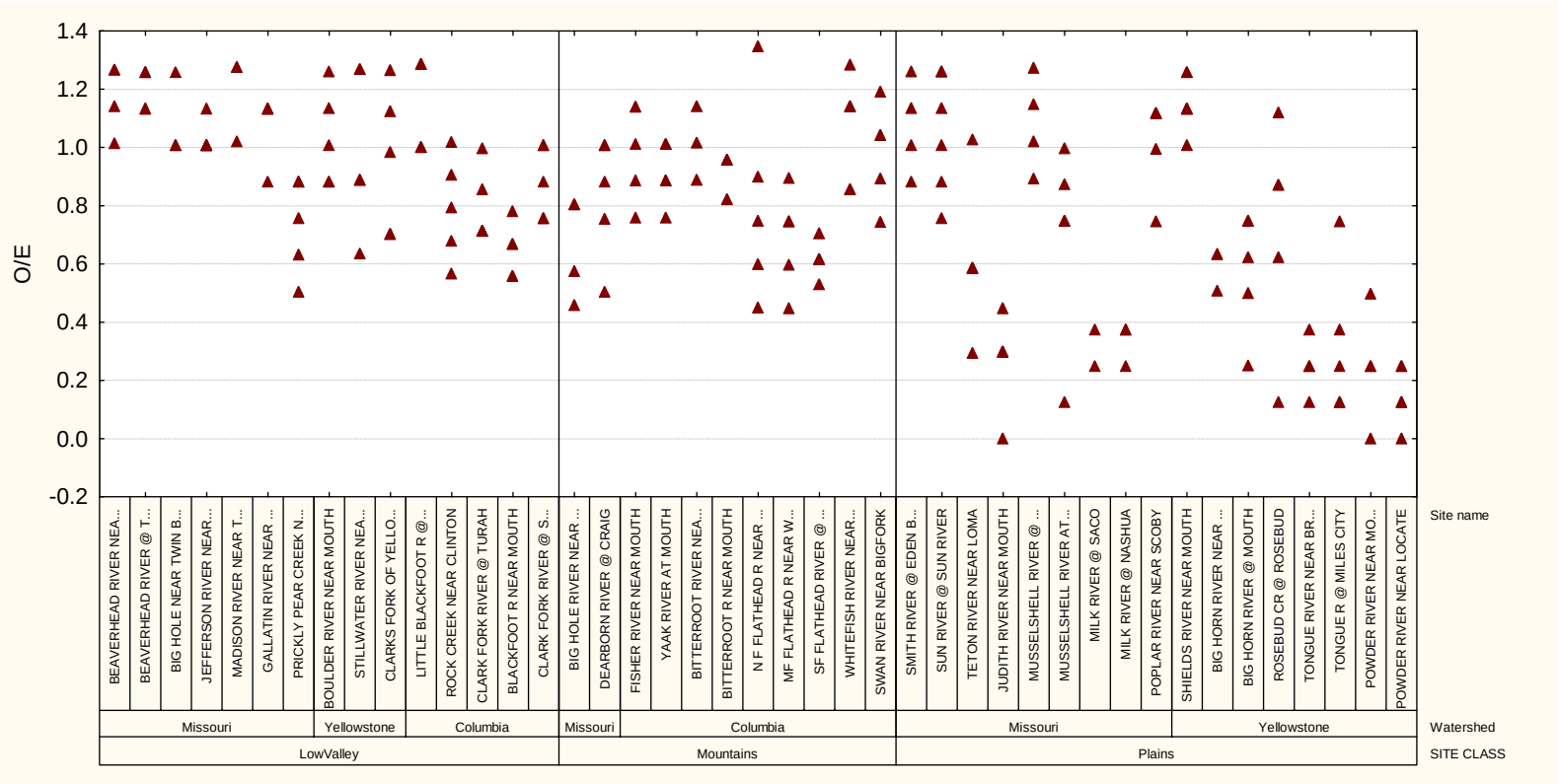


Figure 2. Variation in MMI scores for Statewide monitoring network sites, 2001 – 2005. Sites sampled in a single year are not included. The impairment threshold for Low Valley sites is 48; for Mountain sites 63; and for Plains sites 37.

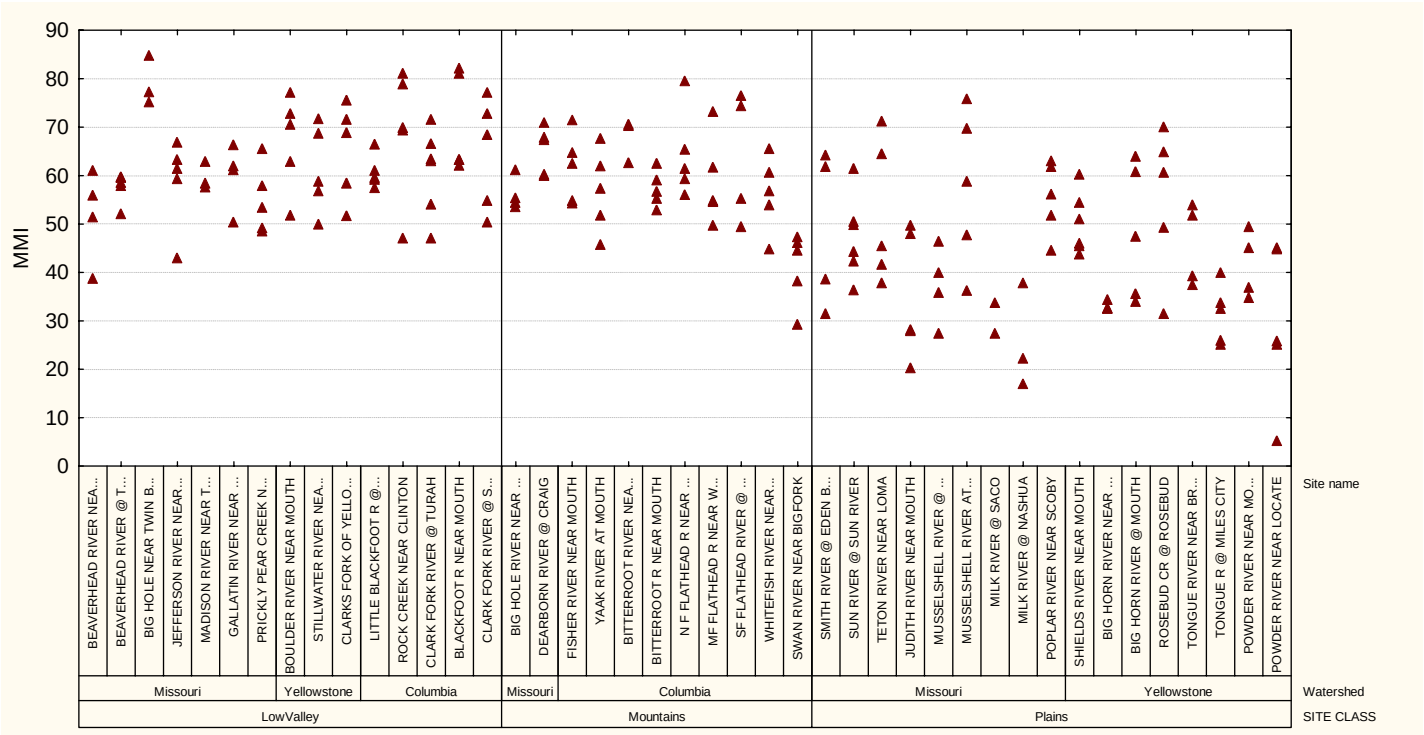


Figure 3. Variation in Historic MMI scores for Statewide monitoring network sites, 2001 – 2005. Sites sampled in a single year are not included. Mountain ecoregions site scores are based on evaluation with the MVFP index. The impairment threshold for all Historic MMI indices is 0.75.

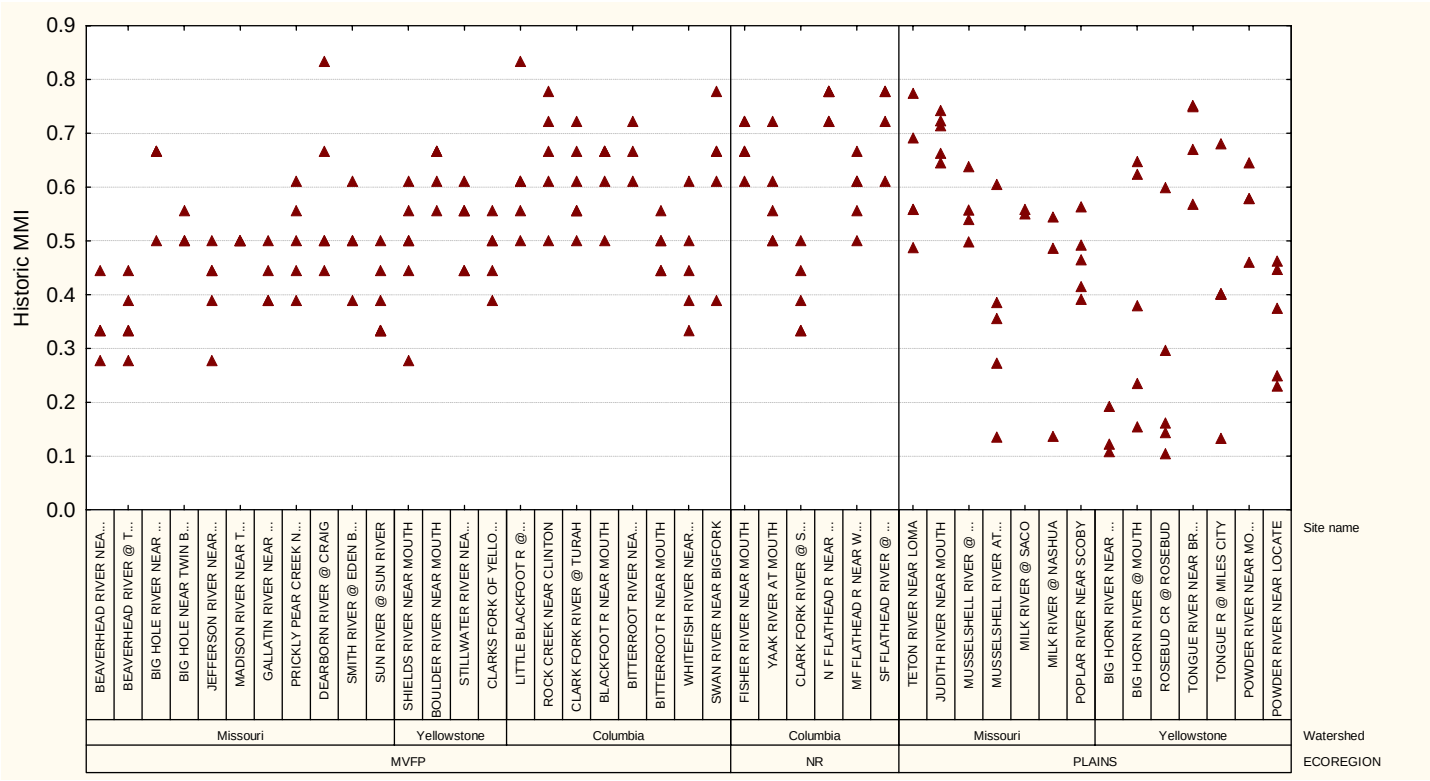


Figure 4. Mean values of standardized scores for all sites using the 3 assessment methods in each of the 5 years of the study. Bars represent 95% confidence intervals.

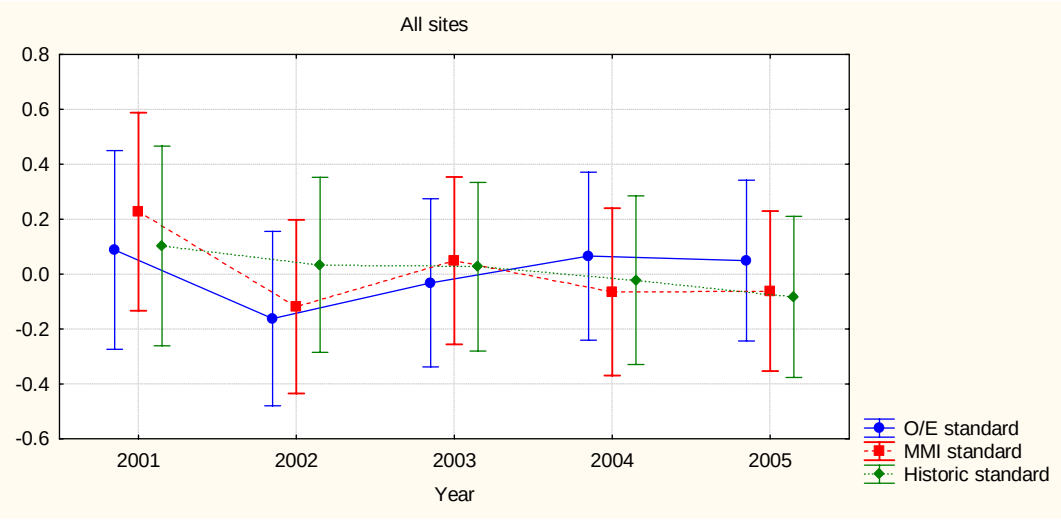


Figure 5. Plots of mean MMI and RIVPACS scores by year with samples grouped by site class. Bars represent 95% confidence intervals.

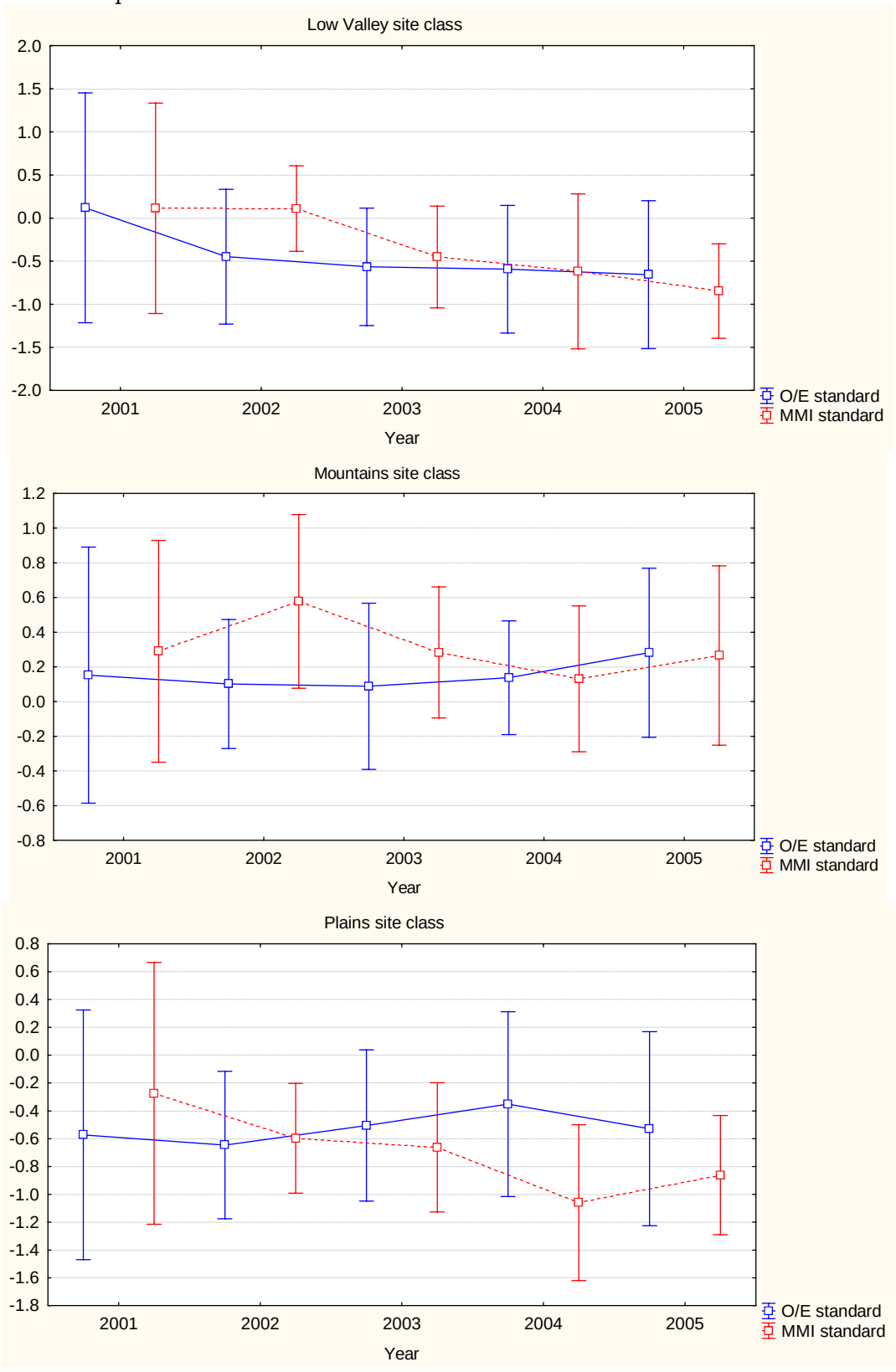
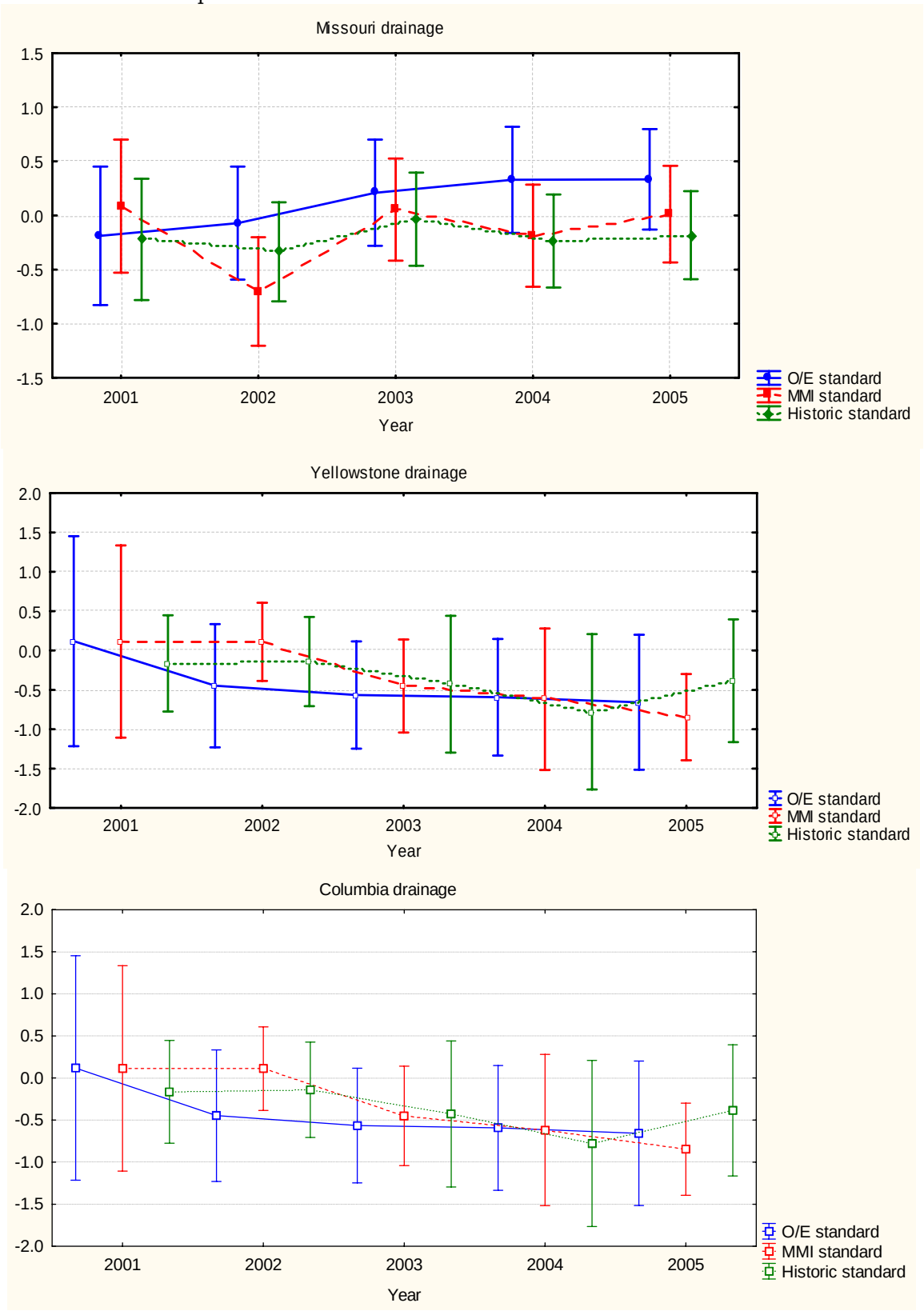


Figure 6. Plots of mean scores for all 3 methods by year with samples grouped by watershed. Bars represent 95% confidence intervals.



3. Agreement between bioassessment methods

To explore the agreement between bioassessment methods, analyses were based on observations where both macroinvertebrate and periphyton samples were collected in the same year (Appendix 3). Concurrent sampling of macroinvertebrate and periphyton occurred only in the years 2001 through 2003. During this time period, not all stations were sampled for macroinvertebrates and/or periphyton in all years. As a result, 110 sample events are considered in this analysis.

Stated protocols for each method, per references listed previously, were followed to assign one of two impairment classifications – "impaired" or "non-impaired". Based on these assessments, error matrices were then constructed (Appendix 4) comparing impairment determinations made by each assessment method to "reference" classifications provided by MDEQ (also listed in Appendix 3). An error matrix summarizes the frequency that samples are assigned to an impairment classification (via the relevant assessment method) relative to the impairment classification (per MDEQ). Columns represent MDEQ classifications and rows represent classifications per the assessment method. All correct classifications are indicated on the main diagonal. For instance, for all 110 samples, 54 samples were correctly classified as "Impaired" using the Historic MMI assessment method. Off-diagonal frequencies indicate misclassification, instances where impairment determinations via the assessment method do not agree with the MDEQ classification.

For each error matrix, a statistic is calculated – the kappa coefficient (Cohen's method, SYSTAT v11) – as a measure of how the impairment determination via the assessment method agrees with MDEQ classification. Specifically, kappa measures the percentage of data values in the main diagonal of the table and then adjusts for the amount of agreement that could be expected due to chance alone. Kappa is always less than or equal to 1. A value of 1 implies perfect agreement and values less than 1 imply less than perfect agreement. Where kappa is negative, this is a sign that the two assessments agreed less than would be expected just by chance (i.e., a flip of a coin). General guidelines for interpretation of kappa are: Poor agreement = Less than 0.20; Fair agreement = 0.20 to 0.40; Moderate agreement = 0.40 to 0.60; Good agreement = 0.60 to 0.80; and, Very Good agreement = 0.80 to 1.00.

Employing statistical methods introduced by Congalton and Mead (1983), the kappa coefficient was then used to test the difference in error matrices resulting from each assessment method. In this manner, null hypotheses were tested stating that no significant difference existed between error matrices (i.e., that the assessment methods agreed with one another relative to the MDEQ classification). Test statistics represent

the difference in kappa, scaled by a pooled standard error term. The resulting test statistics are normally distributed and evaluated against the z-distribution. Test statistics were evaluated at the 95% confidence level ($p < 0.05$) in considering the null hypothesis. Where the test statistic exceeded 1.96, this provided evidence to reject the null hypothesis thereby indicating a significant difference between the two error matrices. By extension, it would then be concluded that the two assessment methods are inconsistent.

Table 4 summarizes statistical comparison of error matrices generated for each assessment where all 110 samples are considered. This table reports kappa and an asymptotic standard error for each error matrix. Test statistics are reported within the table and significant differences between error matrices (and therefore assessment methods) are highlighted in yellow. With the exception of Increaser Taxa, kappa coefficients indicate assessment methods have "Poor" agreement with the MDEQ classifications; agreement of the Increaser Taxa is only "Fair". As a consequence, impairment determinations made via the Increaser Taxa significantly differ from those made via the other assessment methods. Likewise, the Revised MMI and Diatom MMI significantly differ, though to lesser extent. Otherwise, impairment determinations tend to agree amongst one another.

Table 4. Comparison of error matrices for each bioassessment method; all 110 samples are considered.

Rating	Kappa	ASE	Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	0.018	0.093	--	--	--	--
Revised MMI	-0.16	0.073	1.51	--	--	--
RIVPACS	-0.147	0.083	1.32	0.12	--	--
Diatom MMI	0.04	0.052	0.21	2.23	1.91	--
Increaser Taxa	0.305	0.09	2.22	4.01	3.69	2.55

These results are offered in recognition that use of a kappa coefficient requires that assessments be applied independently. While this assumption is satisfied, it is also recognized that year-to-year correlations may exist among samples. The effect of this is tempered by the fact that not all sites were sampled in each year. Furthermore, stream conditions may vary year-to-year, especially among impaired sites. To evaluate this, error matrices between years for each assessment method were compared. Year-by-year error matrices are presented in Appendix 4. Overall, only one significant difference ($p < 0.05$) between error matrices for any year for any assessment method was found – assessments made via the Historic MMI in 2001 and 2002. Otherwise, there were no significant differences between years for all assessment methods. Overall, this result provides caution for interpretation of statistics.

Table 5. Comparison of error matrices for each bioassessment method, using Historic MMI ecoregions.

Northern Rockies Samples

Rating	Kappa	ASE	Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	-0.016	0.117	--	--	--	--
Revised MMI	-0.296	0.195	1.23	--	--	--
RIVPACS	-0.4	0.188	1.73	0.38	--	--
Diatom MMI	-0.25	0.107	1.48	0.21	0.69	--
Increaser Taxa	0.886	0.11	5.62	5.28	5.90	7.40

Moutain Valley Foothill Plains Samples

Rating	Kappa	ASE	Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	0.182	0.128	--	--	--	--
Revised MMI	-0.041	0.068	1.54	--	--	--
RIVPACS	-0.125	0.093	1.94	0.73	--	--
Diatom MMI	0.115	0.045	0.49	1.91	2.32	--
Increaser Taxa	0.153	0.152	0.15	1.17	1.56	0.24

Plains Samples

Rating	Kappa	ASE	Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	0.111	0.109	--	--	--	--
Revised MMI	0.02	0.077	0.68	--	--	--
RIVPACS	-0.182	0.065	2.31	2.00	--	--
Diatom MMI	-0.082	0.092	1.35	0.85	0.89	--
Increaser Taxa	-0.033	0.103	0.96	0.41	1.22	0.35

Per MDEQ questions, evaluations were also conducted at the ecoregion level. Two ecoregion constructs were evaluated. The first construct considers the ecoregions employed by the Historic MMI, which distinguishes between the Plains and two montane ecoregions – Northern Rockies and the Montana Valley and Foothill Prairies (MVFP). The second construct considers a different construct employed by the MMI and RIVPACS methods which distinguish Plains, Mountains, and Low Valley site classes. The periphyton assessment methods – Diatom MMI and Increaser Taxa - simply distinguish between Plains and Mountains, Mountains being a combination of the two Historic MMI montane ecoregions. Because the macroinvertebrate classifications provided finer resolution, and the data supported analysis at this level, the coarser periphyton level was not considered.

Table 5 summarizes statistical comparison of error matrices generated for each assessment method by Historic MMI ecoregion. Again, most assessment methods yield kappa coefficients that indicate “Poor” agreement with the MDEQ classifications. The lone exception is the Increaser Taxa which exhibits “Very Good” agreement for samples from the Northern Rockies ecoregion. Consequently, among Northern Rockies samples, impairment determinations made via the Increaser Taxa significantly differ from those

made via all other assessment methods; otherwise, no significant differences exist. Among samples from the other ecoregions, most impairment determinations agree with one another with few exceptions. Among MVFP samples, RIVPACS determinations significantly differ from those made via the Diatom MMI. Among Plains samples, RIVPACS determinations significantly differ from those made via the Historic MMI and MMI.

Table 6 summarizes statistical comparison of error matrices generated for each assessment method by MMI and RIVPACS site classes. Again, most assessment methods yield kappa coefficients that indicate "Poor" agreement with the MDEQ classifications. The Increaser Taxa yield "Good" agreement with MDEQ classifications for samples representing Mountains site classes; the Historic MMI yields "Fair" agreement among Low Valley samples. Among Mountains samples, determinations made via the Increaser Taxa again significantly differ with those made via all other assessment methods. However, significant differences are evident among the other assessment methods as well. Among Low Valley samples, determinations made via RIVPACS significantly differ from those made via the Diatom MMI and MMI. Among Plains samples, RIVPACS determinations significantly differ from those made via the Historic MMI.

Table 6. Comparison of error matrices for each bioassessment method using MMI and RIVPACS site classes.

Mountains Samples

Rating			Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	-0.082	0.14	--	--	--	--
Revised MMI	0.019	0.152	0.49	--	--	--
RIVPACS	-0.497	0.143	2.07	2.47	--	--
Diatom MMI	-0.096	0.142	0.07	0.55	1.99	--
Increaser Taxa	0.779	0.12	4.67	3.92	6.84	4.71

Low Valley Samples

Rating			Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	0.212	0.141	--	--	--	--
Revised MMI	-0.026	0.053	1.58	--	--	--
RIVPACS	-0.183	0.111	2.20	1.28	--	--
Diatom MMI	0.111	0.053	0.67	1.83	2.39	--
Increaser Taxa	-0.009	0.155	1.05	0.10	0.91	0.73

Plains Samples

Rating			Historic MMI	Revised MMI	RIVPACS	Diatom MMI
Historic MMI	0.138	0.107	--	--	--	--
Revised MMI	0.01	0.059	1.05	--	--	--
RIVPACS	-0.17	0.071	2.40	1.95	--	--
Diatom MMI	-0.061	0.073	1.54	0.76	1.07	--
Increaser Taxa	0.009	0.094	0.91	0.01	1.52	0.59

DISCUSSION

In this report, the biologic conditions of Statewide monitoring sites in Montana as suggested by faunal characteristics of benthic invertebrate assemblages collected over 5 years are ranked and described. Spatial and temporal variation of Historic MMI, MMI, and RIVPACS results for the Statewide monitoring sites over the years of study is also illustrated. Finally, assessment results of the 3 benthic invertebrate models with assessments based on periphyton (diatom) biocriteria were compared, where diatom-based assessments were available.

Overall, assessment methods tend to yield impairment determinations that have generally "Poor" agreement with the MDEQ classifications. In many instances, kappa coefficients are negative indicating that agreement is less than would be expected just by chance. Only the Increaser Taxa yield determinations that have "Good" or "Very Good" agreement and this only occurs in the Mountains/Northern Rockies. Additionally, bioassessment results for the Statewide monitoring sites are considerably variable both spatially and temporally. Differences in site ordering by impairment between methods as well as variable performance within site classes and watersheds were evident, as well.

These findings were unexpected. The Statewide monitoring network is not a random selection of sites that represent all degrees of impairment or all of the natural variability of streams in the State. Thus, results from this study cannot be extrapolated to other sites, and inferences to other sites cannot be made concerning assessments, conditions, or variability. Nevertheless, these results caution against the utility of these methods for detecting impairment in these streams. Consequently, alternative interpretations of biological information are given below. Issues that may account for poor agreement are also hypothesized and recommendations are offered for addressing these issues further.

Alternative interpretations

While biocriteria associated with the assessment methods studied here are apparently unreliable at detecting impairment in the Statewide monitoring network sites, using the taxonomic composition of samples to inform interpretations of probable stressors may offer insights into the condition of these sites. Many studies have investigated the associations between elements of invertebrate assemblages and specific stressors (e.g. Clark 1997, Clements 1994, Bollman 1998, Kiffney and Clements 1994, McGuire 1993, Relyea et al. 2000, Wisseman 2002, Kleindl 1995, Patterson 1996, Fore 1996). These associations provide a basis for analyzing probable stressors at Statewide monitoring sites in this study. Among the stressors suggested by specific taxa as well as

by metric performance are sediment, nutrient enrichment, dewatering or thermal stress, metals contamination, and non-specific stressors to habitat and/or water quality. In a previous report (Bollman 2006), Statewide monitoring sites were evaluated for several of these potential stressors, and results of this analysis are summarized as follows.

1. The Missouri River basin

Metrics and taxonomic components suggested that most sites (85%) in the Missouri River basin supported invertebrate assemblages that were influenced by nutrient enrichment. Only 3 stations did not produce definitively positive response to at least 1 indicator metric value averaged over 5 years. These were: Judith River near mouth, Teton River near Loma, and Big Hole River near Wise River. Non-specific habitat disruptions ranked next in frequency (80%) among Missouri River basin sites. Sediment appeared to influence assemblages at 40% of stations. Evidence for periodic dewatering or thermal stress could be detected at 3 stations (15%); these were Milk River at Nashua, Milk River near Saco, and Musselshell River at Mosby. One station (Prickly Pear at Clancy) may have been impaired by heavy metals.

2. The Yellowstone River basin

Non-specific habitat disruptions were the most common stressors suggested by invertebrate assemblages for sites in the Yellowstone River basin. All but 1 station (Shields River near mouth) demonstrated positive responses to metrics associated with these disturbances. Sediment influence was more prevalent in the Yellowstone basin than in the Missouri River basin; impairment due to sediment deposition was detectable at 67% of stations. Nutrient enrichment was equally frequent (67%). Evidence of dewatering and/or thermal stress was apparent in average metric values calculated for 2 stations (Big Horn River near Hardin and Powder River near Locate), but positive metric responses were recorded for an additional 5 stations (Big Horn River at mouth, Clarks Fork River at Edgar, Powder River near Moorhead, Rosebud Creek near Rosebud, and Tongue River at Miles City) in most years of the study. These findings imply that 58% of the Yellowstone River basin monitoring stations may have been influenced by dewatering, thermal stress, or other stressors in most years between 2001 and 2005.

3. The Columbia River basin

Evidence for the influence of nutrient enrichment could be detected at 93% of Columbia River basin stations, making this stressor the most common probable cause of impairment in that basin. South Fork Flathead River at Spotted Bear was the only Columbia River basin site that did not give a positive response to any metric indicator of nutrient enrichment. Non-specific habitat disruptions were suggested by metric

performance at 6 sites (43%); these were Bitterroot River near mouth, Middle Fork Flathead River near West Glacier, North Fork Flathead River near Columbia Falls, South Fork Flathead River at Spotted Bear, Yaak River at mouth, and Clark Fork River at St. Regis. Stress due to sediment deposition was relatively rare in this watershed; it was detected at only 2 sites (14%); these were Middle Fork Flathead River near West Glacier and South Fork Flathead River at Spotted Bear. None of the Columbia River basin stations appeared to suffer from periodic dewatering or thermal stress.

Issues accounting for poor agreement

Three issues are discussed, hypothesizing possible reasons for the poor performance of macroinverterbrate bioassessment methodologies. All pertain to applicability of these methodologies to larger order streams. First, differences between high linkage stream and low linkage stream communities are described; fundamental differences limit the ability of current biocriteria to characterize impairment in larger order streams. Evidence is offered supporting this assertion in terms of the limitations of metric components of current biocriteria to accurately represent taxa assemblages found in higher order streams. An ordination study of the assemblages sampled at Statewide monitoring sites is used to illustrate inconsistencies with the site classification methods. And finally, concerns inherent with sampling larger stream systems are described, which also may partly account for the poor performance of current methodologies.

1. Limitations of current biocriteria applied to larger stream systems.

All stations in the Statewide monitoring network represent conditions in lower portions of watersheds, integrating large catchment areas, and are located in higher order streams. While some stations from the Statewide monitoring network were considered in development of macroinvertebrate metrics, it can be reasonably stated that all of the examined methodologies were developed using data primarily representing lower order streams. Therefore, biocriteria associated with them may not be appropriate for assessing the type of sites in the Statewide monitoring network, despite the fact that many streams in the network are wadeable. Aspects of the physical environment of higher linkage systems and distinctive attributes of macroinvertebrate communities found in these streams are presented below as a basis for this hypothesis. Many studies demonstrate that position of sites along a longitudinal continuum (e.g. Allan 1975, Minshall et al. 1985, Ward 1986, Finn and Poff 2005) and between biomes (e.g. Corkum 1990, 1991) are primary influences on benthic community structure and function. The importance of these influences is supported by the observation that the assessment methods employed in this study were not able to distinguish impairment

any better in “smaller” streams in the Statewide network than in “larger” streams (R. Apfelbeck, pers. comm). Despite the fact that many of the streams in this study were wadeable, taxonomic and functional differences between large order and small order systems need to be considered in stratification of sites for tool development. These differences affect both metric-based and predictive model-based tools. A small number of Statewide monitoring sites were included in the data set used to derive the MMIs and the RIVPACS model; inappropriate stratification of sites based on site position in the longitudinal continuum may contribute to the reported unreliability of the indices in distinguishing impairment. It is beyond the scope of this study to give an exhaustive review of the extensive literature related to the progression of invertebrate communities, ecological processes, hydrologic, and physical habitat characteristics along the longitudinal continuum. Consideration is given to a few points relevant to the biocriteria evaluated in this study.

The Historic MMI for lower linkage streams in montane ecoregions (i.e. MVFP and Mountain ecoregions) utilizes 3 metrics based on taxonomic composition of invertebrate assemblages (Ephemeroptera richness, Plecoptera richness, Trichoptera richness), 2 metrics based on taxon sensitivity, thermal requirements, and general tolerance to stressors, (Sensitive taxa richness, Percent tolerant taxa), and 1 metric based on functional attributes (Percent filterers). Each of these metrics potentially returns a significantly different result when applied to the fauna of high linkage systems. Mayflies, stoneflies, and caddisflies are present from low linkage headwaters to high linkage riverine sites in MVFP and Mountain ecoregion waters in Montana, although species replacements account for differences in faunal components over the longitudinal continuum. The expected richness of each of these groups over the continuum, however, has not been studied. Sensitive taxa as defined for the Historic MMI are generally cold stenotherm taxa; not unexpectedly, these taxa were rare in samples collected from Statewide monitoring sites (Bollman 2006). Higher order streams have higher water temperatures, and support fewer cold water organisms. Similarly, tolerant invertebrates are expected to be more common in higher order streams, where sediment dynamics, energetic processes, and thermal conditions are more favorable to them. According to the predictions of the River Continuum Concept (Vannote et al. 1980), energy resources in rivers of the size studied here are dominated by fine particulate organic matter, fostering abundant populations of filter-feeders. Filter-feeders are negatively associated with habitat and water quality in second and third order streams, but their abundance is expected to increase as stream order increases. Hawkins and Sedell (1981) and Minshall et al. (1983) found that longitudinal shifts in functional groups were generally consistent with distributions predicted by the

River Continuum Concept. Thus, it is reasonable to expect that the MVFP index would give significantly variable results depending on the location of a given site within the longitudinal continuum.

The Historic MMI (riffles) for Plains ecoregions was derived from collections made on small to medium size streams (Bramblett et al. 2003). Stagliano (2005) describes in detail faunal attributes that characterize Plains streams within the longitudinal continuum. While the progression of feeding groups in Plains streams is not expected to conform to predictions of the River Continuum Concept (Stagliano and Whiles 2002, Dodds et al. 1996), the fauna of high linkage riverine systems (e.g. Large Prairie River Assemblage, Large River Slow Current Assemblage) is demonstrated to differ significantly in both taxonomic and functional composition from those of lower linkage systems (e.g. Prairie Stream Assemblage). The same arguments may be applied to the revised MMI for Plains sites.

The revised MMI (Jessup et al. 2006) for Mountain sites suffers from some of the same limitations as the Historic MMI when applied to high linkage streams. Three metrics are based on the EPT fauna (E richness, P richness, and EPT percent); one metric measures the relative abundance of non-insects. A functional metric (Percent predators) and a habitus measure (Percent burrowers) are included. A modification of the Hilsenhoff Biotic Index (HBI) is also calculated and scored. Scoring for each of these metrics was generally calibrated for smaller, colder, stream systems when the MMI were devised. While species replacements over biomes and longitudinal gradients account for the presence of EPT taxa in most reaches of unimpaired montane streams, richness and relative abundance of these groups may not be similar in dissimilar environments, such as those encountered in lower reaches. Similar to the taxonomic richness-based metrics of the Historic MMI, performance of these metrics in higher linkage streams is probably not directly comparable to their performance in smaller streams. Low numbers of non-insect taxa in low linkage streams is expected, but taxa such as oligochaetes, mites, nematodes, snails, clams, crayfish, and other non-insect aquatic animals are expected to inhabit higher order systems in greater proportion, and most of these animals have important functions in riverine environments. The modified HBI is particularly vulnerable to misinterpretation when criteria for interpreting its value have not been developed for specific environmental conditions. Response of the HBI has been shown to vary with nutrient levels or saprobity (Hilsenhoff 1987), water temperature, abundance of filamentous algae, and sediment (Bollman 1998). Each of these parameters naturally varies over the longitudinal continuum of stream systems. Thus, the MMI for mountain site classes is likely to produce biased scores when applied to high linkage sites.

The MMI for Low Valley sites uses 3 metrics based on the relative abundances of certain taxonomic groups (Percent EPT excluding Baetidae and Hydropsychidae, Percent Chironomidae, and Percent Crustacea and Mollusca). Two additional metrics are based on functional composition (Shredder richness and Percent predators). It is notable that mayflies and caddisflies in the families Baetidae (e.g. *Baetis*, *Acentrella*) and Hydropsychidae (e.g. *Hydropsyche*, *Cheumatopsyche*) are typically the dominant members of their respective orders in higher linkage systems. Exclusion of these groups because of their relative tolerance is a strong indication of the differences in assemblages studied by the MMI developers compared to the assemblages in Statewide monitoring sites. The 2006 investigators (Jessup et al. 2006) found that the relative abundance of midges in their dataset fell when stress increased, which contradicts the conventional hypothesis that this group is universally tolerant, even brutish. Nevertheless, the relationship of midge abundance and impairment in riverine systems has not been adequately investigated; it has already been noted that the large majority of sites used by the MMI developers were lower order streams. Abundance of those midge taxa associated with filamentous algae increases dramatically when such algae is present in samples. Crustacean and molluscan taxa are expected to increase with stressors, particularly sediment stressors in the MMI paradigm. However, these taxa naturally increase in abundance lower in the longitudinal continuum; snails and amphipod crustaceans are important functional contributors in high linkage systems, where macrophytes form substantial instream habitats. Large bivalves are natural denizens of these riverine environs, and their presence usually signals stable, undisturbed habitats and good water quality. According to the 2006 investigation, the number of shredder taxa increased with increasing stress in their data set. This is plausible, since many shredding taxa are associated with filamentous algae. The group also includes the amphipod crustaceans, which are associated with large organic debris in slack water areas of riverine systems. Although large crops of filamentous algae may be an indication of nutrient enrichment, increasing richness in the shredder group as a whole has not been specifically associated with impairment in high linkage systems. The 2006 investigators note that the functional structure of assemblages changed considerably with increasing stress, as demonstrated by the decrease in the relative abundance of predators in impaired sites in their data set. The functional structure of benthic assemblages has also been demonstrated to change over the longitudinal continuum and between biomes; the relationship of this metric to impairment may be confounded when applied to assemblages from high order streams.

These observations suggest the need to devise new indices and other tools that better measure processes and composition associated with water and habitat quality in

higher linkage systems such as those that are part of the Statewide monitoring network. While all indices used either historically or more recently by MDEQ performed well in tests of accuracy and precision at the time of development in more appropriate data sets, extrapolation of these tools to high order systems appears to be ineffective. In fact, the incorporation of higher linkage streams in development data sets may have introduced an unintended level of variability, reducing the reliability of indices and tools.

2. Representativeness of biocriteria stream groupings

An ordination study (Figures 7 and 8) of invertebrate assemblages found at Statewide monitoring sites compares continua expressed by the taxa assemblages to classifications used by Historic MMI and the Revised MMI/RIVPACS methodologies. Potential differences between taxa assemblages found at the Statewide monitoring sites and those presumed by the various methodologies are evident. Classification methods generally agree, however, differences are apparent and add uncertainty to the applicability of current bioassessment methodologies to sites in the Statewide monitoring network.

The ordination results did not entirely support the classification of sites when reference sites were used (Jessup et al. 2006). Instead, assemblages collected at Statewide monitoring sites appeared to better fit a model in which sites located in mountainous regions, including the older Northern Rockies and Montana Valley and Foothill Prairies regions as described by Woods et al. (1999), are distinguished from sites located in the Plains ecoregions. Three sites were classified as Plains sites in the new site classification method, but had been considered MVFP sites in the older method. The new MMI evaluated these sites as non-impaired (Sun River at Sun River, 5 of 6 samples; Shields River at Livingston, 6 of 6 samples; Smith River at Eden Bridge, 3 of 4 samples), whereas the Historic MMI detected impairment at each of these sites, agreeing in these cases with the "reference" classifications made by MDEQ (Appendix 2). These differences in impairment evaluations may be related to the use of a Plains MMI for these sites, which supported assemblages that are more consistent with concepts of montane communities. Ordination results, illustrating the similarity of invertebrate assemblages in the Statewide monitoring dataset, are graphed in Figures 7 and 8; these are identical plots except that each uses a different site stratification scheme. In Figure 7, site class groups, based on the method of Jessup et al. (2006) are evidently confounded with each other; at least 14 sampled assemblages in the Plains site class were more similar to Low Valley and Mountain sites than they were to other Plains sites. Level III ecoregions (Figure 8) did a better job than site classes at stratifying assemblages according to the presence and/or absence of invertebrate taxa. A single

site, Tongue River at State line, appears to be incorrectly classified; this can be attributed to analyst error, since the MVFP designation was not fully supported by ecoregion map criteria.

3. Sampling variability and sampling method limitations at riverine sites.

The variability of invertebrate assemblages at the Statewide monitoring sites may not have been adequately represented by the sampling methods used. Compared to lower-linkage streams, riverine environments are more difficult to sample. Kicknet and Hess samples capture organisms from very small areas when the total range of aquatic environments in these systems is considered. Figure 9 demonstrates that the number of organisms captured at Statewide monitoring sites varied considerably, especially for Plains and Mountain sites. Most of the time, a minimum number of organisms was obtained, but fully 25% of samples did not contain at least 300 animals. In a few instances, a dearth of invertebrates appeared to characterize sites in all years (e.g. Powder River at Locate, Tongue River near Brandenburg). However, it was more typical in Plains and Mountain sites that some years' samples contained many organisms and very few animals were collected in other years. Over and above the performance of bioassessment metrics and observed assemblages, this pattern demonstrates extreme variability in either biotic condition or sampling method; the source of the variability is not clear from the data. However, DEQ staff reports diligent sampling efforts but varying instream conditions, many of which were related to inadequate flow, in Plains regions sites; seasonal low flow conditions may have contributed to the variability of sample numbers for these sampling events (R. Apfelbeck, pers. comm.) At other sites, limitations of sampling methodology using Hess samplers or kicknets in riverine settings may account for variable organism numbers where low flow conditions did not complicate matters.

Recommendations for further study

The hypotheses stated above are offered in recognition that there exists no similar study of smaller order streams. Furthermore, it is restated that the Statewide monitoring network is not a random selection of sites and that results from this study cannot be extrapolated to other sites. Therefore, it is recommended that the State consider a more robust validation of current bioassessment methodologies. The results of this study justify that such an investigation is warranted. In order to gain a clear understanding, a probabilistic sample of stream conditions throughout the state must be considered; this is the only way to evaluate potential strengths and weaknesses in an unbiased, non-speculative manner. By considering large and small streams in the same evaluation, potential effects of stream size – i.e., the hypotheses laid out above – can be

evaluated. Other potential factors should be considered, too. Once performance and agreement of current methodologies is understood, then salient recommendations for improving biocriteria can be made.

Although other investigations into the Statewide monitoring data set were originally proposed by these authors, the results of this study seem to undermine the original rationale for many of them. For example, it does not seem that a statistical investigation of temporal variability of methods, or an evaluation of Aquatic Life Use tiers are warranted, given the lack of consensus between results given by the tools. In general terms, impairment classification accuracy of methods when compared to best professional judgment regarding condition of sites was tested in this study. Annual reporting on Statewide monitoring sites included narrative interpretations of taxonomic composition and metric performance independent of impairment classifications; the accuracy of these interpretations could be examined in a further study. Finally, the proposed exploratory analysis of invertebrate and periphyton taxa co-occurrence remains an interesting question that could be investigated using data from the earlier years of the Statewide monitoring project.

Figure 7. Ordination study of Statewide monitoring sites in all years of study, with sites identified by site classes (Jessup et al. 2006).

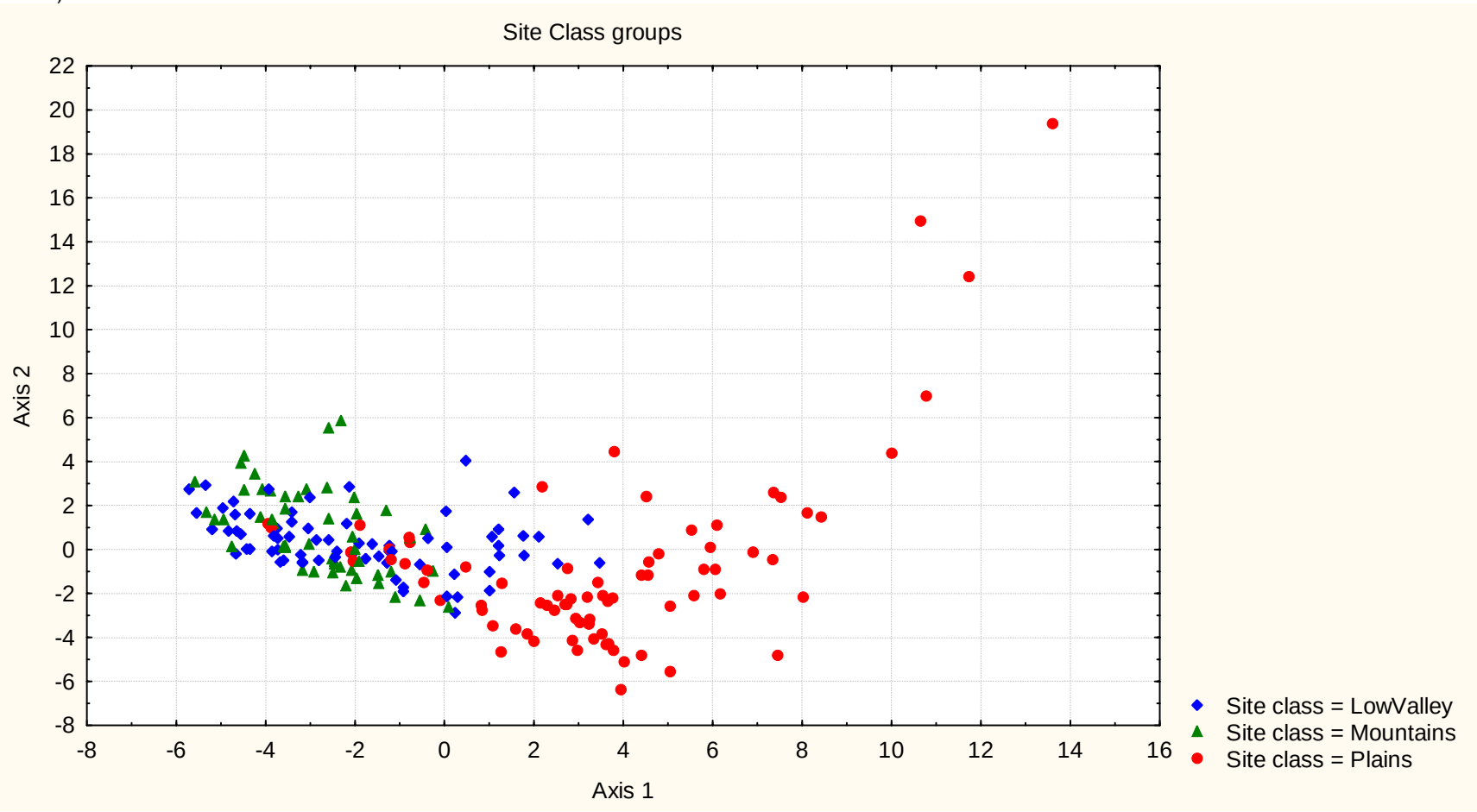


Figure 8. Ordination study of Statewide monitoring sites in all years of study, with sites identified by ecoregions (Woods et al. 1999).

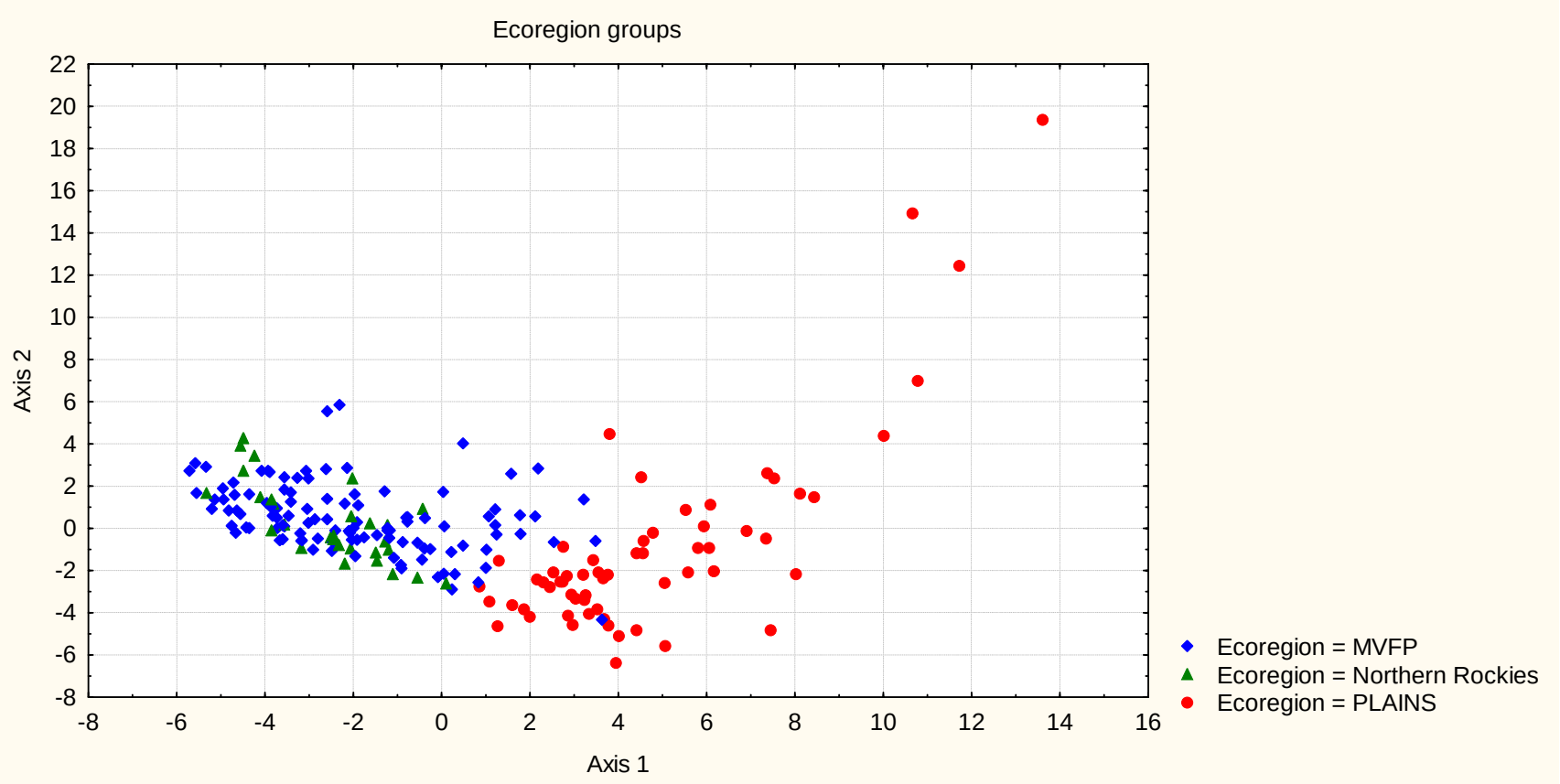
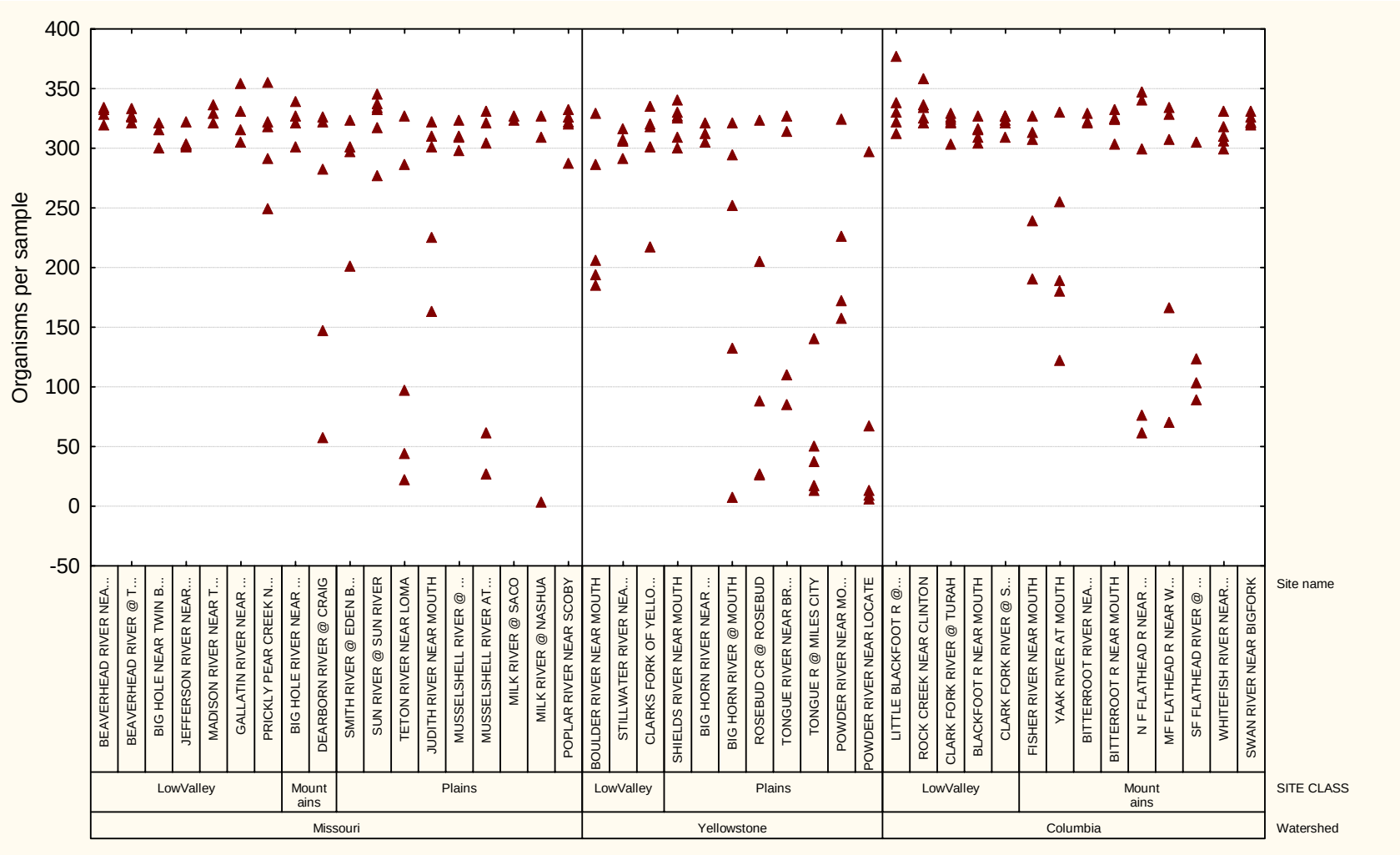


Figure 9. Variation in the number of organisms collected in samples from Statewide monitoring sites in each of 5 years.



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APPENDICES

1. Revised MMI and RIVPACS metrics, scoring and results.

2. Site impairment, estimated degree of impairment and probable causes.

3. Classification results for all assessment methods.

4. Error matrices used to derive Kappa coefficients.

Appendix 1. Revised MMI and RIVPACS metrics, scoring and results.

StationID	WaterbodyName	ActivityID	Lat_Dec	Long_Dec	SiteClass	CollDate	CollMeth	TotalInd	LowValIndex	EPTnoHBPct	EPTnoHBPctScLV
M02BVHDR01	Beaverhead River	02-S112-M	45.18	-112.69	LowValley	7/26/2002	HESS	332	38.65	36.75	51.76
M08BEAVR01	Beaverhead River	02-S113-M	45.55	-112.34	LowValley	7/26/2002	HESS	327	59.52	43.43	61.16
M02BVHDR01	Beaverhead River	03-S133-M	45.18	-112.69	LowValley	7/30/2003	KICK	319	51.31	16.93	23.84
M08BEAVR01	Beaverhead River	03-S134-M	45.55	-112.34	LowValley	7/31/2003	KICK	326	59.73	57.98	81.66
M08BEAVR01	Beaverhead River	M08BEAVR01	45.55	-112.34	LowValley	7/13/2001	UNKNOWN	321	58.49	38.63	54.41
M02BVHDR01	Beaverhead River	S2050-M	45.18	-112.69	LowValley	7/28/2004	HESS	328	61.03	26.83	37.79
M02BVHDR01	Beaverhead River	S2051-M	45.18	-112.69	LowValley	7/28/2004	KICK	333	61.61	19.82	27.92
M08BEAVR01	Beaverhead River	S2052-M	45.55	-112.34	LowValley	7/29/2004	HESS	333	51.97	49.85	70.21
M02BVHDR01	Beaverhead River	S2120-M	45.18	-112.69	LowValley	8/4/2005	UNKNOWN	334	55.77	35.03	49.34
M08BEAVR01	Beaverhead River	S2121-M	45.55	-112.34	LowValley	8/4/2005	UNKNOWN	327	57.87	31.80	44.79
M03BGHLR02	Big Hole River	03-S135-M	45.55	-112.37	LowValley	7/31/2003	HESS	300	84.76	18.67	26.29
M03BGHLR02	Big Hole River	S2053-M	45.55	-112.37	LowValley	7/29/2004	HESS	321	75.06	9.66	13.60
M03BGHLR02	Big Hole River	S2122-M	45.55	-112.37	LowValley	8/4/2005	UNKNOWN	315	77.20	9.84	13.86
C03BLACR01	Blackfoot R	02-S161-M	46.90	-113.76	LowValley	9/11/2002	HESS	315	62.09	29.21	41.14
C03BLACR01	Blackfoot R	03-S128-M	46.90	-113.76	LowValley	7/28/2003	HESS	316	63.19	48.10	67.75
C03BLACR01	Blackfoot R	C03BLACR01	46.90	-113.76	LowValley	8/22/2001	UNKNOWN	304	82.10	27.30	38.45
C03BLACR01	Blackfoot R	S2043-M	46.90	-113.76	LowValley	7/26/2004	HESS	309	81.09	17.48	24.61
C03BLACR01	Blackfoot R	S2044-M	46.90	-113.76	LowValley	7/26/2004	KICK	267	68.55	14.98	21.10
C03BLACR01	Blackfoot R	S2114-M	46.90	-113.76	LowValley	8/2/2005	UNKNOWN	327	63.16	18.35	25.84
Y03BOULR01	Boulder River	02-S156-M	45.83	-109.94	LowValley	8/28/2002	HESS	194	72.76	47.42	66.79
Y03BOULR01	Boulder River	03-S123-M	45.83	-109.94	LowValley	7/17/2003	HESS	206	51.81	37.38	52.65
Y03BOULR01	Boulder River	S2017-M	45.83	-109.94	LowValley	6/24/2004	HESS	185	70.49	65.41	92.12
Y03BOULR01	Boulder River	S2018-M	45.83	-109.94	LowValley	6/24/2004	KICK	328	54.53	30.79	43.37
Y03BOULR01	Boulder River	S2101-M	45.83	-109.94	LowValley	7/16/2005	UNKNOWN	286	62.78	30.42	42.84
Y03BOULR01	Boulder River	Y03BOULR01	45.83	-109.94	LowValley	7/24/2001	UNKNOWN	329	77.13	62.01	87.33
C04CKFKR01	Clark Fork River	02-S154-M	47.30	-115.09	LowValley	8/23/2002	HESS	327	54.82	16.82	23.69
C02CKFKR02	Clark Fork River	02-S163-M	46.82	-113.81	LowValley	9/12/2002	HESS	324	47.00	16.36	23.04
C02CKFKR02	Clark Fork River	03-S127-M	46.82	-113.81	LowValley	7/28/2003	HESS	326	62.99	30.67	43.20
C04CKFKR01	Clark Fork River	03-S149-M	47.30	-115.09	LowValley	8/14/2003	HESS	309	72.76	4.21	5.93
C02CKFKR02	Clark Fork River	C02CKFKR02	46.82	-113.81	LowValley	8/22/2001	UNKNOWN	322	53.94	14.60	20.56
C04CKFKR01	Clark Fork River	C04CKFKR01	47.30	-115.09	LowValley	8/21/2001	UNKNOWN	321	50.32	12.46	17.55
C02CKFKR02	Clark Fork River	S2041-M	46.82	-113.81	LowValley	7/26/2004	HESS	329	71.60	16.41	23.12
C02CKFKR02	Clark Fork River	S2042-M	46.82	-113.81	LowValley	7/26/2004	KICK	310	78.41	16.77	23.63
C04CKFKR01	Clark Fork River	S2069-M	47.30	-115.09	LowValley	8/11/2004	HESS	327	77.09	10.09	14.21
C04CKFKR01	Clark Fork River	S2070-M	47.30	-115.09	LowValley	8/11/2004	KICK	327	76.29	12.54	17.66
C02CKFKR02	Clark Fork River	S2113-M	46.82	-113.81	LowValley	8/2/2005	UNKNOWN	303	66.51	32.67	46.02
C02CKFKR02	Clark Fork River	S2113-M	46.82	-113.81	LowValley	8/2/2005	UNKNOWN	321	63.40	18.07	25.45
C04CKFKR01	Clark Fork River	S2136-M	47.30	-115.09	LowValley	8/10/2005	UNKNOWN	323	68.37	18.89	26.60

Appendix 1. continued

StationID	WaterbodyName	ActivityID	Midge Pct	Midge PctScLV	CrusMolPct	CrusMol PctScLV	Shred derTax	ShredderTaxScLV	PredPct LV	PredPctScLV	OEModel Test	Total OEBugs	O/E_p >half
M02BVHDR01	Beaverhead River	02-S112-M	5.12	12.80	16.27	18.67		100.00	3.31	10.04	P	300	1.14
M08BEAVR01	Beaverhead River	02-S113-M	16.21	40.52	4.89	75.54		100.00	6.73	20.39	P	300	1.26
M02BVHDR01	Beaverhead River	03-S133-M	18.18	45.45	5.02	74.92		100.00	4.08	12.35	P	300	1.27
M08BEAVR01	Beaverhead River	03-S134-M	8.59	21.47	2.15	89.26	0.99	85.80	6.75	20.45	P	300	1.13
M08BEAVR01	Beaverhead River	M08BEAVR01	18.38	45.95	4.98	75.08		100.00	5.61	16.99	P	300	1.26
M02BVHDR01	Beaverhead River	S2050-M	35.37	88.41	9.76	51.22		100.00	9.15	27.72	P	300	1.01
M02BVHDR01	Beaverhead River	S2051-M	50.15	100.00	8.71	56.46		100.00	7.81	23.66	P	300	1.14
M08BEAVR01	Beaverhead River	S2052-M	6.01	15.02	7.81	60.96		100.00	4.50	13.65	P	300	1.13
M02BVHDR01	Beaverhead River	S2120-M	17.37	43.41	2.40	88.02	0.90	87.17	3.59	10.89	P	300	1.27
M08BEAVR01	Beaverhead River	S2121-M	12.23	30.58	1.83	90.83		100.00	7.65	23.17	P	300	1.26
M03BGHLR02	Big Hole River	03-S135-M	39.00	97.50		100.00		100.00	38.00	100.00	P	297	1.01
M03BGHLR02	Big Hole River	S2053-M	58.26	100.00	0.31	98.44		100.00	20.87	63.25	P	300	1.26
M03BGHLR02	Big Hole River	S2122-M	42.86	100.00		100.00		100.00	23.81	72.15	P	300	1.01
C03BLACR01	Blackfoot R	02-S161-M	27.62	69.05		100.00	2.00	71.43	9.52	28.86	P	300	0.56
C03BLACR01	Blackfoot R	03-S128-M	13.29	33.23	0.32	98.42	2.00	71.50	14.87	45.07	P	300	0.56
C03BLACR01	Blackfoot R	C03BLACR01	37.17	92.93	1.32	93.42	1.00	85.71	35.20	100.00	P	284	0.78
C03BLACR01	Blackfoot R	S2043-M	49.19	100.00	0.97	95.15	1.00	85.71	53.72	100.00	P	297	0.67
C03BLACR01	Blackfoot R	S2044-M	61.42	100.00	4.12	79.40	3.00	57.14	28.09	85.12	P	266	0.67
C03BLACR01	Blackfoot R	S2114-M	25.99	64.98	2.45	87.77	2.91	58.42	25.99	78.77	P	300	0.67
Y03BOULR01	Boulder River	02-S156-M	25.77	64.43		100.00	1.00	85.71	15.46	46.86	P	187	1.01
Y03BOULR01	Boulder River	03-S123-M	3.40	8.50		100.00	2.00	71.43	8.74	26.48	P	205	0.88
Y03BOULR01	Boulder River	S2017-M	9.73	24.32	1.08	94.59	1.00	85.71	18.38	55.69	P	183	0.88
Y03BOULR01	Boulder River	S2018-M	7.93	19.82	0.61	96.95	1.00	85.71	8.84	26.79	P	300	0.88
Y03BOULR01	Boulder River	S2101-M	20.28	50.70	0.70	96.50	1.00	85.71	12.59	38.14	P	278	1.13
Y03BOULR01	Boulder River	Y03BOULR01	17.93	44.83	0.91	95.44		100.00	19.15	58.03	P	300	1.26
C04CKFKR01	Clark Fork River	02-S154-M	16.51	41.28		100.00	0.92	86.89	7.34	22.24	F	300	0.88
C02CKFKR02	Clark Fork River	02-S163-M	20.06	50.15		100.00	3.85	44.97	5.56	16.84	P	300	0.71
C02CKFKR02	Clark Fork River	03-S127-M	11.96	29.91		100.00		100.00	13.80	41.83	P	300	0.71
C04CKFKR01	Clark Fork River	03-S149-M	62.78	100.00		100.00		100.00	19.09	57.86	F	300	0.75
C02CKFKR02	Clark Fork River	C02CKFKR02	17.08	42.70		100.00	1.00	85.71	6.83	20.70	P	300	0.71
C04CKFKR01	Clark Fork River	C04CKFKR01	11.53	28.82	0.62	96.88	1.00	85.71	7.48	22.66	F	300	1.01
C02CKFKR02	Clark Fork River	S2041-M	46.50	100.00		100.00	0.91	86.97	15.81	47.90	P	300	0.85
C02CKFKR02	Clark Fork River	S2042-M	45.16	100.00		100.00		100.00	22.58	68.43	P	287	1.14
C04CKFKR01	Clark Fork River	S2069-M	44.95	100.00		100.00	0.92	86.89	27.83	84.33	F	300	0.75
C04CKFKR01	Clark Fork River	S2070-M	62.08	100.00		100.00	0.92	86.89	25.38	76.92	F	300	0.88
C02CKFKR02	Clark Fork River	S2113-M	25.41	63.53		100.00		100.00	7.59	23.00	P	285	1.00
C02CKFKR02	Clark Fork River	S2113-M	32.09	80.22		100.00		100.00	3.74	11.33	P	296	0.71
C04CKFKR01	Clark Fork River	S2136-M	31.89	79.72		100.00	0.93	86.73	16.10	48.79	F	300	1.01

Appendix 1. continued

StationID	WaterbodyName	ActivityID	Lat_Dec	Long_Dec	SiteClass	CollDate	CollMeth	TotalInd	LowValIndex	EPTnoHBPct	EPTnoHBPctScL
Y05CLFYR01	Clarks Fork of Yellowstone	02-S122-M	45.46	-108.84	LowValley	8/2/2002	KICK	320	68.80	48.44	68.22
Y05CLFYR01	Clarks Fork of Yellowstone	03-S121-M	45.46	-108.84	LowValley	7/16/2003	KICK	335	75.52	6.27	8.83
Y05CLFYR01	Clarks Fork of Yellowstone	S2012-M	45.46	-108.84	LowValley	6/23/2004	HESS	301	51.55	13.95	19.65
Y05CLFYR01	Clarks Fork of Yellowstone	S2096-M	45.46	-108.84	LowValley	7/15/2005	UNKNOWN	217	58.40	59.91	84.38
Y05CLFYR01	Clarks Fork of Yellowstone	Y05CLFYR01	45.46	-108.84	LowValley	7/24/2001	UNKNOWN	318	71.50	52.20	73.52
M05GALLR01	Gallatin River	M05GALLR01	45.89	-111.48		7/12/2001	UNKNOWN	320	72.86	39.06	55.02
M05GALLR02	Gallatin River	02-S158-M	45.93	-111.49	LowValley	8/29/2002	HESS	331	50.26	26.28	37.02
M05GALLR02	Gallatin River	03-S137-M	45.93	-111.49	LowValley	8/1/2003	KICK	354	61.96	22.03	31.03
M05GALLR02	Gallatin River	S2056-M	45.93	-111.49	LowValley	7/30/2004	HESS	305	66.27	34.75	48.95
M05GALLR02	Gallatin River	S2123-M	45.93	-111.49	LowValley	8/5/2005	UNKNOWN	315	61.07	41.59	58.57
M08JEFFR01	Jefferson River	02-S164-M	45.89	-111.60	LowValley	9/29/2002	HESS	322	42.85	13.04	18.37
M08JEFFR01	Jefferson River	03-S138-M	45.89	-111.60	LowValley	8/1/2003	HESS	303	59.34	33.66	47.41
M08JEFFR01	Jefferson River	M08JEFFR01	45.89	-111.60	LowValley	7/12/2001	UNKNOWN	302	61.33	32.12	45.24
M08JEFFR01	Jefferson River	S2057-M	45.89	-111.60	LowValley	7/30/2004	HESS	301	63.20	21.59	30.42
M08JEFFR01	Jefferson River	S2058-M	45.89	-111.60	LowValley	7/30/2004	KICK	304	61.27	19.41	27.34
M08JEFFR01	Jefferson River	S2126-M	45.89	-111.60	LowValley	8/5/2005	UNKNOWN	303	66.80	54.13	76.23
C01LTBLR01	Little Blackfoot R	02-S101-M	46.52	-112.79	LowValley	6/28/2002	HESS	377	59.11	36.34	51.18
C01LTBLR01	Little Blackfoot R	03-S104-M	46.52	-112.79	LowValley	6/18/2003	HESS	338	66.34	31.36	44.17
C01LTBLR01	Little Blackfoot R	C01LTBLR01	46.52	-112.79	LowValley	8/21/2001	UNKNOWN	312	60.95	7.05	9.93
C01LTBLR01	Little Blackfoot R	S2027-M	46.52	-112.79	LowValley	6/30/2004	HESS	322	59.53	34.16	48.11
C01LTBLR01	Little Blackfoot R	S2028-M	46.52	-112.79	LowValley	6/30/2004	KICK	323	56.66	36.84	51.89
C01LTBLR01	Little Blackfoot R	S2109-M	46.52	-112.79	LowValley	7/21/2005	UNKNOWN	330	57.49	24.55	34.57
M06MADNR01	Madison River	03-S139-M	45.80	-111.51	LowValley	8/1/2003	KICK	329	62.84	49.24	69.35
M06MADNR01	Madison River	S2054-M	45.80	-111.51	LowValley	7/30/2004	HESS	321	57.60	32.09	45.19
M06MADNR01	Madison River	S2124-M	45.80	-111.51	LowValley	8/5/2005	UNKNOWN	336	58.35	35.12	49.46
M09PRPEC01	Prickly Pear Creek near Clancy	02-S100-M	46.52	-111.95	LowValley	6/27/2002	HESS	355	48.48	41.41	58.32
M09PRPEC01	Prickly Pear Creek near Clancy	03-S100-M	46.52	-111.95	LowValley	6/16/2003	HESS	291	53.28	27.49	38.72
M09PRPEC01	Prickly Pear Creek near Clancy	M09PRPEC01	46.52	-111.95	LowValley	6/19/2001	UNKNOWN	249	49.06	27.31	38.46
M09PRPEC01	Prickly Pear Creek near Clancy	S2025-M	46.52	-111.95	LowValley	6/30/2004	HESS	318	65.53	9.12	12.84
M09PRPEC01	Prickly Pear Creek near Clancy	S2026-M	46.52	-111.95	LowValley	6/30/2004	KICK	305	68.39	22.95	32.33
M09PRPEC01	Prickly Pear Creek near Clancy	S2086-M	46.52	-111.95	LowValley	7/6/2005	UNKNOWN	322	57.85	59.32	83.54
C02ROCKC01	Rock Creek	02-S160-M	46.70	-113.66	LowValley	9/11/2002	HESS	334	47.02	29.04	40.90
C02ROCKC01	Rock Creek	03-S126-M	46.70	-113.66	LowValley	7/28/2003	HESS	358	69.83	20.67	29.11
C02ROCKC01	Rock Creek	C02ROCKC01	46.70	-113.66	LowValley	8/23/2001	UNKNOWN	325	69.34	21.54	30.34
C02ROCKC01	Rock Creek	S2039-M	46.70	-113.66	LowValley	7/26/2004	HESS	321	78.78	14.64	20.62
C02ROCKC01	Rock Creek	S2110-M	46.70	-113.66	LowValley	8/2/2005	UNKNOWN	336	81.00	17.56	24.73
Y04STILR01	Stillwater River	02-S157-M	45.58	-109.34	LowValley	8/29/2002	HESS	307	58.70	47.56	66.98
Y04STILR01	Stillwater River	03-S122-M	45.58	-109.34	LowValley	7/17/2003	HESS	306	56.71	58.17	81.93
Y04STILR01	Stillwater River	S2013-M	45.58	-109.34	LowValley	6/23/2004	HESS	316	68.64	73.42	100.00
Y04STILR01	Stillwater River	S2014-M	45.58	-109.34	LowValley	6/23/2004	KICK	325	68.08	67.08	94.47
	Stillwater River	S2098-M	45.58	-109.34	LowValley	7/15/2005	UNKNOWN	291	49.85	35.74	50.34

StationID	WaterbodyName	ActivityID	Midge Pct	MidgePct ScLV	Crus MolP ct	CrusMo lPctScL V	Shr edd erTa x	Shredd erTaxS cLV	PredP ctLV	PredPc tScLV	OEMo delTe st	Tota lOE Bug s	O/E_p >half
Y05CLFYR01	Clarks Fork of Yellowstone	02-S122-M	12.50	31.25		100.00		100.00	14.69	44.51	P	300	1.12
Y05CLFYR01	Clarks Fork of Yellowstone	03-S121-M	82.99	100.00		100.00		100.00	22.69	68.75	P	300	0.70
Y05CLFYR01	Clarks Fork of Yellowstone	S2012-M	10.30	25.75	1.33	93.36	1.00	85.76	10.96	33.22	P	300	0.98
Y05CLFYR01	Clarks Fork of Yellowstone	S2096-M	1.38	3.46		100.00		100.00	1.38	4.19	P	216	0.70
Y05CLFYR01	Clarks Fork of Yellowstone	Y05CLFYR01	15.72	39.31		100.00	0.94	86.52	19.18	58.13	P	300	1.26
M05GALLR01	Gallatin River	M05GALLR01	27.81	69.53	0.94	95.31	1.00	85.72	19.38	58.71			
M05GALLR02	Gallatin River	02-S158-M	2.42	6.04		100.00		100.00	2.72	8.24	P	300	0.88
M05GALLR02	Gallatin River	03-S137-M	16.10	40.25		100.00		100.00	12.71	38.52	P	300	1.13
M05GALLR02	Gallatin River	S2056-M	15.08	37.70		100.00		100.00	14.75	44.71	P	276	1.13
M05GALLR02	Gallatin River	S2123-M	12.06	30.16	1.27	93.65	0.95	86.39	12.06	36.56	P	300	1.13
M08JEFFR01	Jefferson River	02-S164-M	1.86	4.66		100.00	1.93	72.40	6.21	18.82	F	300	1.01
M08JEFFR01	Jefferson River	03-S138-M	10.23	25.58		100.00	1.00	85.71	12.54	38.00	F	297	1.01
M08JEFFR01	Jefferson River	M08JEFFR01	11.59	28.97	0.33	98.34		100.00	11.26	34.12	F	300	1.01
M08JEFFR01	Jefferson River	S2057-M	18.94	47.34		100.00		100.00	12.62	38.26	F	265	1.13
M08JEFFR01	Jefferson River	S2058-M	16.45	41.12		100.00		100.00	12.50	37.88	F	257	1.01
M08JEFFR01	Jefferson River	S2126-M	9.90	24.75		100.00		100.00	10.89	33.00	F	292	1.01
C01LTBLR01	Little Blackfoot R	02-S101-M	26.26	65.65	0.80	96.02	2.79	60.18	7.43	22.51	P	300	1.00
C01LTBLR01	Little Blackfoot R	03-S104-M	32.54	81.36		100.00	0.89	87.32	6.21	18.83	P	300	1.29
C01LTBLR01	Little Blackfoot R	C01LTBLR01	28.21	70.51		100.00		100.00	8.01	24.28	P	300	1.00
C01LTBLR01	Little Blackfoot R	S2027-M	19.25	48.14		100.00	2.93	58.12	14.29	43.29	P	300	1.29
C01LTBLR01	Little Blackfoot R	S2028-M	12.69	31.73	6.19	69.04	1.93	72.45	19.20	58.17	P	300	1.14
C01LTBLR01	Little Blackfoot R	S2109-M	23.94	59.85		100.00	1.90	72.84	6.67	20.20	P	300	1.00
M06MADNR01	Madison River	03-S139-M	6.99	17.48	0.61	96.96		100.00	10.03	30.40	P	300	1.28
M06MADNR01	Madison River	S2054-M	13.71	34.27	0.93	95.33		100.00	4.36	13.22	P	300	1.02
M06MADNR01	Madison River	S2124-M	14.58	36.46	2.08	89.58		100.00	5.36	16.23	P	300	1.28
M09PRPEC01	Prickly Pear Creek near Clancy	02-S100-M	5.07	12.68	4.79	76.06	2.00	71.43	7.89	23.90	P	300	0.63
M09PRPEC01	Prickly Pear Creek near Clancy	03-S100-M	22.34	55.84	1.37	93.13	2.00	71.43	2.41	7.29	P	284	0.50
M09PRPEC01	Prickly Pear Creek near Clancy	M09PRPEC01	11.24	28.11	2.01	89.96	3.00	57.14	10.44	31.64	P	249	0.88
M09PRPEC01	Prickly Pear Creek near Clancy	S2025-M	42.77	100.00	2.52	87.42	2.89	58.76	22.64	68.61	P	277	0.76
M09PRPEC01	Prickly Pear Creek near Clancy	S2026-M	41.31	100.00	2.62	86.89	3.00	57.15	21.64	65.57	P	296	0.88
M09PRPEC01	Prickly Pear Creek near Clancy	S2086-M	13.35	33.39	4.35	78.26	1.93	72.40	7.14	21.65	P	296	0.88
C02ROCKC01	Rock Creek	02-S160-M	7.19	17.96		100.00	3.69	47.22	9.58	29.03	P	300	0.68
C02ROCKC01	Rock Creek	03-S126-M	63.13	100.00	0.56	97.21	1.84	73.75	16.20	49.09	P	300	0.57
C02ROCKC01	Rock Creek	C02ROCKC01	27.08	67.69	0.31	98.46	0.92	86.81	20.92	63.40	P	300	1.02
C02ROCKC01	Rock Creek	S2039-M	72.90	100.00		100.00	1.87	73.30	42.99	100.00	P	300	0.91
C02ROCKC01	Rock Creek	S2110-M	57.44	100.00		100.00		100.00	26.49	80.27	P	300	0.79
Y04STILR01	Stillwater River	02-S157-M	7.49	18.73	0.33	98.37	1.00	85.72	7.82	23.69	P	300	0.89
Y04STILR01	Stillwater River	03-S122-M	5.88	14.71	0.33	98.37	1.98	71.71	5.56	16.84	P	300	1.27
Y04STILR01	Stillwater River	S2013-M	9.81	24.53	0.32	98.42	1.00	85.71	11.39	34.52	P	300	0.63
Y04STILR01	Stillwater River	S2014-M	10.15	25.38	0.31	98.46	1.00	85.71	12.00	36.36	P	300	1.27
Y04STILR01	Stillwater River	S2098-M	5.15	12.89		100.00	2.00	71.43	4.81	14.58	P	278	0.89
Y04STILR01	Stillwater River	Y04STILR01	13.73	34.31	0.65	96.73		100.00	11.44	34.66	P	300	1.27

Appendix 1. continued

StationID	WaterbodyName	ActivityID	Lat_Dec	Long_Dec	SiteClass	CollDate	CollMeth	Total Ind	MtnIndex	EphemTax	EphemTaxScM	Plec Tax	PlecTaxScM
M03BGHLR01	Big Hole River	03-S132-M	45.86	-113.08	Mountains	7/30/2003	HESS	327	61.14	2.92	29.17	1.83	26.21
M03BGHLR01	Big Hole River	S2048-M	45.86	-113.08	Mountains	7/28/2004	HESS	301	53.48	4.99	49.87	2.00	28.52
M03BGHLR01	Big Hole River	S2118-M	45.86	-113.08	Mountains	8/3/05	HESS	339	54.38	5.73	57.31	1.87	26.74
M03BGHLR01	Big Hole River	S2119-M	45.86	-113.08	Mountains	8/3/2005	UNKNOWN	321	55.37	6.67	66.69	2.80	40.05
C05BITRR01	Bitterroot River	03-S131-M	46.09	-114.17	Mountains	7/29/2003	HESS	321	70.47	5.86	58.65	6.80	97.08
C05BITRR01	Bitterroot River	S2046-M	46.09	-114.17	Mountains	7/27/2004	HESS	329	70.27	5.90	58.97	4.90	70.04
C05BITRR01	Bitterroot River	S2047-M	46.09	-114.17	Mountains	7/27/2004	KICK	319	68.77	5.93	59.30	3.94	56.24
C05BITRR01	Bitterroot River	S2116-M	46.09	-114.17	Mountains	8/3/2005	UNKNOWN	322	62.60	4.79	47.95	4.80	68.50
M12DRBNR01	Dearborn River	02-S111-M	47.20	-112.09	Mountains	7/19/2002	HESS	147	60.22	6.00	60.00	1.00	14.29
M12DRBNR01	Dearborn River	03-S103-M	47.20	-112.09	Mountains	6/18/2003	HESS	322	67.88	7.99	79.91	3.93	56.16
M12DRBNR01	Dearborn River	M12DRBNR01	47.20	-112.09	Mountains	6/20/2001	UNKNOWN	57	59.92	4.00	40.00	1.00	14.29
M12DRBNR01	Dearborn River	S2071-M	47.20	-112.09	Mountains	8/12/2004	HESS	282	67.33	4.00	40.00	5.00	71.43
M12DRBNR01	Dearborn River	S2072-M	47.20	-112.09	Mountains	8/12/2004	KICK	325	58.97	1.92	19.17	4.84	69.15
M12DRBNR01	Dearborn River	S2080-M	47.20	-112.09	Mountains	6/16/2005	UNKNOWN	326	70.90	8.75	87.54	4.83	69.06
K02FISHR01	Fisher River	02-S152-M	48.36	-115.32	Mountains	8/22/2002	HESS	190	71.43	6.00	60.00	4.00	57.14
K02FISHR01	Fisher River	03-S146-M	48.36	-115.32	Mountains	8/13/2003	KICK	313	62.39	6.91	69.14	4.92	70.24
K02FISHR01	Fisher River	K02FISHR01	48.36	-115.32	Mountains	8/8/2001	UNKNOWN	239	54.20	7.00	70.00	4.00	57.14
K02FISHR01	Fisher River	S2067-M	48.36	-115.32	Mountains	8/10/2004	HESS	307	54.77	4.93	49.32	3.95	56.48
K02FISHR01	Fisher River	S2134-M	48.36	-115.32	Mountains	8/10/2005	UNKNOWN	327	64.66	4.91	49.11	3.83	54.78
C07MFKFR01	Flathead R, Middle Fork	02-S128-M	48.51	-113.99	Mountains	8/13/2002	HESS	70	73.13	8.00	80.00	2.00	28.57
C07MFKFR01	Flathead R, Middle Fork	03-S143-M	48.51	-113.99	Mountains	8/12/2003	HESS	334	49.67	5.90	58.97	1.99	28.43
C07MFKFR01	Flathead R, Middle Fork	C07MFKFR01	48.51	-113.99	Mountains	8/7/2001	UNKNOWN	307	54.53	5.98	59.77	3.00	42.86
C07MFKFR01	Flathead R, Middle Fork	S2062-M	48.51	-113.99	Mountains	8/9/2004	HESS	328	61.64	6.91	69.08	2.99	42.66
C07MFKFR01	Flathead R, Middle Fork	S2130-M	48.51	-113.99	Mountains	8/9/2005	UNKNOWN	166	54.82	4.00	40.00	2.00	28.57
C06NFKFR01	Flathead R, N Fork	02-S150-M	48.49	-114.13	Mountains	8/21/2002	HESS	76	59.34	6.00	60.00	3.00	42.86
C06NFKFR01	Flathead R, N Fork	03-S144-M	48.49	-114.13	Mountains	8/12/2003	HESS	299	61.36	7.00	70.00	2.00	28.57
C06NFKFR01	Flathead R, N Fork	C06NFKFR01	48.49	-114.13	Mountains	8/7/2001	UNKNOWN	61	79.48	6.00	60.00	4.00	57.14
C06NFKFR01	Flathead R, N Fork	S2063-M	48.49	-114.13	Mountains	8/9/2004	HESS	340	55.96	5.76	57.63	2.65	37.82
C06NFKFR01	Flathead R, N Fork	S2064-M	48.49	-114.13	Mountains	8/9/2004	KICK	367	41.75	2.60	26.02		0.00
C06NFKFR01	Flathead R, N Fork	S2132-M	48.49	-114.13	Mountains	8/9/2005	UNKNOWN	347	65.29	10.90	100.00	2.00	28.57
C08FRSFK01	Flathead River - S Fork	02-S127-M	47.98	-113.56	Mountains	8/13/2002	HESS	89	74.30	6.00	60.00	4.00	57.14
C08FRSFK01	Flathead River - S Fork	03-S141-M	47.98	-113.56	Mountains	8/11/2003	HESS	123	49.37	5.00	50.00	3.00	42.86
C08FRSFK01	Flathead River - S Fork	S2060-M	47.98	-113.56	Mountains	8/8/2004	HESS	305	55.16	7.00	70.00	3.97	56.67
C08FRSFK01	Flathead River - S Fork	S2061-M	47.98	-113.56	Mountains	8/8/2004	KICK	329	44.75	6.81	68.09	2.74	39.08
C08FRSFK01	Flathead River - S Fork	S2128-M	47.98	-113.56	Mountains	8/8/2005	UNKNOWN	103	76.39	6.00	60.00	4.00	57.14
C10SWANR01	Swan River	02-S126-M	48.04	-113.97	Mountains	8/12/2002	HESS	326	47.22	4.76	47.61	3.91	55.92
C10SWANR01	Swan River	03-S140-M	48.04	-113.97	Mountains	8/11/2003	HESS	331	44.52	4.72	47.19	3.80	54.35
C10SWANR01	Swan River	C10SWANR01	48.04	-113.97	Mountains	8/6/2001	UNKNOWN	319	46.06	5.81	58.11	3.88	55.39
C10SWANR01	Swan River	S2059-M	48.04	-113.97	Mountains	8/8/2004	HESS	321	38.21	3.80	38.04	3.93	56.20
C10SWANR01	Swan River	S2127-M	48.04	-113.97	Mountains	8/8/2005	UNKNOWN	322	29.23	2.86	28.63	1.00	14.29
C09WHTFR01	Whitefish River	02-S151-M	48.32	-114.28	Mountains	8/22/2002	HESS	306	53.85	1.98	19.80	1.96	28.01
C09WHTFR01	Whitefish River	02-S151-M	48.32	-114.28	Mountains	8/22/2002	HESS	306	53.85	1.98	19.80	1.96	28.01
C09WHTFR01	Whitefish River	03-S145-M	48.32	-114.28	Mountains	8/12/2003	HESS	299	60.56	6.00	60.00	5.00	71.43
C09WHTFR01	Whitefish River	C09WHTFR01	48.32	-114.28	Mountains	8/7/2001	UNKNOWN	331	65.54	7.79	77.86	3.72	53.13

StationID	WaterbodyName	ActivityID	Lat_Dec	Long_Dec	SiteClass	CollDate	CollMeth	Total Ind	MtnIndex	EphemTax	EphemTaxScM	Plec Tax	PlecTaxScM
C09WHTFR01	Whitefish River	S2065-M	48.32	-114.28	Mountains	8/9/2004	HESS	318	44.76	3.00	30.00	1.94	27.76
C09WHTFR01	Whitefish River	S2133-M	48.32	-114.28	Mountains	8/9/2005	UNKNOWN	310	56.82	3.90	39.03	1.00	14.27
K01YAAKR01	Yaak River	02-S153-M	48.50	-115.92	Mountains	8/23/2002	KICK	189	67.62	9.00	90.00	2.00	28.57
K01YAAKR01	Yaak River	03-S147-M	48.50	-115.92	Mountains	8/13/2003	KICK	255	61.89	9.00	90.00	1.00	14.29
K01YAAKR01	Yaak River	K01YAAKR01	48.50	-115.92	Mountains	8/9/2001	UNKNOWN	330	45.65	3.82	38.18	1.90	27.16
K01YAAKR01	Yaak River	S2068-M	48.50	-115.92	Mountains	8/10/2004	HESS	180	57.32	5.00	50.00	3.00	42.86
K01YAAKR01	Yaak River	S2135-M	48.50	-115.92	Mountains	8/10/2005	UNKNOWN	122	51.69	4.00	40.00	2.00	28.57

Appendix 1. continued

StationID	WaterbodyName	ActivityID	EPTPct	EPTPctScM	NonInsPct	NonInsPctScM	PredPctM	PredPctScM	BrrwrTaxPct	BrrwrTaxPctScM	HBI	HBIScM	OEModelTest	TotalOEBugs	O/E_p>half
M03BGHLR01	Big Hole River	03-S132-M	84.71	94.12	0.31	98.91	3.06	7.84	29.94	74.73	1.68	96.96	P	300	0.46
M03BGHLR01	Big Hole River	S2048-M	52.49	58.32	12.96	53.73	12.62	32.37	26.96	78.92	3.14	72.63	P	284	0.57
M03BGHLR01	Big Hole River	S2118-M	45.72	50.80	9.73	65.23	14.45	37.06	25.81	80.56	3.72	62.93	P	300	0.80
M03BGHLR01	Big Hole River	S2119-M	49.22	54.69	16.51	41.03	16.20	41.54	26.28	79.89	3.68	63.66	P	300	0.80
C05BITRR01	Bitterroot River	03-S131-M	65.73	73.04	3.12	88.87	8.72	22.37	27.26	78.51	3.01	74.77	P	300	1.01
C05BITRR01	Bitterroot River	S2046-M	60.18	66.87	0.91	96.74	17.63	45.20	28.50	76.76	2.86	77.28	P	300	1.14
C05BITRR01	Bitterroot River	S2047-M	63.01	70.01	0.63	97.76	15.67	40.19	29.22	75.74	2.57	82.13	P	300	0.89
C05BITRR01	Bitterroot River	S2116-M	53.73	59.70	11.18	60.07	21.74	55.74	25.52	80.96	3.58	65.27	P	298	0.89
M12DRBNR01	Dearborn River	02-S111-M	57.82	64.25	4.08	85.42	25.17	64.54	29.17	75.82	4.07	57.21	P	135	1.01
M12DRBNR01	Dearborn River	03-S103-M	73.91	82.13	5.90	78.93	12.73	32.65	30.93	73.34	3.18	72.03	P	300	0.88
M12DRBNR01	Dearborn River	M12DRBNR01	56.14	62.38	8.77	68.67	38.60	98.97	33.33	69.95	3.59	65.20	P	57	0.50
M12DRBNR01	Dearborn River	S2071-M	45.39	50.43	0.35	98.73	39.36	100.00	36.84	65.01	4.76	45.70	P	266	0.75
M12DRBNR01	Dearborn River	S2072-M	23.38	25.98	1.54	94.51	54.15	100.00	33.79	69.30	5.42	34.64	P	300	1.01
M12DRBNR01	Dearborn River	S2080-M	59.20	65.78	1.53	94.52	20.55	52.70	30.23	74.32	4.36	52.41	P	300	1.01
K02FISHR01	Fisher River	02-S152-M	58.42	64.91		100.00	31.05	79.62	23.81	83.37	4.20	55.00	P	190	0.89
K02FISHR01	Fisher River	03-S146-M	35.46	39.40	11.18	60.06	30.99	79.46	32.31	71.39	4.68	47.02	P	300	1.14
K02FISHR01	Fisher River	K02FISHR01	33.47	37.19	12.13	56.66	11.72	30.04	31.03	73.19	4.19	55.19	P	231	1.14
K02FISHR01	Fisher River	S2067-M	24.10	26.78	14.33	48.81	31.92	81.85	25.23	81.37	5.18	38.75	P	300	1.01
K02FISHR01	Fisher River	S2134-M	42.51	47.23	6.73	75.97	36.70	94.10	28.86	76.26	4.19	55.19	P	270	0.76
C07MFKFR01	Flathead R, Middle Fork	02-S128-M	74.29	82.54		100.00	20.00	51.28	20.00	88.73	2.65	80.81	P	67	0.60
C07MFKFR01	Flathead R, Middle Fork	03-S143-M	28.44	31.60		100.00	3.29	8.44	27.45	78.24	4.98	42.02	P	300	0.75
C07MFKFR01	Flathead R, Middle Fork	C07MFKFR01	39.41	43.79	0.65	97.67	7.17	18.37	34.85	67.81	4.42	51.41	P	300	0.75
C07MFKFR01	Flathead R, Middle Fork	S2062-M	44.51	49.46		100.00	10.67	27.36	23.69	83.54	3.94	59.42	P	300	0.89
C07MFKFR01	Flathead R, Middle Fork	S2130-M	40.96	45.52	0.60	97.85	8.43	21.62	7.69	100.00	4.49	50.20	P	166	0.45
C06NFKFR01	Flathead R, N Fork	02-S150-M	36.84	40.94		100.00	6.58	16.87	15.79	94.66	3.90	60.07	P	75	0.75
C06NFKFR01	Flathead R, N Fork	03-S144-M	12.71	14.12		100.00	34.45	88.33	15.79	94.66	5.47	33.83	P	297	0.60
C06NFKFR01	Flathead R, N Fork	C06NFKFR01	83.61	92.90		100.00	27.87	71.46	12.50	99.30	2.97	75.55	P	61	0.45
C06NFKFR01	Flathead R, N Fork	S2063-M	9.41	10.46	1.18	95.80	26.18	67.12	26.34	79.81	4.91	43.12	P	300	0.90
C06NFKFR01	Flathead R, N Fork	S2064-M	3.00	3.33	0.27	99.03	23.71	60.78	31.68	72.28	5.65	30.82	P	300	0.75
C06NFKFR01	Flathead R, N Fork	S2132-M	32.56	36.18	1.73	93.82	19.02	48.77	20.90	87.46	3.77	62.22	P	300	1.35
C08FRSFK01	Flathead River - S Fork	02-S127-M	89.89	99.88	1.12	95.99	15.73	40.33	22.22	85.60	2.63	81.13	P	89	0.62
C08FRSFK01	Flathead River - S Fork	03-S141-M	39.02	43.36	17.89	36.12	17.89	45.86	27.78	77.78	4.52	49.62	P	123	0.53
C08FRSFK01	Flathead River - S Fork	S2060-M	26.56	29.51	11.48	59.02	20.33	52.12	22.68	84.96	5.47	33.84	P	300	0.70
C08FRSFK01	Flathead River - S Fork	S2061-M	10.94	12.16	15.50	44.64	20.97	53.78	30.19	74.38	6.23	21.15	P	300	0.53
C08FRSFK01	Flathead River - S Fork	S2128-M	65.05	72.28		100.00	37.86	97.09	26.32	79.84	3.40	68.40	P	103	0.62
C10SWANR01	Swan River	02-S126-M	28.53	31.70	30.37	0.00	31.90	81.80	25.44	81.07	5.55	32.42	P	300	1.04
C10SWANR01	Swan River	03-S140-M	29.31	32.56	35.35	0.00	24.47	62.75	26.09	80.16	5.42	34.67	P	300	0.89
C10SWANR01	Swan River	C10SWANR01	8.46	9.40	39.18	0.00	46.08	100.00	23.75	83.45	6.54	16.05	P	300	1.19
C10SWANR01	Swan River	S2059-M	15.89	17.65	51.71	0.00	18.69	47.93	22.64	85.01	6.14	22.62	P	300	0.74
C10SWANR01	Swan River	S2127-M	8.39	9.32	53.73	0.00	23.29	59.72	28.62	76.59	6.54	16.04	P	300	1.04
C09WHTFR01	Whitefish River	02-S151-M	74.51	82.79	1.31	95.33	6.21	15.92	27.38	78.34	4.10	56.73	P	262	0.86

StationID	WaterbodyName	ActivityID	EPTPct	EPTPctScM	NonInsPct	NonInsPctScM	PredPctM	PredPctScM	BrrwrTaxPct	BrrwrTaxPctScM	HBI	HBIScM	OEModelTest	TotalOEBugs	O/E_p>half
C09WHTFR01	Whitefish River	02-S151-M	74.51	82.79	1.31	95.33	6.21	15.92	27.38	78.34	4.10	56.73	P	262	0.86
C09WHTFR01	Whitefish River	03-S145-M	42.81	47.57	10.37	62.97	21.40	54.88	25.00	81.69	4.78	45.39	P	292	1.14
C09WHTFR01	Whitefish River	C09WHTFR01	51.66	57.40	4.83	82.74	23.56	60.42	28.48	76.79	4.47	50.46	P	300	1.14
C09WHTFR01	Whitefish River	S2065-M	31.45	34.94	15.41	44.97	18.55	47.57	28.83	76.29	4.39	51.76	P	290	0.86
C09WHTFR01	Whitefish River	S2133-M	39.03	43.37	3.87	86.18	35.81	91.81	28.44	76.84	4.73	46.24	P	300	1.28
K01YAAKR01	Yaak River	02-S153-M	36.51	40.56	1.06	96.22	54.50	100.00	24.00	83.10	5.41	34.86	P	188	0.89
K01YAAKR01	Yaak River	03-S147-M	34.51	38.34	7.84	71.99	52.55	100.00	23.33	84.04	5.42	34.60	P	253	1.01
K01YAAKR01	Yaak River	K01YAAKR01	9.09	10.10	9.09	67.53	76.36	100.00	40.38	60.02	6.51	16.54	P	300	0.76
K01YAAKR01	Yaak River	S2068-M	21.11	23.46	6.11	78.17	42.22	100.00	33.33	69.95	5.29	36.81	P	177	1.01
K01YAAKR01	Yaak River	S2135-M	24.59	27.32	9.02	67.80	45.90	100.00	36.00	66.20	5.58	31.93	P	120	0.89

Appendix 1. continued

StationID	WaterbodyName	ActivityID	Lat_Dec	Long_Dec	SiteClass	CollDate	CollMeth	TotalInd	PlainsIndex	EPTTax	EPTTaxScP
Y11BGHNR01	Big Horn River	03-S120-M	45.52	-107.73	Plains	7/16/2003	KICK	321	34.35		0.00
Y11BGHNR01	Big Horn River	S2011-M	45.52	-107.73	Plains	6/22/2004	HESS	312	32.67	0.96	6.87
Y11BGHNR01	Big Horn River	S2094-M	45.52	-107.73	Plains	7/14/2005	UNKNOWN	305	32.42	2.97	21.19
M50BMDYC01	Big Muddy Creek	02-S104-M	48.22	-104.69	Plains	7/8/2002	KICK	341	27.56	1.00	7.14
Y17BIGH01	Bighorn River	02-S114-M	46.14	-107.47	Plains	7/30/2002	KICK	294	63.93	14.00	100.00
Y17BIGH01	Bighorn River	S2003-M	46.14	-107.47	Plains	20-Jun-04	HESS	7	35.46		0.00
Y17BIGH01	Bighorn River	S2088-M	46.14	-107.47	Plains	7/12/2005	UNKNOWN	132	33.90	2.00	14.29
Y17BIGH01	Bighorn River	Y17BIGH01	46.14	-107.47	Plains	7/25/2001	UNKNOWN	321	60.78	16.80	100.00
Y11BIGH01	Bighorn River	03-S113-M	46.14	-107.47	Plains	13-Jul-03	KICK	252	47.40	8.00	57.14
M23JUDR01	Judith River	02-S165-M	47.66	-109.65	Plains	10/17/2002	JAB	310	47.98	14.97	100.00
M22JUDR01	Judith River	03-S108-M	47.66	-109.65	Plains	24-Jun-03	HESS	301	20.17	8.00	57.12
M23JUDR01	Judith River	M23JUDR01	47.66	-109.65	Plains	7/9/2001	UNKNOWN	163	49.62	12.00	85.71
M23JUDR01	Judith River	S2023-M	47.66	-109.65	Plains	29-Jun-04	KICK	225	27.86	10.00	71.43
M23JUDR01	Judith River	S2106-M	47.66	-109.65	Plains	20-Jul-05	UNKNOWN	322	28.12	12.98	92.69
M45MILKR02	Milk River	02-S106-M	48.51	-107.22	Plains	7/9/2002	HESS	323	33.72	7.78	55.58
M45MILKR01	Milk River	03-S110-M	48.13	-106.37	Plains	7/1/2003	HESS	309	37.82	7.00	50.00
M45MILKR01	Milk River	M45MILKR01	48.13	-106.37	Plains	9/14/2001	UNKNOWN	327	16.87	4.92	35.12
M45MILKR01	Milk River	S2001-M	48.13	-106.37	Plains	6/16/2004	HESS	3	22.22		0.00
M45MILKR02	Milk River	S2082-M	48.51	-107.22	Plains	6/28/2005	UNKNOWN	327	27.34	10.64	76.02
M26MUSSR01	Musselshell River	02-S102-M	46.99	-107.89	Plains	7/7/2002	KICK	304	58.72	2.97	21.24
M24MUSSR01	Musselshell River	02-S123-M	46.43	-109.84	Plains	8/2/2002	KICK	309	35.83	10.00	71.42
M24MUSSR01	Musselshell River	03-S107-M	46.43	-109.84	Plains	6/23/2003	HESS	298	39.90	11.00	78.57
M26MUSSR01	Musselshell River	M26MUSSR01	46.99	-107.89	Plains	7/10/2001	UNKNOWN	321	75.82	7.87	56.21
M26MUSSR01	Musselshell River	S2000-M	46.99	-107.89	Plains	6/15/2004	HESS	61	47.63	1.00	7.14
M24MUSSR01	Musselshell River	S2022-M	46.43	-109.84	Plains	6/29/2004	HESS	310	27.32	9.97	71.20
M24MUSSR01	Musselshell River	S2104-M	46.43	-109.84	Plains	7/19/2005	UNKNOWN	323	46.32	9.79	69.90
M28MUSSR01	Mussleshell River	03-S109-M	46.99	-107.89	Plains	30-Jun-03	KICK	331	69.70	3.89	27.78
M28MUSSR01	Mussleshell River	S2081-M	46.99	-107.89	Plains	27-Jun-05	UNKNOWN	27	36.19	3.00	21.43
M47POPR01	Poplar River	02-S103-M	48.73	-105.43	Plains	7/8/2002	KICK	320	51.70	3.93	28.07
M47POPR01	Poplar River	03-S111-M	48.73	-105.43	Plains	7/1/2003	KICK	332	56.15	10.50	74.99
M47POPR01	Poplar River	M47POPR01	48.73	-105.43	Plains	9/15/2001	UNKNOWN	287	63.01	7.00	50.00
M47POPR01	Poplar River	S2002-M	48.73	-105.43	Plains	6/16/2004	HESS	326	44.57	4.84	34.57
M47POPR01	Poplar River	S2084-M	48.73	-105.43	Plains	6/28/2005	UNKNOWN	322	61.82	5.99	42.79
Y21POWDR01	Powder River	02-S117-M	46.43	-105.31	Plains	7/31/2002	KICK	297	44.69	2.00	14.29
Y18POWDR01	Powder River	02-S120-M	45.06	-105.88	Plains	8/1/2002	KICK	172	49.41	8.00	57.14
Y21POWDR01	Powder River	03-S116-M	46.43	-105.31	Plains	7/14/2003	KICK	9	45.08	2.00	14.29
Y18POWDR01	Powder River	03-S119-M	45.06	-105.88	Plains	7/15/2003	KICK	226	36.84	8.00	57.14
Y21POWDR01	Powder River	S2007-M	46.43	-105.31	Plains	6/21/2004	HESS	67	5.21		0.00
Y18POWDR01	Powder River	S2009-M	45.06	-105.88	Plains	6/22/2004	HESS	324	44.97	5.85	41.76
Y21POWDR01	Powder River	S2091-M	46.43	-105.31	Plains	7/13/2005	UNKNOWN	6	25.08	2.00	14.29
Y18POWDR01	Powder River	S2093-M	45.06	-105.88	Plains	7/14/2005	UNKNOWN	157	34.77	7.00	50.00
Y21POWDR01	Powder River	Y21POWDR01	46.43	-105.31	Plains	7/26/2001	UNKNOWN	13	25.71	4.00	28.57

Appendix 1. continued

StationID	WaterbodyName	ActivityID	TanypodPct	TanypodPctScP	Orth2MidgPct	Orth2MidgPctScP	PredatorTax	PredatorTaxScP	FiltCollPct	FiltCollPctScP	OEModelTest	TotalOEBugs	O/E_p>half
Y11BGHNR01	Big Horn River	03-S120-M	1.87	18.69		100.00	4.00	44.44	94.39	8.63	F	300	0.63
Y11BGHNR01	Big Horn River	S2011-M		0.00	41.67	58.33	6.88	76.47	85.90	21.70	F	300	0.63
Y11BGHNR01	Big Horn River	S2094-M	1.31	13.11	70.13	29.87	6.95	77.23	86.56	20.68	F	298	0.51
M50BMDYC01	Big Muddy Creek	02-S104-M		0.00	100.00	0.00	2.76	30.66	22.58	100.00	P	292	0.37
Y17BIGH01	Bighorn River	02-S114-M	0.68	6.80		100.00	7.00	77.78	77.21	35.06	P	271	0.62
Y17BIGH01	Bighorn River	S2003-M		0.00		100.00	3.00	33.33	71.43	43.96	P	6	0.25
Y17BIGH01	Bighorn River	S2088-M	0.76	7.58	84.21	15.79	4.00	44.44	43.18	87.41	P	131	0.75
Y17BIGH01	Bighorn River	Y17BIGH01	2.18	21.81	14.81	85.19	6.86	76.28	86.60	20.61	P	300	0.75
Y11BIGH01	Bighorn River	03-S113-M		0.00		100.00	4.00	44.44	76.98	35.41	P	245	0.50
M23JUDR01	Judith River	02-S165-M	0.32	3.23	89.47	10.53	7.87	87.44	74.84	38.71	P	244	0.45
M22JUDR01	Judith River	03-S108-M		0.00	80.00	20.00	2.00	22.19	99.00	1.53	P	300	0.30
M23JUDR01	Judith River	M23JUDR01		0.00		100.00	4.00	44.44	88.34	17.93	P	161	0.00
M23JUDR01	Judith River	S2023-M		0.00	88.89	11.11	4.00	44.44	92.00	12.31	P	217	0.30
M23JUDR01	Judith River	S2106-M		0.00	80.95	19.05	2.00	22.17	95.65	6.69	P	300	0.30
M45MILKR02	Milk River	02-S106-M		0.00		100.00	1.00	11.11	98.76	1.91	P	300	0.25
M45MILKR01	Milk River	03-S110-M	0.32	3.24		100.00	1.97	21.90	90.94	13.94	P	279	0.37
M45MILKR01	Milk River	M45MILKR01	0.31	3.06	80.77	19.23	1.92	21.30	96.33	5.65	P	300	0.37
M45MILKR01	Milk River	S2001-M		0.00		100.00	1.00	11.11	100.00	0.00	P	3	0.25
M45MILKR02	Milk River	S2082-M		0.00	66.67	33.33	1.99	22.15	96.64	5.18	P	300	0.37
M26MUSSR01	Musselshell River	02-S102-M	14.47	100.00	15.06	84.94	5.00	55.56	79.28	31.88	P	300	0.75
M24MUSSR01	Musselshell River	02-S123-M	0.97	9.71	72.00	28.00	4.91	54.58	89.97	15.43	P	297	0.89
M24MUSSR01	Musselshell River	03-S107-M	0.34	3.36	66.67	33.33	6.00	66.67	88.59	17.55	P	298	1.27
M26MUSSR01	Musselshell River	M26MUSSR01	14.64	100.00	6.60	93.40	6.74	74.87	64.49	54.64	P	300	0.87
M26MUSSR01	Musselshell River	S2000-M	3.28	32.79	17.86	82.14	5.00	55.56	60.66	60.53	P	47	0.75
M24MUSSR01	Musselshell River	S2022-M		0.00	80.00	20.00	2.97	32.97	91.94	12.41	P	300	1.02
M24MUSSR01	Musselshell River	S2104-M	2.17	21.67	42.86	57.14	4.93	54.76	81.73	28.10	P	300	1.15
M28MUSSR01	Mussleshell River	03-S109-M	22.36	100.00	3.13	96.88	6.00	66.65	62.84	57.17	P	300	1.00
M28MUSSR01	Mussleshell River	S2081-M	3.70	37.04		100.00	1.00	11.11	92.59	11.40	P	27	0.12
M47POPR01	Poplar River	02-S103-M	3.13	31.25	21.88	78.13	6.87	76.35	70.94	44.71	P	300	1.12
M47POPR01	Poplar River	03-S111-M	4.22	42.17	17.16	82.84	4.81	53.41	82.23	27.34	P	300	0.74
M47POPR01	Poplar River	M47POPR01	2.09	20.91	10.00	90.00	9.00	100.00	64.81	54.14	P	281	1.12
M47POPR01	Poplar River	S2002-M	0.92	9.20	7.79	92.21	6.75	75.05	92.33	11.80	P	300	1.12
M47POPR01	Poplar River	S2084-M	1.55	15.53	5.00	95.00	6.93	76.97	48.76	78.83	P	300	0.99
Y21POWDR01	Powder River	02-S117-M		0.00		100.00	6.00	66.67	72.39	42.48	P	297	0.12
Y18POWDR01	Powder River	02-S120-M	1.16	11.63		100.00	6.00	66.67	92.44	11.63	P	171	0.25
Y21POWDR01	Powder River	03-S116-M		0.00		100.00	1.00	11.11	33.33	100.00	P	9	0.25
Y18POWDR01	Powder River	03-S119-M	0.44	4.42	25.00	75.00	3.00	33.33	90.71	14.30	P	210	0.50
Y21POWDR01	Powder River	S2007-M		0.00	85.07	14.93	1.00	11.11	100.00	0.00	P	67	0.25
Y18POWDR01	Powder River	S2009-M	1.54	15.43		100.00	2.93	32.51	77.16	35.14	P	253	0.25
Y21POWDR01	Powder River	S2091-M		0.00		100.00	1.00	11.11	100.00	0.00	P	6	0.12
Y18POWDR01	Powder River	S2093-M		0.00		100.00	1.00	11.11	91.72	12.74	P	152	0.00
Y21POWDR01	Powder River	Y21POWDR01		0.00		100.00		0.00	100.00	0.00	P	13	0.00

Appendix 1. continued

StationID	WaterbodyName	ActivityID	Lat_Dec	Long_Dec	SiteClass	CollDate	CollMeth	TotalInd	PlainsIndex	EPTTax	EPTTaxScP
Y17ROSEC01	Rosebud Cr	02-S115-M	46.27	-106.48	Plains	7/30/2002	KICK	323	64.86	1.00	7.14
Y17ROSEC01	Rosebud Cr	03-S114-M	46.27	-106.48	Plains	7/13/2003	KICK	27	60.63	1.00	7.14
Y17ROSEC01	Rosebud Cr	S2005-M	46.27	-106.48	Plains	6/20/2004	HESS	88	49.27	1.00	7.14
Y17ROSEC01	Rosebud Cr	S2089-M	46.27	-106.48	Plains	7/12/2005	UNKNOWN	26	31.40		0.00
Y17ROSEC01	Rosebud Cr	Y17ROSEC01	46.27	-106.48	Plains	7/25/2001	UNKNOWN	205	70.00	10.00	71.43
Y03SHIER01	Shields River	02-S155-M	45.73	-110.46	Plains	8/28/2002	HESS	340	45.96	13.60	97.18
Y03SHIER01	Shields River	03-S125-M	45.73	-110.46	Plains	7/18/2003	HESS	309	43.77	15.79	100.00
Y03SHIER01	Shields River	S2015-M	45.73	-110.46	Plains	6/24/2004	HESS	330	60.18	13.98	99.88
Y03SHIER01	Shields River	S2016-M	45.73	-110.46	Plains	6/24/2004	KICK	311	62.76	18.85	100.00
Y03SHIER01	Shields River	S2102-M	45.73	-110.46	Plains	7/16/2005	UNKNOWN	325	54.38	17.68	100.00
Y03SHIER01	Shields River	S2102-M	45.73	-110.46	Plains	7/16/2005	UNKNOWN	327	51.00	18.57	100.00
Y03SHIER01	Shields River	Y03SHIER01	45.73	-110.46	Plains	7/23/2001	UNKNOWN	300	45.37	10.00	71.43
M10SMTHR01	Smith River	02-S124-M	47.24	-111.39	Plains	8/8/2002	HESS	297	31.48	9.00	64.29
M10SMTHR01	Smith River	03-S102-M	47.24	-111.39	Plains	6/17/2003	HESS	201	64.13	16.00	100.00
M10SMTHR01	Smith River	S2036-M	47.24	-111.39	Plains	7/14/2004	HESS	301	38.54	15.98	100.00
M10SMTHR01	Smith River	S2037-M	47.24	-111.39	Plains	7/14/2004	KICK	151	50.90	14.00	100.00
M10SMTHR01	Smith River	S2087-M	47.24	-111.39	Plains	7/7/2005	UNKNOWN	323	61.82	20.56	100.00
M13SUNR01	Sun River	02-S110-M	47.55	-111.71	Plains	7/19/2002	HESS	277	36.39	10.00	71.43
M13SUNR01	Sun River	03-S101-M	47.55	-111.71	Plains	6/17/2003	HESS	332	44.26	12.70	90.71
M13SUNR01	Sun River	M13SUNR01	47.55	-111.71	Plains	8/30/2001	UNKNOWN	345	49.83	11.59	82.78
M13SUNR01	Sun River	S2035-M	47.55	-111.71	Plains	7/13/2004	HESS	334	42.30	11.38	81.27
M13SUNR01	Sun River	S2108-M	47.55	-111.71	Plains	7/20/2005	UNKNOWN	317	61.35	12.83	91.65
M13SUNR01	Sun River	S2108-M	47.55	-111.71	Plains	7/20/2005	UNKNOWN	337	50.49	13.74	98.15
M14TETOR02	Teton River near Loma	02-S108-M	47.93	-110.51	Plains	7/12/2002	HESS	22	37.73	4.00	28.57
M14TETOR02	Teton River near Loma	03-S106-M	47.93	-110.51	Plains	6/19/2003	HESS	97	41.58	8.00	57.14
M14TETOR01	Teton River near Loma	M14TETOR01	47.93	-110.51	Plains	7/9/2001	UNKNOWN	286	71.12	8.00	57.14
M14TETOR01	Teton River near Loma	S2030-M	47.93	-110.51	Plains	7/12/2004	HESS	327	64.40	12.74	90.99
M14TETOR02	Teton River near Loma	S2085-M	47.93	-110.51	Plains	6/22/2005	UNKNOWN	44	45.45	5.00	35.71
Y17TONGR01	Tongue R	02-S116-M	46.41	-105.86	Plains	7/31/2002	KICK	140	39.91	7.00	50.00
Y17TONGR01	Tongue R	03-S115-M	46.41	-105.86	Plains	7/14/2003	KICK	50	33.65	8.00	57.14
Y17TONGR01	Tongue R	S2006-M	46.41	-105.86	Plains	6/21/2004	HESS	13	25.87	1.00	7.14
Y17TONGR01	Tongue R	S2090-M	46.41	-105.86	Plains	7/13/2005	UNKNOWN	37	32.46	6.00	42.86
Y17TONGR01	Tongue R	Y17TONGR01	46.41	-105.86	Plains	7/26/2001	UNKNOWN	17	25.08	2.00	14.29
Y16TONGR01	Tongue River	02-S119-M	45.84	-106.22	Plains	7/31/2002	KICK	314	51.70	13.78	98.39
Y15TONGR01	Tongue River	02-S121-M	45.03	-106.81	Plains	8/1/2002	KICK	293	53.81	13.00	92.86
Y16TONGR01	Tongue River	03-S117-M	45.84	-106.22	Plains	7/14/2003	KICK	85	39.17	6.00	42.86
Y16TONGR01	Tongue River	S2008-M	45.84	-106.22	Plains	6/21/2004	HESS	327	53.87	12.83	91.68
Y16TONGR01	Tongue River	S2092-M	45.84	-106.22	Plains	7/13/2005	UNKNOWN	110	37.35	10.00	71.43

Appendix 1. continued

StationID	WaterbodyName	ActivityID	TanypodPct	TanypodPctScP	Orth2MidgPct	Orth2MidgPctScP	PredatorTax	PredatorTaxScP	FiltCollPct	FiltCollPctScP	OEModelTest	TotalOEBugs	O/E_p>half
Y17ROSEC01	Rosebud Cr	02-S115-M	26.63	100.00		100.00	4.93	54.76	59.44	62.40	P	300	0.87
Y17ROSEC01	Rosebud Cr	03-S114-M	33.33	100.00		100.00	3.00	33.33	59.26	62.68	P	27	0.62
Y17ROSEC01	Rosebud Cr	S2005-M	6.82	68.18	12.50	87.50	5.00	55.56	81.82	27.97	P	87	1.12
Y17ROSEC01	Rosebud Cr	S2089-M		0.00		100.00	3.00	33.33	84.62	23.67	P	26	0.12
Y17ROSEC01	Rosebud Cr	Y17ROSEC01	4.39	43.90		100.00	8.00	88.89	70.24	45.78	P	198	0.87
Y03SHIER01	Shields River	02-S155-M	0.29	2.94	75.00	25.00	7.63	84.78	87.06	19.91	P	285	1.13
Y03SHIER01	Shields River	03-S125-M	0.32	3.24	88.10	11.90	7.85	87.27	89.32	16.43	P	300	1.01
Y03SHIER01	Shields River	S2015-M	0.30	3.03	33.33	66.67	5.82	64.64	56.67	66.67	P	300	1.13
Y03SHIER01	Shields River	S2016-M	0.32	3.22	33.33	66.67	8.86	98.43	70.42	45.51	P	300	1.38
Y03SHIER01	Shields River	S2102-M	0.62	6.15	67.39	32.61	6.91	76.80	63.38	56.33	P	300	1.26
Y03SHIER01	Shields River	S2102-M		0.00	89.53	10.47	8.81	97.94	69.72	46.58	P	300	1.13
Y03SHIER01	Shields River	Y03SHIER01	0.33	3.33	39.02	60.98	4.00	44.44	69.67	46.67	P	300	1.26
M10SMTHR01	Smith River	02-S124-M		0.00	35.83	64.17	2.00	22.22	95.62	6.73	P	297	1.01
M10SMTHR01	Smith River	03-S102-M	1.49	14.93		100.00	6.00	66.67	74.63	39.04	P	200	0.88
M10SMTHR01	Smith River	S2036-M	0.66	6.64	87.32	12.68	4.99	55.48	88.37	17.89	P	285	1.13
M10SMTHR01	Smith River	S2037-M	0.66	6.62	73.81	26.19	6.00	66.67	64.24	55.02	P	138	1.01
M10SMTHR01	Smith River	S2087-M	2.48	24.77	45.00	55.00	8.77	97.41	79.26	31.91	P	300	1.26
M13SUNR01	Sun River	02-S110-M		0.00	48.39	51.61	4.00	44.44	90.61	14.44	P	274	0.76
M13SUNR01	Sun River	03-S101-M	1.20	12.05	74.58	25.42	6.80	75.52	88.55	17.61	P	300	1.13
M13SUNR01	Sun River	M13SUNR01		0.00	15.00	85.00	5.00	55.51	83.19	25.86	P	300	0.88
M13SUNR01	Sun River	S2035-M	1.50	14.97	69.09	30.91	5.68	63.16	86.23	21.19	P	300	1.26
M13SUNR01	Sun River	S2108-M	0.63	6.31	25.00	75.00	6.89	76.52	62.78	57.27	P	295	1.26
M13SUNR01	Sun River	S2108-M	0.30	2.97	34.04	65.96	5.67	62.99	85.46	22.37	P	300	1.01
M14TETOR02	Teton River near Loma	02-S108-M		0.00		100.00	1.00	11.11	68.18	48.95	P	19	0.29
M14TETOR02	Teton River near Loma	03-S106-M		0.00	11.11	88.89	2.00	22.22	74.23	39.65	P	74	0.59
M14TETOR01	Teton River near Loma	M14TETOR01	7.69	76.92		100.00	6.00	66.67	64.34	54.87	P	286	0.59
M14TETOR01	Teton River near Loma	S2030-M	2.45	24.46	13.89	86.11	7.66	85.14	77.06	35.29	P	262	1.03
M14TETOR02	Teton River near Loma	S2085-M		0.00		100.00	1.00	11.11	47.73	80.42	P	21	0.59
Y17TONGR01	Tongue R	02-S116-M	2.14	21.43	22.94	77.06	4.00	44.44	95.71	6.59	P	134	0.74
Y17TONGR01	Tongue R	03-S115-M		0.00		100.00	1.00	11.11	100.00	0.00	P	50	0.12
Y17TONGR01	Tongue R	S2006-M		0.00		100.00	2.00	22.22	100.00	0.00	P	11	0.37
Y17TONGR01	Tongue R	S2090-M		0.00		100.00	1.00	11.11	94.59	8.32	P	36	0.25
Y17TONGR01	Tongue R	Y17TONGR01		0.00		100.00	1.00	11.11	100.00	0.00	P	17	0.12
Y16TONGR01	Tongue River	02-S119-M		0.00		100.00	3.96	43.95	89.49	16.17	P	288	0.12
Y15TONGR01	Tongue River	02-S121-M	1.71	17.06		100.00	4.00	44.44	90.44	14.70	P	292	0.39
Y16TONGR01	Tongue River	03-S117-M	2.35	23.53		100.00	2.00	22.22	95.29	7.24	P	77	0.37
Y16TONGR01	Tongue River	S2008-M		0.00	6.45	93.55	5.83	64.83	87.46	19.29	P	300	0.25
Y16TONGR01	Tongue River	S2092-M		0.00		100.00	1.00	11.11	97.27	4.20	P	104	0.25

Appendix 2. Site impairment, estimated degree of impairment and probable causes as determined by best professional judgment of MDEQ.

Missouri River Basin					
Site	**ALU Impairment**	**Degree**	**Confidence**	**Causes (ranked)**	**Comments**
Beaverhead near Dillon	Yes	Moderate	High	nutrients, habitat, flow	Nutrients not on 303(d) list
Beaverhead nead Twin Bridges	Yes	Moderate	High	nutrients habitat, flow, sediment, temperature	Nutrients not on 303(d) list
Big Hole at Wise River	Yes	Moderate	Medium	temp, flow, habitat, metals	
Big Hole at Twin Bridges	Yes	Moderate	High	temp, flow, habitat, metals	
Jefferson	Yes	Severe	High	flow, temp, habitat, sediment, nutrients, metals	Nutrients not on 303(d) list
Madison	Yes	Moderate	Moderate	Temp, sediment, habitat	
Gallatin	Yes	Moderate	High	Nutrients, flow	Nutrients not on 303(d) list
Missouri at Toston	Yes	Moderate	Moderate	Temp, Habitat, sediment, flow	Temp not on 303(d) list
Prickly Pear	Yes	Severe	High	Metals, habitat, sediment	
Dearborn	No	slight	Moderate	Listed for Temp?	SWM data does not show problem
Smith	Yes	Moderate	Moderate	flow, temp, habitat, nutrients	
Sun	Yes	Moderate	Moderate	Flow, habitat, temp, sediment, nutrients	Nutrients not on 303(d) list
Teton	Yes	Severe	High	Flow, sediment, salinity	
Judith	Yes	slight	Moderate	Riparian degradation, temp	Temp not on 303(d) list
Musselshell at Mosby	Yes	Severe	High	Flow, habitat, sediment	Sediment, bacteria and salinity not on 303(d) list
Musselshell at Harlowtown	Yes	moderate	Moderate	Flow, nutrients, sediment, habitat	
Milk River	Yes	Severe	Moderate	Habitat, flow, nutrients	Not assessed on 303(d)
Poplar	No	Slight	Low	listed as sediment, temp (natural sources)	Might also be impacted with nutrients
Big Muddy	Yes	moderate	Moderate	Flow, nutrients, sediment	
Missouri near Culbertson	Yes	Moderate	High	Flow, temp	

Appendix 2. continued

Yellowstone River Basin					
Site	**ALU Impairment**	**Degree**	**Confidence**	**Causes (ranked)**	**Comments**
Yellowstone River@ Livingston	No	Slight	moderate		
Shields River	Yes	Moderate	moderate	Flow, nutrients	
Boulder	Yes	Slight	moderate	Flow, metals	Metals?
Stillwater	Yes	slight	moderate	Flow metals	
Clarks Fork of Yellowstone	Yes	Severe	High	Nutrient, sediment, flow	
Big Horn near Big Horn	Yes	moderate	moderate	nutrients	Not assessed on 303(d) list
Big Horn near Hardin	Yes	moderate	moderate	nutrients	
Rosebud	Yes	Severe	High	flow, habitat, salinity	salinity not on 303(d) list
Tongue @ miles city	Yes	Severe	High	flow, sediment, salinity	Not assessed on 303(d) list
Tongue near Brandenberg	No	slight	low		Not assessed on 303(d) list
Tongue River at Stateline	Yes	moderate	moderate	nutrients	Not assessed on 303(d) list
Powder at Locate	Yes	moderate	moderate	flow, salinity	Not assessed on 303(d) list
Powder River at Moorhead	No	slight	low		Not assessed on 303(d) list
Yellowstone at Sidney	Yes	moderate	High	flow, sediment, metals, pH	metals? pH?

Appendix 2. continued

Columbia River Basin					
Site	**ALU Impairment**	**Degree**	**Confidence**	**Causes (ranked)**	**Comments**
Kootenai	Yes	moderate	low	Flow, temp	Best management of dam?
Fisher River	Yes	moderate	moderate	habitat, flow, sediment	Sediment not on 303(d) list
Yaak River	No	slight	low		Not assessed on 303(d) list
Little Blackfoot	Yes	moderate	high	flow, habitat, sediment, nutrients, metals	
Rock Creek	No	slight	moderate		
Clark Fork @ Turah	Yes	moderate	High	metals, nutrients, habitat	
Blackfoot	No	Slight	moderate		Had historical impacts
Bitterroot at Missoula	Yes	moderate	moderate	nitrogen, sediment, habitat	
Bitterroot at Darby	Yes	Slight	Low	Copper, habitat	Copper?
Clark Fork at St. Regis	Yes	moderate	moderate	nitrogen, copper	
Middle Fork Flathead	No	slight	High		
North Fork Flathead	No	slight	High		
South Fork Flathead	No	Slight	High		
Whitefish River	Yes	moderate	moderate	nutrients, temp, metals	

Appendix 3. Classification results for all assessment methods.

Basin	Site	MDEQ Impairment	Year	Historic MMI Ecoregion	Revised MMI Site Class	Historic MMI Rating	Revised MMI Rating	RIVPACS Rating	Diatom MMI Rating	Increaser Taxa Rating
Columbia	Bitterroot at Darby	Impaired	2003	MVFP	Mountains	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Bitterroot at Missoula	Impaired	2001	MVFP	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Bitterroot at Missoula	Impaired	2002	MVFP	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Bitterroot at Missoula	Impaired	2003	MVFP	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Blackfoot	Non-Impaired	2001	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Columbia	Blackfoot	Non-Impaired	2002	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Columbia	Blackfoot	Non-Impaired	2003	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Columbia	Clark Fork at St. Regis	Impaired	2001	NR	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Clark Fork at St. Regis	Impaired	2002	NR	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Clark Fork at St. Regis	Impaired	2003	NR	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Columbia	Clark Fork @ Turah	Impaired	2001	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Columbia	Clark Fork @ Turah	Impaired	2002	MVFP	LowValley	Non-Impaired	Impaired	Impaired	Non-Impaired	Impaired
Columbia	Clark Fork @ Turah	Impaired	2003	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Columbia	Fisher River	Impaired	2001	NR	Mountains	Non-Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Fisher River	Impaired	2002	NR	Mountains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Fisher River	Impaired	2003	NR	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Little Blackfoot	Impaired	2001	MVFP	LowValley	Non-Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Columbia	Little Blackfoot	Impaired	2002	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Columbia	Little Blackfoot	Impaired	2003	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Impaired	Impaired
Columbia	Middle Fork Flathead	Non-Impaired	2001	NR	Mountains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	Middle Fork Flathead	Non-Impaired	2002	NR	Mountains	Non-Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired
Columbia	Middle Fork Flathead	Non-Impaired	2003	NR	Mountains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	North Fork Flathead	Non-Impaired	2001	NR	Mountains	Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	North Fork Flathead	Non-Impaired	2002	NR	Mountains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	North Fork Flathead	Non-Impaired	2003	NR	Mountains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	Rock Creek	Non-Impaired	2001	MVFP	LowValley	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Rock Creek	Non-Impaired	2002	MVFP	LowValley	Non-Impaired	Impaired	Impaired	Non-Impaired	Impaired
Columbia	Rock Creek	Non-Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	South Fork Flathead	Non-Impaired	2002	NR	Mountains	Non-Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired
Columbia	South Fork Flathead	Non-Impaired	2003	NR	Mountains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Columbia	Swan River	Non-Impaired	2001	NR	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Columbia	Swan River	Non-Impaired	2002	NR	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Columbia	Swan River	Non-Impaired	2003	NR	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Columbia	Whitefish River	Impaired	2001	MVFP	Mountains	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Whitefish River	Impaired	2002	MVFP	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Whitefish River	Impaired	2003	MVFP	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Columbia	Yaak River	Non-Impaired	2001	NR	Mountains	Impaired	Impaired	Impaired	Impaired	Non-Impaired
Columbia	Yaak River	Non-Impaired	2002	NR	Mountains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Columbia	Yaak River	Non-Impaired	2003	NR	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Non-Impaired

Appendix 3. continued

Basin	Site	MDEQ Impairment	Year	Historic MMI Ecoregion	Revised MMI Site Class	Historic MMI Rating	Revised MMI Rating	RIVPACS Rating	Diatom MMI Rating	Increaser Taxa Rating
Missouri	Beaverhead nead Twin Bridges	Impaired	2001	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Beaverhead nead Twin Bridges	Impaired	2002	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Beaverhead nead Twin Bridges	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Beaverhead near Dillon	Impaired	2002	MVFP	LowValley	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Beaverhead near Dillon	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Big Hole at Twin Bridges	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Missouri	Big Hole at Wise River	Impaired	2003	MVFP	Mountains	Impaired	Impaired	Impaired	Impaired	Impaired
Missouri	Big Muddy	Impaired	2002	PLAINS	Plains	Impaired	Impaired	Impaired	Impaired	Non-Impaired
Missouri	Dearborn	Non-Impaired	2001	MVFP	Mountains	Impaired	Impaired	Impaired	Non-Impaired	Impaired
Missouri	Dearborn	Non-Impaired	2002	MVFP	Mountains	Impaired	Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Dearborn	Non-Impaired	2003	MVFP	Mountains	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Gallatin	Impaired	2001	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Gallatin	Impaired	2002	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Gallatin	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Jefferson	Impaired	2001	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Jefferson	Impaired	2002	MVFP	LowValley	Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Jefferson	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Missouri	Judith	Impaired	2001	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Judith	Impaired	2002	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Judith	Impaired	2003	PLAINS	Plains	Non-Impaired	Impaired	Impaired	Non-Impaired	Impaired
Missouri	Madison	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Impaired	Impaired
Missouri	Milk River	Impaired	2002	PLAINS	Plains	Non-Impaired	Impaired	Impaired	Non-Impaired	Impaired
Missouri	Milk River	Impaired	2001	PLAINS	Plains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Missouri	Milk River	Impaired	2003	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Missouri	Musselshell at Harlowtown	Impaired	2002	PLAINS	Plains	Non-Impaired	Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Musselshell at Harlowtown	Impaired	2003	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Musselshell at Mosby	Impaired	2001	PLAINS	Plains	Non-Impaired	Non-Impaired	Non-Impaired	Impaired	Non-Impaired
Missouri	Musselshell at Mosby	Impaired	2002	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired
Missouri	Musselshell at Mosby	Impaired	2003	PLAINS	Plains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Poplar	Impaired	2001	PLAINS	Plains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Poplar	Impaired	2002	PLAINS	Plains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Poplar	Impaired	2003	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Missouri	Prickly Pear	Impaired	2001	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Prickly Pear	Impaired	2002	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Missouri	Prickly Pear	Impaired	2003	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired
Missouri	Smith	Impaired	2002	MVFP	Plains	Impaired	Impaired	Non-Impaired	Impaired	Impaired
Missouri	Smith	Impaired	2003	MVFP	Plains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Missouri	Sun	Impaired	2001	MVFP	Plains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Missouri	Sun	Impaired	2002	MVFP	Plains	Impaired	Impaired	Impaired	Non-Impaired	Impaired
Missouri	Sun	Impaired	2003	MVFP	Plains	Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Missouri	Teton	Impaired	2002	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Missouri	Teton	Impaired	2003	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired

Appendix 3. continued

Basin	Site	MDEQ Impairment	Year	Historic MMI Ecoregion	Revised MMI Site Class	Historic MMI Rating	Revised MMI Rating	RIVPACS Rating	Diatom MMI Rating	Increaser Taxa Rating
Yellowstone	Big Horn near Big Horn	Impaired	2001	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Big Horn near Big Horn	Impaired	2002	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Big Horn near Hardin	Impaired	2003	PLAINS	Plains	Impaired	Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Boulder	Impaired	2001	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Boulder	Impaired	2002	MVFP	LowValley	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Yellowstone	Boulder	Impaired	2003	MVFP	LowValley	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Non-Impaired
Yellowstone	Clarks Fork of Yellowstone	Impaired	2001	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Impaired	Impaired
Yellowstone	Clarks Fork of Yellowstone	Impaired	2002	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Yellowstone	Clarks Fork of Yellowstone	Impaired	2003	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Impaired	Impaired
Yellowstone	Powder at Locate	Impaired	2001	PLAINS	Plains	Impaired	Impaired	Impaired	Impaired	Non-Impaired
Yellowstone	Powder at Locate	Impaired	2002	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Yellowstone	Powder at Locate	Impaired	2003	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Powder River at Moorhead	Non-Impaired	2002	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired
Yellowstone	Powder River at Moorhead	Non-Impaired	2003	PLAINS	Plains	Non-Impaired	Impaired	Impaired	Impaired	Non-Impaired
Yellowstone	Rosebud	Impaired	2001	PLAINS	Plains	Non-Impaired	Non-Impaired	Non-Impaired	Impaired	Non-Impaired
Yellowstone	Rosebud	Impaired	2002	PLAINS	Plains	Impaired	Non-Impaired	Non-Impaired	Impaired	Non-Impaired
Yellowstone	Rosebud	Impaired	2003	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Impaired	Non-Impaired
Yellowstone	Shields River	Impaired	2001	MVFP	Plains	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Shields River	Impaired	2002	MVFP	Plains	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Yellowstone	Shields River	Impaired	2003	MVFP	Plains	Non-Impaired	Non-Impaired	Non-Impaired	Impaired	Impaired
Yellowstone	Stillwater	Impaired	2001	MVFP	LowValley	Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Yellowstone	Stillwater	Impaired	2002	MVFP	LowValley	Impaired	Non-Impaired	Non-Impaired	Non-Impaired	Impaired
Yellowstone	Stillwater	Impaired	2003	MVFP	LowValley	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Yellowstone	Tongue River at Stateline	Impaired	2002	MVFP	Plains	Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Tongue @ miles city	Impaired	2001	PLAINS	Plains	Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Yellowstone	Tongue @ miles city	Impaired	2002	PLAINS	Plains	Impaired	Non-Impaired	Impaired	Non-Impaired	Non-Impaired
Yellowstone	Tongue @ miles city	Impaired	2003	PLAINS	Plains	Non-Impaired	Impaired	Impaired	Non-Impaired	Non-Impaired
Yellowstone	Tongue near Brandenberg	Non-Impaired	2002	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired
Yellowstone	Tongue near Brandenberg	Non-Impaired	2003	PLAINS	Plains	Non-Impaired	Non-Impaired	Impaired	Non-Impaired	Impaired

Appendix 4. Error matrices used to derive Kappa coefficients.

All Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	54	17	71
Non-Impaired	29	10	39
Grand Total	83	27	110

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	14	36
Non-Impaired	61	13	74
Grand Total	83	27	110

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	43	19	62
Non-Impaired	40	8	48
Grand Total	83	27	110

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	21	5	26
Non-Impaired	62	22	84
Grand Total	83	27	110

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	58	9	67
Non-Impaired	25	18	43
Grand Total	83	27	110

2001 Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	13	6	19
Non-Impaired	10	1	11
Grand Total	23	7	30

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	5	4	9
Non-Impaired	18	3	21
Grand Total	23	7	30

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	12	5	17
Non-Impaired	11	2	13
Grand Total	23	7	30

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	5	1	6
Non-Impaired	18	6	24
Grand Total	23	7	30

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	14	3	17
Non-Impaired	9	4	13
Grand Total	23	7	30

Appendix 4. continued.

2002 Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	5	27
Non-Impaired	7	5	12
Grand Total	29	10	39

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	10	4	14
Non-Impaired	19	6	25
Grand Total	29	10	39

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	13	7	20
Non-Impaired	16	3	19
Grand Total	29	10	39

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	6	3	9
Non-Impaired	23	7	30
Grand Total	29	10	39

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	4	26
Non-Impaired	7	6	13
Grand Total	29	10	39

2003 Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	19	6	25
Non-Impaired	12	4	16
Grand Total	31	10	41

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	7	6	13
Non-Impaired	24	4	28
Grand Total	31	10	41

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	18	7	25
Non-Impaired	13	3	16
Grand Total	31	10	41

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	10	1	11
Non-Impaired	21	9	30
Grand Total	31	10	41

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	2	24
Non-Impaired	9	8	17
Grand Total	31	10	41

Appendix 4. continued.

All Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	54	17	71
Non-Impaired	29	10	39
Grand Total	83	27	110

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	14	36
Non-Impaired	61	13	74
Grand Total	83	27	110

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	43	19	62
Non-Impaired	40	8	48
Grand Total	83	27	110

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	21	5	26
Non-Impaired	62	22	84
Grand Total	83	27	110

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	58	9	67
Non-Impaired	25	18	43
Grand Total	83	27	110

MVFP Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	34	4	38
Non-Impaired	14	5	19
Grand Total	48	9	57

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	11	3	14
Non-Impaired	37	6	43
Grand Total	48	9	57

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	20	6	26
Non-Impaired	28	3	31
Grand Total	48	9	57

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	14	0	14
Non-Impaired	34	9	43
Grand Total	48	9	57

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	40	6	46
Non-Impaired	8	3	11
Grand Total	48	9	57

Appendix 4. continued.

NR Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	5	12	17
Non-Impaired	1	2	3
Grand Total	6	14	20

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	2	10	12
Non-Impaired	4	4	8
Grand Total	6	14	20

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	1	9	10
Non-Impaired	5	5	10
Grand Total	6	14	20

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	0	3	3
Non-Impaired	6	11	17
Grand Total	6	14	20

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	6	1	7
Non-Impaired	0	13	13
Grand Total	6	14	20

PLAINS Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	15	1	16
Non-Impaired	14	3	17
Grand Total	29	4	33

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	9	1	10
Non-Impaired	20	3	23
Grand Total	29	4	33

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	4	26
Non-Impaired	7	0	7
Grand Total	29	4	33

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	7	2	9
Non-Impaired	22	2	24
Grand Total	29	4	33

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	12	2	14
Non-Impaired	17	2	19
Grand Total	29	4	33

Appendix 4. continued.

All Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	54	17	71
Non-Impaired	29	10	39
Grand Total	83	27	110

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	22	14	36
Non-Impaired	61	13	74
Grand Total	83	27	110

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	43	19	62
Non-Impaired	40	8	48
Grand Total	83	27	110

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	21	5	26
Non-Impaired	62	22	84
Grand Total	83	27	110

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	58	9	67
Non-Impaired	25	18	43
Grand Total	83	27	110

Low Valley Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	23	2	25
Non-Impaired	11	4	15
Grand Total	34	6	40

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	3	1	4
Non-Impaired	31	5	36
Grand Total	34	6	40

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	17	5	22
Non-Impaired	17	1	18
Grand Total	34	6	40

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	10	0	10
Non-Impaired	24	6	30
Grand Total	34	6	40

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	28	5	33
Non-Impaired	6	1	7
Grand Total	34	6	40

Appendix 4. continued.

Mountains Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	8	14	22
Non-Impaired	3	3	6
Grand Total	11	17	28

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	8	12	20
Non-Impaired	3	5	8
Grand Total	11	17	28

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	1	10	11
Non-Impaired	10	7	17
Grand Total	11	17	28

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	1	3	4
Non-Impaired	10	14	24
Grand Total	11	17	28

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	10	2	12
Non-Impaired	1	15	16
Grand Total	11	17	28

Plains Samples

	MDEQ ALU Impairment		
Historic MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	23	1	24
Non-Impaired	15	3	18
Grand Total	38	4	42

	MDEQ ALU Impairment		
Revised MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	11	1	12
Non-Impaired	27	3	30
Grand Total	38	4	42

	MDEQ ALU Impairment		
RIVPACS Rating	Impaired	Non-Impaired	Grand Total
Impaired	25	4	29
Non-Impaired	13	0	13
Grand Total	38	4	42

	MDEQ ALU Impairment		
Diatom MMI Rating	Impaired	Non-Impaired	Grand Total
Impaired	10	2	12
Non-Impaired	28	2	30
Grand Total	38	4	42

	MDEQ ALU Impairment		
Increaser Taxa Rating	Impaired	Non-Impaired	Grand Total
Impaired	20	2	22
Non-Impaired	18	2	20
Grand Total	38	4	42