Evaluating Beneficial Use: Aquatic Life

G1. Background and Rationale

G1.1 Background

Ohio EPA has been evaluating streams using standardized biological field collection methods for nearly 40 years. Stream assessments are based on the experience gained through the collection of well over 26,000 fish population samples, nearly 13,500 macroinvertebrate community samples and close to 210,000 water chemistry samples. Aquatic life use (ALU) assessments for the 2016 Integrated Report (IR) are based on biological and chemical data collected from primarily 2005-2014 at over 4,250 wadeable stream, large river and Lake Erie shoreline sampling locations; some 2003 and 2004 data were included in the large river assessments. Ohio's Credible Data Law states that all data greater than five years in age will be considered historical, but that it can be used as long as the director of Ohio EPA has identified compelling reasons as to why the data are credible. In the case of biological monitoring data, the use of data older than five years ("historical") is necessary because not enough biological samples are gathered from enough locations each year to conduct a thorough assessment of ALU status across the state. Owing to limited staff and budget resources, it generally takes ten to fifteen years to visit a sufficient number of assessment units (AUs) and sufficiently monitor them to make ALU assessments. A more complete picture of statewide ALU health is presented when data are utilized based on the 10- to 15-year timeframe. Since water resource quality in many watersheds in Ohio today is most susceptible to changing land use patterns that are often subtle, slow to evolve and difficult to monitor and assess, the use of older data is justified.

Ohio's water quality standards (WQS) have seven subcategories of ALUs for streams and rivers (see Ohio Administrative Code 3745-1-07, http://www.epa.ohio.gov/portals/35/rules/01-07.pdf). The WQS rule contains a narrative for each ALU and the three most commonly assigned ALUs have quantitative, numeric biological criteria that express the minimum acceptable level of biological performance based on three separate biological indices. These indices are the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb) for fish and the Invertebrate Community Index (ICI) for aquatic macroinvertebrates. A detailed description of Ohio EPA's biological assessment and biocriteria program including specifics on each index and how each was derived is available (see Biological Criteria for the Protection of Aquatic Life, http://www.epa.ohio.gov/dsw/bioassess/BioCriteriaProtAqLife.aspx).

Procedures established in a specially designed 1983-1984 U.S. EPA study known as the Stream Regionalization Project (Whittier et al. 1987) were used to select reference, or least impacted sites, in each of Ohio's five Level III ecoregions (Omernik 1987). Biological data from a subset of these sites in addition to supplemental data from other least impacted Ohio reference sites were used to establish the ecoregion-specific biocriteria for each ALU. Note that some criteria vary according to stream size and some indices do not apply in certain circumstances. Ohio's WQS rule stipulates that "biological criteria provide a direct measure of attainment of the warmwater habitat, exceptional warmwater habitat and modified warmwater habitat ALUs" [OAC 3745-1-07(A)(6)]. The numeric biological criteria based on IBI, MIwb and ICI thresholds applicable to exceptional warmwater habitat (EWH), warmwater habitat (WWH) and modified warmwater habitat (MWH) waters are found in Table 7-15 of the WQS rule. Neither coldwater habitat (CWH) nor limited resource water (LRW) streams have numeric biological criteria at this time, so attainment status must be determined on a case-by-case basis. For sites and segments designated with these ALUs, attainment status was determined by using biological data attributes (e.g., presence and abundance of coldwater species in CWH streams) and/or interim assessment index targets (*e.g.*, those for LRW streams, Lake Erie lacustuaries, Lake Erie shoreline) to assess consistency with the narrative ALU definitions in the WQS.

G1.2 General Determination of Attainment Status

A biological community at an EWH, WWH or MWH sampling site must achieve the relevant criteria for all three indices or those available and/or applicable, in order to be in full attainment of the designated ALU criteria. Partial attainment is determined if one criterion is not achieved while non-attainment results when all biological scores are less than the criteria or if poor or very poor index scores are measured in either fish or macroinvertebrate communities.

A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology or other effects (ecological condition, pathogens). In this process, the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4 and 5), which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition.

Superimposed on this hierarchy is the concept of stressor, exposure and response indicators. Stressor indicators generally include activities that have the potential to degrade the aquatic environment, such as pollutant discharges (permitted and unpermitted), land use effects and habitat modifications. Exposure indicators are those that measure the effects of stressors and can include whole effluent toxicity tests, tissue residues and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. Response indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices that comprise Ohio's biological criteria. Other response indicators could include target assemblages, i.e., rare, threatened, endangered, special status and declining species or bacterial levels that serve as surrogates for the recreation uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators within the roles that are most appropriate for each indicator.

Identifying the most probable causes of observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data and biological response signatures within the biological data themselves. Thus, the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The identified causes of impairment will serve as the target parameters for future total maximum daily load (TMDL) development or regulatory program actions.

Adequate sampling is necessary to represent the ALU attainment status for large river assessment units (LRAUs, each an average 32 miles in length) or watershed assessment units (WAUs, each an average 28

mi^2 in surface area); these AUs are defined in Sections D1 and G2 and further detailed in Section J of this report. Despite Ohio EPA's significant commitment to biological sampling efforts, about 36 percent of Ohio's 1538 WAUs are precluded from this analysis because of no or insufficient data or data are considered historical (at least 10 years old). However, most large Ohio rivers with LRAU reaches have current data; however, three major rivers (four LRAUs) are being assessed with data collected just outside the 10-year window. While some data may be available for some of the AUs, many have no water quality monitoring data or the scope of monitoring was judged to be too limited to adequately generate an assessment. Generally, at least two sample sites are minimally considered necessary for a WAU assessment, although under specific circumstances, a WAU may be evaluated with one site. Presently, Ohio EPA prefers that the principal investigators make informed decisions about the data relevance for a particular AU evaluation rather than institute specific guidance on minimum effort.

Recognizing the state's limited resources, one way to increase assessment unit coverage is to utilize all available relevant data. While Ohio EPA uses data from a variety of sources in its work, the data used to determine the ALU status in this report were primarily collected by Ohio EPA. For this report and some past reports, additional biological data were provided by the Ohio Department of Natural Resources (ODNR), Northeast Ohio Regional Sewer District (NEORSD), U.S. Geological Survey (USGS), the University of Toledo, the Ohio State University, National Center for Water Quality Research (NCWQR) at Heidelberg College, Midwest Biodiversity Institute (MBI), Cleveland Metroparks and EnviroScience, Inc. Those interested in providing data to Ohio EPA for ALU attainment status determinations must attend appropriate training provided by Ohio EPA or its designee (e.g., through the Ohio Credible Data Program Level 3 Certification) and document and retain competency in Ohio EPA biological sampling protocols. All data used to make attainment determinations are carefully reviewed for consistency with all Ohio EPA methods and guidance.

G2. Evaluation Method

G2.1 Rivers and Streams: LRAUs

Decades of monitoring work by Ohio EPA have resulted in an extensive data set that includes data for all 38 LRAUs in Ohio with sampling spanning 2003-2014. The longitudinal sampling pattern (upstream to downstream and bracketing pollution sources and tributaries) used to measure fish community health, macroinvertebrate community condition and water chemistry allows WQS biocriteria attainment status to be fairly precisely estimated based on linear distances. The length of the large river deemed to be in full attainment, as described in the previous section, is divided by the total assessed length of the large river and multiplied by 100 to yield a value between 0 (no miles in attainment) and 100 (all miles in attainment). An LRAU is considered meeting its designated ALU only if a score of 100 is reported. In other words, if all miles are not in full attainment of the designated ALU, the entire LRAU is listed as impaired and placed in IR Category 4 or 5, depending on whether a TMDL is required.

G2.2 Rivers and Streams: WAUs

Beginning with the 2010 IR, the ALU assessment methodology defined the WAU as the USGS 12-digit hydrologic unit code watershed or HUC12 (1,538 HUCs averaging 28 mi^2 drainage areas), rather than the 11-digit HUC watershed (331 HUC11s averaging 130 mi^2 drainage areas) used in prior IRs. Reporting on the HUC12 scale provides information on a finer scale and allows for better reporting of watershed improvements.

This dramatic reduction in assessment unit size requires consideration of what constitutes adequate sampling within each HUC12 WAU and appropriate evaluation of the sampling results. The relatively small drainage area of the HUC12 WAU requires that the sites evaluated adequately characterize the smaller watershed. For that reason, three scores will be determined for each WAU when sufficient data make this possible. A headwater assessment score that characterizes the aquatic community of the WAU by itself will occur by evaluating all sites with drainage area <20 mi^2 together. A wading stream score will be determined for all sites with drainage area between 20 mi^2 and 50 mi^2 that occur within the WAU. The wading stream score is necessary since a site between 20 mi^2 and 50 mi^2 characterizes the entire watershed upstream from the site, potentially two or more HUC12s, not just to the extent of the WAU boundary where the site resides. A principal stream score for sites >50 mi^2 will also be calculated, as these larger streams reflect a much greater land area than sites at a smaller drainage area. The final assessment unit score will be derived from these three scores. The table below represents this graphically.

WAU (HUC12)	**Headwater Assessment-HA (<20 mi^2)**			**Wading Assessment-WA (≥ 20 mi^2 <50 mi^2)**			**Intermediate Score (IS)**	**Principal Assessment- PA (≥ 50 mi^2 <500 mi^2)**			**WAU Score**
	Total Sites	# Sites Full	HA Score	Total Sites	# Sites Full	WA Score	HA+WA / 2	Total Sites	# Sites Full	PA Score	IS+PA / 2

While the smaller size of the HUC12 WAU greatly reduces the number of sites necessary to be assessed, this creates an emphasis on appropriate sampling locations within the assessment unit. To ensure that decisions regarding adequate coverage are uniformly carried out, a flow chart for the process was created (Figure G-1). The flow chart takes into account the drainage area associated with a minimal number of sites and incorporates questions as to spatial proximity of the sites within the watershed, land use consistency among sampling locations and location of significant dischargers within the WAU.

Once it is determined that sampling coverage is adequate to conduct a WAU assessment, the number of headwater sites demonstrating full ALU attainment are divided by the total number of headwater sites within the WAU. The quotient is then multiplied by 100 to provide the headwater score.

Determining the wading stream and principal stream scores involve a similar approach. The wading stream score is based on the number of wading stream sites (sites draining a watershed between 20 mi^2 and 50 mi^2) demonstrating full attainment of ALU. The total number of wading stream sites in full attainment are divided by the total number of wading stream sites. The quotient is then multiplied by 100 to provide the wading stream score. The same methodology is used to produce the principal stream score, but the scoring is limited to those sites in the WAU draining >50 mi^2.

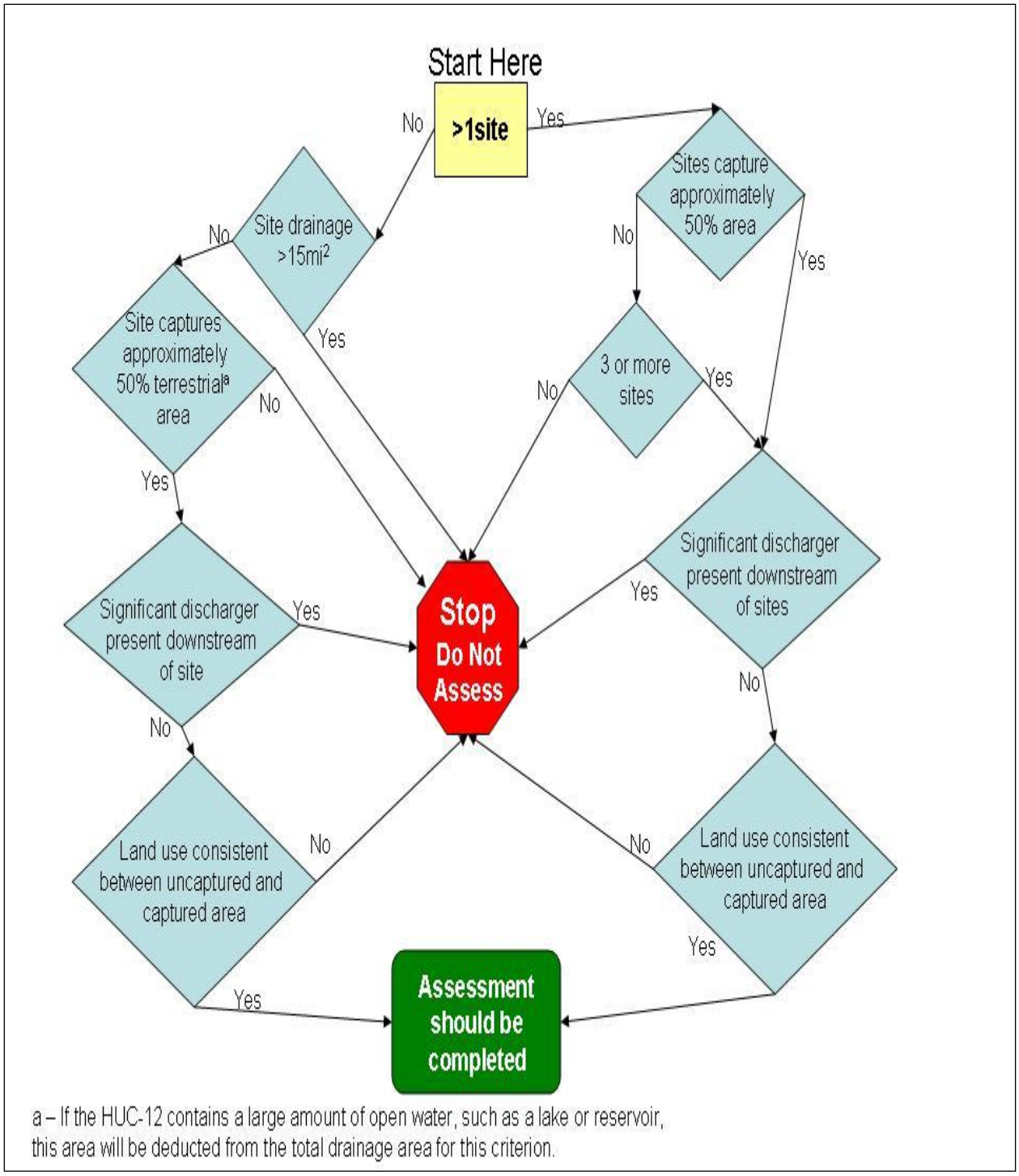

Figure G-1. Flowchart for determining if WAU score can be derived based on available sampling locations.

An intermediate WAU score is calculated as the average of the headwater and wading stream scores. The overall WAU score is derived by averaging the intermediate score and the principal stream score. For HUC12s without principal streams, the intermediate stream score will represent the overall WAU score. This procedure provides some weighting to the assessment when principal stream miles are present (i.e., more influence on the final watershed score by principal streams). This weighting is important in that full use or impairment within the principal streams reflects the overall condition of the much larger primary watershed. A manual scoring adjustment is made in those few instances when a WAU score, with many principal stream sites, is unduly affected by the results from one headwater or one wading site. A WAU meets its aquatic life designated use only if a score of 100 is reported. In other words, if all sites are not in full attainment of the designated ALU, the WAU is listed as impaired and placed in IR Category 4 or 5, depending on whether a TMDL is required.

Additional synthesis of data was used to provide aggregate statewide statistics for Ohio's universe of assessed wading and principal streams and rivers (> 20 mi^2 drainage areas) and large rivers (> 500 mi^2 drainage areas). Baseline IR statistics generated beginning with the 2010 IR were used along with the updated 2016 IR results to track trends of attainment levels across Ohio's watersheds and large rivers in an effort to quantify progress made in point and nonpoint source pollution controls and in meeting Ohio's goals of 80 percent full ALU attainment by 2020 for assessed WAU wading and principal stream and river sites and 100 percent full ALU attainment by 2020 for assessed LRAU miles.

G2.3 Lake Erie Shoreline and Islands: Lake Erie Assessment Units (LEAUs)

ALU determinations are predicated on a narrative description of the aquatic community associated with the relevant use tier. In the absence of numeric criteria, the narrative expectation provides the impairment determination. In 1997, Ohio EPA completed the document *Development of Biological Indices Using Macroinvertebrates in Ohio Nearshore Waters, Harbors, and Lacustuaries of Lake Erie in Order to Evaluate Water Quality* (Lake Erie Protection Fund Grant LEPF-06-94, undated draft). In 1999, the document *Biological Criteria for the Protection of Aquatic Life: Volume IV: Fish and Macroinvertebrate Indices for Ohio's Lake Erie Nearshore Waters, Harbors, and Lacustuaries* was produced (Ohio EPA, undated draft). Also in 1999, the document *Biological Monitoring and an Index of Biotic Integrity for Lake Erie's Nearshore Waters* (Thoma, 1999) was published as a book chapter in *Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities* (Simon, editor, 1999). The data analyses in these documents, including refinement of field sampling protocols and development of assessment indices, provide a foundation to establish numeric biological targets/expectations using IBI and MIwb scores for ALU in Lake Erie along the Ohio shoreline and in lacustuary areas. The term "lacustuary" was coined to specify the zone where Lake Erie water levels have intruded into tributary river channels. The ALU status of a lacustuary is included as part of the assessment of the tributary WAU or LRAU.

Excluding lacustuaries, the status of the Lake Erie shoreline and islands is currently evaluated using fish community assessment targets for the Lake Erie IBI and MIwb based on night electrofishing at sites included in the three LEAUs: Lake Erie Western Basin Shoreline (including Maumee Bay and Sandusky Bay), Lake Erie Central Basin Shoreline and Lake Erie Islands Shoreline. All available fish data were collected from areas within 100 meters of the mainland, bay or island shoreline. Status of LEAUs was determined by the percentage of sites in narrative full attainment of biological targets (scaled to prevailing shoreline habitat type) and where sufficient and current biosurvey data were available.

Ohio EPA was awarded a Great Lakes Restoration Initiative (GLRI) grant in 2010 to develop a comprehensive Lake Erie nearshore monitoring program. This 2011-2013 project included a strategy to design and implement a monitoring program for the Ohio Lake Erie nearshore zone (including bays, harbors and lacustuaries) that can be maintained on an annual basis. It is anticipated that future IRs will include revised AUs and an updated assessment methodology for the LEAUs based on the results of the GLRI study (For a preview of anticipated revisions, see Section I5 of the 2014 IR).

The GLRI grant was a collaborative effort between state agencies (Ohio EPA and ODNR) and major universities with Lake Erie basin research interests and expertise (the Ohio State University, University of Toledo, John Carroll University and Heidelberg University). Physical, chemical and biological parameters monitored from 2011-2013 provided data to support long-term trend analysis, establish background conditions in selected areas and conduct sampling related to the impacts of projects implemented in tributaries of the Lake Erie watershed. Data will be used to monitor the progress of implementation projects in Areas of Concern (AOCs) to restore beneficial uses, track implementation of WAPs, develop TMDLs for pollutants impairing beneficial uses, support Balanced Growth Initiative actions on the shoreline and provide updated information for IRs, Lake Erie quality index updates and updates to the Lake Erie Lakewide Management Plan (LAMP). More information about the GLRI and projects which have been proposed can be found at the Ohio Lake Erie Commission web site (see GLRI, http://www.lakeerie.ohio.gov/GLRI.aspx).

For field years 2016 and 2017, Ohio EPA is utilizing a federal fiscal year[1] 2014 Clean Water Act (CWA) Section 106 Supplemental Monitoring grant to continue funding the base monitoring program conducted by Ohio EPA at shoreline, nearshore and open water sites in Lake Erie. Details of the monitoring program are provided in the current year study plan available at the following web site: http://epa.ohio.gov/dsw/lakeerie/index.aspx#125073721-nearshore-monitoring.

Of note, future Lake Erie assessments will be the collection of shoreline data for the National Aquatic Resource Survey (NARS) of coastal waters of the United States (the National Coastal Condition Assessment - NCCA), which was conducted during the summer of 2015. Coordinated by U.S. EPA in collaboration with Great Lake states, these one-visit snapshots of lake water quality will be used to provide statistically valid national and regional assessments of Great Lakes resource condition. Additional information and 2010 NCCA results, when available, can be found at the U.S. EPA NARS website (see National Aquatic Resource Surveys, http://www.epa.gov/OWOW/monitoring/nationalsurveys.html).

G3. Results

For the 2016 IR, new aquatic life data collected in 2013 and 2014 were incorporated into the assessment database. During this period, biosurvey data from nearly 850 sampling sites located in 226 HUC12 WAUs, 56 sampling sites located in five LRAUs and 21 samples collected from the three LEAUs were available to completely or partially update previously assessed AUs or provide new assessments for AUs with unknown aquatic life status. All data were collected by the Ohio EPA or Level 3 Qualified Data Collector external sources. Watersheds intensively monitored during 2013 and 2014 included the lower Mahoning River, Bokes Creek, lower Muskingum River tributaries, Stillwater River, St. Joseph River, Tiffin River, lower Auglaize River tributaries, Rocky River, Wills Creek, Southwest Ohio River tributaries and Big Darby Creek basins. Large rivers intensively sampled included the Mahoning River, Cuyahoga River,

[1] The federal fiscal year (FFY) is from October 1 to September 30.

Wills Creek, Stillwater River and Tiffin River. Detailed watershed survey reports for many of the basins mentioned above are or will be available from the Ohio EPA Division of Surface Water (see Biological and Water Quality Report Index, http://www.epa.ohio.gov/dsw/document_index/psdindx.aspx).

A further examination of individual AUs was made to determine status changes caused by site data collected during 2003 and 2004 that now exceed the 10-year data threshold and have become "historical" since the 2014 IR. From this examination, it was determined that data from 119 HUC12 WAUs were now insufficient to provide adequate spatial coverage either due to (1) all data being age restricted or (2) enough of the data are age restricted that the number of sites fell below the minimum needed to assess. These AUs are not being delisted if currently Category 5. Significant basins affected, along with last sampling year, include the Olentangy River (2003), Toussaint Creek (2003), Wakatomika Creek (2003), Mad River (2003), lower Grand River (2004) and Hocking River (2004), as well as numerous WAUs in the Tuscarawas River basin assessed in 2003 and 2004. Four LRAUs (Grand River, Hocking River [2] and Mad River) were last sampled in 2003 and/or 2004. However, as these three large rivers were not expected to have changed significantly since the previous sampling, the data is being retained and used in the overall assessment of the large river data.

Summarized 2016 IR statistics for aquatic life assessments for large river, watershed and Lake Erie AUs as well as the comparable statistics from the 2002-2014 IRs are tabulated in Table G-1. More detailed ALU results and statistics for each 2016 AU (watershed, large river and Lake Erie units) with current data are provided at Ohio EPA web pages which can be accessed at http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx.

G3.1 LRAUs

LRAUs in Ohio (38 LRAUs spanning 23 rivers with watersheds in excess of 500 square miles and totaling 1,248 river miles) reflected a small decline in percent of monitored miles in full attainment compared to the same statistic reported in the 2014 IR (Table G-1, Figure G-2). Based on monitoring through 2014, the full attainment statistic now stands at 87.4 percent (1063 of 1216 assessed LRAU miles), down 1.8 percent from the 2014 IR. It should also be noted that there was at least one site in 20 of the 38 LRAUs that was not fully supporting the ALU, so those 20 LRAUs are considered impaired (Table G-4).

Significant large rivers assessed during 2013 and 2014 included the Mahoning River (2013), Tiffin River (2013), Stillwater River (2013), Wills Creek (2014) and Cuyahoga River (2014). Attainment statistics for these five rivers (5 LRAUs) are as follows:

- Mahoning River: 45 percent full attainment over 35 miles
- Tiffin River: 100 percent full attainment over 20 miles
- Stillwater River: 95 percent full attainment over 32 miles
- Wills Creek: 55 percent full attainment over 44 miles
- Cuyahoga River: 69 percent full attainment over 24 miles

While both the Stillwater River and Cuyahoga River have had fairly recent assessments prior to 2013 and 2014, respectively and neither reflected significant change, assessments of the other three rivers documented important positive change since their first comprehensive monitoring in the early 1990s, as follows:

- Mahoning River (1994): 0 percent full attainment over 35 miles
- Tiffin River (1992): 0 percent full attainment over 20 miles
- Wills Creek (1994): 16 percent full attainment over 44 miles

In spite of these three rivers showing substantial improvement in ALU attainment based on the most recent monitoring and assessment, the overall 1.8 percent decline in total LRAU miles in full attainment between the 2014 IR and 2016 IR was due to fact that, collectively, the percentage of miles in full attainment for the Mahoning and Wills AUs stands at only 50 percent. These LRAUs were reported with historical data status in past IRs and, thus, were not included in attainment statistics.

Progress towards the "100 percent by 2020" ALU goal for Ohio's large rivers is depicted in Figure G-2. Between the 2002 and 2016 reporting cycles, the percentage of large river miles in full attainment has increased from 62.5 percent to 87.4 percent and, for the first time, nearly 100 percent of total miles have been assessed. Continued success in approaching the 100 percent full attainment threshold for 100 percent of large river miles by 2020 will be dependent on sustained resources allocated to monitoring LRAUs with an emphasis on those which are likely to become historical between now and 2018 (the last year of data to be included in the 2020 goal assessment) and which are currently not scheduled to be resampled before then (8 large rivers/10 AUs representing nearly 310 large river miles).

G3.2 WAUs

For the 2016 IR, the average HUC12 watershed assessment unit (WAU) score reflected a positive increase from the corresponding score reported in the 2014 IR (Table G-1, Figure G-3). Based on monitoring through 2014, the average HUC12 WAU score stands at 61.5, a 2.3 point increase from the 2014 IR and typical of what has been observed over the last several cycles (a pattern of steady increases of 1-2 points). Included in Table G-1 and depicted in Figure G-3 is the corresponding average score based on the old HUC11 WAUs, which were tracked from 2002 through 2010 and were used to gauge the progress of the "80 by 2010" ALU goal as reported in the 2010 IR.

Table G-2 depicts the breakdown of site full attainment based on the watershed size category used to determine an individual watershed's score based on available sites in the HUC12 WAU. As in previous reports, the results show that biological impairment is more likely at sites on small streams (nearly 1 in 2 headwater sites are impaired) and that impairment lessens significantly as sites drain larger areas (nearly 7 in 10 principal stream and small river sites are in full attainment). This phenomenon correlates well with the most widespread causes associated with aquatic life impairment in these watersheds.

Table G-3 and Figure G-4 depict the attainment status breakdown of the 3875 WAU sites collected from 2005-2014 by designated or recommended (existing) ALU. As would be expected, most sites (72 percent) are assigned the base warmwater habitat (WWH) ALU, for which attainment of biocriteria signifies meeting the fishable/swimmable goal of the Clean Water Act (CWA). For this cycle, about 53 percent of assigned WWH sites are meeting the WWH use. About 20 percent of the 3875 sites are assigned more protective ALUs (exceptional warmwater habitat-EWH, coldwater habitat-CWH or a dual use which includes both-EWH/CWH). The remaining sites (8 percent) are assigned "less than goal" CWA uses (MWH and LRW). Both more protective and "less than goal" uses are only assigned after a use attainability analysis has been conducted based on rigorous field data and this study determines that the assigned ALU is the most appropriate to protect existing high quality/unique biological communities or set reasonable restoration benchmarks for communities challenged by pervasive anthropogenic or natural influences. As might be expected, a high percentage of sites assigned to more protective uses

are fully meeting that use (84 percent) while those with assigned "less than goal" uses have low achievement of even the lower expectations of these uses (57 percent meet).

Table G-4 lists the top five ALU impairment causes for the period 2003 through 2014. For this time period, principal causes for HUC12 WAU impairments were those primarily related to landscape modification issues involving agricultural land use and urban development. These types of impairments would be most manifest in smaller streams, a fact backed up by the numbers presented in Table G-2. It is important to note that between 24 percent and 48 percent of impaired HUC12 WAUs had at least one monitored site impaired by one of these individual causes and many WAUs had several sites affected by three or more of the five causes listed as responsible for the ALU impairment. This would not be an unusual situation given the frequently close association between these impairment causes (e.g., nutrients, sedimentation/siltation, habitat modifications and hydromodifications in rural/agricultural landscapes relying on channelization and field tiles for drainage). Also of note is the prevalence of HUC12 WAUs and LRAUs which are impaired by the generic organic enrichment cause category; 30 percent of impaired WAUs show "sewage" related impairments such as high biochemical oxygen demand, elevated ammonia concentrations and/or in-stream sewage solids deposition. Eight of 20 impaired LRAUs also note sewage related causes. While the WAU percentage is not as high as reported in the 2014 IR, it is still comparable to those percentages reported in past IRs that tracked these cause statistics, which suggests that adequate treatment and disposal of human and animal wastes via wastewater treatment plants, home sewage treatment systems and land applications of septage and animal manure continue to be critical water quality issues in many Ohio watersheds.

Progress towards the "80 percent by 2020" ALU goal for Ohio's wading and principal stream and river sites (those monitored sites draining watersheds between 20 and 500 square miles) is depicted in Figure G-5. Contrasted with the 2010 IR statistic, when the 2020 goal benchmark was established, the percentage of qualifying sites in full attainment has increased nearly five percentage points with an increase from 61.4 percent to 66.1 percent. If this rate of change remains consistent over the next four years (*i.e.*, with new data collected through 2018), the statistic will approach 70 percent but will not reach the goal by the time the 2020 IR is produced. It is readily apparent that more proactive implementation of watershed recommendations in TMDL reports and watershed action plans (WAPs) will be needed to recover impaired aquatic communities and protect those currently meeting aquatic life expectations in order to meet the 80 percent goal. It will also be critical that resources be directed to follow-up monitoring in areas with implemented restoration and protection projects so that success of efforts can be documented and reflected in future goal statistics. This latter effort is now well underway in survey areas with TMDLs approved and implemented beginning in the late 1990s and is an ongoing activity in support of the Ohio EPA Nonpoint Source Program (see http://epa.ohio.gov/dsw/nps/index.aspx for more program information).

G3.3 Lake Erie Assessment Units (LEAUs)

For previous IRs, assessments were based on past data collected in the mid-1990s through the early 2000s. Significant changes appear to be ongoing in Lake Erie and, as a result, these older data are no longer being used to determine ALU attainment status in the three LEAUs. However, these data are used in the following discussion to highlight key trends in fish community condition over two time periods of sampling.

From 2011-2014, 116 fish community collections using night electrofishing methods (day electrofishing at two Sandusky Bay sites) were taken from 45 sites spread over the three LEAUs and these data serve

as the core data set for assessment of Lake Erie shoreline status. For this cycle, and despite the rather limited amount of data, the assessment methodology as used in past IRs was once again used to determine ALU status in the LEAUs. This included the average IBI and MIwb scores for all sampling passes available at a given sampling location which were then compared to target expectations based on the prevailing bottom substrate type at that location (hard bottoms, *e.g.*, bedrock, boulder, rubble or soft bottoms, *e.g.*, sand, silt, muck). Results for the IBI and MIwb scores at 31 shoreline sites (excluding Sandusky Bay and the Lake Erie Islands sites) compared to expectations are presented in Figures G-6 and G-7.

All three LEAUs remain Category 5 with significant impairment of sites due primarily to tributary loadings of nutrients and sediment, exacerbated by continued trophic disruptions caused by the proliferation of exotic species, algal blooms and shoreline habitat modifications. In the aggregate, only six fish community collections were assessed as fully attaining the designated EWH ALU; 14 were assessed as partially attaining and the remaining 25 were in non-attainment (Table G-1). With the exception of attainment results reported for the 2012 IR, when the size of the database was severely restricted, the percentages of sites in full attainment of the EWH ALU have not changed significantly through the IR cycles. One positive may be the increased percentage of sites in partial attainment, at the expense of non-attainment, for the last few cycles when compared to previous earlier cycles. All partial attainment sites were due to MIwb scores meeting expectations which may reflect better aggregated numerical abundance of fish, increased biomass and structural evenness, the latter being a product of species richness and the distribution of numbers and biomass among the various species.

A breakdown of results reflects the following site attainment status for each of the three LEAUs:

LEAU Name	# Sites	# Full	# Partial	# Non
Western Basin Shoreline (incl. Maumee and Sandusky bays)	19	5	7	7
Central Basin Shoreline	22	1	6	15
Lake Erie Islands Shoreline	4	0	1	3

Three of the six sites, with fish communities meeting ALU target expectations, were collected from Sandusky Bay with two full attainment sites collected from the western basin shoreline along the eastern extent of Maumee Bay (between Immergrun and Cedar Point) and one full attainment site along the West Harbor shoreline just to the west of the Cuyahoga River in Cleveland. At several partial attainment sites where MIwb scores were exceeding target expectations, IBI scores, while not quite meeting targets, were approaching acceptable scores. These shoreline locations were located in Sandusky Bay and near the Grand River, Ashtabula River and Conneaut Creek along Ohio's eastern end of the Central Basin.

For this IR, an attempt was made to compare the recent data set collected 2011-2014 to similar electrofishing results collected from co-located sites sampled in the 1990s and early 2000s. Resulting comparisons of Lake Erie IBI and MIwb scores by individual sampling passes at 45 sites and matching historical sites are presented in Figures G-8 and G-9. For the most part, there seemed to be little change in medians and ranges of these two indices at the sites spanning the two timeframes. The biggest changes appeared linked to Islands Shoreline sites but that may be more an artifact of the small sample sizes. One Lake Erie IBI component metric which did seem to reflect a significant change across the two timespans was the proportion of exotic species by numerical abundance in each sampling pass (Figure G-10). For Lake Erie, typical common exotic species which can be collected using the electrofishing

sampling method include round and tube nose goby, white perch, ghost shiner, gizzard shad, common carp and goldfish. Initial assessment of 2011-2014 results implicates large populations of white perch and gizzard shad as the culprits causing the proportional increases in exotic species collected when compared to earlier collections.

Table G-1. Summary of ALU assessment for Ohio's WAUs[2], LRAUs and LEAUs: 2002-2016 IR cycles.

IR Cycle	2002 (1991-2000)	2004 (1993-2002)	2006 (1995-2004)	2008 (1997-2006)	2010 (1999-2008)	2012 (2001-2010)	2014 (2003-2012)	2016 (2003-2014)
HUC11 Watershed AUs (331)								
No. AUs Assessed (% of total)	224 (68%)	225 (68%)	212 (64%)	218 (66%)	221 (67%)	-	-	-
No. Sites Assessed	3272	3620	3785	4030	4200	-	-	-
Average AU Scores								
Full Attainment	**46.6**	**48.3**	**52.5**	**54.7**	**58.5**	**-**	**-**	**-**
Partial Attainment	25.2	23.6	22.6	22.4	21.2	-	-	-
Non-Attainment	28.2	28.1	24.9	22.9	20.3	-	-	-
HUC12 Watershed AUs (1538)								
No. AUs Assessed (% of total)[3]	-	-	-	-	999 (65%)	908 (59%)	933 (61%)	983 (64%)
No. Sites Assessed	-	-	-	-	4200	3867	3876	3875
Average AU Score[4]	-	-	-	-	**56.7**	**57.7**	**59.2**	**61.5**
% Sites Full Attainment	-	-	-	-	55.1	57.0	57.8	59.3
% Sites Partial Attainment	-	-	-	-	20.0	21.6	22.3	20.7
% Sites Non-Attainment	-	-	-	-	24.9	21.4	19.9	20.0
Large River AUs (23 rivers/38 AUs totaling 1247.54 Miles)								
No. Rivers/AUs Assessed	22	21	17	16	18/30	18/31	22/37	23/38
No. Sites Assessed	422	425	374	278	265	312	332	358
No. Miles Assessed (% of total)	905 (70%)	918 (71%)	873 (68%)	850 (66%)	852 (69%)	984 (80%)	1147 (92%)	1216 (98%)
% Miles Full Attainment	**62.5**	**64.0**	**76.8**	**78.7**	**93.1**	**89.0**	**89.2**	**87.4**
% Miles Partial Attainment	23.0	21.4	15.1	13.9	5.5	7.5	6.3	8.7
% Miles Non-Attainment	14.5	14.6	8.1	7.4	1.4	3.5	4.5	3.9
Lake Erie AUs (3)								
No. AUs Assessed	3	3	3	3	3	3	3	3
No. Sites Assessed[5]	92	111	93	49	34	23	38	45
% Sites Full Attainment	**12.0**	**18.0**	**19.4**	**10.2**	**14.7**	**30.4**	**13.2**	**13.3**
% Sites Partial Attainment	13.0	14.4	16.1	22.4	17.7	30.4	34.2	31.1
% Sites Non-Attainment	75.0	67.6	64.5	67.4	67.6	39.2	52.6	55.6

[2] WAUs for the IR 2002-2010 cycles were based on HUC11s; WAUs transitioned to HUC12s for cycles beginning with 2010.

[3] 2010 statistics based on direct assessment of HUC12 AUs with data collected between 2005 and 2008 (n=545) and HUC11 extrapolated assessment of HUC12 AUs with data collected between 1998 and 2004 (n=454). 2012, 2014 and 2016 IR assessments based on direct assessment of HUC12 AUs with data collected between 2001 and 2010 (n=908), 2003 and 2012 (n=933) and 2005 and 2014 (n=983), respectively.

[4] Statistic based on the average of available AU scores with current data, derived as explained in Section G2.2.

[5] Data for sites used in the 2002-2012 IR cycles were generally collected between 1993 and 2002; for the 2014 and 2016 IRs, data were collected 2011-2014.

Table G-2. Breakdown by watershed size category of sites in full, partial and non-attainment in monitored WAUs (983 HUC12s) based on data collected from 2005-2014.

Watershed Size Category (mi^2)	# of Sites (% of total)	Number of Sites in Full Attainment (%)	Number of Sites in Partial Attainment (%)	Number of Sites in Non-Attainment (%)
0-20 (headwater)	2267 (58.5)	1233 (54.4)	466 (20.5)	568 (25.1)
20-50 (wading)	634 (16.4)	387 (61.0)	144 (22.7)	103 (16.3)
50-500 (principal)	974 (25.1)	676 (69.4)	193 (19.8)	105 (10.8)
Total	3875	2296 (59.3)	803 (20.7)	776 (20.0)

Table G-3. Breakdown by designated or recommended ALU of sites in full, partial and non-attainment in monitored WAUs (983 HUC12s) based on data collected from 2005-2014.

ALU	# of Sites (% of total)	Number of Sites in Full Attainment (%)	Number of Sites in Partial Attainment (%)	Number of Sites in Non-Attainment (%)
EWH	456 (11.8)	370 (81.1)	81 (17.8)	5 (1.1)
EWH/CWH	85 (2.2)	76 (89.4)	6 (7.1)	3 (3.5)
CWH	210 (5.4)	182 (86.7)	15 (7.1)	13 (6.2)
WWH	2800 (72.3)	1482 (52.9)	664 (23.7)	654 (23.4)
MWH	253 (6.5)	157 (62.1)	37 (14.6)	59 (23.3)
LRW	71 (1.8)	29 (40.8)	-	42 (59.2)
Total	3875	2296 (59.3)	803 (20.7)	776 (20.0)

- EWH: exceptional warmwater habitat; CWH: coldwater habitat; WWH: warmwater habitat; MWH: modified warmwater habitat; LRW: limited resource water
- Bold text indicates use that meets the minimum fishable/swimmable goal of the Clean Water Act.
- Bold/italics text indicates use that exceeds the minimum fishable/swimmable goal of the Clean Water Act.
- Plain text indicates "less than goal" use that does not meet the minimum fishable/swimmable goal of the Clean Water Act.

Table G-4. Prevalence of the top five causes of aquatic life impairment in watershed and LRAUs based on biological and water quality survey data collected from 2003-2014.

Assessment Unit (AU)	#	Number and Percentage of Monitored AUs with Impaired ALU Listed with a Top Five Cause of Impairment*				
		Siltation/ Sedimentation	Habitat Modification	Nutrient Enrichment	Organic Enrichment	Hydomodification
Watershed	**1,538**					
Monitored 2005-2014	983	304 (48%)	226 (35%)	221 (35%)	190 (30%)	151 (24%)
Impaired ALU	638					
No impairment	345					
Large River	**38**					
Monitored 2003-2014	38	7 (35%)	8 (40%)	8 (40%)	8 (40%)	8 (40%)
Impaired ALU	20					
No impairment	18					

* Listed as an ALU impairment cause for at least one stream within the watershed AU or one reach within the LRAU

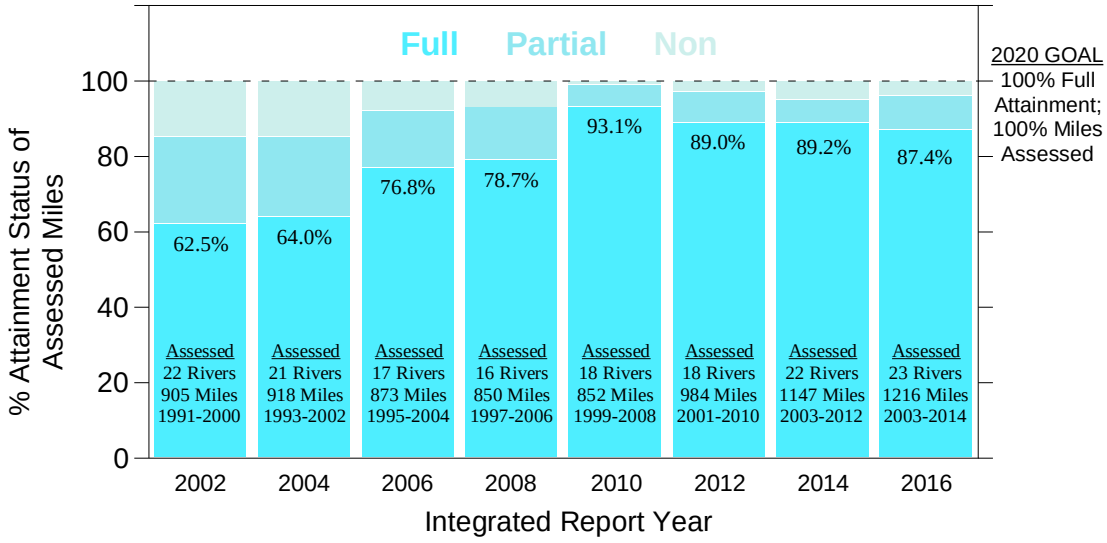

Figure G-2. Percent attainment status and goal progress ("100% by 2020") for monitored miles of Ohio's LRAUs (23 rivers/38 AUs/1247.54 miles total).
Note: Data compiled over the last eight IR cycles with the current 2016 cycle including data collected from 2003-2014.

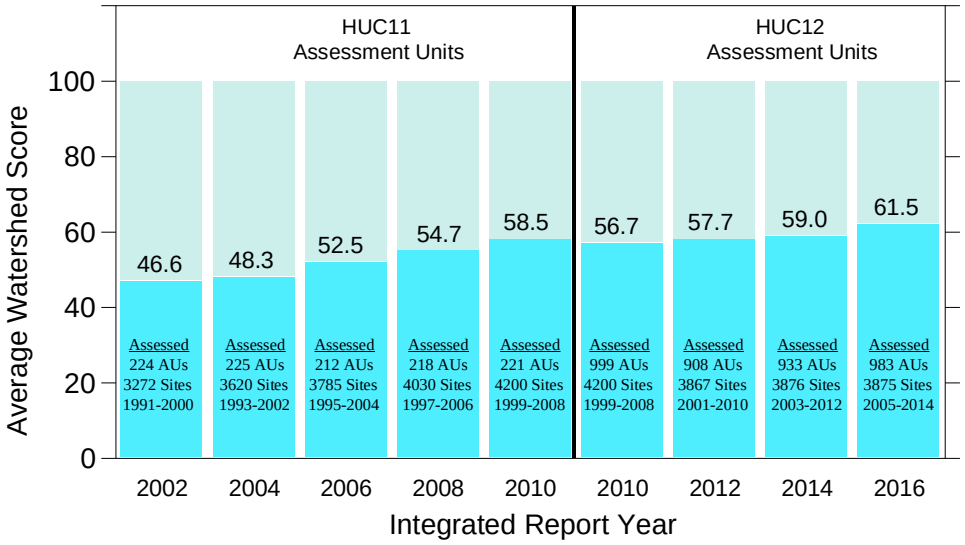

Figure G-3. Average full attainment watershed score for monitored Ohio HUC11 WAUs (IR cycles 2002-2010) and HUC12 WAUs (IR cycles 2010-2016).
Note: Data compiled over the last eight IR cycles with the current 2016 cycle including data collected primarily from 2005-2014.

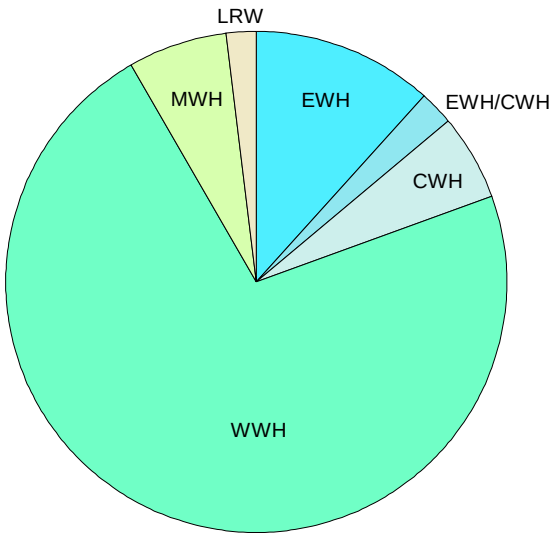

Figure G-4. Breakdown by designated or recommended ALU of sites in monitored WAUs (983 HUC12s) based on data collected primarily from 2005-2014 (n= 3875 sites).

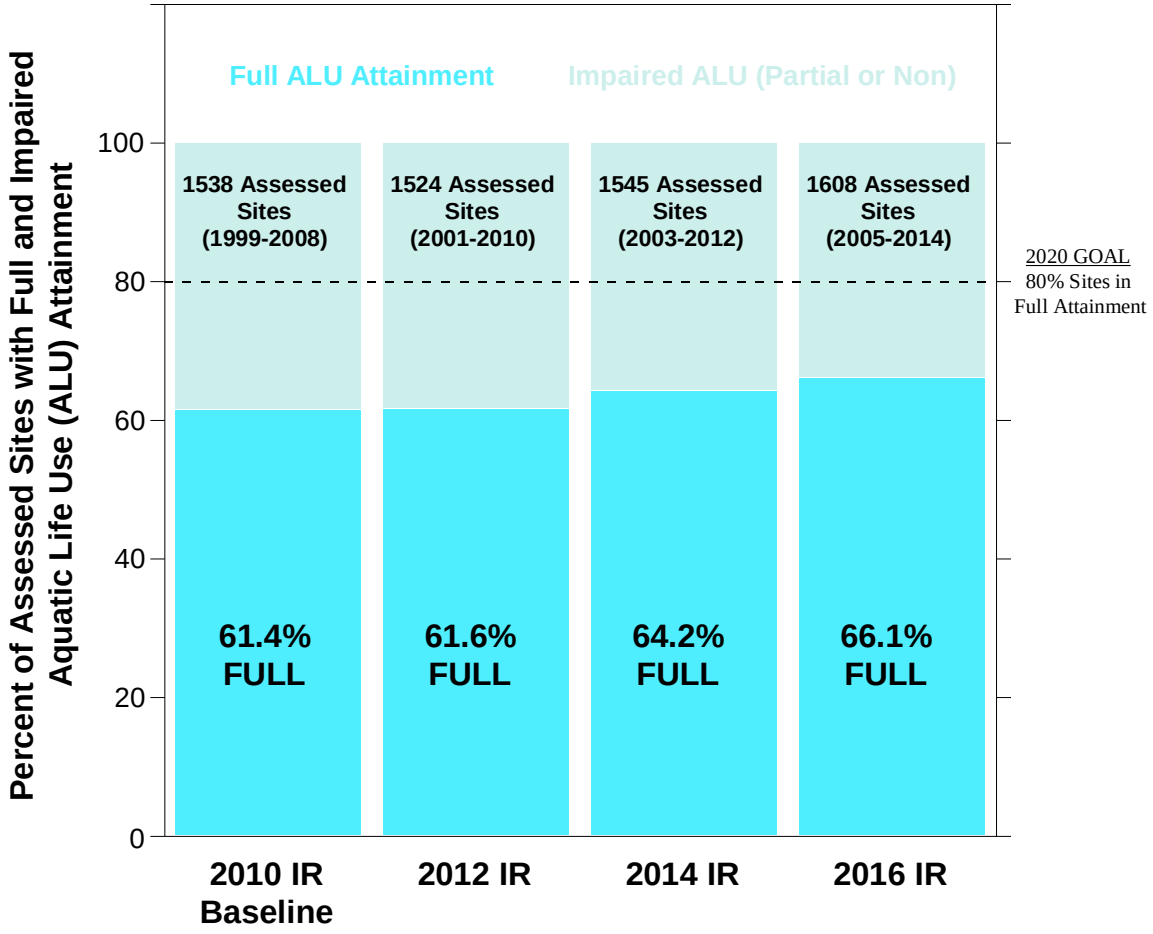

Figure G-5. Status and trend of ALU "80% by 2020" goal for wading and principal stream and river sites in Ohio based on the last four IR cycles.

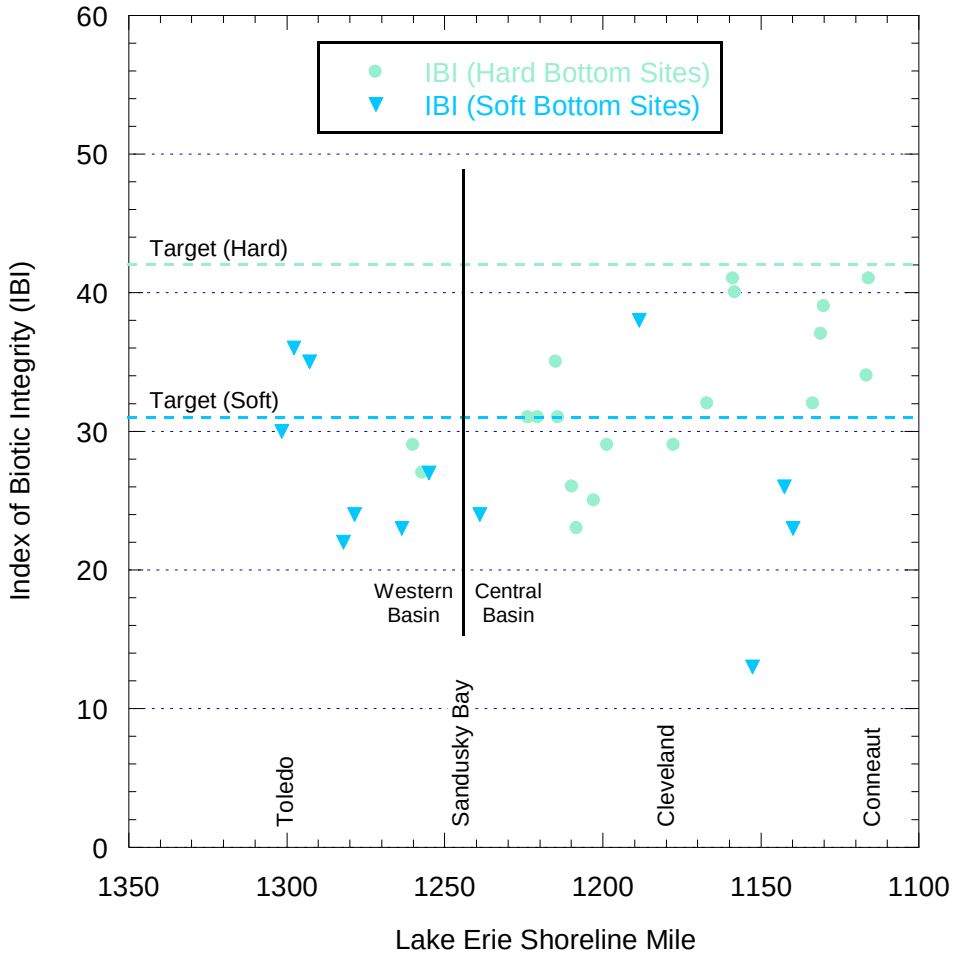

Figure G-6. Average IBI scores compared to habitat-scaled targets based on sampling passes available for sites along the Lake Erie shoreline from Toledo to Conneaut, 2011-2014. Figure does not include average IBI scores for Sandusky Bay or Lake Erie Islands shoreline sites.

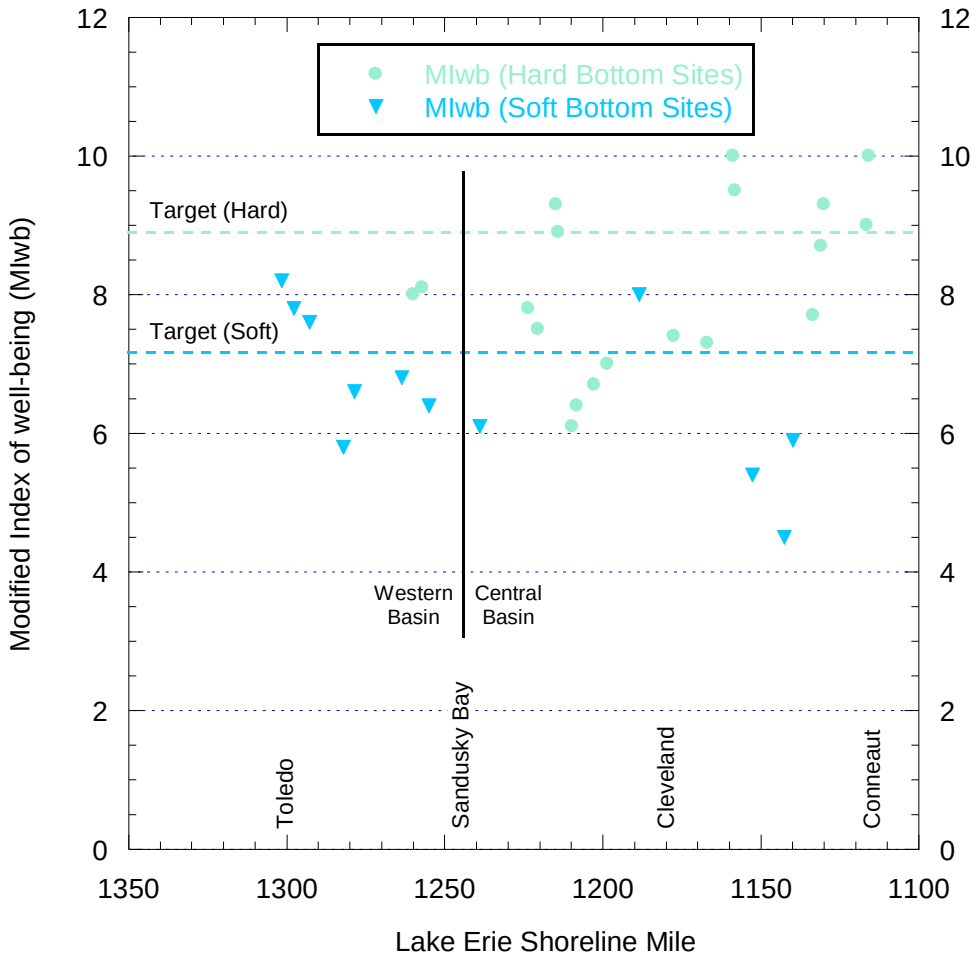

Figure G-7. Average MIwb scores compared to habitat-scaled targets based on sampling passes available for sites along the Lake Erie shoreline from Toledo to Conneaut, 2011-2014. Figure does not include average MIwb scores for Sandusky Bay or Lake Erie Islands shoreline sites.

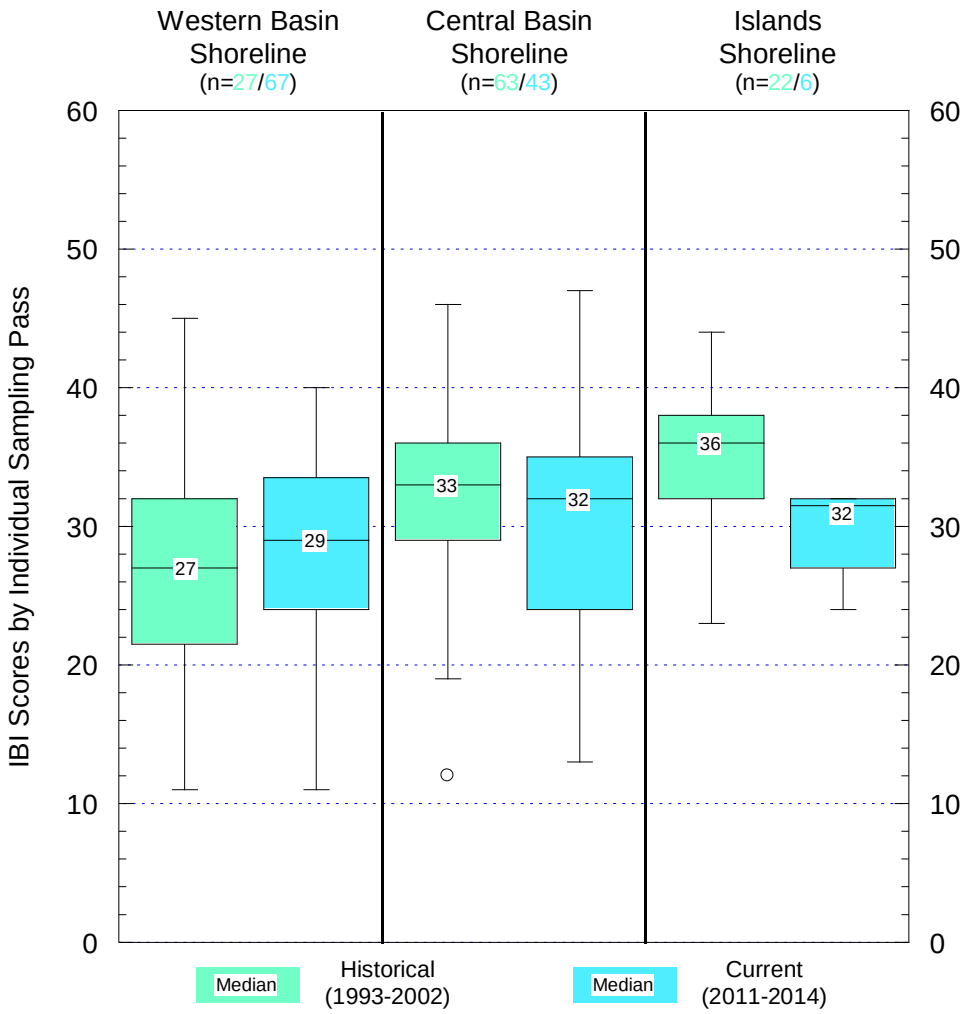

Figure G-8. Comparison of IBI scores for individual electrofishing sampling passes at 45 Lake Erie shoreline sampling locations collected 2011-2014 and at co-located sampling locations collected 1993-2002.

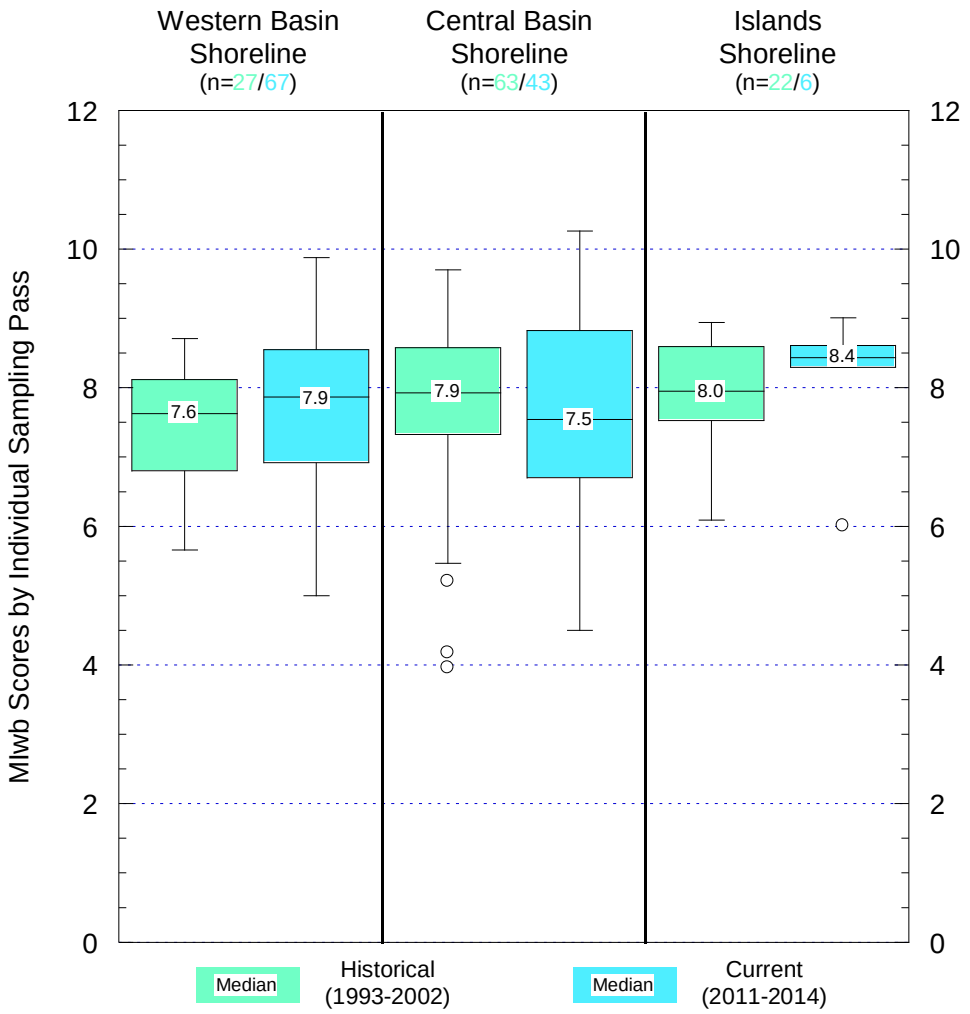

Figure G-9. Comparison of MIwb scores for individual electrofishing sampling passes at 45 Lake Erie shoreline sampling locations collected 2011-2014 and at co-located sampling locations collected 1993-2002.

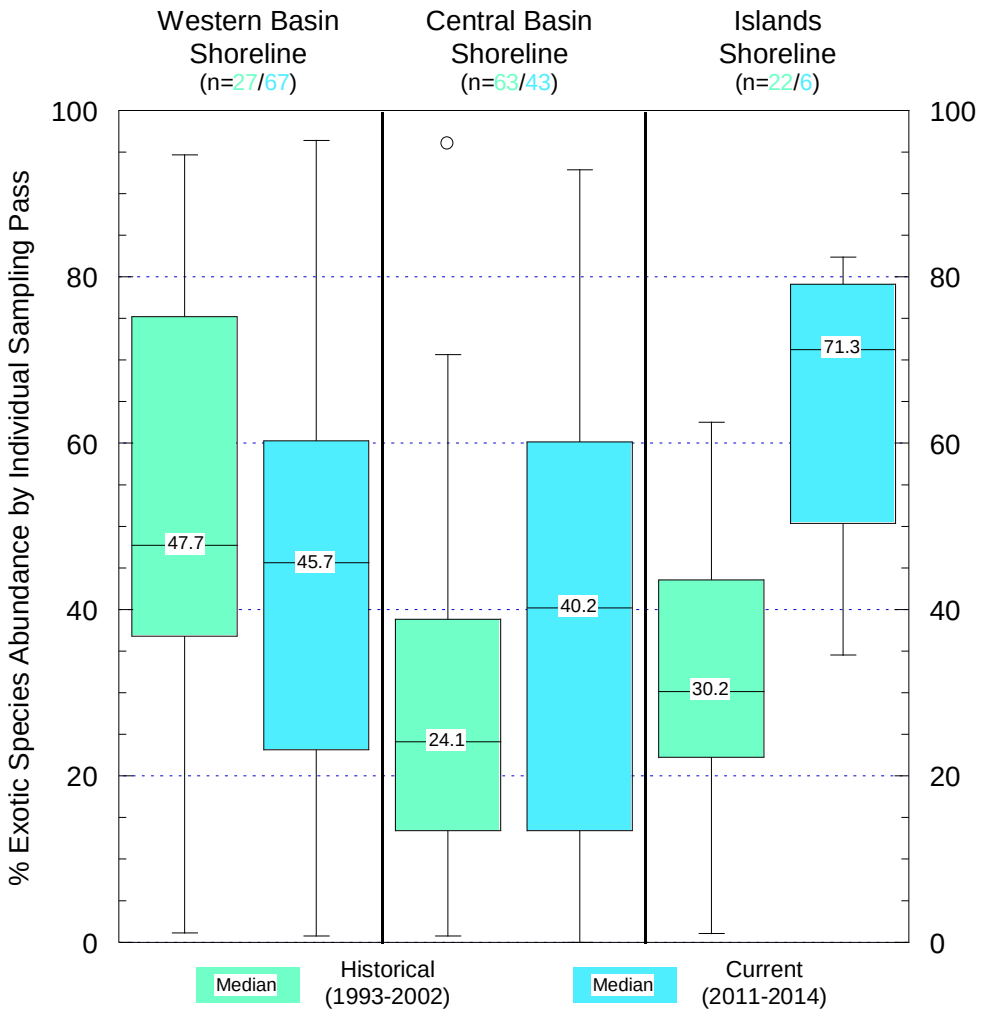

Figure G-10. Comparison of exotic species abundance as a proportion of total catch for individual electrofishing sampling passes at 45 Lake Erie shoreline sampling locations collected 2011-2014 and at co-located sampling locations collected 1993-2002.