

June 2010

## Methods of Assessing Habitat in Lake Erie Shoreline Waters Using the Qualitative Habitat Evaluation Index (QHEI) Approach (Version 2.1)



Arcola Creek Lacustrary, Lake Co. Photo by Scott Winkler

Ted Strickland, Governor  
Lee Fisher, Lt. Governor  
Chris Korleski, Director

**Acknowledgements: Version 2.1**

This version of the Lake Erie/Lacustrary QHEI manual was revised by Paul Anderson, Ohio EPA Division of Surface Water, Northeast District Office with the assistance of Roger Thoma (Ohio EPA, retired). The assistance of Ohio EPA Northeast District Office staff Scott Winkler and Bill Zawiski in proof-reading and review of the document and Megan Talcott in conversion of the original document is gratefully acknowledged. Dave Altfater and Marc Smith of the Division of Surface Water Ecological Assessment Section provided technical review and edits for the final document.

**Acknowledgements: original document (Ohio EPA, 2004)**

Roger Thoma of the Ohio Environmental Protection Agency (Ohio EPA) Northeast District Office, designed the study, directed and conducted field work, analyzed data, and authored this publication. The L-QHEI could not have been developed without the assistance of Ohio EPA interns Kelly Capuzzi, Steve Fouts, Matt Raffenburg, Julie Sullivan, Gina DeMarina, Mike Smith, Corey Timko, Chris Winslow, Paul Pira, Chris Balough, Kelly Riesen, Dan Cacho, Matt Brown, and Ryan Laurich. Ohio EPA Northeast District Office employees Steve Tuckerman, Bill Zawiski, Bob Davic, Paul Anderson, and Scott Winkler; and Ecological Assessment Section employees Marc Smith, Jeff DeShon, Robert Miltner, Ed Rankin, Chris Yoder, Chuck McKnight, and Chuck Boucher helped in the field and with report reviews. Laura Fay of the Ohio EPA Central Office was instrumental in grant preparation and acquisition and in reviewing drafts of this report. Funding for finalization of the field work to collect LQHEI reference site information and prepare this manual was provided by the Ohio Department of Natural Resources (ODNR) from a Coastal Zone Management Grant from the National Oceanic and Atmospheric Administration (NOAA).

**Table of Contents**

Acknowledgements: Version 2.1 ..... i

Acknowledgements: original document (Ohio EPA, 2004)..... i

Table of Contents..... ii

1. Introduction ..... 1

    1.1. River Code, River Mile, Waterbody ..... 2

    1.2. Specific Location, Latitude/Longitude..... 3

    1.3. Distance, Date, Scorer's Initials, Comments ..... 3

2. Habitat Characteristics: The Metrics ..... 4

    2.1. Metric 1: Substrate ..... 4

        2.1.1. Substrate Type and Origin ..... 4

            2.1.1.1. Substrate Type ..... 4

            2.1.1.2. Substrate Origin ..... 6

        2.1.2. Substrate Quality ..... 7

            2.1.2.1. Silt ..... 7

            2.1.2.2. Silt Origin..... 7

    2.2. Metric 2: Cover Types ..... 7

        2.2.1. Cover Types ..... 7

        2.2.2. Cover Amount..... 8

    2.3. Metric 3: Shoreline Morphology..... 9

        2.3.1. Shoreline Sinuosity ..... 9

        2.3.2. Development ..... 10

        2.3.3. Modification ..... 10

2.3.4. Stability ..... 11

2.3.5. Modifications of the Sampled Shoreline..... 11

2.3.6. Shore to Bottom Slope..... 11

2.3.7. Average Depth..... 12

2.4. Metric 4: Riparian Zone and Bank Erosion..... 12

    2.4.1. Riparian Width ..... 13

    2.4.2. Shoreline Quality ..... 14

    2.4.3. Bank Erosion ..... 14

2.5. Metric 5: Aquatic Vegetation Quality ..... 15

3. Additional Information (page 2 of the L-QHEI form)..... 16

4. Literature Cited ..... 19

Appendix A: L-QHEI Form

Appendix B: Photographs

## 1. Introduction

This document summarizes the methodology for completing a general evaluation of Lake Erie shoreline macro-habitat using the Ohio EPA QHEI approach (Ohio EPA 1989a; Ohio EPA 1989b; Thoma, 2006; Ohio EPA, 2006). This document revises and supersedes the previous version of the Lake Erie QHEI manual (Ohio EPA, 2004). Rankin (1995) emphasized the importance of combining habitat data with other environmental factors and the need for habitat assessment when evaluating environmental impacts in aquatic environments. The development of the methodology presented in this document was based primarily on Lake Erie shoreline habitat types found in Ohio. Lake Erie Lake/Lacustrary QHEI (L-QHEI) evaluation sheets (Appendix A) and habitat assessments are normally performed by Ohio EPA fish sampling field crews, but can be used by others to assess shoreline quality when considering shoreline projects that may alter shoreline conditions. The L-QHEI sheet is used to tabulate the data and information used in calculating the L-QHEI score, and the following guidance should be used when completing the L-QHEI sheet. An example of a completed L-QHEI sheet is provided in Appendix A2.

Although this assessment was developed for Lake Erie, it can be applied to other Great Lakes areas or to inland lakes and reservoirs. When assessing wetland areas, the Ohio EPA wetland evaluation procedures as described in other Ohio EPA documents developed by the Division of Surface Water Wetland Ecology Group or the 401 Water Quality Certification Section take precedence over an L-QHEI assessment. However, in certain circumstances, especially for wetlands directly connected to Lake Erie may be used in order to provide supplemental data. The following URL's provide information regarding wetland evaluation and assessment methodologies: Wetland Ecology Section: <http://www.epa.ohio.gov/dsw/wetlands/WetlandEcologySection.aspx#ORAM>; 401 Water Quality Certification Section: <http://www.epa.ohio.gov/dsw/401/index.aspx> .

It must be noted that projects designed to control erosion and stabilize Lake Erie shorelines should **strive to re-create the natural conditions for the area that is being altered**. The goal should be to design projects that create the highest degree of habitat diversity in order to provide the greatest potential for fish communities to achieve a healthy status. Use of the L-QHEI to assess similar, least-impacted, shorelines can be used as an aid for the design of shoreline projects that not only accomplish the goals of the shoreline landowner, but which actually enhance or restore the aquatic habitat potential.

Three examples of well designed shoreline protection projects that use sloping, smooth faced revetments that reproduce the original habitat (sand beaches) naturally found along Lake Erie's glacial till shorelines are depicted in Figure 1. For bedrock cliff areas such as those found around the Lake Erie islands, the habitat features of the natural limestone outcrops found in this part of the lakeshore are best reproduced through use of randomly placed limestone boulder revetments. The shale cliff shorelines found in Lorain and Cuyahoga counties are another example of a locale where approaches

tailored to the local conditions would be appropriate. In this area, the vertical, highly reflective shorelines create a unique habitat that sustains a unique fish community. It should be noted that projects that best mimic natural conditions are likely to be the most stable over the long term and will likely require the least amount of maintenance over time.



**Figure 1.** Three photographs of sloping, smooth-faced revetments in Erie and Lorain Counties. Note the accumulation of sand and ease of access to the water. Photos by Roger Thoma.

### **1.1. River Code, River Mile, Waterbody**

The waterbody name will be either the name of the Great Lake, bay, or tributary stream. Official stream and lake names can be found in the Gazetteer of Ohio Streams (Ohio DNR, 2001) or on USGS 7.5 minute topographic maps. If the stream is unnamed, the river mile of the confluence of the unnamed stream with a named stream or the Lake Erie (Great Lake) lake mile is typically used to identify the stream (e.g. “unnamed tributary Johndoe River RM xx.yy”). Use of nearby landmarks or other important site information should be used in the field to definitively identify the site location. Basin and

river codes refer to a coding system assigned by the Ohio EPA Ecological Assessment Section to uniquely identify streams. External (non-Ohio EPA) users may omit use of this coding system or contact the Ohio EPA for guidance in assigning the river code. River mile (RM) in lacustuaries and Lake Mile (LM) demarcations (for the Lake Erie shoreline) used to identify sampling locations are found on 7.5 minute topographic maps maintained by the Ohio EPA. These maps are available for download from the Ohio EPA web page: <http://www.epa.ohio.gov/dsw/gis/RiverMileSystem.aspx>. The original physical copies stored at the Ohio EPA Division of Surface Water Central Office in Columbus, Ohio.

## **1.2. Specific Location, Latitude/Longitude**

The description of the sampling location should include the site's county and geographic location in relation to a local landmark such as an industry, urban center, stream mouth, or other significant geographic marker. A GPS unit should be used in the field to provide latitude and longitude data for the site. It is preferred that latitude and longitude location information be recorded for each end of the habitat assessment area in order to make the information more usable in GIS databases.

## **1.3. Distance, Date, Scorer's Initials, Comments**

The linear length of the area being assessed should be recorded in meters. Unlike stream QHEI assessments total length including slight bends is not used. Distance is based on a straight line measure from end to end unless there is a distinct point of change of 45° or more at which point a new distance measure will be started. All distance measures are summed to derive a total distance. The standard zone for conducting an L-QHEI evaluation is 500 meters. This is the distance covered by fish community assessments using electrofishing methods for Lake Erie nearshore and lacustuary areas.

When assessing an individual property or project area, record the total distance of the property or project in question. In these circumstances, the length of the reach being evaluated can be reduced as necessary to assess the project. However, reduced L-QHEI zones are not valid to support fish community sampling or to make inferences to habitat quality beyond the project boundaries. It is recommended that the full 500 meter distance be used in all evaluations, with adjustments for project-specific areas within a zone recorded as appropriate to note differences between overall habitat quality and the habitat within the project area.

The date of data collection should be recorded in this format: 11 Aug. 2009 to help avoid confusing day and month numbers. The initials of the person completing the form and the organization they are associated with should be included. If it is the first time a person has submitted an L-QHEI form they should provide the full name of the person completing the assessment as well as the full name of the organization they represent in the Comment field. Additional notes can be provided in the Comment field as

necessary. In addition, a box is provided to check whether the site is a Lake or lacustrine habitat. Thoma (1999, 2006) defined the term "lacustrine" as "...a new word combination using the words lacustrine and estuary and is defined as a transition zone in a river that flows into a freshwater lake and is the portion of river affected by the water level of the lake. Lacustrines begin where lotic conditions end in the river and end where the lake proper begins. They are hydrologically similar to estuaries in that they are affected by tides (primarily wind driven, occasionally barometric) and are lentic habitats. Lacustrines differ from estuaries in their chemical properties being overall, less saline with gradients going from higher concentrations upstream to lower at the lake interface (Brent and Herdendorf, 1972)."<sup>1</sup>

## 2. Habitat Characteristics: The Metrics

Description of the L-QHEI metrics and the scoring criteria are provided in the sections below. It is important to note that for all of the metrics except for metric 4 (Riparian Zone and Bank Erosion, Section 2.4) it is possible to achieve a score that exceeds the maximum score allocated for an individual metric. For example, when scoring the Shoreline Morphology Metric (Section 2.3) it is possible to achieve a score of 30 points when the sub-metric scores are summed. However, in such a case the score for the metric would be reported as 20 points, the maximum score allocated to this metric in the overall scoring scheme.

### 2.1. Metric 1: Substrate

This metric is divided into two basic parts: substrate type and origin and substrate quality. Substrates located on the lake or lacustrine bottom within 15 meters of the land/water interface at the time the evaluation is conducted are considered when scoring this metric.

The final substrate metric score is determined as the sum of all of the components of the metric. Note that although the sum of the individual variables can be greater than 20 points, the maximum substrate score allowed for this metric is 20.

#### 2.1.1. Substrate Type and Origin

##### 2.1.1.1. Substrate Type

Check the two most common substrate types in the sample reach. If one substrate type predominates (greater than 75-80% of the bottom and immediate shore area or it is determined that one substrate type is clearly the most functionally predominant substrate), then this substrate type should be checked twice. **DO NOT CHECK MORE THAN TWO BOXES.** Spaces are provided to note the presence (by check mark, or

---

<sup>1</sup> Note that harbor areas of the lake proper that have been enclosed by breakwalls are not considered to be part of the lacustrine.

estimation of percent composition if time allows) of all substrate types present on the shore and below the waterline. Each type noted should constitute 5% or more of the substrate composition (i.e. they occur in sufficient quantity to support species that may commonly be associated with the substrate type within the habitat). This section must be filled out completely to allow future analysis of the metric. If there are more than four substrate types in the sampling zone that are present in greater than approximately 5% aerial extent, check the appropriate box and add 2 points to the substrate metric score.

Substrate types are defined based upon their size and composition as follows:

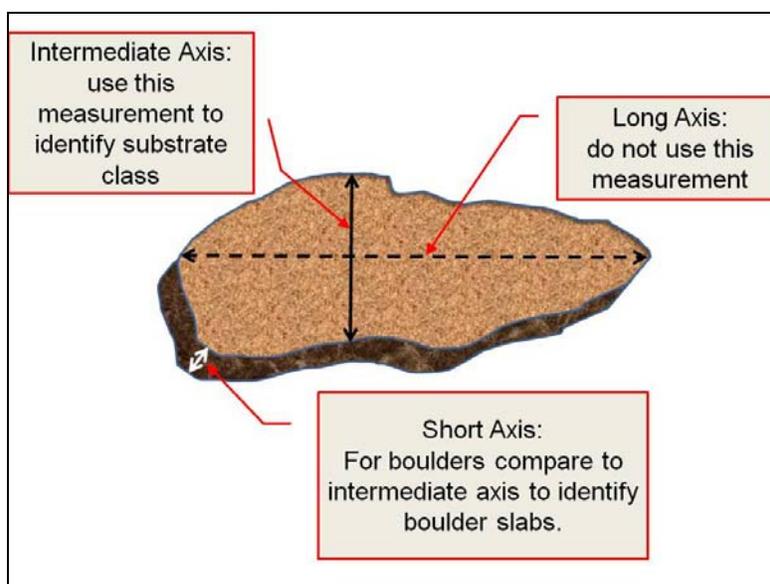
- a) *Bedrock* - solid rock forming continuous surface. Thin layers of other substrate types may be found atop a bedrock layer but are not considered significant if they are sparsely or thinly distributed (see Figures<sup>2</sup> B-1C, B-5E and G, B-6D, B-8E and F).
- b) *Boulder* - rounded stones measuring over 256 mm along the intermediate axis or large slabs more than 256 mm along the intermediate axis (Figures B-1A, B-6D). If slabs exist (Figure B-5G) at a site check the BLDR/SLABS box(s).
- c) *Cobble* - stones measuring from 64-256 mm along the intermediate axis (Figures B-1A, B-8F).
- d) *Gravel* - mixture of rounded coarse material measuring from 2-64 mm along the intermediate axis.
- e) *Sand* - materials 0.06-2.0 mm in diameter, gritty texture when rubbed between fingers (Figures B-6A and B).
- f) *Silt* - 0.004-0.06 mm in diameter, generally feels greasy when rubbed between fingers (Figure B-6F).
- g) *Hardpan* - particles less than 0.004 mm in diameter, usually clay, which forms a dense, gummy surface that is difficult to penetrate. Hardpan frequently can have sand, gravel, and cobble intermixed in low amounts (Figure B-5H).
- h) *Marl* - calcium carbonate; usually grayish-white; often contains fragments of mollusk shells.
- i) *Detritus* - dead, unconsolidated organic material covering the bottom which could include sticks, wood, and other partially or un-decayed coarse plant material.
- j) *Muck* - black, fine, flocculent, completely decomposed organic matter (does not

---

<sup>2</sup> Note: figure references in the text beginning with a capital letter refer to photographs that are included in Appendix B of this document.

include sewage or animal waste sludge). Sludge is defined as a thick layer of organic matter that is decidedly of human or domestic animal origin. NOTE: SLUDGE THAT ORIGINATES FROM POINT SOURCES IS NOT INCLUDED; THE SUBSTRATE SCORE IS BASED ON THE UNDERLYING MATERIAL. This scenario is rarely encountered in Lake Erie waters but if encountered do not underestimate the potential of the normal substrate that underlies sludge.

Measurements and size classifications for substrate particles are based upon the length of the intermediate axis of the particle (Figure 2). The intermediate axis is always perpendicular to the long axis of the particle. Care should be taken to measure the longest point on the particle that is perpendicular to the long axis. For particles determined to meet the definition of a boulder (see above), if the ratio of the measurement of the intermediate axis to the short axis is greater than two the rock is considered to be a boulder-slab.



**Figure 2.** A stylized representation of a substrate particle indicating the proper way to determine the size category for classification.

#### 2.1.1.2. Substrate Origin

Substrate origin refers to the parent material that the shoreline area is derived from. Select one or two of the parent materials that give rise to the predominant substrates that occur within the zone. The appropriate sub-metric score as listed on the form (or an average of the scores if two types of parent material are selected for the site) is used in the calculation of the final Substrate Metric score.

### 2.1.2. Substrate Quality

The substrate quality sub-metric consists of an estimate of the extent of silt cover and the estimation of the origin of the silt.

#### 2.1.2.1. Silt

Silt cover is the extent that a silt layer of approximately 1 inch or more covers substrates. The silt should obviously be affecting habitat suitability. Boxes are checked for silt areal coverage are as follows: **Heavy**  $\geq 75\%$ , **Moderate**  $\geq 50$  to  $< 75\%$ , **Normal**  $\geq 10$  to  $< 50\%$  and confined to distinct areas, **Free**  $< 10\%$ .

#### 2.1.2.2. Silt Origin

The source of the accumulated silts laying on submerged substrates is determined based upon an observation of the physical properties of the accumulated silt material in context with the site setting. Four categories are provided: **Clay** (clayey silts are formed from erosion of adjacent shoreline or bottom clay deposits, or accumulated resulting from upstream erosion of clay materials), **Industrial** (silt accumulations resulting from nearby industrial solids processing activities or industrial land uses), **Organic** (silts formed from the deposition of detritus or other natural depositions of silt fines), and **None** (used in conjunction with the silt-free category for silt cover).

### 2.2. Metric 2: Cover Types

This metric scores the presence of cover types and overall cover extent. Each cover type that is present in greater than 5% of the assessment area should be checked. Cover features such as boulders, root-wads, and woody debris should be in water deep enough to allow fish to find refuge and food on the structure's surface and/or bottom.

Cover should generally not be counted when found in shallow areas of insufficient depth (usually  $< 20$  cm) to be useful to fish. However, if shallow areas at the site are judged to be beneficial for young-of-year (YOY) fish, those habitats should be also be included in the cover type assessment. Young of year fish utilize shallow shoreline areas as refuges and feeding areas, and they also often benefit from the presence of warmer water, especially in early spring.

The maximum metric score for cover types is 20 points and is a summation of two habitat component measures: the Cover Types and Amount sub-metrics.

#### 2.2.1. Cover Types

Cover types to be assessed are:

- a) *Off-Shore Sand Bars*, where the sand bar elevations are  $> 50$  centimeters in

height from the base to the crest;

- b) *Overhanging Vegetation* that is near to or touching the water surface and providing shade (B-2B, B-8H);
- c) *Shallows (on beach)*, areas on beaches 2-10 centimeters in depth with a width of 50 centimeters or greater;
- d) *Root Mats* (usually associated with willow trees) comprised of small roots where root strands are 5 millimeters or less in diameter;
- e) *Deep Waters*, water  $\geq 1$  meter deep;
- f) *Root Wads* comprised of root masses greater than 50 centimeters in total width;
- g) *Boulders*, as defined in Section 3.1.1.1 above;
- h) *Sand Beach*;
- i) *Wetland Pools* located within 15 meters of shore;
- j) *Submerged Aquatic Vegetation*, including both native and non-native species (Figure B-1F);
- k) *Logs or Woody Debris* comprised of woody material  $>30$  cm in diameter (Figures B-2A, B-3E and F); and
- l) *Gravel Beach*.

### **2.2.2. Cover Amount**

The amount of cover is scored under the following categories:

- a) *Extensive* when found throughout the assessment area to comprise  $\geq 75\%$  of the bottom area (Figures B-1A and F, B-2C and E, B-4A and E, B-6G, B-8E);
- b) *Moderate* when found in disconnected areas or one discrete area of the site to comprise  $<75\%$  but  $\geq 25\%$  of the bottom area (Figures B-2A and B, B-3F, and B-7G);
- c) *Sparse* when found to comprise  $<25\%$  but  $\geq 5\%$  of the bottom area (Figures B-3B, B-4D and H, B-6A, B-8C); and
- d) *Nearly Absent* when found to comprise  $<5\%$  of the bottom area (Figures B-3C, B-5H, B-7C, D, E, and H, and B-8B and E).

Only cover found within 15 meters of the water-land interface should be considered in this metric. Cover that is found on an opposing shoreline outside the 15-meter distance should not be included. If uncertain about the amount of cover, or if two discrete cover areas exist, then two boxes may be checked and averaged (i.e. half-vegetated and half-dredged thus results in both “moderate” and “nearly absent” boxes being checked and is averaged as a score of 3).

### **2.3. Metric 3: Shoreline Morphology**

This metric emphasizes the quality of the shoreline as it relates to the creation and stability of microhabitats. It includes shoreline sinuosity (the degree of natural shoreline undulation and not that resulting from artificial modifying structures), shoreline development, shoreline modification, and shoreline stability. One box under each sub-metric should be checked unless conditions are considered to be intermediate between two categories; in which case two boxes are checked and the score averaged.

The maximum metric score for shoreline morphology is 20 points and the metric score is the result of summation of six habitat measures.

#### **2.3.1. Shoreline Sinuosity**

Shoreline sinuosity is an important factor in the quality of habitat development on lakeshores. The straighter a shoreline is the more likely offshore sandbars are to develop. Sandbars and accompanying troughs provide valuable nursery habitat for YOY fish and spawning areas for numerous fish species that prefer to spawn on or above sandy substrates. Slight sinuosity that does not suppress sand bar development can enhance habitat value for other fish species that rely on substrates more textured than sand.

As stated above, anthropogenic modifications to shorelines such as groins and other structures are not to be considered as affecting shoreline sinuosity. This rule is confined to smaller structures of approximately 10 meters width and not large scale human induced changes resulting from structures such as harbor breakwaters. Due to the changing nature of Lake Erie shorelines, only on-site assessments should be used rather than mapping resources.

Shoreline sinuosity sub-metric ratings are as follows:

- a) *None* is a shoreline running in a straight line from start to end of the site being evaluated (Figures B-5B, C, and H, and B-7E).
- b) *Low Sinuosity* is a shoreline with a gradual curvature in one continuing direction (Figures B2A and D).

- c) *Moderate Sinuosity* is a shoreline with gradual curvature in more than one direction, i.e. curving outward and then inward (Figures B-2B, B-3A, B-8F and H).
- d) *High Sinuosity* is a shoreline with strong curvature in one or more directions (B-6E). Gradual curvature is defined, as a change of shoreline direction less than 25 degrees while strong is greater than 25 degrees.

### 2.3.2. Development

The term “development” refers to the development of the land water interface's quality as fish community habitat. Ratings for this sub-metric are as follows:

- a) *Poor* development is a shoreline with vertical steel, cement, or other artificial human armament, or a natural shore with an extremely shallow and only slightly sloped bottom <15 degrees (Figures B-5B and C, B-7D, B-8E).
- b) *Fair* development is checked for shorelines with bottom slopes >15 and <25 degrees with some type of breaking-down modification that is at the time non-vertical and non-functional (Figures B3B and F, B-4H, B-7F).
- c) *Good* development is checked for shorelines either not armored or previously armored but returning to a natural state and having sloped bottoms of >45 degrees (Figures B-2B and D, B-6A and C, B-8H).
- d) *Excellent* development is checked for shorelines either not armored or previously armored but fully returned to a natural state and having sloped bottoms of >25 and <45 degrees (Figures B-2E, B-3A and E, B-5G, B-6B,D, and E, B-8E and F).

### 2.3.3. Modification

The term “modification” refers to anthropogenic physical modifications of the shore water interface. Ratings for this sub-metric are as follows:

- a) *Recent* is checked when visual and physical evidence is indicative that a shoreline has been modified within the past two years or the modification is such that the area has not returned to some degree of natural condition. This almost always occurs along vertical seawalls where sand/gravel substrates cannot reestablish on the shoreline (Figures B-4A and E, B-5B and C, B-7D and H, and B-8E).
- b) *Recovering* is checked when an existing shoreline modification has begun to break down and/or shoreline sediments (sand, gravel) have begun to accumulate at the water land interface (Figures B-3B and F, B-4F, B-5D, and B-7F).
- c) *Recovered* is checked when shoreline modifications have completely broken

down with shoreline sediments accumulated at the water land interface or shoreline sediments have accumulated to such a degree that wave action no longer comes in contact with existing shoreline modifications (Figures B-F and H).

- d) *None* is checked if the shoreline has never been modified with shoreline protection structures (Figures B-2 [all photos] and B-6 [all photos]).

#### **2.3.4. Stability**

The term “stability” refers to the degree that the shoreline is subject to change in position and composition over a one to two year time span. Ratings for this sub-metric are as follows:

- a) *Low* is checked if the shoreline appears to have undergone little change in position or composition in the past two years. This is especially true of shores with armoring structures (Figures B-2A through E, B4A through C, E, and F, B-5B, C, E though G, B-6 [all photos]).
- b) *Moderate* is checked if some change in shoreline position or substrate composition has occurred in the past two years. This can occur at both armored and unarmored shorelines (Figures B-4D and G, B-3B, and B-7E).
- c) *High* is checked for shorelines that are undergoing active erosion, or movement of substrates in the past two years (Figures B-8C and B-5H).

#### **2.3.5. Modifications of the Sampled Shoreline**

For this sub-metric, all types of evident shoreline modifications that are present in the sampling zone should be noted, whether they are believed to be functional or not. It is important to note that the presence of one type of modification can result in two or more modification types being checked (two sided channel modification will normally result in dredging being checked and possibly steel bulkheads also). Points for this sub-metric are determined by adding the scores of all items that are checked for the site in question.

#### **2.3.6. Shore to Bottom Slope**

The general slope of the bottom from the water’s edge out to a distance of 15 meters from the land-water interface is assessed as being <15, <25, ≥25, ≥45, or 90 degrees. The slope type that best describes the sampling area should be checked. Two slope types can be checked distinctly different bottom slope characteristics are noted in the zone and the two scores averaged. This phenomenon is normally the result of some type of anthropogenic modification.

### **2.3.7. Average Depth**

The average depth sub-metric is derived from a minimum of five depth measurements taken within the surveyed zone. Locations for depth measurements should be representative of the variation within the area being evaluated. Depth can be measured with a depth finder in deeper water and a calibrated pole in shallower areas. Scoring is based upon the following depth range categories: <50 cm, 50- <100 cm, ≥100 – 200 cm, >200 – 400 cm, >400 -500 cm, >500 – 900 cm, or >900 cm. When assessing a zone where there are distinct changes in the average depth, the field crew leader should first make a determination as to whether the assessment zone is appropriately located. It may be necessary to adjust the location of the assessment zone to provide a more representative reach, or to assess two separate zones. If the survey reach is determined to be appropriate, the two depth categories that best describe the site can be checked the two scores averaged. Again, this condition is frequently, though not always, the result of anthropogenic modification.

### **2.4. Metric 4: Riparian Zone and Bank Erosion**

This metric emphasizes the quality of the land and water areas (surrounding the sampling zone) that could act as a buffer for environmental stresses originating from non-point runoff inputs. It includes sub-metrics for the width of the natural riparian vegetation, the shoreline quality outside the riparian area (100 meters plus), and bank erosion. Each component is scored for each side of the assessment site. This is the only metric where two sides of the water body are assessed.

When assessing Lake Erie shorelines and harbor areas, the right side is considered the side found on the right when one is facing east or south depending on the orientation of the shoreline. For these sites, the open water of the lake will often be assessed as one of the sides for this metric. Note that for the east-west oriented lake shorelines typical in Ohio, the left side is always the open water. For lacustrary sites, the right side is the side on the right when looking toward the Lake (or facing downstream). Figure 2 provides a schematic representation of these orientation rules.

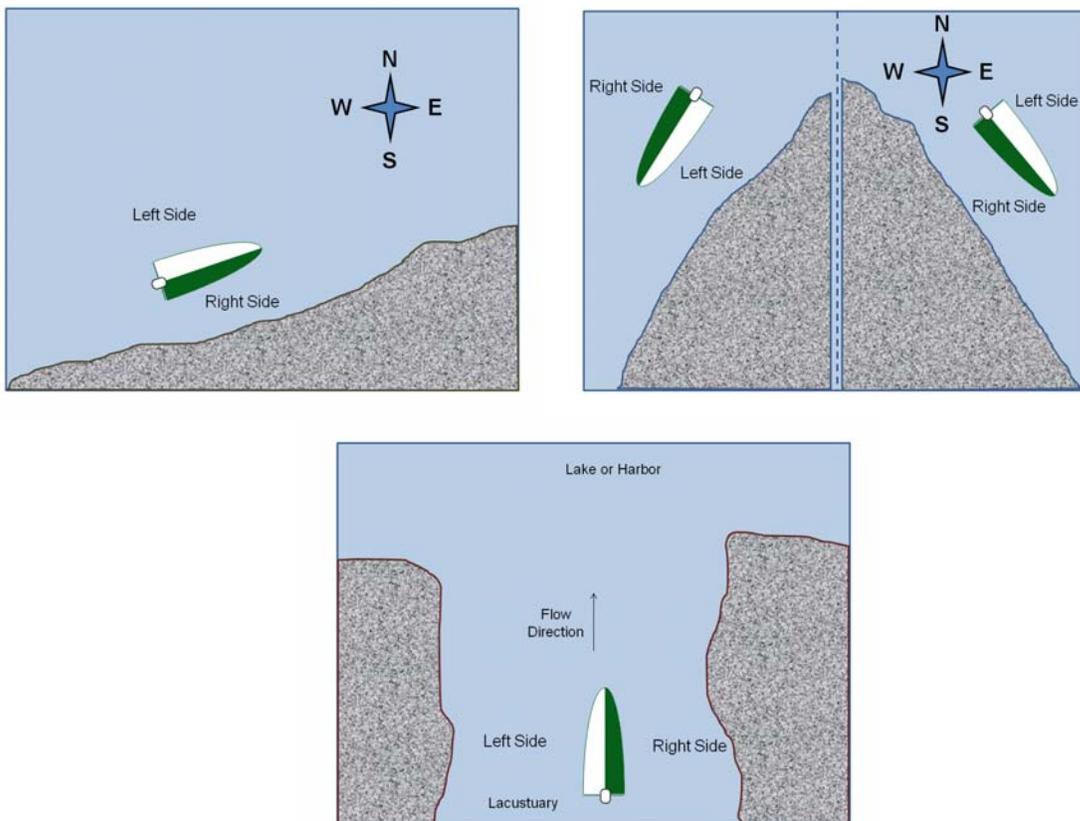
In lacustraries and harbor areas, the biologist conducting the assessment must decide whether to score an opposing shoreline as part of the assessment as one of the “sides.” If the opposing shore is in close enough proximity to have a physical or biological effect on the sampled shoreline, it should be scored. Where wetlands lie on the opposing side, they should always be scored. If the opposing shoreline is determined to be too distant to have either positive or negative effects on the biota of the assessed site, then the open water between the assessed and opposing shores is scored.

For sub-metric scoring, the left and right sides are averaged to derive the component value. Two boxes per side per component can be checked if a distinct change is noted for the component within the sample reach. In these cases the side score is averaged, and then averaged with the opposite side's score to derive the component score. The

maximum score for riparian zone and bank erosion is 10. The overall metric score is derived from a summation of the scores for the three components described below.

### 2.4.1. Riparian Width

The riparian width is the width of the natural vegetation on the land and/or adjacent water body surrounding the assessment area. Width estimates are provided for those surrounding areas that fall into lake, wetland forest, shrub, and old field riparian types. Old field refers to fairly mature vegetation types that have stable woody plant growth with herbaceous plant undergrowth (Figure B-5D). It does not include weedy urban and industrial sites that still have high runoff potential. The left and right sides are checked and averaged to derive the component value. For lake shorelines, the side facing the open water of the lake is always scored as WIDE. For harbor or lacustrary sites where open water exists on one side, the evaluator must determine whether it is suitable as fish habitat or for fish passage. If not, the Riparian Width category for that side should be estimated as the distance to the unsuitable area (typically dredged areas). Two boxes per side for each side can be checked if a distinct change is noted in the component within the sample reach. In these cases each side's score is averaged and then averaged again with the score for the opposite side score to derive the sub-metric score.



**Figure 3.** Schematic representation of orientations used to identify “sides” for Metric 4, Riparian Zone and Bank Erosion.

### 2.4.2. Shoreline Quality

Shoreline quality is rated based upon the most predominant shoreline qualities present on the shoreline or on each side of a river or lacustrary. Only those areas outside the riparian zone or the first 100 feet (if the riparian zone is that wide) are considered for this component of the metric. In addition, only those areas on land that can feasibly and directly contribute runoff during normal rain events should be considered, not the entire drainage basin.

For a lake shorelines, the side toward the open water is scored as FOREST, WETLAND, LAKE, while the other side is scored according to the land use beyond the 100 ft riparian width on the landward side. For lacustrary and harbor areas where the Riparian Width sub-metric is deemed limited because of unsuitable open water habitat (e.g. dredged areas), the URBAN OR INDUSTRIAL category should be considered for the Shoreline Quality sub-metric for that side.

One Shoreline Quality type should be scored for each side (including non-natural conditions) and then the two category scores averaged to determine the number of points for this sub-metric.

### 2.4.3. Bank Erosion

Scoring categories for this sub-metric use qualitative bank erosion categories of NONE/LITTLE, MODERATE, and HIGH/SEVERE. The appropriate box is checked for each side and the scores from each side are averaged to provide the sub-metric score. Two boxes can be checked on a given side, if a distinct change is noted in the component within the sample reach. Follow the averaging convention stated above to derive the component score. Classification of erosion extent is as follows:

1. **NONE/LITTLE** is checked for a bank with 0 <25% active erosion or stress occurring as a result of wave action or high flow episodes (in lacustraries). Active erosion or stress should be light where it is occurring within the zone. Normally lakeshore areas of sediment deposition or armored shorelines will fall into this classification (Figures B-2A through E, B-4A through C, E, and F, B-5B, C, E through G, and B-6 [all photos]). For lake shorelines and lacustrary sites where one "side" is open water, the open water side is always scored NONE/LITTLE unless notable movement of bottom sediments is observed
2. **MODERATE** is checked for a bank with >25<50% active erosion or stress occurring as a result of wave action or high flow episodes (in lacustraries) or where active areas of erosion have resulted in a complete collapse of a portion of the bank (Figures B-4D and G, B-3B, and B-7E).

3. **HEAVY/SEVERE** is checked for a bank with  $\geq 50\%$  active erosion or stress occurring as a result of wave action or high flow episodes (in lacustraries) or where active areas of erosion have resulted in a complete collapse of  $>25\%$  of the bank. At least 50% of the bank should be in a state of active erosion or active erosion should be severe. This measure includes banks that are 100% eroding such as is found down current from harbor breakwater areas. *Heavy/Severe* erosion is frequently characterized by the presence of buildings, pipes, railroads, and roads protruding from the top portions of the bank (Figures B-5H and B-8C).

### 2.5. Metric 5: Aquatic Vegetation Quality

This metric is divided into two categories:

- a) High quality native vegetation types associated with minimally disturbed aquatic environments having clear, low nutrient and/or sediment waters (B-1A, B-2C,E,&F, B-3A).

High quality vegetation groups considered for scoring include pond lilies (*Nymphaea* spp., *Nelumbo lutea*, *Nuphar* spp.), pondweeds (e.g. *Potamogeton* spp.), sedges (Cyperacea), bulrushes (*Scirpus* spp.), wild celery (*Vallisneria americana*), waterweed (e.g. *Elodea canadensis*), and aquatic grasses such as wild rice (*Zizania aquatica*). Each high quality plant group is rated as abundant (3 points), common (5 points), few (1 point), or uncommon (0 points).

- b) Moderate and poor quality vegetation associated with slight nutrient enrichment and disturbance (B-1F, B-2A,F) or associated with degraded environmental conditions resulting from disturbances such as heavy sediment and/or nutrient loads, physical disturbance, or chemical perturbations (B-1B-F, B-2A, B3D).

Moderate quality vegetation groups considered for scoring are Eurasian milfoil (*Myriophyllum spicatum*) and cattail (*Typha* spp.). Poor quality vegetation considered for scoring are purple loosestrife (*Lythrum salicaria*), reed grass (*Phragmites australis*), algae mats (such as *Cladophora* or *Lyngbia*), and excessive or bloom growths of planktonic algae. Presence of these species in increasing abundances has a negative correlation with fish community performance. Each moderate or poor quality plant group is rated as abundant (-2 points), common (-1 point), or few (0 point).

Abundances for aquatic plants are categorized as follows:

- a) *Abundant* = dominating area at  $\geq 70\%$  of surface area;  
 b) *Common* = covering  $<70\%$  but  $\geq 10\%$  of the surface area;  
 c) *Few* =  $<10\%$  coverage of surface area; and

- d) *Uncommon* = 20 or fewer individual plants.

Illustrations of the vegetation types and abundance categories are provided in Figures B-1 through B-3. If an appropriate vegetation type is not listed for an important plant species found to be present, scoring is completed by using the listed plant species that best approximates the ecological role and habitat function of the plant found to be present.

Surface area is defined as the areas within 15 meters of the land water interface on both the lake and landward sides. Submerged aquatic vegetation not reaching the surface must be included in the assessment. If no vegetation is present, a score of zero is awarded for the Aquatic Vegetation Quality metric. It should be noted that areas dominated by poor quality vegetation can result in a negative Aquatic Vegetation Quality score as low as -6. The maximum score for the Aquatic Vegetation Quality metric is 30 points.

### **3. Additional Information (page 2 of the L-QHEI form)**

Additional information (that is not currently incorporated into the final L-QHEI score) is to be recorded on the backside of the L-QHEI sheet (Appendix A1). Each information type is described below.

- 1) *Is the Sampling Reach Representative of Area Habitat?* Each site should be subjectively assessed as to whether it is representative of the general habitat found along the larger area of lakeshore or lacustrine shoreline. If it is determined that the site is not representative, an explanation regarding the differences must be provided. Both natural and anthropogenic causes can result in a site being unrepresentative of an area of shoreline. Where anthropogenic modifications are the cause of the condition, the specific nature of the physical alteration should be noted.
- 2) *Additional comments/Pollution impacts.* The different types of pollution sources (e.g. wastewater treatment plants, combined sewer overflows, feedlots, industrial discharges, non-point runoff, etc.) should be noted along with their proximity to or location within the sampling site. Concentrations of flotsam present at the time of the evaluation should also be noted and described.
- 3) *Depth measures.* Five boxes are provided on the L-QHEI sheet to record depth measurements within the sampling zone taken during the evaluation. These measures are used to derive the score for the *Average Depth* sub-metric of the *Shoreline Morphology* Metric (Section 3.3.7).

- 4) *Zebra mussel coverage.* One of the five boxes provided that best approximates the total coverage of substrates by zebra mussels (*Dreissena polymorpha*) and/or quagga mussels (*Dreissena rostriformis bugensis*) should be checked.
- 5) *Gear.* Record the size of boat used in sampling fish communities and the electrode array deployed (straight droppers, Wisconsin array, or electro-spheres) or whether the assessment was conducted from shore and the gear used to collect fish.
- 6) *Distance.* Record the distance of the sampling zone or assessment area in meters (see Section 2.3).
- 7) *Water clarity.* Water clarity should be assessed as: **Clear** - bottom is clearly visible if shallow enough and the water has no apparent color or staining; **Stained** - usually a brown or greenish coloration to the water with the bottom visible at the shallow edges; or **Turbid** - water brown and bottoms not visible below a few inches of water. The apparent source of staining (usually tannic acid from decaying vegetation) or turbidity (e.g. from runoff of clay or silt, growths of algae and diatoms, sewage discharges, etc.) should be noted on the form. A measure of water clarity should be taken with a Secchi disk, sediment tube, or turbidity meter and the data recorded in the space provided.
- 8) *Wave height.* The actions of waves can have strong effects on fish and fish sampling by driving fish away from shoreline areas and making the physical process of capturing fish difficult thus reducing efficiency. A strict record of wave conditions during sampling or assessment efforts should be kept. This information can then be used at later dates to evaluate the validity of sampling results. Wave height is recorded in meters as the distance from a wave's crest to its trough. It should be noted that under wave height conditions of 1.0 meter (~3 ft.) or more sampling is not considered to be valid. Wind speed and direction could also be recorded under Additional Comments or on the drawing of the site map.
- 9) *Subjective rating.* Record a subjective score of 1 to 10 of the site habitat quality based upon best professional judgment. A rating of "10" would be habitat considered perfect for fish communities to inhabit. In other words, the habitat displays attributes that meet almost all life history needs of fish and would be capable harboring the maximum number of species and individuals that could exist in a zone. A rating of "1" would be habitat so poor that it is not likely to support fish and the only species present are likely to be transients or highly tolerant species. Numbers of individual fish collected in such zones is likely to be less than one hundred and more likely around 20 or less.
- 10) *Aesthetic rating.* Based solely on the appearance of a site, on a scale of 1 to 10, does the site have an appealing ecological manifestation? To paraphrase this question, is the site pleasant to the eye?

- 11) *Photos.* Record the number of photos taken of the site and the indexing system used to allow the evaluator and Ohio EPA to associate each photo to the site at which it was taken. Indications on the site drawing (see below) regarding the locations where photographs were taken and their orientation are also extremely helpful.

*Average Width, Average Depth, Maximum Depth.* Estimate the average width of the water body up to the nearest kilometer (1 kilometer + if greater), average depth (from measurements obtained above), and the maximum depth observed or recorded.

- 12) *Drawing of site.* Provide a drawing of the sampling/assessment site illustrating all significant habitat structures and their position. All aquatic vegetation (including small amounts) should be designated on the map and the species or genus noted. Also note points of potential entry of pollutants such as pipes, streams, gullies, or parking lot/urban runoff debauch points. Other variables to be drawn on the map are buildings near shore, shoreline protection/modification structures, boulder, gravel, sand, bedrock, woody debris, etc. A circle is provided on the form for drawing in a North arrow. **NOTE: THE SITE DRAWING IS EXTREMELY IMPORTANT AND MUST BE PROVIDED.**

#### 4. Literature Cited

- Brant, R.A. & C.E. Herdendorf (1972). Delineation of Great Lakes estuaries. Proceedings 15<sup>th</sup> Conference, International Association for Great Lakes Research 15:710-718.
- ODNR (2001). Gazetteer of Ohio Streams, 2<sup>nd</sup> ed. Water Inventory Report 29. J.C. Krolczyk, V. Childress (ed., 2<sup>nd</sup> ed.). Ohio Department of Natural Resources, Division of Water, Columbus, Ohio. 153 pp.  
[http://www.dnr.state.oh.us/Portals/7/pubs/pdfs/GAZETTEER\\_OF\\_OHIO\\_STREAMS.pdf](http://www.dnr.state.oh.us/Portals/7/pubs/pdfs/GAZETTEER_OF_OHIO_STREAMS.pdf)
- Ohio EPA (1989a). Biological criteria for the protection of aquatic life. Volume III: standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Ohio EPA, Division of Water Quality Planning and Assessment, Ecological Assessment Section, Columbus, Ohio.
- Ohio EPA (1989b). The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Ohio EPA, Division of Water Quality Planning and Assessment, Ecological Assessment Section, Columbus, Ohio.
- Ohio EPA (2004). Methods of assessing habitat in Lake Erie shoreline waters using the qualitative habitat evaluation index (QHEI) approach. Ohio EPA Division of Surface Water, Columbus, Ohio. 21 pp.
- Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Division of Surface Water, Columbus, Ohio. 26 pp. <http://www.epa.ohio.gov/portals/35/documents/QHEIManualJune2006.pdf>
- Rankin, E. T. (1995). Habitat Indices in Water Resource Quality Assessment. pp. 181-208 in W. S. Davis and T. P. Simon (eds.). *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*. CRC Press, Boca Raton, FL.
- Thoma, R. F. (1999). Biological monitoring and an index of biotic integrity for Lake Erie's nearshore waters. pp. 417-461 in T. P. Simon (ed.). *Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities*, CRC Press, Boca Raton, FL, 417-461.
- Thoma, R. F. (2006). Development and assessment of a qualitative habitat evaluation index for application in coastal wetlands of the Great Lakes. pp. 171-194 in T. P. Simon and P. M. Stewart (eds.) *Coastal Wetlands of the Laurentian Great Lakes: Health, Habitat, and Indicators*. AuthorHouse Publishing, Bloomington, IN.

## **Appendix A: The Lake Erie/Lacustrary L-QHEI form**

# Lake / Lacustrary (Lentic) QHEI Field Sheet



Environmental Protection Agency

QHEI Score:

RIVERCODE \_\_\_\_\_ RIVERMILE \_\_\_\_\_ WATERBODY \_\_\_\_\_ DISTANCE ASSESSED (m): \_\_\_\_\_  
 DATE \_\_\_\_\_ LOCATION \_\_\_\_\_  
 SCORER \_\_\_\_\_ LAT. \_\_\_\_\_ LONG. \_\_\_\_\_ COMMENT \_\_\_\_\_

## 1] SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % or note every type present);

LAKE: \_\_\_\_\_ LACUSTUARY: \_\_\_\_\_

TYPE		SHORE		BOTTOM		SUBSTRATE ORIGIN		SUBSTRATE QUALITY	
<input type="checkbox"/> -BLDR/SLABS [7]				<input type="checkbox"/> -HARDPAN [4]		<input type="checkbox"/> -LIMESTONE [1]		<input type="checkbox"/> -SILT HEAVY [-2]	
<input type="checkbox"/> -BOULDER [10]				<input type="checkbox"/> -BEDROCK [3]		<input type="checkbox"/> -TILLS [1]		<input type="checkbox"/> -SILT MODERATE [-1]	
<input type="checkbox"/> -COBBLE [8]				<input type="checkbox"/> -DETRITUS [3]		<input type="checkbox"/> -WETLANDS [1]		<input type="checkbox"/> -SILT NORMAL [0]	
<input type="checkbox"/> -GRAVEL [7]				<input type="checkbox"/> -SILT [2]		<input type="checkbox"/> -LACUSTUARINE [1]		<input type="checkbox"/> -SILT FREE [1]	
<input type="checkbox"/> -SAND [6]				<input type="checkbox"/> -MUCK [2]		<input type="checkbox"/> -SANDSTONE [1]		<input type="checkbox"/> -CLAY [-2]	
						<input type="checkbox"/> -RIPRAP [1]		<input type="checkbox"/> -INDUSTRIAL [-1]	
						<input type="checkbox"/> -HARDPAN [0]		<input type="checkbox"/> -ORGANIC [1]	
						<input type="checkbox"/> -SHALE [-1]		<input type="checkbox"/> -NONE [1]	
						<input type="checkbox"/> -COAL/ORE [-2]			

NOTE: Ignore sludge that originates from point-sources; score on natural substrates

NUMBER OF SUBSTRATE TYPES:  - 5 or More [2]  - 4 or Less [0]

Substrate  Max 20

COMMENTS: \_\_\_\_\_

## 2] COVER TYPES

TYPE: (Check ALL That Apply)

AMOUNT: (Check ONLY One or check 2 and AVERAGE)

<input type="checkbox"/> -OFF-SHORE SAND BARS [4]	<input type="checkbox"/> -DEEPPWATER > 1 M [1]	<input type="checkbox"/> -WETLAND POOLS [1]	<input type="checkbox"/> -EXTENSIVE > 75% [9]
<input type="checkbox"/> -OVERHANGING VEGETATION [1]	<input type="checkbox"/> -ROOTWADS [1]	<input type="checkbox"/> -SUBMERGED AQUATIC VEG. [4]	<input type="checkbox"/> -MODERATE 25-75% [7]
<input type="checkbox"/> -SHALLOWS (ON BEACH) [1]	<input type="checkbox"/> -BOULDERS [1]	<input type="checkbox"/> -LOGS OR WOODY DEBRIS [1]	<input type="checkbox"/> -SPARSE 5-25% [3]
<input type="checkbox"/> -ROOTMATS [1]	<input type="checkbox"/> -SAND BEACH [1]	<input type="checkbox"/> -GRAVEL BEACH [1]	<input type="checkbox"/> -NEARLY ABSENT < 5% [1]

Cover  Max 20

COMMENTS: \_\_\_\_\_

## 3] SHORELINE MORPHOLOGY (Check ONLY one PER category or check 2 and AVERAGE)

### MODIFICATIONS OF SAMPLED SHORELINE

SHORE SINUOSITY	DEVELOPMENT	MODIFICATION	STABILITY	
<input type="checkbox"/> -HIGH [2]	<input type="checkbox"/> -EXCELLENT [6]	<input type="checkbox"/> -NONE [7]	<input type="checkbox"/> -HIGH [3]	<input type="checkbox"/> -CEMENTED [-1] <input type="checkbox"/> -STEEL BULKHEADS [2] <input type="checkbox"/> -RIP RAPPED [1] <input type="checkbox"/> -ISLANDS [1] <input type="checkbox"/> -RAILROAD TIES [-1] <input type="checkbox"/> -DIKES [-1] <input type="checkbox"/> -DREDGED [-1] <input type="checkbox"/> -BANK SHAPING [-1] <input type="checkbox"/> -TWO SIDE CHANNEL MODIFICATIONS [-1] <input type="checkbox"/> -WOOD PILING [1] <input type="checkbox"/> -SHIP CHANNEL [-2]
<input type="checkbox"/> -MODERATE [4]	<input type="checkbox"/> -GOOD [5]	<input type="checkbox"/> -RECOVERED [5]	<input type="checkbox"/> -MODERATE [2]	
<input type="checkbox"/> -LOW [3]	<input type="checkbox"/> -FAIR [3]	<input type="checkbox"/> -RECOVERING [3]	<input type="checkbox"/> -LOW [1]	
<input type="checkbox"/> -NONE [1]	<input type="checkbox"/> -POOR [1]	<input type="checkbox"/> -RECENT OR NO RECOVERY [1]		
<p>SHORE to BOTTOM SLOPE MORPHOLOGIES</p> <input type="checkbox"/> -SLOPE < 15 deg. [0] <input type="checkbox"/> -SLOPE > 45 deg. [2] <input type="checkbox"/> -SLOPE < 25 deg. [1] <input type="checkbox"/> -SLOPE 90 deg. [0] <input type="checkbox"/> -SLOPE > 25 deg. [3]				
<p>AVERAGE DEPTH (of 5 measures)</p> <input type="checkbox"/> - < 50 cm [0] <input type="checkbox"/> - > 400 - 500 cm [4] <input type="checkbox"/> - 50 - < 100 cm [1] <input type="checkbox"/> - > 500 - 900 cm [2] <input type="checkbox"/> - ≥ 100 - 200 cm [2] <input type="checkbox"/> - > 900 cm [1] <input type="checkbox"/> - > 200 - 400 cm [3]				

ShoreLine  Max 20

COMMENTS: \_\_\_\_\_

★ Shore Right Looking East or South on Lake ★  
 ★ Shore Right Looking Toward Lake in Lacustrary ★

## 4] RIPARIAN ZONE AND BANK EROSION (Check ONE box PER bank or 2 and AVERAGE)

RIPARIAN WIDTH		SHORE LINE QUALITY (PAST 100 FOOT RIPARIAN)		BANK EROSION	
L	R (Per Bank)	L	R (Most Predominant Per Bank)	L	R (Per Bank)
<input type="checkbox"/> -WIDE > 50m [4]		<input type="checkbox"/> -FOREST, WETLAND, LAKE [3]		<input type="checkbox"/> -CONSERVATION TILLAGE [1]	<input type="checkbox"/> -NONE/LITTLE [3]
<input type="checkbox"/> -MODERATE 10-50 m [3]		<input type="checkbox"/> -SHRUB OR OLD FIELD [2]		<input type="checkbox"/> -URBAN OR INDUSTRIAL [0]	<input type="checkbox"/> -MODERATE [-1]
<input type="checkbox"/> -NARROW 5-10 m [2]		<input type="checkbox"/> -VINEYARD, ORCHARD [2]		<input type="checkbox"/> -OPEN PASTURE, ROW/CROP [0]	<input type="checkbox"/> -HEAVY/SEVERE [-3]
<input type="checkbox"/> -VERY NARROW < 5 m [1]		<input type="checkbox"/> -FENCED PASTURE [1]		<input type="checkbox"/> -MINING/CONSTRUCTION [0]	
<input type="checkbox"/> -NONE [0]		<input type="checkbox"/> -RESIDENTIAL, PARK, NEW FIELD [1]		<input type="checkbox"/> -DIKED WETLAND [0]	

Riparian  Max 10

COMMENTS: \_\_\_\_\_

## 5] AQUATIC VEGETATION QUALITY: PLANT SPECIES OBSERVED (Sum All Scores)

(Score all for observed abundance: ABUNDANT = [3]; COMMON = [5]; FEW = [1]; UNCOMMON = [0]) \_\_\_\_\_ NO AQUATIC VEGETATION = 0

_____-Pond Lilies (NYMPHAEA)	_____-Sedge (CYPERACEAE)	_____-Wild Celery (VALLISNERIA)
_____-Pond Weed (POTAMOGETON)	_____-Bulrush (SCIRPUS)	_____-Waterweed (ELODEA)
_____-Wild Rice (ZIZANIA)		

(Score all for observed abundance: ABUNDANT = [-2]; COMMON = [-1]; FEW = [0])

_____-Purple Loosestrife	_____-Reed Grass	_____-Eurasian Milfoil	_____-Cattails	_____-Algae (mats)	_____-Algae (planktonic)
--------------------------	------------------	------------------------	----------------	--------------------	--------------------------

Vegetation  Max 30

COMMENTS: \_\_\_\_\_

Is the Sampling Reach Representative of Area Habitat? (Y/N)\_\_\_\_ If Not, Explain: \_\_\_\_\_

Depth measures:				
Zebra Mussel/Quagga Mussel Coverage	<input type="checkbox"/> ->60%	<input type="checkbox"/> -60->25%	<input type="checkbox"/> -25->10%	<input type="checkbox"/> -<10->1% <input type="checkbox"/> -1-0%

	Gear	Distance	Water Clarity	Wave Height
First Sampling Pass:	_____	_____	_____	_____
Second Sampling Pass:	_____	_____	_____	_____
Third Sampling Pass:	_____	_____	_____	_____

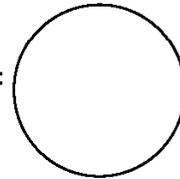
	
Subjective Rating (1-10)	Aesthetic Rating (1-10)

Photos: \_\_\_\_\_

WATERBODY MEASUREMENTS: AVERAGE WIDTH: \_\_\_\_\_ AVERAGE DEPTH: \_\_\_\_\_ Maximum Depth: \_\_\_\_\_

**DRAWING OF SITE:**

North Arrow:



## **Appendix B: Photographs**

(all photos by Roger Thoma)

Appendix B-1. Pictures of various vegetation types and their potential abundance classification.



A



B



C

- A: *Cladophora* can be very abundant in polluted areas
- B: Algae mats are frequently found at shoreline edges
- C: Abundant alga mats.



D



E



F

- D: Abundant growth of planktonic algae along the up to a depth of 10 feet. Cuyahoga County shoreline 1997.
- E: Abundant growth of reed grass, *Phragmites australis*.
- F: Abundant growth at the surface or just under of *Myriophyllum* and common growth of *Vallisneria*.

**Appendix B-2. Pictures of various vegetation types and their potential abundance classification**



**A**



**D**



**B**



**E**



**C**



**F**

- A:** Abundant growth of cattail, *Typha* sp. with woody debris and wooded/shrub riparian.
- B:** Common growth of emergent vegetation, wooded riparian right, lake left.
- C:** Abundant growth of water lotus, wooded riparian, riparian wide.

- D:** Common growth of water lilies with woody debris, wooded riparian, riparian width wide.
- E:** Common growth of water lilies and cattails (emergent) and Potamogeton (submergent) overlain by algae with a shrub riparian zone in the background.
- F:** Potamogeton and Myriophyllum growing together. The Potamogeton is more abundant.

**Appendix B-3. Pictures of various vegetation types and their potential abundance classification**



**A**



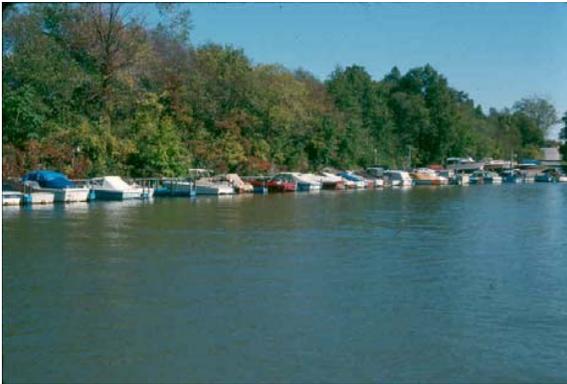
**D**



**B**



**E**



**C**



**F**

- A:** Abundant aquatic vegetation types (primarily lilies) with shrub and woodland riparian in background.
- B:** Planktonic algae common, shoreline quality urban, riparian width none (because of vegetation removal activities).
- C:** No aquatic vegetation and a wooded riparian. A vertical steel seawall exists behind the docked boats.

- D:** Purple loosestrife, cattail, and woody debris common in background. Riparian zone would be classified as wetland.
- E:** Natural woody debris to be found on wooded shoreline areas
- F:** Woody debris remnants resulting from anthropogenic shoreline modifications.

**Appendix B-4. Modified Lake Erie shoreline types with various riprap applications along Lake Erie's shoreline with other shoreline protection structures.**



**A**



**E**



**B**



**F**



**C**



**G**



**D**



**H**

- A:** Rip rapped disposal site with shrub riparian, Federal project.
- B:** Steel bulkhead with riprap at toe on shale cliff, municipal project.
- C:** 100% riprap with urban land use on glacial till, private project.
- D:** Small-scale riprap along shale cliff, single family usage.

- E:** Municipal riprap project using fabricated cement elements- residential riparian.
- F:** Sandstone boulder riprap for private property protection.
- G:** Cement block riprap on shale cliff, storm sewer to right, private project.
- H:** Old riprap showing recovery as sand/gravel substrates accumulate on shoreline.

**Appendix B-5. Modified and natural vertical Lake Erie shorelines.**



**A**



**E**



**B**



**F**



**C**



**G**



**D**



**H**

- A:** Vertical cement wall and shale cliff on Lake Erie's shoreline combining natural and anthropogenic.
- B:** Vertical cement wall, Maumee lacustrary.
- C:** Vertical steel sea wall in Cuyahoga ship channel characteristic of most ship channels.
- D:** Vertical cement wall, hardpan shore, and storm sewer pipe with shrub riparian in lacustrary.

- E:** Vertical shale cliff experiencing mass wasting.
- F:** Vertical shale cliff showing differential weathering, moderate sinuosity.
- G:** Limestone cliff and boulders, Kelleys Island.
- H:** Vertical glacial till cliff resulting from extreme erosion forces down current of the Fairport Harbor breakwater.

**Appendix B-6. Natural shorelines. Lake shore:**



**A**



**E**



**B**



**F**



**C**



**G**



**D**



**H**

- A:** Sandy beach shoreline near mouth of Toussaint Creek/Ottawa NWR.
- B:** Sandy beach at mouth of Old Woman Creek National Estuarine Reserve looking to Lake Erie.
- C:** Shale cliff bedrock shoreline just east of the mouth of Rocky River.
- D:** Limestone bedrock shoreline at Long Point west shore Kelleys Island.

- E:** Undisturbed lacustrine shoreline showing typical natural zones of vegetation.
- F:** Low water period in Old Woman Creek showing mud bottom substrates typical of lacustrines.
- G:** Sheldon Marsh SNP bay area behind barrier sand beach with common sedge and arrowhead growth.
- H:** Mouth of Hemming Ditch in the eastern arm of Sandusky Bay. High turbidity prevents aquatic plant growth below the water line.

**Appendix B-7. Various shoreline modifications found along Lake Erie.**

**Lacustraries:**



**A**



**B**



**C**



**D**

**Lake shore:**



**E**



**F**



**G**



**H**

- A:** Shoreline dredging with side cast of dredged sediments, Sandusky Bay area.
- B:** Dredging and diking at Ottawa National Wildlife Refuge to control water levels.
- C:** Marina development in Rocky River lacustrary, a typical fate of most lacustraries.
- D:** Old piles of slag placed on the Black River lacustrary shore with subsequent erosion.

- E:** Large-scale shoreline modification with re-shaping and placement of grout bags at slope base thus eliminating possible beach formation.
- F:** Miscellaneous construction debris dumped over bank top to serve as erosion protection.
- G:** From right to left: Sloping revetment, vertical wall, and construction debris respectively.
- H:** Waste concrete poured down the bank with old steel gas tanks at base.

**Appendix B-8. Miscellaneous figures.**



**A**



**E**



**B**



**F**



**C**



**G**



**D**



**H**

- A:** Aerial view of Cleveland and its harbor showing urban-industrial land use.
- B:** Aerial view of the Cuyahoga River ship channel with industrial land use.
- C:** Dumping of loose soil over a shale cliff as shoreline protection.
- D:** Zebra mussels on cobble substrate; 10-25% coverage.

- E:** Vertical railroad-tie breakwall providing minimal habitat value and contributing PAH compounds to surrounding waters.
- F:** Limestone bedrock, boulder, cobble, and gravel substrate and shoreline, Rattlesnake Island.
- G:** A gravel/cobble beach and limestone bedrock substrate, Rattlesnake Island.
- H:** Toussaint creek lacustrine; natural wooded left and modified rip-rap/diked right shorelines.