

APPENDIX G:
**IDEM'S 2026 CONSOLIDATED ASSESSMENT AND LISTING
METHODOLOGY (CALM)**

REGULATORY BACKGROUND

The U.S. Environmental Protection Agency (U.S. EPA) is required by Section 305(b) of the 1972 Federal Clean Water Act (CWA) to provide a biennial national water quality inventory report to Congress. The water monitoring and assessment activities conducted by states provide much of the water quality assessment information U.S. EPA uses to develop its report.

The Indiana Department of Environmental Management (IDEM) conducts water quality monitoring to meet many objectives, including to provide information to U.S. EPA for its national report. IDEM has developed this Consolidated Assessment and Listing Methodology (CALM) to guide its 305(b) water quality assessment process. IDEM applies the decision-making processes described in the CALM to the available data to determine whether monitored waterbodies are meeting the designated uses identified in Indiana's water quality standards (WQS).

Section 303(d) of the CWA requires that states identify those waterbodies impaired for one or more designated uses. Waterbodies that do not meet Indiana's WQS are considered impaired and placed on Indiana's 303(d) list. Total maximum daily loads (TMDLs) are then established for those waterbodies on the 303(d) list to provide a pathway for the waterbody to meet the applicable WQS for the impaired designated use(s).

U.S. EPA guidance recommends that states, territories, and authorized tribes submit an Integrated Water Quality Monitoring and Assessment Report (IR) that will satisfy the CWA requirements for both the Section 305(b) water quality report and Section 303(d) list of impaired waters. IDEM adopted this recommendation in 2002 and has provided its biennial IR to U.S. EPA in even-numbered years.

IDEM'S SURFACE WATER QUALITY MONITORING STRATEGY

The [Indiana Water Quality Monitoring Strategy 2022-2026](#) (WQMS; IDEM, 2023a) guides IDEM's surface and ground water quality monitoring activities. Through the collection of surface water chemistry, biological communities, and habitat data, the following goals of the WQMS are met:

- Assess all waters of the state to identify those waters that are not meeting their designated uses.
- Support Office of Water Quality (OWQ) programs, including WQS development, National Pollutant Discharge Elimination System (NPDES) permitting, and compliance.
- Support public health advisories and address emerging water quality issues.
- Support watershed planning and restoration activities.
- Determine water quality trends and evaluate performance of programs.
- Engage and support a volunteer monitoring network across the state.

IDEM employs the following monitoring programs/designs to achieve those goals:

- Probabilistic monitoring on a nine-year rotating basin schedule.
- Trophic status monitoring of approximately 80 lakes each year by the Indiana University O'Neill School of Public and Environmental Affairs (SPEA) Clean Lakes Program (CLP).
- Fixed station monitoring at 165 stream sites across the state.
- Fish tissue and sediment contaminants monitoring on a five-year rotating basin schedule.

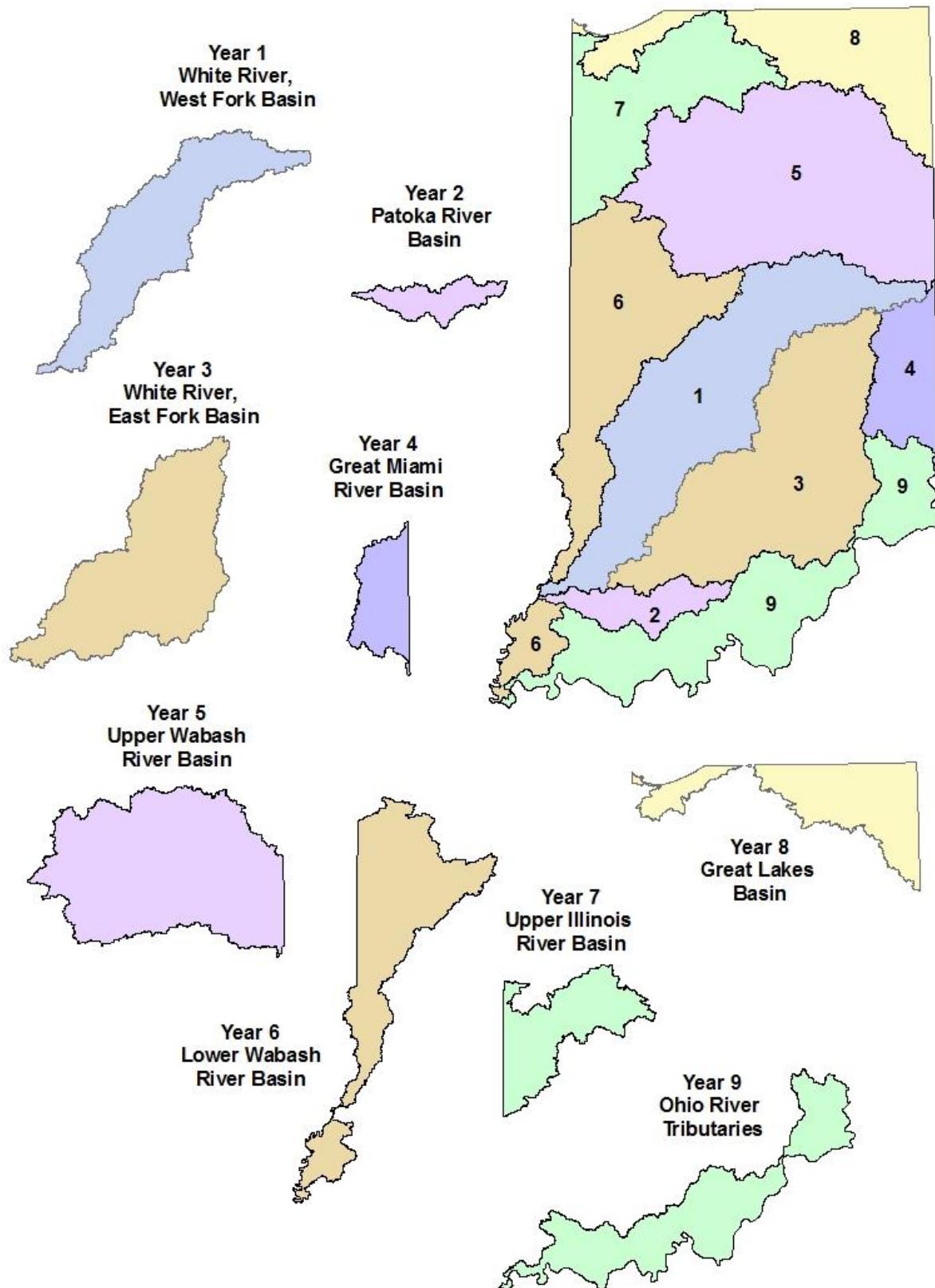
- Targeted monitoring for watershed characterization, TMDL development, and performance measures determinations.
- Cyanobacteria monitoring of 21 swimming beaches on 18 lakes and one dog park lake in selected state parks and recreation areas.
- Thermal verification monitoring.
- Special sampling projects.
- Hoosier Riverwatch volunteer stream monitoring.

IDEM's 305(b) assessment and 303(d) listing processes follow a nine-year, rotating basin schedule (Table G-1), which ensures that all basins in the state are assessed at least once every nine years (Figure G-1) (IDEM, 2023a). The Ohio River Valley Sanitation Commission (ORSANCO), an interstate commission of eight eastern and midwestern states, conducts sampling on the Ohio River and provides this information to member states and the federal government. Lakes and reservoirs in Indiana are monitored for IDEM by the Indiana Clean Lakes Program (CLP) administered by the Indiana University O'Neill School of Public and Environmental Affairs.

Table G-1: IDEM's 305(b) rotating basin monitoring, assessment, reporting and 303(d) listing schedule for aquatic life and recreational uses.

Basin Sequence in IDEM's Rotating Basin Monitoring Strategy	Basin Monitored	Basin Results Assessed	Indiana's Integrated Report and 303(d) List Submitted to U.S. EPA
1) White River, West Fork Basin	2020	2021	2022
2) Patoka River Basin	2021	2022	2024
3) White River, East Fork Basin	2022	2023	
4) Great Miami River Basin (Whitewater River)	2023	2024	2026
5) Upper Wabash River Basin	2024	2025	
6) Lower Wabash River Basin	2025	2026	2028
7) Upper Illinois River Basin (Kankakee and Iroquois Rivers)	2026	2027	
8) Great Lakes Basin	2027	2028	2030
9) Ohio River Tributaries	2028	2029	

Figure G-1: The nine major water management basins in Indiana as defined by IDEM to support the agency's rotating basin monitoring, assessment, reporting, and listing schedule.



WATERBODY ASSESSMENT UNITS

IDE M maintains its CWA Section 305(b) assessment and 303(d) listing information in the U.S. EPA Assessment, Total Maximum Daily Load (TMDL) Tracking And Implementation System (ATTAINS) database. Each waterbody assessment unit (AU) is assigned a unique identifier in ATTAINS to which all assessment information for that waterbody is associated. This identifier is referred to as the assessment unit identifier (AUID).

each AUID corresponds to the watershed in which it is located as defined by the United States Geological Survey (USGS) hydrologic unit code (HUC) system, which is a hierarchical system that divides the United States into successively smaller geographic areas based on surface hydrologic features or drainages. Under this system, the average size of an 8-digit hydrologic unit area in Indiana, referred to as a subbasin, is about 448,000 acres (700 square miles). The 12- and 14-digit hydrologic unit areas, or sub-watersheds, within an 8-digit hydrologic unit area are much smaller, ranging in size from less than five acres (less than one hundredth of a square mile) to about 28,000 acres (almost 44 square miles).

The geographical extent and location of each AU within a given 12- or 14-digit HUC are defined for mapping purposes through a process called reach indexing. Reach indexing uses software tools that work with geographical information system (GIS) applications to delineate for a waterbody one or more units of assessment and to "key" these AUs (as defined by IDE M) to the National Hydrography Dataset (NHD), a database created by the U.S. EPA and the USGS that provides a comprehensive coverage of hydrographic data for the United States. This "key", called the Reach Index, facilitates mapping of Indiana's 305(b) assessments and 303(d) listings in GIS applications and then incorporates this information into the U.S. EPA ATTAINS database.

In these databases, 1589 Indiana lakes and reservoirs, including Lake Michigan, are assigned a single AUID with sizes reported in acres. Indiana's Lake Michigan shoreline is divided into six reaches which are each assigned an AUID and measured and reported in miles.

Indiana rivers and streams in ATTAINS are divided into 14701 reaches with each one assigned a unique AUID in accordance with the 12-digit HUC in which it is located. River and stream reaches are measured in miles and their sizes vary widely, with a single AU potentially representing the entire stream to which it is associated.

The primary factor in determining the size of stream AUs is the hydrology of a system; the mechanisms of large streams and rivers (i.e. average flow, depth, gradient) are very different from those of small streams and tributary systems. Several other factors are considered when deciding how to define water quality AUs:

- Land uses within a watershed as rural and urban development can impact streams differently.
- The presence and locations of permitted wastewater discharge facilities as the volume of discharge can affect the hydrology of the receiving stream as can the chemical makeup of its effluent.
- IDE M also considers any other known factors that might be expected to affect hydrology or water quality, such as the presence of dams and wetlands, or whether the stream has been channelized.
- Aerial photography provides additional information about the presence and thickness of riparian buffers, the spatial extent of rural development, and land use practices in the watershed.

DESIGNATED USES

The CWA provides the underpinning for Indiana's WQS, which are contained in Title 327, Article 2 of the [Indiana Administrative Code \(IAC\)](#) and are designed to ensure that all waters of the state, unless specifically exempted, are safe for full body contact recreation and are protective of aquatic life, wildlife, and human health. These uses are described in the state's WQS as "designated" uses. IDEM monitors and assesses Indiana's surface waters to determine the extent to which they support their designated uses and to identify, where possible, the sources of impairment for those waters that do not support WQS.

OVERVIEW OF IDEM'S WATER QUALITY ASSESSMENT PROCESSES

The designated uses outlined in Indiana's WQS and the narrative and numeric criteria to protect them provide the basis for IDEM's 305(b) assessment process and 303(d) listing decisions. Water quality assessments are made by compiling existing and readily available data from site-specific chemical (water, sediment, and fish tissue), physical (habitat and flow), biological (fish and macroinvertebrate communities), and bacteriological (E. coli) monitoring of Indiana's rivers, streams, and lakes and evaluating those data against Indiana's WQS. Waters identified as not meeting one or more of their designated uses are then placed on Indiana's 303(d) list of impaired waters. IDEM's decision-making criteria include a combination of the narrative and numeric criteria in Indiana's WQS in 327 IAC 2.

Use support status is determined for each waterbody using the assessment guidelines provided in the U.S. EPA's documents regarding the 305(b) and 303(d) reporting methods outlined in the [Guidance for 2004 Assessment, Listing and Reporting Requirements Pursuant to Sections 303\(d\), 305\(b\) and 314 of the Clean Water Act](#) (U.S. EPA, 2003). Subsequent U.S. EPA memorandums containing information concerning CWA Sections 303(d), 305(b), and 314 integrated reporting and listing decisions were provided for the 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2022, 2024, and 2026 cycles (U.S. EPA, 2005, 2006, 2009, 2011, 2013a, 2015a, 2017, 2021a, 2023, 2025). Results from the following types of monitoring data are integrated to provide an assessment of each waterbody for 305(b) reporting and 303(d) listing purposes:

- Physical and chemical water results
- Fish community assessment
- Benthic aquatic macroinvertebrate community assessments
- Fish tissue and sediment contaminant results
- Habitat evaluation
- E. coli monitoring results

The minimum requirements for assessment of each designated use are provided in Table G-2. When the minimum requirements are met for a designated use, IDEM applies the assessment methods described in this document. Assessment data are integrated for the purposes of making water quality assessments, but in accordance with U.S. EPA policy, IDEM generally treats each type of data as independently applicable. Methods for Ohio River assessments, conducted in collaboration with ORSANCO, and CWA Section 314 assessments of lake trends and trophic state are described in later sections of this document.

Table G-2: Minimum data requirements for CWA assessments.

Parameter Type	Minimum Information Required for Assessment	Index Period
Aquatic Life Use Support – Rivers and Streams		
Toxicants ¹	Minimum of three measurements	Most recent five consecutive years
Conventional Inorganics	Minimum of three measurements	Most recent five consecutive years
Nutrient Parameters	Minimum of three measurements and two or more specific parameters must be exceeded on the same date to classify a waterbody as impaired	Most recent five consecutive years
Benthic Macroinvertebrate Community Index of Biotic Integrity (mIBI)	Minimum of one measurement, preferably with corresponding qualitative habitat use evaluation (QHEI) score*	Most recent five consecutive years
Fish Community Index of Biotic Integrity (IBI)	Minimum of one measurement, preferably with corresponding qualitative habitat use evaluation (QHEI) score*	Most recent five consecutive years
<p>*The Qualitative Habitat Evaluation Index (QHEI) is not required to determine aquatic life use support but is used in conjunction with macroinvertebrate (mIBI) and/or fish (IBI) community scores to evaluate the role that habitat plays in waterbodies where biological integrity impairments have been identified.</p>		
Fish Consumption Use Support (Human Health) – All Waters		
PCBs in Fish Tissue	One actual concentration value for the site for a single species and size class	Most recent 12 consecutive years
Mercury in Fish Tissue	One trophic level weighted arithmetic mean concentration value calculated on all samples from the site during a single sampling event	Most recent 12 consecutive years
Recreational Use Support (Full Body Contact) – All Waters		
Bacteria (E. coli)	Geometric mean result calculated from a minimum of five equally spaced samples collected over thirty days	Most recent five consecutive years

¹ See the “Assessment of Selenium for Aquatic Life Use Assessments” section and Tables G-7, G-8, and G-9 for additional information on minimum information requirements and index periods used in selenium assessment.

Parameter Type	Minimum Information Required for Assessment	Index Period
Recreational Use Support (Aesthetics) – Lakes and Reservoirs		
Total Phosphorus and Chlorophyll a	Minimum of three total phosphorus results with corresponding Chlorophyll a results. All readily available data for a given lake that meet IDEM's data quality requirements are evaluated for potential use in assessments	Collected over three years (consecutive or non-consecutive).
Public Water Supply Use Support – All Waters		
Chemical Toxicants	Minimum of three measurements collected within the same year at least one month apart	Most recent five consecutive years
Cyanobacterial Toxins	Minimum of one measurement or One consumption and use notification issued by a water treatment facility based on cyanobacterial toxin concentrations in treated drinking water	Most recent five consecutive years
Conventional Inorganics	Minimum of three measurements collected within the same year at least one month apart	Most recent five consecutive years
Bacteria	All Level 1 or Level 2 assessments, or both, performed in accordance with the Revised Total Coliform Rule (RTCR)	Most recent five consecutive years

CONSOLIDATED LISTING METHODOLOGY

IDE M has followed, to the degree possible, the 305(b) and 303(d) reporting methods outlined in the U.S. EPA Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Sections 303(d), 305(b), and 314 of the CWA (U.S. EPA, 2005) as well as additional guidance provided in U.S. EPA memorandums concerning CWA Sections 303(d), 305(b), and 314 integrated reporting and listing decisions for the 2008, 2010, 2012, 2014, 2016, 2018, 2022, 2024, and 2026 cycles (U.S. EPA, 2006, 2009, 2011, 2013a, 2015a, 2017, 2021a, 2023, 2025). The 303(d) list was developed using the water quality assessment data maintained by IDE M in the U.S. EPA ATTAINS database. Interpretation of the data and listing decisions considers IDE M's assessment methodologies and U.S. EPA guidance.

Data collected from a monitoring site are considered representative of the waterbody for the distance upstream and downstream in which there are no significant influences on the waterbody that might result in a change in water quality. Data may also be extrapolated into tributaries upstream of a given sampling location using this same rationale. Waterbody AUs with one or more monitoring sites and those for which reliable assessments can be made through extrapolation of representative data are classified as monitored and are considered for 303(d) listing purposes. Any waterbody AUs identified as "Not Supporting" of one or more designated are placed on Indiana's 303(d) list of impaired waters.

Interpretation of data through the 305(b) assessment process and 303(d) listing decisions are based primarily on U.S. EPA guidance, which requires a comprehensive listing of all monitored or assessed waterbodies in the state. Waterbody AUs are assigned to one category for each of the following designated uses: aquatic life use, recreational use, fish consumption ², and public water supply ³. The U.S. EPA encourages states to place a waterbody AU into multiple categories as appropriate to illustrate where progress has been made in TMDL development and other restoration efforts. The categories used by IDEM to assess Indiana waters are:

Category 5 The available data and/or information indicate the individual designated use is not supported or is threatened, and a TMDL is needed. These waters constitute Indiana's 303(d) list of impaired waters and are separated into two subcategories.

5A. Waters impaired or threatened by one or more pollutants, and which require a TMDL. Waters are listed in this category if it is determined through assessment following Indiana's CALM that a pollutant has caused, is suspected of causing, or is projected to cause an impairment. When an AU is impaired for more than one pollutant, it will remain in Category 5 until a TMDL has been completed and approved for each pollutant by U.S. EPA.

5B. Waters that are impaired due to the presence of mercury and/or PCBs exceeding Indiana's human health criteria for these contaminants in the edible tissue of fish collected from the AU.

Category 4 The available data and/or information indicate that the individual designated use is not supported or threatened, but a total maximum daily load (TMDL) is not required due to one of the following conditions:

4A. A TMDL for one or more pollutants has been completed and approved by U.S. EPA and is expected to result in attainment of all water quality criteria applicable to the designated use.

4B. Other local, state, or federal pollution control requirements are stringent enough to achieve any water quality criteria applicable to the designated use and are expected to result in the attainment of all water quality criteria in a reasonable period of time ⁴.

² Fish consumption is not a designated use in Indiana's WQS. IDEM assesses Indiana waters for fish consumption pursuant to current U.S. EPA policy and in keeping with CWA goals, which are reflected in Indiana's WQS (327 IAC 2-1-1.5 and 2-1.5-3).

³ Applicable only to waters that serve as a source of water for a public water system.

⁴ A Category 4B listing decision using 40 CFR Part 130.7(b)(1)(i) must be supported by the issuance of technology-based effluent limitations required by Sections 301(b), 306, 307, or other sections of the CWA. A decision to list in Category 4B using Part 130.7(b)(1)(ii) must be supported by the issuance of more stringent effluent limitations required by federal, state, or local authority. The U.S. EPA expects that the state will provide a rationale for why it believes that these effluent limits will achieve WQS within a reasonable period of time. Placement of waters in Category 4B based on Part 130.7(b)(iii) must be supported by the existence of "other pollution control requirements (for example, best management practices) required by local, state, or federal authority" that are stringent enough to implement WQS. EPA expects that the state will demonstrate that these control requirements will achieve WQS within a reasonable period of time.

4C. An impairment is not caused by a pollutant but is, instead, attributed to other types of pollution for which a TMDL cannot be calculated.

Category 3 There is no data and/or information to determine whether the individual designated use is supported, or the available data and/or information are not consistent with the requirements of Indiana's CALM.

Category 2 There is data and/or other information available that meet the requirements of Indiana's CALM and indicate that the individual designated use is supported.

Category 1 There is data and/or information that meet the requirements of Indiana's (CALM) and indicate that all designated uses for that AU are supported, and no designated use is threatened.

The 303(d) list of impaired waters consists of all impairments listed in Category 5 where WQS are not attained because the waterbody AU is impaired or threatened by one or more pollutants(s) with each requiring a TMDL. The current 303(d) list of impaired waters includes impairments identified on previous 303(d) lists, which still require TMDL development. Due to the complex nature of the contaminants involved, IDEM categorizes all fish tissue-related impairments into Category 5B (a state-defined classification similar to U.S EPA's 5M subcategory) which defers development of a conventional TMDL to allow other contaminant clean-up efforts to remedy those impairments.

Because each situation is unique and data sets are sometimes limited, the 303(d) listing process may require IDEM staff to use best professional judgment at times. To help stakeholders understand how designated use support was determined for individual waterbodies of interest, IDEM will make available upon request its water quality assessment notes for any waterbody AU, including any waterbody AU assessed in a different manner than indicated in its CALM.

For an AU to be listed, it must have been assessed using representative data, and the data must support its listing. Any data collected by IDEM and used for assessment and listing decisions must meet the agency's quality assurance and quality control requirements as outlined in IDEM's [Surface Water Programs Quality Assurance Project Plan \(QAPP\) \(IDEM, 2023b\)](#). Data collected from external sources must meet the requirements contained in the technical guidance for IDEM's External Data Framework (IDEM, 2024), which mirror those in IDEM's surface water quality monitoring QAPP.

DELISTING OF IMPAIRMENTS

Existing Federal regulations require states, at the request of the U.S. EPA's Regional Administrator, to demonstrate good cause for not including impairments on the current 303(d) list that were included on previous 303(d) lists (pursuant to 40 CFR Part 130.7(b)(6)(iv)). In general, IDEM will only consider delisting an AU if at least one of the following is true:

- New data indicate that WQS are now being met for the AU under consideration. This would typically occur during IDEM's scheduled assessments when reviewing data collected through IDEM's monitoring programs.
- The assessment and/or listing methodology has changed, and the AU under consideration would be considered not-impaired under the new methodology.
- An error is discovered in the sampling, testing, or reporting of data that led to an inappropriate listing. Reassessment (review of previous assessment or 303(d) listing decisions) typically occurs as a result of ongoing quality assurance and quality control

(QA/QC) of ATTAINS or through inquiry by IDEM staff or external parties. Several types of information are considered during reassessment, including data quality issues, past assessment methodologies, land use data, historical information from the public, or other relevant information. Assessments are not considered invalid based solely on the age of the data.

- It is determined that a program other than the TMDL program, is better suited to address the water quality problem, or the problem is determined not to be caused by a pollutant (see Categories 4B and 4C, above).
- A TMDL has been completed, and the waterbody AU is expected to meet WQS after implementation of the TMDL (see Category 4A, above).

TMDL DEVELOPMENT AND PRIORITIZATION FOR ALL OTHER INDIANA WATERS

The CWA does not clearly define the timeline for TMDL development. 40 CFR Part 130.7 requires states to include with their 303(d) lists a priority ranking of impaired waters that will be targeted for TMDL development in the next two years. IDEM works with U.S. EPA Region 5 during every 303(d) listing cycle to determine a short term TMDL schedule, which identifies the TMDLs to be developed for the next cycle.

IDEF has also developed a long-term schedule to guide TMDL development through 2032. This schedule is included in the Agency's TMDL Program Priority Framework, which describes IDEM's process for implementing U.S. EPA's long-term vision for assessment, restoration, and protection under the CWA Section 303(d) program. IDEM's 303(d) TMDL Program Priority Framework specifically describes IDEM's methods for prioritizing waters for TMDL planning and watershed restoration. In 2024 IDEM updated the [TMDL Program Priority Framework](#) (IDEM, 2025) to meet the U.S. EPA [2022-2032 Vision for the Clean Water Action Section 303\(d\) Program](#) requirements. In the future, IDEM may need to revise its schedule for TMDL development in the short or long-term depending on unanticipated factors that can impact TMDL monitoring activities or development, or both. In such cases, IDEM will follow the methods described in its Program Priority Framework to help ensure ongoing consistency with U.S. EPA's long-term vision.

Because the Ohio River is a boundary between states and U.S. EPA Regions, the development of TMDLs for the river will involve more than one state. To date, Indiana has not developed TMDLs for the reaches of the Ohio River that border Indiana.

AQUATIC LIFE USE ASSESSMENTS

Aquatic life use support assessments are based on the available water chemistry and/or biological data. The processes IDEM uses to make aquatic life designated use support decisions are shown in Table G-3.

IDEF employs independent applicability when multiple types of water quality data are available for assessment, meaning that each type of data is given equal weight in the assessment decision. Therefore, where one type of data indicates impairment and another type indicates support, the waterbody is assessed as impaired. Occasionally, IDEM scientists will give greater weight to one type of data over another based on their best professional judgement (BPJ). These decisions are flagged in IDEM's assessment notes with "BPJ" to make them readily distinguishable to U.S. EPA and the public when assessment information is requested.

Table G-3: Water quality assessment methodology for determining aquatic life designated use support.

Aquatic Life Use Support - Rivers and Streams		
Toxicants ⁵	Data for dissolved metals (and total metals where dissolved metals data are not available), pesticides, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), free cyanide, and ammonia were evaluated on a site-by-site basis and assessed according to the magnitude of the exceedance(s) of Indiana's WQS and the number of times the exceedance(s) occurred. For any one pollutant (grab or composite samples), the following assessment criteria are applied to data sets consisting of three or more measurements.	
	Fully Supporting	Not Supporting
	Not more than one exceedance of the acute or chronic criteria for aquatic life within a three-year period. ⁶	More than one exceedance of the acute or chronic criteria for aquatic life within a three-year period.
Conventional inorganics	Dissolved oxygen, pH, sulfate, and chloride were evaluated for the frequency of exceedance(s) of Indiana's WQS. For any one pollutant, the following assessment criteria are applied to data sets consisting of three or more measurements.	
	Fully Supporting	Not Supporting
	Criteria are exceeded in less than or equal to 10% of measurements.	Criteria are exceeded in greater than 10% of measurements.
Nutrients	<p>Nutrient conditions were evaluated on a site-by-site basis using the benchmarks described below. In most cases, two or more of these conditions must be met on the same date in order to classify a waterbody as impaired. This methodology assumes a minimum of three sampling events.</p> <p>Total Phosphorus – One or more measurements greater than 0.3 mg/L</p> <p>Nitrogen (measured as Nitrate + Nitrite) – One or more measurements greater than 10.0 mg/L</p> <p>Dissolved Oxygen – One or more measurements below the water quality standard of 4.0 mg/L or measurements that are consistently at or close to the standard, in the range of 4.0-5.0 mg/L, or one or more oxygen saturation values greater than 120%</p> <p>pH measurements – One or more measurements exceed the water quality standard of not more than 9.0 pH or measurements are consistently at or close to the standard, in the range of 8.7-9.0 pH</p> <p>Algal Conditions – Algae are described as “excessive” based on field observations by IDEM scientists</p>	

⁵ See the “Assessment of Selenium for Aquatic Life Use Assessments” section and Tables G-7, G-8, and G-9 for additional information on minimum information requirements and index periods used in selenium assessment.

⁶ For Indiana waters within the Great Lakes Basin, “criterion maximum concentration” (CMC) refers to acute aquatic criteria and “criterion continuous concentration” (CCC) refers to chronic aquatic criteria identified in 327 IAC 2-1.5. For downstate waters (those located outside of the Great Lakes Basin) “AAC” values refer to the acute aquatic criteria and “CAC” values refer to chronic aquatic criteria are shown as the shown in 327 IAC 2-1.

	Fully Supporting	Not Supporting
Macroinvertebrate Index of Biotic Integrity (mIBI) and Fish Index of Biotic Integrity (IBI) Scores	mIBI/IBI greater than or equal to 36 (mIBI range of scores is 12-60; IBI range of scores is 0-60)	mIBI/IBI less than 36
Qualitative Habitat Use Evaluation (QHEI)	<p>The Qualitative Habitat Evaluation Index (QHEI) is an index designed to evaluate the lotic habitat quality important to aquatic communities. The QHEI is not used to determine aquatic life use support but is used in conjunction with mIBI and/or IBI data to evaluate the role of habitat in waterbodies where biological integrity impairments have been identified. QHEI scores are calculated using six metrics: substrate, instream cover, channel morphology, riparian zone, pool/riffle quality, and gradient. The possible range of QHEI scores is 0-100 with a higher QHEI score representing a more diverse habitat for colonization of aquatic organisms. IDEM has determined that a QHEI total score below 51 indicates poor habitat. For streams where the macroinvertebrate mIBI or IBI scores indicate the biological integrity of the waterbody is impaired, QHEI scores are evaluated to determine if habitat is the primary stressor on the aquatic communities, or if there may be other stressors/pollutants causing the biological integrity impairment.</p>	

Use Support Criteria for Chemistry Data

Chemical assessments of streams are based on at least three water chemistry samples collected by IDEM either between April – October (i.e., Watershed Monitoring program) or monthly (i.e., Fixed Station program). Chemical parameters that are collected include conventional inorganics, toxicants, and nutrients. Chemistry assessments are based on numeric and narrative criteria listed in the Indiana WQS. During aquatic life use assessments, chemistry results may be brought into question due to issues with field sampling equipment or localized conditions at the site, in which case a site might be determined as meeting WQS even if the results do not indicate that the criteria have been met. These instances are recorded in assessment notes as “Best Professional Judgement” (BPJ) with a description of the potential sampling issue.

Table G-4: Indiana general chemistry criteria and benchmarks used in water quality assessments of aquatic life use support.

Parameter	Great Lakes		Downstate		CAS Number
	CCC	Lake Michigan	CAC	Ohio River and Interstate Wabash River	
General Chemistry and Physical Properties					
Oxygen (Dissolved) _Warmwater Streams	Daily average of 5.0 mg/L; not > 4.0 mg/L at any time	N/A	Daily average of 5.0 mg/L; not > 4.0 mg/L at any time		
Oxygen (Dissolved) Salmonid and Put-and-Take Trout streams	Not < 6.0 mg/L at any time; not < 7.0 mg/L during spawning or imprinting	Not < 7.0 mg/L outside an applicable mixing zone	Not < 6.0 mg/L at any time; not < 7.0 mg/L during spawning or imprinting	N/A	
pH	No values < 6.0 or > 9.0 (except daily fluctuations > 9.0 that are correlated with photosynthetic activity)		No values < 6.0 or > 9.0 (except daily fluctuations > 9.0 that are correlated with photosynthetic activity)		
Total Dissolved Solids		750 mg/L			
Ammonia			$[((0.0577/(1+10^{7.688 - pH})) + (2.487/(1+10^{pH - 7.688}))) * \text{MIN}(2.85, (1.45 * 10^{0.028 * (25 - T)}))$ <p>Where: T = Temperature in °C</p> <p>For the above equation, multiply the parenthetical equation by 2.85 when T is less than or equal to 14.51°C.</p> <p>When T is greater than 14.51°C, multiply the parenthetical equation by (1.45 * 10^{0.028 * (25 - T)})</p>		7664-41-7
Chloride, Total	177.87 * (hardness as mg/L CaCO_3) ^{0.205797} * (mg/L sulfate) ^{-0.07452}	250 mg/L	177.87 * (hardness) ^{0.205797} * (sulfate) ^{-0.07452}		16887-00-6

Parameter	Great Lakes		Downstate		CAS Number	
	CCC	Lake Michigan	CAC	Ohio River and Interstate Wabash River		
Cyanide (free)	5.2		5.2		57-12-5	
Fluoride		1.0 mg/L	2.0 mg/L	1.0 mg/L	16984-48-8	
Sulfate	250 mg/L		Hardness \geq 100 mg/L but \leq 500 mg/L and chloride (mg/L) \geq 5 mg/L but \leq 25 mg/L [-57.478 + (5.79*hardness) + (54.163*chloride)] * 0.65		14808-79-8	
			Hardness \geq 100 mg/L but \leq 500 mg/L and chloride (mg/L) \geq 25 mg/L but \leq 500 mg/L [1276.7 + (5.508*hardness) - (1.457*chloride)] * 0.65			
			Hardness < 100 mg/L and chloride (mg/L) \leq 500 mg/L 500			
			Hardness > 500 mg/L and chloride (mg/L) \geq 5 mg/L but < 25 mg/L [57.478 + (5.79*500) + (54.163*chloride)] * 0.65			
			Hardness > 500 mg/L and chloride (mg/L) \geq 25 mg/L but \leq 500 mg/L [1.276 + (5.508*500) - (1.457*chloride)] * 0.65			
			Chloride < 5 500			

Table G-5: Indiana metals, pesticides, and other toxic chemicals criteria and benchmarks used in water quality assessments of aquatic life use support.

Parameter	Great Lakes		Downstate		CAS Number
	Criterion Continuous Concentration (CCC) (4-Day Average) (µg/L)	CCC Conversion Factors	Chronic Aquatic Criteria (CAC (4-Day Average)) (µg/L)	CAC Conversion Factors	
Metals					
Arsenic	150	1.000	150	1.000	7440382
Cadmium	$e^{(0.7977[\ln \text{hardness}] - 3.909)}$	$1.101672 - [\ln \text{hardness}] * 0.041838$	$e^{(0.7977[\ln \text{hardness}] - 3.909)}$	$1.101672 - [\ln \text{hardness}] * 0.041838$	7440439
Chromium (III)	$e^{(0.819[\ln \text{hardness}] + 0.6848)}$	0.860	$e^{(0.819[\ln \text{hardness}] + 0.6848)}$	0.860	16065831
Chromium (IV)	11	0.962	11	0.962	18540299
Copper	$e^{(0.8545[\ln \text{hardness}] - 1.702)}$	0.960	$e^{(0.8545[\ln \text{hardness}] - 1.465)}$	0.960	7440508
Iron	300 (Lake Michigan only)				
Lead	$e^{(1.273[\ln \text{hardness}] - 4.705)}$	$1.46203 - [\ln \text{hardness}] * 0.145712$	$e^{(1.273[\ln \text{hardness}] - 4.705)}$	$1.46203 - [\ln \text{hardness}] * 0.145712$	7439921
Mercury	0.9081	0.85	0.012		7439976

Parameter	Great Lakes		Downstate		CAS Number
	Criterion Continuous Concentration (CCC) (4-Day Average) (µg/L)	CCC Conversion Factors	Chronic Aquatic Criteria (CAC (4-Day Average)) (µg/L)	CAC Conversion Factors	
Nickel	$e^{(0.846[\ln \text{ hardness}] + 0.0584)}$	0.997	$e^{(0.846[\ln \text{ hardness}] + 0.0584)}$	0.997	7440020
Selenium	See table G-9		See tables G-7 and G-8		
Zinc	$e^{(0.847[\ln \text{ hardness}] + 0.884)}$	0.986	$e^{(0.847[\ln \text{ hardness}] + 0.884)}$	0.986	7440666
Pesticides					
Dichlorodiphenyl-trichloroethane (= DDT; all derivatives)			0.0010		50293
Benzene Hexachloride (= gamma BHC or Lindane)			0.080		58899
Chlordane			0.0043		57749
Chlorpyrifos			0.041		2921882
Dieldrin	0.056		0.0019		60571
Endosulfan			0.056		115-29-7
Endrin	0.036		0.0023		72208
Heptachlor			0.0038		76448
Toxaphene			0.0002		8001352
Parathion	0.013		0.013		56382

Parameter	Great Lakes		Downstate		CAS Number
	Criterion Continuous Concentration (CCC) (4-Day Average) (µg/L)	CCC Conversion Factors	Chronic Aquatic Criteria (CAC (4-Day Average)) (µg/L)	CAC Conversion Factors	
Polychlorinated Biphenyls (PCBs)					
Polychlorinated Biphenyls (PCBs), Total (sum of all <u>congeners</u>)			0.014		
Semi-Volatile Organics (SVOCs)					
Pentachlorophenol	$e^{(1.005[pH]-5.134)}$		$e^{(1.005[pH]-5.290)}$		87-86-5

Assessment of Total Metals Data

In the 2022 integrated reporting cycle, IDEM implemented a new method for evaluating metals data for waterbodies where only total recoverable metals' data are available for arsenic, copper, chromium, lead, nickel, and zinc. This method does not replace IDEM methods for assessing dissolved metals' results. Rather, it provides a set of total metals conversion factors that allow IDEM to estimate the dissolved fraction of the total recoverable metal concentration in a sample. By multiplying the total metal results by the conversion factor developed for that metal, IDEM can then compare the estimated dissolved fraction to the dissolved metals criteria in Indiana's WQS to determine aquatic use support.

This method of converting total metals results to estimated dissolved metals values allows IDEM to use more of its existing and readily available data to gain a fuller understanding of the degree to which metals may be impacting aquatic life in Indiana waters.

How the Conversion Factors Were Determined

The data for this analysis came from samples collected at IDEM's Fixed Stations and its Watershed Monitoring Program sites. To calculate the total metal conversion factors, IDEM first queried its Assessment Management Information System (AIMS) database for all metals data from samples collected by IDEM between 2010-2020. The data were then filtered to extract paired metals data (total and dissolved results from samples collected at the same site on the same day).

For each metal, the ratio of dissolved to total metals was calculated for each paired set of results by dividing the dissolved (D) result by the total recoverable (T) result. Using the D/T ratio values for the paired metals results, the maximum and minimum values for each metal were determined along with the 25th percentile, the 50th percentile (the median), and the 75th percentile.

For sites where IDEM has total metals data but no dissolved metals for assessment, IDEM now uses the 25th percentile of the D/T ratio for that metal as the total metal conversion factor (Table G-9). More detail on this analysis, including IDEM's, evaluation of high D/T ratios and identification and elimination of non-detects and outliers in the data set is discussed below.

Elimination of Non-Detects in the D/T Ratio Calculations

Non-detects in a data set represent samples in which the concentration of the metal is lower than could be detected using the analytical method and/or equipment employed by the laboratory. Paired metals results in which either the total metal result and/or the dissolved metal result was reported as a non-detect were excluded from this analysis because such results cannot be reliably quantified.

Evaluation of High D/T Ratios

The dissolved metal concentration is a fraction of the total recoverable metal in a sample. Therefore, the dissolved concentration in any sample should theoretically never be greater than the total concentration for that metal (i.e., the resulting D/T ratio for a set of paired results should never exceed 1.0).

The data set used for this analysis contained several D/T ratio values greater than 1.0 in which the dissolved metal concentration reported was higher than the total metal concentration. While this seems counterintuitive, it is not uncommon for both the total and dissolved metals values to be at or very close to the minimum reporting limit (MRL), which is the smallest measured

concentration of a substance that can be reliably measured by a laboratory using a given analytical method. In these cases, a small difference between the total and dissolved values resulting from noise and/or uncertainty in the analysis can create a high D/T ratio. This happens because the ratio calculation relies on both the dissolved and total metal concentrations, which together can magnify any noise in the data (i.e., that part of the result that is not attributable to the actual analyte being measured).

According to IDEM's [Indiana Surface Water Programs Quality Assurance Project Plan](#) (IDEM, 2023b), the use of estimated results in decision making processes is determined on a case-by-case basis. IDEM considers dissolved metals results close to the MRL acceptable for aquatic life use assessments. However, IDEM did not consider them acceptable for calculating total metals conversion factors because they can easily be impacted by noise and/or uncertainty in the analysis and as such can degrade the accuracy of the ratio. To eliminate this concern, IDEM excluded all estimated values from its calculations to ensure only the most accurate data was used.

Identification and Elimination of Outliers in the D/T Ratios

After eliminating the non-detects and estimated values from the dataset, IDEM calculated the D/T ratios to be used in calculating the conversion factors for each metal (i.e., the 25th percentile) and applied the interquartile range (IQR) criterion (Crawley 2005) to identify any outliers. The IQR is the difference between the 75th and 25th percentiles; the IQR criterion considers all values that are $1.5 \times \text{IQR}$ above the 75th percentile or $1.5 \times \text{IQR}$ below the 25th percentile as potential outliers. All D/T ratios with IQR criterion values above the 75th percentile were considered outliers and excluded from the calculation of the conversion factors to further improve the accuracy of the results.

Summary Statistics

Table G-6 provides a summary of the data used to calculate each of the total metal conversion factors. Table G-6 also illustrates the distribution of the D/T ratios used to calculate the total metals conversion factors, the variability in the data set and the 25th percentile, the 50th percentile (median), and the 75th percentile for each metal.

How IDEM Applies Total Metals Conversion Factors in Aquatic Life Use Assessments

The total metals conversion factors are not used to make aquatic life use support assessments. Rather, IDEM uses them as a screening tool to identify where additional monitoring is needed to determine whether a metals impairment exists. Total metal conversion factors allow IDEM to use the total metals data it collects from its Fixed Station network to inform water quality assessments. When evaluating total metals results, IDEM first multiplies the total metal results for those metals shown in Table G-6 by their conversion factors to calculate approximate values for the dissolved fraction for each metal. If any of the approximated values exceed the water quality criteria for dissolved metal in question, the site from which the sample was collected is prioritized for follow-up monitoring at which time samples will be collected and filtered to allow for more accurate measurement of dissolved metals concentrations.

This approach provides a cost-effective way to obtain the additional data needed to evaluate metals concentrations at IDEM's Fixed Stations while maintaining consistency with the dissolved metals criteria expressed in Indiana's water quality standards.

Table G-6: Data accumulation and censoring methods, summary statistics and conversion factor results for Arsenic, Chromium, Copper, Lead, Nickel and Zinc.

	Arsenic	Chromium	Copper	Lead	Nickel	Zinc
Data Accumulation						
All Results (n)	24,381	24,373	24,313	24,385	24,278	24,215
Total Metal Results (n)	21,708	21,696	21,636	21,708	21,669	21,576
Dissolved Metal Results (n)	2,558	2,561	2,562	2,561	2,494	2,559
Stations with \geq One Result(s) (n)	719	719	719	719	719	719
Stations with Paired Results (n)	474	474	474	474	473	474
Paired Results (n)	2,556	2,558	2532	2559	2,473	2,533
Data Censoring						
Non-Detects in Paired Results (n)	1,559	2,511	981	2523	423	2,100
Non-Detects in Paired Results (%)	61%	98%	39%	99%	17%	83%
Estimated Values in Paired Results (n)	57	5	99	0	185	21
Outliers Removed from Paired Results (n)	7	0	9	0	37	4
Paired Results used in Analysis (n)	933	42	1443	39	1828	408
Summary Statistics						
Maximum D/T	1.31	1.17	1.30	1.00	1.31	1.18
75 th % D/T	0.94	0.79	0.82	0.77	0.91	0.73

	Arsenic	Chromium	Copper	Lead	Nickel	Zinc
Median D/T	0.85	0.59	0.66	0.60	0.79	0.53
25 th % D/T	0.71	0.39	0.50	0.40	0.63	0.36
Minimum D/T	0.14	0.16	0.01	0.13	0.10	0.60
Metals Conversion Factors						
Conversion Factor	0.71	0.39	0.50	0.40	0.63	0.36
Applicability	Statewide	Statewide	Statewide	Waters Outside the Great Lakes	Statewide	Statewide

Assessment of Selenium for Aquatic Life Use

In 2016, U.S. EPA published its Clean Water Act (CWA) section 304(a) nationally recommended chronic aquatic life criterion for selenium in freshwater systems, replacing the previous 1999 recommended criterion (U.S. EPA, 2021b *draft*). EPA found that fish are the most sensitive to selenium effects and toxicity occurs when the selenium is transferred to eggs, reducing reproductive success and survival (U.S. EPA, 2021c). EPA's updated selenium aquatic life criterion was incorporated into Indiana administrative code at 327 IAC 2-1-6 and 327 IAC 2-1-5-8. EPA approved of Indiana's adoption of the 2016 selenium criterion into its water quality standards on February 1, 2022. U.S. EPA produced a set of draft technical support documents (U.S. EPA, 2021b *draft*) to assist states and authorized tribes in the implementation of the 2016 selenium criterion (U.S. EPA, 2021c) into their waterbody assessment and listing process. IDEM also produced a draft [Guidance for the Collection of Fish Tissue and/or Water Column Data for Implementation of Indiana's Selenium Chronic Aquatic Life Criteria](#) to provide information on the new selenium criteria and its implementation.

Tables G-7, G-8, and G-9 provide the Indiana WQS for selenium concentrations in fish tissue (egg/ovary and whole body/muscle) and water column (monthly average and intermittent exposures) samples for Great Lakes tributaries, downstate-Acipenseriformes waters and downstate non-Acipenseriformes waters. These criteria are hierarchical, in that selenium concentrations derived from fish tissue elements take precedence over the water-column based elements and fish egg/ovary results supersede fish whole-body/muscle results. The whole-body/muscle tissue and water column criterion elements were developed so that states and authorized tribes could more readily implement water quality criteria (WQC) based on EPA's national CWA section 304(a) recommended selenium criterion.

The U.S. EPA criterion for selenium prioritized fish egg/ovary results above other sample media as these elements were the most robust and consistent measurement endpoints tied directly to impaired reproductive effects. However, in practice it is unlikely that egg/ovary samples will be collected or assessed by IDEM for use in determining Aquatic Life Use impairments. Targeted sampling of gravid female fish could exacerbate pre-existing reproductive failures within a waterbody. Asynchronous spawning habits would make it difficult to sample a waterbody for egg/ovary tissue from multiple species during a single sampling event. Also, as selenium concentrates in eggs, sampling for the "worst case scenario" (i.e. the highest concentration of selenium in eggs/ovary) would require fish community sampling prior to or early in the spawning season, frequently during times of high stream flow which poses additional sampling hazards to field crews.

The U.S. EPA criterion for selenium require "steady state" conditions at a site before fish egg/ovary or whole-body/muscle tissue can be used in determining impairments. "Steady state" is defined as "*when the rates of chemical uptake and depuration are equal and tissue concentrations remain constant over time*" for organisms and "*conditions where sufficient time has passed after the introduction of a new or increasing discharge of selenium into a water body so that fish tissue concentrations of selenium are no longer increasing*" for a sample location (U.S. EPA, 2021b *draft*). After new selenium inputs are introduced to a waterbody,

"EPA estimates that the concentration of selenium in fish tissue will not reach steady-state for several months in lotic systems and longer time periods (e.g., 2–3 years) in lentic systems. Achievement of steady-state in an aquatic system also depends on the hydrodynamics of the aquatic system (particularly reservoirs with multiple riverine inputs), the location of the selenium input and the particular food web. EPA expects the time

needed to achieve steady-state with new or increased selenium inputs to be site-specific.” (U.S. EPA, 2021b draft).

Determination of “steady state” conditions may be difficult to make prior to collection or assessment of fish tissue data and will require consultation with IDEM NPDES staff to locate a potential upstream selenium source when an impairment is identified. As stated in IDEM’s draft fish sampling guidance for selenium, IDEM will require a minimum duration of 12 months after any major change to water column selenium concentration before fish tissue may be sampled. If it is determined that “steady state” conditions are not being met at a location, then Aquatic Life Use assessments for selenium will be performed on available water column data.

U.S. EPA (2021c) provided guidance for potential situations in which water column values are the applicable criterion. When fish tissue data are not available, 303(d) water quality assessments may be made on water column data, although a state may consider subsequently collecting fish tissue data to confirm an assessment decision. In waterbodies determined to be “fishless waters” assessments will be performed on available water column data using the appropriate water column criterion. “Fishless waters” are defined as “*waters with insufficient instream habitat and/or flow to support a population of any fish species on a continuing basis, or waters that once supported populations of one or more fish species but no longer support fish (e.g., extirpation) due to temporary or permanent changes in water quality (e.g., selenium pollution), flow, or instream habitat*” (U.S. EPA, 2021c).

The assessment of selenium for the Aquatic Life designated use is unique in that the preferred assessment method utilizes the collection of fish tissue samples, a medium otherwise only used by IDEM for Fish Consumption designated use assessments and development of the Indiana Fish Consumption Advisory. Although IDEM often collected water chemistry, biological communities, and fish tissue samples simultaneously in the 1990’s, these programs have since diverged and the fish tissue program follows a separate sampling and assessment schedule. Due to the limited number of sites where both fish tissue and water column chemistry data will be available, assessments of fish tissue selenium content for the Aquatic Life designated use will mostly occur in conjunction with assessments for the Fish Consumption designated use.

Selenium content in fish tissue whole-body or muscle (skinless, boneless filets) samples will be assessed using the criterion specified in the “Fish Whole-Body or Muscle” column of Tables G-7, G-8, or G-9, depending on the location in Indiana where the sample was collected and whether that waterbody is designated as “Acipenseriformes Waters”. The allowable frequency of exceedances for selenium in fish tissue is “Not to be Exceeded”; therefore, an exceedance of the selenium criterion in any one of these species/length groupings at any time during the index period will result in an impairment of that AUID. In lentic waterbodies selenium assessments of fish tissue whole-body or muscle samples will consider data collected during the previous 12 years in that lake or reservoir. Mebane (2022) suggested that for bio-accumulative substances “*a longer recurrence interval than that for water column exceedances seems appropriate, such as on the order of 5-10 years*”. U.S. EPA (2021c), in reviewing studies of selenium recovery in two lentic waterbodies, suggested “*that a protracted period of time (in excess of 10 years) would be necessary for fish communities to recover once selenium in fish tissue reached concentrations associated with reproductive impacts*”.

In lotic waterbodies, selenium assessments of fish tissue whole-body or muscle samples will consider data collected during the previous five years in the appropriate reaches of that stream or river. Swift (2002) conducted studies of the recovery time of stream ecosystems experimentally exposed to selenium and stated “*...in streams, selenium residues in sediment, plants,*

macroinvertebrates, and fishes will decrease to levels that approach concentrations considered to be non-toxic to fish and wildlife within several years after exposure to selenium in the water ceases". However, Swift (2002) also stated "...two to three years after selenium dosing ceased, macroinvertebrates and plants from all three treatments still contained enough selenium in their tissues to be potentially hazardous to fishes". A five-year index period is on the low end of the range suggested by Mebane (2022) but may be increased if further research indicates that a longer period of time is required to see significant reductions in fish tissue selenium concentrations in lotic waterbodies.

Selenium content in water column samples will be assessed using the criterion specified in the "Monthly Average Exposure" column of Tables G-7, G-8, or G-9 depending on the location in Indiana where the sample was collected, if the waterbody is lentic or lotic, and whether that waterbody is designated as "Acipenseriformes Waters". Selenium assessments will consider data from a minimum of three samples collected during the previous five years for both lentic and lotic waterbodies, following the index period used in assessment of water chemistry for the Aquatic Life designated use. The allowable frequency of exceedances for selenium in the water column is "Not more than once in three (3) years on average"; therefore, more than one exceedance of the selenium criterion within a three-year window of the larger five-year index period will result in an impairment of that AUID. If a selenium exceedance is found, the AUID will be queried for any additional fish tissue data; if none is found, the AUID may then be prioritized for fish tissue sampling to confirm the impairment. Assessments of selenium in water column samples will occur during the assessments for the project in which the samples were collected. Table G-10 presents impairment decisions for various scenarios in which fish assessments consist of fish tissue and\or water column data.

Table G-7: Selenium surface water quality criterion used in assessments of Indiana waterbodies which are downstate and “Acipenseriformes waters”.

Surface Water Quality Aquatic Life Criterion for Selenium Chronic Aquatic Criterion (CAC) – 327 IAC 2-1-6(a)(4)(A) (Table 6-1a)				
Media Type	Fish Tissue ⁷		Water Column ^{8 9}	
Criterion Element	Egg/Ovary ¹⁰	Fish Whole-Body or Muscle ¹¹	Monthly Average Exposure	Intermittent Exposure ¹²
Magnitude	15.1 mg/kg dry weight	8.5 mg/kg dry weight whole-body or 11.3 mg/kg dry weight muscle (skinless, boneless fillet)	1.5 µg/l in lentic aquatic systems	$WQC_{int} =$ $\frac{WQC_{30day} - C_{bkgrnd}(1 - f_{int})}{f_{int}}$
			3.1 µg/l in lotic aquatic systems	
Duration	Instantaneous measurement ¹³	Instantaneous measurement ²⁵	Thirty (30) days	Number of days per month with an elevated concentration
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three (3) years on average	Not more than once in three (3) years on average

⁷ Fish tissue elements are expressed as steady-state; the aquatic system should not be experiencing new or increasing inputs of selenium.

⁸ Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data and for fishless waters. Water column values are based on dissolved total selenium in water and are derived from fish tissue values via bioaccumulation modeling. Instead of the requirements in 327 IAC 5-2-11.1(b)(2), the allowable mixing zone dilution will be determined by applying the guideline in 327 IAC 2-1-4 to the thirty (30) day, ten (10) year (Q30,10) low flow of the receiving stream for the chronic aquatic criterion (CAC) water column criterion element applicable to lotic aquatic systems, in the absence of site-specific mixing zone data.

⁹ The water column criterion element may be modified on a site-specific basis.

¹⁰ Egg or ovary supersedes any whole-body, muscle, or water column element when fish egg or ovary concentrations are measured.

¹¹ Fish whole-body or muscle tissue supersedes the water column element when both fish tissue and water concentrations are measured.

¹² Intermittent Exposure Equation variables mean the following:

WQC_{int} is the water column intermittent element.

WQC_{30-day} is the water column monthly element for either lentic or lotic waters.

C_{bkgrnd} is the average background selenium concentration.

f_{int} is the fraction of any 30-day period during which elevated selenium concentrations occur, with f_{int} assigned a value ≥ 0.033 (corresponding to one (1) day).

¹³ Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish populations at a given site.

Table G-8: Selenium surface water quality criterion used in assessments of Indiana waterbodies which are downstate and “Non-Acipenseriformes waters”.

Site-specific Surface Water Quality Aquatic Life Criterion for Selenium in Non-Acipenseriformes (No Sturgeon or Paddlefish) Waters ¹⁴				
Chronic Aquatic Criterion (CAC) – 327 IAC 2-1-6(a)(4)(B) (Table 6-1b)				
Media Type	Fish Tissue ¹⁵		Water Column ^{16 17}	
Criterion Element	Egg/Ovary ¹⁸	Fish Whole-Body or Muscle ¹⁹	Monthly Average Exposure	Intermittent Exposure ²⁰
Magnitude	19.0 mg/kg dry weight	9.5 mg/kg dry weight whole-body or 13.1 mg/kg dry weight muscle (skinless, boneless filet)	2.7 µg/l in lentic aquatic systems	$WQC_{int} = \frac{WQC_{30day} - C_{bkgrnd}(1 - f_{int})}{f_{int}}$
			5.5 µg/l in lotic aquatic systems	
Duration	Instantaneous measurement ²¹	Instantaneous measurement ³³	Thirty (30) days	Number of days per month with an elevated concentration
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three (3) years on average	Not more than once in three (3) years on average

¹⁴ This criterion is applicable to surface waters for which the department has made, and U.S. EPA has approved, a site-specific determination that fishes in the Order Acipenseriformes do not occur at the site.

¹⁵ Fish tissue elements are expressed as steady-state; the aquatic system should not be experiencing new or increasing inputs of selenium.

¹⁶ Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data and for fishless waters. Water column values are based on dissolved total selenium in water and are derived from fish tissue values via bioaccumulation modeling. Instead of the requirements in 327 IAC 5-2-11.1(b)(2), the allowable mixing zone dilution will be determined by applying the guideline in 327 IAC 2-1-4 to the thirty (30) day, ten (10) year (Q30,10) low flow of the receiving stream for the chronic aquatic criterion (CAC) water column criterion element applicable to lotic aquatic systems, in the absence of site-specific mixing zone data.

¹⁷ The water column criterion element may be modified on a site-specific basis.

¹⁸ Egg or ovary supersedes any whole-body, muscle, or water column element when fish egg or ovary concentrations are measured.

¹⁹ Fish whole-body or muscle tissue supersedes the water column element when both fish tissue and water concentrations are measured.

²⁰ Intermittent Exposure Equation variables mean the following:

WQC_{int} is the water column intermittent element.

WQC_{30-day} is the water column monthly element for either lentic or lotic waters.

C_{bkgrnd} is the average background selenium concentration.

f_{int} is the fraction of any 30-day period during which elevated selenium concentrations occur, with f_{int} assigned a value ≥ 0.033 (corresponding to one (1) day).

²¹ Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish populations at a given site.

Table G-9: Selenium surface water quality criterion used in assessments of Indiana waterbodies which are Great Lakes Tributaries.

Surface Water Quality Aquatic Life Criterion for Selenium Criterion Continuous Concentration (CCC) – 327 IAC 2-1.5-8(b)(3)(B) (Table 8-1a)				
Media Type	Fish Tissue ²²		Water Column ^{23 24}	
Criterion Element	Egg/Ovary ²⁵	Fish Whole-Body or Muscle ²⁶	Monthly Average Exposure	Intermittent Exposure ²⁷
Magnitude	15.1 mg/kg dry weight	8.5 mg/kg dry weight whole-body or 11.3 mg/kg dry weight muscle (skinless, boneless filet)	1.5 µg/l in lentic aquatic systems	$WQC_{int} =$ $\frac{WQC_{30day} - C_{bkgrnd}(1 - f_{int})}{f_{int}}$
			3.1 µg/l in lotic aquatic systems	
Duration	Instantaneous measurement ²⁸	Instantaneous measurement ⁴⁰	Thirty (30) days	Number of days per month with an elevated concentration
Frequency	Not to be exceeded	Not to be exceeded	Not more than once in three (3) years on average	Not more than once in three (3) years on average

²² Fish tissue elements are expressed as steady-state; the aquatic system should not be experiencing new or increasing inputs of selenium.

²³ Water column values are the applicable criterion element in the absence of steady-state condition fish tissue data and for fishless waters. Water column values are based on dissolved total selenium in water and are derived from fish tissue values via bioaccumulation modeling. Instead of the requirements in 327 IAC 5-2-11.1(b)(2), the allowable mixing zone dilution will be determined by applying the guideline in 327 IAC 2-1-4 to the thirty (30) day, ten (10) year (Q30,10) low flow of the receiving stream for the chronic aquatic criterion (CAC) water column criterion element applicable to lotic aquatic systems, in the absence of site-specific mixing zone data.

²⁴ The water column criterion element may be modified on a site-specific basis.

²⁵ Egg or ovary supersedes any whole-body, muscle, or water column element when fish egg or ovary concentrations are measured.

²⁶ Fish whole-body or muscle tissue supersedes the water column element when both fish tissue and water concentrations are measured.

²⁷ Intermittent Exposure Equation variables mean the following:

WQC_{int} is the water column intermittent element.

WQC_{30-day} is the water column monthly element for either lentic or lotic waters.

C_{bkgrnd} is the average background selenium concentration.

F_{int} is the fraction of any 30-day period during which elevated selenium concentrations occur, with f_{int} assigned a value ≥ 0.033 (corresponding to one (1) day).

²⁸ Fish tissue data provide instantaneous point measurements that reflect integrative accumulation of selenium over time and space in fish populations at a given site.

Table G-10: Matrix of assessment scenarios for the National CWA Section 304(a) Recommended Selenium Criterion (adapted from Table 2 of U.S. EPA, 2021b).²⁹

	Water Column Component ³⁰			
	Not Exceeded	Exceeded	Insufficient or Not Available	
Fish Tissue Component ^{31 32 33}	Not Exceeded	(Scenario 1) Criterion Met	(Scenario 2) Criterion Met	(Scenario 3) Criterion Met
	Exceeded	(Scenario 4) Criterion Not Met	(Scenario 5) Criterion Not Met	(Scenario 6) Criterion Not Met
	Insufficient or Not Available	(Scenario 7) Criterion Met	(Scenario 8) Criterion Not Met	(Scenario 9) Not Assessed

	Fish Tissue and Water Column Selenium Scenarios and Impairment Outcomes
Scenarios 1, 2, and 3	Waterbody does not exceed fish tissue criteria. Waterbody does/does not exceed water column criteria or water column data is not available/insufficient. Waterbody is not impaired for selenium.
Scenarios 4, 5, and 6	Waterbody exceeds fish tissue criteria. Waterbody does/does not exceed water column criteria or water column data is not available/insufficient. Waterbody is impaired for selenium.
Scenario 7	Fish tissue data not available/insufficient for waterbody. Waterbody does not exceed water column criteria. Waterbody is not impaired for selenium.
Scenario 8	Fish tissue data not available/insufficient for waterbody. Waterbody exceeds water column criteria. Waterbody is impaired for selenium.
Scenario 9	Fish tissue data not available/insufficient for waterbody. Water column data not available/insufficient for waterbody. Waterbody cannot be assessed for selenium.

²⁹ Decisions assume steady-state conditions.

³⁰ Water column component includes the following two criterion elements: (a) monthly average exposure and (b) intermittent exposure criterion elements. The duration component of both of these elements applies to any 30-day period.

³¹ Fish tissue component includes the following two criterion elements: (a) fish egg/ovary and (b) fish whole-body and/or muscle tissue.

³² There is no primacy between fish whole-body and muscle criterion elements.

³³ The fish egg-ovary criterion element supersedes the fish whole-body and/or muscle criterion element when both types of data are available.

Use Support Criteria for Biological Data

Biological assessments for streams are based on the sampling and evaluation of either the fish communities, or benthic aquatic macroinvertebrate communities, or both. The Index of Biotic Integrity (IBI) score for fish or the macroinvertebrate Index of Biotic Integrity (mIBI) score, or both, were calculated and compared to regionally calibrated models. In evaluating fish communities, streams rating as "fair" or worse are classified as non-supporting for aquatic life uses. For benthic aquatic macroinvertebrate communities, individual sites are compared to a statewide calibration at the lowest practical level of identification for Indiana. All sites at or above background for the calibration are considered to be supporting aquatic life uses. Those sites rated as moderately or severely impaired in the calibration are considered to be not supporting. Waters with identified impairments to one or more biological communities are considered not supporting aquatic life use. The process IDEM uses to make designated use support decisions is shown in Table G-3. The biological thresholds upon which this process is based are shown in Table G-11 to provide greater context for understanding the range of biological conditions that is considered either fully supporting or impaired.

IDE�'s aquatic life use assessments are never based solely on habitat evaluations. However, habitat evaluations are used as supporting information in conjunction with biological data to determine aquatic life use support. Such evaluations, which take into consideration a variety of habitat characteristics as well as stream size, help IDEM to determine the extent to which habitat conditions may be influencing the ability of biological communities to thrive. If habitat is determined to be driving a biological integrity impairment and no other pollutants that might be contributing to the impairment have been identified, the biological integrity impairment is not considered for inclusion on IDEM's 303(d) List of Impaired Waters (Category 5). In such cases, the waterbody is instead placed in Category 4C for the biological impairment.

Revisions to IDEM's Use Support Criteria for Biological Data

IDEM's use support criteria for fish and macroinvertebrate community data have significantly changed since they were first adopted in 1996. Table G-12 summarizes the evolution of IDEM's criteria for making assessments with biological data.

The biological criteria that were developed for both fish and macroinvertebrate communities for the 2004 305(b) and 303(d) assessment and listing cycle were calibrated to reference conditions throughout Indiana and applicable to all waters. However, the resulting criteria were applied only to the basins being assessed at the time. For the 2006 cycle, IDEM began reviewing all aquatic life use support assessments made in basins sampled throughout the state prior to 2002 to ensure their consistency with the statewide criteria developed in 2004. This review was completed for the 2008 cycle.

Although the fish community criteria developed in 2004 remain in effect today, IDEM revised its assessment methods for evaluating macroinvertebrate data for the 2010 cycle.

The statewide mIBI used for the 2004 cycle was based on riffle/run samples collected throughout the state at targeted sites from 1990 through 1994. The Office of Water Quality (OWQ) used the riffle/run method from 1996 through 2003, collecting samples at randomly selected sites which had previously been sampled for the original calibration of the index. Beginning in 1998, the OWQ also collected samples at probabilistic sites chosen for the Watershed Monitoring Program where a suitable riffle/run habitat was present. Unfortunately, fewer than half of the probabilistic sites sampled during this time had riffle/run type habitats within the allowed distance, which reduced the effectiveness of the riffle/run method as a macroinvertebrate community

monitoring tool. This necessitated the development of a macroinvertebrate sampling method which could be used at all sites, regardless of habitat.

The multi-habitat method (mHAB) mIBI differs primarily from the riffle/run method in that it samples all habitats available at a stream site using a D-frame dipnet instead of a kick screen. In 2004, 62 sites (a subset selected from all sites previously sampled with the riffle/run method between 1990 and 2003) were re-sampled with the new mHAB method to develop an index calibrated on a normal distribution of stream quality based on previous mIBI scores instead of the best possible reference conditions. It was later determined that this was too few samples to develop a statewide index; therefore, these 62 samples were combined with probabilistic samples collected in 2005, 2006, and 2007 (a total of 247 samples) to develop the index currently in use.

Twelve metrics were chosen from a pool of more than 100 possible metrics in the development of the new mIBI. These 12 metrics provided the best correlation to the data and describe a diversity of features that characterize the quality of a stream or river. The scores for each individual metric are totaled and can range from 12 to 60. As with the fish community IBI, mIBI scores less than 36 are considered non-supporting of aquatic life use while those greater than or equal to 36 are supporting of aquatic life use.

Table G-11: Biological thresholds upon which IDEM's assessment method for aquatic life designated use support is based.

Biotic Index Score and Associated Assessment Decision	Integrity Class	Corresponding Integrity Class Score	Attributes
Macroinvertebrate community data collected using multihabitat (mHAB) methods (used in assessments from the 2010 cycle to present)			
mIBI greater than or equal to 36 indicates full support	Excellent	53-60	Comparable to "least impacted" conditions, exceptional assemblage of species.
	Good	45-52	Decreased species richness (intolerant species in particular), sensitive species present.
	Fair	36-44	Intolerant and sensitive species absent, skewed trophic structure.
mIBI less than 36 indicates impairment	Poor	23-35	Many expected species absent or rare, tolerant species dominant.
	Very Poor	13-22	Few species and individuals present, tolerant species dominant
	No Organisms	12	No macroinvertebrates captured during sampling.
Fish Community Data			
IBI greater than or equal to 36 indicates full support	Excellent	53-60	Comparable to "least impacted" conditions, exceptional assemblage of species.
	Good	45-52	Decreased species richness (intolerant species in particular), sensitive species present.
	Fair	36-44	Intolerant and sensitive species absent, skewed trophic structure.
IBI less than 36 indicates impairment	Poor	23-35	Top carnivores and many expected species absent or rare, omnivores and tolerant species dominant.
	Very Poor	1-22	Few species and individuals present, tolerant species dominant, diseased fish frequent.
	No Organisms	0	No fish captured during sampling.

Table G-12: Evolution of the criteria used in making aquatic life designated use assessments with biological data.

Cycle	Criteria Development and Changes
1998	<p>IDEM used Karr's 1986 Index of Biotic Integrity (IBI) Classification and Attributes Table to establish criteria to apply to fish community (IBI) data for use support assessments:</p> <ul style="list-style-type: none"> • IBI greater than or equal to 44 = Fully supporting (Excellent/Good) • IBI between 44 and 22 = Partially supporting (Fair/Poor) • IBI less than 22 = Not supporting (Very Poor/No Fish) <p>IDEM's criteria for macroinvertebrate community (mIBI) data collected using kick methods:</p> <ul style="list-style-type: none"> • mIBI greater than or equal to 4 = Fully supporting • mIBI between 4 and 2 = Partially supporting • mIBI less than 2 = Not supporting
2000	<p>IDEM reviewed fish community data from 1990-1995 (a total of 831 samples) to determine new, more accurate limits reflective of Indiana fish communities by subtracting $\frac{1}{2}$ standard deviation from the statewide mean to calculate the following criteria:</p> <ul style="list-style-type: none"> • IBI greater than or equal to 34 = Fully supporting • IBI between 34 and 32 = Partially supporting • IBI less than 32 = Not supporting <p>Criteria for macroinvertebrate community data were unchanged.</p>
2002	<p>Based on IDEM's adoption of the U.S. EPA's integrated reporting format, the category for partially supporting was eliminated for both fish community data and macroinvertebrate community data:</p> <ul style="list-style-type: none"> • IBI greater than or equal to 32 = Fully supporting • IBI less than 32 = Not supporting <p>Criteria for macroinvertebrate community data were unchanged.</p>
2004 to 2008	<p>IDEM completes its first five-year basin monitoring rotation. After reviewing the narrative aquatic life use criteria and definitions of a well-balanced aquatic community in Indiana's water quality standards (327 IAC 2-1 and 327 IAC 2-1.5), IDEM determined that IBI values previously considered partially supporting are reflective of poorer conditions and should be classified as not supporting. The resulting criteria were applied to all basins in Indiana:</p> <ul style="list-style-type: none"> • IBI greater than or equal to 36 = Fully supporting • IBI less than 36 = Not supporting <p>With a more robust set of macroinvertebrate community data, IDEM was also able to calibrate its criteria for this type of data, developing specific criteria applicable to all basins in the state.</p> <p>For samples collected with an artificial substrate sampler:</p> <ul style="list-style-type: none"> • mIBI greater than or equal to 1.8 = Fully supporting • mIBI less than 1.8 = Not supporting <p>For samples collected using kick methods:</p> <ul style="list-style-type: none"> • mIBI greater than or equal to 2.2 = Fully supporting • mIBI less than 2.2 = Not supporting

Cycle	Criteria Development and Changes
2010 to present	<p>Criteria for fish community data remain unchanged.</p> <p>IDEM developed a new mIBI using mHAB sampling methods that accounts for all habitat types available at a given site and that is applicable in all basins in the state. All samples are collected using a D-frame net, and mIBI scores range from 12-60:</p> <ul style="list-style-type: none"> • mIBI greater than or equal to 36 = Fully supporting • mIBI less than 36 = Not supporting

FISH CONSUMPTION SUPPORT ASSESSMENTS

The U.S. EPA "generally believes that fish and shellfish consumption advisories based on reach specific information demonstrate impairment of CWA section 101(s) 'fishable' uses" and continues to require that IDEM make water quality assessments for fish consumption and place waters with fish consumption advisories on its 303(d) list of impaired waters (U.S. EPA, 2000a). However, Indiana's WQS do not contain numeric criteria for the concentration of mercury or polychlorinated biphenyls (PCBs) in fish tissue. IDEM's past and present fish consumption use assessments are a translation of the narrative portion of Indiana's WQS, which states that surface waters "...shall be free from substances in concentrations that on the basis of available scientific data are believed to be sufficient to injure, be chronically toxic to, or be carcinogenic, mutagenic, or teratogenic to humans, animals, aquatic life, or plants." (327 IAC 2-1-6 (a)(2) and 327 IAC 2-1.5-8(b)(2)).

Mercury

In 2001, the U.S. EPA issued a revised human health-based water quality criterion for methylmercury (U.S. EPA, 2001). This criterion was unique among all U.S. EPA (Clean Water Act 304(a)) water quality criteria in that it identifies an acceptable mercury concentration in fish tissue rather than water. A fish tissue criterion is logical because fish are the main source of methylmercury exposure to both humans and wildlife. Also, a tissue-based criterion eliminates the need for a bioaccumulation factor in the criterion calculation, which can be a significant source of uncertainty. The derivation of the methylmercury water quality criterion is based on the reference dose of 0.1 µg/kg body weight/day, exposure data (for example, the amount of methylmercury ingested, inhaled, or absorbed per day), and data about the target population to be protected. The U.S. EPA criterion (U.S. EPA, 2001) is 0.3 mg/kg wet weight methylmercury in fish muscle tissue. Since nearly 100 percent of the mercury in fish muscle is methylmercury, the criterion can reasonably be considered a total mercury criterion.

Polychlorinated Biphenyls (PCBs)

The U.S. EPA has not issued a human health-based criterion for PCBs in fish tissue, and Indiana's WQS do not contain a numeric concentration criterion for PCBs in the edible portion of fish tissue. However, Indiana has adopted human health WQS to protect the public from adverse impacts due to:

- (1) exposure through public drinking water supplies withdrawn from surface waters; and
- (2) nondrinking water exposures, such as consumption of fish caught in Indiana lakes, rivers, and streams.

Although human consumption of sport fish is not explicitly described in Indiana's WQS, fish consumption values are included as part of the calculation of the human health criteria intended to ensure that the levels of a carcinogenic chemical in fish are not at levels harmful to people who consume them.

Without a U.S. EPA criterion derived specifically for fish tissue concentration of PCBs, using the U.S. EPA's methodology for deriving ambient water quality criteria for the protection of human health (U.S. EPA, 2000b) to calculate a concentration value for PCBs is a reasonable alternative that results in a criterion that is more readily applicable to Sections 305(b) and 303(d) water quality assessments than using Fish Consumption Guidelines (FCG) grouping levels. IDEM's benchmark criteria for mercury and PCBs in fish tissue are shown in Table G-13.

Table G-13: Water quality assessment methodology for determining fish consumption designated use support.

Fish Consumption Use Support (Human Health) – All Waters		
	Fully Supporting	Not Supporting
Mercury in Fish Tissue	Trophic level weighted arithmetic mean concentration values for all sampling events are less than or equal to 0.3 mg/kg wet weight	Trophic level weighted arithmetic mean concentration values for one or more sampling events are greater than 0.3 mg/kg wet weight
PCBs in Fish Tissue	Fully Supporting Actual concentration values for all samples are less than or equal to 0.02 mg/kg wet weight	Not Supporting Actual concentration values for one or more samples are greater than 0.02 mg/kg wet weight

Assessment method using the WQS-based criteria

IDE�'s assessment methodology for evaluating fish tissue data is summarized in Table G-13, and reflects a conservative approach intended to both identify waters in which the data indicate impairment for mercury or PCBs, or both, and to provide for the protection of human health.

For PCBs, all samples from a given sampling reach must have results below the benchmark for PCBs in order to be assessed as fully supporting, and all waters with a sample result exceeding the benchmark are classified as impaired. This is a highly conservative approach that considers only the highest sample PCB concentration, which may be one of a number of samples collected at the site.

For mercury, IDE� calculates a single, trophic level, consumption rate-weighted, arithmetic mean result for the site based on all the samples collected during a given sampling event. This result is then compared to the criteria to determine use support. All waters with a trophic level, consumption rate-weighted, arithmetic mean result exceeding the benchmark are classified as impaired. The calculation IDE� uses apportions the national default consumption rate of 17.5 g/day across three trophic levels based on the amount and type of fish (by trophic level) that people might be consuming and, as such, more accurately characterizes human exposure and, therefore, fishable use support.

Sport fish are of particular importance to the question of consumption because they comprise most fish taken by anglers. Most sport fish are predator species but also include

omnivores such as carp. Therefore, to properly determine the degree to which a waterbody supports fish consumption, an appropriate methodology takes into consideration both the types of fish being caught and how differences in species affect the concentrations of the contaminant in question. The differences in IDEM's assessment methods for PCBs and mercury are a function of how these contaminants accumulate in the tissues of fish when the fish ingest them. PCB concentrations in fish are primarily a function of their fat content while mercury concentrations are more a function of their trophic level. Because PCBs accumulate in the fatty tissues of fish, concentrations tend to be higher in more fatty species such as carp and catfish as opposed to species such as bass and sunfish, which are leaner by comparison. In contrast, mercury tends to be higher in predator species because it bio-accumulates up the food chain as larger fish consume smaller fish containing mercury.

The method of calculating a trophic level-weighted, arithmetic mean for mercury is not appropriate for PCBs because trophic levels are less predictive than individual species of PCB concentrations in fish caught at a given site. As a result, trophic levels are less representative of the amount of PCBs a person might consume.

Based on the way that PCBs bioaccumulate in fish tissue (by accumulating in their fatty tissue), IDEM continues to use the results of individual samples for the purposes of assessment, and the type of fish species continues to be a factor in assessment. Based on U.S. EPA's guidance (U.S. EPA, 2010), the fish species is no longer as relevant for evaluating total mercury concentration (most of which is methylmercury) in fish tissue, which is more a function of trophic level for determining fish consumption use support. For evaluating mercury in fish tissue, IDEM uses a trophic level, geometric mean to calculate a consumption-weighted, arithmetic mean for the site, which considers consumption levels across all trophic levels and includes all species types. IDEM's process for determining fish consumption use support is described in more detail in the following steps.

Step 1. Determine adequate data for assessment.

The adequacy of a data set for the purposes of making a 305(b) assessment is determined by the analytical quality of the data set as well as the amount and age of the data. All these factors can affect the degree to which the data accurately represent waterbody conditions.

One sampling event is considered sufficient for assessment purposes. At a given sampling event, composite samples are made for each species within a given size class collected at the site, which provides one or more species-specific results for assessment. For PCBs, results for each individual sample are compared to the 0.02 mg/kg criterion to make the assessment. For mercury, a consumption-weighted, arithmetic mean is calculated for each sampling event using the results from all the samples collected. The arithmetic mean result for each sampling event is treated as an individual result and compared to the 0.3 mg/kg criterion. Multiple sampling events within a single year or multiple years for a site are not pooled together for either mercury or PCB assessments.

U.S. EPA guidance suggests that, while all readily available data should be reviewed, 305(b) assessment decisions should be based on data five or fewer years old. However, IDEM has established 12 years as the appropriate index period for the purposes of evaluating fish tissue data. Given the persistent nature of fish tissue contaminants in the environment, aggregating data over several years minimizes the effects of temporal, spatial, and species-level variability on the assessment process. Based on IDEM's sampling strategy, an index period of 12 years ensures two full cycles of fish tissue data for use in evaluating fish consumption use support.

Each contaminant is assessed independently. Therefore, the use is considered impaired, and the waterbody is listed if either mercury or PCBs in fish tissue fails to meet the corresponding benchmark for full support. Independent applicability is also applied to all results obtained within the index period for assessment. The index period is the period of time over which the data may reasonably be considered representative of conditions in a given waterbody. A single, older result collected within the index period may well be representative of the variability within the waterbody and is considered equally valid as any other sample collected in the same index period.

Therefore, where there are conflicting results from samples collected within the index period, the waterbody is assessed as impaired regardless of when in the index period the exceeding results were collected and even if the more recent results indicate full support.

Step 2: Apply WQS-based concentration thresholds to determine use support.

The WQS-based assessment thresholds shown in Table G-12 were applied to all lakes and streams for which sufficient fish tissue data were available. IDEM's methods for applying these criteria are summarized in Table G-3. All waters found to be not supporting due to either mercury or PCBs, or both, are categorized as impaired and placed in Category 5B of Indiana 303(d) List of Impaired Waters.

Step 3: Determine the appropriate geographical extent to which the assessment applies.

In some cases, fish can be very mobile and difficult to attribute to a discrete portion of a lake or river reach. In determining the appropriate geographical extent to which results can be confidently applied, IDEM follows the general rules described below. Unless otherwise stated, the same general rules are applied to assessments of both PCBs and mercury in fish tissue.

Stream Order Considerations

For flowing waters, stream order is the primary factor considered in determining the appropriate distance over which the results should be applied. Stream order is a good indicator of relative stream size, and, to the extent that size affects flow, the size of a given stream has a significant effect on species and sizes of fish that might be caught there.

Generally, in cases where significant differences in stream order exist in a watershed, results are applied only to the stream on which they were obtained. This is because the fish community found in a third or fourth order stream might reasonably be expected to be very different from the fish communities found in its first and second order tributaries. Likewise, the expectations for the type and sizes of fish found in a fifth order stream would be different from those for a third or fourth order stream. Given this, results obtained from fifth order and greater streams are limited only to the mainstem and are not considered representative of their tributaries. Because of the significant effects that stream order has on the structure of the fish community in each stream, basing extrapolations primarily on stream order allows us to apply fish tissue results more reliably on a stream-specific basis.

Most of Indiana's larger streams and rivers (third, fourth, and fifth order streams) have been monitored for many years, resulting in very robust data sets. On these streams, results are applied to greater lengths where upstream and downstream samples were available.

Results for many of Indiana's smaller streams (first and second order streams) are generally more limited. On these waters, results are applied only to the 12-digit watershed boundary except in cases where additional results from sites in an upstream or downstream watershed support assessment over a greater distance. In these cases, assessments are limited

to mainstem reaches between the sites and are not applied to their tributaries. Results from a mainstem site are also applied to its headwaters if obtained in the same watershed or the watershed immediately downstream.

The Consideration of Background Conditions in Assessments

For PCBs, relative concentrations are used as an indicator of background conditions. Values greater than 1,000 ppb for PCBs are considered suggestive of point sources, most of which are known legacy sources of this contaminant. Values lower than this can be reasonably attributed to atmospheric and biological redistribution of contaminants or low-level nonpoint sources and are considered representative of background conditions. Therefore, for PCBs, monitoring results in a smaller watershed are also extrapolated into other streams of similar stream order in that watershed when values are consistently low such as to suggest background conditions. In cases where the sampling site is located in a particularly large or hydrologically complex watershed or far upstream from most or all streams in the watershed, extrapolations are more limited. Extrapolations around sites with very high PCB concentrations suggesting point sources are also limited.

Atmospheric deposition from local and regional sources is the primary cause of mercury in waterbodies. While mercury is a naturally occurring element in the environment, scientific evidence suggests that human activities may be increasing the levels of mercury released into the atmosphere (Risch and Fredericksen, 2015).

Unlike PCBs, there is no concentration value for mercury that is considered particularly suggestive of point sources. High mercury values in fish tissue are more indicative of localized methylation processes affecting the amount of mercury available for uptake than any sources of contamination. Background conditions for mercury in fish tissue are very difficult to determine because they are highly dependent on the structure of the fish community, which differs significantly depending on the size of the stream in question. While it may be possible to predict background conditions for a given stream order to guide extrapolations of results for mercury in fish tissue, stream order itself remains a more reliable indicator of the extent to which those results may be representative for the purpose of determining use support.

Additional Factors Considered When Evaluating Results from Lake Samples

All fish tissue data are aggregated for a given lake or reservoir unless there is evidence that fish caught from certain parts of the lake were isolated and may have been exposed to a different level of contamination.

Fish community structure within a lake can clearly influence the fish community structure for some distance in streams flowing from lakes. Given this, results from lakes and reservoirs are applied downstream into adjacent watersheds in cases where there are downstream data to support the assessment. In cases where there are no data available for out-flowing streams, results for lake samples are applied only to the lake from which they are collected.

Derivation of Criteria Values for Concentrations of Mercury and PCBs in Fish Tissue

U.S. EPA stipulates that the risk assessment parameters used to categorize fish tissue contaminant data must be at least as protective as those used in the WQS-based fish concentrations. The equation for calculating a fish tissue criterion for PCBs utilizes the guidance provided by U.S. EPA for calculating screening values for target analytes (U.S. EPA, 2000d). U.S. EPA's Office of Water recommends the use of this calculation method because it is the

basis for developing current water quality criteria for the protection of human health. The general equation used for calculating Screening Values (SVs) for carcinogens in fish tissue is derived from this guidance and is as follows:

$$SV_c = [(RL/CSF)*BW]/CR \quad \text{Equation 1}$$

where:

SV_c = Screening value for a carcinogen (mg/kg; ppm)

RL = Maximum acceptable risk level (dimensionless)

CSF = Oral cancer slope factor (mg/kg-d)-1

BW = Mean body weight of the general population (kg)

CR = Mean daily consumption rate of species of interest (kg/d)

Note: The asterisk in the equation represents a multiplication sign.

In determining a screening value or fish tissue criterion for PCBs, the same assumptions and parameters used for calculating human health water quality criteria were applied. These parameters include a BW of 70 kg, CSF (of 2.0 (mg/kg-d)-1, RL of 10-5, and CR of 17.5 (g/d).

The general equation for calculating a fish tissue screening value for PCBs is:

$$\text{Fish Tissue Screening Value (mg/kg)} = \frac{\left[\frac{\text{Cancer Risk Level}}{q1 * ((mg / kg / d)^{-1})} \right] \times \text{Body Weight (kg)}}{\text{Fish Consumption (kg / d)}} \quad \text{Equation 2}$$

Therefore,

Cancer risk level (the RL value from equation 1) = 10-5

q1 (the CSF from equation 1) = of 2.0 (mg/kg-d)-1

BW (same in both equations) = 70 kg

Fish Consumption (CR in equation 1) = 17.5 (g/d) or 0.0175 (kg/d)

Note: The asterisk in the equation represents a multiplication sign.

$$\text{PCB Fish Tissue Screening Value (mg/kg)} = \frac{\left[\frac{1E - 05}{2.0 (mg / kg / d)^{-1}} \right] \times 70 (kg)}{0.0175 (kg / d)} = 0.02 (mg / kg) \quad \text{Equation 3}$$

A tissue-based criterion eliminates the need for a bioaccumulation factor in the criterion calculation while exposure to PCBs in drinking water is negligible due to their low solubility in water.

Relationship of IDEM's WQS-Based Criteria to the FCG

Fish consumption guidelines (FCGs) are determined based on the quantity of a chemical in fish, such as milligrams of chemical per kilogram of the edible portion of fish tissue (mg/kg). WQS, on the other hand, are expressed as the quantity of the chemical in water, such as micrograms of a chemical per liter of water (µg/L). The exposure assumptions upon which the human health criteria are based can be used to calculate a maximum safe fish concentration. That fish concentration value can then be directly compared to the values used to issue fish consumption advisories to determine whether the advisory is less or more protective than the WQS.

The levels of fish tissue contaminants that trigger a FCG and the levels of fish tissue contaminants on which the WQS criteria are based are derived using the same contaminant result, reference dose, and assumptions about the body weight of those consuming the fish. Although EPA derived its recommended screening value for a fish guidance limit for mercury and human health methylmercury criterion from virtually identical methodologies, it is important to clarify the distinctions between the two values. They are consistently derived, but, because the two values differ in purpose and scope, they diverge at the risk management level. Fish guidelines are intended to inform the public about how much consumers should limit their intake of individual fish species from certain waterbodies. In contrast, the human health criterion is used as the basis for regulatory and non-regulatory decisions. The criterion serves as guidance for use in establishing WQS, which, in turn, serve as a benchmark for attainment, compliance, and enforcement purposes.

FCGs are intended to provide for the protection of human health over a lifetime of exposure, maximizing the benefits of eating fish while minimizing the risk. The calculations used to determine if a FCG should be issued are based on the contaminant concentration found in fish, which is treated as a constant while consumption rates are allowed to vary (how much fish a person can safely consume without exceeding a particular dose rate). Allowing for different consumption rates makes it possible to safely consume fish that have different levels of contamination. The recommended consumption rate is reduced as fish tissue contaminant concentrations increase. In contrast, WQS criteria calculations start with an assumed level of fish consumption and derive a criterion for a safe level of exposure to the contaminant in the fish for those who consume them. Because the consumption rate is held constant, the resulting criterion can be applied consistently to all waters. FCGs are expressed for a given waterbody in terms of certain species within certain size ranges. Very few FCGs apply to all fish in a given waterbody, which limits their utility for water quality assessment purposes.

IDE�'s assessment methodology for evaluating fish tissue data is directly applicable to all waters and uses the revised human health-based water quality criterion for methylmercury (U.S. EPA, 2001) and a criterion for PCBs derived from U.S. EPA's (2000b) human health methodology.

While mindful of the differences in purpose and function of the FCG and the 303(d) list, IDE�'s methodology maintains as much consistency as possible between the protocols that ISDH, IDE�, and the Indiana Department of Natural Resources use to assess data for the FCG and the protocols that IDE� uses to assess data for the determination of impairment. For PCBs, the WQS-based threshold is lower than the FCG threshold for a Group 2 guidance. Therefore, there is a concentration range where there could be a WQS exceedance but still unlimited consumption. However, the threshold for mercury is higher than that which would trigger a Group 2 guidance (Table G-14). For mercury, given the existing exposure assumptions upon which the water quality criteria are based, issuance of a FCG does not necessarily indicate an exceedance of WQS.

The fish consumption rates expressed in Indiana's WQS for human health are 15.0 g/day for waters in the Great Lakes basin (327 IAC 2-1.5-14) and 6.5 g/day for downstate waters (327 IAC 2-1-8.6). For mercury, IDE� defaulted to the U.S. EPA water quality criterion 0.3 mg/kg methylmercury wet weight determined at a consumption rate of 17.5 g/day for mercury in fish tissue and a reference dose of 0.1 µg/kg body weight/day (U.S. EPA, 2001).

For calculating the criterion for PCBs in fish tissue, IDE� used the same consumption rate the U.S. EPA used to calculate its criterion for mercury in fish tissue for the general population, which is 17.5 g/day national consumption rate. The use of a higher consumption rate in the PCBs

calculation is consistent with that used by the U.S. EPA and results in a more protective criterion than applying the consumption rate expressed for either the Great Lakes basin or downstate waters. IDEM's decision to use the U.S. EPA's criterion value for mercury in fish tissue was a policy decision since the U.S. EPA's criterion is more protective.

Table G-14: Fish tissue concentrations for levels of consumption advice protective of sensitive populations established by ISDH for mercury and total PCBs and its correspondence to an impairment condition as determined by the WQS criteria. Sensitive populations include pregnant or nursing women, women that will become pregnant, and children under 6 years of age. Shaded cells indicate consumption advice that corresponds to nonsupport and an impaired condition using the WQS-based criteria.

Mercury	Fish Tissue Concentration (mg/kg)				
	Less than 0.05	0.05 – 0.2	0.2 – 1.0	1.0 – 1.9	Greater than 1.9
FCG Groups	Group 1	Group 2	Group 3	Group 4	Group 5
Consumption Advice (FCG)	unlimited	1 meal per week	1 meal per month	1 meal every 2 months	No consumption
PCBs	Fish Tissue Concentration (mg/kg)				
	Less than 0.05	0.05 – 0.2	0.2 – 1.0	1.0 – 1.9	Greater than 1.9
FCG Groups	Group 1	Group 2	Group 3	Group 4	Group 5
Consumption Advice (FCG)	unlimited	1 meal per week	1 meal per month	1 meal every 2 months	No consumption

RECREATIONAL USE ASSESSMENTS

For streams, IDEM applies the decision-making process shown in Table G-15 where data minimums for recreational use assessments in Table G-2 are met. For lakes, IDEM conducts two types of assessments to determine the extent to which Indiana lakes and reservoirs support recreational uses. Where there are available bacteria data, IDEM assesses recreational use support within the context of human health in the same manner as it does with streams (Table G-15). IDEM also evaluates the degree to which Indiana's lakes and reservoirs support recreational use within the context of aesthetics. The types of data used in these assessments and the required data minimums are shown in Table G-2.

Recreational Use Assessments in the Context of Human Health

During Recreational designated use assessments, best professional judgement (BPJ) is often used to list a site as "Not Supporting" or "Impaired" if at least one of the five *E. coli* samples used to calculate the geometric mean is recorded as "> 2419.6 MPN/100 ml", even if the overall geometric mean does not exceed 125 MPN/100 ml. In Standard Method 9223B (Enzyme Substrate Coliform Test: 9223B Enzyme Substrate Test), IDEXX Colilert kits have an applicable concentration range of 1 to 2419 MPN/100 ml. A result of "> 2419.6 MPN/100 ml" indicates that the reading was "out of range" and the actual *E. coli* concentration of that sample may have been much higher than 2419 MPN/100 ml, in which case, the true geometric mean may be well above 125 MPN/100 ml. In these instances, listing the site as "Not Supporting" for the Recreational designated use ensures that human health is being protected.

The IDEM BeachAlert program conducts *E. coli* testing at beaches located on the Lake Michigan shoreline and other bathing beaches in north-eastern and north-central Indiana at a daily to weekly frequency during the "summer beach season" that extends from Memorial Day to Labor Day. Assessing the status of the Recreational designated use requires modification of the geomean calculation methods due to the volume of data collected at these locations, which can approach 500+ samples per beach during the five-year assessment period. Assessment requires a minimum of five samples to be collected at equally spaced intervals within a calendar month, instead of a 30-day period; any additional samples interspersed within these five samples are included in the monthly geomean calculation. This method can result in geomean calculations for the months of June, July, and August (up to 15 geomeans during the five-year assessment period); any monthly geomean exceeding the 125 MPN/100 ml criteria results in Recreational use impairment for the AU in which the beach is located. Exceedances of the single sample maximum value of 235 MPN/100 ml are used to issue temporary advisory and closure notifications for individual beaches in accordance with the standards described in the U.S. EPA Beaches Environmental Assessment and Coastal Health Act (BEACH Act) (U.S. EPA 2000).

Table G-15: Methods used to assess Indiana waters for recreational designated use support within the context of human health.

Recreational Use Support (Human Health) – All Waters		
	Fully Supporting	Not Supporting
WQS for Bacteria (E. coli)	Geometric mean does not exceed 125 cfu (colony forming units)/100mL when data consists of at least five equally spaced samples collected over 30 days.	Geometric mean exceeds 125 cfu/100mL when data consists of at least five equally spaced samples collected over 30 days.
WQS for Bacteria (E. coli)	Up to 10% of samples may exceed 235 cfu/100ml, if the data set consists of at least 10 samples, and the exceedances are incidental, and attributed solely to the discharge of treated wastewater from a wastewater treatment plant.	More than 10% of samples exceed 235 cfu/100ml.

Recreational Use Assessments in the Context of Aesthetics

On a national scale, the number one impairment of lakes and reservoirs has long been identified as nutrients. Prior to 2008, IDEM's lakes assessments were largely limited to CWA Section 314 assessments of lake trends and trophic state, due in part to the absence of numeric water quality criteria for nutrients in the state's WQS. Indiana's WQS do contain narrative criteria applicable to all waters of the state. However, developing an assessment methodology that translates narrative criteria in a scientifically defensible way remains a challenge for states.

In 2008, IDEM developed an assessment method for determining the degree to which nutrient enrichment may be impacting the aesthetic value of Indiana lakes and their use for recreational activities, which is based on benchmark values for total phosphorus (TP) and chlorophyll a (CHL) developed by Limno-Tech, Inc. (LTI, 2007) (Table G-16).

Table G-16: Recommended phosphorus thresholds and their corresponding expected ranges of chlorophyll-a concentrations.

Lake Type	TP (µg/L)	Associated Range in CHL (µg/L)
Natural Lakes	54	4 to 20
Reservoirs	51	2 to 25

Source: Modified from Limno-Tech, Inc. (LTI) 2007.

The associated range of CHL represents the range of concentrations expected when TP concentrations are at or below 54 µg/L for natural lakes or 51 µg/L for reservoirs, respectively. In some cases, the CHL results are not consistent with the expectations shown in Table G-16 based on the TP levels measured for a given lake (for example, low CHL values associated with high TP values or vice versa). For these situations, IDEM's methodology uses the trophic state index (TSI) score as a surrogate response variable (in addition to CHL) to determine impairment status.

While the TSI does not provide a direct response variable for TP, it can be a useful indicator in cases where CHL results are mixed. In addition to providing a surrogate measure for CHL, the TSI score also provides a good measure of the overall trophic condition of a given lake. Recognizing the connection between trophic status and nutrient enrichment, the U.S. EPA generally considers hypereutrophic conditions as measured by the TSI indicative of impairment (U.S. EPA, 2000c).

IDEM does not believe that the TSI score alone is sufficient information for making designated use assessments because it can be affected by a number of variables in addition to nutrient loading, such as levels of non-algal turbidity or factors that may be limiting algal growth. However, in cases where the CHL and TP results are mixed, IDEM uses the most recent TSI score to determine impairment. If the TSI score indicates eutrophic or hypereutrophic conditions, the lake is assessed as impaired. TSI scores are not used in the absence of CHL results and are only reviewed in cases where there are sufficient TP and CHL data, but those data showed conflicting results.

These threshold values are applied as benchmarks for the purposes of determining recreational use support of Indiana's natural lakes and reservoirs within the context of aesthetics in the following manner:

Step 1. Determine the available data to be used for assessment.

Indiana's Clean Lake Program (CLP) samples between 70 and 80 lakes each year selected from a randomized list of all public lakes and reservoirs in the state that have a usable boat ramp and are larger than five acres. Lakes are monitored from July through August, which is the time of year when worst-case scenarios and stable conditions (warm temperatures, thermal stratification, hypolimnetic anoxia, and algal blooms) are expected.

All available data for a given lake were used for assessment purposes. U.S. EPA guidance suggests that, while all readily available data should be reviewed, 305(b) assessment decisions should be based on data that is five or fewer years old. The use of historical data is necessary because the sampling conducted by IDEM's CLP program is designed specifically to support CWA Section 314 assessments of trophic state and lake trends but not to make designated use assessments. As a result, while Indiana's CLP sampling strategy ensures sufficient samples for determining trophic state and trends, it does not guarantee sufficient data for making designated use assessments (see Table G-2 for minimum data requirements). To date, most CWA 305(b) assessments rely on the following CLP data sets:

- One-time samples collected from public access lakes by students at Indiana University's School of Public and Environmental Affairs and analyzed in the CLP's laboratory.
- Monthly TP and CHL samples collected from public and private lakes by trained volunteers and sent to the CLP's laboratory for analysis.

Step 2. Determine adequate data for assessment.

For purposes of determining recreational use support within the context of aesthetics, the following general rules were applied:

- Only TP and CHL data, including volunteer-collected data, analyzed in the CLP's laboratory in accordance with the CLP Quality Assurance Project Plan (Indiana CLP, 2019) were used for assessment purposes.
- A minimum of three years' worth of data was considered sufficient for assessment purposes as long as each TP value had a corresponding CHL value.
- Multiple results within a given year for TP and CHL were averaged to provide a single value for each parameter for that year.
- For consistency in assessments, all samples used in attainment decisions must have been collected during the summer season.

Step 3: Apply benchmark criteria to determine use support.

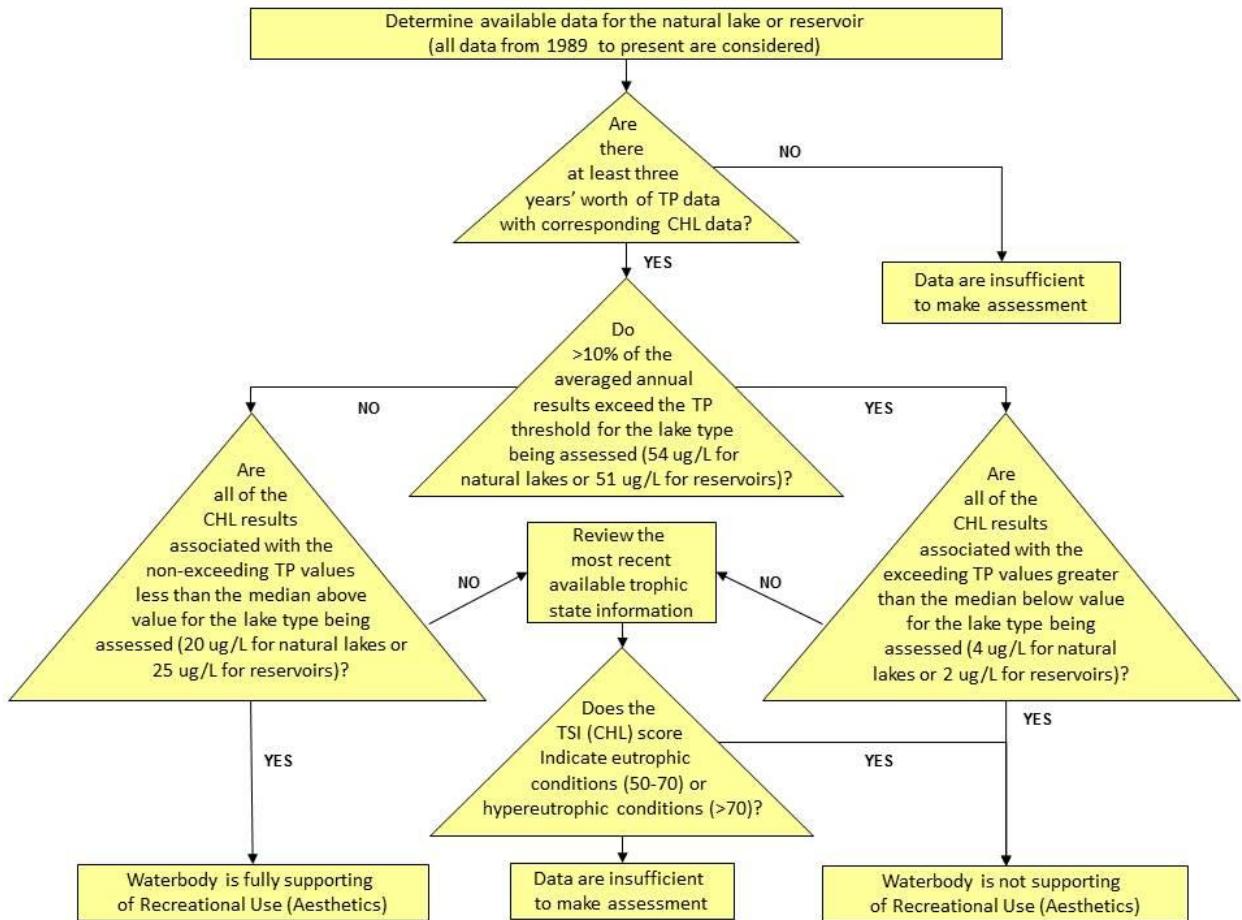
The TP and CHL thresholds shown in Table G-16 were applied to all natural lakes and reservoirs for which sufficient data were available. IDEM's methods for applying these criteria are summarized in Table G-17 and are illustrated in Figure G-2. All waters found to be not supporting of recreational use (aesthetics) were categorized as impaired and placed in Category 5A of Indiana's 303(d) List of Impaired Waters.

Given the robust, Indiana-specific dataset upon which the thresholds recommended in the Limno-Tech, Inc. (LTI) study were developed (LTI, 2017), IDEM believes them to be appropriate for making designated use assessments.

Table G-20: Methods used to assess Indiana lakes and reservoirs for recreational designated use support within the context of aesthetics.

Recreational Use Support (Aesthetics) – Lakes and Reservoirs		
	Fully Supporting	Not Supporting
Natural Lakes	<p>Not more than 10% of all TP values greater than 54 µg/L and their associated (CHL) values are less than or equal to 20 µg/L</p>	<p>Less than 10% of all TP values are greater than 54 µg/L but their associated CHL values are greater than 20 µg/L, and the CHL trophic state index (TSI) score for the lake indicates eutrophic (50-70) or hypereutrophic (greater than 70) conditions.</p> <p>or</p> <p>More than 10% of TP values are greater than 54 µg/L with associated CHL values less than 4 µg/L, but the TSI (CHL) score for the lake indicates eutrophic (50-70) or hypereutrophic (greater than 70) conditions.</p> <p>or</p> <p>More than 10% of all TP values are greater than 54 µg/L with associated CHL values greater than 4 µg/L.</p>
Reservoirs	<p>Not more than 10% of all TP values greater than 51 µg/L and their associated CHL values are less than 25 µg/L</p>	<p>Less than 10% of all TP values are greater than 51 µg/L but their associated CHL values are greater than 25 µg/L and the TSI (CHL) score for the lake indicates eutrophic (50-70) or hypereutrophic (greater than 70) conditions.</p> <p>or</p> <p>More than 10% of all TP values are greater than 51 µg/L with associated CHL values less than 2 µg/L, but the TSI (CHL) score for the lake indicates eutrophic (50-70) or hypereutrophic (greater than 70) conditions.</p> <p>or</p> <p>More than 10% of all TP values are greater than 51 µg/L with associated CHL values greater than 2 µg/L.</p>

Figure G-2: IDEM's assessment process for determining recreational use support for lakes within the context of aesthetics (TP = Total Phosphorus; CHL = Chlorophyll a; TSI = Trophic State Index).



PUBLIC WATER SUPPLY USE ASSESSMENTS

From 2002 to 2016, IDEM's methods for determining support of the public water supply (PWS) use changed very little. In 2015, IDEM convened an internal work group to develop a more comprehensive methodology for assessing waters designated as source waters for public water supplies. The result of this effort was a significant revision to IDEM's previous methods, which were first published for public review and comment on April 6, 2016 (IDEM, 2016) and became effective with the 2018 Integrated Reporting cycle.

IDEM's revised methods for PWS use assessments build on the water quality criteria in Indiana's WQS and other benchmarks intended to protect the quality of source water prior to its withdrawal and treatment by drinking water facilities. These methods describe:

- The type of waterbodies to be assessed and the geographical extent to which the assessment will apply.
- The indicator(s) to be used in the assessment decision and the period of record during which water quality monitoring results and other information are considered representative for assessment purposes³⁴.
- Minimum water quality data and other information required for assessment including the minimum number of monitoring results necessary for the decision and any sampling frequency or seasonality requirements, or both.
- The applicable water quality criteria or other benchmarks, or both and the number of exceedances allowed.

Waterbodies Designated for Public Water Supply Use

Unlike most other designated uses, which apply to all waters of the state, the public water supply use is very narrowly defined in Indiana's WQS. The water quality criteria specific to PWS were established to protect the surface water quality at the intake, which is the point at which the water is withdrawn for treatment. Drinking water provided by PWS facilities is regulated by the Safe Drinking Water Act (SDWA) with the use of maximum contaminant levels (MCLs), which apply to water after it has been withdrawn and treated for human consumption. A comparison of the water quality criteria and benchmarks IDEM uses for its CWA assessments and SDWA MCLs can be found in Table G-21.

IDEM's previous and current methodology designates any waterbody with an active³⁵ surface water intake as a source water for the purposes of making CWA 305(b) assessments and 303(d) listing decisions. However, the revision to the methodology expands the definition of a source water to include surface waters with intakes for emergency water supplies and those waters that have been determined to have a direct influence on a public water supply well. Although intakes for emergency water supplies are not regularly used for source water, they may

³⁴ IDEM considers any existing and readily available data received for the purposes of determining use support. Most assessments are based on data collected during the period of record, which is the period of time in which the data are considered reliable for the purposes of assessment. The period of record varies based on the type of assessment and data being evaluated but always includes the most recent data available. Older data collected prior to the period of record is considered supplementary and can often provide additional insights into current water quality conditions.

³⁵ "Active" intakes are those that are currently in use. "Inactive" intakes are those that were previously in service but taken offline by the treatment facility and which are unlikely to ever be re-activated.

be placed into service if needed and, thus, should carry the same designation as other source waters.

IDEM has also identified five public ground water supply systems that are under the direct influence of surface waters. While the surface waters influencing these systems are not themselves used as source waters, IDEM has designated them as such based on their potential to transport contaminants into the groundwater supplying these systems. When IDEM identifies additional surface waters with the potential to directly influence a public water supply well, they will be designated for the public water supply use and assessed in the manner described in this methodology.

Inland Lakes and Streams

For inland lakes and streams, IDEM's methods for defining assessment units for PWS are based on the approach described in Indiana's Source Water Assessment Plan (SWAP) (IDEM, 2000) for developing source water assessments (SWAs) required under the federal SWDA for public water supplies that rely on surface water as part or all of their supply. This approach includes an evaluation of susceptibility, which is the potential for a PWS intake to draw in surface water with contaminant concentrations that would cause concern for water utility operators or the consumer (IDEM, 2000).

According to the SWAP, susceptibility may be represented as a series of "zones" for the purposes of developing contingency plans and to prepare for emergency response. The zones in close proximity to the intake are those in which contamination has the potential to create a water supply emergency or have otherwise adverse effects within a matter of hours or days. IDEM uses these zones for assessments as they are in keeping with the water quality criteria in Indiana's WQS, which were "established to protect the surface water quality at the point at which water is withdrawn for treatment for public supply." During the 2024 Integrated Report cycle, all stream assessment units which were previously assigned a "Public Water Supply" designated use were re-evaluated. The PWS designated use was removed from all assessment units where an active or emergency drinking water intake was not located.

Inland lakes and reservoirs are treated as individual assessment units for the purposes of PWS assessments, regardless of where in the waterbody an intake is located. This is consistent with Indiana's SWAP in which susceptibility zones are defined around the entire perimeter of the lake. This approach assumes that contaminants introduced anywhere in the lake have the potential to impact the quality of the water withdrawn at the intake and, therefore, provides a representative unit of assessment for the purposes of determining designated use support.

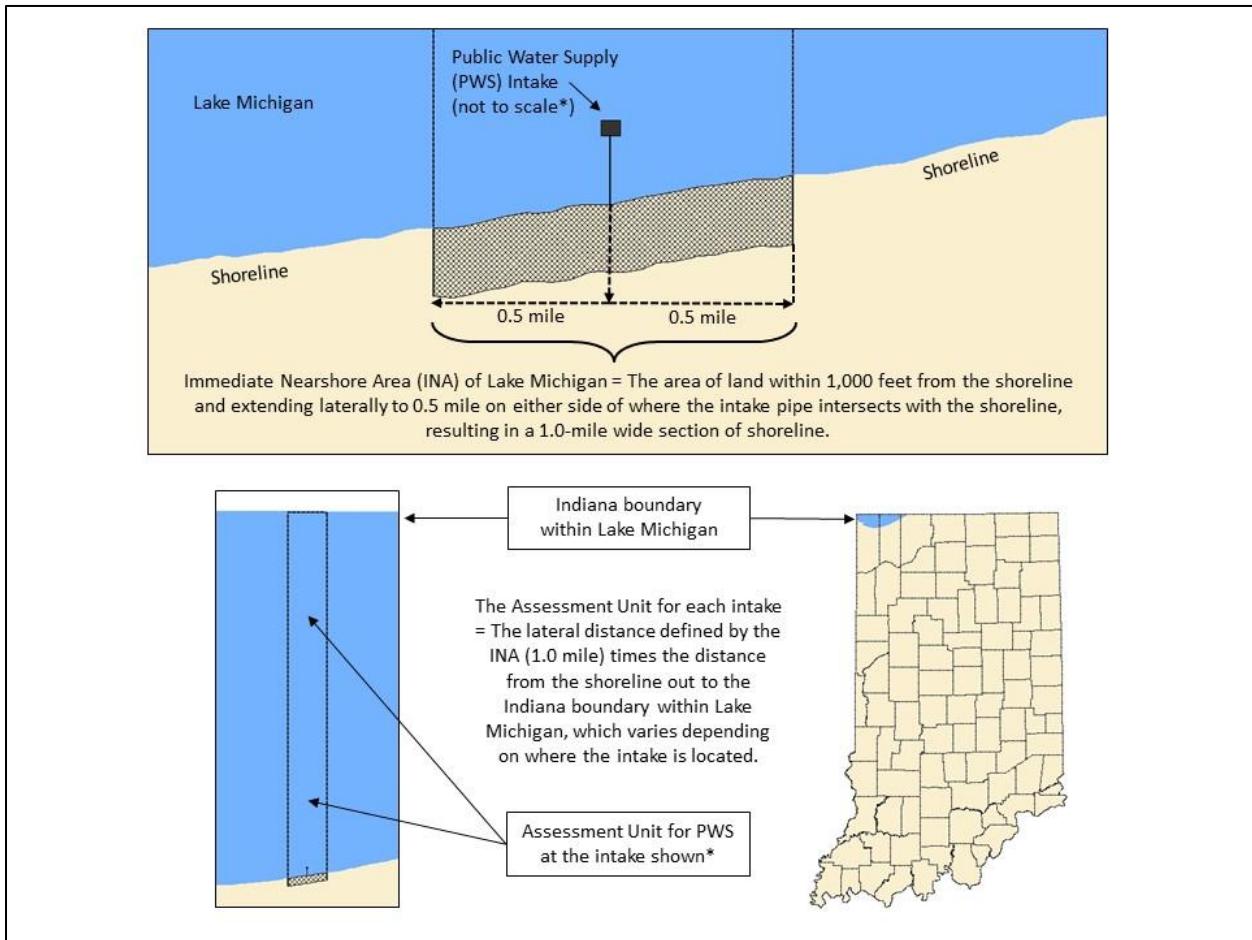
For all streams, including the Ohio River, IDEM has defined assessment units for each intake based on the "Emergency Management Zone", which begins at the point of surface water withdrawal at the intake to 1,000 feet upstream. The assessment units in the Indiana Reach Index, on which surface water intakes are located, are currently much larger than 1,000 feet and will need to be re-indexed to accommodate these more narrowly applied assessments.

Lake Michigan

IDEF's PWS use assessments for Lake Michigan will apply only to the areas in which source waters are withdrawn within Indiana's state boundary. For the purposes of determining support of PWS use in Lake Michigan, IDEM has defined its assessment units based on the "Immediate Nearshore Area" (INA) as defined in Indiana's SWAP. The INA is all the land within 1,000 feet of the shoreline extending 0.5 mile on either side of where the intake pipe intersects

the shoreline area. This is the area that has the greatest potential for contaminants coming from the shoreline to have adverse effects on the PWS within a matter of hours or days. Therefore, the lateral distance of each assessment unit will be limited to the INA and extend from the outer boundary of the nearshore area to the Indiana border, which lies in the offshore waters of Lake Michigan (Figure G-3).

Figure G-3: Definition of Lake Michigan assessment units for the purposes of determining Public Water Supply use support. The source water intake shown is for illustration purposes only and does not represent any specific intake on Lake Michigan.



Surface Waters with a Direct Influence on a Public Water Supply Well

To date, IDEM has identified five public water supply systems with one or more wells that are under the direct influence of surface water. These wells belong to community public water supply systems, which are public water systems that provide water for human consumption to at least 15 service connections used by year-round residents or that regularly serve at least 25 year-round residents (for example, municipalities, subdivisions, and mobile home parks). IDEM expects to identify additional public water supply wells and possibly some non-transient, non-community system wells that are under the direct influence of surface water in the future. Non-transient, non-community systems are public water supply systems that serve at least 25 of the same people more than six months per year (for example, schools, factories, industrial parks, office buildings, etc.).

For any public water supply system well under the direct influence of surface waters, it is possible that pollutants in surface waters located within the well field can reach the well through infiltration, absorption into the soil, or conduits, such as field tiles or water distribution piping that intercepts sandy soils. Specific sources of contaminants vary based on location but can include agricultural chemicals and nonpoint source runoff from roads and highways.

The geographic extent of surface water influence has been modeled in the Wellhead Protection Plans for those community public water supply systems with areas known to be susceptible to surface water. For the purposes of PWS use support assessments, any surface water within the modeled area of influence will be designated as a PWS.

Non-transient, non-community public water systems are not required to complete a Wellhead Protection Plan. When a non-transient, non-community public water system well is found to be under the direct influence of surface water, IDEM will require the system to complete a Source Water Assessment, which will define a 3,000-foot radius of concern around the well. For the purposes of PWS use support assessments, any surface water within the 3,000-foot radius of concern will be designated as a PWS.

Water Quality Indicators for Determining Support of Public Water Supply Use

Indicators used in the assessment of use support for PWS include:

- Any substances for which numeric criteria for human health apply at the point of water intake that have been identified in Indiana's Water Quality Standards³⁶ located in Table 6-1 of 327 IAC 2-1-6 and Table 8-3 of 327 IAC 2-1.5-8.
- Any substances for which numeric criteria are defined specifically for the public water supply use³⁷ except for total coliform bacteria for which Level 1 and Level 2 Assessments under the federal SDWA Revised Total Coliform Rule (RTCR) are used.
- The cyanobacterial toxins Cylindrospermopsin and Microcystin-LR for which U.S. EPA has issued drinking water health advisory values.

Water Quality Criteria and Other Benchmarks for Assessing Support of PWS Use

Human Health Criteria Applicable at the Point of Intake and Other Water Quality Criteria Specific to the PWS Use

Indiana's WQS contain human health criteria for several substances applicable at the point of intake to protect the public from negative health effects that could occur if they are found in high concentrations in source waters. For waters in the Great Lakes basin, IDEM will apply the most stringent of the Human Noncancer Criterion (HNC) or the Human Cancer Criterion (HCC) defined for drinking water in Table 8-3 of Indiana's WQS.

For waters outside the Great Lakes basin, IDEM will apply the continuous criterion concentration (CCC) values shown in Table 6-1 of Indiana's WQS at the point of water intake, which represents the most stringent human health criterion for a given substance and is, thus, the most protective of the PWS use.

³⁶ The criteria identified in Table 6-1 are applicable to waters outside the Great Lakes basin and can be found in 327 IAC 2-1-6. The criteria identified in Table 8-3 apply to waters located within the Great Lakes basin and can be found in 327 IAC 2-1.5-8.

³⁷ For all waters in the Great lakes basin, these substances and criteria are defined in 327 IAC 2-1.5-8(f). For all other Indiana waters, these substances and criteria are defined in 327 IAC 2-1-6(e).

Indiana's WQS contain numeric criteria specifically for waters designated as source waters for PWS, which like human health criteria, are applicable at the point of intake ³⁸. The WQS also include the following criteria to prevent taste and odor issues and to protect human health:

- Chloride (250 mg/l)
- Sulfate (250 mg/l)
- Dissolved solids (750 mg/l) (or 1,200 micromhos specific conductance as a surrogate)
- Nitrite (1 mg/l)
- Nitrogen, measured as the sum of nitrate and nitrite (10 mg/l)

The criteria for chloride, sulfate, and dissolved solids are intended to prevent taste and odor issues. The criteria for nitrite and nitrogen are intended to protect human health.

IDEM will apply these criteria to data sets meeting the minimum data requirements identified in Table G-2 and that were collected from waters designated for PWS in accordance with this methodology.

Indiana's WQS also contain numeric criteria for total coliform bacteria for waters designated as source waters for PWS and that are also applicable at the point of intake ³⁹. However, because exceedances of these criteria in source waters do not prohibit or otherwise limit the use of those waters for PWS, IDEM instead bases its assessment methodology for bacteria in source waters on the federal SDWA RTCR (U.S. EPA, 2013b). The RTCR went into effect in Indiana on April 1, 2016, replacing the Total Coliform Rule which had been in effect since 1989. Under the previous rule, there was no systematic way to determine when MCL violations for bacteria were attributable to source water issues. The RTCR now provides a means of identifying public water supplies adversely impacted by bacterial contamination in source waters and, as such, provides greater opportunity for their protection through IDEM's CWA programs.

The RTCR is intended primarily to ensure the integrity of the drinking water distribution system. However, the Level 1 and Level 2 Assessments, which are required in cases where bacteria are detected in treated water, requires an examination of source waters in addition to the investigation of other factors⁴⁰. Therefore, the results of Level 1 and 2 assessments conducted under the RTCR will reveal those situations in which MCL violations for bacteria are attributable to source water contamination as opposed to issues within the treatment plant or its distribution system, or both.

Although all PWS are required to sample for bacteria, bacterial contamination in source water is primarily a concern for facilities that draw their supplies from surface water, which is vulnerable to far more sources of fecal contamination than ground water. PWS wells under the direct influence of surface water are also somewhat vulnerable to bacterial contamination. However, bacteria can be effectively removed with conventional PWS treatment, specifically, the disinfection portion of the treatment process, which is required for all surface water systems. It is

³⁸ For waters in the Great lakes basin, these substances and criteria are defined in 327 IAC 2-1.5-8(f). For all other Indiana waters, these substances and criteria are defined in 327 IAC 2-1-6(e).

³⁹ See footnote 9.

⁴⁰ See <https://www.in.gov/idem/cleanwater/drinking-water/drinking-water-compliance-section/water-systems/revised-total-coliform-rule-for-drinking-water/> for more detailed information regarding Level 1 and Level 2 Assessments under the RTCR.

rarely the case that MCL violations for bacteria in treated water are the result of excessive bacterial concentrations in source water⁴¹.

By using RTCR assessment results instead of applying a numeric criterion, IDEM's PWS methodology balances the possibility that bacterial contamination in a source water might impair its designated use (by prohibiting or otherwise limiting its use for PWS) with the greater likelihood that MCL violations for bacteria (indicators of potential impairment) are attributable solely to issues within the treatment plant or its distribution system, or both. Using the RTCR ensures that IDEM's assessments:

- Identify those rare cases in which bacterial contamination in source water is limiting or prohibiting the use of an otherwise treatable supply or driving a need for additional treatment beyond conventional treatment methods.
- Do not assess source waters as impaired based on MCL violations attributable to problems within the facility or its distribution system, or both. This may include issues for which other regulatory means already exist to provide a remedy under the SDWA.

A facility that has completed an assessment pursuant to the RTCR and has found a problem to be attributable to bacterial contamination in the source water will assess that source water as impaired. If such an assessment finds the problem to be the result of issues within the facility or distribution system, IDEM will assess the source waters as fully supporting of PWS use. In the absence of any RTCR assessments, the waterbody will remain not assessed for PWS.

Benchmarks Used to Assess for Cyanobacterial Toxins

Algae are a common component of aquatic ecosystems in lakes and streams. However, the concentrated presence of blue-green algae (cyanobacteria) can be linked to some adverse health effects, and, as a result, cyanobacterial toxins are a growing concern for drinking water facilities. However, not all blue-green algal blooms produce toxins, and the specific conditions that lead to cyanobacterial toxin production are not well understood in the scientific community.

The SDWA requires water treatment facilities to notify the public when they detect a health risk in treated drinking water supplies. IDEM considers any consumption and use notification issued by a water treatment facility based on cyanobacterial toxin concentrations in treated drinking water to be indicative of source water impairment.

Currently, there are no U.S. federal numeric water quality criteria or regulations for cyanobacteria or cyanobacterial toxins in drinking water under the SDWA or for ambient waters under the CWA. Indiana's WQS, likewise, contain no numeric criteria for these substances. However, they do contain narrative criteria intended to protect surface water quality, including those waters designated as a PWS. These criteria state that all Indiana surface waters shall be "free from substances in concentrations that on the basis of available scientific data are believed to be sufficient to injure, be chronically toxic to, or be carcinogenic, mutagenic or teratogenic to humans..." ⁴²

In the absence of state or federal numeric criteria for cyanobacteria or cyanobacterial toxins, IDEM considers the following benchmarks provided in U.S. EPA's drinking water 10-day

⁴¹ Personal communication with Stacy Jones, Technical Environmental Specialist for IDEM OWQ's Drinking Water Branch (January 15, 2016).

⁴² 327 IAC 2-1-6 (a)(2) and 327 IAC 2-1.5-8(b)(2).

health advisories defensible for use in assessments based on Indiana's narrative water quality criteria (U.S. EPA, 2015b and 2015c):

- Cylindrospermopsin concentrations greater than 0.7 micrograms per liter ($\mu\text{g}/\text{L}$).
- Total Microcystin concentrations greater than 0.3 $\mu\text{g}/\text{L}$ (using Microcystin-LR, one of the most potent forms of the toxin, as a surrogate).

Cyanobacterial blooms are seasonal in nature with most occurring in later summer. However, high concentrations of cyanobacterial toxins have been found to occur even in colder months. Therefore, IDEM applies these benchmarks to data collected at any time of the year. The occurrence of cyanobacterial toxins in treated drinking water depends on their levels in the raw source water and the effectiveness of treatment methods for removing cyanobacteria and cyanobacterial toxins during the treatment process.

U.S. EPA developed its Health Advisory values to protect the public from exposure to cyanobacterial toxins in treated drinking water rather than in source waters. For this reason, using these values as benchmarks for the assessment of untreated source waters is conservative in nature, and, based on the idea that if source waters meet these benchmarks, drinking water treatment plants can be reasonably confident that their treatment processes will result in concentrations that are below those that might result in adverse health effects.

However, IDEM's CWA 305(b) and 303(d) assessment and listing processes should not be construed as a public health advisory because they do not reflect conditions in real time. U.S. EPA's health advisories for cyanobacterial toxins are intended to guide treatment decisions when the risk of cyanobacterial toxin contamination is high.

It is important to emphasize that the public cannot assume that, because a particular waterbody appears on the 303(d) list for a cyanobacterial toxin impairment, the treated water they draw from the tap is in any way unsafe to drink. The 303(d) list identifies waterbodies that are not fully supporting their designated uses, but the list is not intended to provide the public with information regarding the quality of the treated drinking water they get from a PWS.

While mindful of the differences in purpose and function of U.S. EPA's health advisories and CWA requirements to determine the degree to which our surface water resources are supporting their use as a PWS, IDEM believes that applying U.S. EPA's Health Advisory numbers as benchmarks provides for greater protection of source waters. Many of the same practices that can help to control taste and odor issues, which are often driven by nutrient enrichment, can also help to reduce the occurrence of algal blooms in surface waters. Where sufficient data are available, applying these benchmarks will help to identify those source waters that are more susceptible to cyanobacterial toxins and prioritize them for further evaluation for CWA Sections 303(d) and 305(b) purposes.

Minimum Data Requirements for Assessment

All available water quality data meeting IDEM's data quality requirements, whether collected by IDEM or external parties, will be used for assessment. U.S. EPA guidance suggests that, while all readily available data should be reviewed, 305(b) assessment decisions should be based on data that is five or fewer years old. For bacteria, all Level 1 and Level 2 Assessments performed in accordance with the RTCR within the most recent five consecutive years will be considered valid for the purposes of designated use assessments of PWS.

Table G-2 provides minimum data requirements for assessments of PWS use support along with any corresponding requirements regarding timing and frequency of data collection activities.

For each AU with sufficient data to make one or more designated use assessments, IDEM applies the 305(b) assessment process described in Table G-2. The specific criteria or benchmarks to be applied to the data will depend, in some cases, on the location of the waterbody from which they were collected. Assessment data are integrated for the purposes of making water quality assessments, which means that all data for a given waterbody are considered together and each type of data are treated as independently applicable.

Obtaining the Data Needed for Assessment

The PWS use is unlike other designated uses in that it is very narrowly defined in Indiana's WQS. Given the limited size of the AUs defined and designated for PWS, IDEM has very little existing data in its own database or from other sources to use for assessments with this methodology. IDEM is working to remedy that with the development of a monitoring strategy that is expected to provide usable data for assessments.

In 2016, in collaboration with 22 of Indiana's 32 PWS facilities that have surface water intakes, IDEM began working on a pilot project to monitor for several parameters that are expected to provide data for potential use in IDEM's PWS assessments. The project began as an effort to better understand the potential impacts that algae and cyanobacteria in source water have on the ability of PWS facilities to adequately treat the water for human consumption and to inform future treatment options if concentrations ever reach levels requiring additional methods beyond the conventional measures currently in place.

For this project, samples are collected by each facility from within the facility at its raw water intake, and treated water samples are collected on the same day. IDEM provides the sample bottles and shipping labels to the facilities and pays for them to ship the samples on ice to a laboratory selected by IDEM. IDEM also pays for the analytical costs. Samples are analyzed for several parameters that may yield data suitable for IDEM's PWS assessments, including:

- Chloride and sulfate
- Specific conductance
- Nitrogen, as nitrate + nitrite
- Trihalomethane
- Cylindrospermopsin and Microcystin

IDEM continues to work on building collaborative partnerships with drinking water facilities and other interested parties to collect the high-quality data needed to support assessments in the future. IDEM will also explore the feasibility of expanding its own monitoring program to provide water quality data for assessment and continues to seek additional sources of existing data at or near surface water intakes.

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Table G-21: Comparison of Water Quality Assessment Criteria and Benchmarks for IDEM's Clean Water Act Public Water Supply Assessments and the Safe Drinking Water Act Maximum Contaminant Levels for Treated Drinking Water

Clean Water Act (CWA) water quality assessment criteria and benchmarks used in assessments for Public Water Supply (PWS) use support. CWA Human Health Criteria (HHC) for Downstate waters are found in Indiana Administrative Code (IAC) 327 2-1-6(a)(7), Table 6-4. CWA HHC for Great Lakes Basin waters are found in IAC 327 2-1.5-8(b)(6), Table 8-3 and represent the lesser of the Drinking Water Human Noncancer Criteria (HNC) or Human Cancer Criteria (HCC). Locations in the IAC or citations for other CWA criteria or benchmarks used in PWS assessment are given with the specific criterion. Maximum contaminant levels (MCLs) regulated under the Safe Drinking Water Act (SDWA) are provided for comparison purposes only as MCLs are not used for assessment purposes.

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
General Chemistry and Physical Properties						
Chloride, Total			250 mg/L (327 IAC 2-1.5-8(f)(3))	250 mg/L (327 IAC 2-1-6(e)(3))		
Cyanide, Total	600 µg/L	200 µg/L				0.2 mg/L (free)
Specific Conductance (= Conductivity)			1,200 micromhos/cm at 25° Celsius (327 IAC 2-1.5-8(f)(4))	1,200 micromhos/cm at 25° Celsius (327 IAC 2-1-6(e)(4))		
Solids, Dissolved (or Specific Conductance as Proxy)			750 mg/L or 1,200 micromhos/cm at 25° Celsius (327 IAC 2-1.5-8(f)(4))	750 mg/L or 1,200 micromhos/cm at 25° Celsius (327 IAC 2-1-6(e)(4))		

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
Sulfate			250 mg/L (327 IAC 2-1.5-8(f)(3))	250 mg/L (327 IAC 2-1-6(e)(3))		
Fluoride ⁴³			1.0 mg/L Lake Michigan (327 IAC 2-1.5-8(j)(1))	1.0 mg/L Wabash and Ohio Rivers; 2.0 mg/L all other downstate waters (327 IAC 2-1-6(a)(9))		4 mg/L
Nutrients						
Nitrogen, Nitrate+Nitrite			10 mg/L (327 IAC 2-1.5-8(f)(6)(A))	10 mg/L (327 IAC 2-1-6(e)(6)(A))		10 mg/L
Nitrogen, Nitrite			1 mg/L (327 IAC 2-1.5-8(f)(6)(B))	1 mg/L (327 IAC 2-1-6(e)(6)(B))		1 mg/L

⁴³ Indiana Administrative Code does not contain a criterion for Fluoride that is specific to the Public Water Supply designated use. Instead, the IAC includes a “minimum surface water quality condition” in 327 IAC 2-1-6(a)(9) which applies to all waters outside of the Great Lakes Basin (e.g., downstate waters), except for the Ohio River and Interstate Wabash River, which have a separate “minimum surface water quality condition”. The IAC also includes a “minimum surface water quality condition” for Lake Michigan in 327 IAC 2-1.5-8(j)(1). Due to the general applicability of these criteria, they are here being applied to assessments of the Public Water Supply designated use for those specified waterbodies.

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
Algal Toxins						
Cylindrospermopsin					0.7 mg/L (U.S. EPA 2015c)	
Microcystin-LR (as a surrogate for total Microcystins)					0.3 mg/L (U.S. EPA 2015b)	
Metals						
Antimony, Total		5.6 µg/L				6 µg/L
Arsenic (III), Total		0.022 µg/L				10 µg/L
Barium, Total		1000 µg/L				2,000 µg/L
Copper, Total		1,300 µg/L				1.3 mg/L *
Mercury, Total	0.0018 µg/L	0.14 µg/L				2 µg/L Mercury (inorganic)
Methylmercury, Total	0.0018 µg/L					2 µg/L Mercury (inorganic)
Nickel, Total		610 µg/L				
Selenium, Total		170 µg/L				50 µg/L
Thallium, Total		13 µg/L				2 µg/L

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
Zinc, Total		7,400 µg/L				
Pesticides						
Dichlorodiphenyltrichloroethane (= DDT; all derivatives)	0.00015 µg/L	0.00024 µg/L				
Alpha Hexachlorocyclohexane (= alpha HCH)		0.09 µg/L				
Beta Hexachlorocyclohexane (= beta HCH)		0.16 µg/L				
Benzene Hexachloride (= gamma BHC or Lindane)	0.47 µg/L	0.19 µg/L				0.2 µg/L
Technical Hexachlorocyclohexane (= technical HCH)		0.12 µg/L				
Hexachlorocyclopentadiene		206 µg/L				50 µg/L
Aldrin		0.00074 µg/L				
Chlordane	0.00025 µg/L	0.0046 µg/L				2 µg/L
Dieldrin	0.0000065 µg/L	0.00071 µg/L				
Endrin		1.0 µg/L				2 µg/L

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
Endosulfan		74 µg/L				
Heptachlor		0.0028 µg/L				0.4 µg/L
Toxaphene	0.000068 µg/L	0.0071 µg/L				3 µg/L
Polychlorinated Biphenyls (PCBs)						
Polychlorinated Biphenyls (PCBs), Total (sum of all <u>congeners</u>)	0.0000068 µg/L	0.00079 µg/L				0.5 µg/L
Polycyclic Aromatic Hydrocarbons (PAHs)						
Polycyclic Aromatic Hydrocarbons (PAHs) (<u>includes seven PAH compounds</u>)		0.028 µg/L				
Benzo(a)pyrene		0.028 µg/L				0.2 µg/L
Fluoranthene		42 µg/L				
Semi-Volatile Organics (SVOCs)						
1,2,4,5-tetrachlorobenzene		38 µg/L				
1,2-diphenylhydrazine		0.422 µg/L				
Dichlorobenzenes (all isomers)		400 µg/L				600 µg/L
2,4,5-trichlorophenol		2,600 µg/L				

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Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
2,4,6-trichlorophenol		12 µg/L				
2,4-dichlorophenol		3,090 µg/L				
2,4-dimethylphenol	450 µg/L					
Dinitrophenol		70 µg/L				
2,4-dinitrophenol	55 µg/L					
4,6-dinitro-o-cresol		13.4 µg/L				
2,4-dinitrotoluene		1.1 µg/L				
Benzidine		0.0012 µg/L				
Bis (2-chloroethyl) Ether (= Dichloroethyl Ether)		0.3 µg/L				
Bis (2-chloroisopropyl) Ether		34.7 µg/L				
Bis (chloromethyl) Ether (= BCME or Dioxane)		0.000038 µg/L				
Dichlorobenzidine		0.1 µg/L				
Diethyl Phthalate		350,000 µg/L				
Dimethyl Phthalate		313,000 µg/L				
Dibutyl Phthalate		34,000 µg/L				
Di-2-ethylhexyl Phthalate		15,000 µg/L				

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
Hexachlorobenzene	0.00045 µg/L	0.0072 µg/L				1 µg/L
Hexachloroethane	5.3 µg/L	19 µg/L				
Isophorone		5,200 µg/L				
N-nitrosodibutylamine		0.064 µg/L				
N-nitrosodiethylamine		0.008 µg/L				
N-nitrosodimethylamine		0.014 µg/L				
N-nitrosodiphenylamine		49 µg/L				
N-nitrosopyrrolidine		0.16 µg/L				
Pentachlorobenzene		74 µg/L				
Pentachlorophenol		1,000 µg/L				
Phenol		3,500 µg/L				
Volatile Organics						
1,1-dichloroethylene		0.33 µg/L				7 µg/L
1,1,1-trichloroethane		18,400 µg/L				200 µg/L
1,1,2-trichloroethane		6.0 µg/L				5 µg/L
1,1,2,2-tetrachloroethane		1.7 µg/L				
1,2-dichloroethane		9.4 µg/L				5 µg/L

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Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
2,3,7,8-tetrachlorodibenzo-p-Dioxin (= 2,3,7,8-TCDD or Dioxin)	0.0000000086 µg/L	0.0000001 µg/L				0.00003 µg/L
Dichloropropenes (all congeners)		87 µg/L				
Acrolein		320 µg/L				
Acrylonitrile		0.58 µg/L				
Benzene	12 µg/L	6.6 µg/L				5 µg/L
Nitrobenzene		19,800 µg/L				
Chlorobenzene (= Monochlorobenzene)	470 µg/L	488 µg/L				100 µg/L
Carbon Tetrachloride		4.0 µg/L				5 µg/L
Chloroform		1.9 µg/L				
Ethylbenzene		1,400 µg/L				700 µg/L
Hexachlorobutadiene		4.47 µg/L				
Methylene Chloride (= Dichloromethane)	47 µg/L					5 µg/L
Tetrachloroethylene		8 µg/L				5 µg/L
Toluene	5,600 µg/L	14,300 µg/L				1,000 µg/L

Parameter	CWA Human Health Criteria used in PWS Assessment		Other CWA Criteria used in PWS Assessment		Other Benchmarks for Assessment	SDWA Maximum Contaminant Level
	Great Lakes Basin	Downstate Waters	Great Lakes Basin	Downstate Waters		
Trichloroethylene (= Trichloroethene or TCE)	29 µg/L	27 µg/L				5 µg/L
Vinyl Chloride		20 µg/L				2 µg/L
Halomethanes (all compounds)		1.9 µg/L				

*Indicates a treatment technique (TT) Action Level as opposed to MCL.

Ohio River Assessments

IDE� collaborates with the Ohio River Valley Water Sanitation Commission (ORSANCO) to conduct water quality assessments of the Ohio River reaches that border Indiana. ORSANCO is an interstate water pollution control agency for the Ohio River established in 1948 through a Congressionally approved [interstate compact](#) between the member states. Indiana incorporated the terms of the compact into state law at Indiana Code 13-29-2. Under the terms of this agreement, member states cooperate in the control of water pollution in the Ohio River Basin. ORSANCO monitors the Ohio River on behalf of the compact states under CWA Section 305(b) and produces a biennial water quality assessment report of its water quality condition, although ORSANCO is not required to develop a 303(d) List of Impaired Waters. Identification of Ohio River impairments on a 303(d) list for the purposes of TMDL development is the responsibility of each compact state.

Every two years, ORSANCO prepares a description of its proposed assessment methodology for review by the 305(b) Work Group, which is composed of the Integrated Report coordinators for each compact state and one or more U.S. EPA representatives responsible for reviewing state reports. During this review, provisional assessments based on proposed methods are also presented to the 305(b) Work Group which then works with ORSANCO to achieve a consensus regarding its assessment methods and water quality assessments. After ORSANCO's methodology and preliminary assessments are approved by the 305(b) Work Group, ORSANCO presents them to its Technical Committee for final approval.

ORSANCO's assessment and reporting timeline does not correspond with the publication of IDE�'s draft 303(d) list for public review and comment. ORSANCO's assessment methodology and preliminary assessments for each cycle are always completed prior to or during IDE�'s development of a draft 303(d) list for that cycle but are considered provisional until approved by ORSANCO's Technical Committee, which usually occurs after IDE� has published its draft 303(d) list.

ORSANCO's role in completing Ohio River use attainment assessments and developing a biennial report on Ohio River water quality is to facilitate interstate consistency in CWA 305(b) assessments and the identification of impairments in compact states' 303(d) lists although this consistency is not always possible given the differences in the compact states' WQS and their assessment and listing methodologies. Given these differences, the compact states are not obligated to incorporate ORSANCO's water quality assessments into their own reports. U.S. EPA guidance states that *“data and information in an interstate commission 305(b) report should be considered by the states as one source of readily available data and information when they prepare their Integrated Report and make decisions on segments to be placed in Category 5; however, data in a 305(b) Interstate Commission Report should not be automatically entered in a state Integrated Report or 303(d) list without consideration by the state about whether such inclusion is appropriate.”* (U.S. EPA, 2005). As Indiana is a member of the interstate compact, IDE� actively participates in ORSANCO's decision-making processes regarding its monitoring strategy and biennial water quality assessments and considers ORSANCO's data and assessments appropriate in the development of Indiana's 303(d) list.

Tables G-22 contains a comparison of the applicable criteria in ORSANCO's Pollution Control Standards (PCS) and Indiana's WQS and how these criteria are used to determine the degree to which the Ohio River supports aquatic life use, recreational use, and fish consumption. IDE� generally accepts ORSANCO's methods for evaluating the available data for assessment purposes to achieve consistency with other compact states. Where there are not significant

differences between ORSANCO's PCS and Indiana's WQS, IDEM incorporates ORSANCO's biennial assessments directly into its 305(b) report and 303(d) list, applying them to the corresponding reaches defined in ATTAINS. However, when ORSANCO's PCS are less stringent than the water quality criteria in Indiana's WQS, its methods for applying criteria are inconsistent with IDEM's assessment methodology, or both situations exist, ORSANCO's data are evaluated against IDEM's assessment methodology. Those results are then compared to Indiana's WQS to make the assessment. IDEM's methods for applying ORSANCO's data and assessments for the purposes of Integrated Reporting are described below and summarized in Table G-22.

IDEM's Assessment Units for the Ohio River

The Ohio River is a series of 18 pools resulting from a series of high-lift locks and dams which were installed for navigational purposes to maintain a minimum river depth and to regulate flow. These pools range from seven to 142 miles long, and each has its own unique characteristics that can affect water quality. The beginning and end points of each pool are defined in terms of their Ohio River Miles (ORM). There are six pools located partly or entirely along Indiana's border:

- Markland Pool (ORM 491.1 to ORM 531.61 of this pool border Indiana)
- McAlpine Pool (ORM 531.61 to ORM 609.41)
- Cannelton Pool (ORM 609.41 to ORM 722.99)
- Newburgh Pool (ORM 722.99 to ORM 777.09)
- JT Myers Pool (ORM 777.09 to ORM 853.49)
- Smithland Pool (ORM 853.49 to 855.37 of this pool border Indiana)

IDEM has divided the Indiana reaches of the Ohio River into individual assessment units (ranging from 1.8-13.7 river miles in length) which allow IDEM to apply ORSANCO's recreational use assessments more accurately to specific sections within each pool. IDEM applies ORSANCO's results for aquatic life use and fish consumption for each pool to all the IDEM assessment units within that pool. ORSANCO's assessments of public water supply are provided for the entire river.

Aquatic Life Use Assessments for the Ohio River

ORSANCO monitors biological communities (fish and macroinvertebrates) and chemical water quality at several sites along the Ohio River to determine the degree to which the Ohio River supports aquatic life. Biological monitoring is conducted in three to five pools each year at 15 randomly chosen sites within each pool, resulting in complete coverage of the entire river every five to six years. Physical and chemical water quality data are collected bimonthly from 16 fixed sites along the Ohio River, mostly located at the navigational dams that divide the river into pools, with five located along Indiana's border. Continuous monitoring of dissolved oxygen and temperature is conducted at 14 fixed locations along the Ohio River, four of which are located along Indiana's border.

ORSANCO uses the modified Ohio River Fish Index (mORFI_n) and the Ohio River Macroinvertebrate Index (ORMI_n) to measure the condition of biological communities in the river. The mORFI_n and ORMI_n are multi-metric indices of biotic integrity (IBI), which were based on widely used models designed for smaller streams but customized to assess the Ohio River with expected values developed for the different habitats found in this large river system.

These indices combine various attributes (metrics) of the fish and macroinvertebrate communities to provide two scores for each pool in the river. Individual mORFI_n and ORMI_n scores for each site are compared to a range of expected scores to determine the biological

condition rating for each type of community, which ranges from “Excellent” to “Very Poor”. ORSANCO calculates an average mORFI_n and ORMI_n score for each pool based on a minimum of 15 (fish) or 10 (macroinvertebrates) individual scores from all sites monitored within the pool.

ORSANCO determines chemical water quality conditions for each pool by comparing water sample results ⁴⁴ for each site within the pool to the applicable criteria in Indiana’s WQS or ORSANCO’s PCS (Ohio River Valley Sanitation Commission, 2019), whichever are more stringent. The results for biological and chemical water quality assessments are then evaluated together to determine use support in the manner described in Table G-22.

IDEQ accepts ORSANCO’s approach to evaluating both biological and water chemistry data. However, because Indiana’s water quality criteria for some parameters differs from ORSANCO’s criteria, assessments reported in ORSANCO’s 305(b) report may vary somewhat from those in Indiana’s Integrated Report, depending on the parameter in question and whether ORSANCO’s or Indiana’s criterion is more stringent.

Table G-22: Water quality assessment criteria for determining aquatic life designated use support for the Ohio River.

Aquatic Life Use Support – Ohio River	
<p>ORSANCO combines the results from both its biological and chemical water quality monitoring programs to determine aquatic life use support for the Ohio River. Composite scores for the modified Ohio River Fish Index (mORFI_n) and Ohio River Macroinvertebrate Index (ORMI_n) are calculated by averaging the individual scores for all sites monitored within the pool; the average score is compared to a range of expected scores to determine an overall biological rating for the pool. Chemical water quality conditions are determined for each pool by comparing water sample results ⁴⁵ for each site within the pool to the applicable criteria in Indiana’s WQS or ORSANCO’s Pollution Control Standards (PCS) (Ohio River Valley Sanitation Commission, 2019), whichever are more stringent. The results for biological and chemical water quality assessments are evaluated together to determine use support in the manner described below.</p>	
<p>Assessments of chemical water quality are based on results for conventional inorganics (pH, sulfate, and chloride) and toxicants (dissolved metals, total mercury, total selenium, polychlorinated biphenyls (PCBs), dioxins, free cyanide, and ammonia). Results are evaluated on a site-by-site basis. Exceedances are determined by comparing results for each site to the applicable criteria in Indiana’s WQS or ORSANCO’s PCS, whichever are more stringent.</p>	
<p>Parameter(s) – Chemical pollutants (conventional inorganics and toxicants) and biological communities (fish and macroinvertebrates)</p>	
Fully Supporting	<p>Conventional Water Pollutant – Not more than 10% (<10%) of all water samples exceed the applicable criterion for a given conventional pollutant and</p> <p>Toxic Water Pollutant – No exceedances or one exceedance of the applicable criterion for a given toxic pollutant and/or</p> <p>Biota – Both average mORFI_n and ORMI_n scores for the pool are greater than or equal to 20.0 (≥ 20.0, condition rating of ‘Fair’, ‘Good’, ‘Very Good’, or ‘Excellent’)</p>

⁴⁴ Dissolved oxygen and temperature results are also evaluated for exceedance(s) of the applicable criteria. However, these results are not used to make impairment decisions because the data are not considered representative of conditions throughout each pool or over the entire assessment period.

⁴⁵ Dissolved oxygen and temperature results are also evaluated for exceedance(s) of the applicable criteria. However, these results are not used to make impairment decisions because the data are not considered representative of conditions throughout each pool or over the entire assessment period.

Partially Supporting - Impaired	<p>Conventional Water Pollutant – Between 10% and 25% (>10% to ≤25%) of all water samples exceed the applicable criterion for a given conventional pollutant and</p> <p>Toxic Water Pollutant – More than one (>1) exceedance and less than or equal to 10% (≤10%) of all water samples exceed the applicable criterion for a given toxic pollutant and/or</p> <p>Biota – One index (mORFI_n or ORMI_n) scores greater than 20.0 (>20.0, condition rating of 'Fair' or better) and the other index scores between 10.0 – 19.9 (>10.0 - ≤19.9, condition rating of 'Poor')</p>
Not Supporting - Impaired	<p>Conventional Water Pollutant – Greater than 25% (>25%) of all water samples exceed the applicable criterion for any one water pollutant and</p> <p>Toxic Water Pollutant – More than one (>1) exceedance and more than 10% (>10%) of all water samples exceed the applicable criterion for a given toxic pollutant and/or</p> <p>Biota – Both mORFI_n and ORMI_n scores are less than 20.0 (<20.0, condition rating of 'Poor') or either index scores less than 10.0 (<10.0, condition rating of 'Very Poor')</p>

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Table G-23: Comparison of metals criteria used to determine aquatic life use support. Hardness is expressed as mg/l of CaCO₃.

Metal	Fraction	Acute or Chronic	ORSANCO's Criterion Concentration (µg/L)	ORSANCO's Dissolved Criterion Conversion Factors ^[1]	Indiana's Criterion Concentration (µg/L)	Indiana's Dissolved Criterion Conversion Factors	Most Stringent Criteria
Mercury ^[2]	Dissolved (ORSANCO) Total (Indiana)	Chronic	0.91 (Total)	0.85 (Dissolved)	0.012 (Total)	NA	Indiana
Arsenic III ^[2]	Dissolved ^[3]	Chronic	150	1.0	150	1.0	Equally stringent
Cadmium	Dissolved ^[3]	Chronic	$e^{(0.7409(\ln \text{ hardness})-4.719)}$	1.101672 - $[\ln(\text{hardness}) * 0.041838]$	$e^{(0.7852[\ln (\text{hardness})]-3.490)}$	1.101672 - $[(\ln(\text{hardness}) (0.041838))]$	ORSANCO
Chromium III	Dissolved ^[3]	Chronic	$e^{(0.819[\ln (\text{hardness})]+0.6848)}$	0.86	$e^{(0.8190[\ln (\text{hardness})]+1.561)}$	0.860	ORSANCO
Chromium VI	Dissolved ^[3]	Chronic	11	0.962	11	0.962	Equally stringent
Copper	Dissolved ^[3]	Chronic	$e^{(0.8545(\ln \text{ hardness})-1.702)}$	0.960	$e^{(0.8545[\ln (\text{hardness})]-1.465)}$	0.960	ORSANCO
Lead	Dissolved ^[3]	Chronic	$e^{(1.273(\ln \text{ hardness})-4.705)}$	1.46203 - $[\ln(\text{hardness}) * 0.145712]$	$e^{(1.273[\ln (\text{hardness})]-4.705)}$	1.46203 - $[(\ln \text{ hardness}) (0.145712)]$	Equally stringent
Nickel	Dissolved ^[3]	Chronic	$e^{(0.846(\ln \text{ hardness})+0.0584)}$	0.997	$e^{(0.846[\ln (\text{hardness})]+1.1645)}$	0.997	ORSANCO
Selenium	Total	Chronic	5	--	35	--	ORSANCO

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Metal	Fraction	Acute or Chronic	ORSANCO's Criterion Concentration ($\mu\text{g/L}$)	ORSANCO's Dissolved Criterion Conversion Factors ^[1]	Indiana's Criterion Concentration ($\mu\text{g/L}$)	Indiana's Dissolved Criterion Conversion Factors	Most Stringent Criteria
Silver	Dissolved ^[3]	Acute	$e^{(1.72[\ln \text{hardness}]-6.59)}$	0.85	$e^{(1.72[\ln (\text{hardness})]-6.52)/2}$	0.85	Indiana
Zinc	Dissolved ^[3]	Chronic	$e^{(0.8473[\ln \text{hardness}]+0.884)}$	0.986	$e^{(0.8473[\ln (\text{hardness})]+0.7614)}$	0.986	Indiana

[1] The asterisks used in this column are used to denote a multiplication sign.

[2] This criterion is expressed in ORSANCO's Pollution Control Standards as "Not to Exceed" and in Indiana's WQS as a four-day average.

[3] Unless otherwise shown, dissolved metals criteria are calculated as the total recoverable criterion multiplied by the dissolved criterion conversion factor. Assessments are made by comparing dissolved results against the established or calculated criterion.

Table G-24: Comparison of sulfate and cyanide criteria used to determine aquatic life use support. Hardness is expressed as mg/l of CaCO₃.

Indicator	Type of Criteria	ORSANCO's ALUS Criteria	Indiana's ALUS Criteria	Most Stringent Criteria	
Free Cyanide ^[2] (µg/L)	Chronic	5.2	5.2	Equally stringent	
Chloride ^[3] mg/L)	Chronic	No criterion	$177.87 * (\text{hardness})^{0.205797} * (\text{sulfate})^{-0.07452}$	Indiana	
Sulfate ^[4] (mg/L)	Hardness ≥ 100 mg/L but ≤ 500 mg/L and Chloride (mg/L) ≥ 5 mg/L but ≤ 25 mg/L	Not to Exceed	No criterion	$[-57.478 + (5.79 * \text{hardness}) + (54.163 * \text{chloride})] * 0.65$	Indiana
	Hardness ≥ 100 mg/L but ≤ 500 mg/L and Chloride (mg/L) ≥ 25 mg/L but ≤ 500 mg/L	Not to Exceed	No criterion	$[1276.7 + (5.508 * \text{hardness}) - (1.457 * \text{chloride})] * 0.65$	Indiana
	Hardness < 100 mg/L and Chloride (mg/L) ≤ 500 mg/L	Not to Exceed	No criterion	500	Indiana
	Hardness > 500 mg/L and Chloride (mg/L) ≥ 5 mg/L but < 25 mg/L	Not to Exceed	No criterion	$[57.478 + (5.79 * 500) + (54.163 * \text{chloride})] * 0.65$	Indiana
	Hardness > 500 mg/L and Chloride (mg/L) ≥ 25 mg/L but ≤ 500 mg/L	Not to Exceed	No criterion	$[1.276 + (5.508 * 500) - (1.457 * \text{chloride})] * 0.65$	Indiana

[2] This criterion is expressed in ORSANCO's Pollution Control Standards as "Not to Exceed" and in Indiana's WQS as a 4-day average.

[3] Indiana's criterion for chloride is a calculated criterion which requires both hardness and sulfate values and is rounded to nearest whole number for the purposes of assessment. ORSANCO's Pollution Control Standards do not contain a chloride criterion for the protection of aquatic life. Therefore, IDEM uses the data collected by ORSANCO for the purposes of making its aquatic life use assessments for the Ohio River.

[4] Indiana's criterion for sulfate is a calculated criterion which requires both hardness and chloride values and is rounded to nearest whole number for the purposes of assessment. ORSANCO's Pollution Control Standards do not contain a sulfate criterion for the protection of aquatic life. Therefore, IDEM uses the data collected by ORSANCO to calculate the applicable criteria for the purposes of making its aquatic life use assessments for the Ohio River.

Table G-25: Comparison of ammonia, dissolved oxygen, pH, and temperature criteria used to determine aquatic life use support.

Indicator	Type of Criteria	ORSANCO's ALUS Criteria ^[1]	Indiana's ALUS Criteria ^[1]	Most Stringent Criteria
Ammonia (mg/L) applicable March 1 to October 31	Not to Exceed	$0.8876 * [((0.0278/1+10^{7.688-\text{pH}}) + (1.1994/(1+10^{\text{pH}-7.688})) * (2.126 * 10^{0.028 * (\text{20-Max}(\text{T or }7))})]$ <p>Where: T = Temperature in °C</p> <p>Notes:</p> <p>These criteria apply when unionid mussels are present. For purposes of determining the applicable water quality-based limitations on ammonia-nitrogen, unionid mussels shall be presumed to be present at all times in the Ohio River unless the applicant demonstrates to the satisfaction of the permitting authority and ORSANCO that mussels are absent.</p>	$[((0.0577/(1+10^{7.688-\text{pH}})) + (2.487/(1+10^{\text{pH}-7.688}))) * \text{MIN}(2.85, (1.45 * 10^{0.028 * (25 - \text{T})}))]$ <p>Where: T = Temperature in °C</p> <p>Notes:</p> <p>For the above equation, multiply the parenthetical equation by 2.85 when T is less than or equal to 14.51°C.</p> <p>When T is greater than 14.51°C, multiply the parenthetical equation by $(1.45 * 10^{0.028 * (25 - \text{T})})$</p>	ORSANCO
Dissolved Oxygen (mg/L) applicable April 15 to June 15	Not to Exceed	Minimum concentration 5.0 at all times	Average concentration at least 5.0 per calendar day and a minimum concentration of 4.0 at all times	IDEM
Dissolved Oxygen (mg/L) applicable June 16 to April 14	Not to Exceed	Average concentration at least 5.0 per calendar day and a minimum concentration of 4.0 at all times	Average concentration at least 5.0 per calendar day and a minimum concentration of 4.0 at all times	Equally stringent
pH (Standard units)	Not to Exceed	No value less than 6.0 nor greater than 9.0	No value less than 6.0 nor greater than 9.0	Equally stringent
Temperature (expressed in °C and °F)	Not to Exceed	Allowable values expressed as Period Averages and Maximum Temperatures	Allowable values expressed as Maximum Temperatures	ORSANCO ^[2]

[1] The asterisks used in this column are used to denote a multiplication sign.

[2] Both ORSANCO's Pollution Control Standards and Indiana's WQS articulate maximum allowable temperatures. ORSANCO's standards also include allowable period average temperatures, which are more stringent than the maximum allowable temperatures in either set of standards.

Recreational Use Assessments for the Ohio River

ORSANCO collects Escherichia coli (E. coli) bacteria samples from April through October at sites located upstream and downstream of six large urban communities along the Ohio River. These are communities that have combined sewer overflows (CSOs), which can be significant sources of bacterial contamination to surface waters during wet weather events. Sites are sampled weekly to allow for the calculation of monthly (five-week period) geometric means for each site. ORSANCO also conducted longitudinal bacteria surveys during the recreational season (May through October) along the entire Ohio River between 2003-2008. At each five-mile interval, five consecutive weekly rounds of E. coli sampling were conducted to produce a geometric mean for that segment. E. coli sampling was repeated in each segment in subsequent years (three times per segment for 15 samples total), which produced three geometric means for each segment. ORSANCO determines recreational use support by comparing geometric mean E. coli results from all sites to the E. coli criteria in ORSANCO's PCS. Indiana's E. coli criteria are slightly more stringent than ORSANCO's, although in cases where there are at least ten samples at a given site, up to 10% of the results may exceed the single sample maximum criterion if the exceedances are incidental and attributable solely to the discharge of treated wastewater from a wastewater treatment and the geometric mean criterion is met ⁴⁶. This information is evaluated as shown in Table G-26 to determine whether the Ohio River is meeting its recreational use. As ORSANCO's criteria do not allow exceptions for E. coli exceedances and directly applies its single sample maximum criterion to individual results, ORSANCO's recreational use assessments are more stringent than Indiana's by virtue of its assessment methodology. Indiana, therefore, accepts ORSANCO's assessments of recreational use support for the Ohio River.

Table G-26: Water quality assessment criteria for recreational designated use support for the Ohio River.

Recreational Use Support (Human Health) – Ohio River	
Available data are evaluated in two ways. Both individual results and monthly geometric mean results calculated from five samples, one sample collected each week for five consecutive weeks, are evaluated for exceedances of the applicable criteria in ORSANCO's PCS and the number of times exceedances occurred.	
Parameter(s) - Bacteria (E. coli)	
Fully Supporting	Not more than 10% (<10%) of the monthly geometric mean results exceed the geometric mean criterion of 130 cfu/100mL and Not more than 10% of all single sample results exceed the instantaneous maximum criterion of 240 cfu/100 mL
Partially Supporting - Impaired	Between 10% and 25% (>10% to ≤25%) of the monthly geometric mean results exceed the geometric mean criterion of 130 cfu/100mL
Not Supporting - Impaired	More than 25% (>25%) of the monthly geometric mean results exceed the geometric mean criterion of 130 cfu/100mL or More than 10% of all single sample results exceed the instantaneous maximum criterion of 240 cfu/100 mL

⁴⁶ Relevant sections of the Indiana's water quality standards include 327 IAC 2-1.5-8(e)(3)(b) for waters within the Great Lakes basin and 327 IAC 2-1-6(d)(3), which applies to downstate waters.

Table G-27: Comparison of criteria used to determine recreational use support.

Indicator	Type of Criteria	ORSANCO's Recreational Use Criteria	Indiana's Recreational Use Criteria	Most Stringent Criteria [1]
E. coli	Geometric Mean	Applicable April-October (Recreational Season) May not exceed 130 cfu/100 ml as a 90-day geometric mean based on not fewer than five samples per month	Applicable April-October (Recreational Season) May not exceed 125 cfu/100 ml based on not fewer than five equally spaced samples over a 30-day period. If five equally spaced samples are not available for the calculation of a geometric mean, single sample maximum applies	Indiana
E. coli	Single Sample Maximum	Applicable April-October (Recreational Season) May not exceed 240 cfu/100 ml in more than 25% of samples	Applicable April-October (Recreational Season) In cases where there are at least ten samples at a given site, up to 10% may exceed the single sample maximum if The exceedances are incidental and attributable solely to the discharge of treated wastewater from a wastewater treatment plant as defined in Indiana Code and The geometric mean criterion is met	Indiana

[1] Although Indiana's E. coli numeric criteria are slightly more stringent than ORSANCO's, unlike Indiana's WQS, ORSANCO's criteria do not allow exceptions. ORSANCO's assessment methodology also incorporates analysis of single sample results, which provides a more robust assessment than Indiana's combined criteria and assessment methodology can. Indiana, therefore, accepts ORSANCO's assessments of recreational use support for the Ohio River.

Public Water Supply Use Support Assessments for the Ohio River

To determine whether the Ohio River is meeting its use as a public water supply (PWS), ORSANCO combines the results from its bacteria monitoring and bimonthly chemical monitoring programs with information from surveys of drinking water treatment facilities and U.S. EPA's [Safe Drinking Water Information System \(SDWIS\)](#) database.

During each assessment cycle, ORSANCO mails surveys to all Ohio River water utilities requesting information about the quality of the source water they draw from the Ohio River. In Indiana, two facilities are contacted (Mt. Vernon Water Works and Evansville Water Utility). The surveys ask utilities if there were any intake closures during the assessment period due to spills, whether violations of finished drinking water maximum contaminant levels (MCLs) occurred due to source water quality, or whether "non-routine" or extraordinary treatment due to source water quality was necessary to meet finished water MCLs. ORSANCO also queries SDWIS for records of MCL violations within the assessment period for all Ohio River water utilities. This information is evaluated as shown in Table G-28 to determine whether the Ohio River is meeting its use as a public water supply.

Table G-28: Water quality assessment criteria for determining public water supply designated use support for the Ohio River.

Public Water Supply – Ohio River	
ORSANCO combines the results from its bacteria and chemical water quality monitoring programs with results from surveys of drinking water facilities and information from U.S. EPA's Safe Drinking Water Act Information System (SDWIS) to determine public water supply use support for the Ohio River.	
Assessments of chemical water quality are based on results for bacteria (fecal coliform), conventional inorganics (fluoride, total nitrogen and nitrite, and sulfate) and other substances regulated under the Safe Drinking Water Act (SDWA) with either a maximum concentration limit (MCL) or secondary MCL. These include total metals, total cyanide, and phenols. Results for bacteria and chemical pollutants are evaluated on a site-by-site basis. Exceedances are determined by comparing results for each site to the applicable criteria in Indiana's WQS or ORSANCO's PCS, whichever are more stringent.	
Parameter(s) - Chemical pollutants, bacteria, and information from surveys of drinking water facilities and SDWIS; Pollutants; Mercury in Fish Tissue and Water Samples	
Fully Supporting	<p>Conventional Water Pollutant – Not more than 10% (<10%) of all water samples exceed the applicable criterion for a given conventional pollutant and</p> <p>Toxic Water Pollutant – No exceedances or one exceedance of the applicable criterion for a given toxic pollutant and</p> <p>Survey/USEPA SWDIS – No finished water MCL violations caused by Ohio River water quality were reported</p>
Partially Supporting - Impaired	<p>Conventional Water Pollutant – Between 10% and 25% (>10% to ≤25%) of all water samples exceed the applicable criterion for a given conventional pollutant or</p> <p>Toxic Water Pollutant – More than one (>1) exceedance and less than or equal to 10% (≤10%) of all water samples exceed the applicable criterion for a given toxic pollutant or</p> <p>Survey - Frequent intake closures due to elevated levels of pollutants were necessary to protect water supplies and comply with provisions of the SDWA (meet MCLs) or</p> <p>Survey - Frequent “non-routine” additional treatment was necessary to protect water supplies and comply with provisions of the SDWA (meet MCLs)</p>
Not Supporting - Impaired	<p>Conventional Water Pollutant – Greater than 25% (>25%) of all water samples exceed the applicable criterion for any one water pollutant and</p> <p>Toxic Water Pollutant – More than one (>1) exceedance and more than 10% (>10%) of all water samples exceed the applicable criterion for a given toxic pollutant and</p> <p>Survey – There was a corresponding finished water MCL violation caused by Ohio River water quality</p>

Table G-29: Comparison of human health criteria and other criteria used to determine public water supply use support.

Parameter	ORSANCO's Criterion Concentration	Indiana's Criterion Concentration	Most Stringent Criteria
Antimony (Total)	5.6 µg/L	146 µg/L	ORSANCO
Arsenic III (Total)	10 µg/L	0.022 µg/L	Indiana
Barium (Total)	1,000 µg/L	1,000 µg/L	Equally stringent
Beryllium (Total)	No criterion	0.068 µg/L	Indiana
Cadmium (Total)	No criterion	10 µg/L	Indiana
Copper (Total)	1300 µg/L	No criterion	ORSANCO
Mercury (Total)	0.012 µg/L	0.14 µg/L	ORSANCO
Nickel (Total)	610 µg/L	13.4 µg/L	Indiana
Selenium (Total)	170 µg/L	10 µg/L	Indiana
Silver (Total)	50 µg/L	50 µg/L	Equally stringent
Thallium (Total)	0.24 µg/L	48 µg/L	ORSANCO
Zinc (Total)	7400 µg/L	No criterion	ORSANCO
Cyanide (Total)	140 µg/L	200 µg/L	ORSANCO
Fluoride	1.0 mg/L	1.0 mg/L ^[1]	Equally stringent
Nitrogen (as Nitrate-Nitrite)	10 mg/L	10 mg/L	Equally stringent
Nitrite	1 mg/L	1 mg/L	Equally stringent
Sulfate	250 mg/L ^[2]	250 mg/L	Equally stringent
Chloride	250 mg/L	250 mg/L	Equally stringent
Phenol	0.005 mg/L ^[2]	3.5 mg/L	ORSANCO
Total Dissolved Solids	500 mg/L ^[2]	750 mg/L	ORSANCO

Parameter	ORSANCO's Criterion Concentration	Indiana's Criterion Concentration	Most Stringent Criteria
Specific Conductance	No criteria	1200 micromhos/cm	Indiana
Fecal Coliform	May not exceed 2,000 cfu/100 ml as a geometric mean calculated from five samples collected over a one-month period	May not exceed: 5,000 cfu/100 ml as a monthly average value or 5,000 cfu/100 ml in greater than 20% of samples collected in a given month or 20,000 cfu/100 ml in less than 5% of all samples collected in a given month	ORSANCO

[1] This criterion is applicable to all waters outside the mixing zone and to all designated uses.

[2] This criterion is not a human health criterion. Rather, it is identified as a taste and odor protection criterion as defined in Section 2.2 of ORSANCO's PCS.

Fish Consumption Assessments for the Ohio River

ORSANCO also conducts assessments to determine the degree to which the Ohio River supports fish consumption. In applying these assessments to Indiana reaches of the Ohio River, IDEM emphasizes that this information as presented in the Integrated Report is not intended to be a public health advisory. IDEM recommends that the public refer either to the most current [Indiana Fish Consumption Advisory](#) (FCA) and/or contact the [Indiana State Department of Health](#) (ISDH) with any specific questions or concerns regarding the health risks associated with consuming fish caught from the Ohio River. Important differences between fish consumption use impairments identified because of these assessments and the health advisories provided in the FCA are discussed in more detail in the section describing Indiana's assessment methodology for fish consumption for other Indiana waters and Lake Michigan.

ORSANCO uses both fish tissue data and water column chemistry results to make fish consumption use assessments, and its methods for evaluating data differ somewhat from IDEM's methods for similar assessments. IDEM's assessment methodology relies only on fish tissue data and requires one exceedance of the applicable criterion for impairment. IDEM's methods result in a more conservative estimate of conditions in smaller rivers and streams for which there are fewer available data. In contrast, the Ohio River is a large and complex river system. The data provided by ORSANCO monitoring programs for the assessment of fish consumption use support results in a more robust data set than those available for similar assessments of other Indiana waters. Collaboration with ORSANCO allows IDEM to focus its monitoring resources on other waters and as a result, IDEM's monitoring on the Ohio River is limited.

IDE� accepts ORSANCO's assessment methodology for fish consumption use support for the Ohio River. IDEM reviews results for methylmercury and PCBs in fish tissue independently of ORSANCO water column results using the same methods applied to other Indiana waterbodies. Where IDEM's assessment for a given reach differs from ORSANCO's assessment, IDEM accepts ORSANCO's assessment because it is typically based upon a more recent and robust data set. The criteria ORSANCO applies in its fish consumption assessments are shown in Tables G-30 and G-31.

In its 2014 cycle assessments, ORSANCO began using the U.S. EPA (2010) guidance for implementing the national methylmercury water quality criterion in CWA programs. ORSANCO's criterion for methylmercury in fish tissue is equivalent to that used by IDEM in its fish consumption assessments on other Indiana waters.

ORSANCO's monitoring programs provide results for PCBs, dioxin, and total mercury in the water column, which is used in addition to fish tissue data for assessments. For PCBs and dioxin, ORSANCO's criteria are more stringent than those contained in Indiana's WQS while Indiana's total mercury criterion is equal to ORSANCO's.

ORSANCO currently analyzes fish tissue for PCBs but does not conduct fish consumption use assessments on the data. This sampling is conducted specifically to support the development of a fish consumption advisory for the Ohio River and as such, is heavily weighted toward trophic level 4 fish. IDEM is currently evaluating the representativeness of these data for the purposes of making CWA 305(b) assessments and is working with ORSANCO to augment these results with additional sampling, which should be completed in 2025. When a more robust data set is available for assessment, IDEM will apply its 0.02 mg/kg fish tissue criterion for PCBs using ORSANCO's 10% rule as shown in Table G-30 or if time allows, may explore new methods for the assessment of PCBs in fish tissue.

ORSANCO uses two different criteria for total mercury concentrations in ambient waters, depending on the designated use being assessed. ORSANCO's aquatic life use assessments of total mercury use a chronic criterion which is less stringent than the criterion used by Indiana in downstate waters (outside of the Great Lakes basin; Table G-32), which may result in Indiana's record of aquatic life use impairments differing from those listed by ORSANCO in its biennial CWA 305(b) report. When assessing total mercury in the water column for fish consumption use assessments, ORSANCO applies a more stringent criterion equivalent to that used by IDEM because it considers bioaccumulation of mercury in fish tissue more of a human health concern than a threat to aquatic life (Table G-32). IDEM concurs with ORSANCO's rationale for the use of water column results for mercury in assessments of fish consumption and accepts ORSANCO's fish consumption use assessments for the Ohio River.

For fish consumption assessments at sites where the results for total mercury and/or PCBs in the water column conflict with the fish tissue results for that same contaminant, the fish tissue results are given more weight in the assessment decision. Fish tissue levels of these contaminants are an indicator of more direct potential exposure to individuals consuming fish from the Ohio River, whereas their concentrations in the water column are an indicator of potential bioaccumulation. IDEM concurs with ORSANCO's approach.

Table G-30: Water quality assessment criteria for determining fish consumption designated use support for the Ohio River.

Fish Consumption Use Support (Human Health) – Ohio River	
<p>ORSANCO monitoring results for total mercury, PCBs, and dioxin in water column samples were evaluated for the exceedance(s) of the applicable criteria in Indiana's WQS or ORSANCO's PCS, whichever is more stringent, and the number of times the exceedance(s) occurred. ORSANCO results for methylmercury in fish tissue samples were evaluated for the exceedance(s) of the applicable criteria in Indiana's WQS or ORSANCO's PCS, whichever is more stringent, and the number of times the exceedance(s) occurred. For sites where ORSANCO's total mercury water column sample results conflict with its fish tissue results for methylmercury, the fish tissue results are given more weight in the assessment decision. ORSANCO does not monitor for PCBs in fish tissue.</p>	
<p>ORSANCO uses a modified version that is a trophic level weighted arithmetic mean with trophic level 2 fish removed from the calculation. IDEM's methodology for assessing methylmercury in fish tissue is similar to ORSANCO's. However, based on ORSANCO's most robust data set for this large river, IDEM defers to ORSANCO's methodology for the assessment of fishable use support for the Ohio River.</p> <p>IDEM results for methylmercury and PCBs in fish tissue are reviewed independently of ORSANCO results using the same methods applied to other waterbodies in Indiana. Where IDEM's assessment for a given reach differs from ORSANCO's assessment, IDEM accepts ORSANCO's assessment.</p>	
<p>Parameter(s) - Polychlorinated biphenyls (PCBs) in Water Samples and Fish Tissue Samples, Dioxin in Water Samples, Mercury in Fish Tissue and Water Samples</p>	
Fully Supporting	<p>Water (PCBs, Dioxin and Mercury) – No exceedances or one exceedance of the applicable criterion for a given toxic pollutant or</p> <p>Fish Tissue (Methyl Mercury) - Trophic level weighted arithmetic mean concentration values for all sampling events are less than or equal to 0.3 (≤ 0.3) mg/kg wet weight</p>
Partially Supporting - Impaired	<p>Water (PCBs, Dioxin and Mercury) – More than one (>1) exceedance and less than or equal to 10% ($\leq 10\%$) of all water samples exceed the applicable criterion for a given toxic pollutant</p>
Not Supporting - Impaired	<p>Water (PCBs, Dioxin and Mercury) – More than one (>1) exceedance and more than 10% ($>10\%$) of all water samples exceed the applicable criterion for a given toxic pollutant or</p> <p>Fish Tissue (Methyl Mercury) - Trophic level weighted arithmetic mean concentration values for all sampling events are greater than 0.3 (> 0.3) mg/kg wet weight</p>

Table G-31: Assessment criteria used by ORSANCO and IDEM to determine fish consumption designated use support for the Ohio River.

Mercury (Hg)		
	Fully Supporting	Not Supporting
Concentration in Fish Tissue	Less than or equal to 0.3 (mg/kg wet weight)	Greater than 0.3 (mg/kg wet weight)
Concentration in Water	Less than or equal to 0.012 µg/L	Greater than 0.012 µg/L
Polychlorinated Biphenyls (PCBs)		
	Fully Supporting	Not Supporting
Concentration in Fish Tissue	Less or equal to 0.02 (mg/kg wet weight)	Greater than 0.02 (mg/kg wet weight)
Concentration in Water	Less than or equal to 0.000064 µg/L	Greater than 0.000064 µg/L
Dioxin		
	Fully Supporting	Not Supporting
Concentration in Water	Less than or equal to 0.00000005 µg/L	Greater than 0.00000005 µg/L

Table G-32: Comparison of criteria used to determine fish consumption use support.

Indicator	Type/Source of Criteria	ORSANCO Criteria	Indiana Criteria	Most Stringent Criteria
Methylmercury in Fish Tissue (mg/kg)	Human Health Criterion for Methylmercury (U.S. EPA, 2001)	0.3	0.3	Equally Stringent
Total Mercury in Water (µg/L)	Aquatic Life CAC (4-day average) Outside the Mixing Zone (Indiana) Not to exceed (ORSANCO, 2019)	0.012	0.012	Equally Stringent
Dioxin (2, 3, 7, 8-TCDD) in Water (µg/L)	CCC Human Health (30-day average) Outside the Mixing Zone (Indiana) CWA Section 304(a) Human Health Criterion for Priority Pollutants (ORSANCO, 2019)	0.000000005	0.0000001	ORSANCO
Polychlorinated Biphenyls (PCBs) in Water (µg/L) ^[1]	CCC for Human Health (30-day average) Outside the Mixing Zone (Indiana) CWA Section 304(a) Human Health Criterion for Priority Pollutants (ORSANCO, 2019)	0.000064 ^[2]	0.00079	ORSANCO

[1] Indiana has two criteria for PCBs that could be used to make fish consumption use assessments, both of which address different ways of preventing exposure through consumption of fish, one by preventing bioaccumulation of the contaminant in the fish and the other to protect against exposure through the consumption of contaminated fish. The criterion shown in the table is the CCC Human Health criterion for waters outside the mixing zone. Human health criteria are calculated for and intended to protect from exposure through public drinking water supplies withdrawn from surface waters and nondrinking water exposures, such as consumption of fish. Therefore, the human health criteria (both ORSANCO's and Indiana's) are appropriate for use in fish consumption assessments. The Aquatic Life CAC of 0.014 µg/L for PCBs could be used in a similar manner as the Aquatic Life CAC for total mercury to prevent bioaccumulation of PCBs in fish. However, the Human Health CCC for PCBs is far more protective and is used instead to make fishable use assessments for the Ohio River. The opposite is true for total mercury, which is why the Aquatic Life CAC of 0.012 µg/L is used instead of the Human Health CCC of 0.15 µg/L.

[2] This criterion applies to total PCBs (the sum of all congeners or all isomer or homolog or Arochlor analyses).

CWA SECTION 314 ASSESSMENTS OF INDIANA'S LAKES AND RESERVOIRS

Lakes and reservoirs in Indiana are monitored for IDEM by the Indiana Clean Lakes Program (CLP) administered by the Indiana University O'Neill School of Public and Environmental Affairs. This monitoring does not follow the rotating basin due to the unequal distribution of lakes across the Indiana landscape. In 2010, The Indiana CLP began using a randomized approach to site selection with the goal of providing statistically significant lake water quality data that may eventually be applied to the entire state. From a universe of 401 public lakes with a minimum surface area of five acres and a usable boat ramp, 80 are chosen at random to be monitored each year (Indiana CLP, 2023).

In addition to IDEM's CWA Section 305(b) assessments for fish consumption, recreational use, and PWS, IDEM also conducts trend and trophic state assessments of Indiana lakes and reservoirs. These assessments are made to satisfy the requirements of CWA Section 314, which requires states to report on the trophic status and trends of all publicly owned lakes in Indiana. Most of the data used in these assessments comes from the Indiana Clean Lakes Program (CLP). The CLP samples approximately 80 lakes each year in July and August, which is the time of year when worst-case scenarios and stable conditions (warm temperatures, thermal stratification, hypolimnetic anoxia, and algal blooms) are expected.

Prior to 2010, lakes were selected for sampling based on logistical considerations to minimize travel costs. With 401 public lakes with a minimum surface area of 5 acres and a usable boat ramp in the state, this strategy ensured that most lakes would be monitored once every five years. While these results can be applied to individual lakes, they were regionally restricted and could not be used to make statistical inferences about the trophic conditions of lakes on a statewide basis.

In 2010 and in consultation with IDEM, the CLP began using a randomized approach to select lakes for sampling in order to support a statewide assessment of trophic condition of Indiana lakes. Now, at the beginning of each sampling season, the CLP randomizes its list of public lakes and selects the first 80 on the resulting list to be monitored that season. Each season, the list is re-randomized. Using this approach, it is no longer a given that all 401 of Indiana's public lakes will be monitored in five years. However, the data collected now provides statistically significant results that can be applied to the entire state. These results are published every two years in the CLP's [Indiana Lake Water Quality Assessment Report](#).

The CLP also made changes to its sampling and analytical methods for phytoplankton, which in turn required changes in the methods IDEM uses to determine the trophic status of individual lakes and reservoirs. These changes, which are discussed in more detail in the following section, impact both IDEM's CWA Section 314 assessments and, to a lesser degree, its CWA Section 305(b) assessments.

Prior to 2010, IDEM used the Indiana State Trophic Index (ISTI) to determine the trophic status and trends in individual lakes throughout Indiana using data collected for the most part by the CLP. In 2010, the CLP made the following changes in its sampling and analytical methods for phytoplankton samples:

- Sample Collection – The CLP switched from using a 63-micron vertical tow net, which captures plankton in the water column greater than 63-microns in size, to an integrated sampler, which captures all the plankton in the water column, resulting in a more representative sample.

- Sample Analysis – The CLP changed its methods for counting plankton from natural units per liter (NU/L) to the number of cells per milliliter (cells/ml). NU/L represents a single organism, which may be a single-celled or multi-celled colonial form. Cell density measured as cells/ml is now preferred among phycologists and limnologists today because it represents the total number of phytoplankton cells including those aggregated in multi-celled colonies.

These changes eliminated some of the indicators required to calculate the ISTI. After the first season in which they were implemented, the CLP performed an analysis to determine whether plankton results expressed in cells/ml could be converted to NU/L for the purposes of calculating the ISTI. The CLP found no clear statistical relationship between the results produced by the two methods that would allow such conversion. Given this, future ISTI scores calculated with plankton data collected and analyzed with the new protocols would generate substantially different results not comparable with previous data. Comparability over time is necessary because IDEM also uses trophic scores to determine lake trends for the purposes of CWA Section 314. In order to ensure comparability, IDEM decided to abandon the use of the ISTI in favor of Carlson's TSI (Carlson, 1977) to determine the trophic condition of Indiana lakes and reservoirs.

IDEV now uses Carlson's TSI exclusively in its CWA Section 314 assessment to determine trophic status and trends for individual lakes. IDEM's CWA Section 305(b) assessment methods for lakes, which are discussed in a later section of this methodology, also rely in part on the Carlson's TSI scores. IDEM's addendum to its 2016 Integrated Report provides the most recent Carlson TSI scores for all lakes for which sufficient data exist to calculate them.

Trophic State Assessments

As noted in the previous section, IDEM now uses the Carlson Index to calculate TSI scores for Indiana lakes. The Carlson TSI score is a measure of algal biomass that can be calculated for three variables, all of which can be used as independent indicators of the amount of algal biomass present in the waterbody. This is the trophic state of the lake or reservoir in question.

The three indicators used are Secchi depth (SD), total phosphorus (TP), and Chlorophyll-a (CHL). The TSI is a scale of 0-100 based on the interrelationships of these three variables using data from northern temperate lakes in North America. The equations used to calculate the Carlson TSI are:

$$\text{TSI (SD)} = 60 - 14.41 \ln(\text{SD}) \quad \text{Equation 4}$$

$$\text{TSI (CHL)} = 9.81 \ln(\text{CHL}) + 30.6 \quad \text{Equation 5}$$

$$\text{TSI (TP)} = 14.42 \ln(\text{TP}) + 4.15 \quad \text{Equation 6}$$

Theoretically, each TSI score should independently tell the same “story” about the trophic state of a given lake. However, often they do not. This is because not all the assumptions used in the development of the Carlson Index hold true for Indiana lakes.

The index assumes that suspended particulate matter in the water controls transparency (Secchi depth) and that algal biomass is a major source of particulates. However, many Indiana lakes are affected by non-algal turbidity, which can heavily influence transparency. The index also assumes that total phosphorus is the major limiting factor in algal growth and that all forms of phosphorus are present and playing a role in the production of algal biomass. Like those associated with Secchi depth, these assumptions may not hold true for lakes impacted by

domestic sewage, which can contribute higher amounts of orthophosphate, or in lakes naturally enriched with organic material where humic acids can bind with the phosphorus reducing its concentration in the water column.

Unlike total phosphorus, which may or may not be the primary limiting factor in algal production, CHL concentration provides a more direct measure of phytoplankton abundance. Also, CHL concentration is not affected by non-algal turbidity like Secchi depth can be. Therefore, IDEM uses the TSI for CHL for trophic state classification for the purposes of its CWA 314 assessments using the classification systems shown in Table G-33. However, because divergent results for a given lake allow for comparisons that can yield additional insights into how different components of a lake's ecosystem might be functioning, all three trophic scores are reported for each lake where possible.

Table G-22: Trophic states and predicted characteristics based on Carlson TSI scores for chlorophyll-a (CHL).

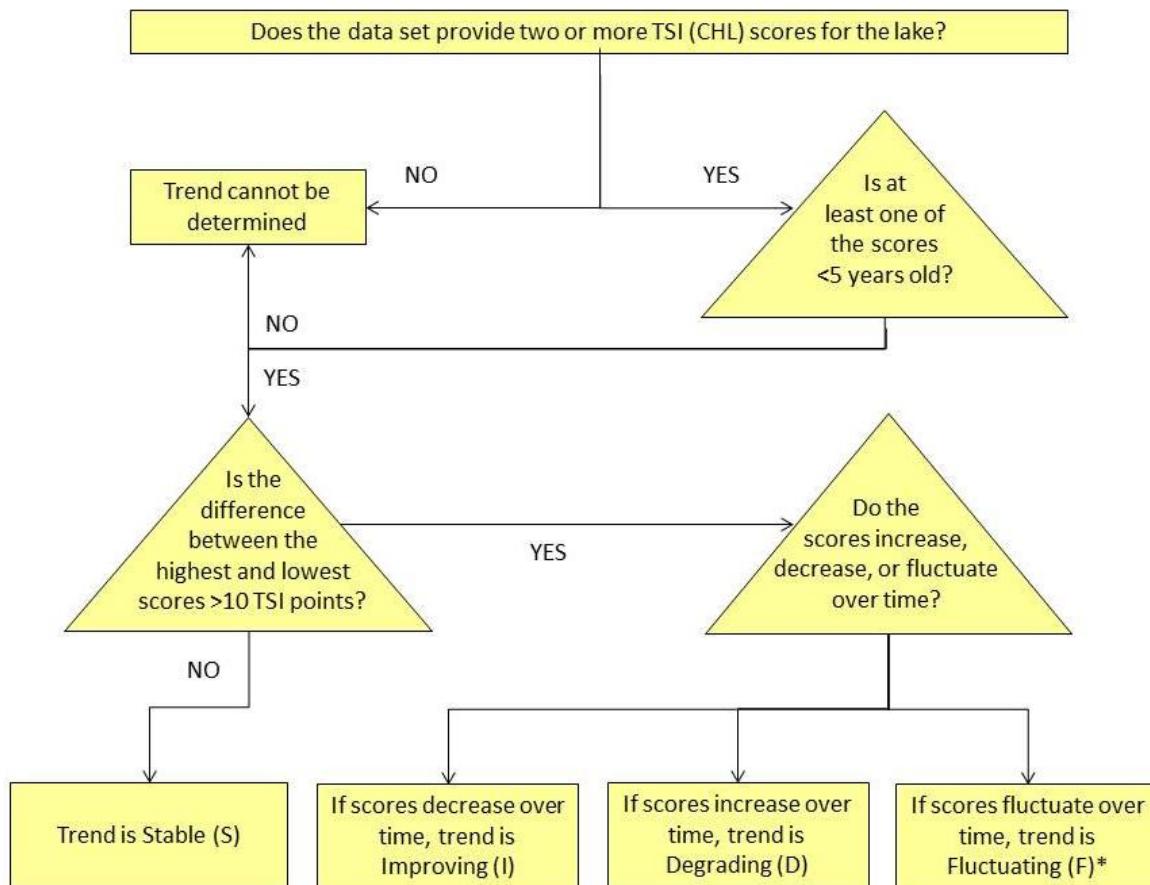
Trophic State	TSI (CHL)	Corresponding CHL values ($\mu\text{g/L}$)	Characteristics of Trophic State
Oligotrophic	Less than 40	Less than 0.95 – 2.6	Low biological productivity High transparency (clear water) Low levels of nutrients Low algal production and little/no aquatic vegetation Well oxygenated hypolimnion year-round; hypolimnion of shallower lakes may become anoxic at TSI scores greater than 30
Mesotrophic	40-50*	2.6-7.3	Moderate biological productivity Moderately transparency (moderately clear water) Moderate levels of nutrients Beds of submerged aquatic plants Increasing possibility of anoxia in the hypolimnion during summer
Eutrophic	50-70	7.3-56	High biological productivity Water has a low transparency High levels of nutrients Large amounts of aquatic plants or algae At TSI scores greater than 60, blue-green algae dominate and algal scums and excessive macrophytes possible Hypolimnion commonly anoxic; fish kills possible
Hypereutrophic	Greater than 70	56-155	Very high biological productivity Very low transparency, usually less than 3 feet

			Very high levels of nutrients Dense algae and aquatic vegetation; algal scums and few aquatic plants at TSI scores greater than 80 Fish kills and/or dead zones below the surface are common Hypolimnion persistently anoxic; Fish kills and/or “dead zones” below the surface common
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Trend Assessments of Indiana Lakes

IDE�'s method for assessing trends for CWA Section 314 is not statistical in nature. Rather, it was developed through the best professional judgement of IDE� scientists and based on very small data sets with results often separated by more than a decade. IDE� uses Carlson TSI scores for CHL for this purpose. Trend assessments require two or more Carlson TSI scores for CHL from sampling conducted from 1990 to present day with at least one score having been determined from data collected in the most recent five years (Figure G-4). Each lake with sufficient data may be assessed as stable, improving, degrading, or fluctuating, which is intended to provide insight as to how natural conditions and human activities may be impacting the lake.

Figure G-4: IDE�'s method for assessing trends in the trophic condition of Indiana lakes.



*A fluctuating trend can only be assessed for lakes with three or more TSI scores.

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