Water Quality Assessment Methodology for North Dakota's Surface Waters

North Dakota Department of Health
Division of Water Quality

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Jack Dalrymple, Governor
Terry Dwelle, M.D., State Health Officer

North Dakota Department of Health
Division of Water Quality
Gold Seal Center, 4th Floor
918 East Divide Avenue
Bismarck, ND 58501-1947

701.328.5210

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I. INTRODUCTION

A. Background

The federal Clean Water Act (CWA) provides the regulatory context and mandate for state water quality monitoring and assessment programs. The North Dakota Department of Health (NDDoH) has been designated as the state water pollution control agency for purposes of the federal CWA and, as such, is authorized to take all actions necessary or appropriate to secure for the state all benefits of the CWA and similar federal acts (NDCC 61-28-04). State law establishes policy to protect, maintain, and improve the quality of waters of state, while the overall goal of the federal CWA is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

Various sections in the CWA require states to conduct specific activities to monitor, assess, and protect their waters. These activities include:

- Develop and adopt water quality standards designed to protect designated beneficial uses (Section 303);

- Establish and maintain monitoring programs to collect and analyze water quality data (Section 106). Reporting on the status of waters and the degree to which designated beneficial uses are supported (Section 305[b]);

- Identify and prioritize waters that are not meeting water quality standards (Section 303[d]);

- Assess the status and trends of water quality in lakes and identifying and classifying lakes according to trophic condition (Section 314); and

- Identify waters impaired due to nonpoint sources of pollution as well as identifying those sources and causes of nonpoint source pollution (Section 319).

B. North Dakota's Surface Water Resources

Based on the state's Assessment Database, the 146 reservoirs have an aerial surface of 476,716 acres. Reservoirs comprise about 67 percent of North Dakota's total lake/reservoir surface acres. Of these, 411,499 acres or 58 percent of the state's entire lake and reservoir acres are contained within the two mainstem Missouri River reservoirs (Lake Sakakawea and Lake Oahe). The remaining 144 reservoirs share 65,217 acres, with an average surface area of 453 acres.

The 143 natural lakes in North Dakota cover 236,531 acres, with approximately 102,376 acres or 43 percent attributed to Devils Lake. The remaining 142 lakes average 945 acres, with approximately 42 percent being smaller than 250 acres.

There are 56,009 miles of rivers and streams in the state. Estimates of river stream miles in the state are based on river and stream waterbodies in the ADB that are reach indexed to the 1:100K National Hydrography Dataset (NHD plus) and include ephemeral, intermittent and perennial rivers and streams.

One of the most significant water resource types in the state are wetlands. There are an estimated 2.5 million acres of wetlands in the state. The majority of these wetlands are temporary, seasonal, semi-permanent and permanent depressional wetlands located in what is commonly called the Prairie Pothole Region.

C. Purpose and Scope

Water quality standards provide the fundamental benchmarks by which the quality of all surface waters are measured. It is the water quality standards that are used to determine impairment. As a general policy, the assessment procedures described in this methodology are consistent with the NDDoH's interpretation of the state's water quality standards.

For purposes of Section 305(b) reporting and Section 303(d) listing, the US Environmental Protection Agency (EPA) encourages states to submit an integrated report (IR) and to follow its integrated reporting guidance, including EPA's 2006 IR guidance, which is supplemented by EPA's 2008, 2010, 2012 and 2014 IR guidance memos (http://water.epa.gov/lawregs/lawsguidance/cwa/tmdl/guidance.cfm). Key to integrated reporting is an assessment of all of the state's waters and placement of those waters into one of five assessment categories. The categories represent varying levels of water quality standards attainment, ranging from Category 1, where all of a waterbody's designated uses are fully supporting, to Category 5, where a pollutant impairs a waterbody and a TMDL is required (Table 1). These category determinations are based on consideration of all existing and readily available data and information consistent with the state's water quality assessment methodology.

The purpose of this document is to describe the assessment methodology used in the state's biennial integrated report. This information, which is summarized by specific lake, reservoir, river reach or sub-watershed, is integrated as beneficial use assessments that are entered into a water quality assessment "accounting"/database management system developed by EPA. This system, which provides a standard format for water quality assessment and reporting, is termed the Assessment Database (ADB).

Table 1. Assessment Categories for the Integrated Report

Assessment Category	Assessment Category Description
Category 1	All of the waterbody's designated uses have been assessed and are fully supporting.
Category 2	Some of the waterbody's designated uses are fully supporting, but there is insufficient data to determine if remaining designated uses are fully supporting.
Category 3	Insufficient data to determine whether any of the waterbody's designated uses are met.
Category 4	At least one of the waterbody's beneficial uses is not supported or has been assessed as fully supporting, but threatened, but a TMDL is not needed. This category has been further sub-categorized as: • 4A - waterbodies that are impaired or threatened, but TMDLs needed to restore beneficial uses have been approved or established by EPA; • 4B - waterbodies that are impaired or threatened, but do not require TMDLs because the state can demonstrate that "other pollution control requirements (e.g., BMPs) required by local, state or federal authority" • (see 40 CFR 130.7[b][1][iii]) are expected to address all waterbody-pollutant combinations and attain all water quality standards in a reasonable period of time; and • 4C - waterbodies that are impaired or threatened, but the impairment is not due to a pollutant.
Category 5	At least one of the waterbody's beneficial uses is not supported or has been assessed as fully supporting, but threatened, and a TMDL is needed. • 5A – waterbodies currently listed on the Section 303(d) list, but are targeted for additional monitoring and assessment during the next two to four years. **Note:** This also includes waterbodies which are assessed as impaired based on biological data alone and for which there are no known pollutant causes of the impairment. These impaired waterbodies will be target for additional stressor identification monitoring and assessment.

II. WATER QUALITY STANDARDS

A. Background

As stated previously, water quality standards are the fundamental benchmarks by which the quality of all of the state's surface waters are assessed. It is the state's water quality standards that are ultimately used to determine beneficial use impairment status.

Water quality standards were first adopted into North Dakota administrative code beginning in the late 1960's. "Water quality standards" is a term which is used in both a broad and narrow sense. In its broadest sense, water quality standards include all the provisions and requirements in water quality rules and regulations, including minimum wastewater treatment requirements and effluent limits for point source dischargers. In the more narrow sense, water quality standards define the specific uses we make of waters of the state and set forth specific criteria, both numeric and narrative, that define acceptable conditions for the protection of these uses, including antidegradation provisions (Appendix A). The term "water quality standards" is used in the more narrow sense throughout this document.

Water quality reporting requirements under Sections 305(b) and 303(d) of the CWA require states to assess the extent to which their lakes, reservoirs, rivers, and streams are meeting water quality standards applicable to their waters, including beneficial uses as defined in their state water quality standards. In addition to beneficial uses, applicable water quality standards also include narrative and numeric standards and antidegradation policies and procedures. While

Section 305(b) requires states and tribes to provide only a statewide water quality summary, Section 303(d) takes this reporting a step further by requiring states to identify and list the individual waterbodies that are not meeting applicable water quality standards and to develop TMDLs for those waters. Both Section 305(b) reporting and Section 303(d) listing accomplish this assessment by determining whether a waterbody is supporting its designated beneficial uses.

B. Beneficial Use Designation

The protected beneficial uses of the state's surface waters are defined in the *Standards of Quality for Waters of the State* (Appendix A). The state's water quality standards provide for four stream classes (I, IA, II, and III) and five lake classes (1-5). While considered "waters of the state" and protected under the state's narrative standards, the state's water quality standards do not define beneficial uses for wetlands.

All classified lakes, reservoirs, rivers, and streams in the state are protected for aquatic life and recreation. Protection for aquatic life means surface waters are suitable for the propagation and support of fish and other aquatic biota, including aquatic macroinvertebrates, and that these waters will not adversely affect wildlife in the area. Protection of all surface waters, except wetlands, for recreation means waters should be suitable for direct body contact activities such as bathing and swimming and for secondary contact activities such as boating, fishing, and wading.

Class I, IA, and II rivers and streams and all classified lakes and reservoirs are designated for use as municipal and drinking water supplies. Specifically, these waters shall be suitable for use as a source of water supply for drinking and culinary purposes after treatment to a level approved by the NDDoH.

While not specifically identified in state water quality standards, fish consumption is protected through both narrative and numeric human health criteria specified in the state's water quality standards (Appendix A). The state's narrative water quality standards provide that surface waters shall be "free from materials attributable to municipal, industrial, or other discharges or agricultural practices" which will "render any undesirable taste to fish flesh or, in any way, make fish inedible." In addition, the state's statewide fish consumption advisory applies to all waters known to provide a sport fishery.

Other beneficial uses identified in the state's water quality standards are agriculture (e.g., stock watering and irrigation) and industrial (e.g., washing and cooling). These uses apply to all classified rivers, streams, lakes, and reservoirs.

Four beneficial uses (aquatic life, recreation, drinking water, and fish consumption) are typically assessed for purposes of Section 305(b) reporting and Section 303(d) listing. All waterbodies included in the assessment database (ADB) and, therefore, all stream classes (I, IA, II, and III) and all lake classes (1-5) are assigned aquatic life and recreation beneficial uses. All Class I, IA, and II rivers and streams and all classified lakes and reservoirs are assigned the drinking water beneficial use. Fish consumption use is assumed to apply to all Class I, IA, and II rivers and streams, to those Class III streams known to provide a sport fishery, and to all Class 1 through 4 lakes and reservoirs.

C. Numeric Water Quality Standards

A numeric water quality standard is considered a safe concentration of a pollutant in water, associated with a specific beneficial use. Numeric standards are associated with all use classes. Ideally, if the numeric standard is not exceeded, the use will be protected. However, nature is very complex and variable, and the NDDoH may use a variety of assessment tools (e.g., chemical and biological monitoring) to fully assess beneficial uses. With few exceptions, protection for aquatic life and/or drinking water uses will also provide protection for less sensitive uses (e.g., agriculture and industrial uses). For some pollutants, numeric standards may applicable to more than one use and may be more stringent for one use than another. For example, the drinking water standard for selenium is 50 µg/L, while the chronic aquatic life standard is 5 µg/L.

As is the case for most states, the state of North Dakota's numeric standards for toxic pollutants are based on the EPA's aquatic life criteria. The EPA develops and publishes these criteria as required by Section 304(a) of the CWA. Most numeric standards have two parts, a chronic value and an acute value. The chronic standard is the highest concentration of a toxicant to which organisms can be exposed indefinitely with no harmful effects, including growth and reproduction. The acute standard protects aquatic organisms from potential lethal effects of a short-term "spike" in the concentration of the toxicant.

In the development of aquatic life criteria and associated standards, the EPA and the NDDoH have addressed some of the many toxicological, water chemistry, and practical realities the affect a toxicant's impact on aquatic biota. For example, pollutant concentrations and flow volumes vary in effluents and in receiving streams over time, aquatic organisms generally can tolerate higher concentrations of toxicants for shorter periods of time, and the sensitivity of aquatic organisms to toxicants often varies over their lifespan. EPA's approach for expressing water quality standards addresses varying toxicant concentrations, length of an averaging period for the standard, and the number of acceptable exceedances over time. These concepts are highly relevant to the interpretation of water quality standards and the assessment of waterbodies based on available data. In the development and implementation of numeric water quality standards, these concepts are referred to as:

- Magnitude;
- Duration; and
- Frequency.

Magnitude refers to the concentration of a given pollutant and is represented by the numeric standard. For example, the chronic and acute standards for copper are 14.0 and 9.3 µg/L, respectively. This is the "magnitude" of copper that, if not exceeded in water, will protect aquatic biota from chronic and acute effects.

Duration refers to the period of time the measured concentration of a toxicant can be averaged and still provide the desired level of protection to the aquatic community. In the context of toxicity to aquatic organisms, it would be unrealistic to consider a standard as an instantaneous maximum concentration never to be exceeded. On the other hand, toxicant concentrations averaged over too long a time could be under-protective, if it allowed exceedingly high lethal concentrations to be masked by the average. In general, EPA recommends a 4-day averaging period for chronic standards and a 1-hour averaging period for acute standards.

Frequency refers to the number of times a standard may be exceeded over a prescribed time period and still provide adequate protection. EPA guidance and state water quality standards specify that the numeric standards, both chronic and acute, should not be exceeded more than once in three years. The three year time frame is based on studies of the time its takes for aquatic communities to recover from a major disturbance.

D. Narrative Water Quality Standards

A narrative water quality standard is a statement(s) that prohibits unacceptable conditions from occurring in or upon surface waters, such as floating debris, oil, scum, garbage, cans, trash, or any unwanted or discarded material. Narrative standards also prohibit the discharge of pollutants, which alone or in combination with other substances, can 1) cause a public health hazard or injury to the environment; 2) impair existing or reasonable beneficial uses of surface waters; or 3) directly or indirectly cause concentrations of pollutants to exceed applicable standards. Narrative standards are often referred to as "free froms" because they help keep surface waters free from very fundamental and basic forms of water pollution (e.g., sediment and nutrients).

The association between narrative standards and beneficial use impairment is less well defined than it is for numeric standards. Because narrative standards are not quantitative, the determination that one has been exceeded typically requires a "weight-of-evidence" approach to the assessment showing a consistent pattern of water quality standards violations. The narrative standards relevant to this guidance document are found in state water quality standards Section 33-16-02.1-08 (Appendix A). These standards protect surface waters and aquatic biota from:

- Eutrophication (particularly lakes and reservoirs);
- Impairment of the biological community (exemplified by the Index of Biotic Integrity); and
- Impairment of fish for human consumption.

E. Antidegradation Policies and Procedures

In addition to numeric and narrative standards and the beneficial uses they protect, a third element of water quality standards is antidegradation. The fundamental concept of antidegradation is the protection of waterbodies whose water quality is currently better than applicable standards. Antidegradation policies and procedures are in place to maintain high quality water resources and prevent them from being degraded down to the level of water quality standards.

State water quality standards has established three categories or tiers of antidegradation protection (Appendix A). Category 1 is a very high level of protection and automatically applies to all Class I and IA rivers and streams, all Class 1, 2, and 3 lakes and reservoirs, and wetlands that are functioning at their optimal level. Category 1 may also apply to some Class II and III rivers and streams, but only if it can be demonstrated that there is remaining pollutant assimilative capacity, and both aquatic life and recreation uses are currently being supported. Category 2 antidegradation protection applies to Class 4 and 5 lakes and reservoirs and to Class II and III rivers and streams not meeting the criteria for Category 1. Category 3 is the highest level of protection and is reserved for Outstanding State Resource Waters. Waterbodies may only be designated Category 3 after they have been determined to have exceptional value for present and prospective future use for public water supplies, propagation of fish or aquatic biota, wildlife, recreational purposes, or agricultural, industrial, or other legitimate beneficial uses.

III. ASSESSMENT DATABASE

North Dakota's Assessment Database (ADB) contains 1,777 discreet assessment units (AUs) representing 56,009 miles of rivers and streams and 289 lakes and reservoirs. Within the ADB, designated uses are defined for each AU (i.e., river or stream reach and lake or reservoir) based on the state's water quality standards. Each use is then assessed using available chemical, physical and/or biological data.

With an estimated 56,009 miles of rivers and streams and 713,248 acres of lakes and reservoirs, it is impractical to adequately assess each and every mile of stream or every acre of lake. However, the NDDoH believes it is important to: 1) accurately assess those waters for which beneficial use assessment information is available; and 2) account for those stream miles and lake acres that are not assessed or for which there are insufficient data to conduct an assessment. As a result, the NDDoH has adopted the ADB to manage water quality assessment information for the state's rivers, streams, lakes, and reservoirs.

Developed by EPA, the ADB is an Access® based "accounting"/database management system that provides a standard format for water quality assessment information. It includes a software program for adding and editing assessment data and transferring assessment data between the personal computer and EPA. Assessment data, as compared to raw monitoring data, describes the overall health or condition of the waterbody by describing beneficial use impairment and, for those waterbodies where beneficial uses are impaired or threatened, the causes and sources of pollution affecting the beneficial use. The ADB also allows the user to track and report on TMDL-listed waters, including their development and approval status and de-listing rationale.

To create North Dakota's ADB, the state's 56,009 miles of rivers and streams and 289 lakes and reservoirs have been delineated into 1,777 discreet AUs. An AU can be an individual lake or reservoir, a specific river or stream reach or a collection of stream reaches in a sub-watershed. North Dakota's ADB is currently represented by 1,487 river and stream AUs and 290 lake and reservoir AUs (Note, Lake Sakakawea is represented by two assessment units in the ADB, one for the main reservoirs and one for the Little Missouri Bay segment of the reservoir.). Each of these AUs is then assessed individually, based on the availability of sufficient and credible data. In order to delineate and define AUs used in the ADB, the NDDoH follows a general set of guidelines:

1. Each AU is within the eight-digit USGS hydrologic unit.

2. Each river and stream AU is composed of stream reaches of the same water quality standards classification (I, IA, II or III).

3. To the extent practical, each AU is within a contiguous Level IV ecoregion.

4. Mainstem perennial rivers are delineated as separate AUs. Where these rivers join with another major river or stream within the eight-digit hydrologic unit, the river was further delineated into two or more AUs.

5. Tributary rivers and streams, which are named on USGS 1:100,000 scale planimetric maps or the National Hydrography Dataset (NHD), are delineated as separate AUs. These AUs may be further delineated, based on stream order or water quality standards classification.

6. Unnamed ephemeral tributaries to a delineated AU are consolidated into one unique AU. This is done primarily for accounting purposes so that all tributary stream reaches identified in the NHD are included in the ADB.

7. Stream reaches, which are identified in the NHD and on USGS 1:24,000 scale maps and which do not form either an indirect or direct hydrologic connection with a perennial stream, are not included in the ADB. This would include small drainages that originate and flow into closed basin lakes or wetlands. (Note: These delineation criteria do not apply to tributaries to Devils Lake)

The ADB provides an efficient accounting and data management system. It also allows for the graphical presentation of water quality assessment information by linking assessments contained in the ADB to the NHD file through "reach indexing" and geographic information systems (GIS). In order to facilitate the GIS data link, the NDDoH has "reach-indexed" each AU in the ADB to the NHD file. The product of this process is a GIS coverage that can be used to graphically display water quality assessment data entered in the ADB. An example can be seen in Figure 1, which depicts each of the reach-indexed AUs delineated in the Knife River Sub-basin (10130201).

Assessments completed and entered into the ADB also form the basis for the state's Section 319 Nonpoint Source (NPS) Assessment Report and Management Plan. Because of the way the NDDoH's Surface Water Quality Management Program is structured, there is complete integration of the state's Section 305(b) Water Quality Assessment Report, the Section 303(d) TMDL List and the Section 319 NPS Assessment Report and Management Plan.

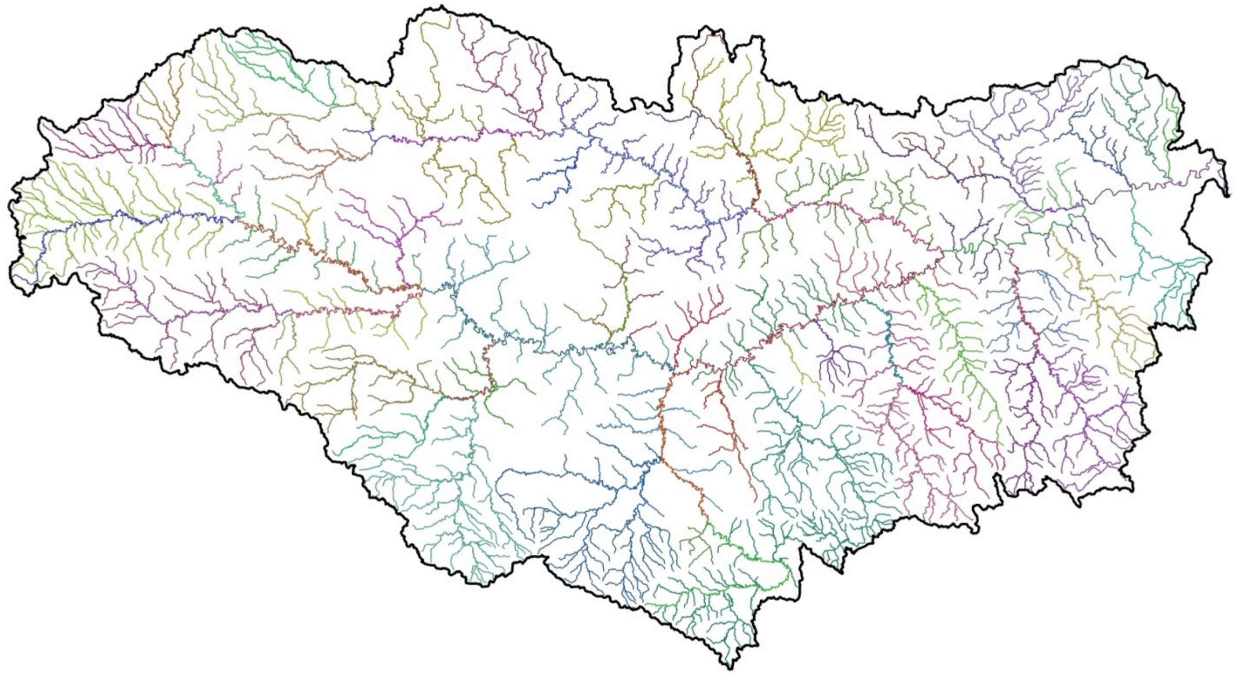

Figure 1. Map of Reach-Indexed Assessment Units Delineated in the Knife River Sub-basin (10130201).

IV. SUFFICIENT AND CREDIBLE DATA REQUIREMENTS AND OVERWHELMING EVIDENCE

A. Sufficient and Credible Data Requirements

For water quality assessments, including those done for purposes of Section 305(b) assessment and reporting and 303(d) listing, the NDDoH will use only what it considers to be sufficient and credible data. Sufficient and credible data are chemical, physical, and biological data that, at a minimum, meet the following criteria:

- Data collection and analysis followed known and documented quality assurance/quality control procedures.

- Water column chemical, biological or fish tissue data are 10 years old or less for rivers and streams and lakes and reservoirs, unless there is adequate justification to use older data (e.g., land use, watershed, or climatic conditions have not changed). Years of record are based on the USGS water year. Water years are from October 1 in one year through September 30 of the following year. It should be noted that it is preferable to split the year in the fall when hydrologic conditions are stable, rather than to use calendar years. Data for all 10 years of the period are not required to make an assessment.
- There are a minimum of 10 chemical samples collected in the 10-year period for rivers and streams. The 10 samples may range from one sample collected in each of 10 years or 10 samples collected all in one year.

- There should be a minimum of two samples collected from lakes or reservoirs collected during the growing season, April-November. The samples may consist of two samples collected the same year or samples collected in separate years.

- A minimum of five E. coli samples are collected during any 30-day consecutive period (e.g., calendar month) from May through September. The five samples per month may consist of five samples collected during the month in the same year or five samples collected during the same calendar month, but pooled across multiple years (e.g., two samples collected in May 2007, two samples collected in May 2008 and one sample collected in May 2012).

- For all chemical criteria that are expressed as a 30-day arithmetic average (e.g., chloride, sulfate, radium 226 and 228, and boron) a minimum of four daily samples must be collected during any consecutive 30-day period. Samples collected during the same day shall be averaged and treated as one daily sample.

- A minimum of two biological samples (fish and/or macroinvertebrate) are necessary in the most recent 10-year period per assessment unit. Samples may be collected from multiple sites within the assessment stream reach, multiple samples collected within the same year, or individual samples collected during multiple years. Samples may consist of a minimum of two fish samples, two macroinvertebrate samples, or one fish and one macroinvertebrate sample. Samples should be collected from sites considered to be representative of the AU. At a minimum one site should be located at the downstream end of the assessed stream reach.

- The mean methylemercury concentration is estimated from a minimum of 3 composite samples (preferred) or 9 individual fish samples representative of the filet. When composite samples are used, each composite sample should consist of a minimum of three individual fish per composite with the smallest fish in the composite no less than 75% of the largest fish by length. Each composite sample should also be representative of a distinct age class of the target fish species in the waterbody. In other words, if three composite samples are collected, one composite should represent small fish, one representing medium sized fish and one representing large fish in the population.

- If individual fish samples are collected then a minimum of 9 fish samples should be used to estimate the mean methylmercury concentration. The same criteria used to collect a composite sample should be used for individual fish samples where fish should be representative of at least three size classes and a minimum of three fish should be collected per size class (3 size classes times 3 fish per size class equals 9 fish). In cases where individual fish samples are used, then the number of fish per size class should be equal.

B. Overwhelming Evidence

There are situations where a single set of data is all that is needed to make a use support determination. For example, a single set of water chemistry data may be sufficient to establish that a waterbody is not supporting aquatic life use. In such situations where a single data set irrefutably proves that impairment exists, an impairment determination may be based on this “overwhelming evidence.”

A number of factors are evaluated when making a determination as to whether data can be used as a basis for an "overwhelming evidence" assessment. Factors include the technical soundness of the methods used to collect the data and the spatial and temporal coverage of the data as it relates to the waterbody being assessed. Data quality and data currency (i.e., how old are the data?) are also factors which are considered.

Data cannot be overwhelming evidence unless the methods used for collection and analysis meets the most stringent standards for reliability and validity. The person evaluating the data must be certain that the data are representative of actual current waterbody conditions. The data must be representative of the spatial extent of the waterbody and of relevant temporal patterns. Data more than three or four years old should not be used as overwhelming evidence unless there is a strong basis for concluding that conditions have not changed since the data were collected.

V. BENEFICIAL USE ASSESSMENT METHODOLOGY

A. Aquatic Life Use Assessment Methodology for Rivers and Streams

The following is a description of the assessment methodology or decision criteria used to assess aquatic life and recreation uses where they are assigned to rivers and streams in the state. The methodologies used to assess drinking water and fish consumption uses are the same for both rivers and lakes and are provided in separate sections of this document.

All water quality assessments entered into the ADB for Section 305(b) reporting and Section 303(d) TMDL listing are based on "sufficient and credible" monitoring data. Physical and chemical monitoring data used for these assessments includes conventional pollutant (e.g., dissolved oxygen, pH, temperature, ammonia, fecal coliform bacteria, and E. coli bacteria) and toxic pollutant (e.g., trace elements and pesticides) data collected for the most recent 10-year period. Biological monitoring data used for assessment includes fish and macroinvertebrate data collected by the NDDoH during the last 10 years (i.e., 2003-2012), EPA National River and Stream Assessment data collected in 2008 and 2009, and Red River mainstem biological assessment data collected in 2010.

As stated previously, use impairment for the state's rivers and streams is assessed for aquatic life and recreation. The following is the beneficial use decision criteria utilized for these assessments.

The NDDoH uses both chemical and biological data when assessing aquatic life use support for the state's rivers and streams. In some cases, both chemical data and biological data are used to make an assessment determination for an AU. Where both data are available, the NDDoH uses a weight-of-evidence approach in making an assessment decision. For example, if there are chemical data that do not show an aquatic life use impairment, but there are sufficient and credible biological data to show an impairment to the aquatic community, then the use-support decision will be to list the river or stream AU as "not supporting."

1. Chemical Assessment Criteria

In general, aquatic life use determinations utilizing chemical data are based on the number of exceedances of the current *Standards of Quality for Waters of the State* (Appendix A) for DO, pH, and temperature and on the number of exceedances of the acute or chronic standards for ammonia, aluminum, arsenic, cadmium, copper, cyanide, lead, nickel, selenium, silver, zinc, and chromium. The acute and chronic water quality standards for trace metals are expressed as total recoverable metals and not as dissolved metals. However, where dissolved metals data are available, use support assessments are made by applying the dissolved metals data to the water quality standards expressed as the total recoverable fraction. Further, for acute and chronic criteria that are hardness dependent (i.e., cadmium, copper, chromium (III), lead, nickel, silver, and zinc), where hardness of the sample is greater than 400 mg/L, the hardness value used in the criteria calculation will be capped at 400 mg/L.

The following are the use support decision criteria that the NDDoH uses to assess aquatic life use based on chemical data:

- *Fully Supporting:*

  For the conventional pollutants DO, pH, and temperature, the standards of 5 mg/L (daily minimum) for DO, 7.0 to 9.0 (Class I and IA streams and all lakes) and 6.0 to 9.0 (Class II and III streams) for pH and 29.4 EC (85 EF) (maximum) for temperature are not exceeded in the AU. Consistent with state water quality standards (Appendix A), if the DO or pH standard is exceeded, but in 10 percent or less of the samples and there is no record of lethality to aquatic biota, then the AU is also assessed as “fully supporting”.

  For ammonia and other toxic pollutants (e.g., trace elements and organics), aquatic life is assessed as “fully supporting” if the acute or chronic standard is not exceeded during any consecutive three-year period.

- *Fully Supporting but Threatened*:

  For DO and pH, one or more standards were exceeded in greater than 10 percent to 25 percent of the measurements taken during the 10-year assessment period. The temperature standard is exceeded, but in 10 percent or less of the measurements taken during the 10-year assessment period.

  For ammonia and other toxic pollutants, the acute or chronic standard was exceeded once or twice during any consecutive three-year period during the 10-year assessment period.

- *Not Supporting*:

  For DO and pH, one or more standards were exceeded in greater than 25 percent of the measurements taken during the 10-year assessment period. The temperature standard is exceeded in greater than 10 percent of the measurements taken during the 10-year assessment period.

  For ammonia and other toxic pollutants, the acute or chronic standard was exceeded three or more times during any consecutive three-year period during the 10-year assessment period.

2. Biological Assessment Criteria

Aquatic-life use, or biological integrity, can be defined as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitats of the region." (Karr, 1981) When the aquatic community (e.g., fish and macroinvertebrates) is similar to that of "least disturbed" habitats in the region, termed "reference condition," aquatic life use can be assessed as fully supporting. When the aquatic community deviates significantly from reference condition, it is assessed as not supporting aquatic life use.

While chemical data provides an indirect assessment of aquatic life use impairment, direct measures of the biological community are believed to be a more accurate assessment of aquatic-life use or biological integrity. The state water quality standards (Appendix A) describe a narrative biological goal that "the biological condition of surface waters shall be similar to that of sites or waterbodies determined by the NDDoH to be regional reference sites." This narrative standard also states that it is the intent of the state, in adopting this narrative goal, "to provide an additional assessment method that can be used to identify impaired surface waters."

IBI Development

The NDDoH began a stream biological monitoring and assessment program in 1993. In order to interpret these biological data and to develop a biological assessment methodology, the NDDoH has adopted the "multi-metric" index of biological integrity (IBI) approach to assess biological integrity or aquatic-life use support for rivers and streams. The multi-metric index approach assumes that various measures of the biological community (e.g., species richness, species composition, trophic structure, and individual health) respond to human-induced stressors (e.g., pollutant loadings or habitat alterations). Each measure of the biological community, termed a "metric," is evaluated and scored on a scale of 0-100 . The higher the score, the better will be the biological condition and, presumably, the lower the pollutant or habitat impact.

Final metrics which go into each IBI are selected after a large set of candidate metrics go through a series of data reduction steps. First, each of the candidate metrics are evaluated through the use of histograms, to ensure each has an adequate range of data. The second step includes a "signal to noise analysis" to evaluate the variation of each metric. Values of less than 1 are eliminated from further consideration. The third step involves tests for responsiveness, including subjecting candidate metrics to the Mann-Whitney U Test and evaluating box plots used to distinguish metric scores from "reference" and "disturbed" sites. A Mann-Whitney U Test is a nonparametric test that evaluates the difference between the medians of two independent data sets (i.e., reference and disturbed sites). Metrics with $p > 0.20$ are eliminated due to a lack of response. Metrics with p values less than 0.20 are retained for further evaluation and subjected to box plot analysis. If the box plots for the metric does not distinguish between reference and disturbed, that metric is eliminated. Finally, a correlation matrix is completed using all remaining metrics that are not eliminated due to low responsiveness or other poor predictive characteristics. When metric pairs are highly correlated ($r>0.80$) one of the pair is eliminated to reduce redundancy within the final set of metrics.

Once the final metrics are determined for an IBI, raw metric values are transformed into standardized metric scores. All metric scores are computed using the following equations developed by Minns et al. (1994) that standardizes metrics on a scale of 0 to 100.

Metrics that decrease with impairment:

$$Ms = (M_R/M_{MAX}) \times 100$$

Metrics that increase with impairment:

$$Ms = (M_{MAX} - M_R) / (M_{MAX} - M_{MIN}) \times 100;$$

Where Ms = standardized metric value;
M_R = the raw metric value;
M_{MAX} = the maximum value; and
M_{MIN} = the minimum metric value.

Maximum (M_{MAX}) and minimum (M_{MIN}) values for each metric are set at the 95th and 5th percentiles, respectively, of the entire data set. The overall IBI score is then calculated as the mean of all standardized metric scores.

To date, the NDDoH has developed final multi-metric IBIs for fish in the Lake Agassiz Plain ecoregion and macroinveretebrates in the Lake Agassiz Plain (48) and Northern Glaciated Plain (46) level III ecoregions (Figure 2).

A revised fish IBI for the Lake Agassiz Plain ecoregion was published in a report entitled *Fish Index of Biotic Integrity for Wadable Streams in the Lake Agassiz Plain (48) Ecoregion* (NDDoH, 2011a). This IBI is based on 7 metrics (Table 2).

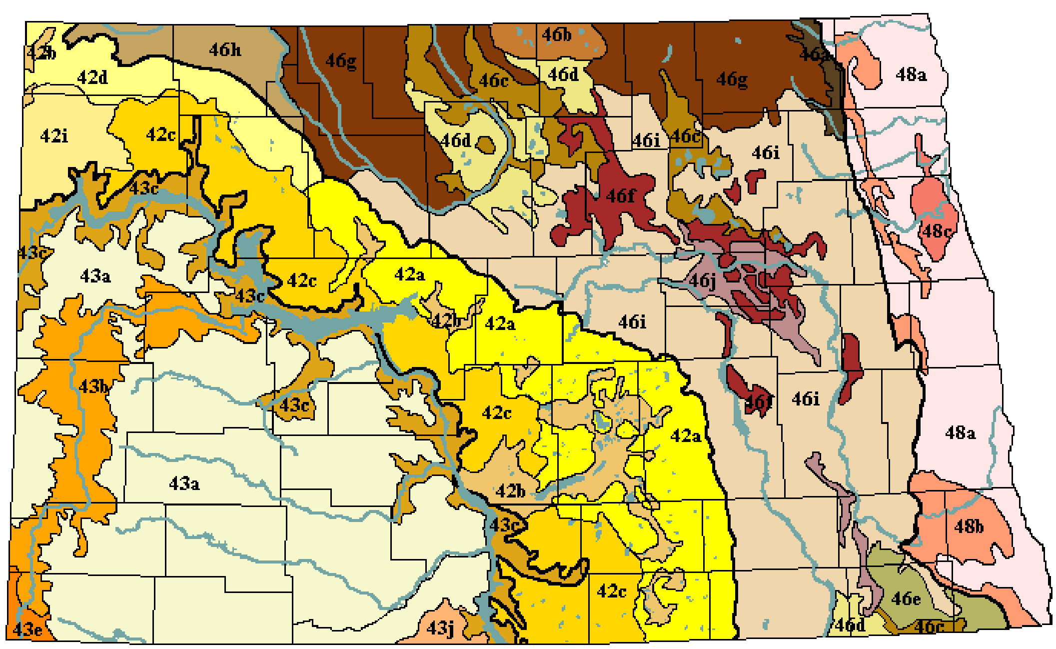

Figure 2. Map Depicting Ecoregions in North Dakota (Lake Agassiz Plain [48], Northern Glaciated Plain [46], Northwestern Glaciated Plain [42], Northwestern Great Plain [43]).

Table 2. Lake Agassiz Plain (48) Ecoregion Fish IBI Metrics.

Final Metric	Category	Response to Perturbation
CPUE (Fish/Minute)	Abundance	Decrease
Percent Dominant Taxon	Composition	Increase
Percent Generalist, Omnivore Individuals	Trophic	Increase
Percent Insectivore Biomass	Trophic	Decrease
Percent Lithophilic Individuals	Reproductive	Decrease
Percent Minnow and Darter Taxa	Richness	Decrease
Total Taxa	Richness	Decrease

The macroinvertebrate IBI which was developed for the Lake Agassiz Plain (48) ecoregion was published in a report entitled *Macroinvertebrate Index of Biotic Integrity for the Lake Agassiz Plain Ecoregion (48) of North Dakota* (NDDoH, 2011b). The macroinvertebrate IBI for the Lake Agassiz Plain ecoregion is based on 7 metrics (Table 3). The macroinvertebrate IBI which was developed for the Northern Glaciated Plain (46) ecoregion was published in the report entitled *Macroinvertebrate Index of Biotic Integrity for the Northern Glaciated Plain Ecoregion (46) of North Dakota* (NDDoH, 2010). The macroinvertebrate IBI for the Northern Glaciated Plain ecoregion is based on 6 metrics (Table 4).

Table 3. Lake Agassiz Plain (48) Ecoregion Macroinvertebrate IBI Metrics.

Final Metric	Category	Response to Perturbation
Diptera Taxa	Richness	Decrease
Hilsenhoff Biotic Index	Tolerance	Increase
Percent EPT	Composition	Decrease
Scraper Taxa	Trophic	Decrease
Shannon Weiner Index	Composition	Decrease
Sprawler Taxa	Habit	Decrease
Total Taxa	Richness	Decrease

Table 4. Northern Glaciated Plain (46) Ecoregion Macroinvertebrate IBI Metrics.

Final Metric	Category	Response to Perturbation
Percent EPT	Composition	Decrease
Percent Non-Insect Individuals	Composition	Increase
Percent Univoltine Individuals	Life Cycle/Composition	Decrease
Tolerant Taxa	Tolerance	Increase
Hilsenhoff Biotic Index (HBI)	Tolerance	Increase
Swimmer Taxa	Habit	Increase

Beneficial Use Assessment Scoring Thresholds

In order to assess biological condition or aquatic life support of rivers and streams, we need to be able to compare what we are measuring to some estimate what would be expected to be good biological condition or fully supporting aquatic life use for the river or stream. This is also referred to as the river or stream's "biological potential." Setting reasonable expectations for a biological indicator, like an IBI, is one of the greatest challenges to making an assessment of biological condition. Is it appropriate to take a historical perspective, and try to compare current conditions to some estimate of pre-Columbian conditions, or to pre-industrial conditions, or to some other point in history? Or is it acceptable to assume that some level of anthropogenic disturbance is a given, and simply use the best of today's conditions as the measuring stick against which everything else is assessed? The answers to all these questions relate to the concept of "reference condition" (Bailey et al. 2004, Stoddard et al. 2006).

Due to the difficulty of estimating historical conditions for most biological indicators, the Department has adopted the "least-disturbed condition" as the operational definition of reference condition. "Least-disturbed condition" is found in conjunction with the best available physical, chemical and biological habitat conditions for a given area or region (e.g., ecoregion) given the current state of the landscape. "Reference" or "least-disturbed" condition is described by evaluating data collected at sites selected based on a set of explicit criteria defining what is "best" or "least-disturbed" by human activities. These criteria vary from ecoregion to ecoregion in the state, and are developed iteratively with the goal of identifying a set of sites which are influenced the least by human activities. The Department's procedure for selecting reference sites is described in Appendix B.

Once a set of "reference sites" are selected for a given ecoregion in the state, they are sampled using the same methods employed at sites used to develop the IBI or where assessments are conducted. The range of conditions (e.g., habitat variables, chemical concentrations, or IBI scores) found at these "reference sites" describes a distribution of values , and extremes of this distribution are used to set thresholds which are used to distinguish sites that are in relatively good condition from those that are clearly not. One common approach, and the one used by the Department, is to examine the range or statistical distribution of IBI scores for a set of reference sites within an ecoregion (Barbour et al. 1999), and, depending on the reference site sample size, to use the 5th or 10th percentile of this distribution to separate the most disturbed (i.e., poor biological condition) sites from moderately disturbed (i.e., fair biological condition) sites. Similarly, the 25th or 50th percentile of the distribution is used to distinguish between moderately disturbed sites and those in "least-disturbed condition." Details on how these thresholds were set for each multi-metric IBI developed by the Department are available in each of the three IBI reports referenced above, while the IBI scoring thresholds for each biological condition class and use support category are provided in Tables 5, 6 and 7.

Table 5. Scoring Thresholds by Biological Condition Class and Aquatic Life Use Support Category for the Lake Agassiz Plain Ecoregion Fish IBI.

IBI Score	Biological Condition Class	Aquatic Life Use Support
≥71	Good	Fully Supporting
<71 and ≥48	Fair	Fully Supporting, but Threatened
<48	Poor	Not Supporting

Table 6. Scoring Thresholds by Biological Condition Class and Aquatic Life Use Support Category for the Lake Agassiz Plain Ecoregion Macroinvertebrate IBI.

IBI Score	Biological Condition Class	Aquatic Life Use Support
≥76	Good	Fully Supporting
<76 and ≥45	Fair	Fully Supporting, but Threatened
<45	Poor	Not Supporting

Table 7. Scoring Thresholds by Biological Condition Class and Aquatic Life Use Support Category for the Northern Glaciated Plain Ecoregion Macroinvertebrate IBI.

IBI Score	Biological Condition Class	Aquatic Life Use Support
≥66	Good	Fully Supporting
<66 and ≥40	Fair	Fully Supporting, but Threatened
<40	Poor	Not Supporting

Aquatic Life Use Support Assessment

Site and Data Requirements

For Section 305(b) assessment and Section 303(d) listing purposes, use assessments based on biological data should ideally be done at the Assessment Unit (AU) scale. The number of sites and samples necessary to conduct an assessment depends on the spatial and temporal variability inherent to the AU. For AUs that are represented by a relatively small, homogeneous stream reach, one site located on the AU may be sufficient. For larger more complex AUs, multiple sample sites with multiple samples collected over time may be necessary. When the number of sites located within an AU is limited, it may be necessary to split the AU into smaller segments and then to assess the smaller AU segment represented by the site. In general, best professional judgment should be used to determine the adequacy of sites and samples when making a use support decision for an AU based on biological data, but as a rule of thumb one should follow these general guidelines.

1. Sites should be located within the AU such that each site represents a homogeneous reach within the AU.

2. At least one site should be located near the downstream end of the assessed stream reach.

3. Additional sites should be located a minimum of 2.5 miles (4 km) apart or where there are significant changes in the hydrology or geomorphology of the stream, or where there is a significant change in landuse adjacent to the stream.

4. When the AU consists of a mainstem segment and tributaries, sites should be located on the mainstem above and below the tributaries as well as on the tributary stream(s).

While it may be possible to conduct an assessment based on one site located within the AU, a minimum of two samples are required to conduct an assessment. Samples should be collected within the last 10 years and may consist of two or more samples collected at one site or one sample collected each at two or more sites. For assessment purposes, a sample consists of one biological assemblage sampled at one point in time. Therefore, two samples may be represented by two biological assemblages (e.g., fish and macroinvertebrates) sampled at the same time or the same biological assemblage sampled at the same site twice. When the same biological assemblage is sampled at the same site, samples should be collected at least 30 days apart.

Using the appropriate biological condition and aquatic life use support scoring thresholds for the biological assemblage and ecoregion, an aquatic life use support assessment is made for each sample collected within the AU. Using each sample aquatic life use support assessment, an overall assessment of the AU is made using the following use support decision criteria:

- *Fully Supporting*:

  Use support assessments for all samples are fully supporting.

- *Fully Supporting, but Threatened*:

  Use support assessment for all samples are fully supporting, but threatened; or

  Use support assessment for at least one sample is fully supporting, and use support assessments for all other samples are not supporting.

- *Not Supporting*:

  Use support assessments for all samples are not supporting.

Section 303(d) Listing Criteria

When biological data results in an aquatic life use support decision that the AU is either fully supporting, but threatened or not supporting and if there are no other chemical or habitat data which can be used to list a pollutant cause, then the AU should be listed on the 303(d) list as category 5A (Table 1), but with the condition that it will be targeted for further stressor identification monitoring and assessment. Only after a stressor identification assessment is completed will the AU be targeted for TMDL development.

Other Biological Assessment Data

The NDDoH recognizes that there may be biological data that are available for waterbodies in the state that meet the sufficient and credible data requirements. Where these data are available the NDDoH encourages the use of this information to make aquatic life use support decisions. While it is not possible to assess these sites or waterbodies as fully supporting, sites that are exemplified by low taxa richness, presence of pollutant tolerant taxa and/or low density, can be assessed as not supporting aquatic life use.

B. Recreation Use Assessment Methodology for Rivers, Streams, Lakes and Reservoirs

Recreation use is any activity that relies on water for sport or enjoyment. Recreation use includes primary contact activities such as swimming and bathing and secondary contact activities such as boating, fishing, and wading. Recreation use in rivers, streams, lakes and reservoirs is considered fully supporting when there is little or no risk of illness through either primary or secondary contact with the water. The state's recreation use support assessment methodology for rivers, streams, lakes and reservoirs is based on the state's numeric water quality standards for E. coli bacteria (Appendix A).

For each assessment based on E. coli data, the following criteria are used:

- Assessment Criterion 1: For each assessment unit, the geometric mean of samples collected during any 30-day consecutive period (e.g., calendar month) from May 1 through September 30 does not exceed a density of 126 CFUs per 100 mL. A minimum of five samples collected during a 30-day consecutive period (e.g., calendar month) is required to compute the geometric mean. If necessary, samples may be pooled by calendar month across years.

- Assessment Criterion 2: For each assessment unit, less than 10 percent of samples collected during any 30-day consecutive period (e.g., calendar month) from May 1 through September 30 exceed a density of 409 CFUs per 100 ml. A minimum of ten samples collected during a 30-day consecutive period is required to compute the percent of samples exceeding the criteria. If necessary, samples may be pooled by calendar month across years.

  The two criteria are then applied using the following use support decision criteria:

  - Fully Supporting: Both criteria 1 and 2 are met.

  - Fully Supporting but Threatened: Criterion 1 is met, but 2 is not.

  - Not Supporting: Criterion 1 is not met. Criteria 2 may or may not be met.

C. Aquatic Life and Recreation Use Assessment Methodology for Lakes and Reservoirs

The following is a description of the assessment methodology or decision criteria used to assess aquatic life and recreation uses for lakes and reservoirs in the state based on trophic response indicators. The methodology used to assess the drinking water, fish consumption, agricultural, and industrial uses is the same for both rivers and lakes and is provided in a separate section of the document.

1. Aquatic Life and Recreation

The state's narrative water quality standards (Appendix A) form the basis for aquatic life and recreation use assessment for Section 305(b) reporting and the Section 303(d) TMDL list. State water quality standards contain narrative criteria that require lakes and reservoirs to be "free from" substances "which are toxic or harmful to humans, animals, plants, or resident aquatic biota" or are "in sufficient amounts to be unsightly or deleterious." Narrative standards also prohibit the "discharge of pollutants" (e.g., organic enrichment, nutrients, or sediment), "which alone or in combination with other substances, shall impair existing or reasonable beneficial uses of the receiving waters."

Trophic status indicators are used by the Department as the primary means to assess whether a lake or reservoir is meeting the narrative standards. Trophic status is a measure of the productivity of a lake or reservoir and is directly related to the level of nutrients (i.e., phosphorus and nitrogen) entering the lake or reservoir from its watershed and/or from the internal recycling of nutrients. Highly productive lakes, termed "hypereutrophic," contain excessive phosphorus and are characterized by large growths of weeds, bluegreen algal blooms, low transparency, and low dissolved oxygen (DO) concentrations. These lakes experience frequent fish kills and are generally characterized as having excessive rough fish populations (carp, bullhead, and sucker) and poor sport fisheries. Due to the frequent algal blooms and excessive weed growth, these lakes are also undesirable for recreational uses such as swimming and boating.

Mesotrophic and eutrophic lakes, on the other hand, have lower phosphorus concentrations, low to moderate levels of algae and aquatic plant growth, high transparency, and adequate DO concentrations throughout the year. Mesotrophic lakes do not experience algal blooms, while eutrophic lakes may occasionally experience algal blooms of short duration, typically a few days to a week.

Due to the relationship between trophic status indicators and the aquatic community (as reflected by the fishery) or between trophic status indicators and the frequency of algal blooms, trophic status becomes an effective indicator of aquatic life and recreation use support in lakes and reservoirs. For purposes of this assessment methodology, it is assumed that hypereutrophic lakes do not fully support a sustainable sport fishery and are limited in recreational uses, whereas mesotrophic lakes fully support both aquatic life and recreation use. Eutrophic lakes may be assessed as fully supporting, fully supporting but threatened, or not supporting their uses for aquatic life or recreation.

Eutrophic lakes are further assessed based on: 1) the lake or reservoir's water quality standards fishery classification; 2) information provided by North Dakota Game and Fish Department Fisheries Division staff, local water resource managers and the public; 3) the knowledge of land use in the lake's watershed; and/or 4) the relative degree of eutrophication. For example, a eutrophic lake, which has a well-balanced sport fishery and experiences infrequent algal blooms, is assessed as fully supporting with respect to aquatic life and recreation use. A eutrophic lake, which experiences periodic algal blooms and limited swimming use, would be assessed as not supporting recreation use. A lake fully supporting its aquatic life and/or recreation use, but for which monitoring has shown a decline in its trophic status (i.e., increasing phosphorus concentrations over time), would be assessed as fully supporting, but threatened.

It is recognized that this assessment procedure ignores the fact that, through natural succession, some lakes and reservoirs may display naturally high phosphorus concentrations and experience high productivity. While natural succession or eutrophication can cause high phosphorus concentrations, research suggests that these lakes are typically eutrophic and that lakes classified as hypereutrophic are reflecting external nutrient loading in excess of that occurring naturally.

Since trophic status indicators specific to North Dakota waters have not been developed, Carlson's trophic status index (TSI) (Carlson, 1977) has been chosen to assess the trophic status of lakes or reservoirs. To create a numerical TSI value, Carlson's TSI uses a mathematical relationship based on three indicators: 1) Secchi Disk Transparency in meters (m); 2) surface total phosphorus concentration expressed as µg/ L; and 3) chlorophyll-a concentration expressed as µg/L.

This numerical value, ranging from 0-100, corresponds to a trophic condition with increasing values indicating a more eutrophic (degraded) condition. Carlson's TSI estimates are calculated using the following equations and is also depicted graphically in Figure 3.

- Trophic status based on Secchi Disk Transparency (TSIS):
  TSIS = 60 - 14.41 ln (SD)
  Where SD = Secchi disk transparency in meters.

- Trophic status based on total phosphorus (TSIP):
  TSIP = 14.20 ln (TP) + 4.15
  Where TP = Total phosphorus concentration in $\mu g\ L^{-1}$.

- Trophic status based on chlorophyll-a (TSIC):
  TSIC = 9.81 ln (TC) + 30.60
  Where TC = Chlorophyll-a concentrations in $\mu g\ L^{-1}$.

In general, of the three indicators, it is believed that chlorophyll-a is the best indicator of trophic status, since it is a direct measure of lake productivity. Secchi disk transparency should be used next, followed by phosphorus concentration. In theory, for a given lake or reservoir, the measures of chlorophyll-a, Secchi disk transparency, and phosphorus concentration are all interrelated and should yield similar trophic status index values. This, however, is usually not the case. Many lakes and reservoirs in the state are shallow and windswept causing non-algal turbidity to limit light penetration. This situation may result in a lake having a high phosphorus concentration, low Secchi disk transparency, and low chlorophyll-a concentration. In other instances, other micronutrients may be limiting algal growth even though excessive phosphorus is present.

When conducting an aquatic life and recreation use assessment for a lake or reservoir, the average trophic status index score should be calculated for each indicator. When the trophic status index scores for each indicator (chlorophyll-a, Secchi disk transparency, and phosphorus concentration) each result in a different trophic status assessment then the assessment should be based first on chlorophyll-a, followed by Secchi disk transparency. Only when there are not adequate chlorophyll-a and/or Secchi disk transparency data available to make an assessment should phosphorus concentration data be used.

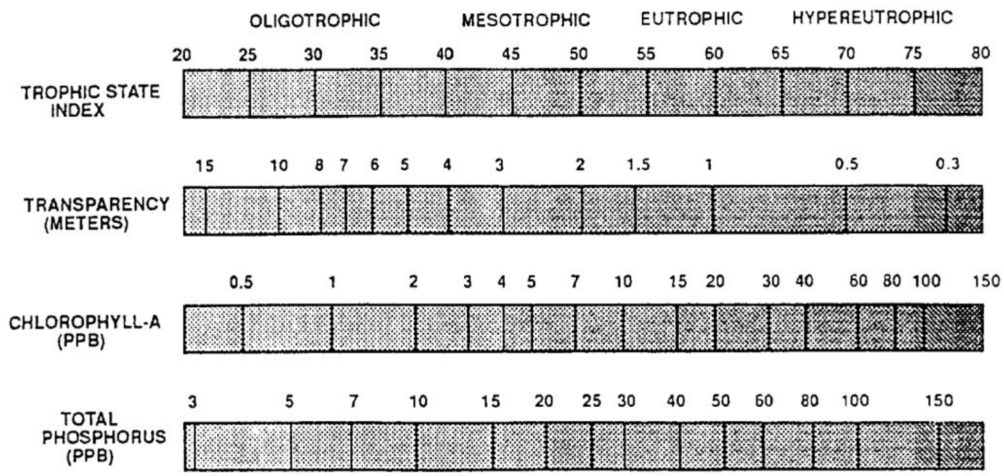

Figure 3. A Graphic Representation of Carlson's TSI.

D. Drinking Water Supply Use Assessment Methodology for Rivers, Lakes, and Reservoirs

Drinking water is defined as “waters that are suitable for use as a source of water supply for drinking and culinary purposes, after treatment to a level approved by the NDDoH” (Appendix A). All Class I, IA, and II rivers and streams, with the exception of the Sheyenne River from its headwaters to 0.1 mile downstream from Baldhill Dam, and all lakes and reservoirs classified in the state water quality standards (Appendix A), with the exception of Lake George in Kidder County, are assigned the drinking water supply beneficial use. While most lakes and reservoirs are assigned this use, few currently are used as a drinking water supply. Lake Sakakawea is the current drinking water supply for the Southwest Water Pipeline and the cities of Garrison, Parshall, Pick City, and Riverdale.

Drinking water use is assessed by comparing ambient water quality data to the state water quality standards (Tables 1 and 2 in Appendix A). Ambient water chemistry data are compared to the water quality standards for chloride, sulfate, and nitrate (Table 8) and to the human health standards for Class I, IA, and II rivers and streams (see Table 2 in Appendix A). Drinking water supply is not a designated use for Class III rivers and streams or for the Sheyenne River from its headwaters to 0.1 mile downstream from Baldhill Dam. The human health standard for Class I, IA, and II rivers and streams considers two means of exposure: 1) ingestion of contaminated aquatic organisms; and 2) ingestion of contaminated drinking water.

Drinking water use is also protected through the state's narrative water quality standards. To paraphrase, narrative standards provide language that waters of the state shall be free from materials that produce a color or odor, or other conditions to such a degree as to create a nuisance. Further, state narrative standards provide language that states that waters of the state shall be "free from substances….in concentrations or combinations which are toxic or harmful to **humans**, animals, plants, or resident biota." There shall also be "no discharge of pollutants, which …..shall cause a public health hazard or injury to environmental resources."

Table 8. State Water Quality Standards for Chloride, Sulfate, and Nitrate (Appendix A).

	Water Quality Standards (mg/L)		
Stream Classification	**Chloride[1]**	**Sulfate[1]**	**Nitrate[2]**
Class I	100	250	10
Class IA	175	450[3]	10
Class II	250	450	10

[1]Expressed as a 30-day arithmetic average based on a minimum of four daily samples collected during the 30-day period.
[2]The water quality standard for nitrite of 1 mg/L shall also not be exceeded.
[3] The site specific sulfate standard for the Sheyenne River from its headwaters to 0.1 mile downstream from Baldhill Dam is 750 mg/L.

In order to make beneficial use determinations for drinking water, the following decision criteria are used:

- *Fully Supporting:*

  Based on Numeric Standards: No exceedances of the water quality standard for nitrate, one or fewer exceedances of the 30-day average standards for chloride or sulfate, and no exceedances of any of the human health standards.

  Based on Narrative Standards: No drinking water complaints on record in the last two years.

- *Fully Supporting but Threatened:*

  Based on Numeric Standards: The fully supporting, but threatened use assessment designation is not applied to the drinking water use. Waters are either assessed as fully supporting or not supporting based on chemical data applied to the numeric standards.

  Based on Narrative Criteria: No impairment based on the numeric criteria, but a declining trend in water quality over time suggests a measurable increase in the cost to treat water for drinking water supply may occur if the trend continues.

- *Not Supporting*:

  Based on Numeric Criteria: One or more exceedances of the water quality standard for nitrate, two or more exceedances of the 30-day average criteria for chloride or sulfate, or one or more exceedances of any of the human health standards.

Based on Narrative Criteria: Knowledge of taste and odor problems or increased treatment costs have been associated with pollutants.

E. Fish Consumption Use Assessment Methodology for Rivers, Lakes and Reservoirs

As stated previously, the state's narrative water quality standards provide that surface waters shall be "free from materials attributable to municipal, industrial, or other discharges or agricultural practices" which will "render any undesirable taste to fish flesh or, in any way, make fish inedible." Fish consumption use is assumed to apply to all Class I, IA, and II rivers and streams, to those Class III streams known to provide a sport fishery and to all Class 1 through 4 lakes and reservoirs.

The beneficial use assessment methodology for fish consumption is based on the U.S. Environmental Protection Agency's (EPA) recommended methylmercury fish tissue criterion of 0.3 µg/g (EPA, 2001), and is consistent with the state's fish advisory guidelines for the general population. The EPA recommended mercury criterion is based on a reference dose (based on noncancer human health effects) of 0.0001 mg methylemercury/kg body weight-day minus the relative source contribution which is estimated to be 2.7×10^{-5} mg methylmercury/kg body weight-day. The EPA criterion assumes an average human body weight default value of 70 kg (154 pounds) for adults and an average meal size of 0.0175 kg (6 ounces).

The Department's assessment methodology for fish consumption is also based on the US EPA's "Guidance for Implementing the January 2001 Methylymercury Water Quality Criterion, Final" (EPA, 2009) and "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories", volume 1 (EPA, 2000). Based on these two guidance documents a waterbody is assessed for fish consumption use using the mean concentration of at least one piscivorous game fish species (e.g., walleye, sauger, northern pike, catfish, largemouth bass, or small mouth bass) found in the waterbody. The mean methylemercury concentration is estimated from a minimum of 3 composite samples (preferred) or 9 individual fish samples representative of the filet. When composite samples are used, each composite sample should consist of a minimum of three individual fish per composite with the smallest fish in the composite no less than 75% of the largest fish by length. Each composite sample should also be representative of a distinct age class of the target fish species in the waterbody. In other words, if three composite samples are collected, one composite should represent small fish, one representing medium sized fish and one representing large fish in the population.

If individual fish samples are collected then a minimum of 9 fish samples should be used to estimate the mean methylmercury concentration. The same criteria used to collect a composite sample should be used for individual fish samples where fish should be representative of at least three size classes and a minimum of three fish should be collected per size class (3 size classes times 3 fish per size class equals 9 fish). In cases where individual fish samples are used, then the number of fish per size class should be equal.

The EPA recommends using the t-test to determine whether the mean methylmercury concentration in fish tissue samples in a waterbody exceeds the criterion with statistical significance. The t-statistic is used to test the null hypothesis that the mean concentration of methylmercury in fish is equal to or less than the fish tissue criterion of 0.3 µg/g. The alternate hypothesis is that the mean concentration of methylmercury in fish is greater than the criterion. Where the null hypothesis is true the result is an assessment where fish consumption is "fully supporting." Where the null hypothesis is rejected in favor of the alternative hypothesis then fish consumption use is assessed as "not supporting." For purposes of the state's assessment methodology the 0.05 significance level ($p \leq 0.05$) has been selected. This means there is a 5% chance of rejecting the null hypothesis when it is really true (Type I error).

The t-test (t_c) is calculated from the sample mean (z) and variance (s^2) from the sample data as:

$$t_c = (z-c) / s$$

Where,

t_c = test statistic;

z = mean methylmercury concentration;

c = methylmercury criterion; and

s = standard deviation of the mean.

The null hypothesis of no difference is rejected in favor of the alternative hypothesis of exceedance if:

$$t_c > t_{\alpha,n-1}$$

Where, $t_{\alpha,n-1}$ is the tabulated value of the Student-t distribution corresponding to the level of significance α=0.05 and n-1 degrees of freedom (n=sample size) (Table 9).

Table 9. One-sided Student-t Distribution Values for α=0.05 and n-1 Degrees of Freedom.

	n-1 degrees of freedom									
	2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Student-t value	2.920	2.353	2.132	2.015	1.943	1.895	1.860	1.833	1.812	1.796

Fish Consumption Use Assessment Example

A sample of nine individual walleye representing three size classes (three fish per class) were collected from Jensen Lake and analyzed for mercury. The mercury samples were collected as dorsal plugs and are assumed to represent the concentration of mercury in the filet of each fish.

Size Class	Length (inches)	Mercury Concentration (µg/g)
Small	12	0.23
	12.5	0.24
	13.6	0.27
Medium	16.5	0.33
	17.1	0.36
	18.0	0.38
Large	23	0.45
	23.5	0.46
	24.2	0.47

The mean concentration (z) for the nine samples (n=9) is 0.35 with a variance (s^2) equal to 0.008828. Based in this mean and variance the test statistic is calculated as:

$$t_c = (z-c) / s$$

$$t_c = (0.35-0.3)/0.09396$$

$$t_c = 0.532$$

The null hypothesis of no difference between the mean and the criterion is accepted if $t_c > t_{\alpha,n-1,}$ where α=0.05 and n-1=8. Since $t_c = 0.532$ is not greater than $t_{\alpha,n-1} = 1.860$ (Table 1) then the null hypothesis is rejected in favor of the alternative hypothesis that the mean methylmercury concentration is greater than the criterion and fish consumption use for Jensen Lake is assessed as not supporting.

F. Agricultural Use Assessment Methodology for Rivers, Lakes and Reservoirs

Agricultural uses are defined in the state water quality standards as " waters suitable for irrigation, stock watering, and other agricultural uses, but not suitable for use as a source of domestic supply for the farm unless satisfactory treatment is provided." While not specifically stated in state water quality standards, the numeric standards for pH (6.0-9.0), boron (750 µg/L as a 30-day average), sodium (less than 50% of cation based on mEq/L), and radium (5 pCi/L as a 30-day average) are intended for the protection of agricultural uses. Further, state water quality standards provide for the protection of agricultural uses by providing language that states that waters of the state shall be "free from substances….in concentrations or combinations which are toxic or harmful to humans, **animals, plants**, or resident biota."

In order to make beneficial use determinations for agricultural uses, the following decision criteria are used:

- *Fully Supporting:*

  Based on Numeric Standards: Ten percent or less of the samples exceed the water quality standard for pH or sodium and one or fewer exceedances of the 30-day average criteria for boron or radium.

  Based on Narrative Standards: Water supply supports normal crop and livestock production.

- *Fully Supporting but Threatened:*

  Based on Numeric Standards: The fully supporting, but threatened use assessment designation is not applied to agricultural use. Waters are either assessed as fully supporting or not supporting based on chemical data applied to the numeric standards.

  Based on Narrative Standards: No impairment based on the numeric criteria, but a declining trend in water quality over time suggests a measurable decrease in crop and/or livestock production may occur if the trend continues.

- *Not Supporting*:

  Based on Numeric Standards: Greater than 10 percent of samples are exceeded for the water quality standard for pH or sodium, or two or more exceedances of the 30-day average criteria for boron or radium.

  Based on Narrative Standards: At least on pollutant has been demonstrated to cause a measurable decrease in crop or livestock production.

G. Industrial Use Assessment Methodology for Rivers, Lakes and Reservoirs

Industrial uses are defined in the state water quality standards as “waters suitable for industrial purposes, including food processing, after treatment.” While there are no specific numeric criteria in the state’s water quality standards intended to protect industrial uses, it is assumed that if the state’s narrative standards are met, or if other numeric water quality standards are met, the beneficial uses for industry will also be met.

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Appendix A

Standards of Quality for Waters of the State

Appendix B

Standard Operating Procedure for the Selection of Reference and Disturbed Sites for Biological Monitoring in North Dakota

STANDARD OPERATING PROCEDURE
FOR THE SELECTION OF REFERENCE AND DISTURBED
SITES FOR BIOLOGICAL MONITORING IN NORTH DAKOTA

Summary

The North Dakota Department of Health (NDDH) utilizes reference (least impaired) and disturbed (most impaired) physical conditions to provide an estimate of natural and human induced variability in biological community structure and in stream habitat quality. Sites are also used to develop threshold values and compile Indices of Biological Integrity (IBI). When selecting reference or disturbed conditions the NDDH Surface Water Quality Management Program (SWQMP) must account for natural and climatic variability across the state of North Dakota. To account for environmental variability in North Dakota, the state's total land area was separated into four regions by US Geological Survey Level III Ecoregions and each area was evaluated individually.

The first step in site selection involves a remote sensing component which utilizes an ESRI ArcView Geographic Information System (GIS), ArcView extensions and various GIS data layers. The Analytical Tool Interface for Landscape Assessments (ATtILA) extension allows users to calculate many common landscape metrics including: landscape characteristics, riparian characteristics, human stressors and physical characteristics. Grouped metrics are used to estimate anthropogenic stressors in a 1000 meter (m) circular buffer around distinct sampling points located on perennial flowing waters of the state. Ultimately a final site score is calculated based on the varying metric scores in the buffer. The most disturbed points are classified with the highest scores while the least disturbed points receive the lowest scores. The highest scoring disturbed sites and lowest scoring reference sites then move to the second evaluation step.

The second screening step is to evaluate each site individually by using additional GIS layers. Sites are plotted and examined for landscape attributes which may result in the site not being suitable for sample collection (e.g. water was too deep). Layers used in screening step two include but are not limited to: roads; aerial photos; public and private land ownership; township, range and section grids; county boundaries; and dam structures. The remaining viable sampling locations are then evaluated with another level of screening.

The third screening step involves site reconnaissance, also known as 'ground truthing'. During this step, SWQMP personnel visit sites to evaluate reference or disturbed using best professional judgment. Some important features to consider while 'ground truthing' are stream geomorphology, stream habitat alterations (e.g. dams, rip-rap), land use in or adjacent to the riparian zone, and other human influences at or near site locations.

Software and Data Layers/Sources

___ ArcView 3.X (ArcView version 3.2a or higher recommended)

Extensions:

___ ArcView 3.X Spatial Analyst Extension
___ Analytical Tool Interface for Landscape Assessments (ATtILA2004v1.0) Extension (EPA)
___ Buffer Theme Builder Extension
___ Display Points Lat/Long Extension
___ Divided line by adding points evenly Extension
___ Grid & Theme Projector version 2 Extension
___ XTools Extension (9/15/03)

Datasets and Layers:

___ Ecoregion GIS Layer (USGS)
___ National Agriculture Imagery Program (NAIP) 2005 Aerial Photography (NRCS) or Digital Orthophoto Quarter Quadrangles (DOQQ) (USGS)
___ National Elevation Dataset (NED) (USGS)
___ National Hydrography Dataset (NHD) (USGS)
___ National Land Cover Data (NLCD) (USGS)
___ North Dakota Public Land Ownership Layer
___ State and County Roads GIS Layer (North Dakota GIS Hub)
___ Township, Range and Section Grid

Procedures

Step 1: Remote Sensing

1. Create a new ArcView 3.X GIS project. Set the map coordinate system to *Universal Transverse Mercator* (UTM) zone 14N (North). Set map coordinate units to decimal degrees. Set map distance units to meters.

2. Select stream reaches in the NHD shapefile that fall inside the target watershed or study area. Create a new shapefile with the selected features. Perennial streams should be selected using the following F_CODEs in the NHD attribute table: 33400, 33600, 46003, 46006, and 55800.

3. Use the *Divide Line by Adding Points Evenly* extension to add points along the NHD shapefile features at intervals of 2000 meters.

4. Make sure the map coordinate system is set to UTM zone 14N. Next use the *Display Points Lat & Long Extension* to add Latitude and Longitude coordinates for each point to the shapefile's attribute table.

5. Use the *Buffer Theme Builder*'s "Create Buffer Theme" button to produce a shapefile of 1000 meter buffers around each potential sampling site in the point shapefile created in step 3.

6. Create a slope grid in percent from a statewide NED grid. Use the map calculator in spatial analyst and the function *[grid].slope (zFactor, percentRise)* to derive slopes where *zFactor* is the conversion factor if x, y, and z are in different units and *percentRise* equals true for percent slope and false for degree slope.

7. With the new Buffer Theme selected as the reporting unit, select and calculate the desired metrics in each of the four groups: landscape characteristics, riparian characteristics, human stressors and physical characteristics. Metric scores result from the evaluation of the NLCD grid, a roads layer, precipitation, and population density. Metrics should be chosen for their sensitivity. The most sensitive metrics will have the most variability in scores and will make site characteristic differentiation simpler.

8. Once the most sensitive metrics are chosen, use ATtILA to calculate an index score for each assessment unit. Scores are based on a summation of quantile rankings. The number of quantiles is user-defined.

9. Select the assessment units with the lowest and highest index scores, which are a measure of human disturbance. Lowest scores will be the least disturbed reference assessment units or "best available" sites in the study population and the highest scores will be the most disturbed sites.

Step 2: Digital Media Screening

10. Use aerial photography, GIS layers and best professional judgment to evaluate land uses within the selected assessment units. This screening step is mainly used to exclude best available sites with obvious landuse and waterbody characteristics that may disrupt or prohibit sample collection.

    Characteristics of Concern

    Reference Sites
    - Animal feeding operations near the waterbody
    - Heavily grazed or degraded riparian area
    - Debris or trash in the water body riparian area
    - Stream banks with large areas of mass wasting

    Reference and Disturbed Sites
    - Areas with significant human alteration (e.g. concrete channels)
    - Dam structures creating deep pools

    GIS Layers used:
    - National Agriculture Imagery Program (NAIP) 2005 Aerial Photography (NRCS) <u>or</u> Digital Orthophoto Quarter Quadrangles (DOQQ) (USGS)
    - Federal and State Highways, County Roads and Township Roads
    - Designated Public Lands and Township, Range, and Sections Grids
    - Dam Structures Point Features

Step 3: Landowner Verification and Site Visitation

11. Before a site visit is scheduled, it is advisable to research the identity of the person(s) or group(s) that own land adjacent to or around a potential monitoring location. The inquiry into the property ownership may prove more useful than waiting to contact local residents during an initial site visit and reduce the time expended to obtain permission to access the site. If the land is determined to be held publicly, an effort should be made to contact any and all renters (e.g., producers renting North Dakota State Land Department School Sections).

12. Once permission to access a site is obtained, a site visit should be scheduled. When first arriving at a site it is important to observe any property ownership signage or placards declaring "No Trespassing" or that hazardous conditions are present. If permission to access has been granted, proceed to the site coordinates.

13. Upon reaching the site coordinates, begin to verify the Level 2 assessment screening of GIS layers and aerial photography. Characteristics of the site location that should be examined include but are not limited to; landuse(s) in and around the stream, stream geomorphology, water depth and obstructions to the flow of water. The site investigator should keep a log of notes pertaining to site characteristics and comment on any features present in aerial photos, county maps, or landowner atlases that could be used during future sampling visits.

    A useful tool for examining stream conditions is the Rapid Geomorphic Assessment (RGA) which was developed by the United States Department of Agriculture. The RGA method classifies stream channel stability and the habitat quality of riparian areas and may be used calculate a general stream and habitat score to classify potential Reference and Disturbed sampling locations. The RGA form and instructions for its completion can be found on the following pages.

RAPID GEOMORPHIC ASSESSMENT (RGA) FORM CHANNEL STABILITY & HABITAT RANKING SCHEME

Station Name: ____

Station Description: ____

Date: ____________ Time: ________ Slope: _______% Pattern: meander/ straight/ braided

Crew: _______________________________ Pictures (circle): u/s, d/s, x-sec, LB, RB

1. Primary bed material

Bedrock	Boulder/Cobble	Gravel	Sand	Silt/Clay
0	1	2	3	4

2. Bed/bank protection

Yes	No	(with)	1 bank	2 banks
0	1		2	3

3. Degree of incision (relative elev. of "normal" low water if floodplain/terrace is 100%)

0-10%	11-25%	26-50%	51-75%	76-100%
4	3	2	1	0

4. Degree of constriction (relative decrease in top-bank width from up to downstream)

0-10%	11-25%	26-50%	51-75%	76-100%
0	1	2	3	4

5. Streambank erosion (dominant process each bank)

	None	Fluvial	Mass Wasting (failures)
Inside or left	0	1	2
Outside or right	0	1	2

6. Streambank instability (percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	0	0.5	1	1.5	2
Outside or right	0	0.5	1	1.5	2

7. Established riparian vegetative cover (woody or stabilizing perennial grasses each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

8. Occurrence of bank accretion (percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

9. Sum of All Values ☐

<u>Instructions for Completion of a Rapid Geomorphic Assessment Form</u>

Define a representative reach 6-20 channel widths long.

1. Primary bed material

Bedrock	The parent material that underlies all other material. In some cases this becomes exposed at the surface. Bedrock can be identified as large slabs of rock, parts of which may be covered by other surficial material.
Boulder/Cobble	All rocks greater than 64 mm median diameter.
Gravel	All particles with a median diameter between 64.0 — 2.00 mm
Sand	All Particles with a median diameter between 2.00 — 0.063 mm
Silt-Clay	All fine particles with a median diameter of less than 0.063 mm

2. Bed/bank protection

Yes	Mark if the channel bed is artificially protected, such as rip rap or concrete.
No	Mark if the channel bed is not artificially protected and is composed of natural material.
Protection	
1 Bank	Mark if one bank is artificially protected, such as with rip rap or concrete.
2 Banks	Mark if two banks are artificially protected.

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

Calculated by measuring water depth at deepest point across channel, divided by bank height from bank top to bank base (where slope breaks to become channel bed). This ratio is given as a percentage and the appropriate category marked.

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

Often found where obstructions or artificial protection are present within the channel. Taking the reach length into consideration, channel width at the upstream and downstream parts of the reach is measured and the relative difference calculated.

5. Stream bank erosion (Each bank)

The dominant form of bank erosion is marked separately for each bank, left and right, facing in a downstream direction.

If the reach is a meandering reach, the banks are viewed in terms of 'Inside, Outside' as opposed to 'Left, Right' (appropriate for questions *5-8).* Inside bank, being the inner bank of the meander, if the stream bends to the left as you face downstream, this would be the left bank. Outside bank, being the outer bank, on your right as you face downstream in a stream meandering left.

None	No erosion
Fluvial	Fluvial processes, such as undercutting of the bank toe, cause erosion.
Mass Wasting	Mass movement of large amounts of material from the bank is the method of bank erosion. Mass Wasting is characterized by high, steep banks with shear bank faces. Debris at the bank toe appears to have fallen from higher up in the bank face. Includes, rotational slip failures and block failures.

6. Stream bank instability (Percent of each bank failing)

If the bank exhibits mass wasting, mark percentage of bank with failures over the length of the reach. If more than 50% failures are marked, the dominant process is mass wasting (see question *5)*.

7. Established riparian woody-vegetative cover (Each bank)

Riparian woody-vegetative cover represents most permanent vegetation that grows on the stream banks. Distinguished by its woody stem, this includes trees and bushes but does not include grasses. Grasses grow and die annually with the summer and thus do not provide any form of bank protection during winter months whilst permanent vegetation does.

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

The percentage of the reach length with fluvial deposition of material (often sand, also includes fines and gravels) is marked.

9. Sum of All Values

Sum all category values for question one through eight. Lower aggregate scores indicate more stable geomorphology and improved habitat. Higher scores indicate unstable geomorphology and decreased habitat.