Minnesota Pollution Control Agency

Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List

2016 Assessment and Listing Cycle

Minnesota Pollution Control Agency

wq-iw1-04i

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wq-iw1-04i

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Forward

Minnesota is blessed with abundant water resources. Our lakes, rivers, and streams play a vital role in the state's economy and the richness of the quality of life residents and visitors enjoy. The health of Minnesota's environment and enormous opportunities for water-related recreation these resources provide depend on good water quality.

Since the Clean Water Act became law in 1972, very significant and often dramatic improvements in the water quality of Minnesota's surface waters have been accomplished. Notable examples include the Mississippi River below the Twin Cities, the Rainy River below International Falls, and the recent improvements to dissolved oxygen concentrations in the Minnesota River. Most of these gains can be attributed to vast improvements in domestic and industrial wastewater treatment.

In spite of these success stories, many Minnesota lakes and streams do not fully support beneficial uses such as swimming and fishing. The contribution of pollutants from nonpoint sources, from agriculture, construction and development sites, forestry, urban runoff, etc., is now the major reason that many of Minnesota's waters are considered impaired. The prevention and control of nonpoint source pollution remains one of the Minnesota Pollution Control Agency's (MPCA), and the publics, greatest pollution challenges.

The MPCA is charged under both federal and state law with protecting the water quality of Minnesota's lakes, rivers, streams, and wetlands. It is the responsibility of the MPCA to monitor Minnesota's water bodies, to assess water quality, and to report the results to the public. This task extends to documenting the water quality "success stories," as well as identifying those water bodies that still need improvement.

This Guidance Manual deals with the need to assess water quality. The methodologies in this Guidance Manual are designed to reap the most information, value, and benefit possible from available data. This information is critical to evaluating the current status of Minnesota's water quality, identifying waters that are impaired and need restoration and waters that need further protection to prevent impairment, and tracking progress over time.

This Guidance Manual was developed to help federal, tribal, state, and county staff, and the public in general, understand the water quality assessment process. It will be updated as assessment methods improve and as new pollution problems emerge that require assessment. Comments and suggestions from readers are encouraged and will be used to help improve the guidance.

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Abbreviations, Acronyms, and Symbols

AUID	Assessment unit identification
BCC	Bioaccumulative Chemicals of Concern
BCG	Biological Condition Gradient
BOD	5-day Biological Oxygen Demand
CALM	Consolidated Assessment and Listing Methodology
CC	Chronic Criteria
ch.	Chapter
chl-*a*	Chlorophyll-*a*, corrected for pheophytin
CS	Chronic Standard
CWA	Clean Water Act
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
GLI	Great Lakes Water Quality Initiative
HDS	Human Disturbance Score
HH-WQS	Human Health-based Water Quality Standards
IBI	Index of Biotic Integrity
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MDNR	Minnesota Department of Natural Resources
MFCA	Minnesota Fish Consumption Advisory
µg/L	Microgram per liter or ppb
mg/L	Milligram per liter or ppm
MPCA	Minnesota Pollution Control Agency
ng/L	Nanogram per liter or parts per trillion
NHD	National Hydrographic Data
PCB	Polychlorinated biphenyls
PFOS	Perfluorooctane Sulfonate
pg/L	Picogram per liter or parts per quadrillion
ppm	Milligram per liter or parts per million
QA/QC	Quality Assurance/Quality Control
R.	Rule
RES	River Eutrophication Standards
RNR	River Nutrient Region
TALU	Tiered Aquatic Life Uses
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

Preface to the 2016 revision of the Guidance Manual

In this edition of the Guidance Manual for Assessing the Quality of Minnesota Surface Waters, the MPCA made a number of changes. Some of the changes are editorial in nature, while others reflect substantive changes in the manner in which the MPCA conducts the assessment and reporting processes.

In several areas, especially, MPCA wants to highlight the following additions:

- Monitoring and assessment approach (I.C.) to include the MPCA's large river monitoring strategy,
- Total suspended solids (V.B.1.c.) to replace turbidity,
- Biological indicators (V.B.1.e.) to include Tiered Aquatic Life Uses (TALU),
- River eutrophication (V.B.1.g. and Appendix G),
- Removal of waterbodies (X.) to include total suspended solids, river eutrophication, and biological indicators, and
- Assessing and communicating the quality of waters that occur wholly or partially within federally recognized Indian Reservations (Appendix E).

Changes to the state's algorithms for human health-based chronic standards (VI.A.1.) are also reflected in this edition. Note also that the appendices have been re-ordered.

I. Introduction

A. Background

Minnesota is blessed with abundant water resources. Our lakes, rivers, and streams play a vital role in the state's economy and the richness of the quality of life residents and visitors enjoy. The enormous opportunities for water related recreation these resources provide, such as aesthetic enjoyment, swimming, fishing, boating and canoeing depend, to a great extent, on good water quality. Within Minnesota's borders lie the headwaters of three major continental watersheds, the Great Lakes/ St. Lawrence River, the Mississippi River, and the Red River of the North/Hudson Bay watersheds. Thus, Minnesotans have the privilege and, with that, the huge responsibility of living "upstream" of millions of downstream users of these major waterways. Minnesota's water resources include about 105,000 river miles, 4.5 million acres of lakes and reservoirs including approximately 1.4 million acres of Lake Superior in Minnesota, and about 9.3 million acres of wetlands.

The Minnesota Pollution Control Agency (MPCA) is charged under both federal and state law with the responsibility of protecting the water quality of Minnesota's lakes, rivers, streams, and wetlands. One goal of the MPCA is to preserve the existing high quality of water bodies that are meeting standards, so beneficial uses are maintained. However, too many surface waters receive enough pollutant loading from a variety of sources that they do not meet one or more water quality standards. If the extent of the violations of standards exceed the guidelines spelled out in this Guidance Manual (Guidance), those surface waters are considered to be "impaired." Another goal of the MPCA is to improve the quality of impaired waters so water quality standards are met and beneficial uses are maintained and restored, where these uses are attainable.

B. About the TMDL List, Assessment and Listing Cycle, and Integrated Report

The federal Clean Water Act (CWA) requires states to adopt water quality standards to protect waters from pollution. These standards define how much of a pollutant can be in the water and still meet beneficial uses, such as drinking water, fishing and swimming. Water quality standards are the fundamental tools used to assess the quality of all surface waters. For more detailed information regarding standards see http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/water-quality-standards.html. States must monitor and assess the water quality of their waters to identify those that are "impaired", i.e., not fully supporting their beneficial uses. Section 303(d) of the CWA requires states to publish and update a list of impaired waters for which a Total Maximum Daily Load (TMDL) Study is needed. This list, known as the "303(d) List" or "TMDL List" is updated every two years via the assessment of water quality data and an extensive public participation process. The draft TMDL List is developed by the MPCA and submitted to the U.S. Environmental Protection Agency (EPA) for final approval. The two-year timeline for assembling and submitting the draft TMDL List is known as the "assessment and listing cycle." This Guidance has been prepared to reflect the 2016 Assessment and Listing Cycle.

The CWA also requires states to submit a report on the status of all of their waters to help measure progress toward the national goals of fishable and swimmable waters. This "Integrated Report" includes the TMDL List as well as the Inventory of Impaired Waters – an accounting of all known impaired waters, not just those requiring TMDLs. The Inventory of Impaired Waters includes those waters needing a TMDL plan, those for which a plan has already been developed and approved by EPA, and water bodies that do not require an TMDL (impaired by a non-pollutant alteration [4C] such as a dam or impoundment, or impaired because natural background exceeds the standard where impacts from human activity are insignificant [4D]). The Integrated Report also includes a narrative component and information about waters that are meeting beneficial uses and also programmatic information

about protection and restoration efforts. As part of the assessment process and the development of the Integrated Report, all waters for which sufficient data have been collected to allow a review are assigned to a category of impaired, unimpaired, or insufficient information to determine impairment status according to an EPA-established system called the Consolidated Assessment and Listing Methodology (CALM – see Appendix A). To view the MPCA's most recent 303(b)/TMDL List and Inventory see http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/impaired-waters-list.html. To view the MPCA's most recent 305(d) Narrative Report see http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/assessment-and-listing/water-quality-assessment-and-listing.html.

C. Monitoring and assessment approach

The MPCA conducts a variety of surface water condition monitoring activities focused on providing critical information to assess the condition of Minnesota's water resources. This information also is used to assess potential and actual threats to water quality and to evaluate the effectiveness of management activities taken to address impairments and other threats to water quality. Monitoring conducted by other local, state, and federal agencies, citizen monitoring as well as remote sensing data are also used for this purpose. For more details on the MPCA's monitoring strategy, see http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/minnesotas-water-quality-monitoring-strategy.html.

The MPCA's primary condition monitoring activities are organized around Minnesota's 80 major watersheds. The watershed monitoring approach involves intensive monitoring on a subset of major watersheds every year. The MPCA has established and is implementing a schedule for intensively monitoring each major watershed every ten years, and the watershed outlets every year. An intended outcome of the monitoring is the identification of waters that are impaired and need restoration and waters that need further protection to prevent impairment. This is followed by TMDL and protection strategy development at the major watershed scale, and ongoing implementation. See http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/watershed-approach/index.html for a more in-depth discussion of the watershed approach and for a map of the 10-year watershed monitoring schedule. For information on TMDL priority rankings as they pertain to reporting to EPA, see Appendix B. An important feature of the watershed approach is the fact that restoration and protection planning and associated implementation will occur in *all* watersheds; the identification of an impaired status is not a key trigger for follow-on planning and implementation.

Until 2010, the MPCA assessed the condition of the state's waters via a biennial, statewide assessment process. With the advent of the intensive watershed monitoring approach the MPCA faced a need to revise the assessment process to align with the watershed monitoring approach, including the 10-year schedule and the increased volume of data generated during watershed monitoring.

An annual assessment process has been designed to keep up with the monitoring work and reflect the more detailed monitoring data available in the watersheds where intensive watershed monitoring has been completed. The development of an annual assessment process has been critical to the MPCA's implementation of the overall watershed approach. With assessments taking place immediately following completion of intensive watershed monitoring, the entire process of monitoring-assessment-restoration-protection can be completed within ten years, at which time the watershed comes up for monitoring again as part of the next scheduled ten-year rotation. In addition, the revised process encourages earlier and more meaningful local involvement in assessment.

More recently (2013), a large river monitoring strategy was initiated to complement the watershed approach for the monitoring, assessment, and CWA reporting of water resources within Minnesota. For the purposes of fulfilling our monitoring and assessment objectives, large rivers are defined as large mainstem rivers that flow through multiple major watersheds and, therefore, were not satisfactorily represented within the watershed approach. In Minnesota, these include the St. Croix,

Minnesota, Upper Mississippi, Red, and Rainy rivers. These rivers will be monitored and assessed longitudinally on a rotating basis once every 5 years. The Lower Mississippi (below Upper St. Anthony Falls) also meets the definition of a large river but is treated separately due to ongoing interstate efforts to develop a consistent and comprehensive monitoring strategy to fulfill CWA objectives for interstate waters of the Mississippi River. For more on the MPCA's large river monitoring, see https://www.pca.state.mn.us/water/large-river-monitoring.

Additionally, MPCA and Minnesota Department of Natural Resources (MDNR) piloted the assessment of aquatic life in lakes utilizing a lake fish index of biotic integrity and a review of existing plant data. Sampling has been aligned so that aquatic life assessments will be completed annually following the watershed monitoring approach.

Some monitoring, namely monitoring of toxic parameters, continues to occur on a statewide basis. Assessment of those parameters is done statewide every two years, to reflect the monitoring design. Watershed assessments focus primarily on the aquatic life and recreation beneficial uses. Statewide assessments focus primarily on aquatic consumption and aquatic life toxicity. Every two years the watershed and statewide assessment results are packaged together into the proposed TMDL List and Integrated Report. For the 2016 Assessment and Listing Cycle, the assessed watersheds are:

- Lake Superior – North
- Lake of the Woods
- Leech Lake River
- Minnesota River – Mankato
- Mississippi River - Headwaters
- Pine River
- Red Lake River
- Red River – Grand Marais Creek
- Rum River
- Snake River (Red River Basin)
- South Fork Crow River
- Two Rivers
- Watonwan River
- Zumbro River
- Upper Mississippi (large river)

While the MPCA's monitoring and assessment efforts primarily follow the major watershed schedule, interested parties are able to propose additional listings outside of the watershed schedule during the call for data or public notice of the draft TMDL List. This proposal process is intended to accommodate instances when assessment and listing outside of the watershed schedule is necessary for a locally led initiative to move forward. To honor the watershed schedule and maintain the integrity of the systematic approach to monitoring/assessment, TMDL development, and implementation, any proposals for listing outside of the watershed schedule must 1) explain why moving forward with assessment is necessary prior to the comprehensive watershed assessment, 2) document how the efficiency and coordination that is lost by deviating from the watershed approach will be offset by a local benefit, and 3) demonstrate that the MPCA's assessment methods in this Guidance were followed for the monitoring, analysis, and comparison of the data against state standards. The MPCA will review the proposal and make the determination regarding impairment and listing prior to submitting the draft list to EPA for approval.

II. Purpose and Scope

A. About the assessment guidance

The purpose of this Guidance is to define the required data and information and lay out the criteria by which water bodies are assessed to determine if beneficial uses are supported.

The scope of this Guidance includes methods for assessing surface waters for the following beneficial uses:

- Aquatic Life (toxicity-based standards, conventional pollutants, biological indicators)
- Drinking Water and Aquatic Consumption (human health-based standards)
- Aquatic Consumption (wildlife-based standards)
- Aquatic Recreation (*Escherichia coli* – *E. coli* – bacteria, eutrophication)
- Limited Value Resource Waters (toxicity-based standards, bacteria, conventional pollutants)

B. Disclaimers and future changes to the Guidance

To people not involved with conducting water quality assessments, the determination of an impaired condition would seem to be a straight-forward process: waters are either impaired or not impaired. However, the assessment process is very complex and it includes a certain amount of uncertainty. The MPCA must consider many different types and sources of data, different categories of pollutants, different uses of surface waters, the variability in natural systems, and many other variables. The goal of this Guidance is to accurately and completely describe the assessment methods, and to make the assessment process as clear and understandable to all parties as possible. Nevertheless, questions about the assessment process will invariably arise that the Guidance fails to answer. Readers are encouraged to access the many resources listed in Section XI, including MPCA staff, for additional information. Two MPCA products which may be especially useful and related to this Guidance are the Volunteer Surface Water Monitoring Guide (MPCA 2003) (http://www.pca.state.mn.us/water/monitoring-guide.html) and the Surface Water Data website (http://cf.pca.state.mn.us/water/watershedweb/wdip/search_more.cfm). The Monitoring Guide provides information on planning a monitoring program, as well as data quality and management. The Surface Water Data website allows Minnesotans to access environmental data on surface waters statewide.

This Guidance does not affect the rights and administrative procedures available to all affected or interested parties. The Guidance is not part of any water quality rule – it does not have the force of law. It serves to guide the interpretation and application of current water quality standards that are in water quality rules. If any party feels that an MPCA decision based on the Guidance is not supported by the facts, or they have any issue related to the MPCA's use of the Guidance, that party can comment or challenge the MPCA's actions in the following ways:

- Directly contact MPCA staff, management, or the Commissioner, orally or in writing.
- Request a contested case hearing if the issue involves an MPCA permit action, or any other MPCA action for which a contested case hearing is an appropriate forum to resolve the concern.
- Challenge the MPCA action in the appropriate legal jurisdiction.

The MPCA updates this Guidance every two years since that is the current EPA mandated schedule for preparation of both the integrated narrative report and the 303(d) List. The MPCA involves the public when major changes to the Guidance are being considered.

C. Other standards

Other toxic or conventional pollutants that are found to exceed water quality standards will be assessed following equivalent methodologies discussed in this guidance, depending on the type of pollutant. Methodologies will be developed and included in this document as new pollutants are added to the assessment process.

III. Assessment Process

As noted in the Introduction, the MPCA redesigned the assessment process during the time between the 2010 and 2012 listing cycles. As mentioned in the agency's Continuing Planning Process document (see http://www.pca.state.mn.us/index.php/water/water-publications/index.html under "Reports"), the shift to watershed-based monitoring and restoration/protection approach with a rotating 10-year watershed schedule resulted in a need for annual assessments. This adjustment along with the large amount of data that this new approach provides presented a timely opportunity to redesign the assessment process (MPCA 2010). As discussed in Minnesota's Water Quality Monitoring Strategy 2011-2021, this process is designed to combine computerized data analysis, expert review, and internal and external partner input to use all available data and information to determine the appropriate assessment decisions for a number of beneficial uses (drinking water, aquatic life, recreation, and consumption, and limited use waters) (MPCA 2011).

A. Steps in the assessment process

The redesigned process expands upon the data analysis steps of the previous assessment process. While this new process focused on the aquatic life use assessments in rivers and streams, concepts of the redesigned process have also influenced how other designated uses (e.g., aquatic recreation) are assessed. Additional reviews at the parameter level and the addition of an internal comprehensive review, prior to the professional judgment group meeting, are the largest changes. These changes reflect the increased volume and complexity of the data gathered during the intensive watershed monitoring effort, and help ensure a robust decision about the appropriate management actions to be pursued for each assessment unit (water body, or AUID) in the planning and implementation phases of the watershed approach (i.e. restoration for impaired waters, and protection for unimpaired waters). Further detail on the specific steps in the process is included below. A note should be made that the aquatic consumption (fish) assessment at this time utilizes only the first two steps in the process.

1. Data Compilation

The initial step in the process is a computerized screening that identifies monitoring results collected on AUIDs over the appropriate period of record and compares each data point to water quality criteria, summarizes the number of data points that exceed the criteria, the total number of data points, and the number of years of data. This step produces a parameter-specific summarization (e.g., dissolved oxygen, Fish IBI, and *E. coli*). For more information on the sources of data that the MPCA uses, see Appendix C.

2. QA/QC review

This stage involves a review of the data for quality assurance that the computerized screening captured the appropriate data and is properly calculating the summaries (particularly important when new assessment methods or new parameters are added). Also included in this stage are additional analysis and review steps required for several parameters (e.g., *E. coli*, chloride, un-ionized ammonia, and nitrate).

3. Desktop assessment

The desktop assessment involves a review of data and summaries by resource-specific staff (e.g., water quality staff review chemistry data, biologists review stream biological data, MDNR review lake biology) for water bodies within a specific 8-digit hydrologic unit code watershed (HUC-8). This review considers multiple lines of evidence – review of flow conditions, precipitation, land use, habitat, etc. – in addition to the summarizations to ascertain the quality of the dataset (temporal and spatial completeness, etc.) and whether the parameter is meeting or exceeding the criterion. During this process any candidates for delisting or natural background review are identified and work begins to determine if those AUIDs meet the criteria to be removed from the Impaired Waters List.

4. **Watershed Assessment Team (WAT)**

   Joint internal meeting of the MPCA and other state agency personnel involved in the individual desktop assessments, the regional watershed project manager and stressor identification staff for a specific HUC-8. In this meeting each AUID is reviewed, considering comments and parameter-level evaluations from the desktop assessment as well as supplemental information, to reach an overall use-support decision. Delisting and natural background candidates may also be identified at this time.

5. **Professional Judgment Group (PJG)**

   The PJG meeting is a joint meeting of WAT and external parties (local data collectors, local government units, etc. as determined by the MPCA regional watershed project manager) to discuss the results of the WAT meeting for a specific HUC-8. Prior to the PJG meeting, the results of the WAT meeting are distributed to all invitees, including parameter-level evaluations, overall use-support recommendations and all comments. Invitees are asked to identify AUIDs they wish to discuss; an agenda is developed based on these submissions. The format of this meeting, instead of an exhaustive review of each AUID, is an overview of the process, a general discussion of the watershed and major subwatersheds and a review of requested AUIDs, delisting and natural background candidates. The results of this meeting are the final use-support determinations.

The analyses and recommendations for each AUID are documented in a database that is archived following the completion of the assessments. Throughout the annual assessment process, care is taken to maintain consistency among the HUC-8 assessment meetings and decisions. This is accomplished via internal training and quality control, the assignment of individual staff to multiple HUC-8 data sets for the expert review and desktop assessments, and the oversight and guidance provided by a technical team and a management team charged with ensuring quality data analysis and consistency among watershed assessment discussions and decisions.

IV. General Aspects of Data Assessment

A. Delineation of reaches, lakes, and wetlands

Assessments of use-support in Minnesota are made for individual water bodies. The water body unit used for stream reaches, lakes, and wetlands is called the "assessment unit." A stream assessment unit usually extends from one significant tributary to another or from the headwaters to the first significant tributary and is typically less than 20 miles in length. Main-stem large rivers utilize hydrologic unit boundaries (10 digit HUC) as the initial assessment unit. A stream or river reach may be further divided into two or more assessment units when there is a change in the use classification (as defined in Minn. R. ch. 7050), or when there is a significant morphological feature such as a dam, or a lake within the river.

The MPCA uses the 1:24,000 scale high resolutions National Hydrography Dataset (NHD) to create geospatial data to represent stream and lake assessment units. All of our assessment units are indexed to the NHD, or have had custom shapes created for addition to the NHD. The high resolution NHD was created from 1:24,000 scale United States Geological Survey Digital Line Graphs and MDNR stream and lake data.

Each water body is identified by a unique water body identifier code called an assessment unit identification or AUID. For streams, the code is comprised of the United States Geological Survey (USGS) 8-digit sub-basin code plus a three character code that is unique within each sub-basin. It is for these specific reaches that the data are evaluated for potential use impairment. The MPCA consults with border states during the assessment process and documents reasons for any discrepancies in assessment determination between Minnesota and the specific border state.

The MDNR's Protected Waters Inventory is the source for lake and wetland identifiers. MDNR uses an 8-digit identifier for water bodies, consisting of a 2-digit prefix that represents county, 4-digit number identifying a lake, and a 2-digit suffix that represents either a whole lake (-00) or representing a specific bay of a lake (-01, -02, etc.). This 8-digit identifier is used by MPCA to represent an assessment unit for lakes and wetlands. Water bodies determined to be wetlands will not be assessed using the eutrophication factors discussed in Section VIII. C; factors used to identify wetlands can be found in Appendix D.

For the purposes for identifying water bodies as either wholly or partially within federally recognized Indian reservations, the MPCA uses the US Census Bureau's 2010 spatial data on tribal lands except with respect to the Mille Lacs Reservation where the State disagrees with the tribe and the federal government on the boundaries of the Mille Lacs Reservation. The US Census Bureau's data are public and can be downloaded off of their website, www.census.gov. For more information on the MPCA's approach for assessing and communicating the quality of waters that occur partially or wholly within federally recognized Indian Reservations, see Appendix E.

Typically, the listing of impaired waters is by individual assessment unit. The major exception to this is the listing of rivers for contaminants in fish tissue. Over the time it takes fish, particularly game fish, to grow to "catchable" size and accumulate pollutants to unacceptable levels there is a good chance they have moved considerable distance to the site where they were sampled. The impaired reach is defined by the location of significant barriers to fish movement such as dams upstream and downstream of the sampled reach. Thus, the impaired reaches often include several assessment units, and for lakes, will include all bays on the lake (may be listed under the -00 suffix, representing the entire water body).

B. Period of record

The MPCA generally uses data collected over the most recent 10-year period for all the water quality assessments considered for 303(d) impairments. Years of record are based on the USGS water year. Water years are from October 1 of one year through September 30 of the following year. It is preferable to split the year in the fall, when hydrological conditions are usually stable, than to use calendar years. A full 10 years of data are not required to make an assessment.

The MPCA uses a period as long as 10 years in its assessments for several reasons. It provides reasonable assurance that data will have been collected over a range of weather and flow conditions and that all seasons will be adequately represented. From a practical standpoint, the 10-year period means there is a better chance of meeting the minimum data requirements.

C. Uncertainty in water quality assessments

The MPCA is very cognizant of the hazards of making assessments with limited data. One benefit of the watershed monitoring approach is that it provides a more robust dataset for assessment. The selection of the minimum data requirements for water quality assessment is clearly a compromise between the need to assess as many water bodies as possible and the importance of minimizing the probability of making an erroneous assessment. The methods described in this Guidance deal with this problem in a variety of ways, depending on the pollutant category. Nonetheless, some level of uncertainty is part of every analysis of water quality data. There is always a chance that a water body will be assessed as impaired when in fact it is not or assessed as un-impaired when in fact it is. The number of data points the MPCA requires as a minimum for water quality assessments is small in the context of statistical analyses of uncertainty. The approach used by the MPCA to make impairment decisions, which is a screening of the data using the impairment thresholds, followed by a review by professionals, makes the best use of limited data. This is the approach recommended by the EPA.

Essentially all assessments are subject to review by a team of professional water quality experts (see next section). Review of the data by professionals is a very important part of minimizing erroneous impairment determinations, and this review would be required whether or not statistical tests are used. The possible erroneous placement of a water body on the 303(d) List is a concern because of the regulatory and monetary implications of 303(d) listing. It has been the experience of the MPCA that very few water bodies have been incorrectly determined to be impaired.

When the professional review of data collected for a lake or stream finds conflicting or inadequate information to make a confident assessment, and more monitoring could resolve the need, notes are recorded in a database and discussions are had with monitoring programs to determine if additional sampling can be pursued.

D. Data sources and quality

Data for assessments are queried primarily from MPCA's water quality data management system, EQuIS (Environmental Quality Information System); a limited amount of data from outside that system is also included in the process. However, to allow for the external data to be included in the process, it must be submitted to MPCA in time for incorporation into the assessment tables; this date is announced via a call for data and is typically November 1st prior to the start of the assessments.

The data used in assessment decisions must be of reliable quality and QA/QC protocols must be carefully followed for each step along the way from field sampling to lab analysis to data management in order to reduce the introduction of errors. Monitoring and data management at the MPCA are performed in accordance with the requirements specified in a Quality Management Plan approved by the EPA and available for review on the MPCA website at http://www.pca.state.mn.us/index.php/about-mpca/mpca-overview/agency-strategy/mpca-quality-system.html.

The MPCA watershed assessment process assigns a quality rating to individual assessment parameters used to assess aquatic life, aquatic consumption, and aquatic recreation. The Assessment Database (ADB) requires that a four tiered assessment confidence rating system be used for each type of data included in the use-support assessment. For more information on data sources, see Appendix C.

E. Dataset quality and parameter-level evaluation

As noted previously, a key step in the assessment process is to determine if individual parameters meet or exceed their criteria (numeric or narrative standards) or have insufficient data to make that determination. In addition to this comparison against standards, the evaluator also makes a determination of the quality of the assessment, assigning a low, medium, or high quality rating (Table 1). These results are stored in a working database and used in the WAT reviews and PJG meetings, with supporting information, to make the final use-support determinations.

For some parameters, the parameter-level evaluation is equivalent to the final use assessment decision (e.g., aquatic consumption). The dataset quality for many of these parameters uses the ADB categories for data quality for the use determination, instead of the matrix in Table 1. For other parameters (e.g., conventional chemistry, biota, bacteria), the parameter-level evaluations are then used in conjunction with supporting data, including dataset quality, to make a final use-support determination. This will be discussed further in specific sections that follow (i.e. aquatic life, aquatic recreation).

Table 1. Indicator Quality Rating for Conventional Pollutants* for Assessing Aquatic Life Use in Streams (each pollutant rated independently).

Rating	Data Quantity/Technical Components	Data Spatial/Temporal coverage	Data Currency
low	- Data of insufficient quantity to provide good indication of overall conditions - Diurnal cycle not represented (where applicable)	- Spatially, data very localized and do not provide good representation of overall reach - Temporally, data cover limited portion of monitoring season or limited to single year - Data biased towards certain types of conditions	Data do not reflect current conditions: -Majority of data greater than 5 years old -Significant changes in watershed since data collected
medium	- Data of sufficient quantity to provide good indication of overall conditions AND - Diurnal cycle not represented (where applicable)	- Spatially, data provide good representation of overall reach OR - Temporally, data cover entire monitoring season through multiple years AND - Data representative of overall conditions rather than biased towards certain types of conditions	Data older than ideal, but reasonable indicator of current conditions: -Majority of data greater than 5 years old -No significant changes in watershed since data collected
high	- Extensive data set (many grab or probe measurements, or continuous monitoring) to provide good indication of overall conditions - Diurnal cycle properly represented (where applicable)	- Spatially, data provide good representation of overall reach - Temporally, data cover entire monitoring season through multiple years - Data representative of overall conditions rather than biased towards certain types of conditions	Data reflect current conditions: -Majority of data less than 5 years old -No significant changes in watershed since data collected

***** Dissolved oxygen, pH, TSS/S-Tube/T-Tube, and Temperature

To assist in parameter-level evaluations, MPCA has developed guidance for technical staff to use in their analyses (Table 2). The 10 percent and 25 percent exceedance frequencies referenced in Table 2 for conventional pollutants are based on EPA guidance (EPA 1997) and have been used by the MPCA in assessments for many years. These thresholds are appropriate for the conventional category of pollutants for several reasons, including that none are considered "toxic" (or bioaccumulative), and all are subject to periodic "exceedances" because of natural causes. For example, total suspended solids levels typically increase in streams after a rain event even in relatively undisturbed parts of the state, and dissolved oxygen can drop below the standard in low gradient rivers and streams for reasons other than pollution, such as the AUID is located downstream of or flows through extensive wetland complexes. These potential pollutants are also natural characteristics of surface waters, the fluctuations of which aquatic organisms have adapted to cope with over time. The existence and extent of natural exceedances are considered during the assessment process.

It should be emphasized that the elements outlined in Tables 1 and 2 are not prescriptive rules, but rather are guidelines as to the types of considerations that are part of the water quality assessments.

The dataset quality rating and notes about the parameter-level evaluation are recorded for use by the Watershed Assessment Team (WAT) and Professional Judgment Group (PJG) in making the use-support assessment. The technical staff that completed the parameter-level evaluations participates in the WAT and PJG meetings.

Table 2. Guidelines for parameter-level evaluations of conventional pollutants.[1]

Assessment	Frequency of Exceedances	Magnitude of Exceedances	Duration of Exceedances	Timing of Exceedances[2]
Water Chemistry Parameter Indicating Unimpaired or Supporting Conditions	Less than 10% exceedances of chronic standard	Exceedances generally within 10% of water quality criteria	Continuous data or extensive grab sample data set indicates no or few instances of prolonged exceedance	Exceedances only occurring during extreme events such as 100 year flood (e.g., TSS) or severe drought conditions (e.g., DO)
Water Chemistry Parameter Indicating Potential Impairment	Between 10 – 25% exceedances of chronic standard	Exceedances generally greater than 10% but less than 25% of water quality criteria	Continuous data or extensive grab sample data set indicates some instances of prolonged exceedance	Exceedances only occurring during periods in which they are most likely to occur (e.g., before 9 am, 7Q10 low flow, storm events, etc.); not counting extreme events above
Water Chemistry Parameter Indicating Potential for Severe Impairment	Greater than 25% exceedances of chronic standard	Exceedances generally greater than 25% of water quality criteria	Continuous data or extensive grab sample data set indicates chronic exceedance or many instances of prolonged exceedance	Exceedances occurring during periods (seasonal or daily cycle) in which they typically do not occur in addition to occurring in periods in which they are most likely to occur.

[1]Most parameters will have data sets that only allow frequency and magnitude to be evaluated. When sufficient data exist (e.g., continuous monitoring or extensive grab samples) or appropriate ancillary data (e.g., flow, precipitation) are accessible, duration or timing of exceedances may also be considered in the evaluation. The parameter-level evaluation requires best professional judgment to integrate information across all applicable columns.

[2]Based on evaluation of available flow data and/or precipitation records as well as observations made by monitoring staff.

F. Reporting

MPCA reports the results of the assessments in a number of different formats, in watershed assessment reports (HUC-8), and in the integrated report (narrative report, ADB data, and geospatial data). A brief description of each is below.

1. Watershed Monitoring and Assessment Report

Results of the assessments are compiled in a watershed monitoring and assessment report following the assessment determinations. AUIDs are discussed by sub-watersheds and overall water quality conditions, potential stressors, and protection areas are identified. These documents inform the restoration (TMDL) and protection strategies that are developed by the agency. An example of a watershed assessment report can be found at http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/little-fork-river.html.

2. Integrated Reporting

The results of the assessments are reported as directed by guidance from EPA. The assessment decisions are loaded into EPA's Assessment Database (ADB). Categories and subcategories used to classify each assessment unit in the ADB can be found in Appendix A. Each designated use is identified as "full support," "not support," "insufficient information," or "not assessed" as a result of the assessments. In addition, the use assessment data types are rated per the levels in the ADB. Impaired use/pollutant combinations without approved TMDL plans are extracted from the ADB and make up the 303(d) List. In conjunction with the ADB upload, a narrative report to the US Congress as required by section 305(b) of the Clean Water Act (CWA) is developed. An Integrated Report consisting of the narrative report, the ADB data, a 303(d) List and NHD indexed geospatial data are completed and submitted to EPA by April 1 every even year.

V. Protection of Aquatic Life

A. Pollutants with aquatic life toxicity-based water quality standards

Protection of "aquatic life" with applicable Class 2 chronic standards means protection of the aquatic community from the direct harmful effects of toxic substances, and protection of human and wildlife consumers of fish or other aquatic organisms. This section of the Guidance deals with the former, the assessment of water quality for pollutants that have aquatic life toxicity-based chronic standards and acute or Maximum Standards (MS) that are always aquatic life toxicity-based. These standards are identified in Minn. R. 7050.0222 by the abbreviation, "Tox," and by column headings, "Aquatic Life Chronic Standards or Maximum Standards," in Minn. R. 7052.0100.

Surface waters are assessed to determine if they are of a quality needed to support the aquatic community that would be found in the water body under natural conditions. In general, two types of data are used in assessments: water chemistry data and biological data. Computer-generated summaries based on chemistry data and biological data are both considered, along with data quality indicators, in aquatic life use-support determinations. Aquatic life use-support determinations are completed for all parameters/indices below for streams and for specific parameters/indices as noted for lakes and wetlands.

1. Toxic Pollutants

The pollutants that have aquatic life toxicity-based standards most often included in MPCA water quality assessments are briefly discussed. Pollutants other than those mentioned here may be assessed also, as data allow.

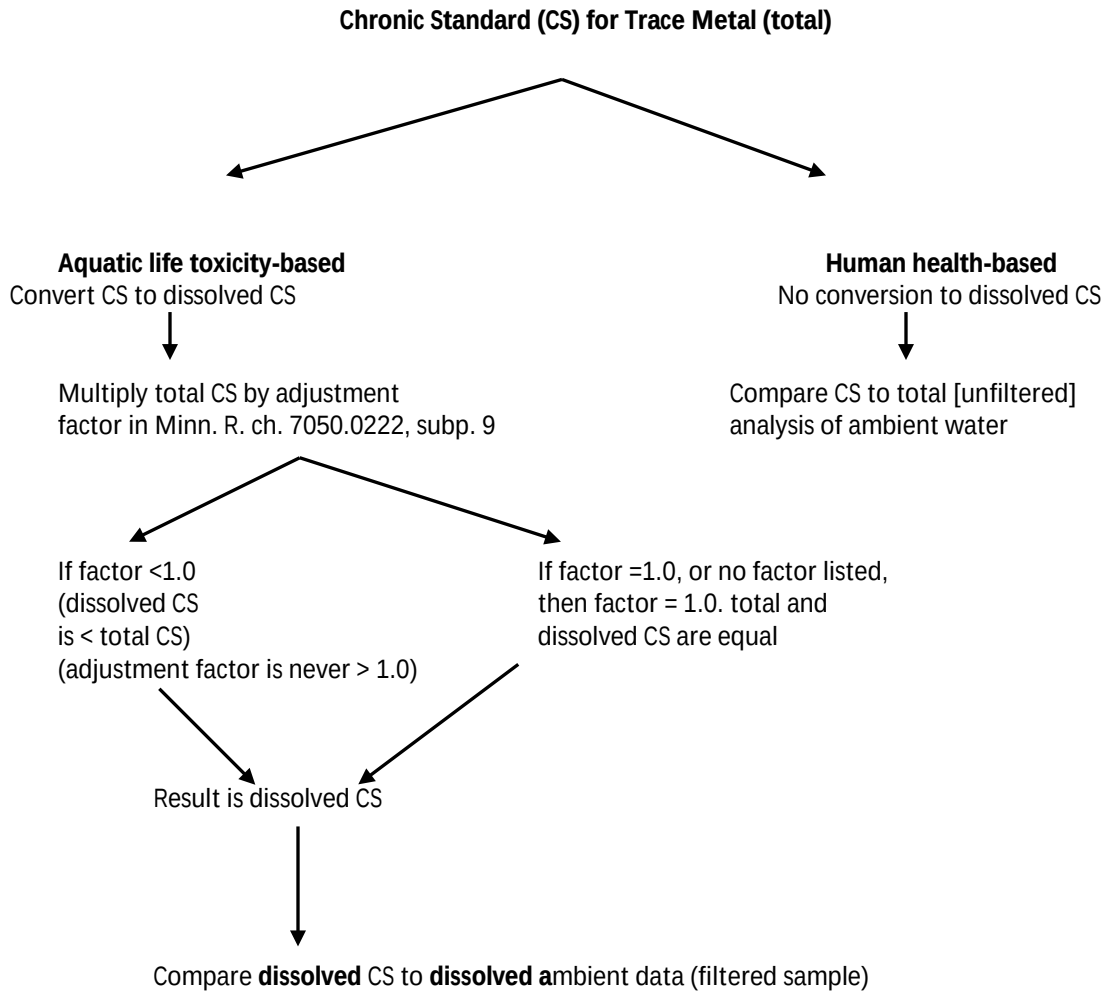
a) Trace metals

Trace metals that have standards to prevent toxicity to aquatic organisms and are used in water quality assessments include aluminum, antimony, arsenic, cadmium, chromium, cobalt, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. Mercury is discussed in the Chapter V because it has human health-based standards.

Minn. R. ch. 7050 and ch. 7052 provide water quality standards for trace metals both in terms of "total" metal and, through conversion factors, "dissolved" metal. The use of dissolved metal standards is based on substantial evidence that the dissolved analysis better estimates the toxic fraction of metals in most water bodies, and it is EPA policy that metal standards should be in the form of dissolved metal (EPA 1993). Total and dissolved metal data will be used in the assessments until there are adequate data to switch all lab analysis completely to dissolved metal data. However, while total metal data can be used to show that concentrations are less than and thus meet dissolved metal water quality standards, total metal data cannot be used to indicate impairment, as they do not provide the necessary evidence that the dissolved fraction fails to meet standards.

The acute and chronic standards for cadmium, chromium III, copper, lead, nickel, silver, and zinc vary with ambient total hardness. Thus, the standards for these metals are in the form of formulas that reflect the hardness/toxicity relationship. Each measured value for a hardness-dependent metal is compared to an individually calculated standard based on the hardness at the same time and place the metal sample was taken.

Figure 1. Use of trace metals data for total metals standards



Hypothetical example: Total Copper CS = 15 µg/L @ a hardness of 200 mg/L

Total CS = 15 µg/L, aquatic life toxicity-based; factor = 0.960;
Dissolved CS = 14.4 µg/L (15 µg/L X 0.960)

Therefore, compare the 14.4 µg/L dissolved CS to the dissolved ambient copper analysis to assess for compliance with water quality standards.

b) Un-ionized ammonia
Ammonia at elevated levels in the un-ionized form (NH_3) is toxic to aquatic life. The chronic un-ionized ammonia standards are shown below:

- Class 2A. 0.016 mg/L un-ionized ammonia
- Class 2Bd, B, C, D. 0.04 mg/L un-ionized ammonia

The fraction of total ammonia in the un-ionized form in water is dependent on ambient pH and temperature. Therefore, pH and temperature as well as total ammonia must be measured at the same time and place to determine the un-ionized ammonia concentration.

c) Chloride
Besides being a general indicator of human impacts on water quality, high levels of chloride can harm aquatic organisms, possibly by interfering with the organism's osmoregulatory capabilities. The Class 2 chronic standard for chloride is 230 mg/L. MPCA began assessing lakes against the existing chloride standards in the 2012 listing cycle and wetlands in the 2014 cycle.

2. Data requirements and determination of impaired condition

Exceedances of standards for toxic pollutants are evaluated over consecutive three-year periods (see Table 3). Two or more exceedances of the chronic standard in three years is considered an impairment. One exceedance of the maximum standard is considered an impairment.

Aquatic life toxicity-based chronic water quality standards are written as 4-day average concentrations. In some cases, pollutant concentrations can be quite variable over such periods, depending on factors such as the type and size of the water body, weather and flow conditions, and the source and nature of the pollutant. For example, chloride concentrations in lakes, streams, and wetlands are relatively stable during low flow conditions over a 4-day period, while pesticide concentrations during storm events in small streams can vary greatly in that same amount of time.

Because standards are expressed as 4-day averages, care must be taken to ensure that the water quality measurements used in assessments provide an adequate representation of pollutant concentrations over the relevant time period. When concentrations are judged to be relatively stable over the 4-day period in question, single samples can be sufficient. When concentrations are more variable, multiple samples or time-weighted composite samples are generally necessary in order to calculate a sufficiently accurate average concentration. Flow-weighted composite samples are taken with the purpose of calculating average concentrations by volume rather than by time, and can be very difficult to interpret in assessment contexts.

If more than one sample was taken within a four-day period for flowing waters the values are averaged (usually an arithmetic mean is appropriate) and the four-day average is counted as one value in the assessment. This includes multiple samples in 4 days at one station or multiple stations along an assessment unit. For lakes, depth of sample must be taken into consideration, as concentrations may change with depth (i.e. chloride often increases with depth). Within the 4-day period, samples will typically be averaged as follows: those samples collected at depths of 2 meters or less (including both grab samples and 0-2 meter integrated samples), those at depth (defined as the deepest two meters of the water column), and the mid-depth values (greater than 2 meters from the surface and the maximum depth). As with flowing waters, this averaging applies to both samples at a single station or samples collected at multiple stations along the assessment unit. Each depth will be compared against the chronic standard. If any 4-day average, regardless of depth, exceeds the standard, it will count as a single exceedance for the water body (e.g. the surface average may meet the standard, while the average at 12 meters may exceed the standard – for that 4-day period, a single exceedance will be counted).

The necessary number and type of samples can vary considerably from one situation to another and the determination of adequacy for the purpose of assessment will necessarily involve considerable professional judgment. It should be noted that because impairment can result from only one or two exceedances, an assessment of full support generally requires extensive monitoring during times when exceedances are most likely to occur.

Table 3. Summary of data requirements and exceedance thresholds for assessment of pollutants with aquatic life toxicity-based standards.

Period of Record	Use-Support or Listing Category	
Most recent 10 years	No more than 1 exceedance of the chronic standard in 3 years, and no exceedances of the maximum standard: Not listed	2 or more exceedances of the chronic standard in 3 years, or 1 or more exceedances of the maximum standard: Listed

B. Conventional pollutants and biological indicators

Conventional pollutants or water quality characteristics most often included in MPCA water quality assessments are dissolved oxygen, pH, temperature, sediment and river eutrophication. Sediment is measured directly through total suspended solids (TSS) concentrations or estimated from transparency tube and/or Secchi tube measurements. River eutrophication consists of a causative variable (TP) and response variables indicating eutrophication. Biological indicators (fish and invertebrates in streams and fish and plants in lakes) are currently evaluated in MPCA assessments.

Pre-assessments based on chemistry data and biological data are both considered, along with data quality indicators and supporting information, in aquatic life use-support determinations. Not all data types are available for all AUIDs, and not all datasets agree. The following paragraphs describe the parameter-level data that inform aquatic life use-support determinations and the process for evaluating the parameter-level and supporting data to make such decisions.

1. Pollutant or water quality characteristic

The conventional pollutants most often included in MPCA water quality assessments are briefly described. Pollutants other than those mentioned here may be assessed also, as data allow.

a) Low dissolved oxygen

Dissolved oxygen (DO) is required for essentially all aquatic organisms to live. When DO drops below acceptable levels, desirable aquatic organisms, such as fish, can be killed or harmed. Dissolved oxygen standards differ depending on the use class of the water:

- Class 2A. Not less than 7 mg/L as a daily minimum
- Class 2Bd, 2B, 2C. Not less than 5 mg/L as a daily minimum
- Class 2D. Maintain background
- Class 7. Not less than 1 mg/L as a daily average, provided that measurable concentrations are present at all times

The standard for DO is expressed in terms of daily minimums and concentrations generally follow a diurnal cycle. Consequently, measurements in open-water months (April through November) should be made before 9:00 a.m.

A stream is considered impaired if 1) more than 10 percent of the “suitable” (taken before 9:00 a.m.) May through September measurements, or more than 10 percent of the total May through September measurements, or more than 10 percent of the October through April measurements violate the standard, and 2) there are at least three total violations.

Because the underlying criterion is that water quality standards can be exceeded no more than 10 percent of the relevant time, it is usually essential that measurements are a representative sample of overall water quality and are not biased towards certain types of conditions, such as storm events or certain times of the year. The relevant time generally refers not to the entire year but rather to the usual water quality monitoring portion of the year. The requirement of at least three exceedances helps ensure that the measured data set is sufficiently large to provide an adequate picture of overall conditions.

In spite of the significant water quality improvements that have resulted from application of the DO standard, the current standard is not necessarily appropriate for all streams. Some low-gradient, heavily wetland-influenced streams may never meet the current DO standard of 5 mg/L, even though pollutant sources and anthropogenic influences are insignificant or even non-existent. In such cases, the current DO standard is not a useful indicator of the health of the water.

Until the DO standard is refined to fit such situations, the following will apply:

- AUIDs where all monitoring sites have wetland characteristics significant enough to preclude the use of the current DO standard as well as current biological criteria will be designated as "not assessable" for aquatic life. The following statement will be used in the documentation: *Not assessed; the waterbody exhibits prevailing wetland characteristics. Assessment is deferred pending refinement of the assessment criteria or reclassification of the waterbody.* Where appropriate, some such waters will subsequently be moved into class 2D during the use-attainability review of the watershed.
- AUIDs where all monitoring sites have wetland influences significant enough to preclude the use of the current DO standard but which are assessable using biological criteria will be designated as "not assessable" for DO. The following statement will be used in the documentation: *Not assessed for dissolved oxygen; the current standard of 5.0 mg/L is not a reliable indicator of the health of this type of heavily wetland-influenced stream. Assessment for dissolved oxygen is deferred pending refinement of the assessment criteria.* (Individual monitoring sites within AUIDs can likewise be determined to be not assessable for DO because of wetland influences.)

A designation of "full support" for DO generally requires at least 20 suitable measurements from a set of monitoring data that give a representative, unbiased picture of DO levels over at least two different years. However, if it is determined that the data set adequately targets periods and conditions when dissolved oxygen exceedances are most likely to occur, a smaller number of measurements may suffice for a determination of "full support."

b) pH

The pH of water is a measure of the degree of its acid or alkaline reaction. The applicable pH standard for most Class 2 waters is a minimum of 6.5 and a maximum of 8.5, based on the most stringent of the standards for the applicable multiple beneficial uses. pH values that are outside the range of the standard because of natural causes are not considered exceedances.

Data are compared to the pH water quality standard for aquatic life use, where the standard for most Class 2 waters is 6.5-9.0. Different pH standards for aquatic life use apply to trout streams (6.5-8.5). A stream is considered to exceed the standard for pH if 1) the standard is exceeded more than 10 percent of the days as determined from a data set that represents unbiased conditions and 2) there are at least three measurements exceeding the standard.

A stream is considered to meet the standard for pH if the standard is met at least 90 percent of the days of the monitoring season. A designation of meeting the standard for pH generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least two different years.

c) Total suspended solids

Total suspended solids (TSS) consist of soil particles, algae, and other materials that are suspended in water and cause a lack of clarity. Excessive TSS can harm aquatic life, degrade aesthetic and recreational qualities, and make water more expensive to treat for drinking.

Transparency values, as measured by Secchi tubes (S-tube), reliably predict TSS and can serve as surrogates. While TSS measurements themselves are generally preferred, datasets for S-tube are often more robust, and their relative strength will be considered in assessments.

Because S-tube measurements are not perfect surrogates, however, their use involves a margin of safety. Therefore, the S-tube surrogate thresholds for determining if a stream exceeds the TSS standard are different than for determining if a stream meets the standard.

Table 4. Minnesota's TSS (mg/L), S-tube (cm) and site-specific standards for specifically named river reaches.

Region or River	TSS	S-tube Exceeds	S-tube Meets
All Class 2A Waters	10	55	95
Northern River Nutrient Region as Modified for TSS	15	40	55
Central River Nutrient Region as Modified for TSS	30	25	35
Southern River Nutrient Region as Modified for TSS	65	10	15
Red River Mainstem – Headwaters to Border	100	5	10
(Assessment season for above waters is April through September)			
Lower Mississippi River Mainstem – Pools 2 through 4	32		
Lower Mississippi River Mainstem below Lake Pepin	30		
(Assessment season for Lower Mississippi is June through September)			

(Details regarding RNR boundaries and assignments as adapted for application of the Minnesota TSS water quality standards can be found in Heiskary and Parson (2013) at https://www.pca.state.mn.us/sites/default/files/wq-s6-18.pdf, including a statewide map in Figure 5.)

A stream is considered to exceed the standard for TSS/S-tube if 1) the standard is exceeded more than 10 percent of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and 2) there are at least three such measurements exceeding the standard. The Lower Mississippi River is considered to exceed the standard for TSS if summer (June through September) average concentrations exceed the standard in more than half of the summers.

A stream is considered to meet the standard for TSS/S-tube if the standard is met at least 90 percent of the days of the assessment season. A designation of meeting the standard for TSS/S-tube generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least two different years. However, if it is determined that the data set adequately targets periods and conditions when exceedances are most likely to occur, a smaller number of measurements may suffice. The Lower Mississippi River is considered to meet the standard for TSS if summer average concentrations do not exceed the standard in more than half of the summers.

S-tube measurements that fall between the two relevant surrogate values are considered to be indeterminate in exceeding or meeting the TSS standard and are not used in calculating overall percentages. If a stream satisfies neither the criterion for exceeding the standard nor the criterion for meeting the standard, the stream is considered to have insufficient information regarding TSS levels.

d) Temperature

High water temperatures, or rapid elevations of temperature above ambient, can be very detrimental to fish. Cold water fish such as trout are particularly intolerant of high temperatures. The temperature standard for Class 2A cold water sport fish is a narrative statement of "no material increase." A demonstration of a "material increase" means that temperature data must show a statistically significant increase when measured, for example, upstream and downstream of a stream modification, upstream and downstream of a point or nonpoint heat source, or before and after a modification that might impact stream temperature. Temperatures must be for similar time frames such as weeks or seasons. The larger the data set, the finer the precision in determining whether a material increase in stream temperature has occurred.

Currently the MPCA is evaluating mostly cold water fisheries for temperature-caused impairment because of the special sensitivity of cold water fish to elevations in temperature in streams.

e) Biological indicators

The presence of a healthy, diverse, and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a lake, stream, or wetland. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a water body over time. Monitoring the aquatic community, or biological monitoring, is therefore a relatively direct way to assess aquatic life use-support. Interpreting aquatic community data is accomplished using an index of biological integrity or IBI. The IBI incorporates multiple attributes of the aquatic community, called "metrics," to evaluate a complex biological system. MPCA has developed fish and invertebrate IBIs to assess the aquatic life use of rivers and streams statewide in Minnesota as well as plant and invertebrate IBIs to assess depressional wetlands. A fish IBI has been developed by the Minnesota Department of Natural Resources (MDNR) with assistance from MPCA to assess the aquatic life use of several lake types. A predictive model based plant indicator has also been developed by MDNR and is a measure of eutrophication stress to lake plant communities; this was piloted for the 2016 list, but was used as supporting information only.

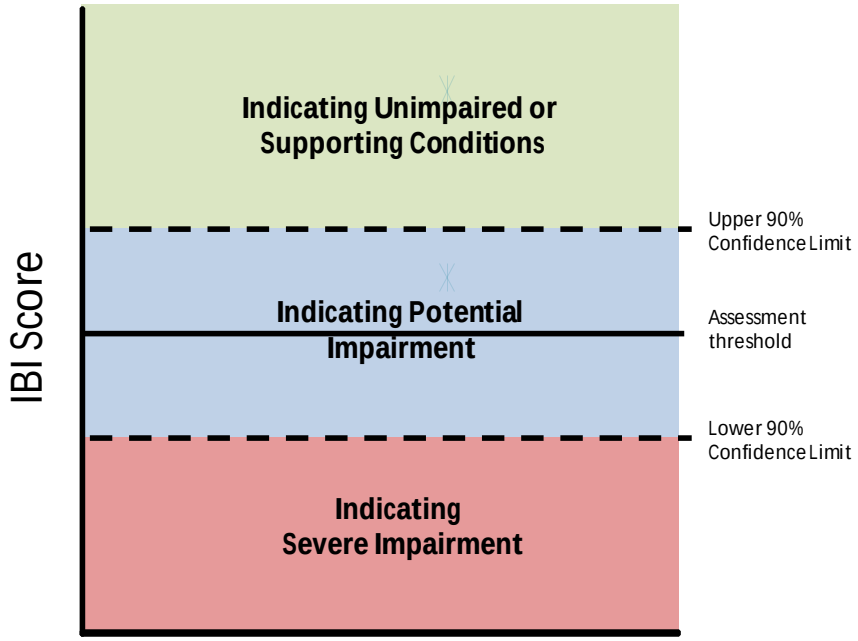
Further interpretation of aquatic community data is provided by an assessment threshold or biocriteria against which an IBI score can be compared. In general, an IBI score above this threshold is indicative of aquatic life use-support, while a score below the threshold is indicative of non-support. Currently, Minnesota is using a combination of two similar concepts to set biocriteria: the Biological Condition Gradient (BCG) and reference condition. To develop biocriteria that are protective of the structural and functional health of biological communities, Minnesota used the median of BCG level 4. Communities at the middle of this level can be best characterized as possessing "*overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes*" which is in line with the language of the CWA interim goal. This BCG-derived criteria was then compared to criteria derived from reference sites to insure that the two approaches were closely aligned in each IBI class. This same BCG process was used to set the threshold for the lake fish IBI classes.

Minnesota is in the process of adopting Tiered Aquatic Life Uses (TALU). This framework refines Minnesota's single goal for aquatic life into three tiers that are bases on the aquatic life potential for a water body. These tiered uses are Exceptional, General (current goal), and Modified. The process for determining the appropriate tier is called a Use Attainability Analysis (see http://www.pca.state.mn.us/index.php/view-document.html?gid=23281) and it is carried out before the assessment process. The actual mechanisms for performing an assessment of TALUs are similar to the current process with the only major difference being the biocriteria threshold. It is also important to note that at this point the TALU framework has not been adopted into rule and therefore impairments based on these assessments cannot added to the Impaired Waters List. However, this is only important for Exceptional Use waters since the General Use is equivalent to the current use and impaired Modified Use waters would be impaired regardless of the adoption of the TALU framework.

Bracketing each IBI assessment threshold is a 90 percent confidence interval that is based on the variability of IBI scores obtained at sites sampled multiple times in the same year (i.e., replicates). Confidence intervals account for variability due to natural temporal changes in the community as well as method error. For assessment purposes, sites with IBI scores within the 90 percent confidence interval are considered "potentially impaired." Upon further review of

available supporting information, an IBI parameter review may change to "indicating support" or "indicating severe impairment" depending on the extent and nature of this additional information (Figure 2).

Figure 2. General diagram illustrating the characterization of individual biological indicator results.



See Appendix F for further information regarding the basis of biological assessments including Minnesota's water quality standards, the development of the BCG, the selection of river and stream reference sites, and the development and the application of the IBI for lakes.

f) River eutrophication

The River Eutrophication Standard (RES) is a two-part standard, requiring an exceedance of the causative variable (total phosphorus) and a response variable which indicates the presence of eutrophication (i.e. undesirable levels of sestonic or suspended algae, benthic or attached algae, or excessive rooted vegetation). This response can be measured directly with sestonic chlorophyll-*a* or indirectly via dissolved oxygen flux, 5-day biochemical oxygen demand (BOD_5) or pH. These measures are highly correlated with each other in rivers and are indicators of stress for aquatic communities.

The first step in applying Minnesota's RES is to determine the appropriate River Nutrient Region (RNR), or regions, for the water body being assessed. (Site-specific navigational pool and Lake Pepin standards do not require this step.) There are 80 eight-digit Hydrological Unit Code (HUC-8) watersheds in Minnesota. These were overlaid with the U.S. Environmental Protection Agency Level III ecoregion map to develop the RNRs. River eutrophication standards vary by RNR and can be found in Table 5.

Table 5. Minnesota's River Eutrophication and site-specific standards for navigational pools, Lake Pepin and specifically named river reaches.

	Causative	Response (stress)		
Region or River	**Total Phosphorus (ug/L)**	**Chlorophyll-*a* (ug/L)**	**Diel Dissolved Oxygen Flux (mg/L)**	**Biological Oxygen Demand (mg/L)**
Northern River Nutrient Region	50	7	3.0	1.5
Central River Nutrient Region	100	18	3.5	2.0
Southern River Nutrient Region	150	40	5.0	3.5
Site-Specific Standards				
Mississippi River Navigational Pool 1	100	35		
Mississippi River Navigational Pool 2	125	35		
Mississippi River Navigational Pool 3	100	35		
Lake Pepin (Mississippi River Navigational Pool 4)	100	28		
Mississippi River Navigational Pools 5 to 8	100	35		
Crow Wing River from Long Prairie River to the Mouth of the Crow Wing River	75	13	3.5	1.7
Crow River from the confluence of the North Fork and South Fork of the Crow River to the mouth of the Crow River	125	27	4.0	2.5

For assessment purposes this means the cause indicator (phosphorus) and response indicators (chl-*a*, BOD_5, diel DO flux, or pH) are used in combination and not independently. The eutrophication rule clearly states the requirement that cause and response indicators must both be exceeded to indicate a polluted condition.

Data minimums and summarizations

For total phosphorus, chlorophyll-*a*, and BOD_5, the following are required:

- A minimum of 12 measurements per parameter within the ten-year assessment period (minimum 2 years required)
- Data compared to the standard is a seasonal average – June to September data only
- If multiple values exist for a parameter along a given reach for a single day, a daily average will be calculated prior to determining a seasonal average

For dissolved oxygen flux

- A minimum of a 4-day deployment is required – June to September
- A minimum of 2 deployments over separate years in the assessment window is required
- It is preferred that the deployments coincide with summers when chemistry is collected and that the deployment is taken during mid-late summer
- Multiple deployments will be summarized separately

For pH

- Existing water quality standards for pH are used for the River Eutrophication Assessment; minimum of 20 samples necessary to indicate standard is met
- Review of data is limited to June to September

Assessment considerations

A stream is considered to exceed the river eutrophication standard if:

1. the total phosphorus concentration exceeds the standard
2. AND chlorophyll-*a,* BOD_5, DO Flux, OR pH exceeds the standard

A stream is considered to meet the river eutrophication standard if:

1. the total phosphorus concentration meets the standard
2. AND all available response variables meet the standard (this includes the situation where no response variables are present). Not all response variables must be available to consider the reach to be meeting the river eutrophication standard. It is also possible to determine the reach is meeting the standard if 1) total phosphorus exceeds the standard AND all response variables are available in sufficient quantities (chl-*a*, BOD_5, DO Flux, pH) and they all meet the standard.

A stream is considered to have insufficient information if:

1. there are less than 12 samples of the causative variable OR no response variables meet the minimum data requirements, or
2. the causative and/or response variables are within the standard error of the mean and confidence does not exist in determining whether the reach meets or exceeds the standard.
3. The causative and/or response variables have low data confidence or are not representative of ambient conditions (poor QA/QC, flood or drought biased sampling, proximity to continuously discharging facilities, etc.).

Due to the complexity of the standard, additional information to aid an assessment decision is available in Appendix G.

2. Data requirements and determination of impaired condition

Overall assessment of whether an AUID adequately supports aquatic life involves the review of the parameter-level evaluations and data quality in conjunction with all available supporting information (flow/water level, habitat, precipitation, plant surveys, etc.) to make an overall use-support determination. For a given AUID, there may be chemistry indicator data, biological indicator data, or both types of data available for assessment. The final assessment takes into consideration the strength of the various indicators and the quality of the data sets and, in addition, looks at upstream and downstream conditions to gain a better understanding of the interactions between the individual AUID and the larger water body and watershed.

In general:

- A stream reach or lake is considered to be **fully supporting** of aquatic life if:
    - IBI scores for all available assemblages indicate fully supporting conditions, or
    - the standards for river eutrophication and/or dissolved oxygen are met AND total suspended solids/Secchi tube are met (streams only) and
    - other lines of evidence considered comprehensively, including upstream/downstream conditions, do not contradict a finding of full support

- A stream reach or lake is considered to be **not supporting** if:
    - IBI scores for at least one biological assemblage indicate impairment, or
    - one or more water chemistry parameters indicates impairment, and
    - other lines of evidence considered comprehensively, including upstream/downstream conditions, do not contradict a finding of non-support
- If the above criteria are not met and the assessment is inconclusive, the result is a determination of **insufficient information**.

In cases where an assessment unit has been determined to be not supporting based on biological indicators, water-chemistry parameters are added to the list of impairments only when the chemical impairment is clear enough that the AUID would be considered impaired even without the biological evidence.

The following paragraphs provide more details of the considerations that occur when analyzing the available data and information to make a comprehensive aquatic life use-support assessment, based on what types of indicator data are available. This information is used by the Watershed Assessment Team and Professional Judgment Group for each watershed as guidance in making use-support decisions.

a) Only biological indicator data available
Fully Supporting – All available fish and invertebrate IBI scores within the assessment unit fall above the upper 90 percent confidence limit. A fully supporting determination does not require that both indicator assemblages have been measured within the assessment unit.

Not Supporting – All fish and/or invertebrate IBI scores fall below the lower 90 percent confidence limit. A not supporting determination does not require agreement between the indicator assemblages; one assemblage indicating severe impairment is sufficient for a not supporting determination.

Otherwise, initial assessment is potentially impaired when one or more IBI scores fall within the 90 percent confidence interval that bounds the assessment threshold OR multiple IBI scores within an indicator assemblage are resulting in discrepant assessments. Further analysis is required to make a use-support determination, consider the following factors:

- co-occurrence of indicator data
- habitat conditions
- sampling conditions
- watershed context

b) Only water chemistry indicator data available
Fully Supporting (streams only) – 1) The standards for river eutrophication and/or dissolved oxygen are met, AND TSS/Secchi Tube are met for streams, AND 2) supporting information including upstream/downstream conditions, do not strongly contradict a finding of full support. In making this determination, consider the following factors:

- co-occurrence of indicator data
- strength of indicator
- parameter-level evaluations
- sampling conditions
- watershed context
- continuous monitoring data (when available)

Not Supporting (streams or lakes) – 1) One or more water chemistry parameters indicate potential or severe impairment AND 2) supporting information including upstream/downstream conditions do not strongly contradict a finding of non-support. If the first condition is met, condition two should primarily be evaluated considering:

- strength of indicator
- parameter-level evaluations
- watershed context
- continuous monitoring data (when available)

In general, information from within the assessment unit (strength of indicator and parameter-level evaluation) serves as the primary arbiter for making a not supporting determination, while assessments and data from adjacent assessment units (watershed context) provides additional information that either corroborates or refutes this determination. Considering these three factors together, a <u>not supporting</u> determination is more likely in situations where

1) parameter-level evaluations indicate potential or severe impairment, 2) the strength of these indicators is medium or high, AND 3) the assessment is corroborated by similar conditions upstream or downstream of the assessment unit in question. Continuous monitoring data, if available, can be used to either corroborate or refute the evidence provided by grab-sample data sets.

c) Both biological and water chemistry indicator data:
Fully Supporting – 1) IBI score for at least one biological assemblage indicates supporting conditions OR the standards for river eutrophication and/or dissolved oxygen are met, and TSS/Secchi tube are met (streams only), AND 2) other data and information considered comprehensively, including upstream/downstream conditions, do not strongly contradict a finding of full support. If the first condition is met, condition two should be evaluated considering the following factors:

- co-occurrence of indicator data
- strength of indicator
- parameter-level evaluations
- habitat conditions
- sampling conditions
- watershed context
- continuous monitoring data (when available)

Not Supporting – 1) IBI score for at least one biological assemblage indicates severe impairment OR 2) IBI score for at least one biological assemblage indicates potential impairment AND the parameter-level evaluations and other data and information considered comprehensively corroborate a finding of non-support OR 3) one or more water chemistry parameters indicate impairment AND the evidence considered comprehensively leads to a conclusion of non-support. To evaluate all three conditions, consider the following factors:

- co-occurrence of indicator data
- strength of indicator
- parameter-level evaluations
- habitat conditions
- sampling conditions
- watershed context
- continuous monitoring data (when available)

d) Insufficient information:
If the criteria are not met for a fully supporting or not supporting assessment and the assessment is inconclusive, the result is a determination of insufficient information. "Insufficient information" determinations include situations where sufficient data are not available to assess the use, or the strength of the available indicator(s) is low and there is no supporting information available to help verify what the weak dataset is indicating. Sites receiving an "insufficient information" assessment may be prioritized for follow-up monitoring during MPCA stressor identification efforts, addressed by local monitoring efforts, or monitored further during the next round of intensive watershed monitoring.

VI. Aquatic Consumption and Drinking Water

This section focuses on Human Health-based Water Quality Standards (HH-WQSs): Class 2 chronic standards (CSs) and site-specific chronic criteria (CC). These standards serve as the basis for developing chronic or long-term protection for humans from toxic pollutants to ensure the beneficial uses of drinking water (where designated) and fish consumption and recreation in all surface waters are met. Class 2 numeric water quality standards and criteria for human health cover elemental and synthetic chemical contaminants characterized as toxic pollutants[1].

The Class 1 designation and associated domestic consumption (DC) standards specifically address drinking water and food processing use of groundwater and designated surface waters. The Federal Safe Drinking Water Act (SDWA) standards incorporated by reference into Minn. R. ch. 7050 provide the numeric basis for protecting this use. Application of Class 1 DC standards for nitrate and nitrite in surface waters designated for drinking water protection is also discussed in this section.

A. Pollutants with Class 2 human health-based chronic standards

Class 2 CSs to protect human health are developed for application in water, as described in the previous chapter, and in fish tissue. For toxic pollutants detected in surface water that lack CSs, the methods in Minn. R. chs. 7050 and 7052 are used to develop site-specific CC. Fish tissue-based CSs (or CC) are described later in this section. Full details on HH-WQS are found in Minn. R. chs. 7050 and 7052 and in the *Human Health-based Water Quality Standards Technical Support Document* (September 2015), available at https://www.pca.state.mn.us/sites/default/files/wq-s6-12.pdf.

1. Algorithms for human health-based chronic standards

HH-WQS are set at concentrations to protect human users of surface waters. That protection considers the toxicity (deleterious, noxious, or injurious) characteristics of the pollutant and how much a population may be exposed to that pollutant through the three designated beneficial uses of surface waters: drinking water, recreational activities, and fish consumption. In short, HH-WQS encompass a pollutant's toxicity and a population's potential exposure and lead to numeric CSs (or site-specific CC) that cannot be exceeded in surface water or fish tissue.

The methods used to develop pollutant-specific numeric HH-WQS (Class 2 CSs or CC) for toxic pollutants were first adopted in 1990 for statewide application and in 1998 for the Lake Superior Basin. Currently, Minn. R ch. 7050 contains class 2 standards for 69 toxic pollutants. Of these, 36 standards are more restrictive to protect human health than aquatic life (Minn. R. 7050.0222). Minnesota R. ch. 7052 contains class 2 standards for 29 pollutants; for 15 of these standards human health is the basis for the most stringent CS (Minn. R. 7052.0100).

HH-WQS can differ based on the class 2 subclasses (classes 2A, 2Bd, and 2B). Class 2A and 2Bd waters are also protected for DC uses (class 1), so include drinking water exposure in their calculations. Class 2B waters are protective of fish consumption and recreation only. To determine the classification of the water body of interest consult Minn. R. 7050.0470. Water bodies not listed are class 2B. HH-WQS for Lake Superior are found in Minn. R. 7052.0100.

[1] Minn. Statute 115: Toxic Pollutant: means those pollutants, or combinations of pollutants, including disease-causing agents, which after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will, on the basis of information available to the agency, cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, including malfunctions in reproduction, or physical deformation, in such organisms or their offspring.

2. Pollutants with human health-based chronic standards

The pollutants that have human health-based CSs that are most often included in MPCA water quality assessments are briefly described. Pollutants other than those mentioned here may be assessed also, as data allow.

a) Arsenic

Arsenic is both a naturally occurring element and anthropogenic pollutant detectable in most surface waters. The presence of arsenic is of greatest concern for drinking water exposure. Available information on health effects associated with arsenic exposure comes from long-term studies of people exposed from drinking contaminated well water. The MPCA has HH-WQS for arsenic and has conducted monitoring studies to assess these standards. Most concerns of arsenic exposure are due to elevated concentrations in groundwater. The surface waters identified with arsenic above CSs are in the Red River of the North Basin. The elevated concentrations are primarily attributed to natural occurrence in soils and sediments of the area.

- 2.0 µg/L. chronic standard, Minn. R. ch. 7050.0222 (statewide class 2A and 2Bd)
- 53 µg/L. chronic standard, Minn. R. ch. 7050.0222 (statewide class 2B)
- 2.0 µg/L. chronic standard, Minn. R. ch. 7052.0100 (waters of Lake Superior Basin)

b) Mercury

Mercury is the classic example of a bioaccumulative element; it never degrades, it can bioaccumulate through the food chain to reach toxic levels in many fish species, which if eaten in high amounts, can lead to serious health effects. Neurodevelopmental effects to children exposed during gestation are of most concern. Because mercury primarily enters water from air sources (local to global), full control of sources is not possible; therefore, the Minnesota Department of Health (MDH) Fish Consumption Advice is an important means for addressing the ongoing presence of mercury in fish and providing guidance to fish consumers to keep exposure from mercury and other bioaccumulative pollutants in fish low (discussed further in the fish pollutant section).

Mercury CSs are based on total concentrations and, thus, total mercury measurements are used in assessments. Minnesota has two water-column Class 2 water quality standards for total mercury, as shown below (although the more stringent CS for Lake Superior is based on fish-eating wildlife, this value is protective of human consumers and assessed the same way as the statewide mercury CS).

- 6.9 ng/L. chronic standard, Minn. R. ch. 7050.0222 (statewide)
- 1.3 ng/L. chronic standard, Minn. R. ch. 7052.0100 (waters of Lake Superior Basin)

In 2008, MPCA also adopted a fish tissue mercury standard into Minn. R. ch. 7050.

- 0.2 mg/kg, total in edible fish tissue

The MPCA began using clean sampling techniques for mercury and other trace metals in 1996, and only data collected in this manner will be used (EPA Method 1631 or equivalent). Mercury levels are assessed by comparing concentrations in water to the ambient standards shown above, and by assessing the mercury in fish tissue directly, as outlined in Section VI.B., where mercury in fish tissue is further discussed.

c) Pesticides (atrazine)

The Minnesota Department of Agriculture (MDA) conducts extensive pesticide monitoring in surface waters. MDA submits all their data to the MPCA for assessments. Most of the pesticides with water quality standards (WQS) are aquatic life toxicity-based, meaning the

concentration to protect aquatic organisms (invertebrates, fish, or plants) is more stringent than the concentration need to protect human health. Atrazine is a pesticide with a more stringent WQS for human health in class 2A and 2Bd surface waters.

- 3.4 µg/L, Class 2A and 2Bd chronic standard, Minn. R. ch. 7050.0222 (statewide)

3. Pollutants with human health- and aquatic life toxicity-based standards or criteria

The MPCA calculates both an aquatic life toxicity-based and a human health-based chronic criterion, and the more restrictive of the two is adopted into Minn. R. ch. 7050 or ch. 7052 (with fish-eating wildlife) as the applicable CS. Because of the different averaging times used when comparing human health-based or aquatic life toxicity-based standards to monitoring data, a complete impaired waters assessment would require comparisons of monitoring data to both values. Minn. R. ch. 7050 and ch. 7052 will only list the more stringent CS, but the MPCA retains a record of all calculated criteria values.

a) Pollutants

Some pollutants such as atrazine, cobalt, nickel, pentachlorophenol, cadmium, lindane, and 2,4,6-trichlorophenol have human health-based and aquatic life toxicity-based standards or criterions that have similar values.

The CS for atrazine is 3.4 µg/L for Class 2A and 2Bd waters. While this human health-based standard is lower than the aquatic life toxicity-based criterion of 10 µg/L, the aquatic life-toxicity value is applicable to all waters to ensure protection of aquatic organisms. Because Class 2B waters are not protected for drinking water, the aquatic life toxicity criterion of 10 µg/L becomes the most stringent value and is the basis for the CS (Minn. R. 7050.0222). The human health-based criterion value for Class 2B waters is 100 µg/L, to protect people who eat fish.

Monitoring data available on atrazine often includes atrazine degradates. In most cases, not enough information is available to determine a water quality standard for degradates, but available human health and aquatic toxicity reviews are considered by the PJG when assessing waters for impairment. For HH-WQS, MDH health-based guidance can be used for degradates. If such guidance is not available, the "parent" chemical HH-WQS are applied. See more information in *C. Additional guidance for assessing human health-based standards.*

4. Data requirements and determination of impaired condition

The requirements for assessing water bodies for exceedances of human health-based CSs and human health- and aquatic life toxicity-based CSs are essentially the same as for chemicals with aquatic life toxicity-based standards (see Section V. A.) The major difference is that data compared to the human health-based CSs are averaged over a 30-day period.

Table 6. Summary of data requirements and exceedance thresholds for assessment of pollutants with human health-based, human health- and aquatic life toxicity-based, and wildlife-based standards.

Period of Record	Use-Support or Listing Category	
Most recent 10 years	No more than 1 exceedance of the chronic standard in 3 years, and no exceedances of the maximum standard: Not listed	2 or more exceedances of the chronic standard in 3 years, or 1 or more exceedances of the maximum standard: Listed

B. Protection for human consumption of fish

This section describes the assessment of fish for human consumption based on fish contaminant data. With revisions to the methods to develop and apply HH-WQS come changes to assessments of fish pollutants. The MPCA now has methods to develop fish tissue CSs (or CC) that will be the basis of determining if pollutants in fish fillets exceed HH-WQS. The application of MDH Fish Consumption Advice (FCA) thresholds for evaluating impairments will be limited as described in this section. Most fish monitoring data will continue to be collected through the interagency Fish Contaminant Monitoring Program (FCMP) and also used by MDH for FCA. See Minn. R. 7050.0219 https://www.revisor.mn.gov/rules/?id=7050.0219 for details.

1. Basis for assessment of fish contaminants

The basis for assessing the contaminants in fish tissue is the narrative water quality standards and assessment factors in Minn. R. ch. 7050.0150, subp. 7, which states the following:

> *Subp. 7. Impairment of waters relating to fish for human consumption.*
>
> *A. In evaluating whether the narrative standards in subpart 3, which prevent harmful pesticide or other toxic pollutant residues in aquatic flora or fauna, are being met, the commissioner must use the methods in:*
> *(1) parts 7050.0218 and 7050.0219 for site-specific fish tissue-based chronic criterion (CC_{ft}); or*
> *(2) parts 7050.0222 and 7052.0100 for fish tissue-based chronic standard (CS_{ft}).*
>
> *B. If CS_{ft} has not been established for a pollutant with chronic standards (CS) applicable in water (CS_{dfr}, CS_{dev}, or CS_{fr}, as defined in parts 7050.0218, subpart 3, item Q, and 7050.0219, subpart 13, item B), the residue levels in fish muscle tissue established by the Minnesota Department of Health must be used to identify surface waters supporting fish for which the Minnesota Department of Health recommends a reduced frequency of fish consumption for the protection of public health. A water body will be considered impaired when the recommended consumption frequency is less than one meal per week, such as one meal per month, for any member of the population. That is, a water body will not be considered impaired if the recommended consumption frequency is one meal per week, or any less restrictive recommendation such as two meals per week, for all members of the population. The impaired condition must be supported with measured data on the contaminant levels in the resident fish.*
>
> *C. When making impairment determinations in an individual water body for a pollutant with both a fish tissue-based CC_{ft} or CS_{ft} and a CS applicable in water, comparison of fish tissue data to the CC_{ft} or CS_{ft} must be the basis for the final impairment determination.*

2. MPCA assessment of pollutants in fish tissue

Chemicals that persist in the environment and "build up" in the tissues of aquatic organisms to higher concentrations than the concentrations in the surrounding water are called bioaccumulative chemicals of concern (BCCs). Uptake through the food chain means that at each step, from plants to prey to predator, the concentrations in the biota increase. This "biomagnification" as it is called is a concern because many game fish (e.g., walleye, northern pike, bass, and lake trout) are at the top of the aquatic food chain and typically carry the highest tissue concentrations of a BCC in the aquatic system.

The bioaccumulation factor (BAF) is the ratio between the concentration of the chemical in the biota and the concentration of the chemical in the water. BAFs can exceed one million for very highly bioaccumulative chemicals. A BAF must be determined to calculate a human health-based water column standard. For pollutants defined as BCCs, BAFs > 1000, the CSs are very low water column concentrations in order to limit their concentration in fish tissue. For these chemicals,

such as mercury, polychlorinated biphenyls (PCBs), and dioxins, exposure from the fish consumption pathway also far exceeds that from drinking water or recreational activities.

The Minnesota Department of Health has had a long-standing public outreach program, Fish Consumption Advice (FCA), to support the continued good health of people that eat fish in Minnesota. The MDH issues guidelines for how often certain fish can be eaten. The FCA addresses mercury, polychlorinated biphenyls (PCBs), and perfluorooctane sulfonate (PFOS) using concentrations in fish tissue that corresponds to meal frequency recommendations (Table 7). The advice also identifies water bodies with fish showing elevated levels of dioxins and furans. As an advisory, the goal of the FCA is to help people make informed decisions on which fish to eat and which to avoid. The advice is not mandatory nor regulatory.

Table 7. Fish tissue concentrations for levels of consumption advice established by MDH (April 2008)

Consumption Advice:	**Unrestricted**	**1 meal per week**	**1 meal per month**	**1 meal per 2 months**	**Do not eat**
*Mercury (mg/kg)	≤ 0.05	>0.05 - 0.22	>0.22 - 0.95		> 0.95
Total PCBs (mg/kg)	≤ 0.05	>0.05 - 0.22	>0.22 - 0.95	>0.95 - 1.89	> 1.89
PFOS (mg/kg)	≤ 0.040	>0.04 – 0.20	>0.20 – 0.80		> 0.80

http://www.health.state.mn.us/divs/eh/fish/eating/mealadvicetables.pdf

*Consumption advice for young children and women who are pregnant or may become pregnant.

The MPCA has now adopted methods to develop fish tissue standards or site-specific criteria for these and any other BCC identified in or with the potential to be present in fish.

a) Mercury

Mercury is a BCC detected in most fish. Concentrations reach levels of concern in many predator species. Based on EPA guidance, MPCA adopted a fish tissue standard for mercury in 2008 to provide a more accurate and directly usable standard to protect fish consumers.

The fish tissue-based CS_{ft} for total mercury is found in Minn. R. 7050.0222. It is applicable in all class 2 surface waters.

- 0.2 mg/kg in edible fish tissue (statewide)

b) Polychlorinated biphenyls (PCBs)

PCBs constitute a group of chlorinated organic compounds distributed world-wide. Their extensive historical use combined with their persistence, bioaccumulative properties, and cancer and non-cancer toxicity, make them very serious environmental pollutants. Concentrations of PCBs in water are very low (typically less than one part per trillion) and difficult to measure. But, because they bioaccumulate as much as a million fold or more in fish, they are readily measured in fish tissues. Thus, PCBs are usually assessed for the 303(d) List on the basis of their presence in fish, resulting in MDH advice to anglers to limit their consumption of certain fish. MDH FCA thresholds will continue to be used for PCBs as water CSs exist in rule and CS_{ft} in fish tissue will need to be adopted, along with revised CSs in water, in a future rulemaking.

Previous and ongoing assessments of PCBs in fish tissue will use the FCA concentration that restricts fish consumption from one meal a week to one meal a month, 0.22 mg/kg, for determining if the fish meet the protection level goals for fish consumers. Concentrations above this amount identified as advisory levels for any fish species in a water body result in that water body being listed as impaired for PCBs.

c) Perfluorooctane Sulfonate (PFOS)

PFOS is a synthetic perfluorinated chemical used for decades to make products that resist heat, oil, stains, grease, and water. The MPCA has been monitoring for PFOS in fish since 2004 and has identified certain waters as impaired due to concentrations in fillets exceeding 0.20 mg/kg. This is the concentration used in FCA to restrict fish consumption from one meal a week to one meal a month. With the adoption of the revised methods for HH-WQS, future assessments will be based on the new methods for developing fish-tissue based chronic criteria or standards in Minn. R. 7050.0217 to 7050.0219. MDH FCA will not be the basis for assessments.

d) Dioxins and Furans

Dioxins and furans are similar to PCBs in many respects. Both represent a family of chlorinated organic chemicals, some of which are very persistent, bioaccumulative and toxic, as well as global in their distribution. Unlike PCBs, dioxins and furans were never intentionally manufactured. The major sources are combustion of waste, plastics, and wood, chlorine bleaching of pulp wood (now largely phased out), and trace contaminants in other manufactured organic compounds. 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) has been shown to be carcinogenic in animals at extremely low doses. The MPCA has Class 2 HH-WQS for 2,3,7,8-TCDD in Minn. R. ch. 7052, applicable only to waters in the Lake Superior basin. These standards also include other dioxins and furans with toxic equivalent factors. Some PCB congeners can also have dioxin-like toxicity and considered when data are available. The only 2,3,7,8-TCDD standard in Minn. R. ch. 7050 is the EPA drinking water standard of 30 pg/L.

The MPCA evaluates waters for dioxins and furans only at site-specific locations where contamination is suspected or where data are needed to support remedial efforts. Evaluation of dioxin and furans in fish tissue will be based on site-specific chronic criteria or standards developed based on Minn. R. 7050.0217 to 7050.0219 and Minn. R. 7052.0270.

3. Data requirements and determination of impaired condition

The 303(d) Impaired Waters List identifies water bodies that do not meet legally enforceable water quality standards or site-specific criteria, and for which a remedial plan may be required. An important caveat is that one cannot assume, because a particular water body does not appear on the 303(d) List, the fish in that water body are safe for unlimited consumption. Most likely it means the fish from that water body have not been tested. Only those water bodies from which the fish have been tested and found to exceed the impairment thresholds will be put on the 303(d) List. In addition, water bodies listed as impaired for fish consumption can still yield fish low in pollutant concentrations. The MDH FCA should be consulted for advice on fish consumption and health risks on a statewide or water body basis (MDH 2001).

The MDH currently relies on a regression approach to determine consumption advice for variable size ranges. The advisory threshold concentrations summarized in Table 7 are applied to the most recent 10 years of data from a water body. Impairments for PCBs are based on a fish tissue concentration exceeding 0.22 mg/kg, which is the upper threshold for one meal per week fish consumption.

For pollutant data in fish, other than PCBs, the determination of impaired waters for fish consumption reflects approaches used to assess water quality data. The 0.2 mg/kg fish mercury concentration is the threshold for determining impairment for total mercury in edible fish tissue[2].

[2] Note: The Statewide Mercury TMDL does not apply to waters with measured fish tissue mercury concentrations greater than 0.57 mg/kg. These waters remain as Category 5 waters on the MPCA 303(d) list.

For other fish pollutants, the MPCA would develop site-specific CC_{ft} or future CS_{ft} to assess fish for impairment.

A water body is defined as impaired based on two approaches depending on the number of fish and species with available monitoring data.

a) Multiple fish of one species:
If more than 10 percent of the fish (minimum of five fish) in a species are greater than the fish tissue-based CS_{ft} or CC_{ft}, the fish are not meeting the water quality standard. This is equivalent to saying the water is impaired if the 90th percentile of the pollutant concentration for any fish species is greater than the CS_{ft} or CC_{ft} . This is the same protocol that has been used to assess mercury in fish.

To determine which water bodies (lake, reservoir, or stream assessment unit) are impaired for fish consumption, the Minnesota Fish Contaminant Monitoring Program (FCMP) database is queried for the following criteria:

- fish collected in the last 10 years, unless the 90th percentile between years 10 to 6 and years 5 to present are statistically different, in which case only the most recent 5 years is used in the assessment,
- filet with or without skin on; no whole fish,
- at least five fish in a species, including fish within a composite sample, is needed for 90th percentile calculation, and
- 90th percentile fish tissue concentration is greater than CS_{ft} or CC_{ft} (i.e., more than 10 percent are greater than CS_{ft} or CC_{ft})

The 90th percentile rank is calculated by multiplying the number of fish by 0.9 and rounding to the nearest whole number. The 90th percentile pollutant concentration is determined for each water body-species by (1) ranking the samples within each water body-species from low to high, (2) concentration of a composite sample is treated as the concentration for all fish within the composite, (3) if the 90th percentile ranked fish is greater than CS_{ft} or CC_{ft} or is in a composite that is greater than CS_{ft} or CC_{ft}, it is marked as impaired.

b) Fewer fish of more than one species:
If a water body has multiple species of fish with pollutant monitoring data, but fewer than five fish per species, the alternate method for determining if WQS are being met is through averaging a concentration across species. In a weight-of-evidence approach, if the average concentration of at least three species exceeds the CS_{ft} or CC_{ft} that water body would also be identified as impaired. Like the evaluation for multiple fish of one species, fish collected in the last 10 years would be used unless enough fish samples are available to compare average concentrations between years 10 and 6 and 5 to present. If the averages are statistically different then only the most recent 5 years is used in the assessment.

Both scenarios recognize that concentrations in fish are a result of a longer-term average exposure and that the fish sampled by the FCMP focus on those species regularly caught and consumed by Minnesotans; reasonable evidence of fish with pollutant concentrations above CS_{ft} or CC_{ft} warrants concern and impairment designation. Based on the FCMP sampling protocol, most water bodies monitored will exceed the minimum data requirements or include the species of most concern for the respective pollutant (i.e., walleye for mercury or bottom feeders, such as carp or catfish, for PCBs).

With the revised HH-WQS methods, fish data for BCCs is the basis for impairment determination if water data are also available (Minn. R. 7050.0222, subp. 7, item C.).

C. Additional guidance for assessing human health-based standards

1. Chemical breakdown products or environmental degradates

Some pollutants, when introduced into the environment, undergo chemical transformation through microbial, photolysis, or other processes. Particularly for pesticides, there are known common environmental breakdown products referred to as degradates that originate from the "parent" chemical. In order to be health protective, breakdown chemicals that originate from a "parent" chemical should be assessed the same as the "parent" when toxicological data on the degradate are insufficient for a chemical-specific health based water value. To address degradates found in surface water, the MPCA applies the parent HH-WQS to environmental degradates or MDH health-based guidance when available (Minn. R. ch. 7050.0222, subp. 7, item D).

2. Mixtures of pollutants in a water or fish sample

Another aspect to assessing class 2 CSs (and CC) based on human health is the presence of more than one toxic pollutant in a sample. This is dependent on the toxicity determination of each pollutant: carcinogen, denoted with a "(c)" next to the pollutant's name in Minn. R. 7050.0220 or 7050.0222, or noncarcinogen.

For linear carcinogens, the additivity algorithm is as listed in Minn. R. 7050.0222, subp. 7, item E, and Minn. R. 7052.0230, subp. 2. The additivity equation applies to chemicals that are linear carcinogens and have HH-WQS calculated with a cancer slope factor. A risk index is calculated for each carcinogen in the sample by dividing the concentration of the pollutant by its CS (or CC) and summing those values. The risk index value has to be equal to or less than one to meet HH-WQS. An index that exceeds one indicates the excess cancer risk level is greater than 1 in 100,000 and is in violation of the HH-WQS.

The MPCA recently added to this existing protection to surface water users by including a new approach for noncancer mixtures: an additivity analysis modeled on the MDH Health Risk Limit rule. The approach is again based on summing up the ratio of each pollutant concentration measured in the surface water or in fish tissue to their respective CS (or CC) based on their *Health Endpoint*. To ensure total exposure does not exceed the threshold for noncancer effects in the target organ, system, or process (development), the sum or *Health Risk Index* has to equal one or less to meet the HH-WQS.

Health Risk Index Endpoints (*Health Endpoints*) will be incorporated into HH-WQS for evaluation of mixtures of noncarcinogens. The MDH lists *Health Endpoints* for each noncarcinogen (or nonlinear carcinogen) unless the available study used to develop the toxicological values (reference dose) did not identify a specific adverse effect. *Health Endpoints* identify the most sensitive target organs or systems (e.g., nervous) or developmental process affected by that pollutant. These endpoints are used to group chemicals to evaluate mixtures if more than one pollutant with the same adverse effect is measured in a fish sample or water body. The details of this evaluation are in Minn. R. 7050.0222, subp. 7, item D.

D. Class 1 drinking water standards for nitrate nitrogen

Class 1 waters are protected as a source of drinking water. In Minnesota, all groundwater and selected surface waters are designated Class 1. The assessment of groundwater (Class 1A) for potential impairment of the drinking water use is outside the scope of this Guidance. The Minnesota Department of Health (MDH) monitors municipal finished water supplies for compliance with drinking water standards. The assessment of Class 1B and 1C listed surface waters for potential impairment by nitrate nitrogen is discussed in this section.

1. Nitrate nitrogen

Nitrate nitrogen poses a risk to human health at concentrations exceeding 10 mg/L in drinking water. Humans, especially infants under six months of age, who are exposed to nitrate in drinking water at concentrations exceeding the 10 mg/L federal safe drinking water standard (which is incorporated by reference into Minn. R. ch. 7050.0221) can develop methemoglobinemia, a blood disorder that interferes with the ability of blood to carry oxygen. The 10 mg/L standard is an acute toxicity standard. Long term, chronic exposure to nitrate in drinking water is less well understood but has been linked to the development of cancer, thyroid disease, and diabetes in humans.

In recognition of the trend of increasing nitrate concentrations in Minnesota streams and the public health and economic impact arising from elevated nitrate concentrations in drinking water (a particular concern in Southeast Minnesota's karst region), the MPCA assesses Class 1B and 1C designated surface waters for potential impairment by nitrate nitrogen.

2. Data requirements and determination of impaired condition

When assessing drinking water-protected surface waters Class 1B and 1C, MPCA compares 24-hour average nitrate concentrations to the 10 mg/L standard. Two 24-hour averages exceeding 10 mg/L within a three-year period indicates impairment.

Single measurements of nitrate concentrations under relatively stable conditions are generally considered to be sufficiently representative of 24-hour average concentrations for the purpose of assessments. When concentrations are more variable, multiple samples or time-weighted composite samples may be necessary in order to calculate a sufficiently accurate average concentration. The necessary number and type of samples can vary considerably from one situation to another and the determination of adequacy for the purpose of assessment will necessarily involve considerable professional judgment.

Table 8. Summary of data requirements and exceedance thresholds for assessment of nitrate nitrogen, Class 1 drinking water standard.

Period of Record	Use-Support or Listing Category	
Most recent 10 years	No more than 1 exceedance of the acute standard in 3 years: Not listed	2 or more exceedances of the acute standard in 3 years: Listed

VII. Pollutants with Wildlife-Based Water Quality Standards

Protection of the aquatic life use includes the protection of wildlife consumers of aquatic organisms. Minnesota has four wildlife-based water quality standards – all in Minn. R. ch. 7052, the Great Lakes Water Quality Initiative (GLI) rule. The GLI rule focuses on the reduction of bioaccumulative toxic chemicals in the Great Lakes ecosystem as a whole. The standards in Minn. R. ch. 7052 are applicable only to the surface waters of the Lake Superior basin in Minnesota. The GLI chronic wildlife-based standards are listed below:

- DDT – 11 pg/L
- Mercury – 1300 pg/L
- PCBs – 122 pg/L (GLI human health-based standards for PCBs are more stringent than the wildlife based standard)
- 2,3,7,8-TCDD – 0.0031 pg/L (GLI human health-based standards for dioxin are more stringent than the wildlife based standard for Lake Superior and Class 2A waters, but not for Class 2Bd and 2B, C & D waters)

The assessment of water bodies for compliance with the GLI wildlife-based standards follows the same protocols used to assess water bodies for human health-based standards, as described in the previous section (Table 7).

VIII. Protection of Aquatic Recreation

This section addresses the assessment of water quality for pollutants that have aquatic recreation-based standards. Standards based on protecting the ability to recreate on and in Minnesota's waters are Class 2 standards. An overview of these standards and their application for assessment is provided below

A. Streams and rivers – *E. coli* bacteria

The numeric standards in Minn. R. ch. 7050 that directly protect for primary (swimming and other recreation where immersion and inadvertently ingesting water is likely) and secondary (boating and wading where the likelihood of ingesting water is much smaller) body contact are the *E. coli* (*Escherichia coli*) standards shown in Table 9. *E. coli* standards are applicable only during the warm months since there is very little swimming in Minnesota in the non-summer months. Exceedances of the *E. coli* standard mean the recreational use is not being met.

The MPCA uses an *E. coli* standard based on a geometric mean EPA criterion of 126 *E. coli* colony forming units (cfu) per 100 mL. *E. coli* has been determined by EPA to be the preferred indicator of the potential presence of waterborne pathogens.

Table 9. *E. coli* water quality standards for Class 2 and Class 7 waters.

Use Class	Standard No. of Organisms Per 100 mL of Water		Applicable Season	Use
	Monthly Geometric Mean*	**10 % of Samples Maximum****		**Body Contact**
2A, trout streams and lakes, 2Bd, 2B, 2C, non-trout (warm) waters	126	1260	April 1 – October 31	Primary
2D, wetlands	126	1260	April 1 – October 31	Primary, if the use is suitable
7, limited resource value waters	630	1260	May 1 – October 31	Secondary

* Not to be exceeded as the geometric mean of not less than 5 samples in a calendar month.
** Not to be exceeded by 10% of all samples taken in a calendar month, individually.

1. Data requirements and determination of impaired condition

There is a considerable amount of *E. coli* data available in Minnesota, and also older fecal coliform data. For assessment purposes, only *E. coli* measurements will be used. Exceptions to the exclusive use of *E. coli* data will be made only in special cases, using a ratio of 200 to 126 to convert fecal coliform to *E. coli*.

Data over the full 10-year period are aggregated by individual month (e.g., all April values for all 10 years, all May values, etc.). At least five values for each month is ideal, while a minimum of five values per month for at least three months, preferably between June and September, is necessary to make a determination. Assessment with less than these minimums may be made on a case-by-case basis.

Where multiple bacteria/pathogen samples have been taken on the same day on an assessment unit, then the geometric mean of all the measurements will be used for the assessment analysis.

If the geometric mean of the aggregated monthly values for one or more months exceeds 126 organisms per 100 mL, that reach is considered to be impaired. Also, a water body is considered

impaired if more than 10 percent of individual values over the 10-year period (independent of month) exceed 1260 organisms per 100 mL This assessment methodology more closely approximates the five-samples-per-month requirement of the standard while recognizing typical sampling frequencies, which rarely provide five samples in a single month and usually only one. Table 10 summarizes the assessment process.

Table 10. Assessment of water bodies for impairment of swimming use - data requirements and exceedance thresholds for *E. coli* bacteria.

Period of Record	Minimum No. of Data Points	Use-support or Listing Category Based on Exceedances of The *E. coli* Standard	
Standard Exceedance Thresholds ® **Monthly geometric mean** **> 126 orgs/100 mL (Class 2)** **> 630 orgs/100 mL (Class 7)**		**No months**	**1 or more months**
Most recent 10 years	see text	Not Listed	Listed
Standard Exceedance Thresholds ® **Exceeds 1260 orgs/100 mL***		**≤ 10 %**	**>10 %**
Most recent 10 years	15	Not Listed	Listed

* In full data set over 10 years.

Expert review of the data provides a further evaluation. When fewer than five values are available for most or all months, the individual data are reviewed. Considerations in making the impairment determinations include the following:

- dates of sample collection (years and months)
- variability of data within a month
- magnitude of exceedances
- 'remark' codes associated with individual values
- previous assessments and 303d listings

In some circumstances where four values are available for some or all months, a mathematical analysis is done to determine the potential for a monthly geometric mean to exceed the 126 organisms/100mL standard. All assessments are reviewed by the Watershed Assessment Team (WAT) for each watershed.

Large datasets:
Aggregating data by month across years for very large datasets diminishes the value of the data and assessment, making it less likely that periodic *E. coli* exceedances will be identified that indicate impairment. Data aggregation should be held to a minimum, no more than necessary to have sufficient data to satisfy the requirements for determining exceedances.

Alternative methods of data analysis may be used based on a professional judgment review of the data. Where there are five values per individual month or 30 day time period, the data will not be aggregated and individual monthly or 30 day geometric means may be calculated. Alternatively, data may be aggregated by month across consecutive two year or five year time periods. If more than 10 percent of the geometric means calculated exceed the 126 org/100 mL standard, the AUID is assessed as not supporting.

B. Great Lakes Shoreline (Lake Superior) beaches – *E. coli* bacteria

The Clean Water Act defines Coastal Recreation Waters as the Great Lakes and marine coastal waters (including coastal estuaries) that are designated under section 303(c) of the Clean Water Act for use for swimming, bathing, surfing, or similar water contact activities. The MPCA is applying the coastal waters definition and Beaches Environmental Assessment and Coastal Health (BEACH) Act water quality standards to all bacteria monitoring sites on the Lake Superior shoreline and in the mouths of tributaries that are representative of shoreline/Lake Superior conditions. The St. Louis River and Duluth-Superior Harbor sites monitored in the BEACH Act program that extends upstream in the St. Louis River to the Boy Scout Landing Beach are also considered within the coastal recreation designation. AUIDs were established for each individual beach, which generally includes only one beach monitoring station.

Lake Superior coastal waters are subject to *E. coli* water quality standards in the BEACH Act rule [November 2004 *Water Quality Standards for Coastal and Great Lakes Recreation Waters* rule (69 FR 67217, November 16, 2004), found at http://www.gpo.gov/fdsys/pkg/FR-2004-11-16/html/04-25303.htm]. These standards as applied in Minnesota are shown in Table 11.

Table 11. *E. coli* water quality standards for coastal recreation waters.

Standard No. of Organisms Per 100 mL of Water		Applicable Season	Use
Monthly Geometric Mean*	**10 % of Samples Maximum****		**Body Contact**
126	235	April 1 – October 31	Primary

* Not to be exceeded as the geometric mean of not less than 5 samples in a calendar month.
** Not to be exceeded by 10% of all samples taken in a calendar month, individually.

1. Data requirements and determination of impaired condition

There is a considerable amount of *E. coli* data collected as part of the BEACH monitoring program in Minnesota. Most beaches are monitored weekly from Memorial Day to Labor Day, while some are monitored twice weekly. To ensure use of the most recent data, data for the most recent five year period are used and assessments are made every other (odd numbered) year.

When there are five or more samples per individual month or 30 day time period, individual monthly geometric means are calculated and compared to the 126 orgs/100mL standard for the period April 1 through October 31. If more than 10% of the geometric means calculated exceed the 126 orgs/100mL standard, or if more than 10% of the individual sample results in the entire dataset exceed the maximum criterion of 235 orgs/100mL, the AUID is assessed as not supporting.

When sampling frequency results in smaller data sets, data is aggregated by month across years. If one or more of the monthly aggregated geometric means exceeds 126 orgs/100mL, or more than 10% of the individual sample results in the entire dataset exceed the maximum criterion of 235 orgs/100mL, the AUID is assessed as not supporting.

Data from adjacent sampling sites on the same beach are combined. For sites with both tributary mouth stations and BEACH stations, data from each station are assessed separately and the results considered using best professional judgment to make an assessment decision. For sites with only tributary mouth samples, the data are assessed against the coastal recreation water standards. Streams tributary to Lake Superior with bacteria data at stations upstream of the mouth are assessed as stream AUIDs using the statewide water quality standards and methodology in part A. above.

The overall use-support assessment also requires best professional judgment to consider and integrate information regarding the timing, frequency, magnitude, and duration of exceedances along with other conditions present at the time of sampling. These longer term use-support assessments based on several years of data are distinguished from the short term beach advisory postings (water contact not recommended) that are based only on current 'real-time' data.

C. Lake eutrophication

Excessive nutrient loads, in particular total phosphorus (TP), lead to increased algae blooms and reduced transparency – both of which may significantly impair or prohibit the use of lakes for aquatic recreation. The ecoregion-based eutrophication standards are the primary basis for aquatic recreational use assessments in lakes.

1. Water body classification and ecoregion determination

As the eutrophication standards are specific to ecoregion and lake depth, a number of steps are required to be completed prior to the actual assessment of the water body. Statue defines lake, shallow lake, reservoir, and wetland (Minn. R. ch. 7050.0150). The determination between the four requires an analysis of basin depth and littoral area. Additionally, a series of questions was developed to help make the differentiation between shallow lake and wetland. These can be found in Appendix D. This step includes a desktop review using GIS and available morphometric data and may include a site visit, if the decisions cannot be made from this review. Decisions are recorded and stored in the assessment database for future reference.

Reservoirs with residence times less than 14 days will not be assessed as lakes, per EPA guidance (EPA 200a, Kennedy 2001). For this purpose, residence times are usually determined under conditions of low flow. A mean flow for the four-month summer season (June – September) with a once in 10-year recurrence interval is normally used. The MPCA may establish a minimum residence time of less than 14 days on a site-specific basis if credible scientific evidence shows that a shorter residence time is appropriate for that reservoir.

The majority of the lakes in the state (98 percent) reside in four of the seven ecoregions (EPA Omernik Level III ecoregions). The remaining 2 percent of lakes reside in one of three ecoregions: Red River Valley, Northern Minnesota Wetlands, and the Driftless Area (Heiskary and Wilson 2005). Percent land use by categories (forest, pasture/open, cultivated, urban, water/wetland) are calculated for the lake watershed using the most recent national land cover dataset. These percentages are then compared to the breakdown of land use for the standards development dataset to see which ecoregion is more similar to the lake in question. The next step involves comparing morphometry of the lake basin (large, small, deep, shallow); different ecoregions have different lake characteristics. This data is used together to determine the proper ecoregion-based standard to address these lakes that do not fall in the ecoregions for which criteria have been developed and for lakes that are near an ecoregion boundary. See Table 12 for Minnesota's ecoregion-based water quality standards.

2. Data requirements and determination of use assessment

a) Minimum data requirements
Samples must be collected over a minimum of 2 years and data used for assessments must be collected from June to September. Typically, a minimum of 8 individual data points for TP, corrected chlorophyll-*a* (chl-*a* corrected for pheophytin), and Secchi are required.

b) Lake assessment determinations
Data used for phosphorus and chlorophyll-*a* calculations are limited to those collected from the upper most 3 meters of the water column (surface). If more than one sample is collected in a lake per day, these values are averaged to yield a daily average value. Following this step,

all June to September data for the 10-year assessment window are averaged to determine summer-mean values for TP, corrected chl-*a*, and Secchi depth. These values are then compared to the standards and the assessment is made (Table 12).

Lakes where TP and at least one of the response variables (corrected chl-*a* or Secchi) exceed the standards are considered impaired. For lakes with excellent data quality (2+ years of data) and where all parameters are better than the standards, an assessment of full support is made. Lakes with good quality data (1-year data plus Secchi trends) may be considered for full support assessment as well. In this case the assessment thresholds have been adjusted by 20 percent (made more stringent) and lakes with good quality data that meet these thresholds will be considered fully supporting. This modification of the thresholds provides a margin of safety to assure that lakes with lesser amounts of data are supporting the beneficial use.

In some instances, a lake may have good or excellent quality data but only one of the thresholds is exceeded (e.g., only TP or only corrected chl-*a* or Secchi). In this instance, the lake will be considered to have insufficient data to assess because both the cause (TP) and at least one response (chl-*a* or Secchi) must either meet to indicate support or both exceed to indicate impairment. For lakes that do not meet minimum data requirements and use-support cannot be determined, a determination of insufficient data will be made.

c) Reservoirs and other special situations

Sampling design and assessments for aquatic recreational use for reservoirs may be different from those used for lakes. Since reservoirs typically exhibit distinct zones, often referred to as inflow segment, transitional segment, and near-dam segment, calculation of "whole reservoir" mean TP may not be an appropriate basis for assessing aquatic recreational use. Rather, the MPCA may evaluate the status of the reservoir based on a specific segment – most likely the near-dam segment. Also, water residence time may vary substantially as a function of river flow (e.g., Lake Pepin, Heiskary and Walker 1995) and may influence algal response to available nutrients. In addition, reservoirs often have very large watersheds that may drain portions of one or more ecoregion. Hence ecoregion-based standards based on where the reservoir is located may not always be the best basis for evaluating use-support.

Lakes with distinct bays, such as Lake Minnetonka, may present a similar situation. The bays (basins) may need to be assessed on an individual basis (data is stored by specific basin, not by whole lake). In some instances, a single bay may exceed the listing thresholds while other bays in the lake do not. In this case it should be determined whether the entire lake should be listed (e.g., there is distinct interaction between the bays) or simply the individual bay. This will likely require knowledge of flow-through patterns in the lake and assistance from local cooperators to make an appropriate determination.

Table 12. Lake eutrophication water quality standards for aquatic recreation use assessments.

Ecoregion	TP (mg/L)	chl-*a* (mg/L)	Secchi (m)
Northern Lakes and Forest – Lake trout (Class 2A)	< 12	< 3	> 4.8
Northern Lakes and Forest – Stream trout (Class 2A)	< 20	< 6	> 2.5
Northern Lakes and Forest – Aquatic Rec. Use (Class 2B)	< 30	< 9	> 2.0
North Central Hardwood Forest – Stream trout (Class 2A)	< 20	< 6	> 2.5
North Central Hardwood Forest – Aq. Rec. Use (Class 2B)	< 40	< 14	> 1.4
North Central Hardwood Forest – Aq. Rec. Use (Class 2B) Shallow lakes	< 60	< 20	> 1.0
Western Corn Belt Plains & Northern Glaciated Plains – Aq. Rec. Use (Class 2B)	< 65	< 22	> 0.9
Western Corn Belt Plains & Northern Glaciated Plains – Aq. Rec. Use (Class 2B) Shallow lakes	< 90	< 30	> 0.7

IX. Protection of Limited Resource Value Waters (Class 7)

Limited resource value waters include surface waters of the state that have been subject to a use attainability analysis and have been found to have limited value as a water resource. These waters are specifically listed in rule (Minn. R. ch. 7050.0470) and are protected so as to allow secondary body contact use, to preserve the groundwater for use as a potable water supply, and to protect aesthetic qualities of the water.

Standards for limited resource value waters include the following:

- *Escherichia (E.) coli*: Not to exceed 630 organisms per 100 mL as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10 percent of all samples taken during any calendar month individually exceed 1260 organisms per 100 mL. The standard applies between May 1 and October 31. Assessment methodology is described in detail in Section VIII.A.
- Dissolved Oxygen: At concentrations which will avoid odors or putrid conditions or at concentrations not less than 1 mg/L as a daily average, provided that measurable concentrations are present at all times.
- pH: minimum value 6.0 maximum value 9.0
- Toxic pollutants not allowed in such quantities or concentrations that will impair the specified uses.

Application of toxic standards to Class 7 waters for assessment purposes includes applying the Maximum Standard (MS) for most pollutants or 100 times the Chronic Standard (CS), whichever is lower (Minn. R. ch. 7050.0222, subp. 7, item E). However, for bioaccumulative pollutants the CS would apply. Because Class 7 waters may be used by game fish for spawning and/or maintaining minnow populations during brief periods in the spring, a special protection against bioaccumulative pollutants is needed.

X. Removal of Water bodies from the 303(d) List

There are four basic ways in which water bodies are removed from the 303(d) List:

1) If, during subsequent monitoring or the development of the TMDL study, new and reliable data or information indicates that the water body is no longer impaired and is meeting water quality standards. Such a water body would be delisted before a TMDL plan was completed.
2) If a TMDL assessment and preliminary plan for reducing the sources of pollution is completed and approved by the EPA.
3) If the sources of impairment are determined to be not caused by a pollutant or non-anthropogenic in origin.
4) If it was determined that a reach was placed on the list in error.

It is important to note that in scenarios 2 and 3 above, the water body is still impaired and still appears on the Impaired Waters Inventory (until such time as the water body supports all its beneficial uses), but because a TMDL study is not required that water body is not included on the 303(d) List. The following paragraphs provide more details on the four scenarios for 303(d) List delisting.

A. Water body no longer impaired

In general, water bodies will be assessed and listing or delisting decisions will be made using the methods described in this Guidance. In practice, there will usually be more data available for the "delisting" assessment than was available for the "listing" assessment. New and old data will be considered together in the re-assessments, unless tangible improvements of sufficient dimension to change impairment status have taken place in the reach, in which case only new data will be used in the delisting assessment. Improvements could include implementation of best management practices to reduce nonpoint sources, improvements in wastewater treatment, or some combination of nonpoint and point source reductions. If the new data show the water body to be un-impaired, the MPCA will recommend that the water body be delisted.

All delisting decisions are subject to review by the appropriate watershed assessment and professional judgment teams (see Section III.) or the delisting committee for waters outside of the watersheds being assessed that year. Information about watershed improvements should be brought to the watershed assessment and professional judgment team or delisting committee for consideration. The MPCA will make a final determination on whether a water body can be considered no longer impaired, and should be submitted to the EPA for delisting.

It is essential that data used in the delisting assessment be collected under appropriate conditions. For dissolved oxygen and for pollutants with toxicity- and human health-based water quality standards, data should be from observations taken during critical conditions, i.e. those conditions most likely to result in exceedances of the standard. For example, if a water body was listed as impaired because of low dissolved oxygen, the measurements used to support delisting would likely need to be collected in the early morning (generally no later than two hours after sunrise, so as to reflect the daily minimum) during periods of very low flow. For other pollutants, data should be from observations that provide an accurate representation of the overall period of time under consideration and are not biased by, for example, being collected only during a certain season or under certain flow conditions.

The following is a summary of the specific data and assessment requirements needed to consider removing a water body from the 303(d) List, impaired because of exceedances of numeric standards:

Total suspended solids must have:

- at least 20 observations (new and old data) in the most recent 10 years, of which at least 10 observations (new and old data) are in the most recent 5 years
- at least 20 observations (new data) in the most recent 5 years, and evidence of action in the watershed of sufficient dimension to change impairment status, and in either case, there must be fewer than 10 percent of samples exceeding the water quality standard

Dissolved oxygen must have:

- at least 20 observations (new and old data) in the most recent 10 years, of which at least 10 observations (new and old data) are in the most recent 5 years, or at least 20 observations (new data) in the most recent 5 years, and evidence of action in the watershed of sufficient dimension to change impairment status
- in either case, there must be fewer than 10 percent of samples exceeding the water quality standard

Un-ionized ammonia and chloride must have:

- at least 5 observations (new and old data) for any 3-year interval in the most recent 10 years, or
- at least 5 observations (new data) for any 3-year interval in the most recent 5 years, and evidence of action in the watershed of sufficient dimension to change impairment status
- in either case, no more than one exceedance of the chronic water quality standard in any 3-year interval (chronic standard is a 4-day average)

River eutrophication must have:

- The causative variable (TP) and the response variable(s) that were used to list the AUID meet the standard.
- It will require a minimum of 12 paired samples over a minimum of 2 years for total phosphorus, chlorophyll-*a*, and/or biochemical oxygen demand.
- It will require a minimum of 20 pH samples over a minimum of 2 years
- It will require a minimum of 2 dissolved oxygen sonde deployments; each with a length of a minimum of 4 days and occurring in separate years during a similar index period to the listing deployment within the assessment window.

Mercury, water column data must have:

- at least 5 observations for any 3-year interval in the most recent 10 years
- no more than one exceedance of the chronic water quality standard in any 3-year interval (chronic standard is a 30-day average)

E. coli bacteria must have for step two:

- at least 15 observations over a two year period in the most recent 10 years
- A minimum of five values per month for at least three months when the standard is applicable (April – October), preferably between June and September – data are combined for each month over most recent 10 years, unless there are a sufficient number of observations to aggregate data by month over consecutive two year time periods or to calculate individual monthly or 30 day geometric means

- A minimum of five values per month for at least three months when the standard is applicable (April – October), preferably between June and September – data are combined for each month over most recent years since corrective actions were taken in the watershed of sufficient dimension to change impairment status, unless there are a sufficient number of observations to aggregate data by month over consecutive two year time periods or to calculate individual monthly or 30 day geometric means
- in either case, no exceedance of the monthly mean standard (126 organisms per liter) by the geometric mean in any of those months for 10 year aggregated data or less than 10 percent of months exceed the standard for two year aggregated or individual monthly or 30 day geometric means
- in either case, fewer than 10 percent of sample observations exceed "maximum" standard (126 organisms per liter)

Lake nutrient eutrophication must have:

- At least 8 paired TP, corrected chl-*a*, and Secchi measurements (June to September) over a minimum of 2 years for the most recent 10 years
- If TP meets the standard, and either chl-*a* or Secchi meet the standard, the lake will be removed from the TMDL List.
- If TP exceeds the standard and corrected chl-*a* AND Secchi meet the standard, and an improving trend in TP is observed or management activities are in place to maintain improved chl-*a* or Secchi observations, the lake may be delisted. This will require the local entity to provide information that details how the response conditions will be met over time.

Biological indicators must have:

- New data from the original listing station(s) indicating conditions are now supporting of aquatic life.
- An evaluation of any new biological data and other lines of evidence considered comprehensively, including upstream/downstream conditions, do not contradict a finding of full support.
- An evaluation that any stressors to the biology that may have been previously identified as part of the TMDL process indicate measured improvement.

Water bodies with impaired aquatic communities can be delisted utilizing the same criterion as listing (Section V. B.) if additional bio-monitoring indicates that the community is no longer impaired when compared to the IBI threshold (±confidence interval). Overall assessment of whether an AUID adequately supports aquatic life involves the review of the parameter-level evaluations and data quality in conjunction with all available supporting information (flow, habitat, precipitation, etc.) to make an overall use-support determination. For a given AUID, there may be chemistry indicator data, biological indicator data, or both types of data available for assessment. The final assessment takes into consideration the strength of the various indicators and the quality of the data sets and, in addition, looks at upstream and downstream conditions to gain a better understanding of the interactions between the individual AUID and the larger water body and watershed.

Lakes and rivers listed as impaired because of fish tissue contaminants will be delisted when additional sampling and analysis show that the fish tissue concentrations, by species and size class, are below 0.2 mg/kg (mg/L) for either mercury or PCBs (in Section VI).

B. EPA-approved TMDL plan

The second major way waters are removed from the 303(d) List is through the completion of the TMDL study. Under the current federal TMDL regulation, the TMDL process must progress through the step where an EPA-approved plan is in place that indicates in general how the river reach or lake is to be brought back into compliance with water quality standards. That is, under current EPA regulations, the water body does not need to be brought back to an un-impaired condition to be delisted. Irrespective of this EPA regulation, the MPCA is committed, with the help of local entities, to improving the water quality in all impaired waters so beneficial uses are restored, where restoration is possible. To that end an AUID that has an approved TMDL plan for a pollutant no longer appears on the 303(d) List, but it remains on the Inventory of Impaired Waters until it is no longer impaired.

C. Water body impaired because of a non-pollutant including natural causes/conditions

A third pathway for removing a water body from the impaired waters list is to determine that there are only non-pollutant sources contributing to the impairment. These sources might include changes to the water body such as dams, impoundments or other anthropogenic factors affecting stream connectivity or flow, or are due to natural conditions with essentially no anthropogenic sources contributing to the impairment. According to EPA's Consolidated Assessment and Listing Methodology, these waters are impaired but no TMDL pollution reduction study plan is required.

D. List correction

If a water body was placed on the list in error either by a wrong AUID being assigned to the data or due to an update in a standard or methodology that would not have caused an initial listing, the reach will be removed from the list as a correction.

XI. Sources of Information and MPCA Contacts

The readers of this document are encouraged to access the sources of information listed in this section. Included are e-mail addresses and phone numbers of MPCA staff that work in areas relevant to the protocols and procedures in this Guidance. They are listed alphabetically by subject area. Also provided are some pertinent websites, listed by agency.

A. MPCA staff

1. 303(d) List, Inventory of Impaired Waters, general questions and comments: Miranda Nichols at miranda.nichols@state.mn.us or 651-757-2614
2. Integrated Assessment [ADB] coordinator: Douglas Hansen at douglas.hansen@state.mn.us or 651-757-2406
3. Integrated narrative report, preparation: Miranda Nichols at miranda.nichols@state.mn.us or 651-757-2614
4. Basin or watershed planning questions: Glenn Skuta at glenn.skuta@state.mn.us or 651-757-2730
5. Biological impairment: Scott Niemela at scott.niemela@state.mn.us or 218-828-6076
6. Citizen lake monitoring program: Shannon Martin at shannon.martin@state.mn.us or 651-757-2874
7. Citizen stream monitoring program: Laurie Sovell at laurie.sovell@state.mn.us or 651-757-2750
8. Effluent limits for toxic pollutants and temperature standard for cold water fisheries: Dann White dann.white@state.mn.us or 651-757-2820
9. Fish consumption advice: Minnesota Department of Health at 800-657-3908. Patricia McCann at patricia.mccann@state.mn.us
10. Lake and river eutrophication methodology: Pam Anderson at pam.anderson@state.mn.us or 651-757-2190
11. Limited Resource Value Waters (Class 7): Carol Sinden at carol.sinden@state.mn.us or 651-757-2727
12. Monitoring and data management: Miranda Nichols at miranda.nichols@state.mn.us or 651-757-2614
13. TMDL process, general questions and comments: Celine Lyman at celine.lyman@state.mn.us or 651-757-2541
14. Water quality data for specific water bodies: Jean Garvin at jean.garvin@state.mn.us or 651-757-2378
15. Water quality standards: Angela Preimesberger at angela.preimesberger@state.mn.us or 651-757-2656

All MPCA staff can also be reached toll free at 800-657-3864 or 651-296-6300 in the Twin Cities Metropolitan Area.

B. Websites

The MPCA and other agencies maintain a number of websites that provide information on aspects covered in this Guidance; some of the more pertinent sites are listed below:

1. MPCA websites

The MPCA home page is at http://www.pca.state.mn.us. From this site the reader can link to all the MPCA websites listed below and many more.

1. Water quality standards, water quality rules, and general information: http://www.pca.state.mn.us/water/standards/index.html
2. 305(b) Report: https://www.pca.state.mn.us/water/minnesotas-impaired-waters-list
3. Lake protection, including Citizen Lake Monitoring Program and lake water quality: https://www.pca.state.mn.us/water/lakes-and-water-quality
4. MPCA Quality Management Plan. Provides guidance on monitoring and data management, approved by the EPA: http://www.pca.state.mn.us/index.php/view-document.html?gid=19485
5. Phosphorus strategy: https://www.pca.state.mn.us/water/detailed-assessments-phosphorus-sources-minnesota-watersheds
6. Quality assurance and quality control requirements for water quality sampling and data assessment for lakes and streams: http://www.pca.state.mn.us/index.php/about-mpca/mpca-overview/agency-strategy/mpca-quality-system.html
7. TMDLs and the 303(d) List: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/impaired-waters-list.html
8. Watersheds and basin management: http://www.pca.state.mn.us/water/basins/index.html
9. Surface Water Data website with environmental data on surface waters statewide: http://cf.pca.state.mn.us/water/watershedweb/wdip/search_more.cfm

2. Minnesota Department of Health websites, fish consumption advice

1. Fish consumption advice, general: http://www.health.state.mn.us/divs/eh/fish/
2. Site-specific advice: http://www.health.state.mn.us/divs/eh/fish/eating/sitespecific.html

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XIII. Appendices

Appendix A. State overall and beneficial use reporting categories

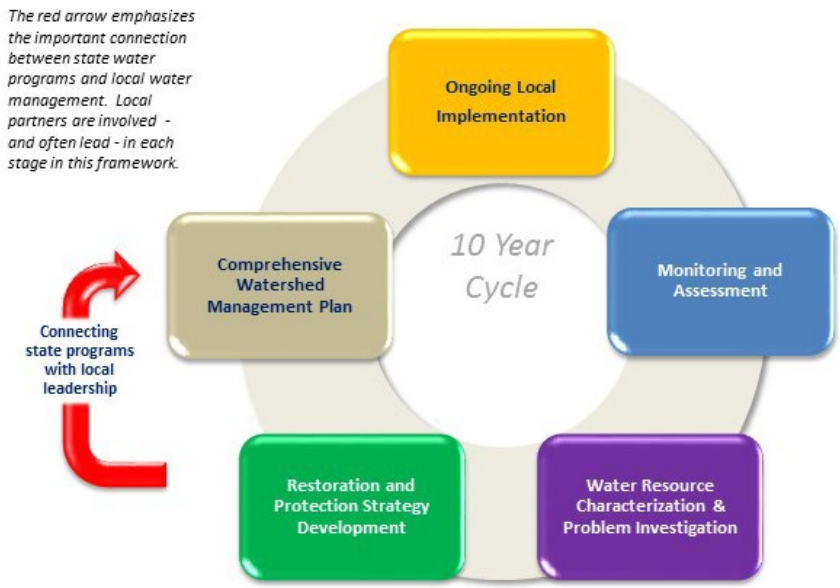
Category/ Subcategory	Description
1	All designated uses are fully assessed and met, and no use is threatened.
2	Some uses or parameters are met but insufficient data to determine if remaining uses or parameters are met.
3	There are insufficient data to assess any uses.
4A	Impaired or threatened but a TMDL study has been approved by EPA.
4B	Impaired or threatened but a TMDL study is not required because water quality standards are expected to be met in the near future.
4C	Impaired or threatened but a TMDL study is not required because the impairment is not caused by a pollutant.
4D	Impaired or threatened but doesn't require a TMDL because the impairment is due to natural conditions with only insignificant anthropogenic influence. To be considered "insignificant", the elimination of the anthropogenic influence would not lead to the attainment of water quality standards and it would not be included in formal pollution reduction goal-setting activities. A reach-specific water quality standard based on local natural conditions has yet to be determined. Upon determination, the assessment unit will be considered non-impaired for the natural conditions and re-categorized to an appropriate category.
4E	Impaired or threatened but existing data strongly suggests a TMDL is not required because impairment is solely a result of natural sources or non-pollutant conditions; a final determination of Category 4C or 4D will be made in the next assessment cycle pending confirmation from additional information (i.e., water quality or land use).
5	Use assessment indicates an impaired status and no TMDL plan has been completed.

Appendix B. Minnesota's TMDL priorities

MPCA has prioritized TMDLs for the years 2016-2022 as part of EPA's **Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program**. These TMDL priorities are a subset of our section 303(d) list and reflect our priorities identified by the TMDL Start and Completion dates on the list. Minnesota's TMDL priorities identified for the prioritization goal of EPA's Long-Term Vision are those waterbodies listed for conventional pollutants with an estimated TMDL Completion date of 2021 or earlier. Waterbodies listed for nonconventional pollutants (chloride and mercury for example) will continue to be done according to the 303(d) list dates, but they will be done through a separate process rather than through the watershed approach. A small number of waterbodies listed for conventional pollutants have been deferred to later dates when Cycle 2 of the watershed approach is in progress. For the entire TMDL Priority Framework Report, go to the MPCA's TMDL policy and guidance webpage at https://www.pca.state.mn.us/water/tmdl-policy-and-guidance.

Conventional Pollutants: WRAPS reports will be done on a ten year watershed cycle and the TMDLs for conventional pollutants in those watersheds will be done as part of the WRAPS process, with some exceptions (see deferred TMDLs below). The conventional pollutants are dissolved oxygen, pH, temperature, turbidity, TSS, bacteria, ammonia, nitrates, nutrients, and biological impairments.

What is the WRAPS Report? The State of Minnesota has adopted a watershed approach to address the state's 80 major watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates water quality assessment, watershed analysis, civic engagement, planning, implementation, and measurement of results into a 10-year cycle that addresses both restoration and protection. The Watershed Restoration and Protection Strategy (WRAPS) report is done as a result of that work. In addition to the WRAPS report, a watershed TMDL study is done.



As part of the watershed approach, waters not meeting state standards are still listed as impaired and Total Maximum Daily Load (TMDL) studies are performed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies and actions for point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. The WRAPS report also serves as a watershed plan addressing EPA's Nine Minimum Elements to qualify applicants for eligibility for section 319 implementation funds.

Appendix C. Sources of data used for assessment

Involvement of local units of government and other governmental agencies in the monitoring of water quality is always encouraged, and the MPCA actively seeks data from all sources utilizing appropriate QA/QC with annual calls for data.

Analytical labs providing data must be certified under the lab certification program operated by MDH, and the data to be used in assessments should be entered into the MPCA's ambient water quality database, EQuIS (Environmental Quality Information System). Criteria used to determine whether to use data from other sources are outlined in Volunteer Surface Water Monitoring Guide (MPCA 2003), found online at http://www.pca.state.mn.us/water/monitoring-guide.html. A major aspect of monitoring that the MPCA must consider when reviewing outside data for use in assessments is the purpose for which the data were collected. For example, samples collected to characterize "events" such as the effects of storm runoff on a river may not be suitable, if used alone, to characterize the overall water quality of the river. It is important that outside data be used and interpreted correctly.

The screening and entry of data from sources outside the MPCA into EQuIS can be very labor intensive but there is a much greater chance that valuable outside data will be used if the outside parties enter the data into EQuIS. In general, data under consideration from any source that has been reviewed and found to satisfy QA/QC requirements will be used in water quality assessments following the priority listed below:

- data collected through the MPCA monitoring programs
- data collections funded by state or federal money (e.g., Clean Water Partnership or Lake Assessment Program data), for which EQuIS entry is required
- data from any source readily accessible through EQuIS
- data in an electronic format from which assessments can be made directly, or in a form easily entered into EQuIS (e.g., data collected by governmental or other major entities that provide monitoring data in places where MPCA has little or no monitoring)
- data in a form amenable to EQuIS entry that fills an important gap in MPCA data
- Minnesota Department of Agriculture water quality data
- Continuous water quality data (e.g., flow, DO, temperature data collected internally or by parties outside the MPCA) accessible through Hydrsta, the MPCA's and MDNR's repository for continuous data

Data obtained through projects the MPCA funds must be the result of a clearly defined and documented purpose and it must satisfy specific data needs. This documentation is called an "information protocol," and it has proven to be very useful to MPCA staff considering the broad range of types and purposes of monitoring programs carried out by agencies and other organizations.

The MPCA may also search out data from sources not amenable to EQuIS entry. Sources of water quality data outside the MPCA that are considered each year for use in water quality assessments include:

- Neighboring states and tribes in Minnesota (found in EPA's STORET data warehouse)
- Metropolitan Council Environmental Services
- United States Geological Survey (found in NWIS or through LTRMP)
- Any other source that may be pertinent to that year's assessments

When receiving monitoring data collected by neighboring states and tribes, the MPCA, on a case by case basis, may consider the use of this data in the state's assessment process. Professional judgment groups will consider the proximity of the collection point to Minnesota, including any intervening tributaries between the monitoring location and the Minnesota border that may affect the ability of the monitoring site to represent the Minnesota water body. In addition, MPCA staff will use such data where it is made available through our calls for data, but will not actively seek out non-Minnesota-collected data. Data from non-Minnesota sources will have to meet all the existing data standards for consideration in assessments, including entry into EQuIS.

Appendix D. Lake, shallow lake, and wetland differentiation

Some of the factors used to separate lakes, shallow lakes, and wetlands are as follows:

Factor	Lakes	Shallow lakes	Wetlands
Protected Waters Inventory Code	Typically coded as "L or LP" in PWI	May be coded as either "L, LP or LW" in PWI	Typically coded as a "LW" in PWI
Depth, maximum	Typically >15 feet	Typically < 15 feet	Typically < 7 feet
Littoral area	Typically <80%	Typically >80%	Typically 100%
Area (minimum)	Typically > 10 acres (NDH)	Typically > 10 acres (NDH)	No minimum
Thermal stratification (summer)	Stratification common but dependent upon depth, size and fetch	Typically do not thermally stratify	Typically do not stratify.
Fetch*	Significant fetch depending on size & shape	Fetch is variable depending on size & shape	Rarely has a significant fetch
Substrate	Consolidated sand/silt/gravel	Consolidated to mucky	Mucky to unconsolidated
Shoreline features	Generally wave formed, often sand, gravel or rock	Generally wave formed, often sand, gravel or rock	Generally dominated by emergents
Emergent vegetation & relative amount of open water*	Shoreline may have ring of emergents; vast majority of basin open water.	Emergents common, may cover much of fringe of lake; basin often has high percentage of open water.	Emergents often dominate much of basin; often minimal open water.
Submergent vegetation	Common in littoral fringe, extent dependent on transparency	Abundant in clear lakes; however may be lacking in algal-dominated turbid lakes.	Common unless dominated by an emergent like cattail.
Dissolved Oxygen	Aerobic epilimnion; hypolimnion often anoxic by midsummer	Aerobic epilimnion but wide diurnal flux possible	Diurnal flux & anaerobic conditions common
Fishery	Typically managed for a sport/game fishery. May be stocked. MDNR fishery assessments typically available.	May or may not be managed for a sport fishery. If so, fishery assessment should be available. Winter aeration often used to minimize winterkill potential.	Typically not managed for a sport fishery. Little or no MDNR fishery information. Seldom aerated May be managed to remove fish & promote waterfowl.
Uses	Wide range of uses including boating, swimming, skiing, fishing; boat ramps & beaches common	Boating, fishing, waterfowl production, hunting, aesthetics; limited swimming; may have boat ramp, beaches uncommon	Waterfowl & wildlife production, hunting, aesthetics. Unimproved boat ramp if any. No beaches.

* Fetch and open water play a large role in these determinations.

Appendix E. Assessing and communicating the quality of waters that occur wholly or partially within federally recognized Indian Reservations

Goal: Work with tribes to monitor, assess, and communicate the quality of waters that are within, or partially, within the boundaries of Indian reservations.

Background: Measuring and communicating water quality is core to the mission of the Minnesota Pollution Control Agency (MPCA). The Clean Water Act requires delegated programs to determine if waters are meeting standards designed to protect uses like fishing and swimming.

Waters that do not meet water quality standards are designated as "impaired." Delegated programs are required to submit a draft list of impaired waters to the U.S. Environmental Protection Agency (EPA) for approval every two years and establish a total maximum daily load (TMDL) of pollutants that, if met, will result in attaining the standards. In addition to federal law requirements, Minnesota state law[3] requires the MPCA to determine if any waters of the state[4] are impaired. Because of the broad definition of waters of the state, the state's impaired waters requirement applies to more waterbodies than the federal requirements. Therefore, the MPCA includes a state-only impaired waters list with the required federal list in order to have a comprehensive listing of impaired waters within Minnesota.

The Grand Portage Band and Fond du Lac Band have received EPA delegation, known as "treatment as a state" (TAS), to establish water quality standards and have adopted water quality standards that have been approved by EPA. Several other Bands are in the process of applying for TAS for water quality standards. On October 26, 2016, EPA adopted regulations to establish a process for eligible tribes to obtain TAS to list waters within their reservations as impaired under section 303(d) and establish TMDLs.

The MPCA uses a watershed approach to monitor the chemical and biological condition of waters around the state. This approach includes working with tribes to develop a monitoring plan for waters that occur wholly or partially within the boundaries of Indian reservations that is mutually agreeable and beneficial. Following two years of watershed monitoring, MPCA scientists strive to work with local resource managers, including tribal staff familiar with the monitoring efforts, to evaluate the data and determine if waters are meeting state water quality standards. The MPCA makes a draft impaired waters list available for public comment prior to submittal to EPA.

The MPCA recognizes that both states and tribes (whether or not they have obtained TAS for the water quality standards program) are invested in protecting and restoring all waters. The MPCA also recognizes that EPA has stated that its approval of the State's 303(d) impaired waters list does not extend to waters within Indian reservations[5], and that EPA will take no action to approve or disapprove the list with respect to waters within Indian reservations for purposes of section 303(d).

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[3] Minn. Stat. §§ 115.03, subd . 1 and 115.44; Minn. Laws 2005, 1st Sp.1, ch. 1, art. 2, § 151; and Minn. R. 7050.0150 (impaired waters authority). See also Minn. Stat. ch. 1140 and Minn. R. 7052.0200 (TMDL authority).

[4] Minn. Stat. § 115.01, subd. 22. "Waters of the state" means all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, reservoirs, aquifers, irrigation systems, drainage systems and all other bodies or accumulations of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state or any portion thereof.

[5] Language from EPA's Approval Letter of MPCA's 2012 Impaired Waters List "EPA's approval of Minnesota's Section 303(d) list extends to all water bodies on the list with the exception of those waters that are within Indian Country, as defined in 18 U.S.C. § 1151. EPA is taking no action to approve or disapprove the State's list with respect to those waters at this time. EPA, or eligible Indian Tribes, as appropriate, will retain responsibilities under CWA Section 303(d) for those waters".

Proposed Approach for Assessing and Communicating Water Quality: Given that people across the state use waters, we would like to establish a common understanding about how data for waters wholly or partially within reservation boundaries will be evaluated and communicated. The MPCA offers the following approach:

1. MPCA will continue to work with tribes in advance of monitoring to agree on plans that include locations, parameters, roles, responsibilities and processes.
2. MPCA will share data with tribes and will engage tribes in the evaluation of monitoring data in light of applicable state water quality standards. The MPCA likewise appreciates tribes sharing their monitoring data.
3. For waters deemed to be impaired that:
    a. are partially within the boundaries of a federally recognized Indian reservation (but are not located wholly within a federally recognized Indian reservation), the MPCA will include such waters on Minnesota's Impaired Waters List and include a footnote with each that states: "*This body of water is partially within a federally recognized Indian reservation. The state and tribe have worked cooperatively on this water quality assessment and agree that the water should be included on the State's impaired waters list. For the purposes of the 303(d) list, the assessment of the portion of the waterbody within the reservation is provided as information only to EPA because EPA does not approve the State's impaired waters listings for purposes of section 303(d) for waters within the boundaries of an Indian reservation.*"
    b. are located wholly within a federally recognized Indian reservation, the MPCA will send a list of these waters to EPA, separate from the impaired water list but accompanying the list and include the following statement in the title of this list: *"This assessment list was prepared under authority in state law to determine whether waters within the state are impaired. The MPCA includes this state-only list in order to have a comprehensive list of impaired waters. For purposes of the 303(d) list, these assessments are provided as information only to EPA because these water bodies are located wholly within a federally recognized Indian reservation and EPA does not approve the State's impaired waters listings for purposes of section 303(d) for waters that are partially or wholly within the boundaries of an Indian reservation."*
    c. are either partially or wholly within the disputed boundaries of the Mille Lacs Reservation), the MPCA will include such waters on Minnesota's Impaired Waters List and include a footnote with each that states: *"The State of Minnesota and the federal government disagree on the boundaries of the Mille Lacs Reservation. As a result, for purposes of the 303(d) list only, the assessment of this water body is provided as information only because EPA does not approve the State's impaired waters listings for purposes of section 303(d) for waters within the boundaries of an Indian reservation. By identifying this water as within the disputed Mille Lacs Reservation and placing it on the 303(d) list, the State does not concede that this water is within the Mille Lac Reservation nor that the MPCA lacks jurisdiction to list this water as impaired under 303(d)."*
4. Prior to putting the draft Impaired Waters List on public notice, the MPCA will communicate with tribes and will use electronic map tools to highlight waters that are partially or wholly within reservation boundaries and determined to be impaired using state water quality standards. Such waters will be indicated with a footnote or included on the separate 'advisory' list as specified in #3 above.
5. MPCA and tribal representatives will discuss and determine whether there is a mutual desire to cooperatively develop restoration and protection strategies, including TMDLs, for impaired waters that are partially or wholly within reservation boundaries.

Appendix F. Supplemental information on biological assessment in Minnesota

Basis for assessment of biological community – narrative standards

The basis for assessing the biological community for impairment is the narrative water quality standards and assessment factors in Minn. R. ch. 7050.0150. The most relevant part, Minn. R. ch. 7050.0150, subp. 6 is quoted below:

Subp. 6. Impairment of biological community and aquatic habitat. In evaluating whether the narrative standards in subpart 3, which prohibit serious impairment of the normal fisheries and lower aquatic biota upon which they are dependent and the use thereof, material alteration of the species composition, material degradation of stream beds, and the prevention or hindrance of the propagation and migration of fish and other biota normally present, are being met, the commissioner will consider all readily available and reliable data and information for the following factors of use impairment:

A. An index of biological integrity calculated from measurements of attributes of the resident fish community, including measurements of:

1) species diversity and composition;
2) feeding and reproduction characteristics; and
3) fish abundance and condition.

B. An index of biological integrity calculated from measurements of attributes of the resident aquatic invertebrate community, including measurements of:

1) species diversity and composition;
2) feeding characteristics; and
3) species abundance and condition.

C. An index of biological integrity calculated from measurements of attributes of the resident aquatic plant community, including measurements of:

1) species diversity and composition, including algae; and
2) species abundance and condition.

D. A quantitative or qualitative assessment of habitat quality, determined by an assessment of:

1) stream morphological features that provide spawning, nursery, and refuge areas for fish and invertebrates;
2) bottom substrate size and variety;
3) variations in water depth;
4) sinuosity of the stream course;
5) physical or hydrological alterations of the stream bed including excessive sedimentation;
6) types of land use in the watershed; and
7) other scientifically accepted and valid factors of habitat quality.

E. Any other scientifically objective, credible, and supportable factors.

A finding of an impaired condition must be supported by data for the factors listed in at least one of items A to C. The biological quality of any given surface water body will be assessed by comparison to the biological conditions determined for a set of reference water bodies which best represents the most natural condition for that surface water body type within a geographic region.

Additional language supporting the use of narrative water quality standards in wetlands is found in Minn. R. ch. 7050.0222, subp. 6, which defines the protection of Class 2D waters (wetlands) as follow:

> *"The quality of Class 2D wetlands such as to permit the propagation and maintenance of a healthy community of aquatic and terrestrial species indigenous to wetlands, and their habitats. Wetlands also add to the biological diversity of the landscape. These waters shall be suitable for boating and other forms of aquatic recreation for which the wetland may be usable. This class of surface water is not protected as a source of drinking water. …"*

The aquatic life use-support assessment methodology described in this Guidance fully supports this narrative standard and protects the biological integrity of rivers, streams, and wetlands by:

- measuring attainment directly through sampling of the aquatic biota
- controlling biological and sampling variability through regionalization, classification and strict adherence to sampling protocol
- establishing impairment thresholds based on data collected from reference (least-disturbed) waters of the same class
- incorporating a confidence limit (based on the repeatability of the IBI) to account for variability within the aquatic community because of natural spatial and temporal differences and sampling or method errors

Biological Condition Gradient

The Biological Condition Gradient (BCG) is a conceptual model of aggregated biological knowledge used to describe changes in biological communities along a gradient of increasing stress. This model is based on a combination of ecological theory and empirical knowledge. A number of indices have been developed to measure the biological condition in aquatic systems (e.g., IBI, RIVPACS; Karr et al. 1986, Hawkins et al. 2000, Whittier et al. 2007), but these measures are based on the available conditions that are used to develop the models. The BCG differs from these in that it provides a common "yardstick" of biological condition that is rooted in the natural condition. As a result, the BCG can be used to develop biocriteria that are consistent across regions and stream types in Minnesota. This is particularly important for a state such as Minnesota where the range of conditions are regionally distinct and extreme (i.e., relatively pristine to degraded). The BCG divides biological condition into six levels that are intended to be manageable and useful for water quality managers (see BCG model below). More detailed descriptions of the BCG can be found in EPA (2005) and Davies and Jackson (2006).

The development of the BCG models for warmwater rivers and streams involved input from biological experts from the MPCA and Minnesota DNR familiar with aquatic communities in Minnesota. BCG models were developed for fish and macroinvertebrates for each of the 7 warmwater stream classes. A coldwater BCG was also developed and involved experts from Minnesota, Wisconsin, Michigan, and several tribes. In Minnesota this included 2 classes each for fish and macroinvertebrates. Model development for each class involved reviewing biological community data from monitoring sites and then assigning that community to a BCG level (1-6). A sufficient number of samples were assessed to develop a model which can duplicate the panel's BCG level assignments. This model was then used to assign BCG levels to all monitoring sites in MPCA's biological monitoring database.

The development of the BCG models for warmwater rivers and streams and lakes involved input from biological experts from the MPCA and Minnesota DNR familiar with aquatic communities in Minnesota. BCG models were developed for fish and macroinvertebrates for each of the 7 warmwater stream classes and for four groups of lakes. A coldwater BCG for streams was also developed and involved experts from Minnesota, Wisconsin, Michigan, and several tribes. In Minnesota this included 2 classes each for fish and macroinvertebrates. Model development for each stream class involved reviewing biological community data from monitoring sites and then assigning that community to a BCG level (1-6). Similar model development was completed for lakes, utilizing the four lake groups. A sufficient number of samples were assessed to

develop a model which can duplicate the panel's BCG level assignments. This model (Figure 1) was then used to assign BCG levels to all monitoring sites in MPCA's biological monitoring database for streams and DNR's Lake Database for lakes.

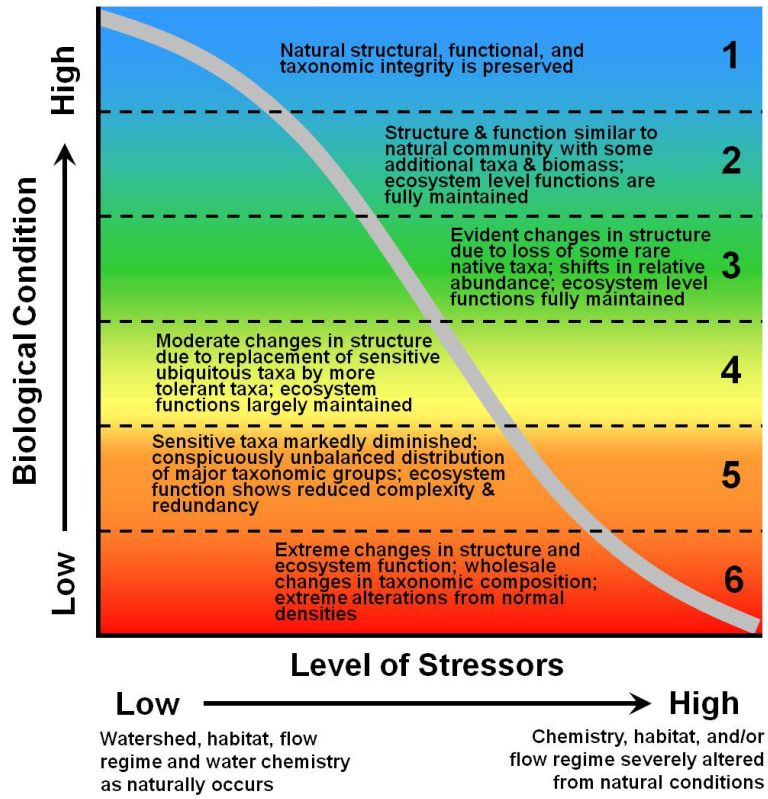


Figure 1. Model used to assign BCG levels to Minnesota's biological monitoring sites.

Selection of Reference Sites for Rivers and Streams

Minnesota has developed an index to measure *a priori* the degree of human disturbance at a stream class called the Human Disturbance Score (HDS) (Table 1). The HDS includes both watershed and reach level measures of human disturbance which when combined have a maximum score of 81 (see Table 1 below). Reference sites were identified as those with an HDS score of 61 or greater (i.e., a 25 percent decline from the maximum score). Once sites were selected based on their HDS score, an additional filter was applied to remove sites disparately influenced by nearby stressors. All sites in close proximity to urban areas (site within or adjacent to urban area), feedlots (feedlot at or immediately upstream of site [only streams >50 mi^2]), or point sources (continuous point source <5 mi upstream of site) were removed. The remaining sites (i.e., those meeting the HDS threshold and meeting the proximity criteria) were considered to be minimally or least disturbed and therefore representative of attainment of Minnesota's aquatic life use goals. Reference sites were selected from each of the fish and macroinvertebrate classes and the 25th percentile of IBI scores was determined.

Table 1. Metrics and scoring for Minnesota's Human Disturbance Score.

Human Disturbance Score Metric	Scale	Primary Metric or Adjustment	Maximum Score
Number of animal units per sq km	watershed	primary	10
Percent agricultural land use	watershed	primary	10
Number of point sources per square km	watershed	primary	10
Percent impervious surface	watershed	primary	10
Percent channelized stream per stream km	watershed	primary	10
Degree channelized at site	reach	primary	10
Percent disturbed riparian habitat	watershed	primary	10
Condition of riparian zone	reach	primary	10
Number of feedlots per sq km	watershed	adjustment	-1
Percent agricultural land use on >3% slope	watershed	adjustment	-1
Number of road crossings per sq km	watershed	adjustment	-1 or +1
Percent agricultural land use in 100m buffer	watershed	adjustment	-1
Feedlot adjacent to site	reach (proximity)	adjustment	-1
Point source adjacent to site	reach (proximity)	adjustment	-1
Urban land use adjacent to site	reach (proximity)	adjustment	-1
		Maximum	**81**

Appendix G. Supplemental information on river eutrophication assessment in Minnesota

The following information is intended to guide the completion of the river eutrophication standard (RES) assessments. This includes determination of the correct regional standard to apply, data requirements and summarization, and guidance for specific situations encountered during the assessments.

Assignment of regional standards

When an HUC-8 watershed is located wholly within a River Nutrient Region (RNR) (Figure 1), or where a vast majority of the watershed is within a single RNR, the RNR assignment is made to the dominant RNR. When a HUC-8 is characterized by multiple RNRs, a closer inspection was required and 11-digit HUCs (Watershed 99 HUC 11 layer) were incorporated into the mapping coverage to allow for refinement of boundaries to determine the appropriate RNR assignment. In a few instances, where two 8-digit HUCs meet prior to entering the major mainstem river (e.g. North Fork and South Fork Crow Rivers) a site-specific standard was required and these reaches are noted on the RNR map. Heiskary and Parson (2013) provide further details on the mapping approach.

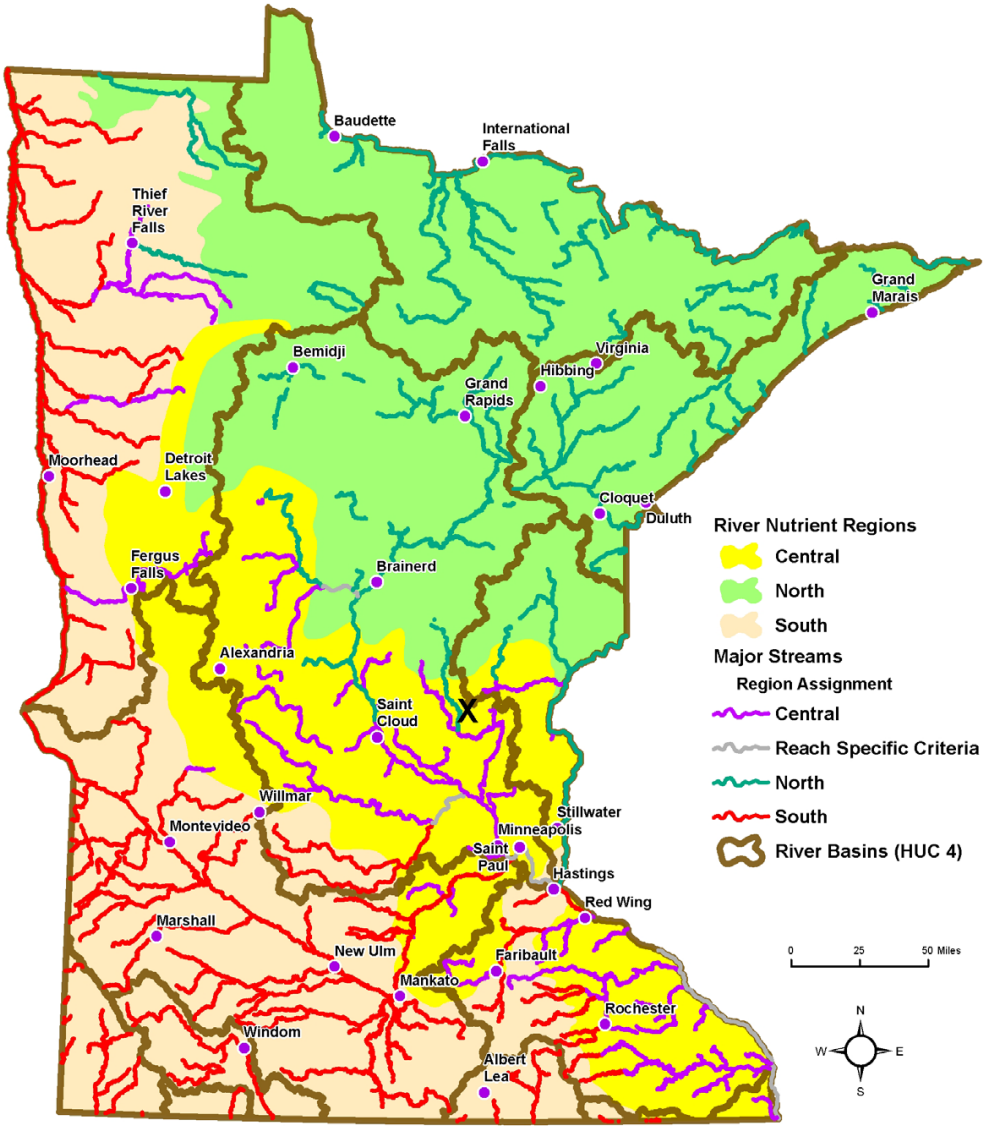


Figure 1. Statewide River Nutrient Region map.

During the assessment the assigned RNR should be reviewed if there are questions regarding the AUID classifications when a river flows from one RNR to the next or where adjacent or upstream/downstream AUIDs have different RNR designations.

Minimum data requirements for TP, chl-*a* corrected for pheophytin or BOD_5 and pH

The rule and the legal documents supporting and explaining the rule (SONAR Book 2, Minn. R. ch. 7050, and Heiskary et. al. 2013) describe the following minimum data parameters:

- **Number of years.** Samples must be collected over a minimum of 2 years within the most recent 10-year time period (SONAR Book 2).
- **Time of year.** Data used for assessments must be collected from June to September (Minn. R. ch. 7050).
- **Number of TP data points.** Based on a minimum of two years of monitoring, a minimum of six individual data points per summer for the causative variable TP must be collected (as noted in SONAR Book 2, pp. 81).
- **Response variables.** In addition, the response variables (chl-*a* corrected for pheophytin or BOD_5 or pH) are collected concurrent with TP. A minimum of 12 measurements considering the above minimum data requirements for the ten-year assessment period are required for an assessment to be conducted (SONAR Book 2). While this minimum will typically be achieved over 2 years of sampling, it may also be achieved by multiple years (e.g. 3 years with 4 samples per year).

The term "representative" is used repeatedly in these definitions and implies that samples are to be collected across the summer season so they "represent" the entire season. Since river flow varies during individual summers and among summers, it is assumed samples will be collected over a range of flows; hence the need to collect multiple samples over each summer and the need for two or more years of sample collection. While no specific flows are established for (or prohibited from) sample collection, the river must exhibit some amount of unidirectional flow for samples to be collected. If flows are so low that water is pooled or stagnant at the sample site and there is no evident downstream flow, these conditions must be documented and samples should not be utilized for river eutrophication assessment.

Data requirements specific to diel dissolved oxygen flux assessment

Diel DO flux is measured by means of probes (also referred to as a sonde) that are deployed for a minimum of 4 consecutive days in the river reach (AUID) being assessed. While these measures could be conducted at any time within the June through September timeframe, it is preferred that the measures be taken late summer from mid-July through August. Ideally, flows are relatively stable during the time the sonde is deployed. Due to interannual variability and the varied duration of single-year diel dissolved oxygen deployments, sonde deployments must meet the minimum deployment length and deployments must occur in a minimum of 2 summers in the assessment period to be considered representative of river conditions. Details on methods for collecting instrumented DO data for the calculation of diel DO flux are provided in technical support documents (Heiskary et al. 2013 and Heiskary and Markus 2003).

Determination of use assessment

The final step is determining if the RES has been met or exceeded for the water body being assessed based on the data collected. Minnesota's RES is a is a two-part standard involving a causative variable (total phosphorus) and response variables that indicate the presence of eutrophication (i.e. undesirable levels of sestonic or suspended algae, benthic or attached algae, or excessive rooted vegetation). For assessment purposes this means the cause indicator (phosphorus) and response indicators (chl-*a*, BOD_5, diel DO flux, or pH) are used in combination and not independently. The eutrophication rule clearly states the requirement that cause and at least one response indicators must both be exceeded to indicate a polluted condition.

Assessment staff should use the following information when assessing water bodies for the river eutrophication standard:

- **Primary and supplementary assessment statistics.** For chl-*a* and BOD_5 data, as with TP data, summer-means for the entire 10-year assessment period are calculated from the available data and considered in the assessment. Supplementary statistics such as number of observations and standard error are also generated. These statistics can aid determinations when an AUID is just above or just below the WQS or where stressor and response variables are not in full agreement.
- **Method detection limits (MDL) for BOD_5 data**. For most RES parameters, MDLs will not be an issue during assessments. For example, MDLs for TP (typically <10 µg/L) and chl-*a* (typically <0.5 µg/L) are well below the WQS and less than values are uncommon. However, BOD_5 MDLs may vary among laboratories. MDL for BOD_5 data used in rule development was 0.5 mg/L (from Minnesota Department of Health), which is well below the WQS. In other laboratories, the MDL may be 2.0 mg/L or higher. These MDLs are at or above the WQS for the North and Central RNRs and in some cases the South RNR. Following are cautions and considerations on the use of BOD_5 non-detect data in RES assessment (see also Figure 2). While BOD_5 is referred to specifically these considerations would also be applicable to TP and chl-*a* data where high MDLs were used and numerous non-detects are present in the assessment data.
    - If the BOD_5 average is above the WQS and there are no non-detects, then the parameter does not meet the WQS.
    - If the BOD_5 average is below the WQS, regardless of presence of non-detects, the parameter meets the WQS.
    - If the BOD_5 average is above the WQS and non-detects are present, there are several methods that can be used for assessment depending on the dataset. These methods should be followed in sequence.
        1. If the BOD_5 average is above the WQS, but with more than 50% non-detects, the data is considered insufficient information.
        2. If the BOD_5 average is above the WQS and 50% or fewer are non-detects then:
            a. Replace non-detects with “0” and recalculate the mean. If the recalculated mean is still above the standard, the concentration can be considered to exceed the standard. [The occurrence of non-detects in a dataset will increase the mean above the true value. This is because the reported non-detect value is higher than the true value. A simple method to determine if non-detects are potentially biasing the assessment is to use a best-case scenario. This is accomplished by replacing non-detects with “0” values. Since the true value is somewhere between the detection limit and “0”, this recalculated represents the lowest possible mean value.]
            b. If replacing non-detects with “0” results in a recalculated mean that is below the standard, then more sophisticated mean estimation methods are required. If the BOD_5 data are critical to the assessment, advanced non-detect methods such as NADA in “R” may be required to allow for a more accurate estimate of the mean value.

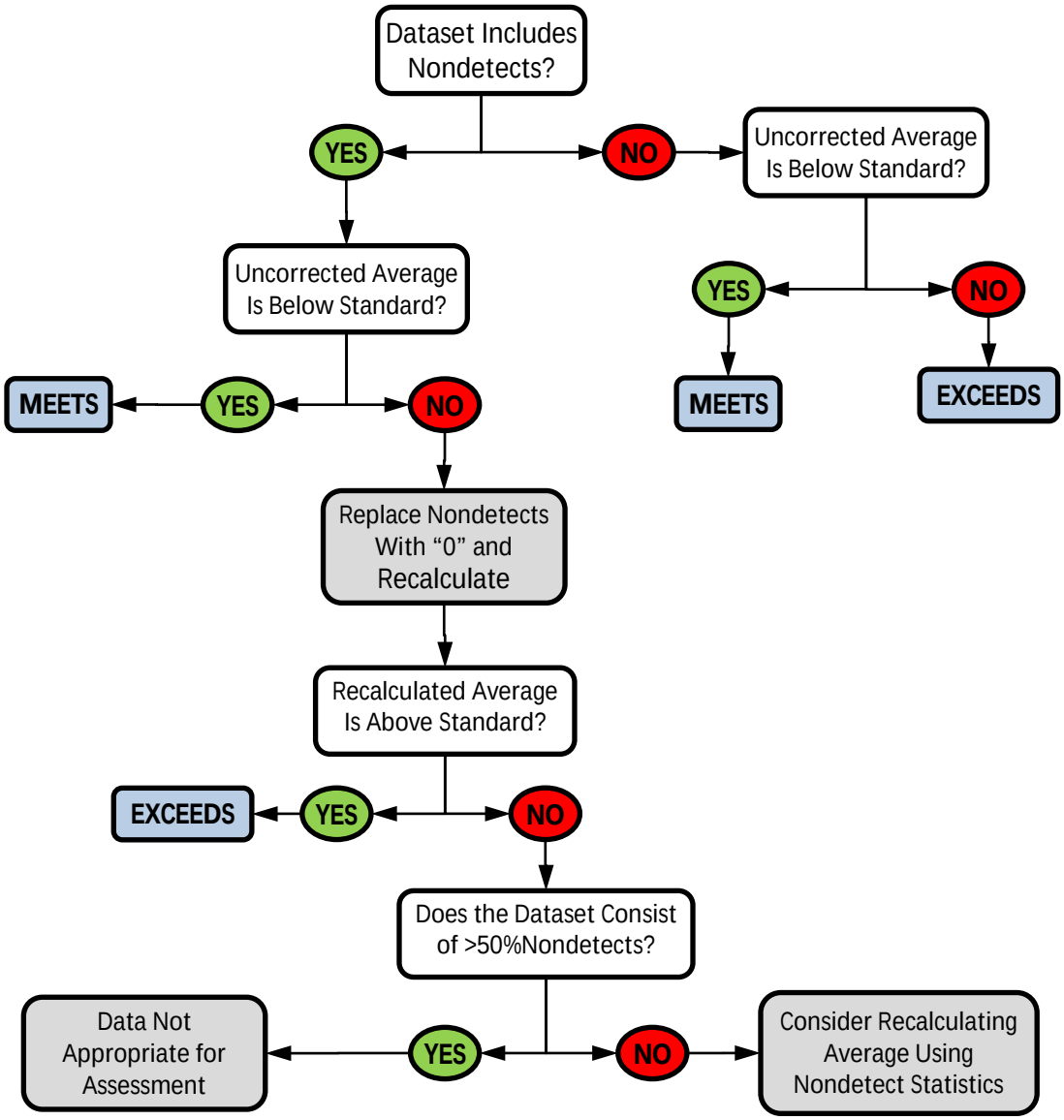


Figure 2. Flow chart for addressing dataset containing non-detects.

- **pH assessment.** Since pH assessments are based on the existing pH water quality standard (WQS), assessments should be done in accord with the existing methodology (i.e. the variable exceeds the standard if the data show a 10% exceedance of the water quality standard based on daily minimum and maximum measurements); however, pH data must be collected during the summer index period to be used as a part of RES assessment.
- **Diel DO flux assessment.** Diel DO flux values are calculated based on the difference between the daily maximum DO and the daily minimum DO. These daily flux values are averaged based on the number of days of measurement. Heiskary et al. (2013; Table 6) provides an example of how data can be assembled for RES assessment purposes. The resulting average diel DO flux measurement is then compared to the WQS to determine if this response variable is met or exceeded.
- **Exceedances of BOD_5 or Diel Dissolved Oxygen Flux caused by other factors.** Indirect response measures can be influenced by other factors which must be considered during the assessment. As with all assessment parameters, each is individually reviewed to determine if the site location was appropriate, if flow conditions and sampling regime were representative (e.g., not biased by flood or drought), and to ensure that there are no quality assurance issues with the data (e.g., data out of hold time, sonde calibration issues). When reviewing BOD_5 data, the proximity to permitted facilities

must be taken into account as data included in the assessment may be within the mixing zone of the facilities discharge. These locations should be reviewed to determine if the discharge is biasing the values. For diel dissolved oxygen flux, flow conditions during deployment should be examined to determine if flow conditions were not typical and impacted diel dissolved oxygen flux measurement.

- **Clear evidence of WQS exceedance.** AUIDs exceed the RES if the causative variable (TP) exceeds the standard and one or more of the response variables (chl-*a*, BOD_5, diel DO flux, or pH) also exceed the standard. Such AUIDs are impaired and the AUID will be included on Minnesota's 303(d) list. Not all response variables need to be present or in agreement for an exceedance to be determined.

- **Clear evidence of meeting the WQS.** An AUID is meeting the RES if total phosphorus is meeting the standard. A determination of full support of the RES does not require response data to be present. However, if response variable data are present and assessable, a determination of full support requires that the response variables also meet the applicable standard. An AUID can also be considered fully supporting if total phosphorus exceeds the threshold and all response variables can be assessed and they meet their respective standard.

- **Insufficient information to assess.** A determination of insufficient information will be assigned when:

  1. insufficient data are present
     a. insufficient total phosphorus data available
     b. sufficient total phosphorus data are available and indicates exceedance of the standard, but no response variable data are present
  2. sufficient data for assessment exists, but there is a lack of confidence in the data (e.g., inappropriate laboratory methods, atypical flow conditions, inappropriate sample location)

- **Average concentrations near the standard.** AUIDs where TP or response variable(s) are slightly above or slightly below the WQS require closer scrutiny of the data. A high standard error (SE), indicative of high variability in measurements, suggests the raw data should be reviewed to determine the frequency of elevated values. If TP ± SE is just above the WQS but response WQS are met, the reach is deemed supporting the WQS. If TP ± SE is just above the WQS and mean chl-*a,* BOD_5, diel flux or pH exceeds the WQS, the reach is deemed not supporting aquatic life use due to eutrophication. If the data are not representative, such as poor site placement (i.e. lake outlet, in mixing zone of permitted facility), data skewed by drought- or flood-biased samples, etc. the reach may be considered insufficient information to assess. If flow data are available, this may help place results in perspective. For example, if summer-mean chl-*a* is equal to the response WQS but collections were made only during high flow summers, it is likely chl-*a* would exceed in summers with lower flow and it may be reasonable to recommend listing the AUID if TP exceeds as well. A recommendation of not listing may be reasonable if collections were made only during low flow summers.

- **Effect of impoundment (≥14-day residence time) upstream or within the AUID.** An impoundment immediately upstream or in the AUID may promote excessive algal growth even when TP meets the river eutrophication WQS. In instances like this, a decision may be needed as to whether the lake or river eutrophication WQS is most appropriate to address this situation. In cases where the upstream impoundment has been deemed a reservoir and was assessed as impaired (based on the lake eutrophication standard (LES)), the "assessment status" of the river AUID may not affect the TMDL since the TMDL for the impoundment would likely address the river eutrophication issue.

- **Effect of impoundment (<14-day residence time) upstream or within the AUID.** Very small or short residence time impoundments or wetland complexes on the mainstem of a river (residence time < 14 days at 122-day one in ten-year low flow) represent a special case and there is a need to determine the status of data collected from reaches affected by these impoundments or wetlands in terms of 1) whether or not the data are assessable, 2) which if any standard is appropriate, and

3) how it may influence a downstream portion of the AUID. To determine if a river reach is impounded a review of dam location (DNR GIS layer), river morphology (aerial photos, site visits), water velocity, etc. will be used. The RES and LES standards were developed using data from un-impounded river stations and lakes that met the 14-day residence time threshold, respectively. These datasets did not include naturally or artificially impounded river reaches so the applicability of the either standard needs to be determined on a case-by-case basis. In most instances, best professional judgment will be used and documented to discern which standard is appropriate for the AUID in question. However, in some cases there will not be sufficient supporting information to determine an appropriate standard and data from the impounded section will need to be flagged as supporting information only. When an AUID includes data from both an impounded and un-impounded reaches, the data from the un-impounded reach may still be assessable against the RES standard.

- **Biased data.** As a part of the data review for assessments, RES datasets should be examined to identify possible biases resulting from irregular timing of sampling (e.g., samples weighted toward part of the year or to high flow events). If the data are not representative of the index period, a time-weighted average can be applied to correct this bias [note this procedure will only be needed when the bias is likely to have a significant impact on the assessment]. In addition to removing within-year temporal biases, the time-weighted average will also weight data from each year equally to reduce weighting toward years with larger sample sizes. However, caution should be used with data from years with few sample events (<4) or with data from only part of the year (e.g., only August samples). Years with only a single sample should be removed from the time-weighted calculation as the temporal weighting cannot be calculated for these years and the single sample would be given too much weight. Years with only 2-3 sample events should be scrutinized to determine how well the limited sample size reflects average annual conditions. These data may be removed or retained depending on this evaluation. Any data that are removed may still be useful as supporting information.

  A time-weighted average can be calculated using the following equation.

$$TWA = \frac{\sum_1^n c_i * t_i}{\sum_1^n t_i}$$

  where c_i = concentration for the ith sample
  t_i = time window for the ith sample

- **Site-specific standards option.** Sometimes it is more appropriate and information is available to derive standards based on information specific to an AUID. Site-specific standards require public comment and must be sent to EPA for approval. Additional data collection work may be required to develop and adopt a proposed site-specific WQS. Once approved, the site-specific standard becomes the basis for assessing the condition of the AUID.

- **Use of data near continuous discharging facilities.** BOD_5 and DO flux data from within 5 miles of a continuously discharging wastewater treatment facility (WWTF) are generally not valid for assessing RES. The intent of these response variables is to identify the presence of eutrophication (i.e. undesirable levels of sestonic or suspended algae, benthic or attached algae, or excessive rooted vegetation). Some river monitoring sites are too close to WWTF outfalls and are biased by dying microbial matter and not algae or rooted vegetation. A 2010 MPCA paper analyzed data and determined that in most instances, data from within 5 miles downstream of a facility may be impacted by the effluent. As a result, it would not be appropriate to use these values in a RES assessment.

- **Mississippi navigational pool assessments.** Navigational pool eutrophication assessments on the Mississippi River should be consistent with other 303(d) assessments; whereby the most recent 10 years of data would be used in the assessment. This should minimize the effect of any extreme high or low flow year and allow for a more comprehensive assessment of each assessment reach.

Assessments will be based on monitoring data collected in the thalweg of the pools just upstream of the dam that forms the pool. The monitoring sites should be consistent with long-term monitoring sites employed by the Metropolitan Council (MCES) and USGS's Long Term Resource Monitoring Program (LTRMP) (see below). The pool is designated as impaired if TP and chl-*a* exceed the WQS as noted in Table 4. Further details on this are found in Heiskary and Wasley (2012).

Station data used for Mississippi River Pools assessments

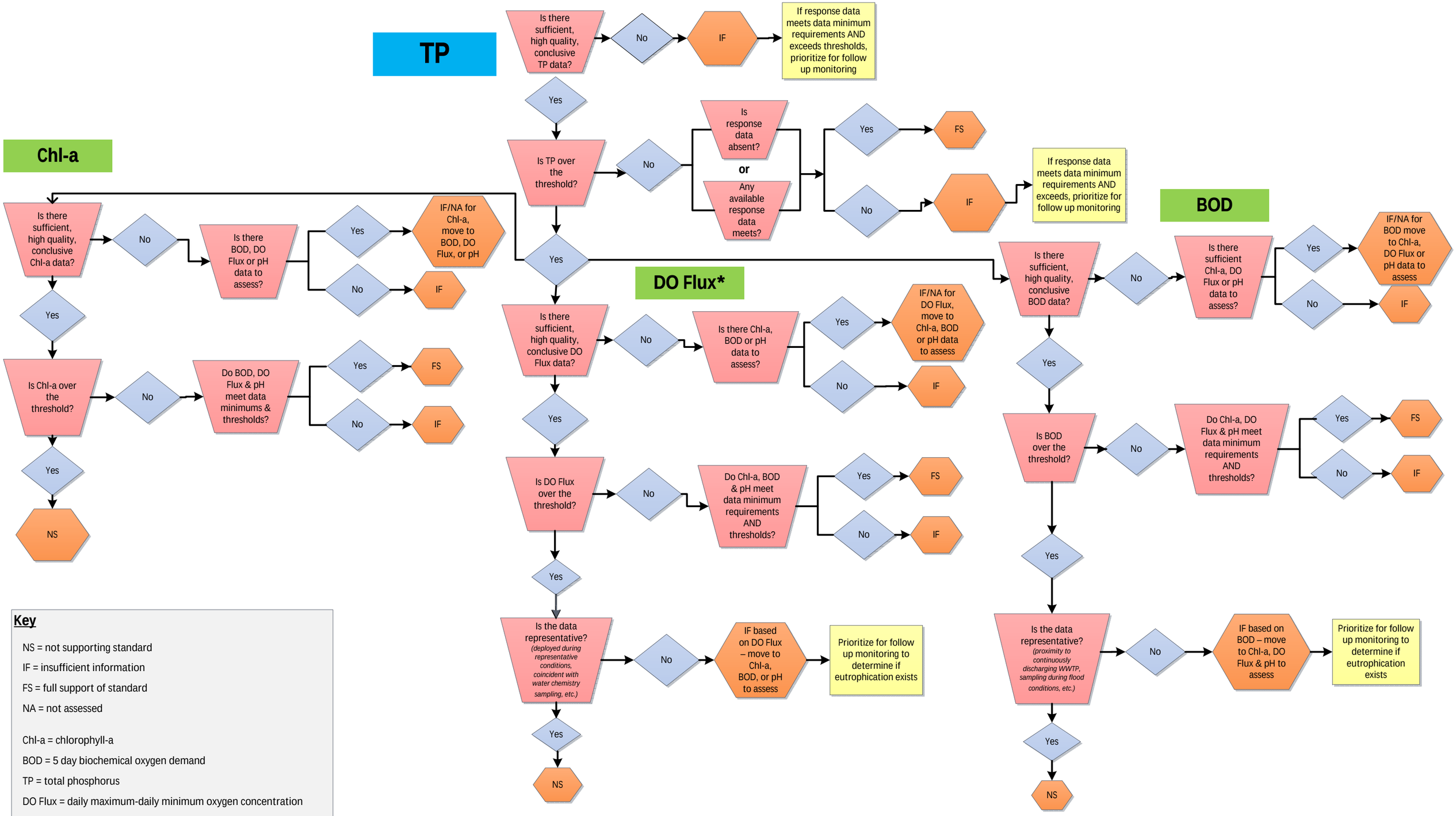
Pool	WID	Stations used for standard development and assessment
Pool 1	07010206-808	MCES 847.7, EQuIS S004-276
Pool 2	07010206-806	MCES 815.6, EQuIS S000-068
Pool 3	07040001-718	LTRMP M796.9, MCES 796.9, EQuIS S005-179, S000-132
Pool 4/Lake Pepin	25-0001-00	LTRMP M776.0I, 771.2P, 775.6Q, 781.2O
Pool 5	07040003-F26	LTRMP M738, EQuIS S000-287
Pool 6	07040003-F27	EQuIS S000-095
Pool 7	07040003-F28	LTRMP M701.1
Pool 8	07060001-692	LTRMP M679.5, EQuIS S000-094

- **Lake Pepin assessments.** Lake Pepin assessments will be based on fixed site monitoring data and incorporate the most recent 10 years of data. This data is collected at 2 sites in the upper segment and 2 sites in the lower segment of the lake and correspond to long-term sites that have been used by LTRMP and MPCA. Data from these 4 sites were the primary basis for listing Lake Pepin as impaired and supported much of the model development and testing. Data from all 4 sites are averaged for the assessment. Site maps and further description are found in Heiskary and Wasley (2011).

Special assessment situations related to RNR assignment

When assessments are made or new AUIDs are established, there may be a need to assign new RNRs or to change an RNR designation because of new information that is gathered in the assessment process. This may occur as a part of the professional judgment group review, as a result of public comment, or in the course of TMDL development. In some instances, this may require some correction in RNR designation, while in others it may require development of a site-specific standard.

Some stream reaches may require site-specific standards within the context of the RNRs (Figure 1). These situations most often occur when two similar order (sized) rivers from two different RNRs join prior to discharging to a major downstream, higher order river. For example, in adoption of the river eutrophication standards Exhibit EU-5 notes: *"In a few instances where two HUC-8s meet prior to entering the major mainstem river (e.g. North Fork and South Fork Crow Rivers) "blended" or site-specific standards are recommended and these reaches are noted on the RNR map."* Where and when such sites are identified in the future, the site-specific WQS for the causative variable (TP) is likely to be based on the midpoint between the values from the two contributing RNRs. The site-specific WQSs for the response variables will be based on the midpoint between the WQS in Table 11 of Heiskary et al. 2013. This approach and values as noted in Table 11 of Heiskary et al. 2013 should be applicable in other instances where this may occur.



Key

NS = not supporting standard

IF = insufficient information

FS = full support of standard

NA = not assessed

Chl-a = chlorophyll-a

BOD = 5 day biochemical oxygen demand

TP = total phosphorus

DO Flux = daily maximum-daily minimum oxygen concentration

*pH follows the same decision tree as DO Flux