Identification and Assessment of Montana Reference Streams: A Follow-up and Expansion of the 1992 Benchmark Biology Study

Prepared by

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EXECUTIVE SUMMARY

The following report describes the Montana Department of Environmental Quality's endeavor to identify and assess reference sites for flowing waters. Identifying reference sites is an outgrowth of the reference condition concept. The reference condition concept asserts that there exist for any group of waterbodies relatively undisturbed examples that can represent the natural biological, physical and chemical integrity of a region; therefore, reference stream sites are those that represent the reference condition. The MT Department of Environmental Quality (DEQ) is interested in reference sites because they help the Department interpret narrative water-quality standards. A number of Montana's narrative standards require that water quality be compared to "naturally occurring", and the DEQ uses reference sites to help interpret what naturally occurring is.

The work detailed in this report was undertaken from 2000 to 2005, and is a continuation and expansion of DEQ work described by Bahls et al. (1992). In 2000, the DEQ re-initiated a Reference Stream Project and began to collect data at existing reference sites (per Bahls et al. 1992) as well as at new sites that were identified around the state. In addition to conducting field sampling, in 2004 the DEQ began to assemble a comprehensive list of potential reference stream sites (and their associated data) available in the Water Quality Planning Bureau. This list included not only the sites from the DEQ Reference Stream Project, but also sites from a variety of other statewide water-quality sampling projects (e.g., the USGS Hydrologic Benchmark Network).

An evaluation process was developed and used to assess each candidate reference site in a consistent way. (Some established reference sites that had already been thoroughly reviewed using similar techniques did not go through this process, and were automatically classified as final reference sites.) The process consisted of performing quantitative watershed and water-quality analyses for each site, as well as qualitative assessments of stream health and condition using a set of criteria and best professional judgment (BPJ). Each quantitative analysis or BPJ criterion evaluated some aspect of stream or watershed condition that could potentially impact water quality and aquatic life. Sixteen BPJ criteria (e.g., bank erosion, sediment deposition, grazing impacts) were tailored for cold-water streams (mountainous regions), and were slightly different from thirteen BPJ criteria tailored for warm-water streams (prairie regions). A series of seven tests, or "screens", was then used to create the final list of reference sites. The screens were constructed from the qualitative BPJ assessments and also from numeric values identified as impact thresholds in the quantitative analyses, and addressed factors operating at the watershed-scale, site-specific scale and, in many cases, both. The seven screening tests were: cumulative impacts from multiple causes; site-specific data sufficiency; impacts from land-use based on the proportion of agriculture; numeric water-quality standards exceedences for heavy metals; impacts from mines; road density; and timber-harvest intensity (the later two applicable to cold-water streams only). To make the final list, a site had to pass each applicable screen. Sites that passed all applicable screens can be considered general-purpose reference sites, since they were found to be in an unimpacted condition for all categories.

Using the process described above, a group of Montana reference stream sites has been identified. However, there remains the need to assure that the reference sites are sufficiently similar to the stream sites against which they are compared. In general, Omernik level-III ecoregions have shown themselves to be an excellent tool for the initial partitioning of Montana reference streams. However, in certain cases more specific geospatial characteristics than level III ecoregions alone may need to be determined for the reference site and the comparison site. What those geospatial characteristics will be varies according to the parameter of interest. For example, elevation is important when considering aquatic insect (macroinvertebrate) populations, watershed area is important when considering prairie stream fish populations, and nutrient concentrations are best explained by level IV (fine-scale) ecoregions. It is likely that some water quality parameters and biological assessment metrics can be "referenced" at a fairly coarse scale (e.g. level III ecoregions), while others cannot. The reader should refer to specific reports (many cited in this report) and their associated stream assessment "tools" to decide how to best apply the reference sites provided here. And there are limitations to the use of the reference stream data. Most of the sites are located in lower Strahler stream orders — mainly 1st through 4th but including a few 5th order sites — and the data are most applicable to streams of that size range (the so-called "wadeable" streams). Therefore, the extension of these data to sites from much larger waterbodies (e.g., Yellowstone River, 6th order) should be undertaken with caution.

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SECTION 1.0
INTRODUCTION AND RATIONALE FOR STUDYING REFERENCE SITES

1.1 Introduction

This document describes work undertaken by the Montana Department of Environmental Quality (DEQ) to identify and assess reference sites for flowing waters of the state. The need to identify reference stream sites is an outgrowth of the reference condition concept. The reference condition concept asserts that there exist for any group of waterbodies relatively undisturbed examples that can represent the natural biological, physical and chemical integrity of a region (Hughes et al. 1986; Barbour et al. 1996; Gibson et al. 1996); therefore, reference stream sites are those that can represent the reference condition. The work detailed in this report was carried out from 2000 to 2005, and is a continuation and expansion of the DEQ's earlier reference stream work described in the 1992 report, "Benchmark Biology of Montana Reference Streams" by L. Bahls and others. Unlike the Bahls et al. (1992) report, this report does not detail the physical, chemical and biological characteristics of MT reference sites. The main purpose of this report is to propose a process for consistently identifying reference stream sites, including specific techniques that can be used to assess the quality of each reference site. We also describe the fieldwork undertaken as part of the DEQ Reference Stream Project, the effort to collate reference data from other agencies working in the state and the final development of the reference-site list.

1.2 Rationale for Studying Reference Stream Sites, and Definitions

The DEQ needs to identify reference sites because they help the Department interpret water quality standards. Water quality standards are expressed in either numeric or narrative forms. Numeric standards are specific values not to be exceeded, for example the MT human health standard for copper which is 1.3 mg/L (DEQ 2004a). Narrative standards, on the other hand, describe in a concise way a water quality condition that must be maintained and do not have specific numbers associated with them. These types of standards are often referred to as the "free from" standards, since many of them are worded to include that phrase (e.g., ARM[1] 17.30.637, "State surface waters must be free from substances attributable to municipal, industrial, agricultural practices…that will…create floating debris, scum, a visible oil film…").

A number of Montana's narrative standards specifically require that water quality be compared to "naturally occurring" conditions. The state of Montana has defined naturally occurring as "conditions or materials present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservations practices have been applied" (ARM 17.30.602[19]). The Administrative Rules of Montana (ARM) then define reasonable land, soil and water

[1] Administrative Rules of Montana.

conservation practices as activities that, in essence, completely protect all beneficial water uses (see ARM 17.30.602[24]). The core idea here is that man's activities in a watershed are an integral component of the landscape, as long as those activities do not negatively impact the various uses of the water (drinking, recreation, fisheries, etc.). Reference sites, therefore, are used to characterize naturally occurring conditions and reflect a group of waterbodys' greatest potential for water quality. (See also the reference condition definition in Appendix A of DEQ [2004b].)

The DEQ has taken this concept a step further by drafting definitions for two levels (tiers) that meet the state's naturally occurring definition, but which more specifically describe the gradient of conditions that may be expected. The development of these definitions is part of a larger effort underway nationally to better define criteria to protect aquatic-life uses (U.S. EPA 2005a). The definitions for each tier are as follows:

> *Tier 1 — Natural Condition***:** The characteristics of a waterbody that is unaltered from its natural state, or there are no detectable human-caused changes in the completeness of the structure and function of the biotic community and the associated physical, chemical, and habitat conditions. All numeric water quality standards must be met and all beneficial uses must be fully supported unless impacts are clearly linked to a natural source. The natural condition is the highest attainable biological, chemical, physical, and riparian condition for waterbodies.
>
> *Tier 2 — Minimally Impacted Condition*: The characteristics of a waterbody in which the activities of man have made small changes that do not affect the completeness of the biotic community structure and function and the associated physical, chemical, and habitat conditions, and all numeric water quality standards are met and all beneficial uses are fully supported unless measured impacts are clearly linked to a natural source. Minimally impacted conditions can be used to describe attainable biological, chemical, physical, and riparian habitat conditions for waterbodies with similar watershed characteristics within similar geographic regions and represent the water body's best potential condition.

Waterbodies that meet the conditions described in either of the two definitions above may be used as reference sites, since both definitions fall under the broader definition of naturally occurring found in the ARM.

Provided below is the definition for the next tier in the series, tier 3. Tier 3 describes waterbodies that have a degree of impairment sufficient to generally warrant listing on the state's 303(d) list of impaired waterbodies (i.e., DEQ 2004b). The tier-3 definition will become important later in this report in relation to the assessment of candidate reference sites. There are two further definitions for waterbodies that have increasingly severe levels of impairment (tiers 4 and 5), however waterbodies of this nature are outside the context of this report and therefore their definitions have not been provided.

Tier 3 — Moderately Impaired Condition: The characteristics of a waterbody in which the activities of man have made obvious changes to the completeness of the biotic community structure and function and the associated physical, chemical, and riparian habitat conditions, but the impacts have not caused a major displacement of sensitive taxa and acute numeric water quality standards are not exceeded.

SECTION 2.0
IDENTIFICATION & SAMPLING OF REFERENCE SITES

2.1 The Montana DEQ Reference Stream Project

After the initial work by Bahls et al. (1992) there was some follow-up work in the mid-1990's at the original sites, but no effort was made to locate new regional stream reference sites. With additional funding made available in 2000, the DEQ reinitiated a wadeable stream reference-site project. The objective of the project is to locate and characterize new reference-stream sites around the state, and to perform periodic follow-up visits to sites originally examined by Bahls et al. (1992). In 2000 and 2001 the field-work was undertaken statewide in coordination with the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP; Lazorchak et al. 1998; U.S. EPA 1998), since the same field crews performed the work. Beginning in 2003, the project was undertaken in coordination with the University of Montana by field crews exclusively focused on reference-site monitoring. Sampling sites were located statewide in 2003. In 2004, there was an emphasis on foothill and valley streams of southwest Montana. In 2005, sampling focused on foothill and valley streams of both southwest and southeast Montana. Table 1.0 below shows the candidate reference stream sites that were sampled in each year of the project.

DEQ has successfully relied upon intensive field reconnaissance and best professional judgment (BPJ) to locate reference watersheds and sites. Crews examined overall watershed conditions during driving reconnaissance tours, and when a watershed was deemed to have minimal human impacts specific stream sampling sites were selected. Preliminary Geographic Information System (GIS) work examining watershed logging intensity, intensity of agricultural use and presence of abandoned mines has in recent years been used to pre-screen potential sites and watersheds. Reference sites were normally visited three times during each field season (roughly June through September). Stream sites were assessed in short reaches using the Western Pilot EMAP physical habitat characterization protocols (Lazorchak et al. 1998). Reach lengths were established as 40x the wetted width measured at the initial visit, or a minimum of 150 m. Each reach was divided into 10 equally spaced subreaches, which provide a total of 11 transects perpendicular to stream flow along the entire reach. In addition to EMAP habitat characterization, all sites were assessed using standardized DEQ or NRCS stream reach assessment forms (e.g., Pick et al. 2004; DEQ 2005a). These forms document human impacts to the streams, overall riparian condition and geomorphic stability. Geomorphic classification following Rosgen (1996) was also determined. Water quality samples such as sediment and water-column metals concentrations, nutrients, and common ions were collected from each site. Biological sampling has varied somewhat from year to year, but typically involved sampling for diatom and macroinvertebrate populations (DEQ 2004c, DEQ 2005b), as well as biomass (measured as chlorophyll *a* and ash free dry weight) of both benthic and water-column algae. A subset of sites has been sampled over multiple years to better understand the year-to-year variation of the sites.

Table 1.0. Stream sites identified as candidate reference sites and sampled for the DEQ Reference Stream Project. Sites are organized by year sampled.

Year Sampled[†]												
2000			2001			2003			2004		
Site Name	Lat (DMS)	Long (DMS)	Site Name	Lat (DMS)	Long (DMS)	Site Name	Lat (DMS)	Long (DMS)	Name	Lat (DMS)	Long (DMS)
W FK Poplar R[†]	483354	1053607	Wisconsin Cr*	453548	1132025	Blacktail Deer Cr	450019	1122642	Rock Cr 2[†]	483509	1065953
Larb Cr[†]	480936	1071707	Waldron Cr*	475512	1125002	Wisconsin Cr*	453548	1132025	Rock Cr (BLM land)	483925	1070220
Rock Cr 1*	485233	1065348	N FK Teton River*	475801	1124840	Clear Cr	481822	1092926	Bitter Cr	483856	1065409
O'Fallon Cr 1[†]	460608	1044518	Blackleaf Cr	480047	1124135	E Rosebud Cr	451336	1093621	Porcupine Cr	481229	1062253
Spring Creek	460811	1044001	Cow Cr	475140	1085748	Seeley Cr	450553	1091757	Wolf Cr at Wolf Pt.	480512	1054037
Muddy Cr	481220	1094534	Battle Cr[†]	485310	1092326	O'Fallon Cr 1[†]	460608	1044518	WF Poplar River[†]	484150	1054955
			Stony Cr*	461833	1134009	O'Fallon Cr 2[†]	462816	1044611	Pole Cr	452119	1131050
			Seymour Cr*	455945	1131114	W FK Poplar River[†]	484149	1054955	Willow Cr (I)	452653	1124940
			E FK Bull River*	480730	1154339	Stony Cr*	461833	1134009	Willow Cr (II)	452617	1124432
			Calf Cr*	465042	1105736	Calf Cr*	465042	1105736	Blacktail Deer Cr	450019	1122642
			Spring Park Creek	465551	1105214	Tenderfoot Cr[†]	465525	1105348	Elk Springs Cr	443840	1113949
			Tenderfoot Cr[†]	465525	1105348	Roaring Lion Cr *	461134	1141436	Cottonwood Cr	445633	1122546
			Blacktail Deer Cr	450019	1122643	Wolf Cr at Wolf Point	480516	1054041			
			Seeley Cr	450553	1091758	E FK Bull River*	480730	1154339			
			Wyoming Cr	450313	1092425	N FK Teton River*	475801	1124827			
			Elk Cr[†]	453544	1112320	Rock Cr 1*	485233	1065348			
			Elk Springs Cr	443840	1113949	Rock Cr 2[†]	483525	1070004			
			Frenchman Cr	485452	1071832						
			Redwater River[†]	480127	1051452						
			O'Fallon Cr 2[†]	462818	1044611						
			Little Powder R	452015	1041840						
			Little Powder R	451908	1051904						
			Fish Cr	461502	1094608						
			M FK Beaver Cr	465724	1093257						

*Site originally sampled by Bahls et al. (1992).

[†] Same stream sampled by Bahls et al. (1992) but in a different location.

[‡] No reference sites were sampled in 2002.

Table 1.0, Cont. Candidate sites sampled in 2005 for the DEQ Reference Stream Project.

Year Sampled		
2005		
Name	Lat (DMS)	Long (DMS)
Willow Cr (I)	45 26 53	112 49 40
Cherry Creek	45 35 27	112 45 59
Willow Cr (II)	45 26 17	112 44 32
Cottonwood Cr	44 56 33	112 25 46
EF Blacktail Deer Creek	44 51 57	112 13 07
Sarpy Creek (#2)	46 05 54	107 04 09
Sunday Creek	46 27 20	105 52 29
Pumpkin Creek	46 11 18	105 37 18
Custer Creek	46 42 34	105 33 36
O'Fallon Creek (Site 2)†	46 28 16	104 46 11
Cedar Creek	46 47 29	104 33 27
Little Missouri River #1	44 59 43	104 25 25
Little Missouri River # 3.5	45 14 11	104 14 28
Box Elder Creek	45 50 42	104 08 37

† Same stream sampled by Bahls et al. (1992) but in a different location.

2.2 Collation of Other Reference Sites and Associated Data

Over the years, DEQ Water Quality Planning Bureau staff has been using data from a variety of least disturbed sites around Montana to interpret the state's narrative water quality standards. In March 2004 we began collating all data associated with stream sites that were considered "reference" by the Water Quality Planning Bureau, but which were external to the DEQ Reference Stream Project. Bureau staff was asked to provide sites and associated data that they believed met the following definition: "relatively undisturbed stream segments that can serve as examples of the natural biological, physical and chemical integrity of a region". Although in use by the DEQ, these data were not necessarily collected by it. The data were collected over a number of years by a variety of agencies, including the United State Geological Survey (USGS), the MT Department of Natural Resources and Conservation, The Bureau of Land Management (BLM), the U.S. Environmental Protection Agency (U.S. EPA), the University of Montana and others.

In addition to the DEQ Reference Stream Project sites and the sites collated from within the Bureau, a number of potential reference sites were identified in other projects and programs from around the state. These were:

I. *USGS Hydrologic Benchmark Network (HBN) stations for MT (1963-1995*). Three sites in Montana were identified by USGS as meeting the objectives of the HBN program. The HBN program sought to collect water quality data from basins minimally affected by human activities and which would serve as controls for separating natural from artificial changes in other streams (Alexander et al. 1996). The sites are: Swiftcurrent Creek at Many Glaciers, MT; Rock Creek below Horse Creek near International Boundary; and Beauvais Creek near St. Xavier, MT.

II. *Tri-State Water Quality Council (1998-2002).* Two sites were included (one on Rock Cr near Clinton and the other on the lower Blackfoot River) from this ongoing monitoring study in the Clark Fork River basin. The project is focused on nutrient sampling and the data are reported in a series of reports, one of the more recent being Land and Water Consulting Inc. (2003). McGuire (2001) also identified these two sites as being of the highest quality, and having excellent biological integrity, in a long-term study (1986 to present) of aquatic macroinvertebrates in the Clark Fork River basin.

III. *Western EMAP (2000-2004).* EMAP sites were sampled throughout the Western United States (including Montana) in a stratified random design developed by the U.S. EPA (U.S. EPA 1998). The DEQ and University of Montana provided the field sampling crews and logistics used to conduct this work in Montana. Twenty-five stream sites were identified during the course of sampling as potential reference sites, and these were added to the list of candidate sites.

IV. *Regional EMAP (1999-2001).* The regional EMAP project (REMAP) was a cooperative effort between the U.S. EPA and Montana State University. The project's objective was to develop indices of biological integrity (IBIs) for fish, macroinvertebrates and diatoms for eastern Montana prairie streams. In order to identify reference sites necessary to develop the IBI's, a series of evaluation criteria were developed and a total of eight reference reaches were identified (Bramblett et al. 2003). These eight sites were added to the list of candidate sites.

V. *Utah State University Science to Achieve Results (STAR) reference stream work, & data from the U.S. Forest Service PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program (PIBO; 2000-2004).* Dr. C. Hawkins of Utah State University (USU) is developing regional models (RIVPACS; Hawkins et al. 2000) for the western United States that are designed to predict stream condition based on aquatic insect populations. He collected nutrient, macroinvertebrate, periphyton and other data from more than 400 candidate reference sites around the western U.S., a number of which were located in Montana and some of which were part of the PIBO network of reference sites (Kershner et al. 2004; Hawkins 2005). He then applied a screening process analogous to ours that rated the sites as pristine, minimally disturbed or least disturbed. The forty-four sites that rated as pristine and minimally disturbed were considered as established reference sites in the present work. (A number of these sites overlapped with sites the DEQ had sampled for its Reference Stream Project.)

VI. *The Montana Natural Heritage Program (2001 to present).* The Natural Heritage Program is the state's source of information on the status and distribution of native animals and plants, emphasizing species of concern and high quality habitats. Fifty-three sites that the Natural Heritage Program identified as high quality were acquired and added to the candidate reference sites.

VII. *DEQ Fixed Station Monitoring Project (1999-present).* Three stream sites in this ongoing trends-analysis project were selected as candidate reference sites (lower Blackfoot River, Rock Cr nr Clinton, and the Middle Fork Flathead River nr West Glacier). Although sampled near some of the Tri-State Water Quality sites, the sampling locations were spatially separated and/or undertaken at different times.

VIII. *DEQ Nutrient Pilot Project (2001-2002).* DEQ and the University of Montana carried out a two-year study of prairie streams in Northeastern Montana with the objective of developing regional nutrient criteria (Suplee 2004). The study identified four stream sites meeting the general reference site definition given above. The study included monthly sampling of nutrients and algal biomass during the growing season (May to September), less frequent samplings for macroinvertebrates and periphyton, and detailed evaluations of stream habitat conditions.

SECTION 3.0
EVALUATION OF THE CANDIDATE REFERENCE SITES

3.1 General Considerations and Assumptions

After having assembled a list of candidate reference stream sites, the next step was to evaluate each potential reference site using a set of criteria. (Sites from the STAR project, the Suplee (2004) study, and sites from Bahls et al. (1992) that were rated as 'fully supporting all uses', did not go through the evaluation process described here. These sites had been extensively reviewed and were already considered to be established reference sites.) We assigned each site a unique number and used level III ecoregions (Omernik 1987; Woods et al. 2002) to categorize them as either warm water or cold water. Ecoregions are designed to be multi-purpose ecological zones in which the aggregate of all aquatic and terrestrial ecosystem characteristics of one zone differs from that of the other zones (Omernik and Bailey 1997). Stream sites located in the level III ecoregions Canadian Rockies (41), Northern Rockies (15), Idaho Batholith (16) and Middle Rockies (17) were labeled as cold water, and those in the Northwestern Glaciated Plains (42), Northwestern Great Plains (43) and the Wyoming Basin (18) were labeled as warm water (Woods et al. 2002). Cold-water streams are generally located in the western mountainous region of the state, and are expected to support salmonids — fish preferring temperatures lower than 65 ^{o} C. Warm-water streams are generally located east of the Rocky Mountain Front, and comprise prairie streams and rivers that support walleye, bullhead, bass and a variety of other fish that prefer temperatures 65 ^{o} C or greater (Holton and Johnson 1996). Overall, the geographic location of warm- and cold-water sites based on ecoregions closely parallels the state's beneficial use classifications for warm- and cold-water fisheries (see ARM 17.30.607).

There existed a number of stream sites that were of reference quality for some attributes (e.g., riparian condition, geomorphology) but failed in another important category, for example having excessive abandoned mine sites & elevated metals concentrations. It was our intent that sites of this description would **not** be included on the final list of reference sites, and that only those that passed all key criteria would be included. That is, to be considered a reference site using our approach a site needed to satisfy all evaluation categories reasonably well, and not possess any "fatal" flaws. (This general concept has elsewhere been referred to as the Anna Karenina principal [Diamond 1997].) It has been shown that both local-scale and watershed-scale human impacts play a role in affecting stream ecology (Snelder and Biggs 2002; King et al. 2005). How factors operating at these two scales interact is complex, and not fully understood. Therefore, one of our key assumptions was that local, on-stream impacts were equal in importance to upstream, watershed-scale impacts, an approach similar to that used by the Oregon Department of Environmental Quality (Drake 2003). Assessment of the local and watershed scale factors was undertaken using two approaches, one based on best professional judgment (BPJ) and the other based on quantitative watershed analyses. Each of these approaches is described below.

3.2 Best Professional Judgment

A series of evaluation criteria were selected based on DEQ and EPA staff expertise, and other state's examples (Table 2.0, 3.0). Each criterion assessed some aspect of stream or watershed condition that could potentially impact water quality and aquatic life. Slightly different criteria were used for cold-water streams (those in level III ecoregions 41, 15, 16 and 17) than for warm-water streams (those in level III ecoregions 42, 43 and 18).

Using available data, each candidate site was evaluated using the applicable criteria by DEQ or EPA staff. (This process is a very simplified version of the DEQ's sufficient credible data/ beneficial use-support assessment process (DEQ 2004b) that is used to develop the biennial 303(d) list of impaired state waters.) Criteria that addressed watershed level factors were evaluated by reviewing aerial photographs delineated at the 5th code HUC level (Seaber et al. 1987). If the site had a high Strahler order (e.g., 5; Strahler 1964) then a larger basin was examined. A larger basin could be a 4th code HUC, or an aggregation of 5th code HUCs that — together— best defined a stream's watershed. For each site, each criterion was assigned a score of 1 (reference condition), 0 (stressed condition), or ND (insufficient data to assess). For example, if examination of aerial photos showed few or no roads in the upstream watershed, that criterion would receive a 1. Reviewers also recorded notes as to why a criterion was given a particular score. Finally, based on the totality of information reviewed, an overall condition rating for the site was made by indicating if the stream site was tier 1 (natural condition), tier 2 (minimally impacted) or tier 3 (non-reference; Tables 2.0, 3.0). A stream site could have been rated as tier 4 or 5, however only sites of fairly high quality made it to the candidate list to begin with, and we did not identify any sites that rated 4 or 5. Reviewers had the discretion to decide which data were most important in determining a site's tier level. It was important that reviewers recorded their assessment notes with sufficient detail that a second reviewer could understand why a particular tier rating was made.

It should be noted that locating stream sites that rigidly fit the tier 1 definition on page 2 that there be "no detectable human-caused changes in the completeness of the structure and function of the biotic community…" may be very difficult to achieve, even in some wilderness areas, given the degree to which non-native salmonids were actively stocked in the 19th and 20th century in mountainous areas of Montana and the West (Hanzel 1959; Brown 1971; Moyle et al. 1976; Liknes and Gould 1987). Streams that received a tier 1 rating in this report, therefore, should be viewed as having the absolute minimal human influences observable, but could still contain some non-native species.

Table 2.0. Criteria used to evaluated reference and stressed conditions for cold water streams. Example evaluation conclusions for each criterion are shown in the 'Reference Condition' column. In this example, the large number of zeros resulted in a tier 3 (non-reference) rating.

Parameter Evaluated	Reference Criteria (1)	Stressed Criteria (0)	Reference Condition Score
Physical Habitat Category			1=Y; 0=N; ND= No Data
Road densities (secondary data)	Minimal number of roads and roads are not close to streams.	> 4 miles/ sq. mile	0
New and old timber harvests (secondary data)	Minimal harvest activities, outside of the riparian areas; timber management activities attempt to mimic a natural fire regime	Extensive harvesting within watershed (>25%); harvests occurring within riparian area.	0
Percent surface fines	Low fines, representative of the geologic conditions.	>30% fines less than 2mm.	ND
Sediment Deposition	Between 0-25% of the substrate surrounded by fine sediment (RBP language).	Greater than 75% of the substrate surrounded by fine sediment (RBP language).	0
Bank Erosion	No erosion or limited to “natural” occurrences. Stable banks.	Extensive bank erosion caused by anthropogenic activities.	0
Bank Vegetation	Over 90% of the streambank covered by stabilizing vegetation; vegetated zone width > 100 feet.	Less than 50% of the streambank covered by stabilizing vegetation; vegetated zone width < 10 feet.	0
Permitted point sources	Few to no point source discharges in the watershed. Site located greater than 5miles downstream or above the permitted discharge.	Many point sources discharges present. Site located less than 2 miles downstream of a point source discharge.	1
Land under agricultural use	Minimal to no agricultural use occurring.	Extensive agricultural activities present and may occur within the riparian area.	1
Grazing Use	Light grazing occurs; impacts are minimal.	Heavy grazing causing moderate impacts.	ND
Mining sites	Site not located in DEQ priority abandoned hardrock mining subbasin; or, basin mine density low.	Site located in DEQ priority abandoned hardrock mining subbasin; or, basin mine density high.	1
Professional Judgment Category			
Anecdotal evidence from non-standard sources	No anecdotal evidence of significant disturbance encountered.	Evidence of significant recent or persistent physical or chemical disturbance is credible and verifiable.	ND
Field observations not listed as criteria	No source of stress or evidence of existing stress exists and is not considered in other criteria.	A source of stress or evidence of existing stress exists and is not considered in other criteria.	0
Aesthetics	Site has exceptional aesthetic quality without apparent disturbances in watershed, riparian areas, or channel.	Aesthetically unappealing due to elements that probably affect water resource quality (must be described).	0
Other Determinations	Other agency/entity has determined that the site is of reference quality using acceptable documented procedures or non-biological criteria.	Other agency/entity has determined that the site is stressed using documented procedures or non-biological criteria	ND
Previous Investigations and Regulatory Involvement Secondary data http://nris.state.mt.us/interactive.html			ND
On 2004 303(d) list (or re-assessment list)?			***NO***
Probable Tier Level (1, 2, 3, 4, 5)			**3**

Table 3.0. Criteria used to evaluated reference and stressed conditions for warm water streams. Example evaluation conclusions for each criterion are shown in the 'Reference Condition' column. In this example, the large number of ones resulted in a tier 2 (reference) rating.

Parameter Evaluated	Reference Criteria (1)	Stressed Criteria (0)	Reference Condition Score
Physical Habitat Category			1=Y; 0=N; ND= No Data
Road densities (secondary data)	Minimal number of roads and roads are not close to streams.	> 4 miles/ sq. mile	1
New and old timber harvests (secondary data)	Minimal harvest activities, outside of the riparian areas; timber management activities attempt to mimic a natural fire regime	Extensive harvesting within watershed (>25%); harvests occurring within riparian area.	1
Permitted point sources	Few to no point source discharges in the watershed. Site located greater than 5miles downstream or above the permitted discharge.	Many point sources discharges present. Site located less than 2 miles downstream of a point source discharge.	1
Land under agricultural use	Minimal to no agricultural use occurring.	Extensive agricultural activities present and may occur within the riparian area.	1
Grazing Use	Light grazing occurs; impacts are minimal.	Heavy grazing causing moderate impacts.	ND
Mining sites	Site not located in DEQ priority abandoned hardrock mining subbasin; or, basin mine density low.	Site located in DEQ priority abandoned hardrock mining subbasin; or, basin mine density high.	1
Oil and Gas Wells	Absence of oil and gas development in the watershed.	Presence of oil and gas development above the site.	1
Professional Judgment Category			
Anecdotal evidence from non-standard sources	No anecdotal evidence of significant disturbance encountered.	Evidence of significant recent or persistent physical or chemical disturbance is credible and verifiable.	ND
Field observations not listed as criteria	No source of stress or evidence of existing stress exists and is not considered in other criteria.	A source of stress or evidence of existing stress exists and is not considered in other criteria.	ND
Aesthetics	Site has exceptional aesthetic quality without apparent disturbances in watershed, riparian areas, or channel.	Aesthetically unappealing due to elements that probably affect water resource quality (must be described).	1
Other Determinations	Other agency/entity has determined that the site is of reference quality using acceptable documented procedures or non-biological criteria.	Other agency/entity has determined that the site is stressed using documented procedures or non-biological criteria	ND
Previous Investigations and Regulatory Involvement Secondary data http://nris.state.mt.us/interactive.html			1
On 2004 303(d) list (or re-assessment list)?			***NO***
Probable Tier Level (1, 2, 3, 4, 5)			**2**

3.3 Quantitative Watershed-level and Site-specific Analyses

Two quantitative watershed-level analyses and one quantitative site-specific analysis were undertaken for each candidate reference site. How these data were used in the assessment of candidate reference sites will be further detailed in the next section.

The first watershed analysis determined the proportional area of different land-cover types using the MT Gap Analysis Program (GAP) GIS layer (Fig. 1.0; Fisher et al. 1998). We were most interested in the proportion of agricultural land use in each basin. The area delineated was the area within the 5th code HUC upstream of the reference site.

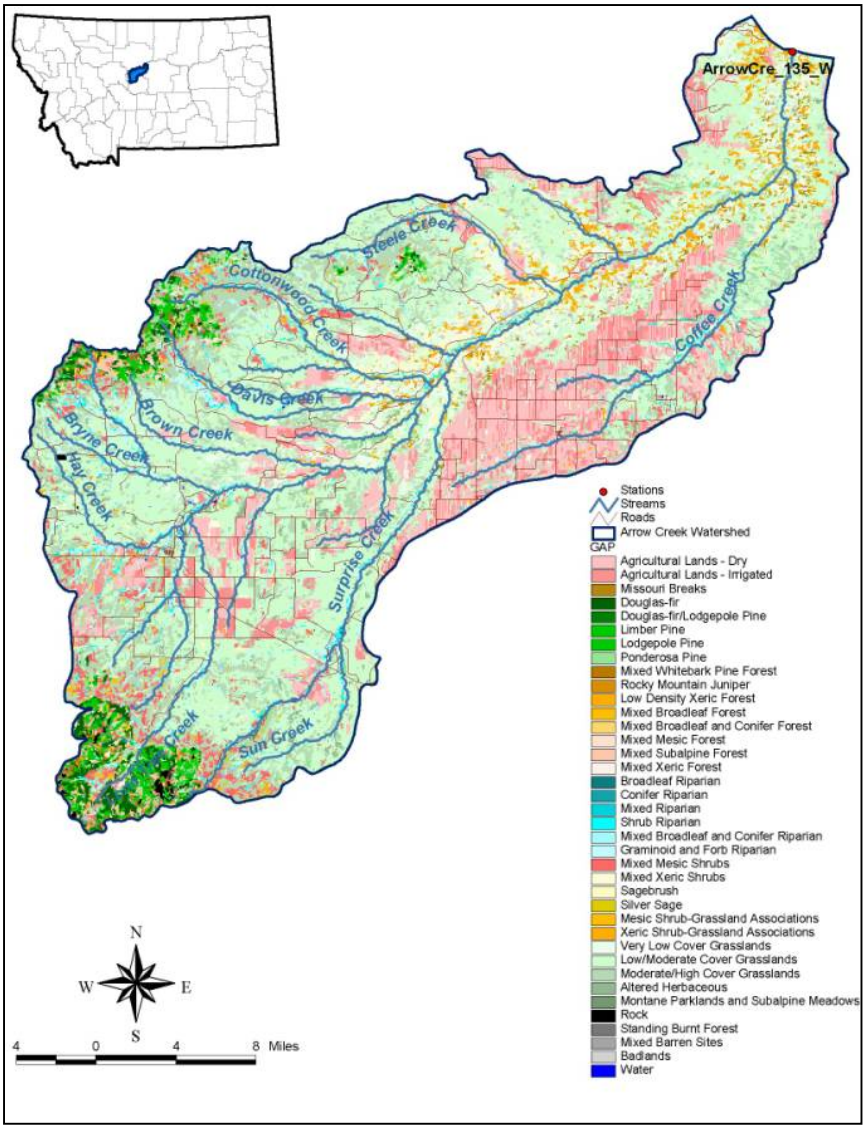

Fig. 1.0. Example quantitative watershed land-type analysis. The basin is delineated at the 5th code HUC level. The area of each GAP land-type was calculated for the watershed upstream of the reference site. Map provided courtesy of Tetra Tech Inc.

The second watershed analysis determined the density of roads (miles/mile^2) in the 5th code HUC upstream of each site. Road density of reference site watersheds was based on the U.S. Census Bureau's 2000 Topologically Integrated Geographic Encoding and Referencing system (TIGER) road-density atlas (1:100,000 scale; U.S. Census Bureau 2005). Road density was delineated for individual road types (e.g., secondary and connecting roads, vehicular trails), as well as total roads.

Where available, metals and hardness water-quality data were located, primarily from EPA's modernized and Legacy STORET databases. The chronic and acute aquatic life standards (DEQ 2004a) for individual sites were then calculated using these data. These site-specific analyses examined whether or not heavy metals (cadmium, copper, lead, zinc, mercury and dissolved aluminum) exceeded Montana's numeric standards.

3.4 Final Screening Process Applied to Candidate Reference Sites

Final selection of the reference sites was achieved by passing each site through a series of tests, or "screens" (Fig. 2.0). The screens addressed impacts at the watershed-scale, the site-specific scale and, in many cases, both. Screens were constructed from both the BPJ assessment criteria and results from the quantitative analyses outlined in Section 3.3. For example, the timber harvest screen (screen 4) is based on the BPJ criteria "New and Old Timber Harvests" (Table 2.0). During the BPJ evaluation the assessor considered not only overall intensity of timber harvest in the watershed, but also field notes regarding localized timber harvest activities that may have locally impacted the reference site.

Sites that passed all of the screens were included on the final reference site list. Each screen is discussed in detail below.

Screen 1: Probable Tier Level: Any site that was determined to be tier 3 (or worse) in the BPJ assessments was removed at this step. A tier 3 rating generally reflected cumulative impacts from multiple causes (i.e., too many zero ratings in the criteria; see example in Table 2.0). The corollary to this is that a zero rating in a single criterion (e.g. "Bank Vegetation") may not necessarily have warranted a tier 3 rating. Zero ratings could occur due to problems at the watershed level, site-specific level, or a combination of both. As discussed in Section 3.2, each reviewer had discretion to make the final tier-level determinations.

Screen 2: Local Level Screen for Sufficiency: The purpose of this screen was to remove sites that had insufficient site-specific data. Although watershed-scale data were generated by GIS methods for all sites, on-site data collected in the field were considered critical. Therefore, candidate reference sites lacking on-site data were removed at the step. (Note: these sites should be targeted for future data collection.)

> *For Warm Water Streams:* If sufficient data existed to assess $\geq$ 3 of 7 BPJ categories (i.e., the categories received a 0 or 1), the waterbody was passed to the next screen. The seven BPJ categories were: Grazing Use; Aesthetics; Field Observations not Listed as Criteria; Other Determinations; Previous

Investigations and Regulatory Involvement Secondary Data; Anecdotal Evidence from Non-standard Sources; and Land under Agricultural Use (Table 3.0).

For Cold Water Streams: If sufficient data existed to assess ≥ 4 of 11 BPJ categories (i.e., the categories received a 0 or 1), the waterbody passed to the next screen. The eleven BPJ categories were: Grazing Use; Aesthetics; Field Observations not Listed as Criteria; Other Determinations; Previous Investigations and Regulatory Involvement Secondary Data; Anecdotal Evidence from Non-standard Sources; Percent Surface Fines; Sediment Deposition; Bank Erosion; Bank Vegetation; and Land Under Agricultural Use (Table 2.0).

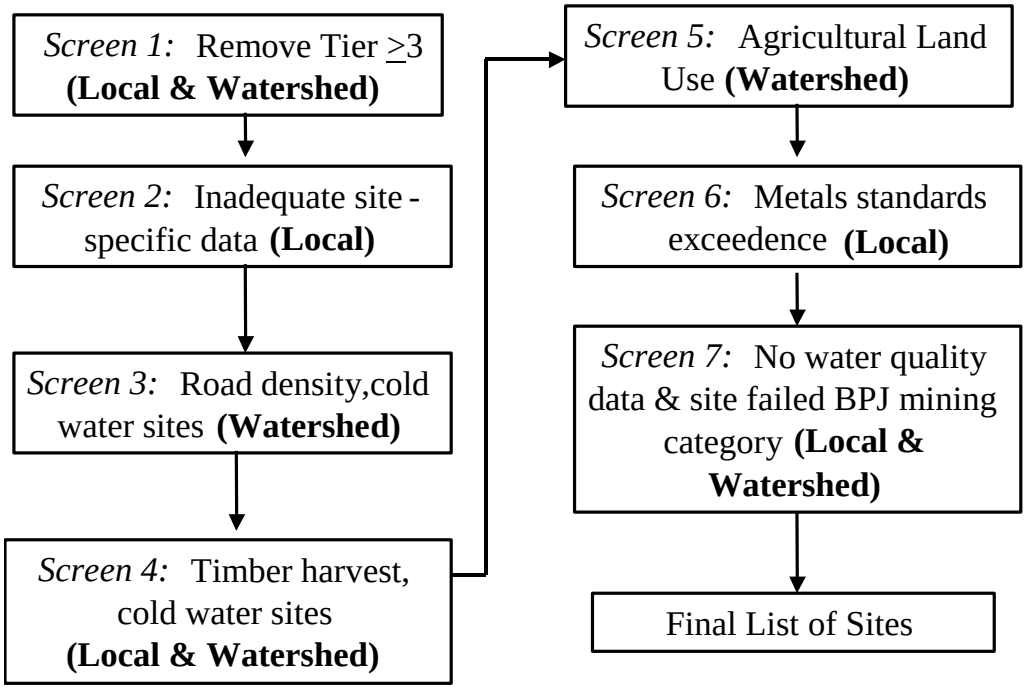

Figure 2.0. Diagram showing the screening steps reference sites were passed through. Each box indicates whether the screen operated at a watershed scale, site-specific scale, or both. A site that failed any one of the applicable screening steps was not included among the final reference sites.

Screen 3: Road Density Screen (*applicable to cold water streams only*): Cold-water streams (as defined in the present work) are found in MT level III ecoregions 41, 15, 16 and 17, ecoregions that are predominantly forested (Woods et al. 2002). Studies show that logging roads produce by far the largest proportion of sediment among forest management practices (see literature review by Waters [1995]), and for this reason this screen was applied only to the cold water streams. The TIGER road density atlas does not map small, unimproved roads (i.e., logging roads) to the degree we expected (Boschen, personal communication). Due to the incompleteness of the TIGER road coverage, it was unclear if we could use previously published road-density

recommendations for forested areas (e.g., USDA 1995; USFWS 1998). We opted to build a road-density index for this screen, based on the BPJ assessments of the candidate cold-water reference sites. The TIGER road densities for cold water streams that received a 0 on the BPJ assessment criterion "Road Densities" (Table 1.0) were placed in one group and those that received a 1 were placed in another. The mean road density in the group receiving 0 was significantly higher than the mean for the other group ($p = 0.03$; T-test for means, unequal variance). We selected as a threshold the 90th percentile of total road density for the stream group that received 1's, equal to 1.19 mi/mile^2. This value, whose metric equivalent is 0.74 km/km^2, is fairly close to the road density threshold (< 0.5 km/km^2) used by the U.S. Forest Service for defining reference watersheds in forested lands of the West (Kershner et al. 2004). Cold-water sites having a road density greater than 1.19 mi/mile^2 (0.74 km/km^2) were removed at this step.

Screen 4: Timber Harvest Screen *(applicable to cold water streams only)***:** We applied this screen only to cold water streams, since this land-use activity is applicable almost exclusively to the level III ecoregions 41, 15, 16 and 17 (Woods et al. 2002). We reviewed the assessment notes for each candidate reference site that received a 0 in the BPJ assessment criterion "New and Old Timber Harvests". Depending upon the intensity of harvest in the watershed (based on the BPJ of the assessor and team consensus after reviewing the orthoquads), the site was either removed at this step or allowed to move to the next.

Screen 5: Agricultural Land Use Screen: Studies show that the percent of agricultural land use in a basin has an effect on water quality, for example increasing nutrient concentrations (Miller et al. 2005; King et al. 2005). Negative impacts to aquatic life may occur when approximately 30 to 60% of a basin's land area is in agricultural use (Sheeder and Evans 2004[2]; Zheng et al. 2005). This screen was designed to reflect this range. Percent agricultural land use in each basin was determined from the 5th code HUC GAP analyses described above. The percent of lands in the GAP system classified as "Agricultural Land-Dry" (No. 2010) and "Agricultural Land-Irrigated" (No. 2020) was summed to determine the total agricultural land use in the basin. (These two land-use types do not include lands used exclusively for cattle grazing. Cattle grazing could only be assessed at the site-specific level via the BPJ criterion "Grazing Use", and would have been addressed in Screen 1.) The screen was then run as follows:

a) Sites in basins having $\geq$ 51% agricultural land-use were removed.

b) For the remaining sites, those streams that received a 0 in the BPJ criterion "Land under agricultural use" were removed.

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[2] Sheeder and Evans (2004) report that unimpaired watersheds have 18.1% agricultural land cover, while impaired watersheds have 46.6%. However, the authors do not indicate at what proportion of agricultural use the transition from unimpaired to impaired occurs. Therefore, in this report we approximated the impact threshold as the percent agricultural land use (32%) midpoint between the unimpaired and impaired designations reported by Sheeder and Evans (2004).

c) The remaining waterbodies with agricultural land use between 30-50% were flagged. These were then hand-reviewed by staff and, based on the notes recorded by the assessor and a review of the orthoquads by the team, sites were removed at this step or allowed to move to the next. In making these decisions, we considered the proximity of agricultural land to the stream site and to the stream channel upstream of the site.

Screen 6: Screen for Numeric Water Quality Standards Exceedences: Sites were screened for exceedences of the MT acute and chronic aquatic life water-quality standards for cadmium, copper, lead, zinc, mercury and dissolved aluminum (DEQ 2004a). These metal were selected as they are among the most common heavy metals found in streams contaminated by hardrock mining, and have been extensively sampled throughout the mined regions of the state. Hardness and metals data were matched by date of collection, and for each site the number of cases was recorded where a metal concentration did (or did not) exceed the standard. Sites that showed water quality exceedences were then hand screened. In those cases where an isolated exceedence could have been the result of poor data quality (e.g., metals data from before 1980 often had very high detection limits) or some other one-time, short term reason, the site was flagged but allowed to move to the last step. Sites that showed a clear tendency towards water quality exceedences were removed at this step.

Screen 7: Screen for Abandoned Mine Sites: This screen applied to sites flagged in Screen 6 and also to sites lacking metals water-quality data. If a site received a 0 in the BPJ criterion "Mining Sites", the site was hand-reviewed by staff and, based on the notes recorded by the assessor and the team consensus, was either removed at this step or allowed to move to the end. In general, a 'guilty until proven innocent' approach was taken. For example, sites were removed that had substantial (based on BPJ) mine density in their watersheds but did not have water quality or sediment data that could be used to assess actual standards exceedences.

The sites that passed through all seven screens were considered reference sites, and are mapped in Fig. 3.0 and listed in Appendix A.

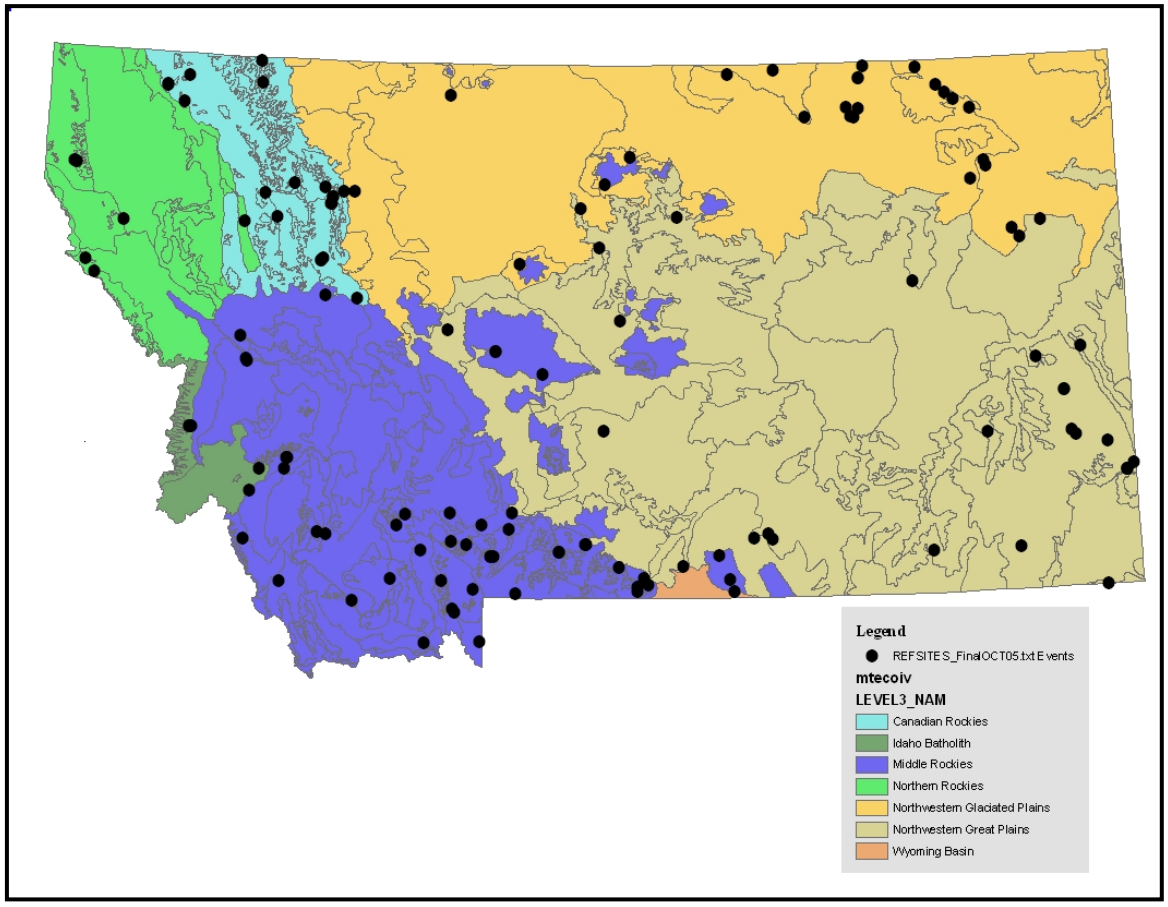

Fig. 3.0. Screened DEQ reference sites identified in this project. Colored background areas show the Omernik Level III ecoregions.

SECTION 4.0
DISCUSSION AND CONCLUSIONS

4.1 Application of the Reference Sites

The reference sites shown in Fig. 3.0 and listed in Appendix A may be considered "general purpose" reference stream sites that can be used in regional analyses and site-specific applications. This list of reference sites has been evaluated using a comprehensive list of assessment categories (riparian condition, mining impacts, geomorphology, point sources, etc.), and because the sites were found to be in an unimpacted condition for all important categories, data collected from the sites may be considered of reference quality. However, there remains the need to assure that the reference sites are sufficiently similar to the sites against which they are being compared.

The process of selecting appropriate reference sites for the purpose of making comparisons of water quality and other parameters has already been outlined as DEQ's "primary" methodology, found in Appendix A of DEQ 2004b. For example, the DEQ's periphyton biocriteria procedural guidelines (Bahls 1993) describe a two-part, sub-regionalization process for making comparisons to reference sites. Protocol I is a coarse-scale geographic approach, in which stream impairment assessments are made by comparing a particular site's diatom assemblage to diatom data from reference streams aggregated into two groups of level III ecoregions ('mountain' ecoregions and 'prairie' ecoregions). Protocol II uses a nearby reference site with similar Strahler stream order for more sensitive comparisons (Bahls 1993), and is supposed to be used when greater confidence in the analysis is required.

In general, Omernik ecoregions (Woods et al. 2002) have shown themselves to be excellent tools for (at least) the initial grouping of Montana reference streams. For example, recent work shows that level III ecoregions explain the broadest patterns of fish and aquatic macroinvertebrate community diversity found across Montana (Stagliano 2005). Similarly, statistical analyses by Varghese and Cleland (2005) indicate that ecoregions —both level III and IV— are superior to two other geospatial classifications (MT lithology and Strahler stream order) for the purpose of segregating Montana stream nutrient concentrations.

In certain cases, more specific geospatial characteristics than just ecoregions alone may need to be determined for the reference site and the stream site against which it is compared. Example geospatial characteristics include: elevation (important to the distribution of aquatic macroinvertebrates and fish; Hughes et al. 1987; Bollman 1998); soil-type and stream order (Snelder and Biggs 2002); and stream morphology, including the stream classification system of Rosgen (1996) and alternative classification approaches such as that of Montgomery and Buffington (1993). Snelder and Biggs (2002) propose a river/stream classification system for New Zealand that places stream-controlling factors into the following hierarchical order of importance (listed from most to least important): climate; source of flow; geology; land cover (i.e., vegetative cover in

the watershed); stream order; and valley landform (slope, gradient, etc). Since ecoregions essentially integrate the first four of the six factors listed (Omernik 1987), stream order and valley landform can be considered supplemental geospatial characteristics that might be used to further enhance any comparison to reference. Closer to home, Suplee (2004) uses stream entrenchment ratio and characteristics of the riparian area to create two prairie-stream groups that best explain variation in northeastern Montana's aquatic plant communities. Sub-stratification was needed in spite of the fact that the prairie streams are wholly contained within a single level III ecoregion (the Northwestern Glaciated Plains). Reference sites sharing geospatial characteristics with prairie streams in a group could then be used to represent the expected condition of the group. Similarly, Bramblett et al. (2005) report that watershed area was a key factor in the development of an index of biological integrity (IBI) for Montana prairie fishes, since fish species richness increases with watershed area. Their fish IBI is applicable to prairie streams found in two Montana level III ecoregions, the Northwestern Glaciated Plains and Northwestern Great Plains.

It is likely that some water quality parameters and biological assessment metrics can be "referenced" at a fairly coarse scale, while others cannot. Ongoing work in Montana on nutrient & sediment criteria development, biocriteria development and other related efforts, some of which have been cited here, is providing indications as to which geospatial factors will achieve the most useful reference comparisons. Table 4.0 below highlights some of these important geospatial factors, and the parameters to which they apply. The reader should refer to specific reports and their associated stream assessment "tools" to decide how to best apply the reference sites listed in Appendix A.

Table 4.0. Montana studies that use geospatial factors to best apply reference stream data to various parameters.

Parameter	Geospatial Factors	Citation
Periphyton	Grouped Omernik level III ecoregions: mountains; prairies.	Bahls (1993); Teply and Bahls (*Draft;* 2005)
Nutrient concentrations	Omernik ecoregions: level III (coarse-scale); level IV (fine-scale).	Varghese and Cleland (2005)
Macroinvertebrates	Columbia River Basin; Canadian Rockies (level III ecoregion); elevation; watershed area	Jessup et al. (*Draft* ; 2005)
Prairie fish IBI	Northwestern Glaciated Plains; Northwestern Great Plains; watershed area.	Bramblett et al. (2005)
Filamentous algae & phytoplankton density of prairie streams	Northwestern Glaciated Plains; stream entrenchment ratio; riparian canopy density; woody riparian density.	Suplee (2004)

4.2 Confidence in the Applicability of Reference Sites

The degree of confidence one has in the accuracy of a comparison between reference and a given site can vary, and is influenced by how the reference sites were chosen (i.e., the methods outlined in this report), the types of geospatial stratification factors used to apply the reference sites, and the quantity and quality of data supporting the stratification factors. In general, increased confidence incurs increased cost because of the need for: higher levels of data resolution for the geospatial characteristics; expansion of reference stream sampling; improved understanding of cause/effect relationship between pollutants and impacts to water uses; and, more time to conduct these undertakings.

Deciding if greater confidence (i.e., incurring higher cost) is needed when making a reference-to-stream site comparison can be influenced by a number of considerations. Some key considerations that the DEQ has identified are: public interest in the resource; watershed sensitivity; and resource value. Public interest considers the interest level of local or other groups, the degree of public awareness of the waterbody, etc. Watershed sensitivity considers issues such as the erosiveness of basin soils and the consequential need for bank-stabilizing riparian vegetation, time required for regeneration of riparian areas, etc. Resource value should consider the potential value of the water resource (e.g., contains a blue ribbon fishery, is a core bull trout area) and should also consider the role of the waterbody in the adjacent region (e.g., it is adjacent to a wilderness area, surrounds a national park such as Yellowstone, or is an important agricultural water source). If, for example, the degree of public interest, watershed sensitivity and resource value were all found to be "high", then a high degree of confidence in the reference-to-stream site comparison is needed.

4.3 Precautionary Considerations When Using the Reference Sites

There are limitations to the use of the reference stream data. Most of the sites are located in lower Strahler stream orders — mainly 1st through 4th but including a few 5th order sites — and the data are most applicable to streams of that size range (the so-called "wadeable" streams). Therefore, the extension of these data to sites from much larger waterbodies (e.g., Yellowstone River, 6th order) should be undertaken with caution.

Some areas of the state are better represented than others. Density of reference sites in Western Montana is generally good, and the Middle Rockies ecoregion is arguably the best represented; it has the largest number of reference sites among all Montana ecoregions and contains sites from high mountain streams, foothill and valley streams, and a 5th order river (the Blackfoot near its mouth). On the other hand, the number of sites in the Northwestern Great Plains and Northwestern Glaciated Plains are less dense and there are probably a number of stream types that remain to be sampled. For example, we know that that the "Woody Draw" (Hansen et al. 1995) is a common riparian stream type in the Northwestern Glaciated Plains, but there are currently no reference examples of the Woody Draw in the dataset.

4.4 Recommendations For Future Directions, and Data Availability

4.4.1 Recommendations For Future Directions

To date, work on reference sites has focused on the sampling of existing sites, identifying new sites (including locating reference sites in areas where they have been difficult to locate, such as the Northwestern Great Plains), and the collation of existing data from a variety of sources inside and outside of the DEQ. Our experience has shown that annual sampling of a few existing sites while concurrently locating a number of new ones is better than exclusively focusing on locating new sites. This is because the year-to-year variability of conditions at existing sites (driven by climate, fires, etc.) can be characterized, and new field crews can be trained at familiar sites. And at the same time, the total number of reference sites in the database continues to increase, thus providing greater statistical confidence in the analyses made with the data. We have also found that focusing on a region or two each field season is more effective than attempting statewide sampling, as staff and field crews can become better acquainted with a smaller geographic area and the likelihood of locating high-quality reference sites increases.

Currently, the Reference Stream Project is designed to sample each year specific regions of the state (northeast Montana, southwest Montana, etc.) that roughly correspond to Omernik level-III ecoregions. As discussed in Section 4.1, ecoregions (level III and IV) have shown themselves to be useful for the initial stratification of both chemical and biological stream data in Montana. Therefore, we suggest that ecoregions be used to select and monitor reference sites. A single level-III (coarse) ecoregion could be selected each year, with specific level IV ecoregions targeted within it, as needed. The specific level IV ecoregions should be selected based on identified spatial gaps in the landscape coverage of the existing reference site list. Individual sites within each level IV ecoregion can be targeted for sampling based on the preliminary GIS approaches already discussed in Section 2.1. Nested within this approach should be a degree of flexibility, so that as other key stream-influencing variables (e.g., elevation, riparian type) “rise to the top” in terms of importance, they may be incorporated into the sampling plan.

How often should reference sites be re-sampled? Sanders et al. (1983) describe in detail techniques that can be used to determine sampling frequency, most of which involve statistical analysis of time-series data. We have not carried out these analyses to date. There are currently several sites in the Reference Stream Project having up to three continuous years of data, plus additional non-consecutive sampling events. It is intended that these data be analyzed so that a more reasonable return interval can be developed. However at this point, a BPJ recommendation for a return interval would be on the order of every 5 years. We also recommend continuation of the current sampling approach, wherein three sampling events per field season (roughly once each month during the summer) are completed at each site. This is because reference sites are targeted and few in number, and therefore water quality and biological parameters that vary over the sampling season cannot be characterized — as can be done for stream sites in a large, random-sampling design — by undertaking sampling at many spatially-separated sites during the same time period.

4.4.2 Data Availability

The type and quantity of data inventoried during the 2004 collation process varied greatly from site to site, and are available, along with data from the Reference Stream Project, in several different formats (electronic, hardcopy, etc.). A general inventory of existing data from all sites is available in the DEQ Water Quality Planning Bureau, although the data itself may be housed in a number of different locations (STORET database, hardcopy files, electronic spreadsheets, etc.; see Appendix B for details on database resources). The BPJ criteria assessment records (Tables 2.0, 3.0) are also housed in the DEQ Water Quality Planning Bureau. We acknowledge that a more detailed plan is needed for future tracking and maintenance of data associated with reference sites, and we are coordinating with the DEQ Data Management Section to achieve this goal.

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Appendix A. List of Reference Sites and their Locations

Table A. List of reference sites and associated location information for the Columbia and Hudson Bay major basins.

Major Basin	4th field HUC	LAT(DD)	LONG(DD)	Stream Site Name	REF. SITE No.	Review Notes*
St. Mary (Hudson Bay drainage)	10010001	48.96806	-113.68222	Belly River at 3-mile campsite (Glacier NP)	BellyRiv_408_C	Rvd
St. Mary (Hudson Bay drainage)	10010002	48.7992	-113.6558	Swiftcurrent Creek at Many Glacier MT	Swiftcur_132_C	Estb
Columbia	17010202	46.7225	-113.6822	Rock Creek near Clinton	RockCree_071_C	Rvd
Columbia	17010202	46.70889	-113.6725	Rock Creek	RockCree_070_C	Rvd
Columbia	17010203	46.89944	-113.7561	Blackfoot River	Blackfoo_006_C	Rvd
Columbia	17010203	47.2281	-112.8472	Trib of N. Fork Blackfoot	TribofNF_091_C	Rvd
Columbia	17010204	47.4025	-115.5164	Silver Creek (Site 2)	SilverCr_078_C	Rvd
Columbia	17010204	47.31055	-115.4047	Deer Creek	DeerCree_023_C	Rvd
Columbia	17010205	46.1928	-114.2572	Roaring Lion Creek	RoaringL_068_C	Rvd
Columbia	17010205	46.1928	-114.257	Roaring Lion Ck	RoaringL_241_C	P
Columbia	17010205	46.1939	-114.2406	ROARING LION CREEK NEAR TRAIL HEAD	ROARINGL_069_C	Rvd
Columbia	17010206	48.8292	-114.4908	Moose Creek	MooseCre_056_C	Rvd
Columbia	17010207	48.0639	-113.2453	Schafer Creek	SchaferC_074_C	Rvd
Columbia	17010209	47.9789	-113.5608	SOUTH FK FLATHEAD R. ABV HUNGRY HORSE RES	SOUTHFKF_115_C	Estb
Columbia	17010209	47.8055	-113.414	S. Fk. Flathead R.	SFkFlath_244_C	P
Columbia	17010210	48.74	-114.7331	Chepat Creek	ChepatCr_108_C	Estb
Columbia	17010210	48.7513	-114.727	Chepat Ck	ChepatCk_194_C	P
Columbia	17010210	48.62556	-114.5275	Chicken Creek	ChickenC_019_C	Rvd
Columbia	17010211	47.75834	-113.7811	Goat Creek (Site 2)	GoatCree_043_C	Rvd
Columbia	17010213	48.125	-115.7275	E. Fk. Bull River (Down)	EFkBullR_025_C	Rvd
Columbia	17010213	48.1219	-115.6983	EAST FORK BULL RIVER ABV. N. FK OF E. FK.	EASTFORK_031_C	Rvd
Columbia	17010213	48.1212	-115.698	E. Fk. Bull R.	EfkBullR_205_C	P
Columbia	17010213	47.7129	-115.128	Deerhorn Ck	Deerhorn_202_C	M

* **Rvd** means reviewed using the screening process in this report; **Estb** means an established reference site, from Bahls et al. (1992) or Suplee (2004); **P** means site was rated as pristine by USU; **M** means site was rated as minimally disturbed by USU.

Table A, Cont. List of reference sites and associated location information for the Upper Missouri major basin.

Major Basin	4th field HUC	LAT(DD)	LONG(DD)	Stream Site Name	REF. SITE No.	Review Notes*
Upper Missouri	10020001	45.0653	-113.2153	Browns Creek	BrownsCr_015_C	Rvd
Upper Missouri	10020001	44.64444	-111.6636	Elk Springs Creek	ElkSprin_037_C	Rvd
Upper Missouri	10020002	44.9425	-112.4294	Cottonwood Cr	Cottonwo_021_C	Rvd
Upper Missouri	10020003	45.12194	-112.0392	N. FK. Greenhorn Creek	NFKGreen_058_C	Rvd
Upper Missouri	10020003	45.5217	-111.9853	Mill (Up)	MillUp99_053_C	Rvd
Upper Missouri	10020004	45.37305	-113.6197	Little Lake Creek	LittleLa_049_C	Rvd
Upper Missouri	10020004	45.7335	-113.57283	Mussigbrod Cr.	Mussigbr_154_C	Rvd
Upper Missouri	10020004	45.9072	-113.4811	Pintler Creek	PintlerC_066_C	Rvd
Upper Missouri	10020004	45.91083	-113.2172	LaMarche Creek	LaMarche_048_C	Rvd
Upper Missouri	10020004	45.9985	-113.19	Seymore Ck.	SeymoreC_249_C	P
Upper Missouri	10020004	45.99583	-113.1872	Seymour Creek	SeymourC_076_C	Rvd
Upper Missouri	10020004	45.4481	-112.8278	Willow Cr (I)	WillowCr_103_C	Rvd
Upper Missouri	10020004	45.4381	-112.7422	Willow Cr (II)	WillowCr_104_C	Rvd
Upper Missouri	10020005	45.6047	-111.897	S. Fk. Willow Ck.	SFkWillo_245_C	M
Upper Missouri	10020007	45.3408	-111.718	O'Dell Ck	ODellCk9_236_C	M
Upper Missouri	10020007	45.115	-111.4981	No Man Creek	NoManCre_059_C	Rvd
Upper Missouri	10020007	45.6267	-111.414	Elk Ck	ElkCk999_209_C	M
Upper Missouri	10020007	44.905	-111.3725	W. Fk. Beaver Creek	WFkBeave_095_C	Rvd
Upper Missouri	10020007	44.8764	-111.34	Cabin Creek	CabinCre_016_C	Rvd
Upper Missouri	10020007	44.65778	-111.06972	Madison R., nr West Yellowstone in Yellowstone NP	MadisonR_406_C	Rvd
Upper Missouri	10020008	45.41028	-111.39861	SF Spanish Cr, Spanish Peaks Wilderness	SFSpanis_407_C	Rvd
Upper Missouri	10020008	45.3904	-111.24	Cascade Ck	CascadeC_193_C	P
Upper Missouri	10020008	45.05444	-111.1564	Gallatin River	Gallatin_040_C	Rvd
Upper Missouri	10020008	45.53444	-111.0806	S. Cottonwood Creek	SCottonw_073_C	Rvd
Upper Missouri	10030102	47.2131	-112.495	Lone Pine Creek	LonePine_051_C	Rvd
Upper Missouri	10030102	47.4994	-110.7164	Highwood Creek	Highwood_044_W	Rvd
Upper Missouri	10030103	46.9947	-111.4858	Whitetail Creek	Whitetai_102_W	Rvd
Upper Missouri	10030103	46.845	-110.96	Calf Creek	CalfCree_017_C	Rvd
Upper Missouri	10030103	46.8464	-110.958	calfck	calfck99_192_C	M
Upper Missouri	10030104	47.4916	-112.909	sfksun	sfksun99_250_C	P
Upper Missouri	10030104	47.4917	-112.9086	South Fk. Sun River	SouthFkS_080_C	Rvd
Upper Missouri	10030104	47.5064	-112.8903	SUN RIVER S. FORK BELOW STRAIGHT CREEK	SUNRIVER_116_C	Estb
Upper Missouri	10040201	46.2506	-109.7689	Fish Creek	FishCree_038_W	Rvd

* **Rvd** means reviewed using the screening process in this report; **Estb** means an established reference site, from Bahls et al. (1992) or Suplee (2004); **P** means site was rated as pristine by USU; **M** means site was rated as minimally disturbed by USU.

Table A, Cont. List of reference sites and associated location information for the Lower Missouri major basin.

Major Basin	4th field HUC	LAT(DD)	LONG(DD)	Stream Site Name	REF. SITE No.	Review Notes*
Lower Missouri	10030201	48.04056	-112.9000	Crazy Cr blw Mount Patrick Gass, Bob Marshall Wilderness	CrazyCre_409_C	Rvd
Lower Missouri	10030204	48.7567	-111.5216	Willow Creek	WillowCr_172_W	Rvd
Lower Missouri	10030205	47.92	-112.8339	Waldron Creek	WaldronC_117_C	Estb
Lower Missouri	10030205	47.9193	-112.817	waldrn	waldrn99_270_C	P
Lower Missouri	10030205	47.9711	-112.811	nfktet	nfktet99_234_C	P
Lower Missouri	10030205	47.96695	-112.8075	N. Fk. Teton River	NFkTeton_114_C	Estb
Lower Missouri	10030205	48.01305	-112.6931	Blackleaf Creek (Site 1)	Blacklea_007_C	Rvd
Lower Missouri	10030205	48.01278	-112.5633	Blackleaf Creek (Site 2)	Blacklea_008_W	Rvd
Lower Missouri	10040101	47.92111	-110.035	Eagle Creek (Site 3)	EagleCre_030_W	Rvd
Lower Missouri	10040101	48.10083	-109.7689	Eagle Creek (Site 1)	EagleCre_028_C	Rvd
Lower Missouri	10040102	47.62564	-109.83562	Arrow Creek	ArrowCre_135_W	Rvd
Lower Missouri	10040103	47.07944	-109.5989	Beaver Creek	BeaverCr_002_W	Rvd
Lower Missouri	10040104	47.86111	-108.9633	Cow Creek	CowCreek_022_W	Rvd
Lower Missouri	10040106	47.3413	-106.363	Little Dry Cr.	LittleDr_151_W	Rvd
Lower Missouri	10040201	46.6756	-110.4389	Basin Creek	BasinCre_001_C	Rvd
Lower Missouri	10050004	48.30611	-109.4906	Clear Creek (Nut pilot)	ClearCre_121_W	Estb
Lower Missouri	10050010	48.92265	-108.37948	Woody Island Coulee	WoodyIsl_174_W	Rvd
Lower Missouri	10050011	48.95661	-107.85937	Whitewater Creek	Whitewat_170_W	Rvd
Lower Missouri	10050011	48.600061	-107.519465	Whitewater Creek	Whitewat_169_W	Rvd
Lower Missouri	10050015	48.6569	-107.0389	Rock Cr (BLM land)	RockCrBL_122_W	Estb
Lower Missouri	10050015	48.59028	-107.0011	Rock Creek (Site 2)	RockCree_124_W	Estb
Lower Missouri	10050015	48.58472	-106.9625	Willow Creek	WillowCr_171_W	Rvd
Lower Missouri	10050015	48.6489	-106.9025	Bitter Cr	BitterCr_120_W	Rvd
Lower Missouri	10050015	48.8789	-106.8992	ROCK CREEK NORTHEAST OF HINSDALE	ROCKCREE_125_W	Estb
Lower Missouri	10050015	48.87583	-106.8967	Rock Creek (Site 1)	RockCree_123_W	Estb
Lower Missouri	10050015	48.9694	-106.8389	ROCK CREEK BELOW HORSE CREEK NEAR INT BOUNDARY	ROCKCREE_133_W	Estb
Lower Missouri	10060001	48.08778	-105.6781	Wolf Creek @ Wolf Pt.	WolfCree_130_W	Estb
Lower Missouri	10060001	48.2236	-105.5175	Tule Creek	TuleCree_092_W	Rvd
Lower Missouri	10060001	48.18355	-105.49147	Tule Creek	TuleCree_164_W	Rvd
Lower Missouri	10060002	47.70639	-105.2456	Pasture Creek (Site 1)	PastureC_064_W	Rvd
Lower Missouri	10060002	47.63972	-105.1617	Pasture Creek (Site 2)	PastureC_065_W	Rvd
Lower Missouri	10060002	47.75806	-104.9228	E. Redwater Creek	E.Redwat_027_W	Rvd
Lower Missouri	10060004	48.9442	-106.2503	WEST FORK POPLAR RIVER AT BRIDGE ON COUNT	WESTFORK_127_W	Estb
Lower Missouri	10060004	48.8081	-106.0206	WEST FORK POPLAR RIVER NEAR RICHLAND MONT	WESTFORK_128_W	Estb
Lower Missouri	10060004	48.7478	-105.9286	WEST FORK POPLAR RIVER S OF PEERLESS	WESTFORK_129_W	Estb
Lower Missouri	10060004	48.69695	-105.8319	W. Fk. Poplar River	WFkPopla_126_W	Estb
Lower Missouri	10060004	48.6225	-105.6525	WEST FORK POPLAR RIVER NEAR FOUR BUTTES	WESTFORK_099_W	Rvd

* **Rvd** means reviewed using the screening process in this report; **Estb** means an established reference site, from Bahls et al. (1992) or Suplee (2004); **P** means site was rated as pristine by USU; **M** means site was rated as minimally disturbed by USU.

Table A, Cont. List of reference sites and associated location information for the Yellowstone major basin.

Major Basin	4th field HUC	LAT(DD)	LONG(DD)	Stream Site Name	REF. SITE No.	Review Notes*
Yellowstone	10070001	45.02944	-110.69944	Gardner River at mouth, Yellowstone NP	GardnerR_404_C	Rvd
Yellowstone	10070002	45.3053	-110.9819	BIG CREEK ABOVE BIG CREEK STATION	BIGCREEK_110_C	Estb
Yellowstone	10070002	45.3034	-110.94	Big Ck	BigCk999_180_C	M
Yellowstone	10070002	45.5063	-110.789	Pine Ck	PineCk99_238_C	M
Yellowstone	10070002	45.6347	-110.7511	ARMSTRONG SPRING CREEK AT O'HAIR RANCH	ARMSTRON_109_W	Estb
Yellowstone	10070002	45.3408	-110.2464	Fourmile Creek	Fourmile_112_C	Estb
Yellowstone	10070002	45.3407	-110.246	Four Mile Ck	FourMile_212_C	P
Yellowstone	10070005	45.3981	-109.9683	WEST FORK STILLWATER CUS001 ABOVE ADIT	WESTFORK_118_C	Estb
Yellowstone	10070005	45.3988	-109.961	wfkstl	wfkstl99_274_C	P
Yellowstone	10070005	45.22667	-109.6058	East Rosebud Creek	EastRose_033_C	Rvd
Yellowstone	10070006	45.0794	-109.4081	LAKE FORK OF ROCK CREEK	LAKEFORK_113_C	Estb
Yellowstone	10070006	45.05361	-109.4069	Wyoming Creek	WyomingC_107_C	Rvd
Yellowstone	10070006	45.15056	-109.33944	West Fork Rock Cr, abv Silver Run	WFRockCr_405_C	Rvd
Yellowstone	10070006	45.09806	-109.2992	Seeley Creek	SeeleyCr_075_C	Rvd
Yellowstone	10070006	45.2356	-108.925	lfkrok	lfkrok99_222_W	P
Yellowstone	10070008	45.31665	-108.5406	Pryor Creek	PryorCre_159_C	Rvd
Yellowstone	10080010	45.1334	-108.428	crookd	crookd99_200_C	P
Yellowstone	10080010	45.0433	-108.385	CROOKED CREEK ABOVE TILLETT RANCH	CROOKEDC_111_C	Estb
Yellowstone	10080015	45.44316	-108.16282	Beauvais Creek	Beauvois_136_W	Rvd
Yellowstone	10080015	45.47694	-108.0081	Beauvais Creek near ST. Xavier MT	Beauvais_131_W	Estb
Yellowstone	10080015	45.4328	-107.9619	Muddy Creek	MuddyCre_057_W	Rvd
Yellowstone	10090102	45.3092	-106.2497	Cow Creek	CowCreek_141_W	Rvd
Yellowstone	10090102	46.189011	-105.621715	Pumpkin Creek	PumpkinC_161_W	Rvd
Yellowstone	10090208	45.3189	-105.3178	Little Powder River	LittlePo_050_W	Rvd
Yellowstone	10100004	46.7917	-104.5583	Cedar Cr.	CedarCr9_140_W	Rvd
Yellowstone	10100005	46.73498	-105.057378	O Fallon	OFallon9_157_W	Rvd
Yellowstone	10100005	46.47068	-104.76994	O Fallon	OFallon9_156_W	Rvd
Yellowstone	10100005	46.47111	-104.7697	O'Fallon Creek (Site 2)	OFallonC_062_W	Rvd
Yellowstone	10100005	46.16694	-104.71528	Milk Creek near mouth	MilkCree_416_W	Rvd
Yellowstone	10100005	46.1364	-104.6669	Spring Creek	SpringCr_081_W	Rvd
Yellowstone	10110201	44.9952	-104.42346	Little Missouri River	LittleMi_152_W	Rvd
Yellowstone	10110201	46.06778	-104.33583	Little Beaver Creek	LittleBe_410_W	Rvd
Yellowstone	10110202	45.8444	-104.1439	Box Elder Creek	BoxElder_013_W	Rvd
Yellowstone	10110202	45.84472	-104.14361	Box Elder Creek	BoxElder_137_W	Rvd
Yellowstone	10110202	45.8448	-104.14289	Box Elder Creek	BoxElder_138_W	Rvd
Yellowstone	10110202	45.89405	-104.07163	Box Elder Creek	BoxElder_382_W	Rvd

* **Rvd** means reviewed using the screening process in this report; **Estb** means an established reference site, from Bahls et al. (1992) or Suplee (2004); **P** means site was rated as pristine by USU; **M** means site was rated as minimally disturbed by USU.

Appendix B. Database Stations Associated with Reference Sites

To aid in the cataloging of data associated with each reference site, applicable station ID's from large water-quality databases (Legacy STORET, modernized STORET, NWIS) were associated with each reference site (Table B, below). Some database stations are not located precisely at the reference site coordinates, and database data could pre-date (by some years) a site's recognition as a reference site. To be associated with a reference site, a database station had to be within 0.5 miles up- or downstream of the reference site coordinates. If the possibility existed that a database station downstream of a reference site was located below a mine adit or other known point source, the database station was not associated with the reference site.

Table B. Database station ID's associated with reference sites. In the 'Database' column, MONT-DEQ and MT-DEQ refer to organizational codes found in modernized STORET. MONT-DEQ is associated with DEQ data collected prior to 1998, MT-DEQ with DEQ data collected since 2000. NWIS is the USGS's National Water Quality Information System database. EMAP and USU designate data collected for particular EPA projects, which will ultimately be housed in modernized STORET.

REF SITE No.	Stream Site Name	LAT (dd)	LONG (dd)	Database Station ID	Database
ARMSTRON_109_W	ARMSTRONG SPRING CREEK AT O'HAIR RANCH	45.6347	-110.7511	2544AR01	Legacy STORET, or Modern STORET under MONT-DEQ
ArrowCre_135_W	Arrow Creek	47.62564	-109.83562	M21ARRWC02	Modern STORET, under MT-DEQ
BasinCre_001_C	Basin Creek	46.6756	-110.4389	WMTP99-0716	EMAP
Beauvais_131_W	Beauvais Creek near ST. Xavier MT	45.47694	-108.0081	06288200	NWIS
BeaverCr_002_W	Beaver Creek	47.07944	-109.5989	M22BEVRC04	Modern STORET, under MT-DEQ
BellyRiv_408_C	Belly River at 3-mile campsite (Glacier NP)	48.96806	-113.68222	GLAC_NURE_732	Legacy STORET
BigCk999_180_C	Big Ck	45.3034	-110.94	EPA01-436	USU
BIGCREEK_110_C	BIG CREEK ABOVE BIG CREEK STATION	45.3053	-110.9819	2241BI01	Legacy STORET, or Modern STORET under MONT-DEQ
BitterCr_120_W	Bitter Cr	48.6489	-106.9025	M43BITRC01	Modern STORET, under MT-DEQ
Blackfoo_006_C	Blackfoot River	46.89944	-113.7561	CFR14	Modern STORET, under MT-DEQ
Blackfoo_006_C	Blackfoot River	46.89944	-113.7561	4118BL01	Legacy STORET, or Modern STORET under MONT-DEQ
Blackfoo_006_C	Blackfoot River	46.8997	-113.7556	12340000	NWIS
Blacklea_007_C	Blackleaf Creek (Site 1)	48.01305	-112.6931	WMTP99-R031	EMAP
Blacklea_008_W	Blackleaf Creek (Site 2)	48.01278	-112.5633	MT14BLKLC01	Modern STORET, under MT-DEQ
BoxElder_013_W	Box Elder Creek	45.8444	-104.1439	WMTP99-0623	EMAP
BoxElder_382_W	Box Elder Creek	45.89405	-104.07163	3097BO01	Legacy STORET, or Modern STORET under MONT-DEQ
BrownsCr_015_C	Browns Creek	45.0653	-113.2153	WMTP99-0745	EMAP
CabinCre_016_C	Cabin Creek	44.8764	-111.34	06038550	NWIS
CabinCre_016_C	Cabin Creek	44.8764	-111.34	1738CA01	Legacy STORET, or Modern STORET under MONT-DEQ
calfck99_192_C	calfck	46.8464	-110.958	EPA01-425	USU
calfck99_192_C	calfck	46.8464	-110.958	4141CA01	Legacy STORET, or Modern STORET under MONT-DEQ
CalfCree_017_C	Calf Creek	46.845	-110.96	REFCAC	Modern STORET, under MT-DEQ
CalfCree_017_C	Calf Creek	46.845	-110.96	WMTP99-R027	EMAP
CascadeC_193_C	Cascade Ck	45.3904	-111.241	EPA01-438	USU
CedarCr9_140_W	Cedar Cr.	46.7917	-104.5583	BKK038	Legacy STORET, or Modern STORET under MONT-DEQ
ChepatCk_194_C	Chepat Ck	48.7513	-114.727	EPA01-452	USU
ChepatCr_108_C	Chepat Creek	48.74	-114.7331	STSF08	DNRC
ChickenC_019_C	Chicken Creek	48.62556	-114.5275	STSF03	DNRC
ClearCre_121_W	Clear Creek (Nut pilot)	48.30611	-109.4906	REFCC	Modern STORET, under MT-DEQ
Cottonwo_021_C	Cottonwood Cr	44.9425	-112.4294	M02CTWD01	Modern STORET, under MT-DEQ
CowCreek_022_W	Cow Creek	47.86111	-108.9633	WMTP99-R032	EMAP
CowCreek_141_W	Cow Creek	45.3092	-106.2497	2280CO01	Legacy STORET, or Modern STORET under MONT-DEQ

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crookd99_200_C	crookd	45.1334	-108.428	EPA01-429	USU
CROOKEDC_111_C	CROOKED CREEK ABOVE TILLETT RANCH	45.0433	-108.385	1962CR02	Legacy STORET, or Modern STORET under MONT-DEQ
DeerCree_023_C	Deer Creek	47.31055	-115.4047	C04DEERC01	Modern STORET, under MT-DEQ
Deerhorn_202_C	Deerhorn Ck	47.7129	-115.128	EPA01-449	USU
E.Redwat_027_W	E. Redwater Creek	47.75806	-104.9228	M48RDWEC04	Modern STORET, under MT-DEQ
EagleCre_028_C	Eagle Creek (Site 1)	48.10083	-109.7689	M23EAGLC01	Modern STORET, under MT-DEQ
EagleCre_030_W	Eagle Creek (Site 3)	47.92111	-110.035	M23EAGLC06	Modern STORET, under MT-DEQ
EASTFORK_031_C	EAST FORK BULL RIVER ABV. N. FK OF E. FK.	48.1219	-115.6983	EPA01-450	EMAP
EASTFORK_031_C	EAST FORK BULL RIVER ABV N. FK. OF E. FK	48.1219	-115.6983	5503EA01	Legacy STORET, or Modern STORET under MONT-DEQ
EastRose_033_C	East Rosebud Creek	45.22667	-109.6058	06202915	NWIS
EastRose_033_C	East Rosebud Creek	45.22667	-109.6058	REFERC	Modern STORET, under MT-DEQ
EFkBullR_025_C	E. Fk. Bull River (Down)	48.125	-115.7275	WMTP99-R019	EMAP
ElkCk999_209_C	Elk Ck	45.6267	-111.414	EPA01-440	USU
ElkSprin_037_C	Elk Springs Creek	44.64444	-111.6636	M01ELKC01	Modern STORET, under MT-DEQ
ElkSprin_037_C	Elk Springs Creek	44.64444	-111.6636	WMTP99-R038	EMAP
FishCree_038_W	Fish Creek	46.2506	-109.7689	WMTP99-0628	EMAP
Fourmile_112_C	Fourmile Creek	45.3408	-110.2464	2247FO01	Legacy STORET, or Modern STORET under MONT-DEQ
FourMile_212_C	Four Mile Ck	45.3407	-110.246	EPA01-432	USU
Gallatin_040_C	Gallatin River	45.05444	-111.1564	M05GLTNR01	Modern STORET, under MT-DEQ
GardnerR_404_C	Gardner River at mouth, Yellowstone NP	45.02944	-110.69944	Y01GARDR01	Modern STORET, under MT-DEQ
GoatCree_043_C	Goat Creek (Site 2)	47.75834	-113.7811	C10GOATC04	Modern STORET, under MT-DEQ
Highwood_044_W	Highwood Creek	47.4994	-110.7164	WMTP99-0729	EMAP
LAKEFORK_113_C	LAKE FORK OF ROCK CREEK	45.0794	-109.4081	1954LA01	Legacy STORET, or Modern STORET under MONT-DEQ
LaMarche_048_C	LaMarche Creek	45.91083	-113.2172	M03LMCHC01	Modern STORET, under MT-DEQ
lfkrok99_222_W	lfkrok	45.2356	-108.925	EPA01-428	USU
lfkrok99_222_W	lfkrok	45.2356	-108.925	451409108552701	NWIS
LittleDr_151_W	Little Dry Cr.	47.3413	-106.363	M29LDRYC01	Modern STORET, under MT-DEQ
LittleDr_151_W	Little Dry Cr.	47.3413	-106.363	4677LI01	Legacy STORET, or Modern STORET under MONT-DEQ
LittleDr_151_W	Little Dry Cr.	47.3413	-106.363	BKK070	Modern STORET, under MT-DEQ
LittleDr_151_W	Little Dry Cr.	47.3413	-106.363	06130950	NWIS
LittleDr_151_W	Little Dry Cr.	47.3413	-106.363	BKK069	Modern STORET, under MT-DEQ
LittleLa_049_C	Little Lake Creek	45.37305	-113.6197	M03LTLKC01	Modern STORET, under MT-DEQ
LittlePo_050_W	Little Powder River	45.3189	-105.3178	WMTP99-0648	EMAP
LonePine_051_C	Lone Pine Creek	47.2131	-112.495	WMTP99-0722	EMAP
MadisonR_406_C	Madison R., nr West Yellowstone in Yellowstone NP	44.65778	-111.06972	06037500	NWIS

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MooseCre_056_C	Moose Creek	48.8292	-114.4908	WMTP99-0515	EMAP
MuddyCre_057_W	Muddy Creek	45.4328	-107.9619	MT634738	EMAP
Mussigbr_154_C	Mussigbrod Cr.	45.7335	-113.57283	BKK091	Modern STORET, under MT-DEQ
NFKGreen_058_C	N. FK. Greenhorn Creek	45.12194	-112.0392	M04GHCNF01	Modern STORET, under MT-DEQ
nfktet99_234_C	nfktet	47.9711	-112.811	EPA01-423	USU
nfktet99_234_C	nfktet	47.9711	-112.811	5426TE01	Legacy STORET, or Modern STORET under MONT-DEQ
NFkTeton_114_C	N. Fk. Teton River	47.96695	-112.8075	REFNFTR	Modern STORET, under MT-DEQ
NFkTeton_114_C	N. Fk. Teton River	47.96695	-112.8075	WMTP99-R002	EMAP
NoManCre_059_C	No Man Creek	45.115	-111.4981	MAD-004	EMAP
ODellCk9_236_C	O'Dell Ck	45.3408	-111.718	452032111425201	NWIS
ODellCk9_236_C	O'Dell Ck	45.3408	-111.718	EPA01-441	USU
OFallon9_156_W	O Fallon	46.47068	-104.76994	Y22OFALC07	Modern STORET, under MT-DEQ
OFallonC_062_W	O'Fallon Creek (Site 2)	46.47111	-104.7697	REFOFC2	Modern STORET, under MT-DEQ
PastureC_064_W	Pasture Creek (Site 1)	47.70639	-105.2456	5185PA01	Modern STORET, under MT-DEQ
PastureC_064_W	Pasture Creek (Site 1)	47.70639	-105.2456	M48PSTRC01	Modern STORET, under MT-DEQ
PastureC_065_W	Pasture Creek (Site 2)	47.63972	-105.1617	M48PSTRC02	Modern STORET, under MT-DEQ
PineCk99_238_C	Pine Ck	45.5063	-110.789	EPA01-435	USU
PintlerC_066_C	Pintler Creek	45.9072	-113.4811	WMTP99-0517	EMAP
RoaringL_068_C	Roaring Lion Creek	46.1928	-114.2572	EPA01-448	EMAP
ROARINGL_069_C	ROARING LION CREEK NEAR TRAIL HEAD	46.1939	-114.2406	3314RO01	Legacy STORET, or Modern STORET under MONT-DEQ
RockCrBL_122_W	Rock Cr (BLM land)	48.6569	-107.0389	M43ROCKC01	Modern STORET, under MT-DEQ
RockCree_070_C	Rock Creek nr Clinton	46.7225	-113.6822	464321113405601	NWIS
RockCree_070_C	Rock Creek	46.70889	-113.6725	3918RO01	Legacy STORET, or Modern STORET under MONT-DEQ
RockCree_071_C	Rock Creek near Clinton	46.7225	-113.6822	12334510	NWIS
RockCree_123_W	Rock Creek (Site 1)	48.87583	-106.8967	REFRC1	Modern STORET, under MT-DEQ
RockCree_123_W	Rock Creek (Site 1)	48.87583	-106.8967	WMTP99-R005	EMAP
RockCree_124_W	Rock Creek (Site 2)	48.59028	-107.0011	REFRC2	Modern STORET, under MT-DEQ
ROCKCREE_125_W	ROCK CREEK NORTHEAST OF HINSDALE	48.8789	-106.8992	6472RO01	Legacy STORET, or Modern STORET under MONT-DEQ
ROCKCREE_133_W	ROCK CREEK BELOW HORSE CREEK NEAR INT BOUNDARY	48.9694	-106.8389	06169500	NWIS
SchaferC_074_C	Schafer Creek	48.0639	-113.2453	5522SC01	Legacy STORET, or Modern STORET under MONT-DEQ
SCottonw_073_C	S. Cottonwood Creek	45.53444	-111.0806	M05SCTNC01-A	Modern STORET, under MT-DEQ
SCottonw_073_C	S. Cottonwood Creek	45.53444	-111.0806	M05SCTNC01-B	Modern STORET, under MT-DEQ
SCottonw_073_C	S. Cottonwood Creek	45.53444	-111.0806	M05SCTNC01-C	Modern STORET, under MT-DEQ
SCottonw_073_C	S. Cottonwood Creek	45.53444	-111.0806	M05SCTNC01-D	Modern STORET, under MT-DEQ
SeeleyCr_075_C	Seeley Creek	45.09806	-109.2992	WMTP99-R035	EMAP
SeeleyCr_075_C	Seeley Creek	45.09806	-109.2992	REFSEC	Modern STORET, under MT-DEQ

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SeymoreC_249_C	Seymore Ck.	45.9985	-113.19	EPA01-446	USU
SeymourC_076_C	Seymour Creek	45.99583	-113.1872	3122SE01	Legacy STORET, or Modern STORET under MONT-DEQ
SeymourC_076_C	Seymour Creek	45.99583	-113.1872	BKK126	Modern STORET, under MT-DEQ
SeymourC_076_C	Seymour Creek	45.99583	-113.1872	WMTP99-R015	EMAP
SFkFlath_244_C	S. Fk. Flathead R.	47.8055	-113.414	EPA01-453	USU
SFkWillo_245_C	S. Fk. Willow Ck.	45.6047	-111.897	EPA01-454	USU
SilverCr_078_C	Silver Creek (Site 2)	47.4025	-115.5164	C04SLVRC04	Modern STORET, under MT-DEQ
SilverCr_078_C	Silver Creek (Site 2)	47.4025	-115.5164	C04SLVRC02	Modern STORET, under MT-DEQ
SOUTHFKF_115_C	SOUTH FK FLATHEAD R. ABV HUNGRY HORSE RES	47.9789	-113.5608	C08FRSFK01	Modern STORET, under MT-DEQ
SOUTHFKF_115_C	SOUTH FK FLATHEAD R. ABV HUNGRY HORSE RES	47.9789	-113.5608	12359800	NWIS
SOUTHFKF_115_C	SOUTH FK FLATHEAD R. ABV HUNGRY HORSE RES	47.9789	-113.5608	5419SO01	Legacy STORET, or Modern STORET under MONT-DEQ
SouthFkS_080_C	South Fk. Sun River	47.4917	-112.9086	EPA01-424	EMAP
SpringCr_081_W	Spring Creek	46.1364	-104.6669	WMTP99-0549	EMAP
SUNRIVER_116_C	SUN RIVER S. FORK BELOW STRAIGHT CREEK	47.5064	-112.8903	4825SU01	Legacy STORET, or Modern STORET under MONT-DEQ
Swiftcur_132_C	Swiftcurrent Creek at Many Glacier MT	48.7992	-113.6558	05014500	NWIS
TribofNF_091_C	Trib of N. Fork Blackfoot	47.2281	-112.8472	WMTP99-0837	EMAP
TuleCree_092_W	Tule Creek	48.2236	-105.5175	WMTP99-0804	EMAP
TuleCree_164_W	Tule Creek	48.18355	-105.49147	5683TU01	Legacy STORET, or Modern STORET under MONT-DEQ
waldrn99_270_C	waldrn	47.9193	-112.817	EPA01-421	USU
WaldronC_117_C	Waldron Creek	47.92	-112.8339	5326WA01	Legacy STORET, or Modern STORET under MONT-DEQ
WaldronC_117_C	Waldron Creek	47.92	-112.8339	WMTP99-R020	EMAP
WESTFORK_099_W	WEST FORK POPLAR RIVER NEAR FOUR BUTTES	48.6225	-105.6525	6181WE01	Legacy STORET, or Modern STORET under MONT-DEQ
WESTFORK_118_C	WEST FORK STILLWATER CUS001 ABOVE ADIT	45.3981	-109.9683	BKK160	Modern STORET, under MT-DEQ
WESTFORK_118_C	WEST FORK STILLWATER CUS001 ABOVE ADIT	45.3981	-109.9683	2349WE03	Legacy STORET, or Modern STORET under MONT-DEQ
WESTFORK_127_W	WEST FORK POPLAR RIVER AT BRIDGE ON COUNT	48.9442	-106.2503	6577WE01	Legacy STORET, or Modern STORET under MONT-DEQ
WESTFORK_128_W	WEST FORK POPLAR RIVER NEAR RICHLAND MONT	48.8081	-106.0206	6379WE01	Legacy STORET, or Modern STORET under MONT-DEQ
WESTFORK_129_W	WEST FORK POPLAR RIVER S OF PEERLESS	48.7478	-105.9286	6379WE02	Legacy STORET, or Modern STORET under MONT-DEQ
WFkBeave_095_C	W. Fk. Beaver Creek	44.905	-111.3725	1738WE01	Legacy STORET, or Modern STORET under MONT-DEQ
WFkPopla_126_W	W. Fk. Poplar River	48.69695	-105.8319	REFWFPR	Modern STORET, under MT-DEQ
wfkstl99_274_C	wfkstl	45.3988	-109.961	EPA01-430	USU
Whitetai_102_W	Whitetail Creek	46.9947	-111.4858	MT222052	EMAP
Whitewat_170_W	Whitewater Creek	48.95661	-107.85937	06156000	NWIS
WillowCr_103_C	Willow Cr (I)	45.4481	-112.8278	06025800	NWIS
WillowCr_103_C	Willow Cr (I)	45.4481	-112.8278	M03WILOC01	Modern STORET, under MT-DEQ
WillowCr_104_C	Willow Cr (II)	45.4381	-112.7422	M03WILOC02	Modern STORET, under MT-DEQ
WolfCree_130_W	Wolf Creek @ Wolf Pt.	48.08778	-105.6781	REFWC	Modern STORET, under MT-DEQ
WoodyIsl_174_W	Woody Island Coulee	48.92265	-108.37948	6560WO01	Legacy STORET, or Modern STORET under MONT-DEQ
WoodyIsl_174_W	Woody Island Coulee	48.92265	-108.37948	BKK165	Modern STORET, under MT-DEQ
WyomingC_107_C	Wyoming Creek	45.05361	-109.4069	WMTP99-R036	EMAP
WyomingC_107_C	Wyoming Creek	45.05361	-109.4069	Y05WYOMC01	Modern STORET, under MT-DEQ