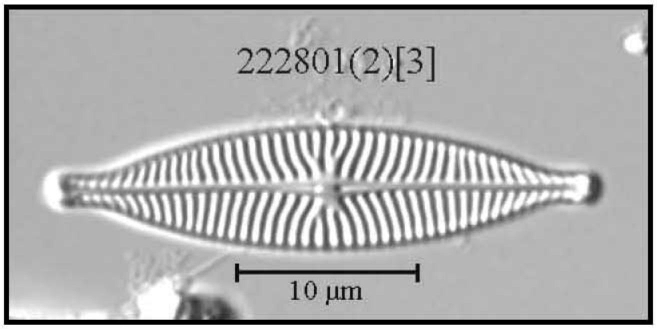
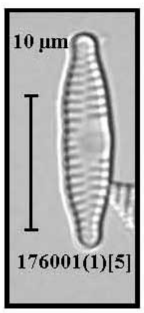
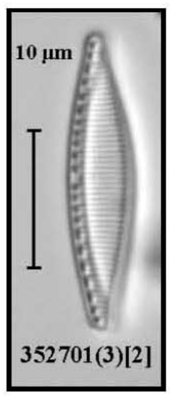
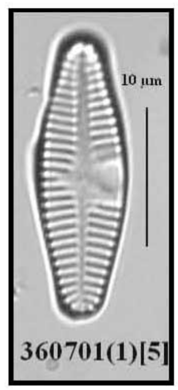
DIATOM BIOCRITERIA FOR MONTANA STREAMS - MIDDLE ROCKIES ECOREGION 2006









Prepared By:
Mark Teply
Larix Systems, Inc.

Loren Bahls
Hannaea

Prepared For:

The Montana Department of Environmental Quality.
Water Quality Monitoring Section. Rosie Sada. Project Manager.
1520 E 6th Avenue. Helena, MT 59620.

February 5, 2007

Cover. Examples of common diatom species in streams of the Middle Rockies ecoregion of Montana whose populations increase in response to sediment impairment. Top: *Navicula capitatoradiata.* Bottom (l to r): *Fragilaria vaucheriae, Nitzschia fonticola, Planothidium lanceolatum*.

Diatom Biocriteria for Montana Streams - Middle Rockies Ecoregion

Prepared by

Mark Teply[1] and Loren Bahls[2]

February 2006

[1] Larix Systems, Inc., 44 No. Last Chance Gulch, No. 4, Helena, MT 59601. (406) 458-0045.

[2] Hannaea, 1032 12th Street, Helena, MT 59601. (406) 443-2196.

Table of Contents

List of Tables

List of Figures

Introduction

Periphyton Bioassessment Methods for Montana Streams (Bahls 1993) presents procedural guidelines and numeric biocriteria for using the composition and structure of periphyton communities to assess biological integrity and impairment of aquatic life in Montana streams. This manual was based on the findings of a 1990 Montana reference stream study and follow-up surveys in 1991 (Bahls et al. 1992). Three metrics - sediment index, pollution index, and diversity index - and two sets of biocriteria are provided, one for mountain and foothill streams and one for plains streams. These original metrics have been supplemented by additional metrics adopted by the Montana Department of Environmental Quality (State). These metrics and biocriteria are linked to beneficial use classifications in Montana Surface Water Quality Standards.

Recently, Teply and Bahls (2005) employed recent advances in biological data analysis and a large amount of periphyton data collected since 1993 to review existing metrics, test new ones, and develop revised biocriteria. Biocriteria were evaluated for their ability to address two key questions directly relevant to the State's assessment of naturally flowing streams:

1) Do diatom sample results indicate impairment under 303(d) guidelines?
2) If so, do diatom sample results indicate the cause of impairment?

Of specific interest to the State was the level of impairment where aquatic life use support is partial or none. Criteria were developed that addressed instances where diatom community response was most likely; that is, impairment due to sediment, nutrients, and/or metals. Diatom community response to other causes was confirmed to be limited, regardless of level of impairment, and therefore not addressed.

As in Bahls (1993), two sets of biocriteria are provided by Teply and Bahls (2005), one for mountain and foothill streams and one for plains streams. These models employed "Increaser Taxa" - taxa that, as a group, exist in detectable amounts in all stream classes (non-impaired and impaired) and demonstrate a meaningful, measurable, and significant response to sediment, nutrients, or metals. Increaser Taxa lists were founded in much the same ecological basis as lists used for "traditional" diatom metrics (e.g., Bahls 1993); but they were based on empirical observations that were directly relevant to the streams considered. Because they were empirically based, and not presumptive, Increaser Taxa lists developed by Teply and Bahls (2005) showed demonstrable improvement over those currently in use by the State.

But, it was recognized that stream grouping at such a coarse scale (either in Teply and Bahls 2005 or Bahls 1993) presumed a high degree of similarity among taxa assemblages from samples within each group. This is critical for local application of these models, as both sets of biocriteria rely on homogeneous taxa assemblages to occur within each stream group. This is likely not the case. Recent work by Tison et al. (2005) describes how geology and relief are important determinants in the natural variability of diatom communities. Tison et al. (2005) cite several other studies in which ecoregion factors such as water mineral content and current velocity are key determinants of diatom distribution (Biggs 1995, Pan et al. 1999, Potapova and Charles 2003, Soininen 2004, Gevery et al. 2004). Similar evaluations are on-going by the State and preliminary findings indicate differences in reference assemblages among ecoregions (Teply and Bahls 2006, in preparation).

Therefore, whereas the findings of Teply and Bahls (2005) provide a critical review of existing biocriteria and present biocriteria that are applicable at the Level I ecoregion scale (mountains or plains), it was recognized that refinement at smaller ecoregion scales could improve biocriteria for local application (e.g., TMDL assessments). Thus, the purpose of this study is to employ methods similar to those used in Teply and Bahls (2005) to develop biocriteria for a selected Level III ecoregion per US EPA (2000) - Ecoregion 17 (Middle Rockies). The Middle Rockies is the only ecoregion currently represented by enough diatom samples from Montana to support selection of modeling **and** validation data sets, validation being a requirement critical to the defensibility of the biocriteria. On-going sampling of impaired and non-impaired streams will support modeling and validation in other ecoregions in the future.

Methods

In addressing key questions posed above, we sought to develop three models that used Increaser Taxa lists to discriminate between those streams impaired for sediment, nutrients, or metals and those streams not impaired for these causes. Following methods described by Teply and Bahls (2005), discriminant analysis was used to evaluate the usefulness of Increaser Taxa lists in discriminating between impaired and non-impaired streams. This was accomplished via metrics derived from the Increaser Taxa lists that represented the total percent relative abundance of taxa found on each list. An advantage of discriminant models (e.g., versus ANOVA or percentile-based threshold setting) is that models can be used to directly calculate the probability of class membership (i.e., the probability that a sample represents impaired conditions). Meaningful application of discriminant models in this way assumes normality and equal variance in metric values among impaired and non-imparied samples. These assumptions were verified as part of all discriminant analyses that were performed for this study. Discriminant analysis was performed using SYSTAT® Version 11.

Increaser Taxa lists were compiled through screening criteria that were applied to samples selected for modeling each cause of impairment:

1. Diatom counts were filtered to identify those taxa that, as a group, represent about 10 to 15 percent of total abundance in non-impaired samples;

2. Taxa occurrence was filtered to identify those taxa that, individually, were counted in at least one-third of non-impaired and impaired samples; and,

3. Diatom counts representing non-impaired and impaired sites were compared to identify those taxa that increase with impairment.

The first two criteria sought to identify taxa that exist in detectable amounts in all stream classes; the third criterion sought to identify taxa that demonstrate a meaningful, measurable response to sediment, nutrients, or metals impairment. Because of the discrete nature of any list, criteria listed above served as a starting point. In practice, we found that further restricting criteria (e.g., finding taxa that show greater percent relative increase or those that occur in more samples) led to shorter lists that tended to improve overall model performance. However, we also found that if criteria were too restrictive, lists were too short and led to models that were not significant and/or not accurate. Therefore, for each cause, several sets of progressively restrictive criteria (and resultant lists) were considered. Ultimately, the selection of the preferred Increaser Taxa list was based on model selection criteria described below.

Following methods employed by Teply and Bahls (2005), discriminant models were evaluated based on the following criteria:

1. Model meaning (i.e., does the metric match expected behavior);

2. Significance of the model (at the 95% confidence level);

3. Classification accuracy (65% overall classification accuracy); and,

4. False positive rates (individual classification accuracies greater than 50%).

In combination, these criteria sought selection of models that were meaningful, significant, and robust (i.e., able to accurately classify with no tendency to indicate impairment for any reason other than the one being considered). To be considered for use by the State, all of these criteria had to be met.

Model meaning was assessed through published sources of diatom autoecology (e.g., van Dam et al. 1994) and professional judgment. Model significance was assessed by p-values reported by SYSTAT® Version 11. Where sufficient samples existed, classification accuracies were calculated using independently drawn datasets (validation datasets). Where sufficient samples did not exist to permit drawing an independent data set, jackknifed classification matrices (i.e., approximations) were used to state classification accuracy. The 65% threshold for overall classification accuracy was chosen as the proportion of correct classifications needed to demonstrate classification accuracy significantly greater than 50% at the 95% level of significance. When considering several potential Increaser Taxa lists, preference was given to the list that that minimized false positive results. We sought lists that were most specific to the cause of impairment - sediment, nutrients, or metals - being evaluated.

Samples used in modeling and validation were drawn from the Montana Diatom Database described in Teply and Bahls (2005) and classified according to the Montana 303(d) list in the 2004 Water Quality Assessment Database:

http://nris.state.mt.us/wis/environet/2004Home.html.

Impaired streams were classified as those where aquatic life use support was listed as partial or none **and** where the cause of impairment was sediment, nutrients, or metals. **Non-impaired** streams were classified as those where support for aquatic life use was full **or** where the cause of impairment was other than sediment, nutrients, or metals. Non-impaired streams included those listed for causes such as habitat degradation, flow alteration, or thermal loading. Furthermore, samples representing non-impaired streams were drawn separately for each cause recognizing that a stream impaired for one cause may be classified as non-impaired for another. In order to be representative of recent 303(d) designations, only samples collected since 1995 were considered.

Model development and model validation was conducted using independently drawn datasets. Where possible, modeling and validation datasets each consisted of 20 impaired samples and 20 non-impaired samples. This target of 20 is generally considered a “rule-of-thumb” for discriminant analyses and is supported by power analyses being conducted for reference assemblages in the ecoregion (Teply and Bahls 2006, in preparation). Samples were drawn separately for each cause to achieve representativeness, randomness, and independence among sample data. Representativeness was achieved by drawing a number of samples proportional to the frequency of impairment causes listed for streams in the mountains ecoregions. Randomness and independence were achieved via random selection techniques, which minimized the number of samples representing any given hydrologic unit, and limited the number of samples for any listed stream segment to one.

Samples representing **reference** streams were not considered in modeling, but they were considered in validation. Modeling focused on the practical need to distinguish impairment status among impaired and non-impaired streams as defined above. This was done recognizing that protocols for classification of reference streams already exist (Suplee et al. 2005). Reference streams identified via these protocols represent the natural biological, physical and chemical integrity of a region. Nevertheless, it was also recognized that models should be expected to distinguish reference streams as non-impaired. Therefore, additional samples were drawn for samples representing reference streams to validate this expected model behavior. These validation results were included in model evaluation, as described above. Similar random selection techniques were employed as described above for selecting reference samples and the same set of reference samples was considered for evaluating all models.

Results

Samples used in modeling and validation are listed in **Appendix A**. For **impaired** streams, target sample sizes were met for modeling and for validation of Increaser Taxa lists discriminating impairment due to sediment. Target sample sizes were also met for modeling impairment due to metals, but sample draws fell short (15) of target for modeling impairment due to nutrients. No samples were available representing impaired streams to validate Increaser Taxa lists discriminating impairment due to nutrients or metals. For **non-impaired** streams, target sample sizes for modeling were met in all instances. Target sample sizes were also met for validating Increaser Taxa lists discriminating impairment due to nutrients and metals, but sample draws fell short (15) of target for validating models discriminating impairment due to sediment. Among **reference** streams meeting the criteria in Suplee et al. (2005) in the Middle Rockies ecoregion, fifteen (15) spatially independent samples could be randomly selected for validating Increaser Taxa lists discriminating impairment for each cause.

Of the three causes of impairment considered – sediment, nutrients, and metals – Increaser Taxa for only one cause – sediment – could be screened in a manner meeting all of the model selection criteria outlined above:

(1) $Score_{ER17Sediment} = (\%\ Increasers_{ER17Sediment} - 24.31) / 11.95$

where:

if $Score_{ER17Sediment} >= 0$, then classify as Sediment Impaired; or,

if $Score_{ER17Sediment} < 0$, then classify as Not Sediment Impaired.

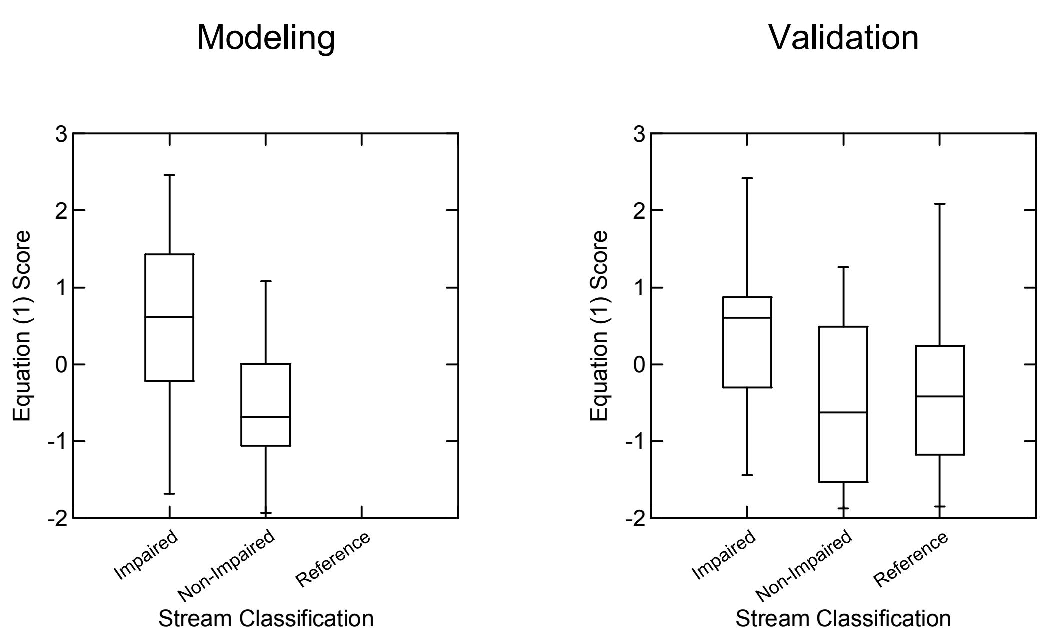
Sediment Increaser Taxa are listed in **Table 1**. This model is considered meaningful in that taxa on this list have been observed to increase – individually and as a group – in response to observed sediment impairment within the Middle Rockies ecoregion. Furthermore, a review of independent autecological data for these taxa supports their listing as increasers in response to general pollution, including sediment disturbance (Beaver 1981, Lange-Bertalot 1979, Lowe 1974, van Dam et al. 1994). Moreover, several of these taxa are listed by these sources as preferring epipelic (muddy) habitats.

The model was significant ($p<0.01$) and overall classification accuracy was independently verified to be 68%. Reference sites were correctly classified 73% of the time and impaired and non-impaired sites were correctly classified at rates of 65% and 67%, respectively. **Figure 1** demonstrates this through the distribution of scores obtained by this model among the modeling and validation samples. Although the validation dataset did not include samples impaired solely for nutrients or metals, 80% of such samples drawn for modeling were correctly classified by this model as non-impaired due to sediment. This Sediment Increaser Taxa list in **Table 1** was not prone to indicate impairment for any other reason (i.e., nutrients, metals) than sediment.

Table 1. Sediment Increaser Taxa screened for streams in the Middle Rockies ecoregion.

Sediment Increaser Taxa
Amphora pediculus
Cocconeis pediculus
Eolimna minima
Fragilaria vaucheriae
Gomphonema parvulum
Navicula capitatoradiata
Navicula reichardtiana
Navicula tripunctata
Nitzschia fonticola
Nitzschia heufleriana
Nitzschia linearis
Planothidium lanceolatum
Sellaphora pupula
Staurosira construens
Staurosirella leptostauron
Staurosirella pinnata
Stephanocyclus meneghiniana

Figure 1. Distribution of Equation (1) scores among modeling and validation samples for streams in the Middle Rockies ecoregion.



Significant Increaser Taxa lists could be screened for impairment due to nutrients and metals. These models could not be fully validated, yet overall jackknifed classification matrices indicated approximate classification accuracies of 86% and 68%, respectively. These models also classified most reference sites correctly. However, samples representing sites impaired for reasons other than nutrients or metals tended to be classified as impaired. In other words, these models could only indicate that a site was impaired, but not necessarily for the specified cause. In most cases, these Increaser Taxa lists indicated impairment due to sediment. Therefore, whereas these models could indicate impairment, they tended to indicate impairment for the wrong reason and were not considered meaningful or robust. Furthermore, given the lack of data, these models could not be independently verified.

Scores calculated from Equation (1) are distributed normally and centered about the criterion of zero. Therefore, the probability of the sample representing a stream impaired due to sediment can be determined via tables of normal distributions. For instance, if the percent relative abundance of taxa on the Sediment Increaser Taxa list is 35 percent, using Equation (1) yields a calculated score value of 0.895. By using a normal probability table and standardizing this score about the criterion of 0.0, the probability that the sample represents a stream impaired by sediment is about 81%. **Table 2** presents classification probabilities for discrete values of percent relative abundance, as a group, of Sediment Increaser Taxa represented in **Table 1.**

Table 2. Probability of sediment impairment in streams in the Middle Rockies ecoregion based on the percent relative abundance of Sediment Increaser Taxa (Table 1).

Percent Relative Abundance	Probability of Sediment Impairment
5	5.31%
10	11.56%
15	21.80%
20	35.92%
25	52.30%
30	68.30%
35	81.45%
40	90.54%
45	95.83%
50	98.42%

Discussion

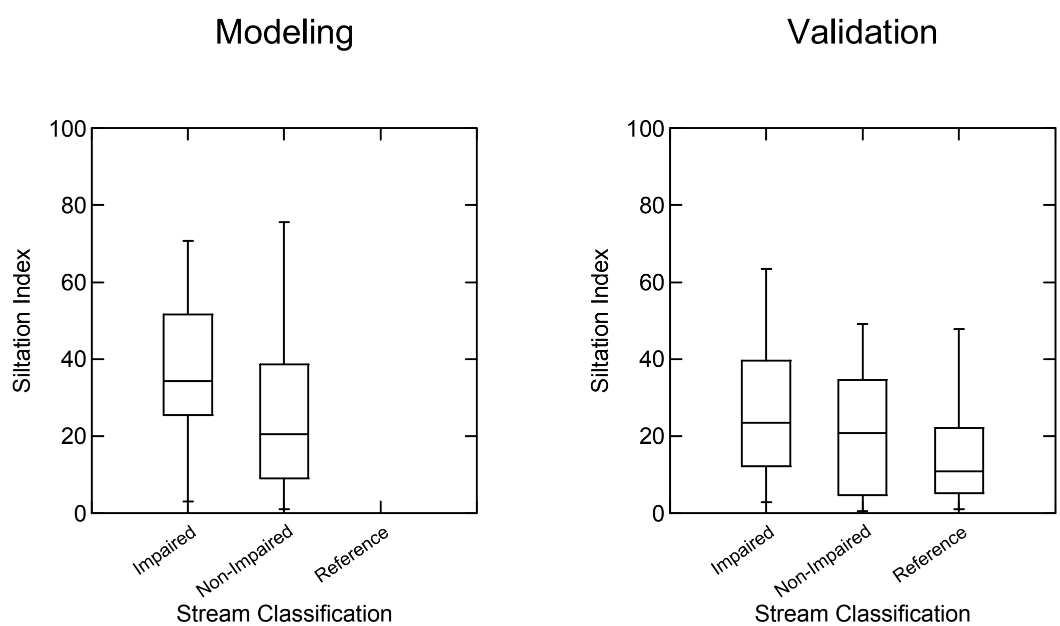
The Sediment Increaser Taxa list in **Table 1** leads to a meaningful, significant, and robust model for evaluating impairment due to sediment. Given the lack of numeric State standards for sediment impairment, this model can offer an important piece of evidence in water quality assessments. About half of the impaired streams in the Middle Rockies ecoregion are impaired due to sediment – either solely or in combination with other causes. Therefore, this model is offered as a useful alternative to existing metrics (e.g., Siltation Index) and biocriteria used by the State. In application, it is specific to impairment due to sediment. Non-impairment classifications resulting from this model do not necessarily indicate that the stream is unimpaired; it could still be impaired due to a cause other than sediment. Likewise, impairment classifications do not necessarily mean that the stream is not also impaired by a cause other than sediment. Overall, any interpretations and assignment of cause requires review by a qualified ecologist and consideration of the entirety of sample results.

Given the foregoing, how does this model compare to Periphyton Bioassessment Methods for Montana Streams (Bahls 1993)? The current State biocriteria for evaluating sediment impairment in mountain samples are presented in **Appendix B**. Classification accuracies that result from applying these criteria to validation samples are presented in **Table 3**. These results indicate that use of Siltation Index and the current State biocriteria would not meet model classification performance criteria stated above. While the overall classification accuracy is about 60%, only 25% of samples from streams impaired by sediment are correctly classified. Furthermore, the distribution of Siltation Index values obtained among the modeling and validation samples do not demonstrate as great a difference among stream classifications (**Figure 2**). Although they exhibit meaningful trends, the motile taxa used in the Siltation Index (*Navicula, Nitzschia, and Surrirella*), as a group, are not significantly different among non-impaired streams and impaired streams. Therefore, biocriteria implemented via Equation (1) can be independently demonstrated to have a better ability to discriminate sediment impairment compared to biocriteria currently in use by the State. This is a meaningful, significant, and robust improvement in biocriteria for the State's assessment of sediment in naturally flowing streams.

Table 3. Comparison of classification accuracies among validation samples evaluating sediment impairment using the current State biocriteria (Appendix B) and using the Sediment Increaser Taxa list presented in Table 1.

Stream Classification	Classification Accuracies	
	Bahls (1993)	Equation (1)
Impaired	25%	65%
Non-Impaired	80%	67%
Reference	93%	73%

Figure 2. Distribution of Siltation Index values among modeling and validation samples for streams in the Middle Rockies ecoregion.



Given the foregoing, how does this model compare to Increaser Taxa lists developed for mountains and foothill ecoregions by Teply and Bahls (2005)? Comparisons of classification accuracies among validation samples would not be valid as many of these same validation samples were used in modeling by Teply and Bahls (2005). Therefore, we must rely on approximate classification accuracies presented in that study. Those results indicate that use of the Increaser Taxa list for sediment in Teply and Bahls

(2005) would meet model classification performance criteria stated above; overall classification accuracy was about 70% and classification accuracy of non-impaired and impaired samples exceeded 50%. However, among impaired samples, it was also demonstrated that the ability to discriminate sediment impairment in combination with either nutrients or metals was below 50%. In comparison, using the Sediment Increaser Taxa list in **Table 1**, there is no combination of impairment for which classification accuracy falls below 50%. Furthermore, although performance of the metric derived from the Increaser Taxa list in Teply and Bahls (2005) is similar to that demonstrated by Equation (1), presumably the Increaser Taxa in **Table 1** are more specific to the Middle Rockies ecoregion and therefore likely to discriminate more consistently and at a larger number of sites within the ecoregion. The recently published studies cited in the Introduction on geographic determination of diatom assemblages support this assertion. These are meaningful, significant, and robust improvements for the State's assessment of sediment in naturally flowing streams.

In conclusion, Equation (1) is offered as a useful, meaningful, significant, and robust alternative in the Middle Rockies ecoregion to the Siltation Index presented by Bahls (1993) and Increaser Taxa lists presented by Teply and Bahls (2005). Based on the empirical investigation of sample data, it is directly applicable to evaluating sediment impairment in naturally flowing streams within the Middle Rockies ecoregion. The occurrence of taxa on the Sediment Increaser Taxa list is consistent with autecology reported independently by other sources. Independent validation over the range of stream conditions in the ecoregion has allowed us to state their reliability and demonstrate improved performance compared to biocriteria currently in use by the State. Refinement of Increaser Taxa lists at the Level III ecoregion scale has improved model robustness and application at the local scale (e.g., for TMDL assessments). In many of these regards, this model can be considered an improvement. With on-going validation at the ecoregion and local (e.g., watershed) scale, the State will be able to further improve its confidence in these biocriteria and refine them where necessary.

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Appendix A: Sample Listing, Sediment Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
M	Impaired	35203	6/27/2002	10030101	MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	N	SXM
M	Impaired	39404	7/12/2001	10020005	MT41G001_010	JEFFERSON RIVER from headwaters to mouth (Missouri R)	N	SXM
M	Impaired	107601	7/28/1990	10020004	MT41D004_190	STEEL CREEK from headwaters to mouth (Big Hole R)	N	SNM
M	Impaired	184401	8/16/1999	10020007	MT41F004_060	NORTH MEADOW CREEK from headwaters to the mouth (Enis Lake)	F	SNX
M	Impaired	198301	7/21/2000	10070005	MT43C001_010	STILLWATER RIVER from headwaters to Flood Cr	P	SXM
M	Impaired	198401	8/1/2000	10020004	MT41D003_070	CALIFORNIA CREEK from headwaters to mouth (French Cr-Deep Cr)	N	SXM
M	Impaired	201301	9/19/2000	10070003	MT43A001_012	SHIELDS RIVER from headwaters to Cottonwood Cr	P	SXX
M	Impaired	207101	7/19/2000	10020004	MT41D002_100	BIRCH CREEK from National Forest Boundary to mouth (Big Hole R)	N	SXX
M	Impaired	207701	8/8/2000	10020003	MT41C001_010	RUBY RIVER from Ruby Dam to the mouth (Beaverhead R)	P	SXX
M	Impaired	215901	6/21/2001	17010203	MT76F002_070	ARRASTRA CREEK from headwaters to mouth (Blackfoot R)	P	SXX
M	Impaired	216201	6/26/2001	17010203	MT76F002_030	POORMAN CREEK from headwaters to the mouth (Blackfoot R)	P	SXM
M	Impaired	236801	8/29/2001	10020007	MT41F002_020	ELK CREEK from headwaters to the mouth (Madison R)	N	SNX
M	Impaired	237101	8/10/2001	10020002	MT41B002_030	BLACKTAIL DEER CREEK from headwaters to mouth (Beaverhead R)	N	SXX
M	Impaired	249401	7/12/2002	10020005	MT41G002_140	WHITETAIL CREEK tributary of the Jefferson R T3N R5W	P	SXX
M	Impaired	249501	7/12/2002	17010201	MT76G003_020	SILVER BOW CREEK from the Warm Springs Pond 2 outlet to headwaters	N	SNM
M	Impaired	291201	8/14/2003	10020003	MT41C002_040	ALDER GULCH from headwaters to mouth (Ruby R)	N	SXM
M	Impaired	292501	8/17/2003	10020003	MT41C003_060	SWEETWATER CREEK from headwaters to mouth (Ruby R)	P	SNX
M	Impaired	294701	9/24/2003	10020002	MT41B002_100	FRENCH CREEK from headwaters to mouth (Rattlesnake Cr-Beaverhead R)	N	SXX
M	Impaired	304101	9/14/2003	17010203	MT76F005_060	BLANCHARD CREEK from the North Fork to the mouth (Clearwater R)	P	SXX
M	Impaired	325901	8/28/2003	10030101	MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	N	SNM
M	Non-Impaired	8206	8/19/2003	10070002	MT43B004_131	BOULDER RIVER from the mouth (Yellowstone R) five miles upstream	P	XXM
M	Non-Impaired	25707	7/31/2003	10020004	MT41D001_010	BIG HOLE RIVER from Divide Cr to the mouth (Jefferson R)	N	XXM
M	Non-Impaired	75224	9/11/2002	17010203	MT76F001_033	BLACKFOOT RIVER from Belmont Cr. to mouth (Clark Fork)	P	XNX
M	Non-Impaired	149810	8/14/2002	10020007	MT41F001_030	MADISON RIVER from Hebgen Dam to Quake Lake	F	XXX
M	Non-Impaired	198901	8/1/2000	10070003	MT43A002_031	COTTONWOOD CREEK, Little Cottonwood Cr to the mouth (Shields R)	P	XXX
M	Non-Impaired	200201	8/8/2000	10040103	MT41S004_040	CASINO CREEK, Headwaters to mouth (Big Spring Cr)	P	XNX
M	Non-Impaired	206501	7/21/2000	10020004	MT41D004_140	MINER CREEK from headwaters to mouth (Big Hole R)	F	XXX
M	Non-Impaired	206901	7/27/2000	10020004	MT41D004_130	LITTLE LAKE CREEK from headwaters to mouth (Big Hole R)	F	XXX
M	Non-Impaired	215701	6/21/2001	17010203	MT76F001_010	BLACKFOOT RIVER from headwaters to Landers Fork	N	XXM
M	Non-Impaired	219501	8/21/2001	10040103	MT41S004_051	COTTONWOOD CREEK from headwaters to county road bridge in T14N R18E Sec18.	F	XXX
M	Non-Impaired	255101	8/6/2002	17010201	MT76G002_132	PETERSON CREEK from Jack Cr. to the mouth (Clark Fork R)	N	XXX
M	Non-Impaired	256301	9/20/2002	10040203	MT40B001_050	SOUTH FOOK FLATWILLOW CREEK, Headwaters to confluence with North Fork	F	XXX
M	Non-Impaired	257301	9/12/2002	10020008	MT41H002_031	SOUTH COTTONWOOD CREEK, Middle Cr Assoc Ditch diversion to the mouth (Gallat	P	XXX
M	Non-Impaired	266601	9/11/2002	10030101	MT41I006_179	GRANITE CREEK from headwaters to mouth (Austin Cr - Greenhorn Cr - Sevenmile Cr)	F	XXX
M	Non-Impaired	290001	8/15/2003	10070002	MT43B004_132	BOULDER RIVER from NF boundary to 5 mi above the mouth (Yellowstone R)	F	XXX
M	Non-Impaired	291801	8/13/2003	10020003	MT41C002_030	INDIAN CREEK from headwaters to mouth (Mill Cr-Ruby R)	P	XXX
M	Non-Impaired	292401	8/15/2003	10020003	MT41C002_060	CURRANT CREEK, Headwaters to mouth (Ramshorn Cr) T4S, R4W, S35	F	XXX
M	Non-Impaired	307301	8/7/2003	10070002	MT43B004_120	MOL HERON CREEK, Yellowstone National Park boundary to mouth (Yellowstone R)	P	XXX
M	Non-Impaired	331601	9/26/2003	17010203	MT76F003_060	BLACK BEAR CREEK T12N R12W Sec 22SE	N	XXX

Appendix A: Sample Listing, Sediment Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
M	Non-Impaired	332501	9/29/2003	17010203	MT76F003_022	JEFFERSON CREEK from 1 mi above Madison Gulch to mouth (Nevada Cr)	P	XXX
V	Impaired	12302	8/21/2001	17010201	MT76G004_010	LITTLE BLACKFOOT RIVER from Dog Cr to the mouth (Clark Fork R)	P	SNM
V	Impaired	25907	7/31/2003	10020002	MT41B001_020	BEAVERHEAD RIVER from Grasshopper Cr to mouth (Jefferson R)	N	SXX
V	Impaired	27828	8/22/2001	17010205	MT76H001_030	BITTERROOT RIVER from Eightmile Cr to the mouth (Clark Fork R)	P	SNM
V	Impaired	149909	8/8/2001	10020007	MT41F001_010	MADISON RIVER from Ennis Dam to the mouth (Missouri R)	P	SXM
V	Impaired	168902	7/30/2001	10030101	MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	P	SNM
V	Impaired	184001	6/18/1999	10030103	MT41J001_020	SMITH RIVER from Hound Cr. to the mouth (Missouri R)	P	SNX
V	Impaired	184201	8/18/1999	10020007	MT41F004_050	JACK CREEK from headwaters to the mouth (Madison R)	P	SXX
V	Impaired	184801	8/20/1999	10020005	MT41G002_050	NORTH WILLOW CREEK from headwaters to mouth (Willow Cr)	N	SXM
V	Impaired	194502	7/11/2001	10020004	MT41D003_210	PATTENGAIL CREEK from headwaters to mouth (Wise R)	P	SXX
V	Impaired	206301	7/27/2000	10020004	MT41D004_120	ROCK CREEK from headwaters to mouth (Big Hole R)	P	SNX
V	Impaired	206401	7/18/2000	10020004	MT41D002_160	ROCHESTER CREEK from headwaters to mouth (Big Hole R) T3S R7W	P	SXM
V	Impaired	208101	7/17/2000	10020005	MT41G002_040	LITTLE PIPESTONE CREEK, Headwaters to mouth (Big Pipestone Cr)	P	SXX
V	Impaired	216501	6/21/2001	17010203	MT76F002_020	WILLOW CREEK from Sandbar Cr to mouth, T15N R7W (Blackfoot R)	P	SXX
V	Impaired	216701	6/18/2001	17010203	MT76F002_060	SANDBAR CREEK from forks to mouth (Willow Cr)	P	SXM
V	Impaired	220501	6/28/2001	10020004	MT41D004_070	TRAIL CREEK from headwaters to Joseph Cr	N	SXX
V	Impaired	223301	7/31/2001	10030101	MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	P	SXM
V	Impaired	331401	9/25/2003	17010203	MT76F003_130	BUFFALO GULCH, headwaters to mouth (Nevada Cr)	P	SXX
V	Impaired	346301	8/7/2004	10020003	MT41C002_050	RAMSHORN CREEK from headwaters to mouth (Ruby R)	P	SXM
V	Impaired	346801	8/8/2004	10020003	MT41C003_110	POISON CREEK, Headwaters to mouth (Ruby R) T11S, R3W	P	SXX
V	Impaired	350601	8/25/2004	17010203	MT76F003_012	NEVADA CREEK from Nevada Lake to the mouth (Blackfoot R)	N	SNX
V	Non-Impaired	140210	8/23/2001	17010202	MT76E002_010	ROCK CREEK mainstem from headwaters to mouth (Clark Fork)	F	XXX
V	Non-Impaired	156901	7/20/1995	10050006	MT40G001_020	SAGE CREEK, Headwaters to Laird Cr	F	XXX
V	Non-Impaired	183401	9/14/1998	10030103	MT41J002_012	SMITH RIVER NORTH FORK from headwaters to Lake Sutherlin	F	XXX
V	Non-Impaired	185203	8/15/2003	10070002	MT43B004_143	EAST BOULDER RIVER from headwaters to the NF boundary	F	XXX
V	Non-Impaired	199701	8/17/2000	10070002	MT43B004_061	TOM MINER CREEKTepee Cr. to the mouth (Yellowstone R)	P	XXX
V	Non-Impaired	220101	6/29/2001	10020004	MT41D004_040	SCHULTZ CREEK from headwaters to mouth (Johnson Cr)	F	XXX
V	Non-Impaired	235901	8/2/2001	10020004	MT41D003_120	TWELVEMILE CREEK from headwaters to mouth (Deep Cr)	F	XXX
V	Non-Impaired	265301	8/20/2002	10020007	MT41F004_030	BEAVER CREEK from headwaters to the mouth (Quake Lake)	F	XXX
V	Non-Impaired	267201	8/29/2002	10020008	MT41H001_010	GALLATIN RIVER from Spanish Cr to the mouth (Missouri R)	P	XXX
V	Non-Impaired	287701	6/23/2003	10070003	MT43A002_052	ROCK CREEK from headwaters to Little Rock Cr.	F	XXX
V	Non-Impaired	292301	8/18/2003	10020003	MT41C003_070	NORTH FK GREENHORN CR from headwaters to confluence with South Fk	F	XXX
V	Non-Impaired	295001	6/10/2003	10040101	MT41T002_040	EAGLE CREEK from headwaters to Dog Cr	F	XXX
V	Non-Impaired	303301	9/11/2003	17010203	MT76F004_100	MONTURE CREEK from headwaters to the mouth (Blackfoot R)	P	XXX
V	Non-Impaired	331201	9/11/2003	17010203	MT76F004_090	ROCK CREEK from headwaters to the mouth (North Fork Blackfoot R)	P	XXX
V	Non-Impaired	332301	9/28/2003	17010203	MT76F003_071	WASHINGTON CREEK from headwaters to Cow Gulch	N	XXX
V	Reference	48601	7/14/1978	10020008	SFSpanis_407_C	South Fork Spanish Creek, Spanish Peaks Wilderness	F	XXX
V	Reference	75213	8/10/1992	17010203	Blackfoo_006_C	Blackfoot River	F	XXX
V	Reference	77901	2/11/1981	10070001	GardnerR_404_C	Gardner River at mouth, Yellowstone National Park	F	XXX

Appendix A: Sample Listing, Sediment Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
V	Reference	101402	8/5/1992	10070006	WFRockCr_405_C	West Fork Rock Creek above Silver Run	F	XXX
V	Reference	106001	7/31/1990	10020007	ODellCk9_236_C	O'Dell Ck	F	XXX
V	Reference	106301	9/13/1990	10070002	Fourmile_112_C	Fourmile Creek	F	XXX
V	Reference	106602	7/29/2001	10030103	CalfCree_017_C	Calf Creek	F	XXX
V	Reference	106701	7/10/1990	10080010	CROOKEDC_111_C	CROOKED CREEK ABOVE TILLETT RANCH	F	XXX
V	Reference	106901	7/26/1990	10070002	BigCk999_180_C	Big Ck	F	XXX
V	Reference	140212	7/28/2003	17010202	RockCree_071_C	Rock Creek near Clinton	F	XXX
V	Reference	201501	8/21/2000	10020008	Gallatin_040_C	Gallatin River	F	XXX
V	Reference	206801	7/26/2000	10020004	LittleLa_049_C	Little Lake Creek	F	XXX
V	Reference	237301	8/14/2001	10070006	SeeleyCr_075_C	Seeley Creek	F	XXX
V	Reference	237501	9/1/2001	10020001	ElkSprin_037_C	Elk Springs Creek	F	XXX
V	Reference	339001	8/28/2003	10070005	EastRose_033_C	East Rosebud Creek	F	XXX

Appendix A: Sample Listing, Nutrient Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
M	Impaired	12302	8/21/2001	17010201	MT76G004_010	LITTLE BLACKFOOT RIVER from Dog Cr to the mouth (Clark Fork R)	P	SNM
M	Impaired	27828	8/22/2001	17010205	MT76H001_030	BITTERROOT RIVER from Eightmile Cr to the mouth (Clark Fork R)	P	SNM
M	Impaired	75224	9/11/2002	17010203	MT76F001_033	BLACKFOOT RIVER from Belmont Cr. to mouth (Clark Fork)	P	XNX
M	Impaired	107601	7/28/1990	10020004	MT41D004_190	STEEL CREEK from headwaters to mouth (Big Hole R)	N	SNM
M	Impaired	168902	7/30/2001	10030101	MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	P	SNM
M	Impaired	184001	6/18/1999	10030103	MT41J001_020	SMITH RIVER from Hound Cr. to the mouth (Missouri R)	P	SNX
M	Impaired	184401	8/16/1999	10020007	MT41F004_060	NORTH MEADOW CREEK from headwaters to the mouth (Enis Lake)	F	SNX
M	Impaired	200201	8/8/2000	10040103	MT41S004_040	CASINO CREEK, Headwaters to mouth (Big Spring Cr)	P	XNX
M	Impaired	200501	8/9/2000	10040103	MT41S001_020	JUDITH RIVER from Ross Fork to Big Spring Cr	P	SNX
M	Impaired	206301	7/27/2000	10020004	MT41D004_120	ROCK CREEK from headwaters to mouth (Big Hole R)	P	SNX
M	Impaired	236801	8/29/2001	10020007	MT41F002_020	ELK CREEK from headwaters to the mouth (Madison R)	N	SNX
M	Impaired	249501	7/12/2002	17010201	MT76G003_020	SILVER BOW CREEK from the Warm Springs Pond 2 outlet to headwaters	N	SNM
M	Impaired	292501	8/17/2003	10020003	MT41C003_060	SWEETWATER CREEK from headwaters to mouth (Ruby R)	P	SNX
M	Impaired	325901	8/28/2003	10030101	MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	N	SNM
M	Impaired	350601	8/25/2004	17010203	MT76F003_012	NEVADA CREEK from Nevada Lake to the mouth (Blackfoot R)	N	SNX
M	Non-Impaired	25707	7/31/2003	10020004	MT41D001_010	BIG HOLE RIVER from Divide Cr to the mouth (Jefferson R)	N	XXM
M	Non-Impaired	156901	7/20/1995	10050006	MT40G001_020	SAGE CREEK, Headwaters to Laird Cr	F	XXX
M	Non-Impaired	198301	7/21/2000	10070005	MT43C001_010	STILLWATER RIVER from headwaters to Flood Cr	P	SXM
M	Non-Impaired	198401	8/1/2000	10020004	MT41D003_070	CALIFORNIA CREEK from headwaters to mouth (French Cr-Deep Cr)	N	SXM
M	Non-Impaired	198901	8/1/2000	10070003	MT43A002_031	COTTONWOOD CREEK, Little Cottonwood Cr to the mouth (Shields R)	P	XXX
M	Non-Impaired	201301	9/19/2000	10070003	MT43A001_012	SHIELDS RIVER from headwaters to Cottonwood Cr	P	SXX
M	Non-Impaired	215701	6/21/2001	17010203	MT76F001_010	BLACKFOOT RIVER from headwaters to Landers Fork	N	XXM
M	Non-Impaired	215901	6/21/2001	17010203	MT76F002_070	ARRASTRA CREEK from headwaters to mouth (Blackfoot R)	P	SXX
M	Non-Impaired	216201	6/26/2001	17010203	MT76F002_030	POORMAN CREEK from headwaters to the mouth (Blackfoot R)	P	SXM
M	Non-Impaired	237101	8/10/2001	10020002	MT41B002_030	BLACKTAIL DEER CREEK from headwaters to mouth (Beaverhead R)	N	SXX
M	Non-Impaired	249401	7/12/2002	10020005	MT41G002_140	WHITETAIL CREEK tributary of the Jefferson R T3N R5W	P	SXX
M	Non-Impaired	255101	8/6/2002	17010201	MT76G002_132	PETERSON CREEK from Jack Cr. to the mouth (Clark Fork R)	N	XXX
M	Non-Impaired	257301	9/12/2002	10020008	MT41H002_031	SOUTH COTTONWOOD CREEK, Middle Cr Assoc Ditch diversion to the mouth (Gallat	P	XXX
M	Non-Impaired	266601	9/11/2002	10030101	MT41I006_179	GRANITE CREEK from headwaters to mouth (Austin Cr - Greenhorn Cr - Sevenmile Cr)	F	XXX
M	Non-Impaired	291801	8/13/2003	10020003	MT41C002_030	INDIAN CREEK from headwaters to mouth (Mill Cr-Ruby R)	P	XXX
M	Non-Impaired	295001	6/10/2003	10040101	MT41T002_040	EAGLE CREEK from headwaters to Dog Cr	F	XXX
M	Non-Impaired	304101	9/14/2003	17010203	MT76F005_060	BLANCHARD CREEK from the North Fork to the mouth (Clearwater R)	P	SXX
M	Non-Impaired	307301	8/7/2003	10070002	MT43B004_120	MOL HERON CREEK, Yellowstone National Park boundary to mouth (Yellowstone R)	P	XXX
M	Non-Impaired	331601	9/26/2003	17010203	MT76F003_060	BLACK BEAR CREEK T12N R12W Sec 22SE	N	XXX
M	Non-Impaired	332501	9/29/2003	17010203	MT76F003_022	JEFFERSON CREEK from 1 mi above Madison Gulch to mouth (Nevada Cr)	P	XXX
V	Non-Impaired	25907	7/31/2003	10020002	MT41B001_020	BEAVERHEAD RIVER from Grasshopper Cr to mouth (Jefferson R)	N	SXX
V	Non-Impaired	140210	8/23/2001	17010202	MT76E002_010	ROCK CREEK mainstem from headwaters to mouth (Clark Fork)	F	XXX
V	Non-Impaired	149909	8/8/2001	10020007	MT41F001_010	MADISON RIVER from Ennis Dam to the mouth (Missouri R)	P	SXM
V	Non-Impaired	184201	8/18/1999	10020007	MT41F004_050	JACK CREEK from headwaters to the mouth (Madison R)	P	SXX

Appendix A: Sample Listing, Nutrient Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
V	Non-Impaired	184801	8/20/1999	10020005	MT41G002_050	NORTH WILLOW CREEK from headwaters to mouth (Willow Cr)	N	SXM
V	Non-Impaired	194502	7/11/2001	10020004	MT41D003_210	PATTENGAIL CREEK from headwaters to mouth (Wise R)	P	SXX
V	Non-Impaired	199701	8/17/2000	10070002	MT43B004_061	TOM MINER CREEKTepee Cr. to the mouth (Yellowstone R)	P	XXX
V	Non-Impaired	206401	7/18/2000	10020004	MT41D002_160	ROCHESTER CREEK from headwaters to mouth (Big Hole R) T3S R7W	P	SXM
V	Non-Impaired	208101	7/17/2000	10020005	MT41G002_040	LITTLE PIPESTONE CREEK, Headwaters to mouth (Big Pipestone Cr)	P	SXX
V	Non-Impaired	216501	6/21/2001	17010203	MT76F002_020	WILLOW CREEK from Sandbar Cr to mouth, T15N R7W (Blackfoot R)	P	SXX
V	Non-Impaired	216701	6/18/2001	17010203	MT76F002_060	SANDBAR CREEK from forks to mouth (Willow Cr)	P	SXM
V	Non-Impaired	219501	8/21/2001	10040103	MT41S004_051	COTTONWOOD CREEK from headwaters to county road bridge in T14N R18E Sec18.	F	XXX
V	Non-Impaired	220501	6/28/2001	10020004	MT41D004_070	TRAIL CREEK from headwaters to Joseph Cr	N	SXX
V	Non-Impaired	223101	8/1/2001	10030101	MT41I006_120	CLANCY CREEK from headwaters to the mouth (Prickly Pear Cr)	N	SXM
V	Non-Impaired	223301	7/31/2001	10030101	MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	P	SXM
V	Non-Impaired	267201	8/29/2002	10020008	MT41H001_010	GALLATIN RIVER from Spanish Cr to the mouth (Missouri R)	P	XXX
V	Non-Impaired	290001	8/15/2003	10070002	MT43B004_132	BOULDER RIVER from NF boundary to 5 mi above the mouth (Yellowstone R)	F	XXX
V	Non-Impaired	332301	9/28/2003	17010203	MT76F003_071	WASHINGTON CREEK from headwaters to Cow Gulch	N	XXX
V	Non-Impaired	346301	8/7/2004	10020003	MT41C002_050	RAMSHORN CREEK from headwaters to mouth (Ruby R)	P	SXM
V	Non-Impaired	346801	8/8/2004	10020003	MT41C003_110	POISON CREEK, Headwaters to mouth (Ruby R) T11S, R3W	P	SXX
V	Reference	48601	7/14/1978	10020008	SFSpanis_407_C	South Fork Spanish Creek, Spanish Peaks Wilderness	F	XXX
V	Reference	75213	8/10/1992	17010203	Blackfoo_006_C	Blackfoot River	F	XXX
V	Reference	77901	2/11/1981	10070001	GardnerR_404_C	Gardner River at mouth, Yellowstone National Park	F	XXX
V	Reference	101402	8/5/1992	10070006	WFRockCr_405_C	West Fork Rock Creek above Silver Run	F	XXX
V	Reference	106001	7/31/1990	10020007	ODellCk9_236_C	O'Dell Ck	F	XXX
V	Reference	106301	9/13/1990	10070002	Fourmile_112_C	Fourmile Creek	F	XXX
V	Reference	106602	7/29/2001	10030103	CalfCree_017_C	Calf Creek	F	XXX
V	Reference	106701	7/10/1990	10080010	CROOKEDC_111_C	CROOKED CREEK ABOVE TILLETT RANCH	F	XXX
V	Reference	106901	7/26/1990	10070002	BigCk999_180_C	Big Ck	F	XXX
V	Reference	140212	7/28/2003	17010202	RockCree_071_C	Rock Creek near Clinton	F	XXX
V	Reference	201501	8/21/2000	10020008	Gallatin_040_C	Gallatin River	F	XXX
V	Reference	206801	7/26/2000	10020004	LittleLa_049_C	Little Lake Creek	F	XXX
V	Reference	237301	8/14/2001	10070006	SeeleyCr_075_C	Seeley Creek	F	XXX
V	Reference	237501	9/1/2001	10020001	ElkSprin_037_C	Elk Springs Creek	F	XXX
V	Reference	339001	8/28/2003	10070005	EastRose_033_C	East Rosebud Creek	F	XXX

Appendix A: Sample Listing, Metals Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
M	Impaired	8206	8/19/2003	10070002	MT43B004_131	BOULDER RIVER from the mouth (Yellowstone R) five miles upstream	P	XXM
M	Impaired	12302	8/21/2001	17010201	MT76G004_010	LITTLE BLACKFOOT RIVER from Dog Cr to the mouth (Clark Fork R)	P	SNM
M	Impaired	25707	7/31/2003	10020004	MT41D001_010	BIG HOLE RIVER from Divide Cr to the mouth (Jefferson R)	N	XXM
M	Impaired	27828	8/22/2001	17010205	MT76H001_030	BITTERROOT RIVER from Eightmile Cr to the mouth (Clark Fork R)	P	SNM
M	Impaired	35203	6/27/2002	10030101	MT41I006_050	PRICKLY PEAR CREEK from Spring Cr to Lump Gulch	N	SXM
M	Impaired	39404	7/12/2001	10020005	MT41G001_010	JEFFERSON RIVER from headwaters to mouth (Missouri R)	N	SXM
M	Impaired	107601	7/28/1990	10020004	MT41D004_190	STEEL CREEK from headwaters to mouth (Big Hole R)	N	SNM
M	Impaired	149909	8/8/2001	10020007	MT41F001_010	MADISON RIVER from Ennis Dam to the mouth (Missouri R)	P	SXM
M	Impaired	168902	7/30/2001	10030101	MT41I006_160	SEVENMILE CREEK from headwaters to the mouth (Tenmile Cr)	P	SNM
M	Impaired	184801	8/20/1999	10020005	MT41G002_050	NORTH WILLOW CREEK from headwaters to mouth (Willow Cr)	N	SXM
M	Impaired	198301	7/21/2000	10070005	MT43C001_010	STILLWATER RIVER from headwaters to Flood Cr	P	SXM
M	Impaired	206401	7/18/2000	10020004	MT41D002_160	ROCHESTER CREEK from headwaters to mouth (Big Hole R) T3S R7W	P	SXM
M	Impaired	215701	6/21/2001	17010203	MT76F001_010	BLACKFOOT RIVER from headwaters to Landers Fork	N	XXM
M	Impaired	216201	6/26/2001	17010203	MT76F002_030	POORMAN CREEK from headwaters to the mouth (Blackfoot R)	P	SXM
M	Impaired	216701	6/18/2001	17010203	MT76F002_060	SANDBAR CREEK from forks to mouth (Willow Cr)	P	SXM
M	Impaired	223301	7/31/2001	10030101	MT41I006_220	SKELLY GULCH tributary of Greenhorn Cr-Sevenmile Cr T10N R5W Sec 2	P	SXM
M	Impaired	249501	7/12/2002	17010201	MT76G003_020	SILVER BOW CREEK from the Warm Springs Pond 2 outlet to headwaters	N	SNM
M	Impaired	291201	8/14/2003	10020003	MT41C002_040	ALDER GULCH from headwaters to mouth (Ruby R)	N	SXM
M	Impaired	325901	8/28/2003	10030101	MT41I006_020	PRICKLY PEAR CREEK from Helena WWTP Discharge Ditch to Lake Helena	N	SNM
M	Impaired	346301	8/7/2004	10020003	MT41C002_050	RAMSHORN CREEK from headwaters to mouth (Ruby R)	P	SXM
M	Non-Impaired	75224	9/11/2002	17010203	MT76F001_033	BLACKFOOT RIVER from Belmont Cr. to mouth (Clark Fork)	P	XNX
M	Non-Impaired	149810	8/14/2002	10020007	MT41F001_030	MADISON RIVER from Hebgen Dam to Quake Lake	F	XXX
M	Non-Impaired	198901	8/1/2000	10070003	MT43A002_031	COTTONWOOD CREEK, Little Cottonwood Cr to the mouth (Shields R)	P	XXX
M	Non-Impaired	199701	8/17/2000	10070002	MT43B004_061	TOM MINER CREEKTepee Cr. to the mouth (Yellowstone R)	P	XXX
M	Non-Impaired	200201	8/8/2000	10040103	MT41S004_040	CASINO CREEK, Headwaters to mouth (Big Spring Cr)	P	XNX
M	Non-Impaired	200501	8/9/2000	10040103	MT41S001_020	JUDITH RIVER from Ross Fork to Big Spring Cr	P	SNX
M	Non-Impaired	201301	9/19/2000	10070003	MT43A001_012	SHIELDS RIVER from headwaters to Cottonwood Cr	P	SXX
M	Non-Impaired	206501	7/21/2000	10020004	MT41D004_140	MINER CREEK from headwaters to mouth (Big Hole R)	F	XXX
M	Non-Impaired	207101	7/19/2000	10020004	MT41D002_100	BIRCH CREEK from National Forest Boundary to mouth (Big Hole R)	N	SXX
M	Non-Impaired	249401	7/12/2002	10020005	MT41G002_140	WHITETAIL CREEK tributary of the Jefferson R T3N R5W	P	SXX
M	Non-Impaired	255101	8/6/2002	17010201	MT76G002_132	PETERSON CREEK from Jack Cr. to the mouth (Clark Fork R)	N	XXX
M	Non-Impaired	257301	9/12/2002	10020008	MT41H002_031	SOUTH COTTONWOOD CREEK, Middle Cr Assoc Ditch diversion to the mouth (Gallat	P	XXX
M	Non-Impaired	266601	9/11/2002	10030101	MT41I006_179	GRANITE CREEK from headwaters to mouth (Austin Cr - Greenhorn Cr - Sevenmile Cr)	F	XXX
M	Non-Impaired	290001	8/15/2003	10070002	MT43B004_132	BOULDER RIVER from NF boundary to 5 mi above the mouth (Yellowstone R)	F	XXX
M	Non-Impaired	291801	8/13/2003	10020003	MT41C002_030	INDIAN CREEK from headwaters to mouth (Mill Cr-Ruby R)	P	XXX
M	Non-Impaired	292501	8/17/2003	10020003	MT41C003_060	SWEETWATER CREEK from headwaters to mouth (Ruby R)	P	SNX
M	Non-Impaired	304101	9/14/2003	17010203	MT76F005_060	BLANCHARD CREEK from the North Fork to the mouth (Clearwater R)	P	SXX
M	Non-Impaired	307301	8/7/2003	10070002	MT43B004_120	MOL HERON CREEK, Yellowstone National Park boundary to mouth (Yellowstone R)	P	XXX
M	Non-Impaired	331601	9/26/2003	17010203	MT76F003_060	BLACK BEAR CREEK T12N R12W Sec 22SE	N	XXX

Appendix A: Sample Listing, Metals Impairment Evaluation

Data Set	Strata	Sample	Date	HUC	Segment ID	Segment Name	ALU	Cause(s)
M	Non-Impaired	332501	9/29/2003	17010203	MT76F003_022	JEFFERSON CREEK from 1 mi above Madison Gulch to mouth (Nevada Cr)	P	XXX
V	Non-Impaired	25907	7/31/2003	10020002	MT41B001_020	BEAVERHEAD RIVER from Grasshopper Cr to mouth (Jefferson R)	N	SXX
V	Non-Impaired	140210	37126	17010202	MT76E002_010	ROCK CREEK mainstem from headwaters to mouth (Clark Fork)	F	XXX
V	Non-Impaired	156901	34900	10050006	MT40G001_020	SAGE CREEK, Headwaters to Laird Cr	F	XXX
V	Non-Impaired	184001	6/18/1999	10030103	MT41J001_020	SMITH RIVER from Hound Cr. to the mouth (Missouri R)	P	SNX
V	Non-Impaired	184201	8/18/1999	10020007	MT41F004_050	JACK CREEK from headwaters to the mouth (Madison R)	P	SXX
V	Non-Impaired	194502	7/11/2001	10020004	MT41D003_210	PATTENGAIL CREEK from headwaters to mouth (Wise R)	P	SXX
V	Non-Impaired	206301	7/27/2000	10020004	MT41D004_120	ROCK CREEK from headwaters to mouth (Big Hole R)	P	SNX
V	Non-Impaired	208101	7/17/2000	10020005	MT41G002_040	LITTLE PIPESTONE CREEK, Headwaters to mouth (Big Pipestone Cr)	P	SXX
V	Non-Impaired	216501	6/21/2001	17010203	MT76F002_020	WILLOW CREEK from Sandbar Cr to mouth, T15N R7W (Blackfoot R)	P	SXX
V	Non-Impaired	219501	8/21/2001	10040103	MT41S004_051	COTTONW OOD CREEK from headwaters to county road bridge in T14N R18E Sec18.	F	XXX
V	Non-Impaired	220101	6/29/2001	10020004	MT41D004_040	SCHULTZ CREEK from headwaters to mouth (Johnson Cr)	F	XXX
V	Non-Impaired	220501	6/28/2001	10020004	MT41D004_070	TRAIL CREEK from headwaters to Joseph Cr	N	SXX
V	Non-Impaired	256301	37519	10040203	MT40B001_050	SOUTH FOOK FLATW ILLOW CREEK, Headwaters to confluence with North Fork	F	XXX
V	Non-Impaired	265301	8/20/2002	10020007	MT41F004_030	BEAVER CREEK from headwaters to the mouth (Quake Lake)	F	XXX
V	Non-Impaired	267201	8/29/2002	10020008	MT41H001_010	GALLATIN RIVER from Spanish Cr to the mouth (Missouri R)	P	XXX
V	Non-Impaired	287701	37795	10070003	MT43A002_052	ROCK CREEK from headwaters to Little Rock Cr.	F	XXX
V	Non-Impaired	295001	6/10/2003	10040101	MT41T002_040	EAGLE CREEK from headwaters to Dog Cr	F	XXX
V	Non-Impaired	332301	37892	17010203	MT76F003_071	WASHINGTON CREEK from headwaters to Cow Gulch	N	XXX
V	Non-Impaired	346801	8/8/2004	10020003	MT41C003_110	POISON CREEK, Headwaters to mouth (Ruby R) T11S, R3W	P	SXX
V	Non-Impaired	350601	8/25/2004	17010203	MT76F003_012	NEVADA CREEK from Nevada Lake to the mouth (Blackfoot R)	N	SNX
V	Reference	48601	7/14/1978	10020008	SFSpanis_407_C	South Fork Spanish Creek, Spanish Peaks Wilderness	F	XXX
V	Reference	75213	8/10/1992	17010203	Blackfoo_006_C	Blackfoot River	F	XXX
V	Reference	77901	2/11/1981	10070001	GardnerR_404_C	Gardner River at mouth, Yellowstone National Park	F	XXX
V	Reference	101402	8/5/1992	10070006	WFRockCr_405_C	West Fork Rock Creek above Silver Run	F	XXX
V	Reference	106001	7/31/1990	10020007	ODellCk9_236_C	O'Dell Ck	F	XXX
V	Reference	106301	9/13/1990	10070002	Fourmile_112_C	Fourmile Creek	F	XXX
V	Reference	106602	7/29/2001	10030103	CalfCree_017_C	Calf Creek	F	XXX
V	Reference	106701	7/10/1990	10080010	CROOKEDC_111_C	CROOKED CREEK ABOVE TILLETT RANCH	F	XXX
V	Reference	106901	7/26/1990	10070002	BigCk999_180_C	Big Ck	F	XXX
V	Reference	140212	7/28/2003	17010202	RockCree_071_C	Rock Creek near Clinton	F	XXX

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

Biological Integrity/ Impairment or Stress/ Use Support	No. of Species Counted[1]	Diversity Index[2] (Shannon)	Pollution Index[3]	Siltation Index[4]	Disturbance Index[5]	% Dominant Species[6]	% Abnormal Cells[7]
Excellent/None Full Support	>29	>2.99	>2.50	<20.0	<25.0	<25.0	0
Good/Minor Full Support	20-29	2.00-2.99	2.01-2.50	20.0-39.9	25.0-49.9	25.0-49.9	>0.0, <3.0
Fair/Moderate Partial Support	19-10	1.00-1.99	1.50-2.00	40.0-59.9	50.0-74.9	50.0-74.9	3.0-9.9
Poor/Severe Nonsupport	<10	<1.00	<1.50	>59.9	>74.9	>74.9	>9.9
References	Bahls 1979 Bahls 1993	Bahls 1979	Bahls 1993	Bahls 1993	Barbour et al. 1999	Barbour et al. 1999	McFarland et al. 1997
Range of Values	0-100+	0.00-5.00+	1.00-3.00	0.0-90.0+	0.0-100.0	~5.0-100.0	0.0-30.0+
Expected Response	Decrease[8]	Decrease[8]	Decrease	Increase	Increase	Increase	Increase

[1]Based on a proportional count of 400 cells (800 valves)
[2]Base 2 [bits] (Weber 1973)
[3]Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[4]Sum of the percent abundances of all species in the genera *Navicula, Nitzschia* and *Surirella*
[5]Percent abundance of Achnanthidium minutissimum (synonym: *Achnanthes minutissima*)
[6]Percent abundance of the species with the largest number of cells in the proportional count
[7]Cells with an irregular outline or with abnormal ornamentation, or both
[8]Species richness and diversity may increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment