Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams

Creek chub

Two-lined salamander

Stonefly larva

January 2012 (Version 3.0)

John Kasich, Governor
Mary Taylor, Lt. Governor
Scott Nally, Director

THIS PAGE INTENTIONALLY LEFT BLANK

Notices:

Ohio EPA has developed this manual to provide standardized assessment methodologies for conducting use attainability analyses of primary headwater habitat streams. The methods provided in this manual are used to properly classify the actual and expected biological conditions in primary headwater habitat streams. The use of the procedures in this manual is particularly relevant in the context of Section 401 water quality certifications and antidegradation reviews. All statements regarding aquatic life use designations for primary headwater habitat streams are made in the context of revisions to Rule 07 of Ohio's water quality standards (OAC Chapter 3745-1) as proposed on December 28, 2011.

This manual replaces prior documents made available to the public on standardized sampling in primary headwater habitat streams (Davic, 1996; Anderson et al. 1999; Ohio EPA, 2002 a; Ohio EPA, 2009 a). Any future changes to this manual following its reference in rules within the water quality standards will be conducted in conjunction with formal agency rule updates. Questions regarding Ohio EPA water quality standard regulations and aquatic life use designations should be directed to the Division of Surface Water, PO Box 1049, Columbus Ohio 3216-1049 [(614) 644-2876]. Ohio EPA maintains a Primary headwater habitat web page, accessible at http://www.epa.ohio.gov/dsw/wqs/headwaters/index.aspx that contains this field manual as well as related documents and information.

All addresses for access to internet sites for sources of information referenced in this manual were accurate at the time of publication. Over time it can be expected that these links may become outdated. However, the Ohio EPA maintains copies of all documents referenced in this manual that can be obtained by contacting the Ohio EPA Division of Surface Water.

The proper citation for this document is as follows:

Ohio EPA. 2012. Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams. Version 3.0. Ohio EPA Division of Surface Water, Columbus, Ohio. 117 pp.

Acknowledgments:

The original version of this manual was authored by Robert Davic, Paul Anderson and Steve Tuckerman. This 2012 revision of the manual was edited by Paul Anderson, Mike Bolton, Greg Orr, and Chris Skalski, Ohio EPA Division of Surface Water. Technical questions regarding the procedures described in this manual should be directed to Paul Anderson at: (330) 963-1228; Ohio EPA Northeast District Office, 2110 East Aurora Road, Twinsburg, Ohio 44087; or via e-mail: paul.anderson@epa.state.oh.us. Lead investigators for the Ohio EPA primary headwater habitat stream assessment program were: Paul Anderson, Mike Bolton, Robert Davic, and Steve Tuckerman; under the direction of project coordinators Dan Dudley, Bill Schumacher, and Chris Skalski. Other members of the Ohio EPA primary headwater habitat work-group who contributed technical review and/or field data were: Jim Grow, Joe Loucek, MaryAnne Mahr, Ed Moore, Louise Snyder, Ric Queen, Ed Rankin, Hugh Trimble, and Chris Yoder. We acknowledge the significant efforts of numerous Ohio EPA summer interns as well as Matt Scharver and Chad Edgar of the Lake Soil and Water Conservation District for their contribution in the collection of data. We also thank members of the Ohio Academic Panel that was convened by Dr. Gene Willeke of Miami University in Oxford, Ohio for their valuable technical comments on sampling procedures contained in the original version of this manual.

Conversions:

Throughout this manual various metric and English measurement units are cited due to different protocols established in the engineering and basic sciences. Some useful conversions are given below:

To covert	into	Multiply by, or use formula
Square mile	hectare	259
Square mile	square kilometer	2.590
Feet	meters	0.3048
Inches	centimeters	2.540
Miles	kilometers	1,609
Hectares	acres	2.471
Celsius	Fahrenheit	(1.8 * °C) + 32
Fahrenheit	Celsius	5/9 * (°F - 32)

List of Acronyms:

7Q10	Minimum seven-day average flow with a ten-year recurrence interval (see USGS, 2001 for Ohio data).
CWA	Clean Water Act (Public Law 92-500, October 18, 1972)
CWH	Coldwater Habitat (OAC Chapter 3545-1)
DQO	Data quality objective
EPT Taxa	Benthic macroinvertebrates from the Ephemeroptera, Plecoptera, and Trichoptera (mayflies, stoneflies, and caddisflies, respectively)
EWH	Exceptional Warmwater Habitat (OAC Chapter 3745-1)
GIS	Geographic Information System
GPS	Geographic Positioning System
HHEI	Headwater Habitat Evaluation Index
HMFEI	Headwater Macroinvertebrate Field Evaluation Index
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
MWH	Modified Warmwater Habitat (OAC Chapter 3745-1)
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly SCS)
OAC	Ohio Administrative Code (state administrative rules)
Ohio EPA	State of Ohio Environmental Protection Agency
ODNR	State of Ohio Department of Natural Resources
ORC	Ohio Revised Code (state law)
PHWH	Primary Headwater Habitat
QHEI	Qualitative Habitat Evaluation Index
SCS	Soil Conservation Service (now NRCS)
SWCD	Soil and Water Conservation District
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWH	Warmwater Habitat (OAC Chapter 3745-1)

Preface to Version 1.0 (Ohio EPA, 2002):

The Federal Clean Water Act provides for "maintaining the biological integrity of the nation's waters", from the mouths to the headwaters. In carrying out the regulatory responsibilities for streams in the State of Ohio, there is a need for a methodology that deals with proposed activities in the extreme headwaters areas, what Ohio EPA calls "primary headwater habitat" (PHWH) streams. It is well established in the scientific literature that headwater streams of the kind addressed in this manual are important to the quality of water and biological communities in larger streams to which these primary headwater streams are tributary.

The primary headwater streams addressed in this manual are quite small, less than 1.0 mi^2 drainage area. Many of them would not show up as blue lines on USGS 1:24,000 quadrangle maps, although almost all of them would be visible and marked on county soil maps. These streams are not often defined or assigned beneficial uses in Ohio water quality standards. The sampling methods, and concurrent biological and habitat indices now used by OEPA to classify waterways for existing water quality (e.g., IBI, ICI, QHEI) are oriented toward larger streams. Because these "index of biotic integrity" assessment systems are watershed size dependent, they often cannot be used to identify the well-being of the native fauna that survive and reproduce in small headwater stream ecosystems.

In the absence of comparable measures of stream quality for extreme headwaters, government agencies responsible for protection of water resource integrity may appear to be arbitrary if they seek to approve or deny a permit or certification application to lower water quality in primary headwater streams. The stream classification methodology presented in this manual helps to fill that void, in a manner similar to the Ohio EPA (ORAM) sampling methods now being used to classify jurisdictional wetlands. This primary headwater stream manual outlines a predictable three-tiered protocol that can be used to conduct rapid assessment of headwater stream quality. The lowest level of field effort is a relatively rapid habitat evaluation procedure known as the "Headwater Habitat Evaluation Index" (HHEI). It is based on three physical measurements that have been found to correlate well with biological measures of stream quality. Two levels of biological assessment, one at an order-family level of taxonomic identification, the second to genus-species, provide flexibility in reaching a final decision on the appropriate aquatic life use designation needed to protect the native fauna of any primary headwater stream.

The great number of primary headwater streams in Ohio, their diverse ecological functions, and their value to the well-being of the larger rivers, lakes, and wetlands to which they are tributary underscores the importance of their proper classification and protection.

Gene E. Willeke, Ph.D., P.E.
Director, Institute of Environmental Sciences
Miami University
Oxford, Ohio

Table of Contents

Notices ……. ii
Acknowledgements …… iii
Conversions …… iii
List of Acronyms ……. iv
Preface to Version 1.0 (Ohio EPA, 2002) …….. v
Table of Contents ……... vi
List of Figures …….. ix
List of Tables …… x
List of Attachments ……. x
A Quick Guide to the PHWH Assessment Process …….. xi

1.0 Introduction and Rationale …… 1
1.1 PHWH Stream Classes ……. 3
1.1.1 Class I PHWH ……. 3
1.1.2 Class II PHWH …… 3
1.1.3 Class III PHWH …….. 3
1.2 Modified PHWH Streams …….. 5
1.3 Physical Characteristics of PHWH Streams …….. 5
1.4 Assessment Overview for PHWH Streams …… 10
1.4.1 Levels of PHWH Assessment …….. 11
1.4.2 Documentation and responsible Practices …… 12
2.0 Preparation for PHWH Surveys …….. 12
2.1 Data Quality Objectives …… 12
2.2 Desktop Evaluation …… 14
2.2.1 Mapping Resources …..……... 14
2.2.2 Determination of Upstream Drainage Area …… 15
2.3 When to Sample ……. 17
2.4 Equipment Checklist …….. 18
2.5 Reference Materials …….. 18
3.0 Stream Reach Delineation and Site Selection …….. 19
3.1 Site Selection …….. 20
3.2 QHEI vs. HHEI Evaluation in Headwater Streams ……... 22
4.0 Rheocrene Habitats and Seepage Areas …… 23

Table of Contents (cont.)

5.0		Level 1 Assessment: Conducting a HHEI Evaluation	24
5.1		General Stream Information	24
5.2		Channel Modification Category Determination	25
5.3		Calculation of the HHEI Score	27
	5.3.1	Metric #1: Stream Channel Substrate	27
	5.3.2	Metric #2: Maximum Pool Depth	32
	5.3.3	Metric #3: Average Bankfull Width	33
	5.3.4	Total HHEI Score	38
5.4		Using the HHEI Assessment to Assign PHWH Classifications	38
5.5		Riparian Zone and Flood Plain Quality	40
5.6		Flow Regime	41
5.7		Sinuosity	42
5.8		Stream Gradient	43
5.9		PHWH Form – Page 2	43
	5.9.1	QHEI Assessment	43
	5.9.2	Downstream Designated Use(s)	44
	5.9.3	Location Information	44
	5.9.4	Miscellaneous Information	44
	5.9.5	Biological Evaluation Summary	45
	5.9.6	Drawing and PHWH Stream Reach Narrative Description	46
6.0		Level 2 and Level 3 Assessments: Biological Sampling	46
6.1		Fish in PHWH Streams	47
6.2		Salamanders in PHWH Streams	49
	6.2.1	Sampling methods for Salamanders in PHWH Streams	51
	6.2.1.1	Level 2 Assessment: Qualitative Salamander Evaluations	58
	6.2.1.2	Level 3 Assessment: Salamander Visual Encounter Survey	58
	6.2.2	Salamanders Voucher Specimens	59
6.3		Benthic Macroinvertebrates in PHWH Streams	59
	6.3.1	Benthis macroinvertebrate Sampling Methods	60
	6.3.1.1	Level 2 Assessment: the Headwater Macroinvertebrate Field Evaluation Index (HMFEI)	61
	6.3.1.2	Level 3 Assessment: Lowest Taxonomic Level Analysis for benthic macroinvertebrates	64

Table of Contents (cont.)

6.3.2	Benthic Macroinvertebrate Voucher Specimens ……..	65
7.0	Summary of the Criteria to Classify PHWH Streams ……..…….	65
7.1	Determination of a Class I PHWH …….……..	67
7.2	Determination of a Class II PHWH ……..	67
7.3	Determination of a Class III PHWH ……..……..	67
8.0	Recommended Levels of Protection for PHWH Stream Classes ……..	72
9.0	References ……..	73

List of Figures

Figure 1. The river continuum concept and its relationship to biological communities found in primary headwater habitat streams ……... 1

Figure 2. Ohio EPA PHWH sampling locations 1999-2001 …….. 2

Figure 3. Conceptual water pathways in different types of PHWH streams …….. 9

Figure 4. Representative NRCS (aka SCS) County Soil Map showing location of Primary Headwater Habitat (PHWH) streams in a local watershed …… 15

Figure 5. Example watershed delineation from the Ohio STREAMSTATS web page .. 16

Figure 6. Example of basin data provided from the Ohio STREAMSTATS web page following watershed delineation …… 16

Figure 7. Hypothetical relationship of the primary headwater stream reach concept … 21

Figure 8. An example of a completed Substrate Metric section from page 1 of the PHWH Form ……. 29

Figure 9. A stylized representation of a substrate particle indicating the proper way to determine the size category for classification ……. 30

Figure 10. Schematic representation of the relationship of bankfull and floodprone stream widths …….. 35

Figure 11. Measuring bankfull width in an incised PHWH stream ……. 36

Figure 12. Bankfull indicators noted for a Class II PHWH stream from Fulton County, Ohio …… 36

Figure 13. Bankfull indicators noted for a Class III PHWH stream from Hocking County, Ohio …… 37

Figure 14. A line level ……. 37

Figure 15. PHWH classification flow chart based on HHEI scoring …… 39

Figure 16. Diagram indicating the method for determining sinuosity as recorded on the PHWH form …….. 42

Figure 17. PHWH classification flow chart: Level 1 Assessment …….. 69

Figure 18. PHWH classification flow chart: Level 2 Assessment …….. 70

Figure 19. PHWH classification flow chart: Level 3 Assessment …….. 71

List of Tables

Table 1. Summary of estimated miles of flowing waterways in Ohio ……. 7

Table 2. Suggested terminology to identify different types of hydrology associated with biological communities and stream classes in primary headwater streams in Ohio 8

Table 3. Important definitions from proposed rule OAC 3745-1-02 …… 11

Table 4. Guidelines for the determination of the stream channel modification category for the HHEI form …….. 26

Table 5. Fish species observed/collected in Primary Headwater Habitat streams in Ohio, 1999-2000. Fish were captured in 67 of the streams sampled …….. 48

Table 6. Species of salamanders that can be used as bio-indicators of Class III (cold water, perennial flow) and Class II (warm water, intermittent flow) PHWH streams in Ohio ……... 52

Table 7. List of salamander species in Ohio that use primary headwater stream corridors as a habitat for egg deposition (oviposition) and larval growth ……. 53

Table 8 Summary of benthic macroinvertebrate community characteristics associated with PHWH stream classes …… 61

Table 9. Headwater Macroinvetebrate Field Evaluation Index (HMFEI) scoring categories for use in assessing primary headwater habitat streams in Ohio …… 63

List of Attachments

Attachment 1. The Ohio Primary headwater Habitat Evaluation Form (PHWH Form)

Attachment 2. Field Check List for Primary Headwater Stream Sampling

Attachment 3. List of cold water indicator and sensitive macroinvertebrate taxa used to classify Class III PHWH streams

Attachment 4. Substrate Pebble Count Data Sheet

Attachment 5. Qualitative Substrate Evaluation Form

Attachment 6. Headwater Stream Salamander Voucher Sheet

A Quick Guide to the PHWH Assessment Process

The following sequence of tasks summarizes the various steps involved in a PHWH stream assessment.

Desktop Evaluation (Section 2.0)

Step 1 Develop a study plan for conducting the PHWH stream assessment. Identify the data quality objectives for the study, personnel to be utilized and the equipment and supplies to be used for the study (Sections 2.0 and 2.1).

Step 2 Obtain the NRCS county soil map, the USGS 7.5 min. topographic map, or other suitable mapping resource for the watershed area under investigation. (Section 2.2.1)

Step 3 Delineate the boundaries for the PHWH classification on the site map. Determine total linear feet (or meters) of all potential PHWH streams.

Step 4 Select sites to be assessed using the guidelines in Section 3.0. Determine the total watershed area for PHWH streams at the most downstream location of the property boundary or assessment area using the USGS STREAMSTATS web page, the USGS topographic map, the NRCS soil map, or other mapping tools at the appropriate scale. (Section 2.2.2)

Step 5 Prepare to conduct an on-site PHWH stream evaluation if the watershed area is less than 1 mi^2 (259 ha). Prepare to conduct a QHEI/WWH stream evaluation if the watershed area is greater than 1 mi^2 (259 ha) (Section 3.2).

> Note: Where determined to be appropriate by a qualified biologist, a PHWH evaluation can be conducted in streams with watershed areas greater than 1 mi^2 (259 ha), or a QHEI/WWH evaluation can be conducted in streams with watershed areas less than 1 mi^2 (259 ha) (see Section 3.2).

Field Reconnaissance and Sampling

Step 6 Determine if the streams in question are at or near base flow for the period of the year that the survey is being conducted (Section 2.3). If **NO**, do not proceed with evaluation. If **YES**, proceed with the assessment. In addition, determine if severe drought conditions exist or whether or not stream flows in the vicinity of the study area are above 7Q10 using USGS stream flow information. If the area is under drought conditions or stream flows in the vicinity of the study area are less than 7Q10 flow, the PHWH stream assessment should not be conducted (see Section 2.3).

Step 7 Delineate (with flags) 200 ft (60m) stream reach sections for each mainstem PHWH stream. Begin stream reach delineation starting at the most downstream point of interest, and continue in an upstream direction. Tributaries of the mainstem with channel lengths greater than 200 ft (60 m) should be evaluated as separate PHWH streams. Very small seepage areas can be assessed as being part of the associated 200 ft (60 m) PHWH stream reach. (Section 3.0)

Step 8 Record observational data on the PHWH Form (Attachment 1) regarding the physical nature of the stream corridor including the stream flow condition observed, riparian zone land use and buffer width, channel modification category, etc. (Section 5.0). Take photographs and index them for later association with the appropriate data sheet. (Section 5.9.4)

Step 9 If appropriate, conduct water chemistry sampling before walking in the stream water and adding turbidity. (Section 5.9.4)

Step 10 **If conducting a biological survey (Level 2 or Level 3 Assessment)**; begin by sampling for amphibians (salamanders), then fish, and finally benthic macroinvertebrates. Collect voucher specimens where appropriate. The sequence of sampling from vertebrates to invertebrates is important because water with low turbidity is very important to accurately conduct a visual search for aquatic salamander larvae. However, it is also important that clear water be present when conducting the fish and invertebrate surveys. Thus you must wait until the water is clear to conduct these surveys. Record all biological data on pages 3 and 4 of the PHWH Form. (Section 6.0)

Step 11 **Complete the HHEI assessment for all sites (Level 1 Assessment).** Measure the bankfull width, maximum pool depth, and substrate composition as directed in this manual. Record all data on pages 1 and 2 of the PHWH Form. Be sure to complete the entire PHWH Form in Attachment 1. (Section 5.0)

Step 12 Optional habitat measures for parameters such as gradient (surveyed), flood prone width, and quantitative pebble counts may now be conducted if deemed necessary. (Section 5.3.1, Attachment 4)

Final Report

Step 13 Use data from the HHEI evaluation (Attachment 1) **and** the results of the biological survey (if conducted) to determine the appropriate PHWH stream class (Class I, II, III). Use the decision making flowchart in Figure 15 when using the HHEI information in the absence of a biological survey. Use the guidelines from Section 7.0 and Figures 17 through 19 of this manual when using biological data to classify the stream reach.

Results from the biological survey take precedence over results from a HHEI survey unless there is reason to believe that chemical stressors are present which could limit the presence of biological communities (i.e., warm water resulting from the lack of riparian cover, toxic levels of heavy metals, elevated ammonia-N, low dissolved oxygen, low pH, excessive stream bed siltation, etc.). Where chemical stressors are shown to be present, the results from the HHEI survey can be used to identify the potential PHWH stream class.

Summarize the results of the field evaluation and write a report describing the PHWH stream classification results for the streams investigated.

THIS PAGE INTENTIONALLY LEFT BLANK

1.0 Introduction and Rationale

The methods in this manual are calibrated to provide data necessary to assess and classify primary headwater habitat streams in Ohio. Primary headwater habitat streams are defined in revisions to Rule 07 of Ohio's water quality standards [Ohio Administrative Code (OAC) Chapter 3745-1] as follows:

> **"All stream segments with drainage areas less than one square mile are designated primary headwater habitat use unless site-specific data indicate a different aquatic life use designation or an alternative drainage area delineation is appropriate and the specific stream is so identified in rules 3745-1-08 to 3745-1-32 of the Administrative Code."** OAC 3745-1-07 (F)(9)

Primary headwater habitat (PHWH) streams are the very smallest swales and streams that are the origin of larger water bodies in the state. The chemical, physical, and biological quality in larger streams and lakes are closely connected to the overall health of headwater streams and their watersheds (Alexander et al., 2007; Meyer et al., 2007; Peterson et al., 2001; Wipfli, 2005). Primary Headwater Habitat streams provide important economic and ecological functions through the retention of sediment, water, and organic matter; nutrient reduction; and by providing corridors for wildlife dispersal (Ohio EPA, 2003; Meyer and Wallace, 2001; Peterson et al., 2001). They may harbor a unique native fauna of vertebrates, benthic macroinvertebrates, and aquatic plants that are adapted to specific stream flow patterns or thermal conditions found in PHWH streams. These small streams are a natural extension of the stream continuum concept (Figure 1), which identifies how larger streams in a watershed are dependent on chemical and biological processes that occur in the smaller streams that flow into them.

Some think of small streams as nuisances or merely storm water conveyances. The concept that the conditions present in these seemingly insignificant streams can cumulatively have substantial consequences on downstream water quality is not well known to the general public.

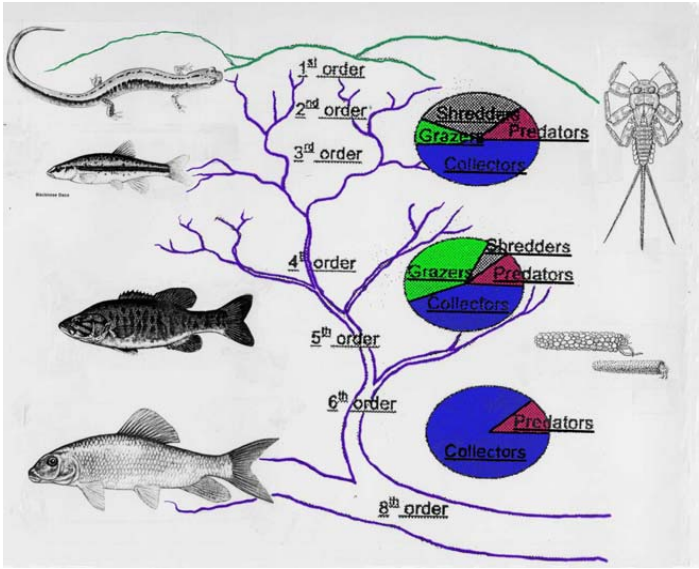


Figure 1. The river continuum concept and its relationship to biological communities found in primary headwater habitat streams (after Vannote et al., 1980).

The primary objective of the federal Clean Water Act (CWA, Sec. 101 a) is "to... restore and maintain the chemical, physical, and biological integrity of the nation's waters", a goal that clearly applies not only to large rivers but also to the smaller headwater streams of the nation's watersheds. In Ohio, PHWH streams that connect to other flowing waters are defined as "waters of state" in the Ohio Revised Code (ORC 6111.01). Discharges from point sources into small streams and drainage channels are regulated by National Pollutant Discharge Elimination System (NPDES) permits as discharges to waters of the state.

In Ohio, water quality standards contain both chemical and biological criteria (OAC Chapter 3745-1). Biological water quality criteria include the Index of Biotic Integrity (IBI) for fish and the Invertebrate Community Index (ICI) for macroinvertebrates. However, experience in the use of these indices over the past 30 years has found that these sampling methods, that work well in larger streams, are not appropriate for PHWH streams given their small size and lack of sufficient habitat to support well-balanced fish communities. Research has shown that there are strong relationships between hydrology, geomorphology, and the biotic potential of PHWH streams. Conservation of these resources requires a watershed perspective which acknowledges the continuum of water quality from headwaters to larger streams and rivers.

Recognizing the limitations of the biological assessment methods used in larger streams, a study was conducted to develop assessment methodologies at the small watershed scale. From 1999 to 2001 Ohio EPA conducted a statewide biological, chemical, and physical habitat evaluation of PHWH streams located within four of the major ecoregions of Ohio (Figure 2). This evaluation was a continuation of a PHWH stream assessment initiative that Ohio EPA has made available to the public since the 1990's (Davic, 1996; Anderson, et al, 1999; Ohio EPA, 2002a; Ohio EPA, 2009 a).

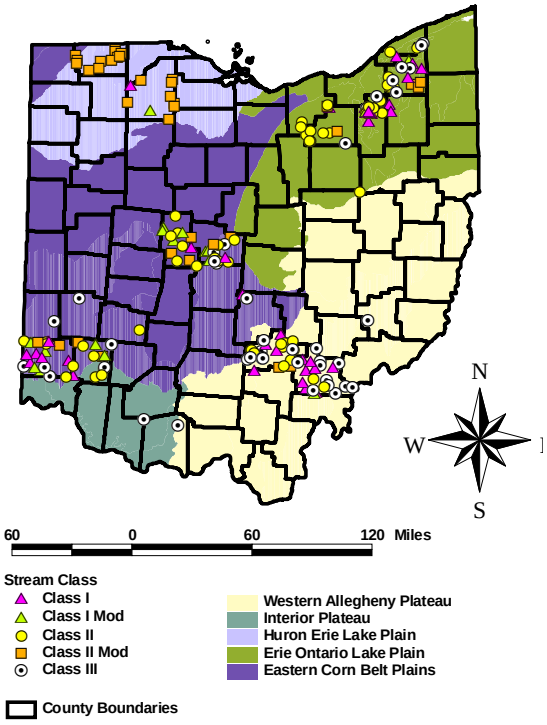


Figure 2. Ohio EPA PHWH sampling locations, 1999-2001.

Fifty-nine PHWH streams were surveyed in 1999 with an additional 215 streams randomly sampled in 2000 from 5 rapidly developing areas in 10 Ohio counties. In 2001, 18 streams were sampled for seasonal trends (benthic macroinvertebrates), and additional data were collected from select counties. Detailed information on the results of these surveys is available in separate technical reports (Ohio EPA, 2002b; Ohio EPA, 2002c; Ohio EPA, 2002d). The results of these studies were used to develop a biological classification system capable of defining the aquatic life use potential of PHWH streams in Ohio.

1.1 PHWH Stream Classes

The classification of PHWH streams is based upon the type of biological community that can be supported by the stream. The biological community present is indicative of the interaction of all of the physical and biological characteristics including the stream's flow regime, the underlying geology, stream thermal characteristics, water quality, and land use within the watershed. Based upon the results of the statewide sampling effort, three classifications for PHWH streams became evident based upon the types of biological communities that may be present. These PHWH stream classes are defined in OAC 3745-1-07 (F)(9)(d) as follows:

1.1.1 Class I PHWH [OAC 3745-1-07 (F)(9)(d)(i)]:

Class I PHWH streams are ephemeral streams. They have little or no aquatic life potential, except seasonally when flowing water is present for short time periods following precipitation or snow melt. Streams assigned to Class I PHWH may be typified by one or more of the following characteristics:

- no significant habitat for aquatic fauna;
- no significant aquatic wildlife use; and
- limited or no potential to achieve higher PHWH class functions.

1.1.2 Class II PHWH [OAC 3745-1-07 (F)(9)(d)(ii)]:

Class II PHWH streams are normally intermittent but may have perennial flow. They may exhibit moderately diverse communities of warm water adapted native fauna present either seasonally or year-round. The native fauna is characterized by species of vertebrates (temperature facultative species of amphibians and pioneering species of fish) and benthic macroinvertebrates. Pool depth and water volume are normally insufficient to support the biological criteria associated with other sub-categories of aquatic life described OAC Rule 3745-1-07. Prevailing temperature conditions in Class II PHWH streams prevent establishment of Class III biology and function.

1.1.3 Class III PHWH [OAC 3745-1-07 (F)(9)(d)(iii)]:

Class III PHWH streams are perennial streams in which the prevailing flow and temperature conditions in Class III PHWH streams are influenced by groundwater. They exhibit moderately diverse to highly diverse communities of cold water adapted native fauna present year-round. Pool depth and water volume are normally insufficient to support the biological criteria associated with other sub-categories of aquatic life described OAC Rule 3745-1-07.

The Class III PHWH classification is further divided into two sub-classes as follows:

Class IIIA PHWH:

These are perennial streams that exhibit diverse communities of native fauna. The native fauna is characterized by:

- reproducing populations of one or more of these salamander species (sub-species): the Northern Two-Lined Salamander (*Eurycea bislineata bislineata*), the Southern Two-Lined Salamander (*Eurycea bislineata cirrigera*), the Northern Longtail Salamander (*Eurycea longicauda*); or

- benthic macroinvertebrates, including four or more cold water macroinvertebrate taxa from Table 7-2 of OAC Rule 3745-1-07.

Class IIIB PHWH:

These are perennial streams that exhibit superior species composition or diversity of native fauna. The native fauna is characterized by:

- a reproducing population of one or more vertebrate species listed in Table 7-2 of OAC Rule 3745-1-07; or

- a macroinvertebrate community consisting of at least four Coldwater taxa from Table 7-2 of OAC Rule 3745-1-07 and also having two or more of the following attributes:
    - six or more cold water macroinvertebrate taxa listed in Table 7-2 of OAC Rule 3745-1-07;
    - six of more taxa from the insect orders Ephemeroptera, Plecoptera and Trichoptera;
    - six or more sensitive macroinvertebrate taxa.

NOTE TO USERS: a list of cold water indicator macroinvertebrate taxa identified in Table 7-2 of OAC Rule 3745-1-07 is included in Attachment 3 to this manual. The list of sensitive macroinvertebrate taxa, defined as pollution intolerant and moderately pollution intolerant macroinvertebrate taxa is also included in Attachment 3.

THE THREE TYPES OF PRIMARY HEADWATER STREAMS IN OHIO:

1. **Class III-PHWH Stream (perennial stream, cold water adapted native fauna)**
2. **Class II-PHWH Stream (warm water adapted native fauna)**
3. **Class I- PHWH Stream (ephemeral stream, normally dry channel)**

1.2 Modified PHWH Streams

A number of PHWH streams in Ohio are channelized, often with significant removal of riparian vegetation. Channelization leads to changes in stream hydrology, physical habitat degradation, and sedimentation problems that are recognized among the leading causes of impairment of Ohio's surface waters (Ohio EPA, 2010). Channelization or other forms of drainage improvement are often essential for agricultural production, especially in western and central Ohio. In general, projects that result in the placement of fill material into streams or wetlands often require a federal permit (CWA Section 404) and state water quality certification (CWA Section 401).

The PHWH stream classification system in OAC 3745-1-07 lists criteria for identification of channels with relatively permanent anthropogenic disturbance. The rule [OAC 3745-1-07 (F)(9)(d)(iv)] indicates that Class I and Class II PHWH streams may be further classified as modified habitats if they:

- are historically channelized watercourses as defined in ORC 6111.01;
- have permanent structures to impound free-flowing water; or
- otherwise have human induced channel modifications that are of long-lasting duration.

There are cases where highly modified stream channels have been documented to support Class III PHWH biological communities. However, these types of streams are rarely encountered and are their presence is difficult to predict using rapid assessment methodologies. Inevitably, these systems are linked to upstream stream segments where groundwater contribution to the stream flow is significant and where refugia exist capable of supporting reproducing populations of cold water adapted fauna. Where these situations arise, the stream segment should be managed as a Class III PHWH stream and be protected accordingly.

1.3 Physical Characteristics of PHWH Streams

The primary physical habitat distinction between a Class I and Class II PHWH stream is the presence of flowing water or isolated pools for extended periods of time in Class II PHWH stream channels during dry periods of the year. The primary biological distinction is that Class I PHWH streams either have no species of aquatic life present, or if present, the biological community is of relatively low diversity.

During the years 1999-2001, biological sampling and accompanying measurements of numerous physical habitat attributes was conducted at 274 PHWH stream locations following field methods described in Anderson, et al. (1999). The purpose of this sampling was to determine the feasibility of using a rapid assessment of physical habitat variables to predict, with a high degree of statistical confidence, the biological characteristics of a PHWH stream. Using methodologies similar to those employed to develop the Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989; Rankin, 1995), a Headwater Habitat Evaluation Index (HHEI), was constructed. The HHEI can be used to score physical habitat features that have been found to be statistically important determinants of biological community structure in PHWH streams with drainage area less than 1 mi^2 (259 ha).

The HHEI assessment is similar to, but different from, the "Habitat Suitability Index" approach used by the U.S. Fish and Wildlife Service to predict ecological habitat requirements for specific wildlife species (U.S. Fish and Wildlife Service, 1981). The Habitat Suitability Index (HSI) uses measures of habitat variables to predict life history characteristics of individual species of wildlife. In contrast, the primary design objective of the HHEI approach is to use measures of habitat variables to predict the presence or absence of an assemblage of cold water adapted vertebrates (fish and/or lungless salamanders) and benthic macroinvertebrates (Class III biology). The secondary objective was to determine scoring parameters for use in predicting Class II and Class I biological communities.

Statistical analysis of a large number of physical habitat measurements showed that three habitat variables (channel substrate composition, bankfull width, and maximum pool depth) are sufficient to statistically distinguish Class I, II, and III PHWH streams using the HHEI. Assigning positive and negative weighted scores to these three habitat variables results in the formation of a final composite HHEI score. The HHEI rapid assessment tool is most predictive when "modified" channels (e.g., channels modified by relocation, channelization, dredging) are separated from "natural" channels (those with little or no evidence of historical channel modification, or where the channel has recovered from such impacts). Thus indirectly, the final HHEI scoring process incorporates many more aspects of the geomorphology and hydrology of small stream channels (i.e., entrenchment, degree of sinuosity, etc.) than the limited set of three variables that require quantitative measurement.

The headwater stream network of watersheds is complex, and the proportion of the three PHWH stream classes varies among the ecoregions in Ohio (OSU, 2001). The average stream miles of the different types of streams estimated in Ohio are shown in Table 1. Some waterways without a defined stream bed and bank (non-stream waterways), constituting 18.4% of the total PHWH drainage network in Ohio, fall outside the concept of a headwater "stream". These statistics were derived from data collected by Ohio EPA in 2001 using a random survey of PHWH streams in various ecoregions. Man-made roadside ditches that are not a continuation of a natural stream channel ("captured streams") are also included in the non-stream waterway category (see Section 1.4 and Table 3 for further discussion).

The type of biological community found in PHWH streams can shift abruptly from one PHWH stream class to another, such as when cold spring-fed groundwater flow intercepts a dry stream channel (e.g., Class I stream becomes a Class III). Other changes in species composition are gradual (e.g., when a cold Class III stream is sequentially diluted by contributions of warmer surface runoff or when incident sunlight warms the stream where shading is reduced). Yet other PHWH streams maintain the same type of biological community throughout their length. Terms that relate hydrology to the different classes of PHWH streams is provided in Table 2, and Figure 3.

Many different hydrological terms relate to the three classes of PHWH streams described in this manual. Terms such as perennial, permanent, continuous, intermittent, temporary,

Perennial flow (continuous, permanent)	**=**	**either Class III or Class II PHWH stream**
Interstitial flow (interrupted)	**=**	**either Class III or Class II**
Intermittent flow (temporary, summer-dry)	**=**	**Class II**
Ephemeral flow	**=**	**Class I**

Table 1. Summary of estimated miles of flowing waterways in Ohio. Statistics from OSU (2001).

Waterway Type	Length in Miles	Percent of Total
Named Streams		
(ODNR, USGS blue lines)	21,048	12.61%
Unnamed Streams*		
Class I PHWH	36,405	21.80%
Class II PHWH	51,250	30.69%
Class III PHWH	27,551	16.51%
Unnamed Waterways		
Non-stream waterways#	30,708	18.39%
Total of all types: mean	166,962	100
95% Upper CI of mean	250,636	

*A random site selection statistical approach was used to estimate the total length of "unnamed stream" miles. This value would include intermittent blue lines on USGS topographic 7.5 min. series maps.

#Non-stream waterways do not have a well-defined bed and bank, thus they do not meet the concept of a "Primary Headwater Habitat stream". However, these waters do meet the definition of "waters of the state" in Ohio Revised Code, Section 6111.

Table 2. Suggested terminology to identify different types of hydrology associated with biological communities and stream classes in primary headwater streams in Ohio. See also Figure 3.

"**Continuous flow**". Water that flows permanently in a stream channel. Also referred to as "**perennial**" or "**permanent**" flow. There are two general types of continuous flowing primary headwater streams:

"**Suprafacial flow**"**. Streams with continuous flow on the surface of the stream bed substrate. Streams with suprafacial flow maintain surface flowing water at most times of the year (except for years of extreme drought) due to constant infiltration of surface runoff and/or groundwater recharge from subsurface aquifers. These streams may have Class II PHWH biology (if warm in summer) or Class III PHWH biology (if cold-cool in summer).

"Interstitial flow". Streams with continuous flow that occurs seasonally under the surface of the stream bed within the interstitial spaces of course substrate, or cracks in bedrock. Also called "**interrupted flow**". Streams with interstitial flow have visually dry stream beds with isolated pools of water that are hydraulically connected by slowly moving water. At times of sustained drought, this type of stream may only have water flowing within the subsurface alluvium. The perennial flow is maintained by either deep groundwater recharge from the water table, or from surface wetlands. These streams can maintain either a Class II (if warm in summer) or Class III type biology (if cold-cool in summer) in isolated pools of water, or in the interstitial spaces of the subsurface hyporheic zone, depending on the origin of the flowing water. The biology in warm water interstitial streams tends to resemble that of the intermittent stream type during sustained drought.

"**Periodical flow**". Water that stops flowing along the stream channel during periods of no precipitation and/or groundwater recharge. There are two general types of periodical flow:

"**Intermittent flow**". Also called "**temporary flow**", or "**summer-dry**" type of stream. These streams have flow for extended periods of time seasonally, but gradually reach a state where there are either isolated pools of water that are not hydraulically connected by sub-surface flow, or a dry channel. Biology may be present in wet hyporheic subsurface substrate. Usually have a warm water Class II type of biology present from roughly October to June.

"**Ephemeral flow**". These streams are normally dry and only flow during and after precipitation runoff **(episodic flow)**. These streams normally have a dry stream channel with no evidence of isolated pools of water. May have Class I type biology present seasonally in the spring.

** Note: The roots of the term "suprafacial flow" are: **supra=**above or surface; and **facial=**on the face of.

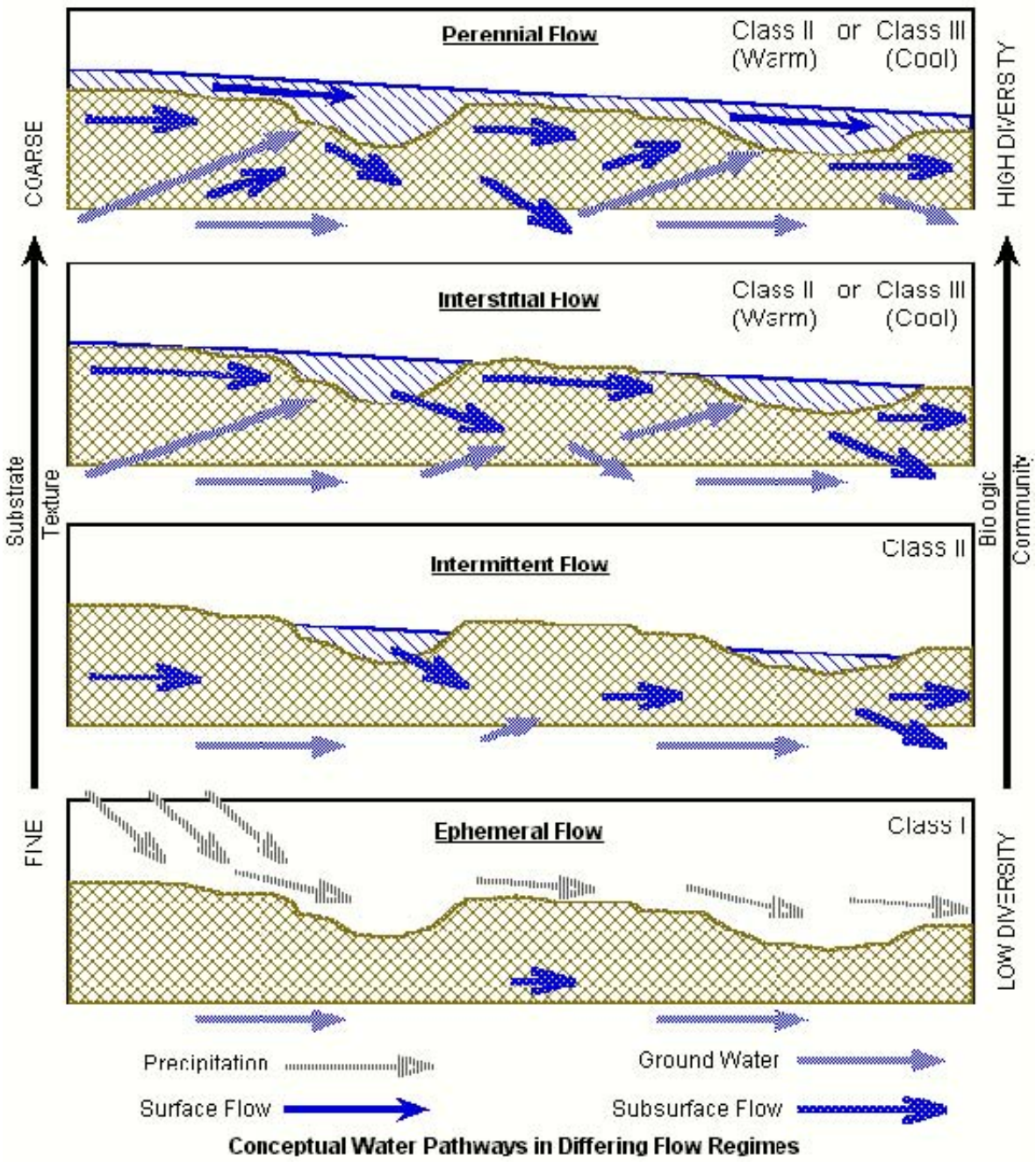


Figure 3. Conceptual water pathway diagram for different types of PHWH streams.

interrupted, and ephemeral are routinely used to describe the type of flow present in stream channels. The relationship between hydrology and potential PHWH stream class is summarized in the box above (see also Figure 3 and Table 2). For example, a perennial flowing PHWH stream may have either Class III (cold water) or Class II (warm water) type of biology present, with the primary difference being water temperature, not flow regime.

Users should note that the flow regime descriptions used in this manual are presented to describe the underlying physical characteristics that result in the different types of biological communities present in PHWH streams. These descriptions may or may not be synonymous with definitions for stream types used by federal regulatory agencies. For the purposes of PHWH stream assessment, it is the biological condition, not the perceived flow condition which is definitive in determining the proper assignment of classification.

1.4 Assessment Overview for PHWH Streams

The methods in this manual are based upon measurement of biological, chemical, and physical (HHEI) habitat characteristics that can be used to assign the appropriate classification for a PHWH stream. A PHWH assessment should only be conducted after the following determinations have been made:

- the water body meets the definition of a stream; and
- the stream is not specifically assigned to another aquatic life use [i.e., Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Coldwater Habitat (CWH), or Modified Warmwater Habitat (MWH)] in OAC rules 3745-1-08 to 3745-1-32; and
- the stream does not support a well-balanced fish community as measured by the IBI as the result of habitat features and watershed characteristics that rule out other aquatic life use designations found in OAC Chapter 3745-1.

The definition of a stream and associated terms in proposed rule OAC 3745-1-02 are provided in Table 3. Non-stream waterways, including roadside ditches, grass swale waterways, erosion features, and other temporary drainage features without a defined channel or bed and banks should not be assessed using the PHWH stream classification methods.

In general, any stream with a watershed area greater than 1.0 mi^2 (259 ha), <u>or</u> with predominant pools having maximum pool depths over 40 cm, should first be evaluated using the QHEI and biological sampling methods appropriate for the WWH, EWH, CWH, or MWH aquatic life use designations (Ohio EPA, 1989; Rankin, 1989; Rankin, 1995; Ohio EPA, 2006). It is sometimes appropriate to use the PHWH methodologies for streams with drainage areas greater than 1 mi^2 based upon the watershed characteristics. Conversely, some streams with drainage areas within the PHWH range that are capable of supporting well-balanced fish communities may be best described using other aquatic life designations. This manual attempts to provide guidance to identify situations where these exceptions exist and to adjust the assessment methodology to provide the most accurate analysis.

Table 3. Important definitions from proposed rule OAC 3745-1-02

Term	Rule Paragraph	Definition
"Stream"	(B)(84)	"…a water body having a channel with well-defined bed and banks, either natural or artificial that confines and conducts continuous or periodical flowing water. The term "stream" includes captured streams, …. but does not include roadside ditches and temporary channel-like features on the land surface created by water erosion."
"Captured Stream"	(B)(18)	"….a portion of an existing stream that lies or has been relocated to lie within a roadway right of way."
"Roadside Ditch"	(B)(80)	"…a drainage feature adjacent to or within a right of way along private or public roads, railroads or other similar development feature that has been constructed or modified and serves to collect and transport water draining from the development feature or the right of way."

1.4.1 Levels of PHWH Assessment

There are three levels of stream assessment methodologies provided to classify PHWH streams:

- Level 1 Assessment (Section 5.0) consists of a physical assessment of the habitat using the HHEI. The result of the HHEI analysis is used as a predictor of the biological classification of the stream using protective statistical relationships.

- Level 2 Assessment combines qualitative biological sampling results with the Level 1 Assessment to provide a higher degree of certainty in the classification of the PHWH stream.

- Level 3 Assessment includes definitive biological assessments of the vertebrate and macroinvertebrate communities (all taxa evaluated to the lowest practicable taxonomic level) in PHWH streams.

Level 1 and Level 2 Assessment protocols are rapid assessment methodologies as that term is defined by the U.S. Environmental Protection Agency (USEPA) (USEPA, 1989). As with the QHEI for larger streams, the use of the HHEI and qualitative biological evaluations, when used in the proper context can accurately predict the biological potential of a PHWH stream. However, the structure of the biological community, as determined by a Level 3 Assessment is the final arbiter of the PHWH classification process. Exceptions to this tenet are cases where profound effects caused by drought conditions, in-stream toxicity, or pollution stress exist which prevent the stream from meeting its biological potential. In

these situations, the classification of the stream should be based upon a determination of the potential for the stream to support the biological communities associated with the PHWH stream classes. This determination should be based upon a weight-of-evidence approach using all available data, particularly the HHEI, to determine the type of community that could reasonably exist if the pollution stress was reduced or eliminated.

1.4.2 Documentation and Responsible Practices

All field observations and physical and biological data collected during PHWH assessments should be recorded on the Ohio EPA PHWH Stream Evaluation Form included as Attachment 1 of this manual. Where stream assessments are conducted using the protocols designed for larger streams in Ohio, the appropriate field forms for these methodologies should be used (e.g., the QHEI form). An overview of the sequence of tasks involved in a PHWH stream evaluation is found in the "Quick Guide to the PHWH Assessment Process" located in the front of this manual.

Field personnel conducting PHWH assessments should obtain permission from property owners to gain access to the streams. In addition, users should make certain to obtain any necessary local, state or federal permits for conducting biological collections prior to carrying out PHWH assessments.

2.0 Preparation for PHWH Surveys

The use of the procedures described in this manual will be most efficient when field studies are well planned prior to engaging in field sampling and assessment. Field activities should be guided through the preparation of a written study plan that includes: information regarding the area to be sampled; the stream resources of interest; the methods to be used; lists of involved personnel including the levels of training required; a list of necessary equipment and supplies; safety precautions to be taken; and other relevant information. The study plan should also describe quality assurance and quality control procedures that will be followed to ensure that the data quality objectives of the field study will be met. All personnel involved in the study must have the proper training to collect the data required or be supervised by personnel who can ensure that sampling and data recording are conducted properly.

2.1 Data Quality Objectives

The establishment of Data Quality Objectives (DQOs) for PHWH stream evaluations is necessary to specify how "good" data must be to support decision making, including the level of uncertainty that is acceptable. Study plans should always be developed prior to going out into the field so that the appropriate data can be collected to support the DQO's for PHWH classification. Ohio EPA strongly encourages the use of a weight-of-evidence approach that combines the assessment of the physical and biological characteristics of a stream to make final classification determinations. This approach will result in the highest level of confidence that PHWH classification decisions are accurate.

It is up to the investigator for any individual project to assign the DQO's for PHWH assessments. Survey plans for PHWH streams should be constructed with an understanding of the balance between level of effort and the degree of certainty necessary to achieve the goals of the project. Confidence in PHWH classification decisions will improve as the level of effort increases. Level 1 Assessments using only the HHEI for PHWH classification will often result in conservative predictions of the in-stream biological community (i.e., the Level 1 Assessments will tend to over-classify Class I and Class II streams). However, addition of biological sampling to the HHEI scoring reduces the level of classification uncertainty. Level 2 Assessments (qualitative biology) can significantly improve the classification decision, and are often definitive. Level 3 Assessment of the stream will result in definitive classifications under almost all circumstances.

DQOs specify:

- the problem to be resolved;
- the decision to be made;
- the inputs to the decision;
- the boundaries of the study;
- the decision rule; and
- the acceptable limits of uncertainty*.

*It is important to note that DQOs are the user-defined target values for data quality and are not necessarily criteria for the acceptance or rejection of data by Ohio EPA.

Data from the PHWH stream evaluation will be used to support classification decisions. Two example approaches for such evaluations/decisions include:

- If the purpose of the evaluation is to generally classify the PHWH stream, data from a Level 1 or Level 2 Assessment can be used to determine the appropriate PHWH class (Class I, II, III)*.

  *Note: for assessments conducted to Level 1 or Level 2 where the resulting classification is Class III PHWH: it must be assumed that the stream is a Class IIIB PHWH stream unless a Level 3 Assessment (full biological survey) is conducted to prove otherwise.

- If the purpose of the evaluation is to obtain an accurate classification of the PHWH stream while tracking potential changes in the stream biota (for purposes, such as restoration, enforcement, management efforts, etc.), a more thorough assessment strategy must often be taken from the outset. Under this scenario, a Level 3 analysis including a detailed taxonomic evaluation of the fish, benthic macroinvertebrate, and salamander communities must often be conducted.

To ensure scientific credibility and study repeatability, all project activities of HHEI evaluation need to be adequately documented. These activities include (if appropriate) adherence to sampling protocols, equipment calibration, use of standardized field sampling methods, review of data sheets, the use of field notes, data quality assessment, data analyses, and data interpretation.

2.2 Desktop Evaluation

Prior to going into the field, a desktop evaluation of the potential PHWH resources should be conducted in order to direct the field activities. This exercise includes identification of the potential PHWH stream(s) of interest, gathering of metadata regarding the stream location and access points for field surveys, and the calculation of the upstream drainage area(s) for the stream(s) to be sampled. The user is encouraged to utilize all desktop resources available within a particular locale to identify the presence of potential PHWH streams prior to conducting field surveys.

2.2.1 Mapping Resources

The potential location of a PHWH stream in the landscape can be identified using the USDA, National Resources Conservation Service (NRCS, formerly SCS) soil survey maps that are available for each of the 88 counties in Ohio (Figure 4). Different terminology is used in the various county soil surveys to identify potential PHWH streams. Terms such as "drainage", "stream-perennial", "stream-intermittent", "stream-unclassified", "ditches", "springs", "drainage end", "alluvial fan", etc. are used to identify small watercourses on these county soil maps. Each of these watercourses that connect to downstream surface waters of the state is a potential PHWH stream. County soil survey maps can be obtained at the following URL: http://soils.usda.gov/survey/online_surveys/ohio/ using the internet. Copies of the maps can also be obtained at county Soil and Water Conservation District (SWCD) offices and at many local and university libraries. All counties in Ohio now have digitized soil maps available for Geographic Information System (GIS) interfaces. However, these resources may be of limited use statewide since many counties have not digitized the hydrologic drainage information along with the soils distribution information. A directory of contact information for Ohio SWCD's can be found on the ODNR Division of Soil and Water Resources web page: http://ohiodnr.com/tabid/9093/Default.aspx .

The NRCS mapping scale represents the most detailed knowledge of the distribution and abundance of potential primary headwater streams in Ohio. A common soil mapping scale is 1:15,840, but others do exist. Because the field and aerial survey data shown on many county soil survey maps were collected prior to 1970, a field assessment of a property may show that a potential PHWH stream has been relocated or placed in a drainage culvert. In some rare cases, a PHWH stream observed to be present during a site visit will not be shown on a county soil map, but may be shown on a U.S. Geologic Survey (USGS) topographic map. Thus both NRCS and USGS maps should be consulted to determine if any PHWH streams are potentially present.

Many Ohio counties have also developed other mapping resources such as high resolution aerial photography, small scale topographic maps (including maps of "derived" streams determined using topography), and drainage mapping resources in GIS formats that are readily available.

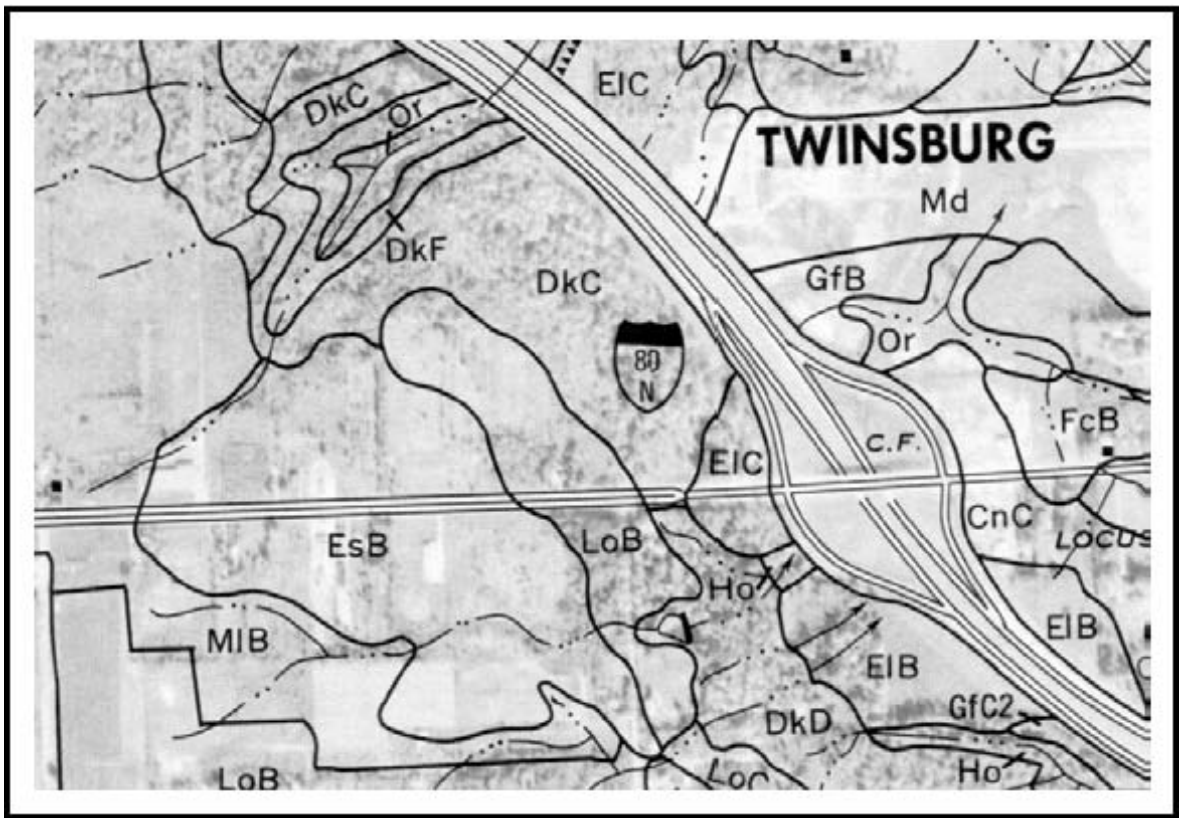


Figure 4. Representative NRCS (aka SCS) County Soil Map showing location of PHWH streams in a local watershed. First order PHWH streams are those primary streams at the uppermost limits of the drainage network. Two first order PHWH streams merge to form a second order stream and so on until the drainage empties into a larger stream that has a specific designated use. Streams in Ohio with assigned designated uses are found in OAC Chapter 3745-1. Total area shown in this figure is about 0.63 mi^2 (163 ha).

2.2.2 Determination of Upstream Drainage Area

Drainage areas for the watershed upstream of the evaluated PHWH stream reaches can be determined in a number of different ways including the use of a planimeter over a topographic map on which the watershed boundaries have been determined. Computer aids using GIS software can also be used to accurately calculate upstream drainage areas. A very useful on-line resource developed by USGS in cooperation with other federal and state agencies for determining watershed areas is the Ohio STREAMSTATS web page (http://water.usgs.gov/osw/streamstats/ohio.html). The STREAMSTATS web page uses an interactive mapping tool to delineate drainage basins and provide data regarding watershed areas and available flow and land use data (Figures 5 and 6). Although the mapping scale varies somewhat across various regions in Ohio, in many locales the scale of the underlying stream layer is suitable for the PHWH universe.

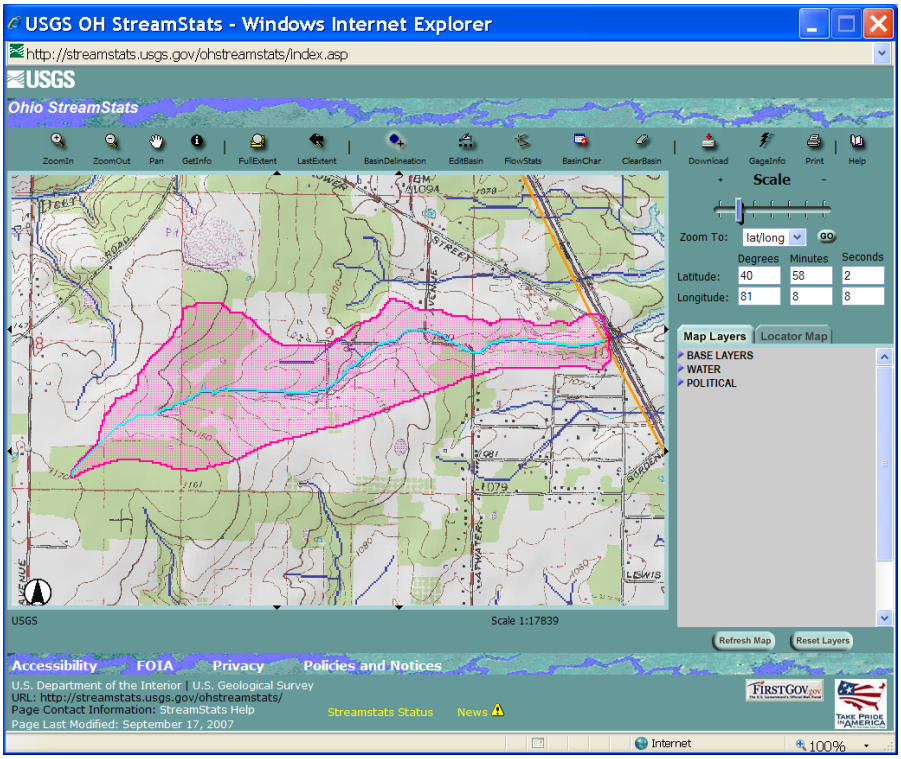


Figure 5. Example watershed delineation from the Ohio STREAMSTATS web page. http://water.usgs.gov/osw/streamstats/ohio.html

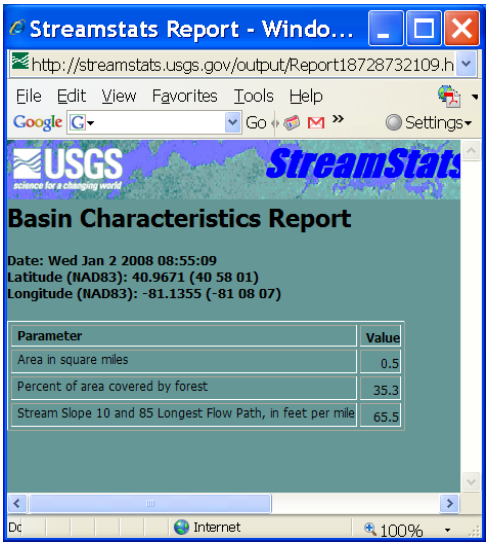


Figure 6. Example of basin data provided from the Ohio STREAMSTATS web page following watershed delineation.

2.3 When to Sample

A biological or HHEI physical habitat assessment can be conducted at any time of the year, but must be conducted when the stream is under seasonal base flow conditions. Base flow conditions in small headwater streams recover quickly after rain events, usually within 24 hours. Evidence of elevated flows due to runoff consists of observation of surface runoff draining into the stream, stream water depths near or above the bankfull depth (see Section 5.3.3), and elevated turbidity.

Biological sampling during drought conditions [defined in OAC 3745-1-07(B)(32)] and for up to one year following drought conditions can also result in misclassification of biotic potential. Two methods, the Palmer Drought Condition Index (Palmer, 1965) and the minimum seven-day average flow with a ten-year recurrence interval (7Q10), can be used to determine if drought conditions exist within a specific geographical area. "Drought", is defined in OAC 3745-1(B)(32) as the condition of severe or extreme soil dryness as measured by values of minus 3.0 (-3.0) or less on the Palmer Drought Severity Index published weekly by the National Oceanic and Atmospheric Administration (NOAA). Consult NOAA drought monitoring data for current and historic Palmer Drought Severity Index data before any biological sampling is performed. This information can be accessed at http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml.

Lacking other information, the 7Q10 value from the nearest hydrologic unit as reported by the USGS can be used to estimate critical low flow on the date of assessment (Straub, 2001). The 7Q10 flow is used in OAC 3745-2-05(A) to protect the aquatic life potential of surface waters in Ohio from chronic stressors. Real time flow data from USGS gage stations can be found at: http://waterdata.usgs.gov/oh/nwis/rt. Gage data from the nearest USGS gage station can be compared to the historic stream flow characteristics (available at http://oh.water.usgs.gov/reports/wrir/wrir01-4140.pdf). In situations where the flow conditions at the nearest local stream gages indicate that stream flows are below the 7Q10 for the area of interest, biological data may not be indicative of PHWH stream potential.

Evaluations using the HHEI (Level 1 Assessments) can be done at any time of the year to determine the potential class of PHWH streams. This statement is made with the understanding that: 1) reasonable and appropriate sampling conditions prevail at the time of the assessment; and 2) that the HHEI metrics have been selected, and weights adjusted, to allow for statistical protection of Class III PHWH streams during the summertime low-flow period of the year. The sampling period of June through September will most accurately distinguish the various classes of PHWH streams relative to other times of the year. For dry stream channels, the minimum level of documentation required is a habitat evaluation using the HHEI after the stream has been thoroughly evaluated to determine that interstitial perennial flow or permanent pools are not present.

Vertebrates that live in cold spring-fed PHWH streams are present throughout the year because they are adapted to permanent flow conditions. For amphibians, it is the gilled larvae that are most sensitive to stream desiccation. This life stage may therefore be present in some streams in the spring and early summer, but be later excluded from the stream when the local groundwater table is depressed during the dryer months of the year.

See Section 6.2.1 for a further discussion of issues relating to seasonality with respect to salamander assessments.

Biological assessments using Level 2 or Level 3 methodologies for macroinvertebrates can also be conducted at any time of the year as long as limitations in data interpretation resulting from seasonal effects are borne in mind. Again, these assessments are more representative during the summer sampling period (June through September). When sampling is conducted outside of this index period, it should be recognized that there is generally an increase in the number of macroinvertebrate taxa present in many PHWH streams associated with spring-emerging taxa (January through May). In addition, special precautions should be used when sampling from October through December after leaf-fall has occurred. Accumulated leaf litter present in small streams at this time of the year will often mask stream substrate conditions and make it difficult to visually locate stream dwelling vertebrates.

When multiple physical measurements or biological samples are collected at the same location at different times of the year, the measurements taken during the June through September time period are used to distinguish PHWH stream classes. When multiple samples are collected within the June through September time period, a weight of evidence approach should be used to determine the appropriate stream classification. Except for the exceptions outlined in this manual, greatest weight should always be given to biological sampling results (Level 2 or 3 Assessments) in determining the PHWH stream class over Level 1 Assessments, regardless of the time of year that the data was collected.

2.4 Equipment Check List

An equipment checklist for conducting chemical, physical and biological measurements is included as Attachment 2 of this manual.

2.5 Reference Materials

Additional references that may prove useful to aid in conducting physical stream measurements used in this manual can be found in Rosgen (1996), Rankin (1989), and the most recent field manual for the QHEI methodology (Ohio EPA, 2006). Field chemical sampling follows procedures as given in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA, 2009 b). Recommended general reference materials for macroinvertebrate taxonomic identifications are Merritt et al. (2008), Smith (2001), Voshell (2002), and Bouchard (2004). References for the identification of macroinvertebrates to the lowest taxonomic level necessary to determine the number of cold water adapted species of benthic macroinvertebrates are listed in the Ohio EPA guidance manual for conducting biological assessments (Ohio EPA, 2008 a).

Fish should be identified using Trautman (1981), "The Fishes of Ohio", or other appropriate taxonomic keys. Salamanders should be identified to the species level using "The Salamanders of Ohio" (Pfingsten and Downs, 1989), and/or "Salamanders of the United States and Canada" (Petranka, 1998). Both of these references have keys for adults and larvae with numerous photographs of various life stages of salamanders found in Ohio.

Other useful references for Ohio amphibians are the Field Guide to Reptiles and Amphibians by Conant and Collins (1991) and a guide to Ohio amphibians developed by the ODNR Division of Wildlife (ODNR, 2008). ODNR also provides an on-line guide to amphibians that provides life history and identification information at the following link: http://ohiodnr.com/tabid/20293/Default.aspx. Pfingsten (1998) and Pfingsten and Matson (2003) provide updated range distribution maps, by county, for amphibians in Ohio.

3.0 Stream Reach Delineation and Site Selection

The PHWH stream evaluation process consists of a combination of physical, chemical, and biological characterization of a **PHWH stream reach**. A PHWH stream reach is defined as a stream with a continuous channel bed up to 200 ft (61 m) length, a modification of the stream reach concept adopted by the Government of British Columbia (1998). Stream reaches for a PHWH assessment may be shorter than 200 ft in situations where tributaries have a junction with mainstem PHWH streams or where features within the stream channel (either natural or artificial) warrant restricting the evaluation reach to a distance less than 200 feet of channel length. Such tributaries will usually be "first order" streams at the NRCS county soil mapping scale (see Figure 4). Where deemed appropriate, these first order tributaries can be evaluated as being part of the larger mainstem PHWH stream. The mainstem of a PHWH stream drainage network is the channel with the longest length that forms a junction with a larger named stream (see Figure 7). It must be noted that the use of data for stream reaches that are less than 200 ft may be suspect since the PHWH methodology is calibrated for this length, especially the physical measurements related to the HHEI.

Discrete stream reach boundaries are used to divide the stream channel into consecutive watercourse units for standardized assessment. At the headwaters of a watercourse, the location of the upper boundary of the uppermost stream reach is the location where the first (or last, depending on direction of travel) evidence is found of scour through the mineral substrate or alluvial deposition (Government of British Columbia, 1998). A 200 ft (61 m) distance was selected because this was the distance used to calibrate the association between biological and habitat variables during the 1999 and 2000 calibration survey. This length of stream allows for a complete assessment of the natural scale of habitat variability that is present in these types of headwater streams.

Following the desktop evaluation to map and identify stream reach features and to delineate watershed boundaries, the physical, chemical, and biological characteristics of the stream can be determined in the field. Marked variability in land use or channel character observed within a stream reach should be noted during the site visit. The stream delineation always begins at the most downstream location, or the lower limits of a property boundary, as shown in Figure 7. If a stream reach is dissected by natural geological features such as a bed-rock outcropping, the length of the stream reach for assessment can be adjusted accordingly.

3.1 Site Selection

It is anticipated that sampling of PHWH streams will occur for a variety of reasons, including but not limited to, the following examples:

1. to delineate the total number, and total linear feet, of different classes (I, II, III, or modified PHWH stream classes) of PHWH streams present within a specified property boundary (for example, as required for a CWA Section 401 water quality certification);

2. to delineate the relative number and percentage of PHWH stream types that may be impacted by extensive road building, pipeline, or power line projects that may affect many numerous potential PHWH streams;

3. to determine the existing aquatic life use (PHWH or another tiered aquatic life use) and assign the appropriate class of PHWH if necessary when considering NPDES permit applications or CWA Section 401 water quality certifications;

4. to determine if a wastewater discharge, or other environmental alteration, is having a significant impact on the chemistry and/or biology of a PHWH stream; and/or

5. as a standardized evaluation protocol used in association with land use planning, storm water management, or scientific surveys related to PHWH streams.

In example 1 above, all PHWH streams in the assessment area should be mapped and delineated using 200 ft (61 m) stream reach assessments. In example 2, photographs and HHEI evaluations at discrete locations where PHWH stream channels will be crossed can be used to quickly estimate the relative percentage of different PHWH stream classes that will potentially be impacted by various project routes across the landscape. In example 3, a multiple number (3-5) of discrete 200 ft (61 m) stream reach assessments should be conducted along the length of the mainstem PHWH channel. Areas of recent habitat modification should be avoided in these types of PHWH stream assessments. In example 4, 200 ft (61 m) stream reaches should be identified upstream (reference site) and downstream from the proposed wastewater discharge, or source of impact. Potential chemical impacts should be evaluated against the applicable water quality criteria found in OAC Chapter 3745-1. Potential biological impacts should be evaluated using the sample methods found in this manual. In the final example, study plans should incorporate sufficient coverage of streams to accomplish the DQO's and scale of resolution necessary to meet the goals of the study in question.

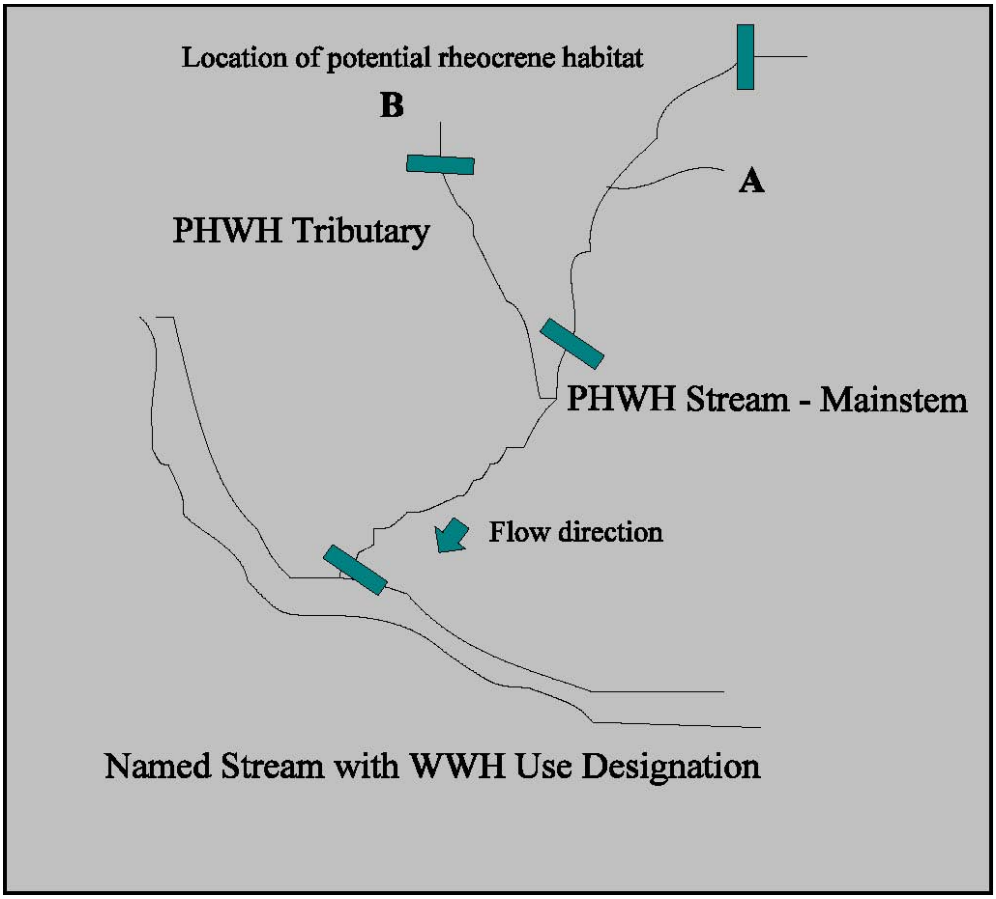


Figure 7. Hypothetical relationship of the PHWH stream reach concept, showing 200 ft (61 m) upper and lower reach boundaries (dark rectangles). Delineation always begins at the most lower downstream location (or the lower property boundary). Total length of PHWH stream mainstem in this example is 430 ft (131 m). Small tributary (A) in upper zone of the PHWH mainstem may be included in assessment of that stream reach, or it may require its own assessment if it differs significantly from the mainstem conditions. PHWH tributary (B) receives its own 200 ft (61 m) stream reach assessment. The small section above the upper reach boundary for (B) may be included in the assessment of the lower 200 ft (61 m) section. The stream section near (B) would represent the potential location of a "rheocrene" habitat. The river mile (RM) where PHWH mainstem empties into the WWH designated stream should be recorded, as well as the RM location where PHWH tributary (B) empties into the PHWH mainstem.

3.2 QHEI vs. HHEI Evaluation in Headwater Streams

If watershed size is greater than 1.0 mi^2 ***or*** the predominant natural pools are greater than 40 cm in depth regardless of watershed size, a Qualitative Habitat Evaluation Index (QHEI) evaluation should be completed in accordance with standard Ohio EPA procedures (Rankin, 1989; Ohio EPA, 2006). The QHEI evaluation can be used to determine if the stream has potential to support a WWH community of fish, and has been used to assign aquatic life use designations for streams with drainage areas greater than 1.0 mi^2. The decision making flow chart found in Figures 15 and 16 of Rankin (1989) should be used to determine if the stream has WWH potential using the QHEI technique. The stream length for a QHEI evaluation in a headwater stream should extend a minimal distance of 100 m and should incorporate the entire 200 ft PHWH stream reach.

If deemed appropriate by a qualified biologist, a HHEI habitat evaluation can also be conducted in conjunction with the QHEI evaluation in streams where watershed area is less than 1.0 mi^2, but pools are greater than 40 cm in depth, to insure correct classification of the aquatic life use potential. This is particularly relevant in high gradient, step-pool streams. In these systems the energy within the stream will often create pools greater than 40 cm in depth. Where these systems exist and the watershed area is less than 1 mi^2, it is important to determine whether these streams are capable of supporting well-balanced fish communities or whether assigning the PHWH aquatic life use is appropriate. These types of decisions are best left to a biologist trained in the use of both the QHEI and HHEI evaluation methods.

The HHEI should be used with caution to make PHWH stream classification decisions in rheocrene habitats (see discussion in Section 4.0 of this manual), and in streams with drainage areas greater than 1.0 mi^2 (even if the stream is ephemeral), since the index was not calibrated using sufficient data for these types of habitats.

4.0 Rheocrene Habitats and Seepage Areas

Where deep groundwater (saturated zone) suddenly emerges to the land surface from an underground aquifer, a "spring" type aquatic habitat is formed. There are three general types of springs: (1) those that form a well-defined channel (rheocrene); (2) those that form small pools or basins (limnocrene); and (3) those that form a marsh, or swamp (helocrene). Springs are unique freshwater ecosystems because their thermal, physical and chemical environments are usually more stable. In Ohio, persistent springs are generally of cold groundwater origin, maintain relatively constant temperatures throughout the year, and have exceptional chemical water quality. They are warmer in winter and colder in summer than surface water recharge streams. Hot springs are not known to exist in Ohio. The type of biology present in springs will vary according to the type of spring that is formed (i.e., rheocrene, limnocrene, helocrene). Helocrene habitats are best evaluated using Ohio EPA wetland monitoring techniques (Mack, 2001; Micacchion, 2002), which are available online at: http://www.epa.ohio.gov/dsw/wetlands/WetlandEcologySection.aspx

For the purposes of a PHWH stream assessment, the potential location of a "rheocrene" type of habitat will be identified if the stream under investigation has constant flowing water, forms a defined bed-bank, and has a watershed size less than 0.1 mi^2 (25.9 ha). In many cases, the HHEI cannot reliably be used as an indicator to predict the biological community present in rheocrene habitats and should not be used as the sole evaluation methodology in these situations (see Section 5.4 and Figure 15). Following the decision-making flow chart (Figure 15), a biological survey using Level 3 Assessment methods for amphibians and benthic macroinvertebrates (Section 6.0) must be conducted in potential rheocrene habitats when the watershed area is less than 0.1 mi^2 (25.9 ha), the stream is flowing, the HHEI score for the site is greater than 30 points and less than 50 points, and the percent of large substrates (boulder, bedrock, and cobble) is less than 10% of the total substrate composition.

The proper PHWH stream classification to be given to waterways that meet the definition for a rheocrene habitat will be based on the types of vertebrate and benthic macroinvertebrate species present. Evaluation of these habitats should be conducted using the biological methods outlined in Section 6.0 of this manual. In addition, seepage areas adjacent to and hydraulically connected to the main stream channel (e.g., within ravines) may also be included as part of the assessment of the receiving stream for purposes of biological evaluation. Seepage areas with diffuse flow that have wide and very shallow drainage ways lacking a defined bed and bank fall outside the assessment methods of this manual. However, this type of habitat may meet the definition of a wetland, and Ohio EPA wetland assessment methods (Mack, 2001; Micacchion, 2002) may apply in these situations.

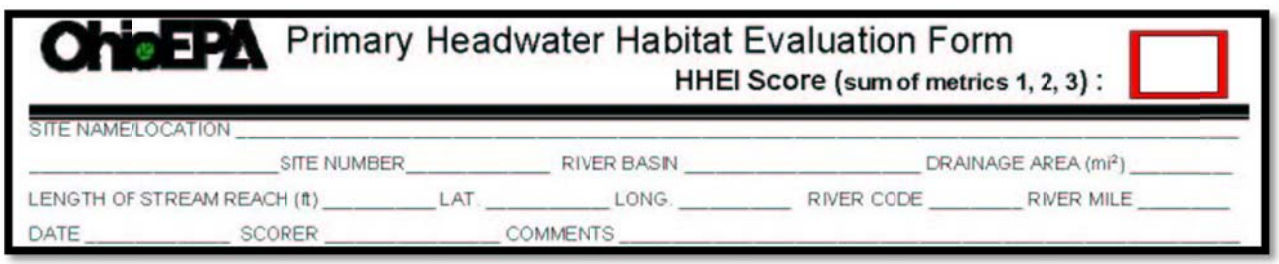
The habitat comprising the zone of saturated sediments beneath and adjacent to an active stream channel that is available for aquatic organisms is called the hyporheic zone. This zone is the biologically and chemically active interface or ecotone among the atmosphere, land, surface waters and ground waters. This manual does not address sampling techniques to be used in hyporheic habitats. However, users should be aware of zones of interstitial flow within stream systems that should be evaluated as part of both the physical and biological evaluation process for PHWH streams.

5.0 Level 1 PHWH Assessment: Conducting a HHEI Evaluation

If the watershed size is less than 1.0 mi^2 (259 ha), and deep pools are less than 40 cm, a PHWH stream evaluation must be completed. A copy of the form to be used to record data is provided in Attachment 1, and is referred to as the "PHWH Form" throughout this manual. This section of the manual provides instructions for collecting the essential data needed to complete the PHWH Form. The PHWH Form is to be used to record all field measures and observations for physical (i.e., HHEI), and biological assessments. The PHWH Form is divided into four (4) pages. Detailed instructions for completion of pages 1 and 2 (the HHEI evaluation) are described in this section and constitute a Level 1 Assessment for PHWH streams. Pages 3 and 4 of the PHWH form are used for recording the results of biological sampling (Level 2 and 3 Assessments). Biological assessment methods are described in Section 6.0.

PHWH FORM - PAGE 1

5.1 General Stream Information


OhioEPA Primary Headwater Habitat Evaluation Form
HHEI Score (sum of metrics 1, 2, 3) :
SITE NAME/LOCATION _____
_____ SITE NUMBER _____ RIVER BASIN _____ DRAINAGE AREA (mi²) _____
LENGTH OF STREAM REACH (ft) _____ LAT. _____ LONG. _____ RIVER CODE _____ RIVER MILE _____
DATE _____ SCORER _____ COMMENTS _____

- Provide the site descriptive information as requested on the top of the first page of the PHWH Form. Information should be provided with enough specifics to allow for return visits to the same location. Observations on landmarks, etc. are important in order to relocate the site at a later time.

- The river basin represents the major basin in the stream network that the PHWH stream ultimately flows into. River code information specific to the Ohio EPA data tracking system and can be left blank for non-Ohio EPA users.

- Latitude and longitude can be determined using a Global Positioning System (GPS) unit in the field, estimated from a 7.5 min. series USGS topographic map using standardized measurement tools, or from one of the many free or fee based internet based topographic mapping sites such as Google Earth, Terra Server, Topozone, etc. The latitude and longitude should be identified from the center point of the 200 ft reach and should be reported on the PHWH Form in decimal degrees with negative values reported for west latitude values in the dd.ddddd, -ddd.ddddd format.

Example conversions:

N 41° 45' 23.2" = 41+ (45÷60) + (23.2÷3600) = 41 + 0.75 + 0.00644

= 41.75644

W 80° 25' 13.1" = -1 × [80 + (25÷60) + (13.1÷3600)] = -1 × (80 + 0.41667 + 0.00364)

= -80.42031

- Determine the upstream drainage area for the PHWH stream segment under investigation (see Section 2.2.2). Note that it is likely that many PHWH streams will not be identified at the USGS 1:24,000 mapping scale.

- Record the date of the assessment and the name of the scorer in the space provided at the top of the PHWH Form.

5.2 Channel Modification Category Determination

The PHWH field evaluation process for a stream reach begins with a determination of whether or not the stream channel has been modified by channelization. A determination must be made as to the extent the channel geomorphology has been modified and sinuosity reduced as well as the degree of recovery that has occurred over time resulting in re-naturalization from past channel modifications. Guidelines to determine the proper characterization category are listed in Table 4 and are further described in the Ohio EPA QHEI guidance (Ohio EPA, 2006 – see discussion for Metric 3: Channel Morphology). Streams in the "NONE/NATURAL CHANNEL" and the "RECOVERED" categories are considered **"natural"** channels for HHEI classification (Figure 15), while those in the "RECOVERING" and the "RECENT OR NO RECOVERY" categories are considered **"modified"** channels.

On the front of the PHWH Form, determine the proper level of channel modification and check the appropriate box in the area provided next to the heading "Stream Channel Modifications". Research regarding historical land use patterns for an area is often useful in properly completing this classification of the evaluated stream reach. In addition, the degree of natural features which should be present in any given stream reach must be taken into account in light of the watershed characteristics, flow patterns and geologic setting of the evaluated reach when categorizing the reach and assigning the stream channel modification categorization.

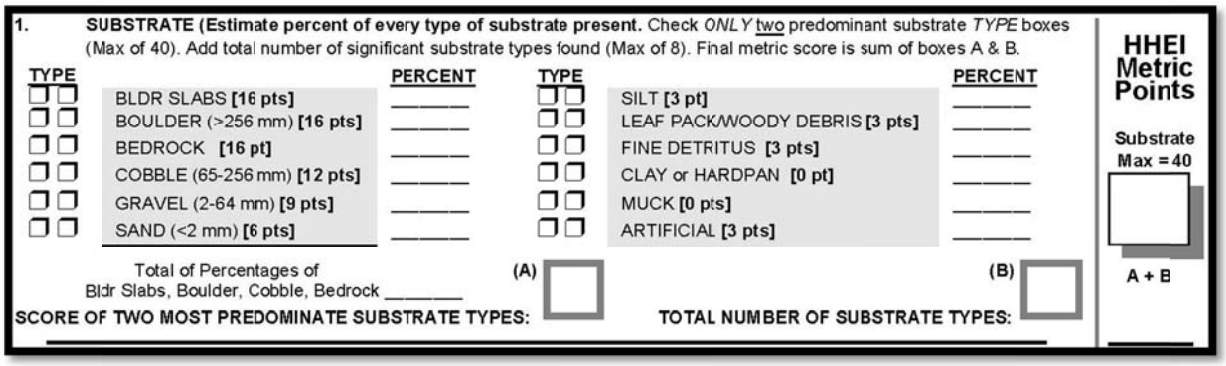
Table 4. Guidelines for the determination of the stream channel modification category for the HHEI form.

Stream Channel Modification Category	Narrative Description
NONE/NATURAL CHANNEL	No obvious historical relocation or alteration of the stream channel is evident. The stream channel is characterized by the presence of riffles and pools, heterogonous substrate deposition, the presence of point bars or other evidence of floodplain sediment deposition, appropriate stream channel sinuosity for the setting of the stream in the landscape, varied water depths and current velocity (when flowing), no obvious evidence of current or past bank shaping or armoring activities is present. Natural wooded or wetland riparian vegetation dominates the stream margin.
RECOVERED	Visual evidence is present of historical channel alteration, channel relocation, bank shaping, or armoring. However, the stream has fully recovered many of the natural characteristics as listed above. Wooded or wetland riparian vegetation in either a natural condition or exhibiting significant recovery is present along the stream margin.
RECOVERING	Visual evidence is present of historical channel alteration, channel relocation, bank shaping, or armoring. The stream is in the process of adjustment, but has not fully recovered the natural characteristics listed above. Stream channel sinuosity may be less than appropriate for the setting of the stream in the landscape. Wooded or wetland riparian vegetation may be present along the stream margins, but is in the early stages of re-growth.
RECENT OR NO RECOVERY	Visual evidence of stream channel relocation or alteration (including bank shaping and/or armoring) exists where few if any of the natural stream characteristics listed above are present. Typical appearance of the stream channels in this condition reveals obvious signs of channel straightening, bank alteration, floodplain alterations, riparian vegetation removal, entrenchment, and trapezoidal channel geometry. Highly modified streams tend to have uniform depths, over-wide channels, homogenous substrate types, high levels of substrate embeddedness, and low sinuosity.

5.3 Calculation of the HHEI Score

The HHEI is a multi-parameter rapid assessment of the physical habitat that can be used to predict the biological potential of most PHWH streams. The HHEI is calibrated to streams with watershed size less than 1.0 mi^2 (259 ha) where the deepest pools of water are less than 40.0 cm, and should only be used with extreme caution outside of these limitations (see Sections 3 and 4 of this manual). All HHEI measurements are to be made within the 200 ft (61 m) stream reach zone. On the front of the PHWH Form, within the large box, are three field measurements that must be taken to calculate a final HHEI score. Information obtained from the HHEI scoring is then used to determine the biological potential of the PHWH stream following the HHEI decision-making flowchart in Figure 15.

5.3.1 HHEI Metric # 1: Stream Channel Substrate


1. **SUBSTRATE (Estimate percent of every type of substrate present.** Check *ONLY* two predominant substrate *TYPE* boxes (Max of 40). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B.

TYPE		PERCENT	TYPE		PERCENT
☐☐	BLDR SLABS [16 pts]	_____	☐☐	SILT [3 pt]	_____
☐☐	BOULDER (>256 mm) [16 pts]	_____	☐☐	LEAF PACK/WOODY DEBRIS [3 pts]	_____
☐☐	BEDROCK [16 pt]	_____	☐☐	FINE DETRITUS [3 pts]	_____
☐☐	COBBLE (65-256 mm) [12 pts]	_____	☐☐	CLAY or HARDPAN [0 pt]	_____
☐☐	GRAVEL (2-64 mm) [9 pts]	_____	☐☐	MUCK [0 pts]	_____
☐☐	SAND (<2 mm) [6 pts]	_____	☐☐	ARTIFICIAL [3 pts]	_____

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock _____ (A) ☐ (B) ☐

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: TOTAL NUMBER OF SUBSTRATE TYPES:

HHEI Metric Points

Substrate Max = 40

A + B

Next to water temperature and an adequate supply of water, the composition of the substrate found in the stream channel is the most important feature that predicts biological potential. Acting in conjunction with other physical characteristics of the stream channel, the substrate composition is indicative of stream hydrology, the dynamics of sediment transport to downstream water bodies, and the type of biology present. Class III PHWH fauna are seldom found in streams dominated by fine grained or monotonous substrate types. This metric is calibrated to separate Class III PHWH streams from all other types of headwater streams.

The characterization of the channel substrate includes a visual assessment of the 200 ft (61 m) stream reach using a reasonably detailed evaluation of both the dominant types of substrate, and the total number of substrate types. For flowing streams, the substrate evaluation is restricted to the **wetted channel only** (locales where obligate aquatic organisms can survive). For dry stream channels, the substrate evaluation includes the **entire** channel bottom within the bounds of the bankfull width.

To complete the substrate scoring section of the PHWH Form, the following protocol must be followed:

- Estimate and record the presence and percentage of all of the substrate types observed that are potentially biologically significant (i.e., provide usable habitat for obligate aquatic fauna) in the blanks included in the "PERCENT" column of the form. As a general practice, this will usually, but not necessarily always, be limited to substrate types estimated to cover 1% or greater of the stream channel. A detailed estimate of the percent coverage of each substrate type is required in order to complete the HHEI decision flowchart found in Figure 15. Ensure that the substrate percentages add up to 100% when entry of the substrate metric information is complete.

- Record the two most dominant substrate types by checking the appropriate two boxes in the "TYPE" column adjacent to the names of the substrate types estimated to be dominant in the evaluated reach. Note that only two substrate type boxes can be checked on the form and that only these two substrate types are used to calculate the score entered in Box A of the substrate metric. If it is determined that one type of substrate completely dominates the stream channel within the reach (based upon one substrate type exceeding 90% of the coverage and no other type exceeding 5%), check both substrate type boxes next to the appropriate substrate type and check no other boxes in the "TYPE" column.

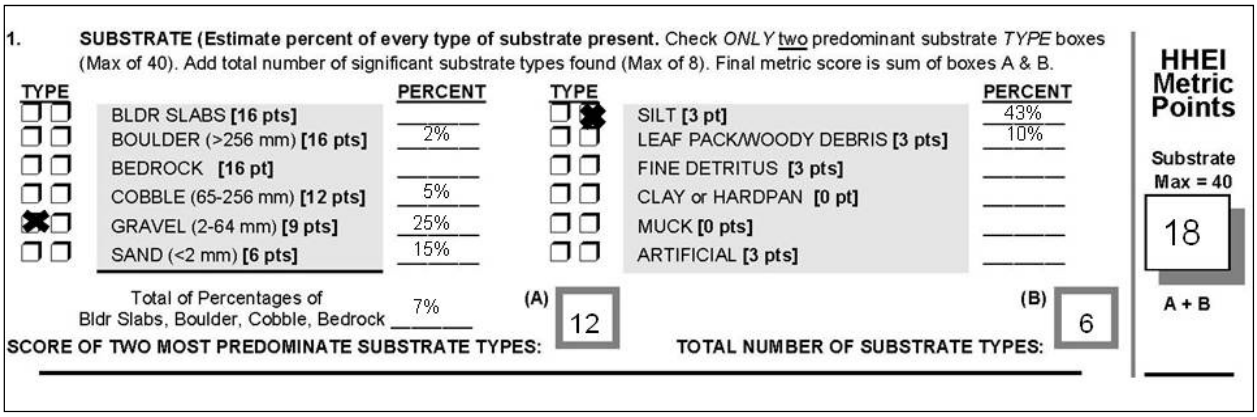
- Add the scores associated with the two dominant substrate types and record the sum in Box A of the substrate metric section (note: if there is only one dominant substrate type, the score in Box A equals two times the score associated with the substrate type).

- Count the number of substrate types observed (those for which percentages are estimated) and enter the result in Box B of the substrate metric section. Box B has a maximum possible score of 8 points, even if more than 8 functional substrate types are present.

- Add the score in Box A to the score in Box B and enter the result in the Substrate metric box on the right hand side of the PHWH Form. [Note that the substrate metric score cannot exceed 40 points, see previous bullet]

- Add the percent coverage of Bedrock, Boulders, Boulder Slabs, and Cobble and record the sum as a percentage in the space to the left of Box A in the substrate metric section of the PHWH form. This estimate may be important when categorizing the stream using the decision flow chart (Figure 15).

An example of a properly completed substrate metric section of the PHWH form is provided in Figure 8.



1. **SUBSTRATE (Estimate percent of every type of substrate present.** Check *ONLY* two predominant substrate *TYPE* boxes (Max of 40). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B.

TYPE		PERCENT	TYPE		PERCENT
☐ ☐	BLDR SLABS **[16 pts]**		☐ ☒	SILT **[3 pt]**	43%
☐ ☐	BOULDER (>256 mm) **[16 pts]**	2%	☐ ☐	LEAF PACK/WOODY DEBRIS **[3 pts]**	10%
☐ ☐	BEDROCK **[16 pt]**		☐ ☐	FINE DETRITUS **[3 pts]**	
☐ ☐	COBBLE (65-256 mm) **[12 pts]**	5%	☐ ☐	CLAY or HARDPAN **[0 pt]**	
☒ ☐	GRAVEL (2-64 mm) **[9 pts]**	25%	☐ ☐	MUCK **[0 pts]**	
☐ ☐	SAND (<2 mm) **[6 pts]**	15%	☐ ☐	ARTIFICIAL **[3 pts]**	

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock 7%

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: (A) 12

TOTAL NUMBER OF SUBSTRATE TYPES: (B) 6

HHEI Metric Points

Substrate Max = 40

18

A + B

Figure 8. An example of a completed Substrate Metric section from page 1 of the PHWH Form. Note that only two substrate types are checked under the "TYPE" column and that these scores are added to produce the score in Box A. The percentage estimates for observed substrate types are entered in the "PERCENT" column, and the total percentages of boulder slabs, boulders, bedrock and cobble are added and recorded in the space to the left of Box A. The total number of substrate types is counted and the result entered in Box B. Scores from Box A and Box B are added to obtain the Substrate Metric score and the result is recorded in the box provided in the "HHEI Metric Points" column on the right hand side of the form.

Although not required, pebble-counts can be used to quantify the percentages of the most common substrate types. However, the user should note that substrate types that are visually observed and deemed to be biologically available habitat within the evaluated reach must always be counted toward the scoring for the number of substrate types present regardless of whether or not that substrate type was encountered during a pebble count analysis. The HHEI substrate metric was calibrated based upon use of the visual estimation method.

Experience among Ohio EPA field staff has shown that pebble count analyses often miss one or more substrate types that can be visually observed and which are available to aquatic organisms. In addition, it has also been observed that pebble count analyses tend to under-estimate the percent composition of large substrates in PHWH stream evaluations. Therefore, extreme care should be taken to ensure that the minimum number of observations made during pebble counts is sufficient to capture the true variability of the substrate in the evaluated stream and that this data is verified by cross checking with visual observations. Pebble-count data can be recorded on the field form provided in Attachment 4 or other published sources. For further information regarding conducting, recording, and interpreting pebble count data, the following references can be consulted: Bevenger and King (1995); Kondolf (1995); Kondolf and Li (1992); Rosgen (1996); and Wolman (1954). A stream mapping and qualitative substrate evaluation form used by Ohio EPA field staff is

also provided as Attachment 5 to this manual. Use of this optional form can provide a standardized, semi-quantitative aid for determining substrate composition for use in scoring the Substrate Metric of the HHEI.

The measurement of substrate particles during an HHEI assessment is conducted with the use of a small metric ruler with gradations in millimeters. Measurements and size classifications are based upon the length of the intermediate axis of the particle (Figure 9). 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, the ratio of the measurement of the intermediate axis to the short axis is used to distinguish between boulders and boulder-slabs (see definition below).

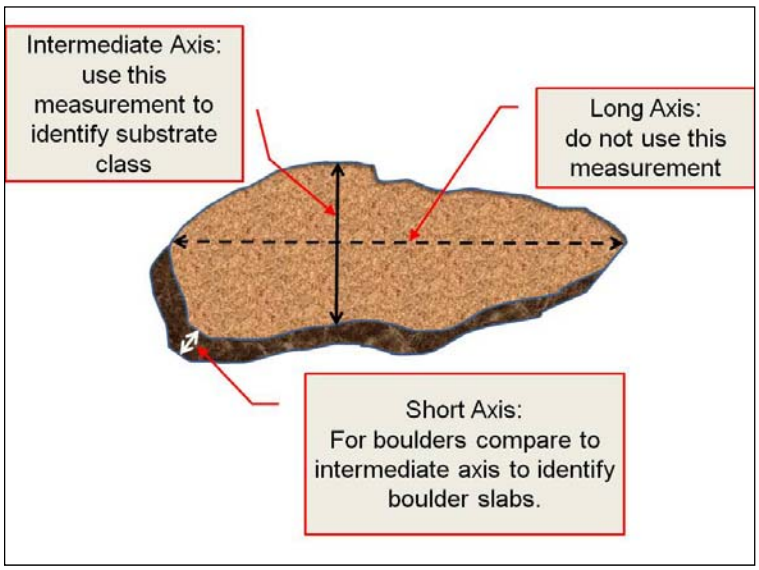


Figure 9. An example representation of a substrate particle indicating the proper axes used to determine the particle size category for classification in HHEI scoring.

A summary of definitions for the nine major substrate types that apply to the HHEI evaluation follows:

Bedrock Substrates: Streambed characterized by the presence of monolithic bedrock outcropping. May be fractured, and often associated with boulder and cobble substrates. Since PHWH streams with bedrock substrate are often associated with the surface discharge of groundwater, a high degree of association was found at these sites with the presence of cold water adapted native fauna of obligate salamanders and benthic macroinvertebrates (Class III PHWH stream biology).

Boulder Substrates: These substrate types provide excellent habitat for obligate aquatic salamanders, fish, and benthic macroinvertebrates because of their inherent stability. They are separated into two types:

> **Boulder Slabs:** Greater than 256 mm, flat instead of round (see Figure 9: ratio of intermediate axis length to the short axis length >2).
>
> **Boulders:** Greater than 256 mm, round, (see Figure 9: ratio of intermediate axis length to the short axis length ≤ 2).

Cobble Substrates: Stones with intermediate axis lengths greater than 64 mm and less than 256 mm. This substrate type has a strong association with Class III PHWH streams.

Gravel Substrates: Particles 64 mm or less, but at least 2 mm in size along the intermediate axis. This substrate type is neutral in its ability to separate the three classes of PHWH streams, but is often a secondary component of Class III PHWH streams.

Sand Substrates: Particles less than 2 mm in size along the intermediate axis, gritty texture when rubbed between fingers. This substrate type is often a secondary component of Class III PHWH streams.

Silt Substrates: Substrate particles less than 0.6 mm in size, exhibiting a greasy texture when rubbed between the fingers. Silt is most often a conglomerate of eroded clays and very fine organic matter which has deposited in the stream channel. There is a negative association of silt with Class III PHWH streams, but silts can be present in limited amounts in natural channels with low energy dynamics.

Clay or Hardpan Substrates: This substrate type is typically found when the stream bed has eroded to a depositional clay layer within the underlying sub-soil. This substrate is typically hard and gummy and is difficult to penetrate. Unlike silts, this substrate type is not deposited in the stream channel by recent fluvial processes. It provides a poor habitat for most native fauna.

Muck Substrates: Muck consists of decayed organic matter with little or no clay content. Muck differs from silt in that it is almost entirely organic in nature, less dense, and more odorous. Muck differs from detritus in that it is partially decayed and not coarse or readily identifiable as to the material of origin. This substrate type is strongly associated with Class II PHWH streams. Caution should be taken to ensure that the material is not actually sludge deposited downstream of a discharge from a failing wastewater treatment system or animal management operation. In such cases, the sludge is ignored and the underlying substrate is identified and used for scoring.

Detritus Substrates: Detritus refers to the presence of partially or un-decayed sticks, wood, leaves or other plant material deposited in the stream channel. The allochthonous input of organic matter is the primary energy resource for the biological community of PHWH streams. Two categories are recognized:

Leaf Pack/Woody Debris: The presence of leaf packs and woody debris provides an energy resource as well as habitat for colonization of plants and animals. Although this substrate type was found to be neutral in its ability to separate the three classes of PHWH streams, it is often found as a secondary component of Class III PHWH streams with heterogenous substrates. It provides potential microhabitat and is the primary food source for benthic macroinvertebrates that are in turn prey for fish and obligate aquatic salamanders. This substrate type is also positively associated with the presence of salamander larvae.

> NOTE: Users should be aware that assessments conducted during the period of leaf fall (September through November) may temporarily overwhelm the stream channel with leaf litter. These conditions should be noted on the HHEI form and adjustments made to the substrate score where deemed appropriate to accurately represent the stream substrates under normal stream conditions.

Fine Detritus: This substrate type refers to fine, partially decomposed plant material which has accumulated within the stream channel as a precursor to the development of muck deposits. These materials are subject primarily to microbial decomposition processes. Fine particular organic matter may be correlated with the presence of macroinvertebrate fauna that "collect" fine organic matter as a food source.

Artificial Substrates: "Artificial" substrate types include all man-made or engineered materials in the stream channel whether or not they have been intentionally placed in the stream. Artificial substrates include materials such as crushed stone (rip-rap or aggregate), concrete, bricks, lumber, trash, asphalt, metal, etc. that have either been placed in or found their way into the stream. Where engineered structures or substrates have been placed in the stream for the purposes of stream restoration, a trained biologist who determines that the placed materials are functioning as viable habitat for aquatic fauna may categorize these substrates into the appropriate substrate category associated with natural substrates (e.g., boulder, cobble, gravel, woody debris, etc.) and score the substrate metric accordingly.

5.3.2 HHEI Metric #2: Maximum Pool Depth

2. **Maximum Pool Depth** ***(Measure the maximum pool depth within the 61 meter (200 ft)*** evaluation reach at the time of evaluation. Avoid plunge pools from road culverts or storm water pipes) (Check *ONLY* one box):

- ☐ > 30 centimeters **[20 pts]**
- ☐ > 22.5 - 30 cm **[30 pts]**
- ☐ > 10 - 22.5 cm **[25 pts]**
- ☐ > 5 cm - 10 cm **[15 pts]**
- ☐ < 5 cm **[5 pts]**
- ☐ NO WATER OR MOIST CHANNEL **[0 pts]**

Pool Depth Max = 30

CONMENTS_____ **MAXIMUM POOL DEPTH (centimeters):** _____

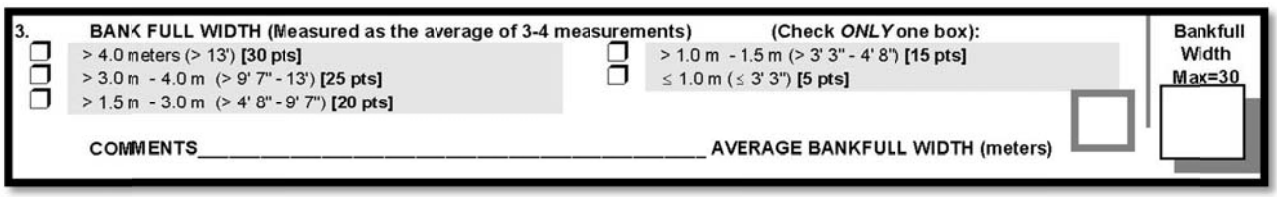
The maximum pool depth within the stream reach is important since it is a key indicator of whether the stream can support a well-balanced fish community. Streams with pools less than 40 cm in depth during the critical low flow period of the year are less likely to have

well-balanced WWH fish communities (see Figure 16 in Rankin, 1989), and thus more likely to have dense populations of lungless salamanders. Maximum pool depth is also related to the type of flow present in the stream channel (i.e., continuous, intermittent, interstitial), and thus serves as a good discriminator of the various classes of PHWH streams. Scoring of the Pool Metric is based upon the maximum pool depth within the 200 ft (61 m) stream reach. In the field, several depth measurements should be taken within each pool in order to verify that the deepest point(s) have been measured.

To complete this section of the PHWH Form, check the appropriate box for the maximum pool depth observed and record the corresponding Pool Depth metric score in the box in the right hand column of the form. If no water can be found within the evaluated reach, the Pool Metric score is zero (0). The maximum pool depth observed should be recorded to the nearest centimeter.

Care should be taken to avoid measurements in plunge pools located on the downstream ends of road culverts or other man-made structures as these depths are not characteristic of overall stream morphology. Evaluation reaches should be selected to exclude these features whenever possible. In addition, it is important to ensure that the stream is under seasonal base flow conditions (see Section 2.3) in order to properly score the Pool Metric. Since the HHEI was calibrated based upon evaluations conducted during critical low flow periods of the year (June-September), assessments conducted during high flow periods of the year may result in higher overall HHEI scores based solely upon differences in the Pool Metric score.

5.3.3 HHEI Metric #3: Average Bankfull Width


3. BANK FULL WIDTH (Measured as the average of 3-4 measurements) (Check *ONLY* one box):
- ☐ > 4.0 meters (> 13') [30 pts]
- ☐ > 3.0 m - 4.0 m (> 9' 7" - 13') [25 pts]
- ☐ > 1.5 m - 3.0 m (> 4' 8" - 9' 7") [20 pts]
- ☐ > 1.0 m - 1.5 m (> 3' 3" - 4' 8") [15 pts]
- ☐ ≤ 1.0 m (≤ 3' 3") [5 pts]

COMMENTS_____ AVERAGE BANKFULL WIDTH (meters) ☐

Bankfull Width Max=30 ☐

Bankfull width is a morphological characteristic of streams that is determined by the energy dynamics related to water discharge. The bankfull width of the stream therefore relates strongly to its annual flow condition and has been found to be a strong discriminator of the three types of PHWH streams in Ohio. The bankfull width of a stream channel should be measured in straight sections of the stream (riffle, run, or glide). Pools and bends in the stream or other areas where the stream width is affected by the deposition of debris, fallen trees, etc. should be avoided. For the purpose of this manual, the bankfull width is defined as the elevation on the stream banks where the flow is at the bankfull discharge. The bankfull discharge is defined as follows:

> " ... the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels." Dunne and Leopold (1978).

The elevation of bankfull discharge may not be at the top of the stream bank in incised or entrenched streams. Rosgen (1996) gives several suggestions for determining bankfull width in streams:

- "a break in slope of the banks and/or a change in the particle size distribution (since finer material is associated with deposition by overflow, rather than the deposition of coarser material within the active channel)";
  [*Note: the highest elevation of gravel and/or sand bars ("point bars") is an excellent indicator of the bankfull discharge elevation*]
- "evidence of an inundation feature such as small benches";
- "staining of rocks"; and/or
- "exposed root hairs below an intact soil layer indicating exposure to erosive flow."

The boundary elevation on the stream bank where terrestrial vegetation begins along the stream margin can also indicate the edge of the bankfull width (Figures 10 through 13). This indicator can be extremely helpful when used in combination with other indicators mentioned above. However, caution must be taken when evaluations are conducted under drought conditions when pioneering terrestrial vegetation may temporarily invade the stream channel.

Further guidance, including a series of training videos relating to the determination of bankfull stage, can be accessed through the USDA Forest Service web page via the following link: http://www.stream.fs.fed.us/publications/videos.html . Users of this manual are highly encouraged to review this video training series in order to develop competence at identifying bankfull stage elevation.

Following the measurement of 3-4 bankfull widths along the evaluated stream reach, the average bankfull width (in meters) is entered into the appropriate box in the Bankfull Width Metric section on page one of the PHWH Form. The bankfull width category for the reach is checked and the corresponding metric score is entered in the box in the right hand column of the form.

In the field it will often be possible to determine the bankfull stage on only one bank of the stream. However, this point can be used as a reference to determine the bankfull elevation on the opposite bank by creating a level line across the stream from the identified bankfull elevation perpendicular to the stream flow (see Figures 10 through 13). The following procedure can then be used to determine the bankfull width:

- mark the bankfull elevation with a stake;

- connect a length of string to the stake at the bankfull elevation;

- place bubble type line level on measuring string (Figure 14);
- suspend the measuring string perpendicular to the stream flow from the staked location to the opposite bank;
- pull string taut and manipulate up and down until the line level indicates that the string is level. Mark the location where the string intersects the opposite bank;
- measure the distance between the marked bankfull locations on either bank of the stream; then
- repeat the procedure to result in 3-4 measurements throughout the 200 ft (61 m) stream reach and record each measurement.
- Calculate an average bankfull width for the stream segment. Record the average bankfull width on the PHWH Form in the space provided.

Line levels are readily available at home improvement and hardware stores at a reasonable cost. Ohio EPA has also had good success using carpenter's laser levels placed at the bankfull elevation to shoot the bankfull elevation of the opposing bank along a level plane. These types of laser levels may be ineffective on sunny days along streams with little forest canopy or where the stream is very wide. For very narrow streams (widths less than 1 meter at bankfull) with highly visible bankfull indicators on both banks, the use of levels to mark the bankfull elevations may be unnecessary in order to get a valid measurement.

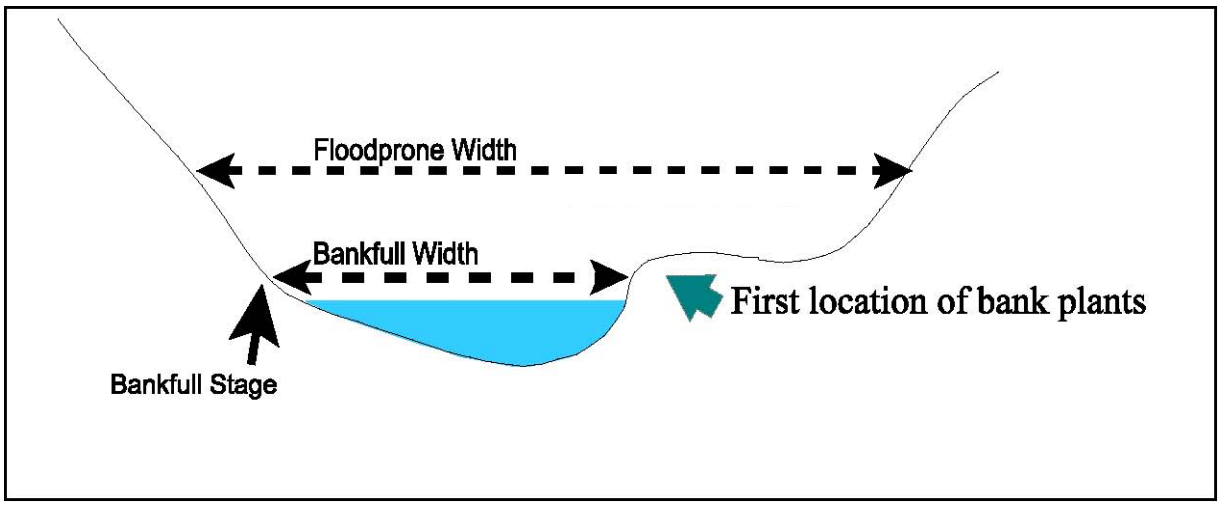


Figure 10. Schematic representation of the relationship between bankfull and floodprone stream widths.

Figure 11. Measuring bankfull width in an incised PHWH stream. Note that the bankfull indicators are below the top of the bank in this incised channel.

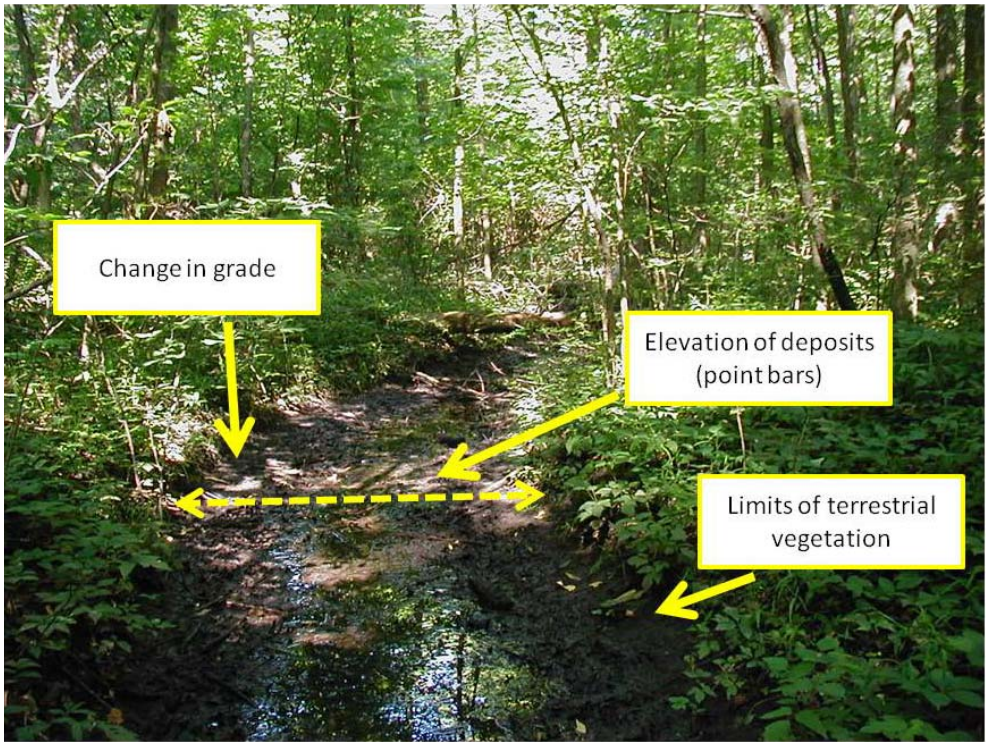


Figure 12. Bankfull indicators noted for a Class II PHWH stream from Fulton County, Ohio. The dashed line represents the bankfull width for this location.

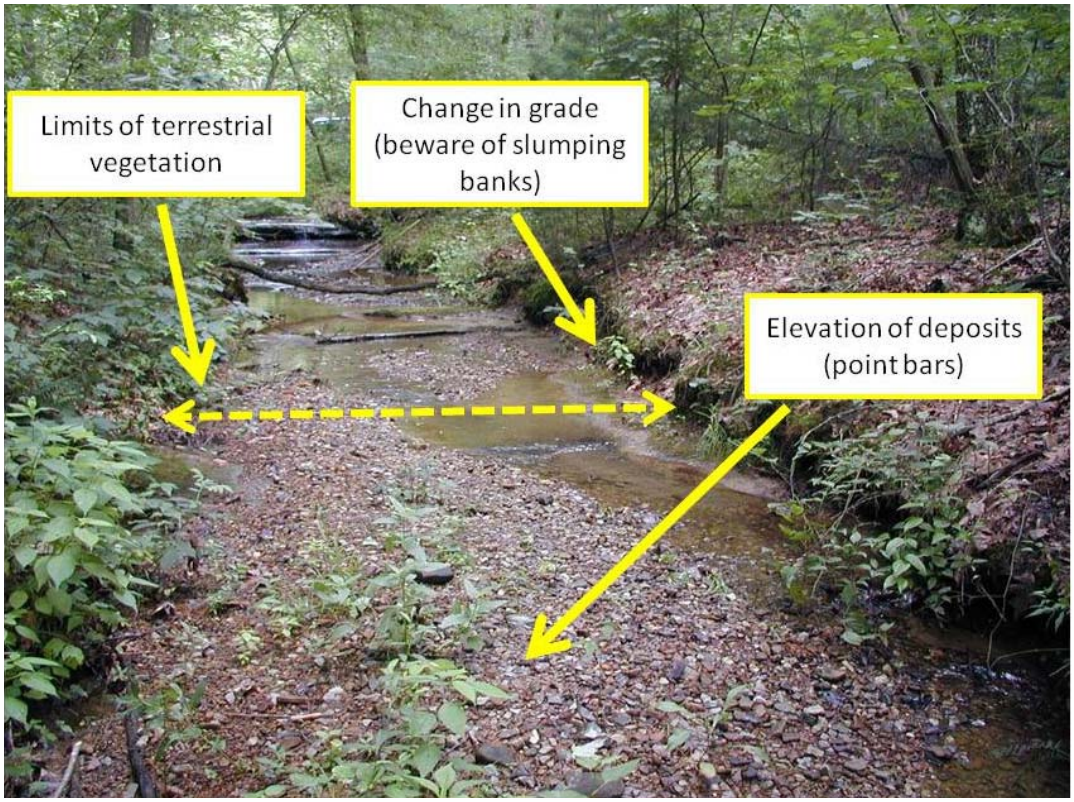


Figure 13. Bankfull indicators noted for a Class III PHWH stream from Hocking County, Ohio. The dashed line represents the bankfull width for this location.

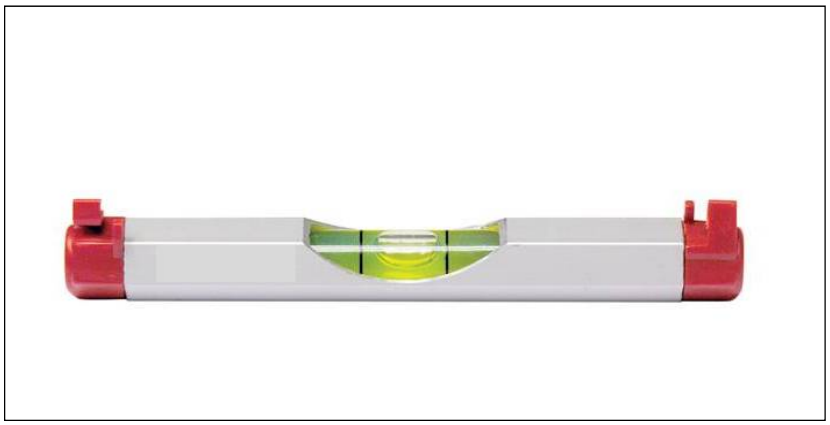


Figure 14. A line level. The instrument is hung from a taut string suspended between a known bankfull elevation to determine the bankfull elevation on the opposite stream bank.

5.3.4 Total HHEI Score

The total HHEI score is derived by adding the three metric scores (substrate + pool depth + bankfull width). The resulting value is then entered into the "HHEI Score" box located in the upper right hand corner of page one of the PHWH Form.

5.4 Using the HHEI Assessment to Assign PHWH Classifications

The Ohio EPA currently uses a rapid habitat assessment tool, the QHEI, to assess the biological potential of larger streams in Ohio. As a rule of thumb, if multiple QHEI assessments along a stream corridor have an average QHEI score greater than 60 points, this information can be used to assign a WWH aquatic life use designation to an undesignated stream with deep pools greater than 40 cm (see Figures 15 and 16 in Rankin, 1989). However, a QHEI less than 60 points does not necessarily suggest that a WWH use cannot be obtained unless the QHEI score is significantly degraded due to a high number of modified metrics (see Rankin, 1989 for guidance).

In a manner similar to use of the QHEI, it is possible to use the HHEI to determine the biological potential of PHWH streams in Ohio. Whereas the QHEI is calibrated to the presence of a well-balanced fish assemblage, the HHEI is calibrated to the presence or absence of salamander species with obligate aquatic multi-year larval periods. These species often replace fish as the top vertebrate predator in perennial headwater streams. Neither the QHEI nor the HHEI are primarily calibrated to the presence or absence of well-balanced or cold water adapted benthic macroinvertebrate communities. However, the HHEI can be used to predict the presence of cold water adapted species of macroinvertebrates where they are strongly associated with the presence of reproducing Class III indicator salamander species.

The decision making flowchart found in Figure 15 **must** be used to assign the appropriate classification to a PHWH stream when the stream classification is based solely on a HHEI assessment. This flowchart allows for both natural and modified PHWH stream channels to be placed into one of six potential PHWH stream types (rheocrene, Class I, Class II, Class III, Modified Class I, and Modified Class II). When the results of both a biological assessment and a HHEI assessment are available, the data from the biological assessment is used to classify the PHWH stream. Users should note that the HHEI evaluation process does not provide sufficient data needed to differentiate between Class IIIA streams and Class IIIB streams. In cases where the HHEI analysis indicates that a stream has the potential to support a Class III biological community, it must be assumed that the stream may be a Class IIIB PHWH until sufficient biological data is collected to discern the appropriate stream class. See Sections 6.0 and 7.0 of this manual for further guidance regarding the appropriate level of biological data collection necessary to differentiate Class III community types.

The exceptions to the use of biological data to definitively classify PHWH streams without reference to the HHEI data are cases where drought conditions exist (Section 2.3) or there

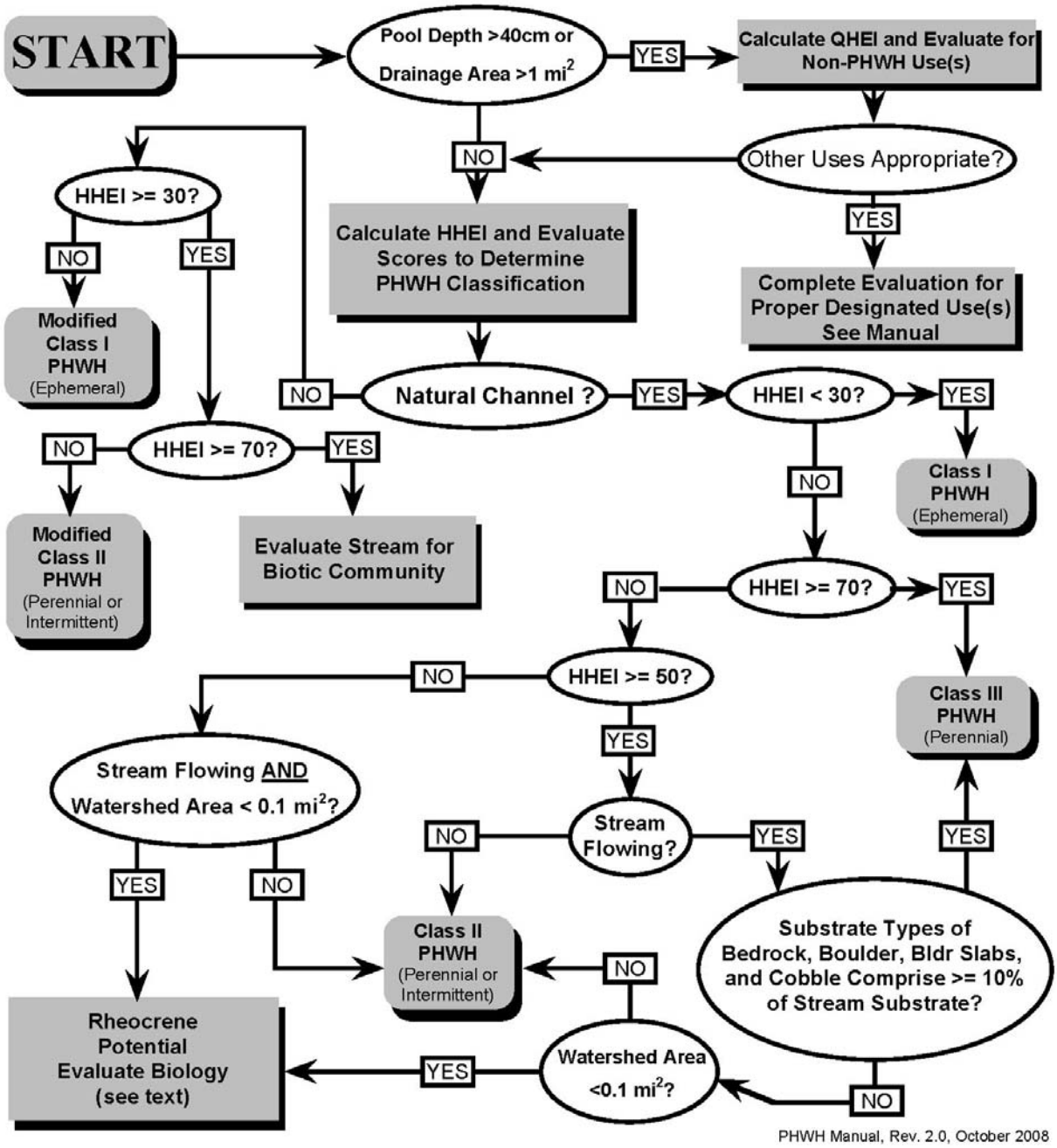


Figure 15. PHWH stream classification flow chart based on HHEI scoring. http://www.epa.ohio.gov/portals/35/wqs/headwaters/HHEIFlowChart.pdf

is reason to suspect that chemical toxicity or another pollution source (typically organic or nutrient enrichment or sedimentation) is limiting the full biological potential of the stream. If degraded water quality resulting in toxicity, enrichment, or sedimentation is present, the HHEI assessment should be used to determine the potential aquatic life use that would be present once the chemical pollution problem is eliminated. A similar approach is used in larger streams with the QHEI evaluation, which is used by Ohio EPA to determine if a stream has the potential to attain a WWH fish community in the absence of chemical toxicity. Chemical-physical parameters that could affect headwater stream biology include ammonia-N, low dissolved oxygen, excessive siltation, heavy metals from mine drainage, pH, and excessive increases in water temperature.

5.5 Riparian Zone and Floodplain Quality

RIPARIAN ZONE AND FLOODPLAIN QUALITY ☆NOTE: River Left (L) and Right (R) as looking downstream☆

RIPARIAN WIDTH			FLOODPLAIN QUALITY					
L	R	(Per Bank)	L	R	(Most Predominant per Bank)	L	R	
❒	❒	Wide >10m	❒	❒	Mature Forest, Wetland	❒	❒	Conservation Tillage
❒	❒	Moderate 5-10m	❒	❒	Immature Forest, Shrub or Old Field	❒	❒	Urban or Industrial
❒	❒	Narrow <5m	❒	❒	Residential, Park, New Field	❒	❒	Open Pasture, Row Crop
❒	❒	None	❒	❒	Fenced Pasture	❒	❒	Mining or Construction

COMMENTS_____

The riparian ecotone between the flowing water of the stream and the adjacent flood plain is critical for the fauna that lives in PHWH streams. The riparian stream margin provides the primary source of food in the form of fallen leaves (detritus) for the benthic macroinvertebrate food web. Physical structure in the form of leaf litter and decayed logs provide shelter for amphibians and other animals. The shading provided by a well formed canopy of woody vegetation helps to maintain cool water temperatures in the summer months in cold-cool Class III PHWH corridors. The riparian zone is also an important migratory corridor for many forms of wildlife including mammals, reptiles, amphibians, and birds.

The "Riparian Width" and "Floodplain Quality" check boxes on the PHWH Form are completed by checking the appropriate selection for the riparian width and land use(s) for each bank. The riparian width refers to the overall average distance from the stream bank that is vegetated by woody vegetation (mature trees and shrubs). The right and left banks (a.k.a.,"river right" and "river left") are determined looking in the downstream direction. In cases where the riparian width or land use varies significantly along one or both stream banks within the stream reach being evaluated, the two most appropriate selections should be checked. It may also be of interest to record the type of plant community found in the riparian corridor of the stream reach under investigation. This information should be recorded in the comments section.

[NOTE: the term "mature forest" in the PHWH context does not have the same meaning as used in wetlands assessments using the Ohio Rapid Assessment Method (ORAM). For PHWH stream assessments, relatively mature second or third growth forest cover (20+ year trees) should be counted as "mature forest".]

5.6 Flow Regime

FLOW REGIME *(At Time of Evaluation)* (Check *ONLY* one box):

- ❒ Stream Flowing
- ❒ Subsurface flow with isolated pools (Interstitial)
- ❒ Moist Channel, isolated pools, no flow (Intermittent)
- ❒ Dry channel, no water (Ephemeral)

COMMENTS_____

For purposes of completing an evaluation of PHWH streams, the following are definitions used to describe the apparent flow characteristics at the time of the evaluation:

Stream Flowing: flowing water present at time of assessment.

Interstitial Flow with Isolated Pools: flowing water is present in isolated pools (often widely spaced), which remain connected by subsurface flows. Dye testing may be needed to document pool connection. Alternatively, a test can be made for interstitial flow by digging away the substrate in a "dry" portion of the stream (preferably in the thalweg) to see if the substrates are saturated (i.e. water fills the hole). If the water in the hole clears of suspended silts quickly, or obvious stream flow is present, and/or the water is at temperatures indicating groundwater contribution (temperatures ≤ 20 °C in the summer), interstitial flow through the channel substrates is indicated.

Moist Channel, Isolated Pools, No Flow: moist substrate and/or water present in isolated pools, but no visual evidence that the water in the pools is flowing.

Dry Channel, No Water: a completely dry channel for the entire 200 ft (61 m) stream reach. No pools, moist substrates or interstitial flow present.

Record the appropriate flow condition at the time of evaluation in the space provided on the PHWH Form. This information can be very useful in making a final PHWH classification decision. If it is believed that low flow conditions would be significantly different than that observed at the time of the evaluation, this can be confirmed by either waiting until the stream is at seasonal low flow conditions, or by conducting a biological evaluation of the stream.

NOTE: Temporal and seasonal variations in the flow condition of PHWH streams are common and should be expected. Base flow conditions present during an evaluation should be verified as typical (not drought related) based upon an analysis of the drought index and critical low flow data for the area in question as discussed in Section 2.3. If drought conditions exist, the results of the HHEI evaluation may be suspect and assignment of the appropriate PHWH classification should be delayed until normal flow conditions resume in the area. Where drought conditions are suspected, or where the stream channel is dry, the Palmer Drought Severity Index value for the area should be recorded in the "comments" section in the "Flow Regime" section of the PHWH Form. Information regarding local flow conditions from nearby USGS stream gages can also be recorded in this area of the form.

5.7 Sinuosity

SINUOSITY (Number of bends per 61 m (200 ft) of channel) (Check *ONLY* one box):

❒ None	❒ 1.0	❒ 2.0	❒ 3.0
❒ 0.5	❒ 1.5	❒ 2.5	❒ >3

Although not determined to be a significant discriminator of PHWH stream types, the sinuosity of a stream may be related to channel modification, which is one of the primary factors used in the HHEI assessment flow chart to assign a final PHWH classification (Figure 16). Determine the number of complete and well-defined outside bends in the 200 ft (61 m) stream reach (Figure 16) and record on the PHWH Form (Attachment 1). Incomplete bends not fully included in the evaluation reach should be counted as half bends at the discretion of the observer. Indicators that can be helpful to determine the sinuosity pattern in the field are steep and eroded banks on outside bends and the presence of point bars on the inside of the bend. For recovering and recovered channels (stream modification category – Section 5.2), sinuosity of the wetted channel and thalweg may form before the stream banks have fully adjusted laterally and vertically following a disturbance of the stream channel. The user may wish to document this forming stream pattern as sinuosity on the form, using caution and noting this alternative interpretation.

The method of estimating sinuosity presented in this manual differs from the more quantitative stream geomorphology technique typically used in stream geomorphology studies [e.g., Rosgen (1996)]. This more technical approach is based on the ratio of the channel length to valley length to define a unit-less sinuosity coefficient (K).

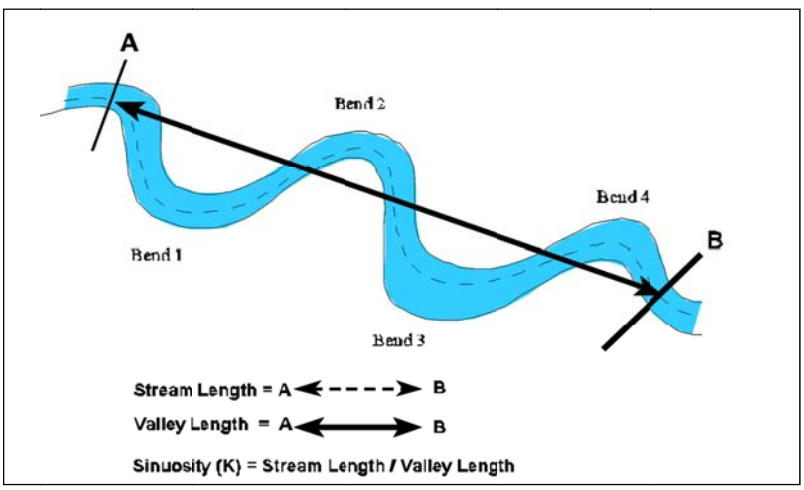


Figure 16. Diagram indicating the method for determining sinuosity as recorded on the PHWH Form. Note that points "A" and "B" represent the limits of the 200 ft (61 m) PHWH evaluation reach. This particular example has four complete bends and would be entered as ">3" on the PHWH form.

5.8 Stream Gradient

STREAM GRADIENT ESTIMATE

☐ Flat (0.5 ft/100 ft) ☐ Flat to Moderate ☐ Moderate (2 ft/100 ft) ☐ Moderate to Severe ☐ Severe (10 ft/100 ft)

Stream gradient was not determined to be a significant overall discriminator of PHWH stream class. However, stream gradient was found to be suitable for separating Class III PHWH streams from all other types. In general, Class III PHWH streams typically have a moderate gradient of 2% slope (0.02 feet/foot) and are rarely greater than 10% slope (0.10 feet/foot). Both very high gradient streams and sluggish streams do not provide optimal flow hydrology for the types of biological communities adapted for life in Class III PHWH streams. On the front of the PHWH Form, check the box with the best visual estimate of stream gradient for the stream reach.

Although several methods are available to accurately measure stream gradient using surveying techniques, these methods are often time consuming and require the use of expensive equipment. An excellent visual estimation method to accurately estimate the gradient without the need for specialized equipment is as follows:

1. stand at the mid-point of the 200 ft (61 m) evaluation zone look upstream at the marker indicating the upstream limit of the zone;

2. estimate the height (in feet) at which a level line extending from the upstream marker would be at the mid-point of the zone;

3. this height gives the gradient of the stream equivalent to the units provided on the PHWH Form (ft/100 ft).

If the stream gradient is markedly different between the upstream and downstream halves of the zone, the same procedure can be repeated by observing from the downstream limit of the zone and looking upstream to the mid-point of the zone. In this case, record the average of the readings <u>or</u> check both boxes and provide explanatory notes on the form regarding the differences within the evaluated reach.

5.9 PHWH FORM - PAGE 2

5.9.1 QHEI Assessment

Check the appropriate box as to whether or not a QHEI evaluation was performed. If yes, attach a copy of the final QHEI sheet. See Section 3.2 for a discussion regarding how to determine whether a QHEI assessment is necessary when categorizing a suspected PHWH stream.

5.9.2 Downstream Designated Use(s)

If known, mark the box which indicates the downstream designated uses (within two river miles). Check a box only if the stream segment feeds to a wetland or to a stream with a known use designation. If the downstream segments are un-designated, check no boxes, but describe downstream characteristics in the space provided.

Please be specific in responses to this item! Information provided in this section can be used to evaluate potential beneficial uses of the water body and to evaluate potential impacts on downstream uses. A description of the drainage hierarchy downstream of the segment being analyzed to the nearest named stream should be provided if possible.

5.9.3 Location Information

Attach a copy of both the USGS topographic map and the NRCS county soil map with the watershed areas of the PHWH streams clearly identified. Enter information regarding the maps on which the evaluated reach lies on the PHWH Form in the spaces provided. Also identify the county and township or municipality where the site is located.

A useful feature of the STREAMSTATS web tool for the delineation of watershed areas is a feature for exporting the watershed map in an electronic format. For users with GIS software, a shape file of the watershed, superimposed upon the USGS topographic map can be uploaded from the STREAMSTATS web page (see Section 2.2.2).

5.9.4 Miscellaneous

Several items on page 2 of the PHWH Form are provided for entering miscellaneous information about the evaluated stream reach and its condition on the day the survey. They include:

- A space to indicate whether or not the stream was at base flow conditions for the season of the year when the field evaluation was conducted. Two additional pieces of information are recorded in this portion of the form that can be helpful in making this determination, the date and quantity of the last local precipitation (if known) and whether or not the turbidity of the water is elevated on the day of the site visit. If there has been significant rainfall or snow melt within the previous 48 hours and the turbidity of the stream is high, the PHWH evaluation should be postponed until the stream returns to base flow conditions.

- Information regarding photographs taken of the assessed stream reach can be recorded in this section of the PHWH Form. It is highly recommended that sufficient photographs be taken to document the conditions and the habitat present at the time of the evaluation. Provide information on the form that will allow for later identification of the photos.

- A space is provided to record an estimate of the percent openness of the overhanging tree canopy over the stream reach. The amount of open area in the tree canopy should be estimated as that which would be experienced at the time of maximum leaf cover. In most situations, a visual estimate of the percent openness of the canopy is sufficient, although quantitative estimates can be obtained through the use of a leaf densiometer. Information regarding the amount of shading of the stream can be useful for making a final determination of the appropriate use designation for the PHWH stream under investigation.

- Spaces are provided to record field measurements for dissolved oxygen, pH, water temperature, and conductivity using standard Ohio EPA quality control methods (Ohio EPA, 2009 b). If no field monitoring equipment is available, at a minimum, the water temperature of the stream (if water is present) should be recorded during each PHWH assessment. Temperature in summer months can be used to verify potential cool-cold water Class III PHWH streams. In general, Class III PHWH streams will have daily average summer water temperature below 20° C, with values less than 18° C near the spring source. Water in Class III PHWH streams can have daily maximum summer water temperature higher than 20° C well downstream from their spring source(s), but average daily temperatures will rarely be above 23° C (see Ohio EPA 2002 b).

- A space is provided to record whether water samples were collected for laboratory analyses. Water samples for analyses in addition to the field parameters listed above do not need to be collected routinely in order to classify PHWH streams. However, in the event that upstream chemical pollution of the water is suspected, a sample should be collected for analysis in order to ensure that site biology is not affected by water chemistry. If a sample is collected, provide the sample identification information and provide copies of the analytical report. Under these circumstances, analyses should be conducted for nutrient parameters (ammonia-N, nitrate+nitrite-N, total phosphorus), COD, chlorides, heavy metals, and *E. coli* bacteria. Where mine drainage impacts are suspected, include samples for iron, manganese, and sulfates. The Water Quality Standards found in OAC Chapter 3745-1 should be consulted in order to determine if any applicable standards are exceeded. Appropriate comparisons for Class I and Class II PHWH streams are the aquatic life water quality criteria applicable to WWH streams, while the aquatic life water quality criteria for CWH streams should be used to evaluate water quality data from Class III PHWH streams.

5.9.5 Biological Evaluation Summary

If a biological evaluation is conducted, complete the information in this section of the form as indicated. A detailed summary of biological data should be recorded on pages 3 and 4 of the PHWH Form (see Section 6.0).

Even in cases where a detailed biological evaluation (Level 2 or Level 3 Assessment) is not conducted, cursory observations of the in-stream biology noted during the HHEI evaluation

process can often be extremely helpful in making correct PHWH stream classification decisions. Often, fish, amphibians, and macroinvertebrates will be observed while completing the field measurements associated with conducting the HHEI analysis.

5.9.6 Drawing and Narrative Description of the PHWH Stream Reach

In the space provided on the HHEI form, or using the Qualitative Substrate Evaluation Form included as Attachment 5, make a drawing of the evaluated PHWH stream reach. Include the following information on the map: important landmarks, habitat features, notations regarding substrate distribution, bankfull width measurement locations, pools and pool depths, riffles, the direction of water flow, a north arrow, and any other features of interest. Also include information regarding any road crossings or points for access. The drawing should include comments on the type of riparian zone and land use adjacent to the stream reach, and any observations regarding seepage areas or confluences with other tributary channels. The stream drawing is a critical component of the assessment process and is extremely useful to document the condition of the evaluated reach on the day of the site evaluation. **The PHWH evaluation process should not be deemed to be complete unless the stream drawing is completed.**

PHWH FORM - PAGES 3 & 4

6.0 Level 2 and Level 3 Assessments: Biological Sampling

The PHWH stream classification system is based upon the communities of aquatic life that are, or have the potential to be, supported within the stream. Therefore, proper use of biological sampling is critical to provide the data necessary to properly classify streams that meet the PHWH designation. The following sections provide information on the biological communities found in PHWH streams that are used for classification. Standardized methods to be used to collect and preserve biological specimens are also described. All data collected for biological assessments should be recorded on pages 3 and 4 of the PHWH Form (Attachment 1).

Some general notes apply for all of the biological sampling techniques described in this manual. It is extremely important that the flow conditions of the stream are appropriately understood prior to committing resources toward the collection of biological samples. Elevated stream flows as well as drought can both create stream conditions that are unsuitable for the assessment of the in-stream biology (see Section 2.3). In addition, extra precautions must be taken when sampling during times of leaf fall because of the interference that the leaves cause in searching for organisms. The time allocated for collecting fish, salamanders, or benthic macroinvertebrates may have to be lengthened significantly to account for the additional effort needed to properly sort through the detritus to capture organisms. Similar cautions also apply for times of year when streams are frozen, since the physical conditions will interfere with access to the various habitat types within the stream and limit collection efficiency. In short, common sense should prevail in

determining whether the stream conditions are suitable for conducting valid biological assessments.

6.1 Fish in PHWH Streams

Many PHWH streams contain fish that are classified by Ohio EPA (Ohio EPA, 1989) into one of three major categories: (1) cold water adapted species listed as CWH indicator species in Table 7-2 of OAC 3745-1-07 (e.g., Redside Dace); (2) pioneering species (e.g., Creek Chub), or (3) headwater adapted species (e.g., Blacknose Dace). All three types of headwater fish species have been collected in PHWH streams less than 1.0 mi^2 (259 ha). A list of all species of fish collected from PHWH streams by Ohio EPA in 1999 and 2000 is provided in Table 5. The Creek Chub was the most common species, collected in 32.8% of all samples, with Bluntnose Minnow (19.4%), and Blacknose Dace (10.4%) next in frequency of occurrence (see also Ohio EPA, 2002 c).

Although many different species of fish are present in PHWH streams as shown in Table 5, it becomes increasing less likely that a well-balanced fish community, as measured by the IBI, can be supported as watershed size falls below 1.0 mi^2 (259 ha). Limitations to the establishment of well-balanced fish communities in PHWH streams can result from the lack of suitable habitat or forage, barriers to migration (natural or artificial), or the lack of refugia during low and zero flow conditions. The lack of permanent nursery areas for young-of-the-year fish also may preclude the establishment of well-balanced fish communities in PHWH systems. Therefore, many fish species may be only temporally resident as they move in and out of PHWH streams to exploit seasonally available food resources. There often exists in natural watersheds a lower limit in watershed size and stream scale where fish are no longer observed, but are replaced by salamanders as the dominant vertebrate predator (see Figure 1).

The presence of cold water fish species from Table 7-2 of OAC 3745-1-07 is a definitive indicator that the stream meets the definition of a Class IIIB PHWH. A Class II PHWH stream may be indicated by the presence of warm water adapted populations of fish in the absence of any other Class III indicator taxa. If the maximum depth of the predominant pools is greater than 40 cm, then the Ohio EPA QHEI habitat evaluation should be conducted, and the stream evaluated for potential to attain the Ohio EPA WWH or EWH use designations according to established agency procedures (Rankin, 1989; see also Section 3.2).

Sampling methods to collect fish in PHWH streams can include electro-fishing techniques (i.e., long-line or backpack methods), use of a 10 ft seine, or collection with a fine mesh benthic invertebrate net. If assessing the stream for potential WWH, CWH, or EWH use designations, standard procedures using electro-fishing techniques must be followed (Ohio EPA, 1989).

For a PHWH stream survey, fish must be collected for at least 15 minutes throughout the 200 ft (61 m) stream reach under investigation. Focus on pools, undercut banks, and other deep cover features within the stream reach. These are areas used as refuge for fish when the stream is disturbed. All fish collected should be identified to species. Record all

Table 5. Fish species observed/collected in Primary Headwater Habitat streams in Ohio, 1999-2000. Fish were captured in 67 of the 215 streams sampled. Fish species in **bold** represent PHWH stream indicator species based upon habitat preference. Species listed in *italics* indicate cold water adapted Class IIIB indicator species. "Yes" indicates that the species is associated with the listed ecological category by Ohio EPA (Table 7-2 of OAC Rule 3745-1-07; Ohio EPA, 1989).

Species (common name)	Percent Occurrence	Pioneering Species	IBI-Headwater Species	Coldwater Species
Creek Chub	32.8	Yes	---	---
Bluntnose Minnow	19.4	Yes	---	---
Blacknose Dace	10.4	---	Yes	---
Rainbow Darter	7.5	---	---	---
Bluegill Sunfish	4.5	---	---	---
Johnny Darter	4.5	Yes	---	---
Stoneroller Minnow	4.5	---	---	---
Largemouth Bass	2.9	---	---	---
Fantail Darter	2.9	---	Yes	---
Greenside Darter	2.9	---	---	---
White Sucker	2.9	---	---	---
Green Sunfish	2.9	Yes	---	---
Redside Dace	1.5	---	Yes	Yes
Mottled Sculpin	1.5	---	Yes	Yes
Brook Trout (native)	1.5	---	---	Yes
Goldfish*	1.5	---	---	---
Central Mudminnow	1.5	---	---	Yes
Orangethroat Darter	1.5	Yes	---	---

Fish Species expected to occur in PHWH streams in Ohio but not observed during 1999 and 2000 surveys

Creek Chubsucker	-	Yes	---	---
Southern Redbelly Dace	-	---	Yes	Yes
Rosyside Dace	-	---	Yes	---
Silverjaw Minnow	-	Yes	---	---
Fathead Minnow	-	Yes	---	---
Brook Stickleback	-	---	Yes	Yes

species collected and their total numbers on page 3 of the PHWH form (Attachment 1). Record in minutes the total time spent searching for fish.

Voucher specimens should be collected for each species that cannot be positively identified in the field and preserved in a solution consisting of one part buffered formalin and nine parts water. If voucher specimens are to be held longer than 2-3 weeks, the specimens should be transferred to a 70% ethanol preservative solution using the methods described in the Ohio EPA methods manual (Ohio EPA, 1989). Place a field tag in and on the jar which includes date, collector name, county, township, and stream identification as listed on the HHEI field evaluation form (see Attachment 6).

6.2 Salamanders in PHWH Streams

In the headwaters of watersheds, aquatic to semi-aquatic salamander species replace fish as the primary aquatic vertebrate predator functional group (Figure 1). These amphibians are distributed throughout Ohio except for the counties in the northwest area of the state. Detailed maps for the distribution of salamanders in Ohio by county are given in Pfingsten and Downs (1989), Pfingsten (1998), and Pfingsten and Matson (2003). Based on the results of the 1999 and 2000 Ohio EPA survey, three assemblages of salamander species have been identified from PHWH streams throughout the state, which are summarized in Table 6, and discussed in detail below:

Class III PHWH Salamander Assemblage (perennial flow; egg and larval development dependent upon year-round presence of flowing water, usually with greater than 12 month larval period)

This salamander assemblage is represented by species of obligate aquatic species that have larvae resident in the stream channel on a year-round basis. Most of these species have larval stages that last for at least two years based on available literature, with a maximum span between 4-5 years (Petranka, 1998; Pfingsten and Downs, 1989). These species also require flowing water for egg deposition, with females usually laying eggs in habitats saturated with flowing water. The larvae of these species also require perennial flow conditions throughout their larval development, during which time they reside within the stream channel. Salamander species associated with Class III PHWH stream types in Ohio are taxonomically related, all classified within the Tribe Hemidactyliini, Subfamily Plethodontinae, of the Family Plethodontidae. The presence of Class III indicator salamander species in PHWH streams is also highly associated with the presence of cold water adapted species of benthic macroinvertebrates.

The Class III salamander taxa are sub-divided into two groupings for regulatory purposes. Although the presence of reproducing populations of any of the Class III indicator taxa is indicative of perennial flow conditions, Class IIIA indicator taxa are separated from the Class IIIB indicator taxa based upon life history and thermal tolerances as described below and in Tables 6 and 7.

1. Class IIIA PHWH Salamander Assemblage

Three species, the Northern Two-Lined Salamander (*Eurycea bislineata*), the Southern Two-Lined Salamander (*Eurycea cirrigera)*, and the Longtail Salamander, *Eurycea longicauda* are listed as indicator taxa for Class IIIA PHWH streams in Ohio [OAC 3745-1-07(F)(9)(d)(iii)]. The Northern Two-Lined Salamander and the Southern Two-Lined Salamander were the most common species collected from PHWH streams in Ohio. These two species also have the widest geographic ranges of all of the salamander indicator species for Class III streams in the state. Similar to other Class III indicator salamanders, the Two-Lined salamander species have larval periods extending well beyond 12 months (Table 7) where the presence of flowing water is necessary for survival. The exception to this general characteristic is the Longtail Salamander, which may or may not have a larval period greater than 12 months in Ohio.

The Class IIIA indicator salamander species are separated from the Class IIIB indicator species based upon the thermal requirements for survival. Reproducing Class IIIA species can commonly be found in streams with warmer thermal regimes compared to the cold water indicator species. In addition, reproducing populations of the Northern Two-Lined Salamander and the Southern Two-Lined Salamander can commonly be found in larger, non-PHWH streams in Ohio, where Class IIIB indicator species are generally restricted to smaller catchments associated with springs.

In the absence of other cold water indicator taxa (salamanders, fish, or macroinvertebrates meeting the definition of Class IIIB), the presence of reproducing Class IIIA indicator salamander species alone results in the Class IIIA stream classification.

2. Class IIIB PHWH Salamander Assemblage

Six species or subspecies from the genera *Eurycea*, *Gyrinophilus*, and *Pseudotriton* are recognized as Class IIIB indicator taxa and are listed as cold water fauna in Table 7-2 of OAC Rule 3745-1-07 (Tables 6 and 7) . Two of these species, the Cave Salamander (*Eurycea lucifuga*), and the Midland Mud Salamander (*Pseudotriton montanus diasticus*) are listed as endangered and threatened, respectively, in ORC 1531.25. Evidence of the presence of reproducing populations of these species is definitive in classifying a stream as a Class IIIB PHWH [OAC 3745-1-07(F)(9)(d)(iv)].

Class II PHWH Salamander Assemblage (intermittent flow warm water adapted; larvae present in the stream seasonally, less than 12 month larval period)

The second assemblage of salamanders found in PHWH streams in Ohio are distinguished from the Class III obligate aquatic assemblage of salamanders by having a larval period less than 12 months (Tables 6 and 7). The Class II indicator species can be associated with a continuum of permanent to intermittent flow conditions. These <u>non-obligate</u> aquatic salamander species are taxonomically different from the obligate salamander assemblage, being classified within the Subfamily Desmognathinae of the Family Plethodontidae, the Family Ambystomatidae, and the rarely encountered species *Hemidactylium scutatum* (Four-Toed Salamander). Although salamanders from this non-obligate group may be found coexisting with obligate Class III salamander species, these <u>non-obligate</u> aquatic

species have life history traits that do not require residence in flowing water on a year-round basis.

Salamanders in Ohio from the genus *Desmognathus* do not require flowing water for egg clutch deposition, but instead lay eggs in stream bank habitats, usually under rocks, moss, or logs; although seepage areas may also be utilized. Species from the genus *Ambystoma*, which may lay eggs within the flowing water of a PHWH stream channel, have short larval periods. They tend to be found in streams that become intermittent or completely dry during summer months. A third aquatic salamander genus, *Hemidactylium*, is largely found in sphagnum bogs, but may migrate to headwater streams that connect to these bogs. The presence of species of salamanders from this non-obligate aquatic assemblage can be used to identify the presence of a warm water Class II PHWH stream types. Two species from this second group, the Blue-Spotted Salamander (*Ambystoma laterale*) and the Four-Toed Salamander (*Hemidactylium scutatum*), are listed as endangered and special concern, respectively, in ORC 1531:25.

Other Salamanders in PHWH Streams (taxa with no aquatic larval development stage; adults may forage in dry channels in search of food).

The third group of salamander species that may be encountered in PHWH streams consists of species that are adapted for life in terrestrial forest habitats. These species often migrate into PHWH stream corridors, usually during wet periods, to forage for food. This group includes species from the genus *Plethodon* [examples include the Redback Salamander, (*P. cinereus*) the Ravine Salamander (*P. richmondi)* , and the Slimy Salamander (*P. glutinosus*). These salamander species have terrestrial modes of existence and lack aquatic larval stages, but they are an important component of the food web structure of second growth forests in Ohio. *Plethodon* species are good bio-indicators of various stages of forest succession, with preference for old growth forest seral stages. They are common in Beech-Maple associations that once were dominant throughout Ohio. *Plethodon* salamanders live in burrows and under decaying logs and leaf litter in forested areas throughout the state. The presence or absence of these species is not used in the PHWH stream classification system.

6.2.1 Sampling Methods for Salamanders in PHWH Streams

The goal for assessment of the salamander community in PHWH streams is to document the presence or absence of reproducing populations of species from the indicator groups discussed above. Two techniques for assessing PHWH streams for salamanders are presented in this manual. The qualitative technique described in Section 6.2.1.1 is a Level 2 Assessment that is typically suitable for differentiating Class I, II, and III PHWH streams. Oftentimes, the use of this technique will provide sufficient documentation to definitively identify the PHWH stream class. However, this technique cannot be used exclusively to rule out the presence of reproducing populations of Class IIIB indicator species when Class IIIA species have been identified from the stream, or when only a single life stage of a Class IIIB indicator species is documented. For PHWH classification, only evidence of reproduction (larvae, eggs, or mixture of juveniles and adults) can be used to determine

Table 6. Species of salamanders that can be used as bio-indicators of Class III (cold water, perennial flow) and Class II (warm water, intermittent flow) PHWH streams in Ohio.

Species adapted to Perennial Flow, with Larval Periods > 12 Months (Class III PHWH Indicators)

Family Plethodontidae (Lungless Salamanders)

Subfamily Plethodontinae; Tribe Hemidactyliini

Eurycea bislineata (Northern Two-Lined Salamander)

Eurycea cirrigera (Southern Two-Lined Salamander)

Eurycea longicauda (Long-Tailed Salamander)
[Some populations may have short larval periods.]

Eurycea lucifuga (Cave Salamander)**

Gyrinophilus porphyriticus porphyriticus (Northern Spring Salamander)

Gyrinophilus porphyriticus duryi (Kentucky Spring Salamander)

Pseudotriton montanus diasticus (Midland Mud Salamander)**

Pseudotriton ruber ruber (Northern Red Salamander)

Species Adapted to Survive Intermittent Flow, with Larval Periods < 12 months (Class II PHWH Indicators)

Family Ambystomatidae (Mole Salamanders)

Ambystoma barbouri (Streamside Salamander)

Other *Ambystoma spp.* (Such as Smallmouth Salamander, Tiger Salamander)

Family Plethodontidae (Lungless Salamanders)

Subfamily Desmognathinae

Desmognathus fuscus (Northern Dusky Salamander)

Desmognathus ochrophaeus (Allegheny Mountain Dusky Salamander)

Subfamily Plethodontinae; Tribe Hemidactyliini

Hemidactylium scutatum (Four-Toed Salamander)**
[This species not common in headwater streams.]

** Note: The salamander species, *Eurycea luifuga* (Cave Salamander), *Ambystoma laterale* (Blue-Spotted Salamander), and *Aneides aeneus* (Green Salamander) are listed as "endangered" species in Ohio (ORC 1531:25). The species *Pseudotriton montanus diasticus* (Midland Mud Salamander) is listed as a "threatened" species and *Hemidactylium scutatum* (Four-Toed Salamander) is listed as a species of "special concern" in ORC 1531:25.

Adapted from "Salamanders of the United States and Canada", 1998. James W. Petranka.
Smithsonian Institution Press, Washington, DC.

Table 7. List of salamander species in Ohio that use primary headwater stream corridors as a habitat for egg deposition (oviposition) and larval growth. Species ordered from shortest length of larval period to longest. Life history data from personal observations of R.D. Davic (Ohio EPA), Harding (1997), Pfingsten and Downs (1989), Petranka (1998), Hulse et al. (2001). *Plethodon* and *Aneides* species with direct development not included in the table. When multiple species are collected in the same stream segment, the species with the highest numerical classification is used to indicate potential appropriate PHWH stream class (I, II, or III). **Only evidence of reproduction (larvae, eggs, or mixture of juveniles and adults) can be used to determine stream class.** Table by R. D. Davic, Ohio EPA.

Species	**Micro-habitat and Season for Egg Clutch Deposition** **PHWH Stream Class Indicator**	**Length/Season of Larval Period**
Four-Toed Salamander (*Hemidactylium scutatum*)	Found in bog habitats, eggs usually found in moss (sphagnum) from March to May. Eggs may be found in slow moving headwater streams associated with bog habitat. Adults terrestrial. **If evidence of reproduction found, a Class II PHWH stream indicator species.** Protected as a Special Interest species in ORC, Section 1531.25.	1-2 months (May to June) Pond type larval development
Streamside Salamander (*Ambystoma barbouri*)	SW Ohio only. Oviposition from January to March in headwater streams with few fish. Stream usually becomes intermittent during summer. Often in limestone type geology. Eggs found in water under rocks from December to March. **If evidence of reproduction found, a Class II PHWH stream indicator species.**	2-3 months (March to May)
Allegheny Mountain Dusky Salamander (*Desmognathus ochrophaeus*)	Extreme NE Ohio only. Oviposition near seepage areas, mostly from August to October. Known to breed in sub-surface habitats. Stream may become intermittent in summer. Adults will forage in riparian areas. **If evidence of reproduction found, a Class II PHWH stream indicator species.** May be found in Class III stream habitats.	1-3 months. Most common in September to November, but may occur in March-April in some Ohio populations.
Northern Longtail Salamander (*Eurycea longicauda*)	Statewide except northwest and north-central Ohio. Oviposition over winter in streams and seepage areas associated with rock outcrops or in sub-surface areas. Often in limestone or shale geology, around caves. **If evidence of reproduction found, then a Class IIIA PHWH stream indicator.**	4-5 months, (March to July) but may extend to12-14 months in local populations. Larval period not well known for Ohio.

Table 7 (cont.). List of salamander species in Ohio that use primary headwater stream corridors as a habitat for egg deposition (oviposition) and larval growth. Species ordered from shortest length of larval period to longest. Life history data from personal observations of R.D. Davic (Ohio EPA), Harding (1997), Pfingsten and Downs (1989), Petranka (1998), Hulse et al. (2001). *Plethodon* and *Aneides* species with direct development not included in the table. When multiple species are collected in the same stream segment, the species with the highest numerical classification is used to indicate potential appropriate PHWH stream class (I, II, or III). **Only evidence of reproduction (larvae, eggs, or mixture of juveniles and adults) can be used to determine stream class.** Table by R. D. Davic, Ohio EPA.

Species	**Micro-habitat and Season for Egg Clutch Deposition** **PHWH Stream Class Indicator**	**Length/Season of Larval Period**
Northern Dusky Salamander (*Desmognathus fuscus*)	Statewide except northwest and north-central Ohio. Oviposition in stream bank microhabitats or seepage areas, outside flowing water (June to. August). Eggs not in flowing water, but located streamside under rocks, logs, moss with brooding female. **If evidence of reproduction found, a Class II PHWH stream indicator species.** May be found in Class III stream habitats.	9-10 months (September to May) No larvae in late June-early August. Young and old larvae may be found along stream banks outside of flowing water.
Cave Salamander (*Eurycea lucifuga*)	Extreme southwest counties of Ohio, at northern edge of geographic range. Oviposition from September to February within caves. **If evidence of reproduction found, a Class IIIB PHWH stream indicator species.** Very rare, classified as an Endangered Species in Ohio (ORC 1531.25).	Mostly 14-18 months with two larval age classes common in Indiana populations. Larval period not well known for Ohio.
Midland Mud Salamander (*Pseudotriton montanus diasticus*)	Extreme south-central Ohio. Oviposition in autumn, embryos hatch in winter. Common in burrows; egg nests in cryptic underground sites. **If evidence of reproduction found a Class IIIB PHWH stream indicator species.**	15 to 30 months, larval period not well known for Ohio populations.
Northern Two-Lined Salamander (*Eurycea bislineata*)	North Central to North East Ohio. Common in perennial flowing PHWH streams. Oviposition from April to May, in shallow running water under flat rocks. May be found in dry streams with interstitial sub-surface flow. **If evidence of reproduction found, a Class IIIA PHWH stream indicator species.** Known to migrate into higher order streams.	24 to 36 months in Ohio. Three distinct larval age classes observed in some populations.

Table 7 (cont.). List of salamander species in Ohio that use primary headwater stream corridors as a habitat for egg deposition (oviposition) and larval growth. Species ordered from shortest length of larval period to longest. Life history data from personal observations of R.D. Davic (Ohio EPA), Harding (1997), Pfingsten and Downs (1989), Petranka (1998), Hulse et al. (2001). *Plethodon* and *Aneides* species with direct development not included in the table. When multiple species are collected in the same stream segment, the species with the highest numerical classification is used to indicate potential appropriate PHWH stream class (I, II, or III). **Only evidence of reproduction (larvae, eggs, or mixture of juveniles and adults) can be used to determine stream class.** Table by R. D. Davic, Ohio EPA.

Species	**Micro-habitat and Season for Egg Clutch Deposition** **PHWH Stream Class Indicator**	**Length/Season of Larval Period**
Southern Two-Lined Salamander (*Eurycea cirrigera*)	Southern portion of Ohio, considered a sub-species of E. bislineata by Petranka (1998). Same behavior as northern two-lined salamander. **If evidence of reproduction found, a Class IIIA PHWH stream indicator species.**	24 to 36 months in Ohio. Three distinct larval age classes in summer.
Red Salamander (*Pseudotriton ruber*)	Eastern portions of state, north to south. Oviposition from October to February, usually in sub-surface areas. Adults migrate away from streams in spring-summer, but overwinter in headwater springs. Associated with sandstone geology. **If evidence of reproduction found, a Class IIIB PHWH stream indicator species.**	24 to 36 months, may overwinter to a fourth year as larvae.
Spring Salamander complex (*Gyrinophilus p. porphyriticus, and G. p. duryi*)	East to east-central and southern portions of the state. Oviposition in summer months, in sub-surface areas. Adults may forage away from streams. This species has a propensity for a subterranean mode of life in cold-cool headwater springs. May be associated with caves. **If evidence of reproduction found, a Class IIIB PHWH stream indicator species.**	36 to > 48 months.

stream class. The semi-quantitative visual encounter survey (VES) technique described in Section 6.2.1.2 is considered a Level 3 Assessment method. The VES method should always be accompanied by the qualitative sampling described in Section 6.2.1.1. Results of a Level 3 salamander survey are definitive for determining the PHWH stream classification based on this organism group and for differentiating between Class IIIA and Class IIIB salamander assemblages.

The general collection and handling techniques for salamanders are similar for both Level 2 and Level 3 Assessment methods described in the sub-sections below. Because salamanders are most active during the night in response to predation by other vertebrates, they are found during the daylight hours hiding under different types of microhabitat cover including rocks, logs, leaves, moss, bark, burrows, etc. Thus efforts to collect salamanders along a stream corridor must include an effort to sampling of all the different types of micro-habitat cover available in the stream reach under investigation. Emphasis should be placed on sampling both within the stream channel and at least 1-2 meters (3-7 ft) from the wetted channel along the stream margins in order to maximize the potential to capture salamanders from all life stages. The presence of salamander larvae is the best predictor that the salamander population is resident in the stream on a continual basis. However, it is also extremely important to document the presence or absence of juvenile and mature salamanders at a site since this also indicates that a population is using the stream channel for reproduction.

An ordinary metal strainer, bent to a triangular shape, or a fine mesh aquatic invertebrate net is recommended for the collection of salamanders, especially the small slippery and elusive larvae. Flat edge insect nets can also be used. Due to high oxygen demand, gilled, pre-metamorphic larvae are restricted to the flowing water of the stream. They are often found hiding under cover objects such as rocks, leaves, and woody material as a protection from possible predators.

As the collection effort moves upstream, first place the net against the bottom substrate and then lift cover objects in front of the net. To capture larval salamanders, position the net in front of the salamander's head, and gently touch the tail; more often than not they will move forward into the net. Replace cover objects that are lifted to their original position to minimize habitat disturbance. Another technique used to capture salamander larvae is to attach a 200 ml suction bulb to a small rubber tube of sufficient diameter to allow salamander larvae to enter. Place the tube near the larvae and use the suction bulb to capture the larvae in the tube. This method is useful in areas of the stream where larvae are hiding in such a way that nets are strainers will not work, such as within bedrock crevices. A high intensity head light may be helpful in some headwater streams due to low light conditions under tree canopy.

Spring Salamanders (*Gyrinophilus spp.*) are often found at the terminal limits of a PHWH stream, near the ground water source. These salamanders are known to bury into gravel substrate as adults, although larvae can be located under rocks throughout the stream channel. When searching for salamanders near a ground water source, extra time should be spent digging into any gravel substrate that may be present.

All captured salamanders should be placed into a plastic container with a vented lid or a sealable bag (double) so that species can be identified and the total number of each type counted. Great care should be taken to insure that the captured salamanders cannot escape prior to identification and enumeration. Take note of any salamanders that escape capture and include those in the total tally if they can be positively identified. The stream margin should be searched within at least 1-2 m (3-7 ft) on each side of the wetted stream channel for juvenile and adult salamanders. This search zone may need to be widened to be sufficiently thorough dependent upon site-specific conditions. These age classes often migrate away from the water in search of food or places to hide from predators.

To identify the captured specimens, place all captured salamanders into a white tray with a small amount of water. Gills on the head of the larvae will be visible against the white background to allow them to be identified. Record the total number of each salamander species collected on page 3 of the PHWH Form. Include in the tally the total number of salamanders observed but that escaped capture. It is highly recommended that any salamanders that cannot be positively identified and larvae from each identifiable taxon be vouchered for positive identification in the laboratory. After voucher specimens are taken (Section 6.2.2), return all remaining salamanders into the stream from which they were collected.

Sampling for salamanders is best conducted during the spring and summer months. Spring sampling (April and May) will often provide the best overall assessment of in-stream reproduction, as this is the period of the year when stream-obligate salamander species will be laying eggs in the stream. Sampling in the summer months will provide the best overall capture probabilities for larvae (often multiple year classes will be present), juveniles, and adults. Larvae from species with short larval development periods (e.g., Dusky Salamanders and Longtail Salamanders) will often only be observed in the flowing stream in the late spring to early summer (May – June). Sampling during the fall months is often much more difficult, as the level of effort must be intensified due to the presence of heavy leaf litter in many PHWH streams. Wintertime sampling will seldom, if ever, result in the capture of adult salamanders, since the adults hibernate and will be very difficult to find. Larvae of the Class III indicator species will continue to reside in the stream during the winter months, as they require flowing water for survival. Therefore, the presence of larvae alone in a PHWH stream during the winter months is considered evidence of a reproducing population for that species since the larvae must have hatched in the stream and survived through the critical low-flow period of the year.

For both salamander sampling protocols, the same procedures are used to document the results: 1) collect the salamanders; 2) identify all individuals to species and life stage (larvae, juveniles, and adults); and 3) tally the results on Page 3 of the PHWH Form (Attachment 1). Be sure to record on the page the sampling method(s) used to collect the salamanders, and the time (in minutes) that was spent searching the stream. Compare the results to the criteria presented in Tables 6, and 7 and the protocols described in Section 7.0 to assign the PHWH class to the stream.

6.2.1.1 Level 2 Assessment: Qualitative Salamander Evaluations

A variety of collection methods and tools can be used to qualitatively survey a PHWH stream reach for salamanders. The techniques described in Section 6.2.1 above can be carried out throughout the stream reach in areas of suitable salamander habitat. In addition, salamanders are often captured when seining for fish (Section 6.1), or when kick-net or dip-net sampling for macroinvertebrates (Section 6.3). Additional time should always be allocated to specifically search for salamanders beyond the efforts for other organism groups. A diligent search for salamanders, assaying all available micro-habitats and the stream margins should detect whether populations are present. In most cases this assessment will provide sufficient information to determine the full array of indicator species present sufficiently determine the PHWH classification based upon the salamander species assemblage.

6.2.1.2 Level 3 Assessment: Salamander Visual Encounter Survey

A Level 3 Assessment for salamanders is conducted in situations where a definitive classification is needed to discern between Class IIIA and Class IIIB PHWH stream communities for regulatory purposes, or where semi-quantitative data is needed to meet the DQO's for a study of PHWH streams. The Level 3 Assessment utilizes a technique that is a modification of a Visual Encounter Survey (VES) as described by Heyer, et al. (1994). Although a VES survey is semi-quantitative, more vigorous sampling techniques can be utilized to quantify salamander densities if required. Examples include the 4 m^2 quantitative sampling method as described by Rocco and Brooks (2000), or the placement of artificial substrates such as flat boards or leaf bags. These types of quantitative estimates of salamander abundance have not been calibrated for this PHWH manual.

Begin the salamander VES by selecting **TWO** 30 ft (9.1 m) sections of stream within the 200 ft (61 m) stream reach under investigation. Choose each sample zone where an optimal number and size of cobble type microhabitat substrate is present (64 to 128 mm length), even over bedrock. This substrate size class has been shown to be a good predictor of the presence of obligate aquatic salamander species. If both a salamander VES and benthic invertebrate sampling is to be conducted at the same time by two people, place the salamander sample zones upstream from the initial macroinvertebrate survey to eliminate problems with water turbidity caused by kick net sampling. Sampling for salamanders within the VES zone utilizes the general sampling techniques described in Section 6.2.1 above, with a meticulous downstream to upstream search of all available micro-habitats within the 30 ft (9.1 m) zone and associated stream margins. If no salamanders are observed in the first 30 ft (9.1 m) sample zone, repeat the process for the second zone. At least 30 minutes should be spent searching for salamanders, and the entire 30 ft (9.1 m) zone should be thoroughly searched during the survey.

Within each 30 ft (9.1 m) sample zone, salamander abundance can be estimated using the VES technique as described by Heyer et al. (1994). Time is expressed as the number of person-hours of searching within the 30 ft (9.1 m) zone. Record the exact amount of time expended in searching for salamanders to the minute on the PHWH Form. A VES can be used to determine the salamander species richness of a stream segment, and to estimate

the relative abundances of species on a time basis. Because turbidity can greatly affect the results of a VES, monitoring should only be conducted when water is clear. Extra care must be taken if the sampling occurs during leaf fall in September through November of the year as the leaves will make searching more difficult.

6.2.2 Salamander Voucher Specimens

Collect voucher specimens and transport them live to the laboratory for proper preservation. Place adult and juvenile salamanders into double plastic bags (or plastic containers with air holes) with some moist leaf litter or moss. Larvae should be transported in stream water (typically in a sealable plastic bag) in order to keep them alive. Use a cooler with block ice for transport to the lab for preparation of scientific voucher specimens. At least five larvae and two juvenile-adults should be preserved for each species type observed in the field, if possible.

At the lab, salamanders should be euthanized as quickly and humanely as possible in a way that leaves them in a relaxed position. Salamanders may be euthanized by placing the individuals in a shallow pan and immersing them in a weak (15%-20%) ethanol solution. It may be necessary to straighten the organism several times prior to death in order to ensure that they are not fixed in a curled position. Once dead, the specimen is fixed by placing in a tray lined with white paper towel soaked with 10% formalin. The individual should be laid out straight with the limbs pointing forward parallel to the body. The toes should be spread with the palmar surface facing down. Cover with a second paper towel and add 10% formalin to the tray to a depth of 1 cm. Cover the tray to stop formalin odors and place the tray in a well-ventilated place, preferably under a fume hood. The salamanders should harden somewhat within 2 hours. Specimens should then be transferred to a jar of 10% formalin for shipment or short term storage. Place a field tag in/on the jar which includes date, collector name, county, township, and stream identification as listed on the field evaluation form (see Attachment 6 to this manual). For long-term storage, run the formalin preserved salamanders through a series of first distilled water, then 15% ethanol, 30% ethanol, and finally 70% ethanol. Salamanders should stay in each solution for 24 hours.

6.3 Benthic Macroinvertebrates in PHWH Streams

As presented in Section 1.1, OAC 3745-1-07(F)(9)(d) provides specific definitions for PHWH stream classifications based upon the biological communities that they can support. The benthic macroinvertebrate community is one of the definitive biological indicators for this classification system. Based upon collections conducted by the Ohio EPA, three distinct macroinvertebrate assemblages have been identified for PHWH streams (Ohio EPA, 2002 d). These communities are defined based upon the following characteristics: the number of cold water indicator taxa present; the number of taxa from the Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa); and the number of sensitive taxa found at a surveyed location. Cold water macroinvertebrate taxa are specifically listed in Table 7-2 of OAC Rule 3745-1-07. Sensitive macroinvertebrate taxa are listed in Attachment 3 of this manual. For convenience, the cold water indicator taxa from the Water Quality Standards are also listed in Attachment 3.

The benthic macroinvertebrate community assemblages for PHWH streams are described in Ohio EPA (2002 d) and are summarized in Table 8. Note that when evaluating macroinvertebrate assemblages to determine whether the community meets the definition of a Class IIIB PHWH [Section 1.1.3, OAC 3745-1-07(F)(9)(d)(iii)(b)], an individual taxon may count under multiple categories. Also note that some EPT taxa are not considered cold water indicators or sensitive taxa and are not listed in Attachment 3. However, these taxa must still be counted toward the number of EPT taxa present for the site.

6.3.1 Benthic Macroinvertebrate Sampling Methods

Benthic macroinvertebrates are to be collected following the standard qualitative macroinvertebrate collection techniques used by Ohio EPA for all stream types (Ohio EPA, 1989, Ohio EPA, 2008 a). All potential habitats (riffles, runs, pools, and along stream margins) should be searched thoroughly for macroinvertebrates. Visually scan the stream bottom for organisms and their retreats. Pick up and examine numerous larger substrates such as rocks, woody debris, and leaf packs. Place a small net (about 10 inches wide with a curved or flexible rim) with small mesh size downstream from substrates when they are disturbed to capture dislodged specimens. Wash small amounts of fine particle sized substrates through the net and examine the contents with a white pan. Use the white pan to sort through the rocks and debris and to help identify and keep track of the taxa collected. Special care must be given to searching for the very small and often cryptic midge larvae of the Chironomidae. Many cold water indicator taxa that are associated with Class III PHWH streams belong to this taxonomic group.

Collect aquatic macroinvertebrates for at least 30 minutes from all available habitats and thereafter until no new taxa are found. Extend the collection period as necessary when new taxa continue to be found or if conditions warrant (e.g., heavy accumulations of detritus in the stream). Record the total time spent collecting and sorting organisms in the field on Page 4 of the PHWH Form (Attachment 1).

Record the presence and relative abundance (i.e., rare, common, abundant) of all major taxa collected within the sampling area on Page 4 of the PHWH Form (Attachment 1). For the EPT taxa, record the total number of field-identifiable taxa observed for each group. This determination is typically at the Family taxonomic level and can often be made based on body shape and size. Record the family names of the EPT taxa collected at the site on the HMFEI form.

Table 8. Summary of benthic macroinvertebrate community characteristics associated with PHWH stream classes.

Class III	Streams with four or more taxa of cold water adapted taxa present. The Class III PHWH aquatic life category is further divided into two subcategories:
Class IIIA	Class IIIA PHWH streams are those that have no cohabitating cold water vertebrates listed in Table 7-2 of OAC Rule 3745-1-07 and where the benthic macroinvertebrates do not exhibit the characteristics of a Class IIIB community.
Class IIIB	Class IIIB PHWH streams meet the following characteristics: • streams with cohabitating cold water listed vertebrate species; and/or • Streams where the two of the following three characteristics are present within the benthic macroinvertebrate community: ✓ six or more cold water adapted benthic macroinvertebrate taxa; ✓ six or more EPT taxa; ✓ six or more sensitive taxa.
Class II	Class II PHWH benthic macroinvertebrate communities are defined as those where three or fewer cold water adapted taxa are present. The macroinvertebrate communities in Class II PHWH streams are characterized by warm water adapted macroinvertebrates of moderate to high diversity.
Class I	Class I benthic macroinvertebrate communities may be non-existent due to ephemeral flow conditions or have reproducing populations of native short lived, primarily springtime macroinvertebrate assemblages with low diversity.

6.3.1.1 Level 2 Assessment: the Headwater Macroinvertebrate Field Evaluation Index (HMFEI)

The overall condition of the benthic macroinvertebrate community can be evaluated using a modified version of the Ohio DNR Stream Quality Monitoring scoring system for the State Scenic Rivers program (see the following web link for further information: http://ohiodnr.com/watercraft/sqm/tabid/2550/default.aspx). The methodology developed for PHWH streams is referred to as the Headwater Macroinvertebrate Field Evaluation Index (HMFEI). The HMFEI is a rapid bio-assessment field sampling method designed by Ohio EPA biologist Mike Bolton. The index has been documented to be a good predictor of the various classes of PHWH streams in Ohio. The HMFEI is designed for use in the field, but does require the taxonomic expertise to distinguish taxa to the Family level in many cases. Although the HMFEI can be a useful rapid assessment tool, it is inferior to a more detailed identification of cold water adapted species of benthic macroinvertebrates as obtained through analysis of a voucher sample to the lowest practical taxonomic level back at the laboratory (see Section 6.3.1.2). Cold water indicator benthic macroinvertebrate taxa that

are associated with Class III PHWH streams are listed in Table 7-2 of OAC 3745-1-07 and are also listed in Attachment 3 of this document.

The HMFEI uses field level identification at the Family or Order level of taxonomy to classify different assemblages of benthic macroinvertebrates found in headwater streams. The HMFEI is designed to be calculated in the field. However, if it is calculated from a voucher sample, care should be taken that the same level of identification possible in the field is used. Field identification of the EPT taxa is usually possible only at the family level. The HMFEI is roughly based on a scoring system used by the Ohio DNR Scenic Rivers Stream Quality Monitoring system, with modifications to reflect the faunal composition found in small PHWH streams.

Three scoring categories are used for benthic macroinvertebrate taxa to derive the HMFEI score (Table 9). Scoring values are assigned to the macroinvertebrate categories based upon the correlation of each taxa group to Class III biological communities. The final HMFEI is calculated as follows: for Taxa Groups 1 and 2 each taxa group present at the site is multiplied by the appropriate scoring value; for Taxa Group 3, the scoring protocol is identical except for the EPT taxa, where each field-recognizable taxon belonging to these groups is multiplied by the scoring value of three points. Use Page 4 of the PHWH Form to record the information needed to calculate a final HMFEI score.

An example of a HMFEI scoring procedure is given below. In this example a 200 ft (61 m) PHWH stream reach was sampled and the eight (8) major Taxa Groups were collected. A voucher sample was collected for each of the major taxa observed as follows:

==========

Taxa Group	Group Type:	Metric Scores:
Turbellaria (aquatic worm)	1	1
Mayflies: 2 taxa	3	2 x 3 = 6
Corydalidae (fishfly)	3	3 x 1 = 3
Caddisflies: 3 taxa	3	3 x 3 = 9
Tipulidae	3	3
Blackflies (other Diptera)	1	1
Midges	1	1
Snails	1	1
		Total HMFEI Score= 25

Based on a final HMFEI score of 25, the stream reach described above has a benthic macroinvertebrate assemblage associated with vertebrates found in a Class III PHWH stream.

Table 9. Headwater Macroinvertebrate Field Evaluation Index (HMFEI) scoring categories for use in assessing primary headwater habitat streams in Ohio.

Group 1 Taxa (Scoring Value = 1)	**Group 2 Taxa (Scoring Value = 2)**	**Group 3 Taxa (Scoring Value = 3)**
Sessile Animals (Porifera, Cnidaria, Bryozoa)	Crayfish (Decapoda)	Mayfly Nymphs[1] (Ephemeroptera)
Aquatic Worms (Turbellaria, Oligochaeta, Hirudinea)	Dragonfly Nymphs (Anisoptera)	Stonefly Nymphs[1] (Plecoptera)
Sow Bugs (Isopoda)	Riffle Beetles (Dryopidae, Elmidae, Ptilodactylidae)	Caddisfly Larvae[1] (Trichoptera)
Scuds (Amphipoda)		Fishfly Larvae (Corydalidae)
Water Mites (Hydracarina)		Water Penny Beetles (Psephenidae)
Damselfly Nymphs (Zygoptera)		Cranefly Larvae (Tipulidae)
Alderfly Larvae (Sialidae)		
Other Beetles (Coleoptera)		
Midges (Chironomidae)		
Larvae of Other Flies (Diptera)		
Snails (Gastropoda)		
Clams (Bivalvia)		

Note: Hemiptera (True Bugs) do not receive any points in the HMFEI.

[1] Note: each identified taxon of the Ephemoptera, Plecoptera, and Trichoptera (EPT taxa) receives three points under the HMFEI scoring system.

The HMFEI is reasonably good at separating Class III (cold water adapted) from Class II (warm water adapted) benthic macroinvertebrate species groups. A HMFEI score of greater than or equal to 20 provides separation between these two types of streams at approximately the 75th percentile level. Because the HMFEI is designed to be used with a level of taxonomy that is inferior to the identification of organisms to the lowest practical level at the laboratory, it is crucial that the biologist conducting the survey have the Family level of taxonomic expertise. Although it is not required in all circumstances, it is highly recommended that HMFEI analyses be conducted by a biologist who has been qualified as a Level 2 Qualified Data Collector for benthic macroinvertebrates under the Ohio Credible Data Program (http://www.epa.ohio.gov/dsw/credibledata/index.aspx). The HMFEI can be conducted any time of the year. However, for the most representative results it is suggested that it be conducted during the summer (June to September) in order to avoid the increase in the number of taxa present during the spring time (January through May) and the sampling difficulty associated with leaf fall in the fall (October through December).

The following guidelines are to be used with the HMFEI evaluation to make a decision on the appropriate PHWH classification:

IF Final HMFEI Score is ≥20,	then **CLASS III**	PHWH STREAM
IF Final HMFEI Score is 7 to 19,	then **CLASS II**	PHWH STREAM
IF Final HMFEI Score is < 7,	then **CLASS I**	PHWH STREAM

For circumstances where the HMFEI evaluation results in a classification of Class III PHWH, a more detailed identification of the macroinvertebrate voucher sample may also be necessary to determine the appropriate PHWH classification (Class IIIA or Class IIIB). The HMFEI only predicts whether four or more cold water macroinvertebrate taxa are present (base Class III biological community). In the absence of cold water vertebrate indicator species, the benthic macroinvertebrate community, identified to the lowest practical taxonomic level (Section 6.3.1.2 below) becomes definitive for differentiation of Class IIIA and Class IIIB aquatic community types. Where users do not conduct such an analysis, it must be assumed that a Class III stream meets the definition of Class IIIB, and the stream should be managed accordingly. A detailed summary of the correct interpretation of biological results from PHWH surveys is provided in Section 7.0 of this manual.

6.3.1.2 Level 3 Assessment: Lowest Taxonomic Level Analysis for Benthic Macroinvertebrates

Definitive macroinvertebrate evaluations of a PHWH stream consist of identification of taxa down to the lowest practical level. The lowest practical level is typically to genus, but may require positive identification to the species level in some cases. The Ohio EPA biocriteria documents (Ohio EPA, 1989; Ohio EPA, 2008 a; Ohio EPA 2008 b) fully detail the methodologies for sample collection, handling and identification. Lists of cold water indicator taxa and sensitive macroinvertebrate taxa are provided as Attachment 3 of this manual. Identification of macroinvertebrates to the lowest practical level typically requires both training and experience to a degree where the biologist is eligible for qualification as a

Level 3 Qualified Data Collector under the Ohio Credible Data Program (http://www.epa.ohio.gov/dsw/credibledata/index.aspx).

6.3.2 Benthic Macroinvertebrate Voucher Specimens

It is recommended that voucher samples for macroinvertebrates be collected and retained for all assessments where biological sampling is conducted. For assessments conducted in conjunction with permit applications to the Ohio EPA, a voucher sample must be retained in order to be considered valid. Voucher specimens of all taxa collected should be maintained by preserving them 70% ethanol or higher. Idnetification of all taxa collected to the lowest practical level is used to provide a Level 3 Assessment for PHWH streams (Section 6.3.1.2). Special effort should be made to collect specimens of all potential EPT taxa (i.e., mayflies, stoneflies, and caddisflies) to allow for calculation of the HMFEI (see Section 6.3.1.1). Place a field tag in the jar which includes: date, collector name, county, township, and stream identification as listed on the PHWH Form.

7.0 Summary of the Criteria Used to Classify PHWH Streams

The following steps outline a sequential protocol to be used to reach a classification decision for an unclassified PHWH stream. The sequence presented is in rank order of techniques beginning with those that are least costly and time consuming (Level 1 Assessment) and progressing to those that are more resource intensive (Levels 2 and 3 Assessments).

The information presented within this section assumes that the stream in question meets the definition of a stream and that the stream meets the definition of a PHWH (see Section 1.1). In addition, it is assumed that the PHWH stream is being assessed under the appropriate conditions to render reliable classification data (see Section 2.3). During periods when drought or high flow conditions exist, PHWH evaluations should not be conducted.

Level 1 Assessments consist of classifications of PHWH streams based solely upon the use of the HHEI (Figure 17). The decision making flowchart for Level 1 Assessments found in Figure 17 should be used in conjunction with the HHEI decision flow chart (Figure 15) to assign the appropriate classification to a PHWH stream. It should be noted that a Level 1 Assessment does not provide sufficient data needed to differentiate between Class IIIA and Class IIIB streams. Therefore when the potential classification of a stream is determined to be Class III using a Level 1 Assessment, it must be assumed that the stream is classified as a Class IIIB PHWH stream until a biological survey is conducted proving otherwise (conduct Level 2 or 3 Assessment).

A biological survey (Level 2 or Level 3 Assessment) must be conducted in the following situations:

- when HHEI classification is insufficient to classify the stream based upon the lack of adequate calibration data (e.g., rheocrene streams, see Section 5.4 and Figure 15);

- when observations in the field lead the investigator(s) to believe that data is necessary to refute or confirm the classification based upon HHEI and/or HMFEI scoring; and as stated above;

- when the data quality objectives for classification require the differentiation of Class IIIA and Class IIIB streams.

Biological evaluations will not produce reliable PHWH classification results where there is evidence of profound pollution impacts that have overwhelmed the local biological communities in the stream (see Section 5.4). In cases where these conditions are discovered to exist, the Level 1 Assessment should be used to assign the PHWH stream class. This analysis will provide the best description of the potential for the stream to support aquatic life.

If there is reason to question the HHEI assessment results, study-specific DQO's are not met, or additional data is necessary to confirm the PHWH classification (e.g., rheocrene streams), then perform a Level 2 Assessment (Figure 18). Conduct a rapid bio-assessment of the vertebrate and benthic macroinvertebrate communities. Apply the HMFEI scoring criteria from Section 6.3.1.1 (Page 4 of Attachment 1). Apply the salamander criteria found in Tables 6 and 7 (Section 6.2.1.1). The presence of reproducing populations of cold water salamanders or cold water fish indicator species (Table 5) indicates that the stream is a Class IIIB PHWH stream. If there is evidence of warm water fish species, reproducing populations of Class II salamanders, and the HMFEI score is ≥7, then assign a Class II PHWH classification. If none of the abovementioned conditions exist, and the HMFEI score is <7, then assign Class I PHWH classification.

Level 3 Assessments consist of identification of vertebrate and benthic macroinvertebrate taxa to the lowest taxonomic level (Figure 19). A Level 3 Analysis is typically necessary in the following circumstances:

- there is reason to question the HMFEI classification results based upon site-specific observations;
- there is evidence of the presence of Class III indicator salamanders, but the data is inconclusive as to whether reproducing populations are present;
- data is necessary to positively differentiate between Class IIIA and Class IIIB PHWH communities; or
- the project DQO's specify the collection of data meeting the Level 3 Assessment protocols.

A Level 3 Assessment consists of the performance of a VES for salamanders (Section 6.2.1.2) and the identification of the macroinvertebrates in the voucher sample to the lowest taxonomic level in order to identify the taxa within the community to determine the appropriate PHWH stream class (Section 6.3.1.2).

For Level 3 Assessments, if there are cold water fish present, or reproducing populations of cold water salamanders, or a macroinvertebrate community with ≥4 cold water indicator taxa meeting the conditions described in Sections 1.1 and 6.3 and Table 8 indicating a Class IIIB biological community, assign the Class IIIB PHWH classification. If there are ≥4

cold water macroinvertebrate taxa and there is evidence of reproducing populations of only Two-Lined or Longtail salamanders present, assign the Class IIIA PHWH classification. If there are <4 cold water macroinvertebrate taxa present, but there are warm water fish (as described in Section 6.1) and/or evidence of reproducing Class II salamanders present (Table 7), assign Class II PHWH classification. If none of these conditions exist, and the HMFEI score is <7 then assign the Class I PHWH classification.

Ohio EPA strongly recommends that a weight-of-evidence approach, combining physical, chemical and biological measurements, be used to classify PHWH streams. Except where in-stream toxicity resulting from water pollution is present, biological evaluations are definite for assigning PHWH classes. Judicious use of the HHEI in conjunction with qualitative biological sampling (rapid assessment tools) and/or detailed biological evaluations will provide the greatest degree of certainty for stream classifications. Users should be aware when designing PHWH survey plans, that the HHEI is based upon metrics designed to minimize the potential of under-classifying Class III PHWH streams. Therefore, by design PHWH categorizations based upon use of HHEI scoring alone may result in over-classification (e.g., indicating that a Class I PHWH stream is a Class II, etc.).

If using a biological assessment to assign an aquatic life use designation for a PHWH stream, then the following criteria must be followed:

7.1 Determination of a Class I PHWH Stream (Ephemeral Flow)

A PHWH stream that lacks any evidence of obligate aquatic vertebrate aquatic life, or has a benthic macroinvertebrate HMFEI score less than 7, has a very high probability of becoming ephemeral. These types of headwater streams represent the highest percentage of all PHWH streams in Ohio [about 45 to 50 % of all headwater streams with watershed area 1.0 mi^2 (259 ha) or less]. Adult salamanders of the genera *Plethodon* and *Ambystoma* may be found in Class I-PHWH stream corridors, but reproduction of indicator species within them is not supported.

7.2 Determination of a Class II PHWH Stream (Warm Water Adapted Community)

A Class II PHWH stream will be identified by the presence of warm water adapted species of vertebrates (either fish or amphibians) **and/or** warm water species of benthic macroinvertebrates that score a HMFEI score of >6 and <20. Lists of warm water vertebrates found in Class II PHWH streams are found in Tables 5, 6, and 7.

7.3 Determination of a Class III PHWH Stream (Cold Water Adapted Community)

A Class III PHWH stream can be identified by the presence of cold water adapted species of fish (Table 5) **and/or** by the presence of reproducing populations of one of the eight species (subspecies) of obligate aquatic salamander species from the genera *Eurycea*, *Pseudotriton*, or *Gyrinophilus* as listed in Tables 6 and 7.

A Class III PHWH stream can also be identified by a detailed taxonomic evaluation of the benthic macroinvertebrate community using the cold water species list found in Attachment

3. The presence of four or more species of cold water benthic invertebrates from this list can be used to assign the Class III PHWH classification to an undesignated stream.

As an alternative to a detailed laboratory identification of cold water macroinvertebrate taxa, the qualitative Headwater Macroinvertebrate Field Evaluation Index (HMFEI) method can be used to assign a classification to a PHWH stream as detailed on Page 4 of the PHWH Form (Attachment 1). Where data regarding the presence of both cold water adapted taxa and HMFEI data are available, the more detailed taxonomic approach to genus-species level of taxonomy will be used to make a final PHWH stream use designation.

Distinction between Class IIIA and Class IIIB biological communities is based upon the presence-absence of cold water adapted vertebrates as well as the characteristics of the macroinvertebrate community. Therefore, a Level 3 Analysis will almost always be necessary to distinguish between these two community types.

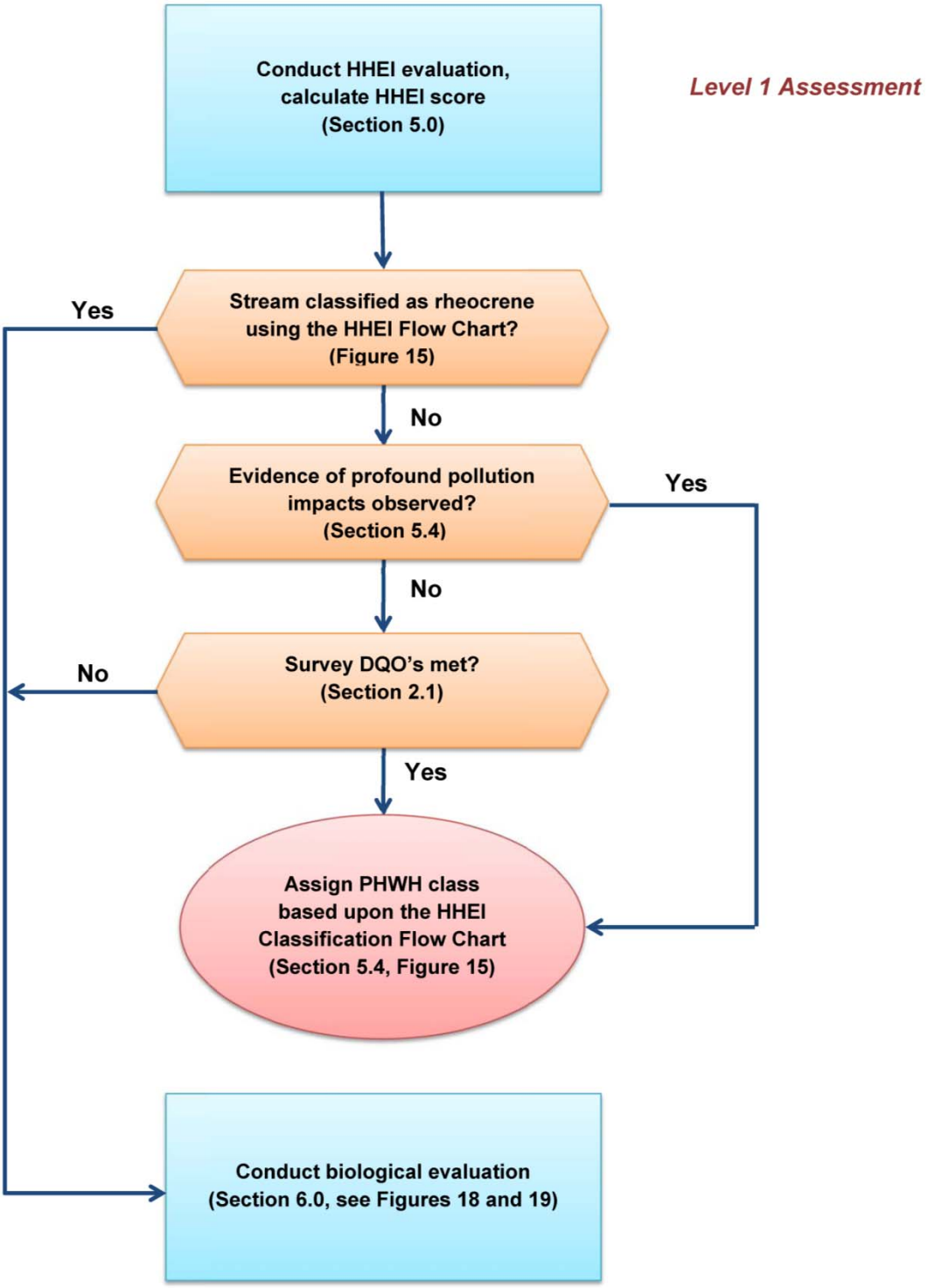


Figure 17. PHWH stream classification flow chart: Level 1 Assessment.

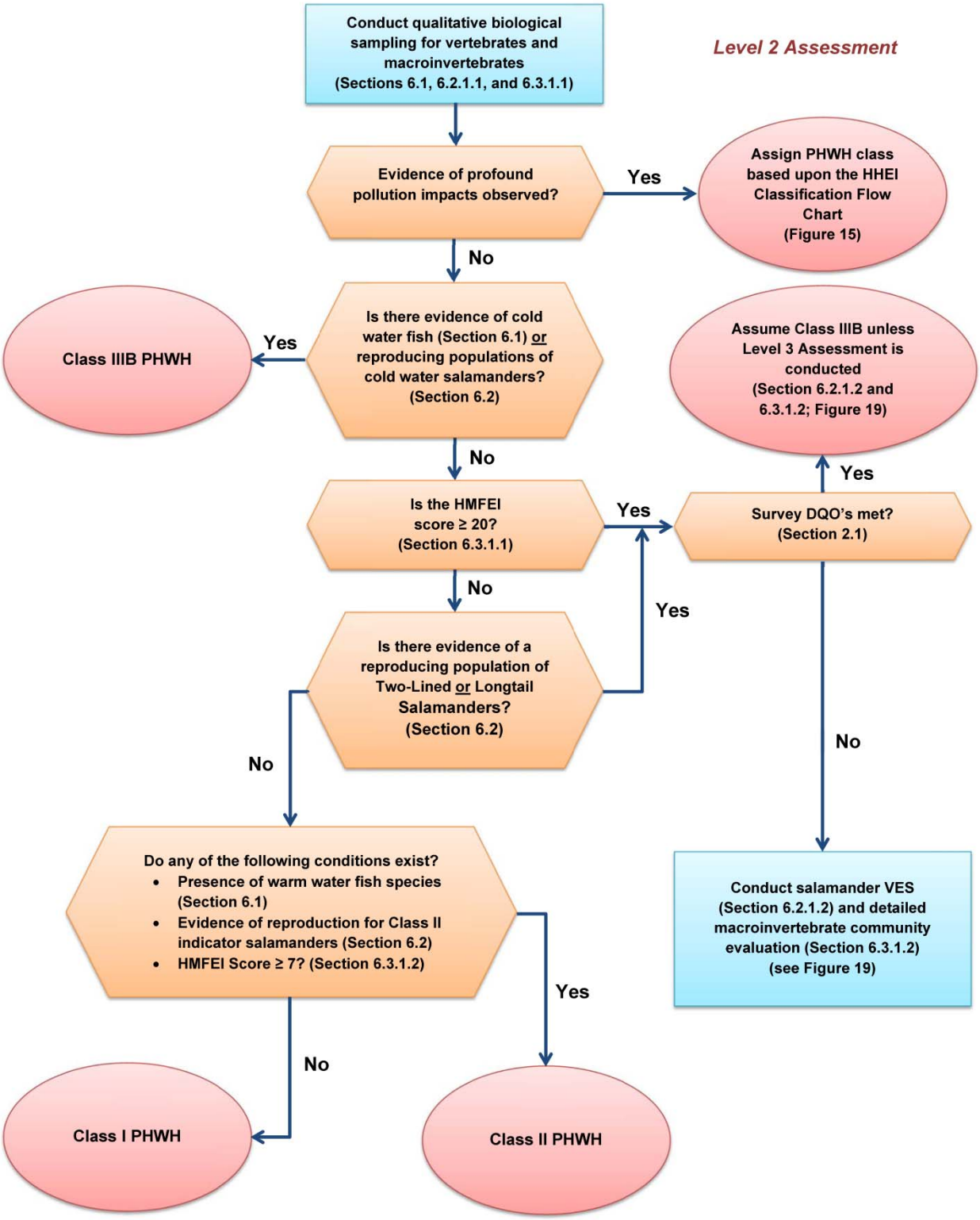


Figure 18. PHWH stream classification flow chart: Level 2 Assessment.

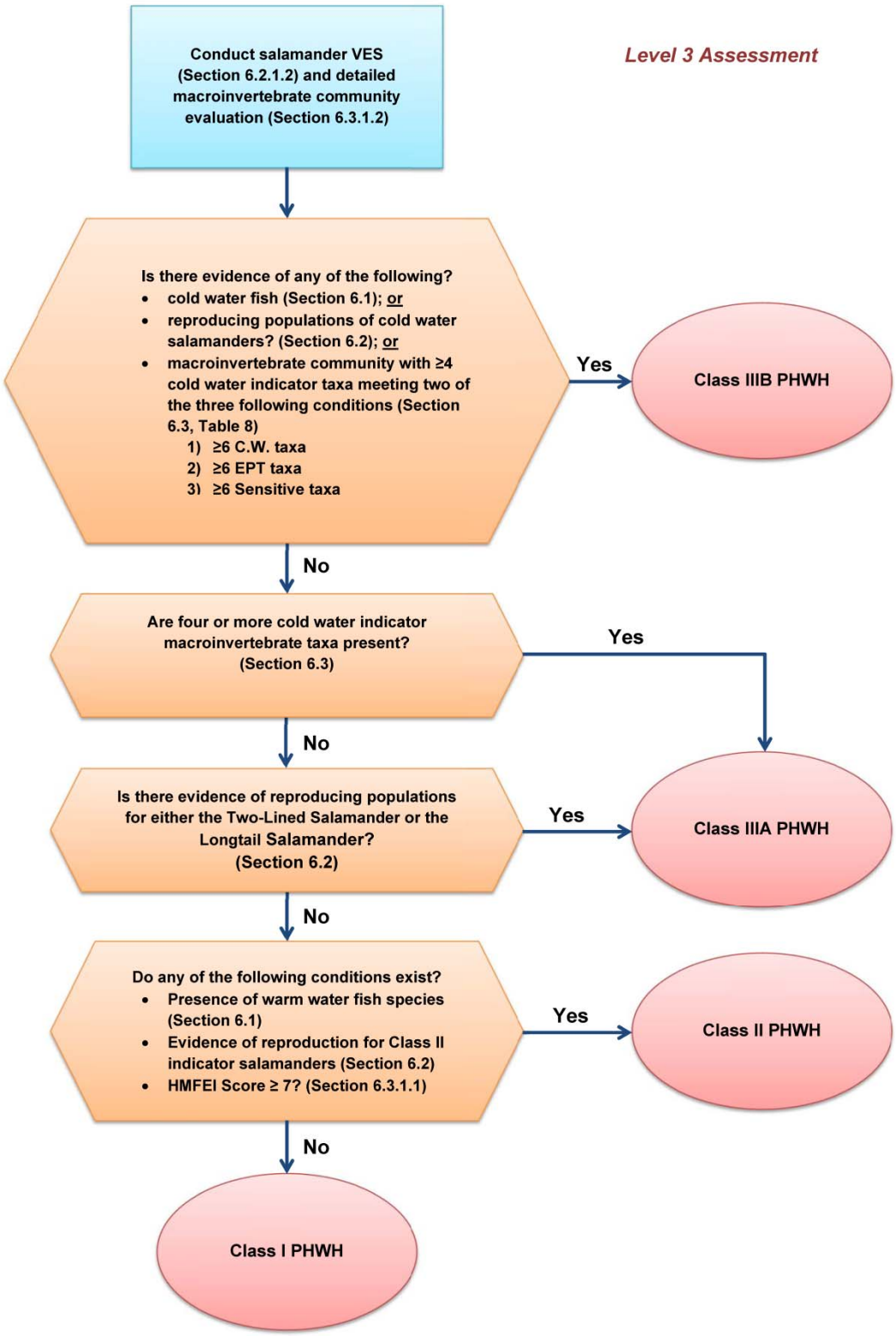


Figure 19. PHWH stream classification flow chart: Level 3 Assessment.

8.0 Recommended Levels of Protection for PHWH Stream Classes

Different types and degrees of aquatic life protection should be given to protect and restore the biological integrity present in the three different classes of PHWH streams in Ohio. The following discussion presents ideas that should be considered when impacts are contemplated or proposed relating to PHWH streams in Ohio. It is recommended that any antidegradation review impacts relating to PHWH streams follow this strategy whenever possible.

> **Note: the recommendations within this section do not constitute a regulatory requirement. Specific statutory and regulatory requirements related to potential stream impacts are found in the Ohio Revised Code, the Ohio Administrative Code and other applicable federal and local laws and regulations.**

Class I PHWH streams, due to their ephemeral nature, can be managed using a non-aquatic life approach that focuses upon the protection of downstream uses related to watershed hydrologic function, such as mitigation of changes related to water energy, sediment retention, flood storage, and riparian function.

Class II PHWH streams represent a moderately diverse assemblage of vertebrates and benthic macroinvertebrates that are well adapted to a spectrum of warm water flow hydrology, similar to the current WWH aquatic life use designation found in OAC Chapter 3745-1. As such, Class II PHWH streams should receive protection identical to larger streams currently designated WWH in OAC Chapter 3745-1.

Class III PHWH streams represent a very unique assemblage of cool-cold water adapted species of fish, and/or salamanders, and/or cold water adapted benthic macroinvertebrates that require flowing water on a year-round basis for the resident species to complete their life cycles. On a statewide basis, Class III PHWH streams are uncommon, representing approximately 16% of all PHWH streams less than 1.0 mi^2 (259 ha) (Table 1). These streams may be more abundant in localized geologic areas of the state associated with groundwater recharge glacial end moraines or similar geologic formations. Class III PHWH streams should receive water quality criteria protection identical to larger streams currently designated Cold Water Habitat in OAC Chapter 3745-1. Given the unique requirements of the aquatic fauna within these streams for perennial flowing cold water, all efforts should be taken to avoid direct impacts to Class III PHWH stream channels and to protect natural riparian and flow hydrology, including groundwater recharge areas. If a Class III PHWH stream must be modified, then a concerted effort should be made to restore the stream channel and flow hydrology back to natural conditions. Periodic biological monitoring should be performed to assess the restoration efforts using techniques described within this manual and compared to baseline data. Mitigation enhancements should be made as necessary to restore the aquatic community to its pre-disturbance condition based upon results of monitoring data. Suitable additional mitigation through preservation of equivalent habitats should also be provided in these situations.

9.0 References

Anderson, P., R. D. Davic, S. Tuckerman. 1999. Primary headwater habitat assessment program field evaluation manual, training version. Ohio EPA, Division of Surface Water, Columbus, Ohio.

Alexander, R. B, E. W. Boyer, R. A. Smith, G. E. Schwarz, and R. B. Moore. The role of headwater streams in downstream water quality. Journal Of The American Water Resources Association 43:41-49

Bevenger, G.S. and R.M. King. 1995. A pebble count procedure for assessing watershed cumulative effects. Research Paper RM-RP-319. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 17 pp. http://www.treesearch.fs.fed.us/pubs/20748
[NOTE: downloadable software available at http://www.stream.fs.fed.us/publications/software.html]

Bouchard, R. W. 2004. Guide to aquatic macroinvertebrates of the Upper Midwest. Water Resources Center, University of Minnesota, St. Paul, Minnesota. 208 pp."

Conant, R., and J. T. Collins. 1991. A field guide to reptiles and amphibians of eastern and central North America, Third Edition. Houghton Mifflin Co., 450 pp.

Davic, R. D. 1996. Standardized field sampling methods for assessing headwater habitat streams in Ohio. Final Draft. Ohio EPA, Division of Surface Water, Northeast District Office, Twinsburg, Ohio.

Dunne T., and L. B. Leopold. 1978. Water in Environmental Planning. W. H. Freeman and Co. 818 pp.

Government of British Columbia. 1998. Fish-stream identification guidebook, Second Edition.

Harding, J. 1997. Amphibians and reptiles of the Great Lakes region. The University of Michigan Press, Ann Arbor, MI.

Heyer, W. R. et.al, 1994. Measuring and monitoring biological diversity-standard methods for amphibians. Smithsonian Institution Press, Washington, DC. 364 pp.

Hulse, A.C., C.J. McCoy, and E. Censky. 2001. Amphibians and reptiles of Pennsylvania and the Northeast. Comstock Publishing Associates, Ithaca, NY. 419 pp.

Kondolf, G. M. and S. Li. 1992. The pebble count technique for quantifying surface bed material size in instream flow studies. Rivers 3:80-87.

Kondolf, G. M. 1995. Discussion: use of pebble counts to evaluate fine sediment increase in stream channels. Water Res. Bull. 31:537-538.

Mack, J. J. 2001. Vegetation index of biotic integrity (VIBI) for wetlands: ecoregional, hydrogeomorphic, and plant community comparisons with preliminary wetland aquatic life use designations. Final report to US EPA Grant No. CD985875-01. Ohio Environmental Protection Agency. Division of Surface Water, Columbus, Ohio.

Merritt R. W., and K. W. Cummins, and M. B. Berg. 2008. An introduction to the aquatic insects of North America, Fouth Edition. Kendall Hunt Pub. Co., Dubuque, Iowa. 1158 pp.

Meyer, J.L. and J.B. Wallace. 2001. Lost linkages and lotic ecology: rediscovering small streams. pp. 295-317. In: M.C. Press, N. Huntly and S. Levin (eds.) Ecology: Achievement and Challenge. Blackwell Science.

Meyer, J. L., D. L. Strayer, J. B. Wallace, S. L. Eggert, G. S. Helfman, and N. E. Leonar. 2007. The contribution of headwater streams to biodiversity in river networks. Journal American Water Resources Association 43:86-103

Micacchion, M. 2002. Amphibian index of biotic intergrity (AmphIBI) for wetlands. Final report to US EPA Grant No. CD985875-01. Ohio Environmental Protection Agency. Wetland Ecology Group, Division of Surface Water, Columbus, Ohio.

Ohio Department of Natural Resources. 2008. Amphibians of Ohio Field Guide. ODNR Division of Wildlife Publication 348 (308). Columbus, Ohio. 47 pp.
http://ohiodnr.com/tabid/20293/Default.aspx

Ohio Environmental Protection Agency, 1989. Biological criteria for the protection of aquatic life, Vol. III: Standardized biological field sampling and laboratory methods for assessing fish and macro invertebrate communities. Ohio EPA Division of Surface Water, Columbus, Ohio.
http://www.epa.ohio.gov/dsw/bioassess/BioCriteriaProtAqLife.aspx

_____. 2002 a. Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams. Final Ver. 1.0. Ohio EPA Division of Surface Water, Columbus, Ohio. 60 pp.

_____. 2002 b. Ohio EPA Primary Headwater Habitat Initiative Data Compendium, 1999-2000 Habitat, Chemistry, and Stream Morphology Data. Ohio EPA Division of Surface Water, Columbus, Ohio. 84 pp.
http://www.epa.ohio.gov/portals/35/wqs/headwaters/PHWH_Compendium.pdf

_____. 2002 c. Technical Report: Ohio's Primary Headwater Streams-Fish and Amphibian Assemblages. Ohio EPA Division of Surface Water, Columbus, Ohio. 41 pp.
http://www.epa.ohio.gov/portals/35/wqs/headwaters/TechRep_FishAmphibian_2002.pdf

_____. 2002 d. Technical Report: Ohio's Primary Headwater Streams-Macroinvertebrate Assemblages. Ohio EPA Division of Surface Water, Columbus, Ohio. 25 pp.
http://www.epa.ohio.gov/portals/35/wqs/headwaters/TechRep_Macroinvert_2002.pdf

_____. 2003. Fact Sheet: the importance and benefits of primary headwater streams. Ohio EPA Division of Surface Water, Columbus, Ohio.
http://www.epa.ohio.gov/portals/35/wqs/headwaters/HWH_import_jan2003.pdf

_____. 2006. 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

_____. 2008 a. Updates to Biological Criteria for the Protection of Aquatic Life: Volume III. Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities. 11 pp.
http://www.epa.ohio.gov/portals/35/documents/BioCrit88_Vol3Updates2008.pdf

_____. 2008 b. 2008 Updates to Biological Criteria for the Protection of Aquatic Life: Volume II and Volume II Addendum. Users Manual for Biological Field Assessment of Ohio Surface Waters. Ohio EPA Division of Surface Water. Columbus, Ohio 14 pp.
http://www.epa.ohio.gov/portals/35/documents/BioCrit88_Vol2Updates2008.pdf

_____. 2009 a. Field Evaluation Manual for Ohio's Primary Headwater Habitat Streams. Version 2.3. Ohio EPA Division of Surface Water, Columbus, Ohio. 86 pp.

_____. 2009 b. Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices. Ohio EPA Division of Surface Water, Columbus, Ohio. 60 pp.
http://www.epa.ohio.gov/portals/35/documents/Field_Manual_1-9-09_revision.pdf

_____. 2010. Ohio 2010 Integrated Water Quality Monitoring and Assessment Report. Ohio EPA Division of Surface Water, Columbus, Ohio.
http://www.epa.ohio.gov/dsw/tmdl/2010IntReport/2010OhioIntegratedReport.aspx

Ohio State University. 2001. Headwater rapid assessment study. Report prepared for Ohio EPA, Division of Surface Water by Statistical Consulting Service, Department of Statistics, The Ohio State University, Columbus, Ohio.

Palmer, W.C. 1965. Meteorological drought. *Research Paper No. 45*. U.S. Weather Bureau. [NOAA Library and Information Services Division, Washington, D.C. 20852]

Peterson, B,J., W. M. Wollheim, P.J. Mulholland, J.R. Webster, J.L. Meyer, J.L. Tank, E. Martí, W.B. Bowden, H.M. Valett, A.E. Hershey, W.H. McDowell, W.K. Dodds, S.K. Hamilton, S. Gregory, and D.D. Morrall. 2001. Control of Nitrogen Export from Watersheds by Headwater Streams. Science 292:86-90.

Petranka., J. W. 1998. Salamanders of United States and Canada. Smithsonian Institution Press, Washington, DC. 587 pp.

Pfingsten, R. A. 1998. Distribution of Ohio amphibians. *in*, M. J. Lannoo, editor. Status and conservation of midwestern amphibians. University of Iowa Press. 507 pp.

Pfingsten, R. A. and F. Downs, eds. 1989. Salamanders of Ohio. Ohio Biol. Surv. Bull. New Series Vol 7 No. 2. 315 pp.

Pfingsten, R. A. and T. O. Matson. 2003. Ohio Salamander Atlas. Ohio Biological Survey, Columbus, Ohio. 32 pp.

Rankin, E. 1989. The qualitative habitat evaluation index (QHEI): Rational, methods, and applications. Ohio EPA, Division of Surface Water, Columbus, Ohio.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rocco, G. L., and R. P. Brooks. 2000. Abundance and distribution of a stream plethodontid salamander assemblage in 14 ecologically dissimilar watersheds in the Pennsylvania central Appalachians. Penn State Cooperative Wetlands Center, Forest Resources Laboratory. Report No. 2000-4, prepared for: U.S. EPA, Region III.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado. 343 pp.

Smith, D. G. 2001. Pennak's Freshwater Invertebrates of the United States, Porifera to Crustacea. Fourth Edition. John Wiley and Sons, New York, New York. 638 pp.

Straub, D. E. 2001. Low-flow characteristics of streams in Ohio through Water Year 1997. Water-Resources Investigations Report 01-4140. United States Geologic Survey, Columbus, OH. 415 pp. http://oh.water.usgs.gov/reports/Abstracts/wrir01-4140.html.

Trautman, M. B. 1981. The fishes of Ohio. Ohio State University Press. Columbus, Ohio. 782 pp.

United States Environmental Protection Agency, 1989. Rapid bioassessment protocols for use in streams and rivers. EPA/444/4-89-001.

United States Geological Survey. 2001. Low-flow characteristics of streams in Ohio through water year 1997. Water-Resources Investigations Report 01-4140. USGS, Columbus, Ohio. 415 pp. http://oh.water.usgs.gov/reports/Abstracts/wrir01-4140.html

United States Fish and Wildlife Service. 1981. Standards for the development of habitat suitability index models for use in the Habitat Evaluation Procedures. USDI Fish and Wildlife Service. Division of Ecological Services. ESM 103.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C. E. Cushing. The river continuum concept. Can. J. Fish. And Aq. Sci. 37:130-137.

Voshell, J. R. Jr. 2002. A Guide to Common Freshwater Invertebrates of North America. McDonald and Woodward Publishing Co., Blacksburg, VA. 442 pp.

Wipfli, M. 2005. Rophic linkages between headwater forests and downstream fish habitats: implications for forest and fish management. Landscape and Urban Planning 72:205-213.

Wolman, M. G. 1954. A method for sampling coarse river-bed material. Trans. Amer. Geophysical Journal 35:951-956.

THIS PAGE INTENTIONALLY LEFT BLANK

Attachment 1

The Ohio EPA Primary Headwater Habitat Evaluation Form

(PHWH Form)

Note: An automated adobe acrobat evaluation form can be downloaded at the following URLs:

HHEI form:

http://www.epa.ohio.gov/portals/35/wqs/headwaters/HHEI_Form_Clickable_10-02.pdf

Biological Assessment:

http://www.epa.ohio.gov/portals/35/wqs/headwaters/PHWH_Biology_Forms_Clickable_4-03.pdf

Primary Headwater Habitat Evaluation Form

HHEI Score (sum of metrics 1, 2, 3) : ☐

SITE NAME/LOCATION _____

_____SITE NUMBER_____ RIVER BASIN _____ DRAINAGE AREA (mi^2) _____

LENGTH OF STREAM REACH (ft) _____ LAT. _____ LONG. _____ RIVER CODE _____ RIVER MILE _____

DATE _____ SCORER _____ COMMENTS _____

NOTE: Complete All Items On This Form - Refer to "Field Evaluation Manual for Ohio's PHWH Streams" for Instructions

STREAM CHANNEL MODIFICATIONS: ☐ NONE / NATURAL CHANNEL ☐ RECOVERED ☐ RECOVERING ☐ RECENT OR NO RECOVERY

HHEI Metric Points

1. **SUBSTRATE (Estimate percent of every type of substrate present.** Check *ONLY* two predominant substrate *TYPE* boxes (Max of 40). Add total number of significant substrate types found (Max of 8). Final metric score is sum of boxes A & B.

TYPE		PERCENT	TYPE		PERCENT
☐ ☐	BLDR SLABS **[16 pts]**	_____	☐ ☐	SILT **[3 pt]**	_____
☐ ☐	BOULDER (>256 mm) **[16 pts]**	_____	☐ ☐	LEAF PACK/WOODY DEBRIS **[3 pts]**	_____
☐ ☐	BEDROCK **[16 pt]**	_____	☐ ☐	FINE DETRITUS **[3 pts]**	_____
☐ ☐	COBBLE (65-256 mm) **[12 pts]**	_____	☐ ☐	CLAY or HARDPAN **[0 pt]**	_____
☐ ☐	GRAVEL (2-64 mm) **[9 pts]**	_____	☐ ☐	MUCK **[0 pts]**	_____
☐ ☐	SAND (<2 mm) **[6 pts]**	_____	☐ ☐	ARTIFICIAL **[3 pts]**	_____

Total of Percentages of Bldr Slabs, Boulder, Cobble, Bedrock _____ **(A)** ☐ **(B)** ☐

SCORE OF TWO MOST PREDOMINATE SUBSTRATE TYPES: **TOTAL NUMBER OF SUBSTRATE TYPES:**

Substrate Max = 40 ☐

A + B

2. **Maximum Pool Depth** ***(Measure the maximum pool depth within the 61 meter (200 ft)*** evaluation reach at the time of evaluation. Avoid plunge pools from road culverts or storm water pipes) (Check *ONLY* one box):

☐ > 30 centimeters **[20 pts]**
☐ > 22.5 - 30 cm **[30 pts]**
☐ > 10 - 22.5 cm **[25 pts]**
☐ > 5 cm - 10 cm **[15 pts]**
☐ < 5 cm **[5 pts]**
☐ NO WATER OR MOIST CHANNEL **[0 pts]**

COMMENTS_____ **MAXIMUM POOL DEPTH (centimeters):** ☐

Pool Depth Max = 30 ☐

3. **BANK FULL WIDTH (Measured as the average of 3-4 measurements)** **(Check *ONLY* one box):**

☐ > 4.0 meters (> 13') **[30 pts]**
☐ > 3.0 m - 4.0 m (> 9' 7" - 13') **[25 pts]**
☐ > 1.5 m - 3.0 m (> 4' 8" - 9' 7") **[20 pts]**
☐ > 1.0 m - 1.5 m (> 3' 3" - 4' 8") **[15 pts]**
☐ ≤ 1.0 m (≤ 3' 3") **[5 pts]**

COMMENTS_____ **AVERAGE BANKFULL WIDTH (meters)** ☐

Bankfull Width Max=30 ☐

This information must also be completed

RIPARIAN ZONE AND FLOODPLAIN QUALITY ☆NOTE: River Left (L) and Right (R) as looking downstream☆

L R	RIPARIAN WIDTH (Per Bank)	L R	FLOODPLAIN QUALITY (Most Predominant per Bank)	L R	
☐ ☐	Wide >10m	☐ ☐	Mature Forest, Wetland	☐ ☐	Conservation Tillage
☐ ☐	Moderate 5-10m	☐ ☐	Immature Forest, Shrub or Old Field	☐ ☐	Urban or Industrial
☐ ☐	Narrow <5m	☐ ☐	Residential, Park, New Field	☐ ☐	Open Pasture, Row Crop
☐ ☐	None	☐ ☐	Fenced Pasture	☐ ☐	Mining or Construction

COMMENTS_____

FLOW REGIME *(At Time of Evaluation)* (Check *ONLY* one box):

☐ Stream Flowing
☐ Subsurface flow with isolated pools (Interstitial)
☐ Moist Channel, isolated pools, no flow (Intermittent)
☐ Dry channel, no water (Ephemeral)

COMMENTS_____

SINUOSITY (Number of bends per 61 m (200 ft) of channel) (Check *ONLY* one box):

☐ None ☐ 1.0 ☐ 2.0 ☐ 3.0
☐ 0.5 ☐ 1.5 ☐ 2.5 ☐ >3

STREAM GRADIENT ESTIMATE

☐ Flat (0.5 ft/100 ft) ☐ Flat to Moderate ☐ Moderate (2 ft/100 ft) ☐ Moderate to Severe ☐ Severe (10 ft/100 ft)

ADDITIONAL STREAM INFORMATION (This Information Must Also be Completed):

QHEI PERFORMED? - ❒ Yes ❒ No QHEI Score _____ (If Yes, Attach Completed QHEI Form)

DOWNSTREAM DESIGNATED USE(S)

❒ WWH Name: _____ Distance from Evaluated Stream _____

❒ CWH Name: _____ Distance from Evaluated Stream _____

❒ EWH Name: _____ Distance from Evaluated Stream _____

MAPPING: ATTACH COPIES OF MAPS, INCLUDING THE ENTIRE WATERSHED AREA. CLEARLY MARK THE SITE LOCATION

USGS Quadrangle Name:_____ NRCS Soil Map Page:_____ NRCS Soil Map Stream Order _____

County: _____ Township / City:_____

MISCELLANEOUS

Base Flow Conditions? (Y/N):_____ Date of last precipitation:_____ Quantity:_____

Photograph Information: _____

Elevated Turbidity? (Y/N): _____ Canopy (% open): _____

Were samples collected for water chemistry? (Y/N): _____ (Note lab sample no. or id. and attach results) Lab Number:_____

Field Measures: Temp (°C)_____ Dissolved Oxygen (mg/l) _____ pH (S.U.) _____ Conductivity (µmhos/cm) _____

Is the sampling reach representative of the stream (Y/N)_____ If not, please explain:_____

_____

Additional comments/description of pollution impacts:_____

_____

BIOTIC EVALUATION

Performed? (Y/N): _____ (If Yes, Record all observations. Voucher collections optional. NOTE: all voucher samples must be labeled with the site ID number. Include appropriate field data sheets from the Primary Headwater Habitat Assessment Manual)

Fish Observed? (Y/N)_____ Voucher? (Y/N)_____ Salamanders Observed? (Y/N)_____ Voucher? (Y/N)_____
Frogs or Tadpoles Observed? (Y/N)____ Voucher? (Y/N)____ Aquatic Macroinvertebrates Observed? (Y/N)____ Voucher? (Y/N)____

Comments Regarding Biology:_____

_____

_____

DRAWING AND NARRATIVE DESCRIPTION OF STREAM REACH (This must be completed):

Include important landmarks and other features of interest for site evaluation and a narrative description of the stream's location

FLOW ➜

PHWH STREAM BIOLOGICAL CHARACTERISTICS FIELD SHEET:

1. Fish: **Voucher Specimens Retained? (circle) Y / N** **Time Spent (minutes):_____**
Sample Method _____ Stream Length Assessed (meters) _____

Species	Number Caught	Notes

2. Salamanders: **Voucher Specimens Retained? (circle) Y / N** **Time Spent (minutes):_____**
Sample Method _____ Stream Length Assessed (meters) _____

Species *(Genus)*	# Larvae	# Juveniles/Adults	Total Number
Mountain Dusky (*Desmognathus ochrophaeus*)			
Northern Dusky (*Desmognathus fuscus*)			
Two-lined (*Eurycea bislineata*)			
Long-tailed (*Eurycea longicauda*)			
Cave (*Eurycea lucifuga*)			
Red (*Pseudotriton ruber*)			
Mud (*Pseudotriton montanus*)			
Spring (*Gyrinophilus porphyriticus*)			
Mole spp. (*Ambystoma spp.*)			
Four-toed (*Hemidactylium scutatum*)			
Other (name)			
Total			

Notes on Vertebrates: _____

3. Macroinvertebrate Scoring Sheet:

THE HEADWATER MACROINVERTEBRATE FIELD EVALUATION INDEX (HMFEI) SCORING SHEET

Indicate Abundance of Each Taxa Above each White Box.

Record HMFEI Scoring Value Points Within each Box.

For EPT taxa, also indicate the different taxa present.

Key: V = Very Abundant (> 50); **A** = Abundant (10 -50); **C** = Common (3 -9); **R** = Rare (< 3)

Sessile Animals (**Porifera, Cnidaria, Bryozoa**) (HMFEI pts = 1)	Crayfish (**Decapoda**) (HMFEI pts = 2)	Fishfly Larvae (**Corydalidae**) (HMFEI pts = 3)
Aquatic Worms (**Turbellaria, Oligochaeta, Hirudinea**) (HMFEI pts = 1)	Dragonfly Nymphs (**Anisoptera**) (HMFEI pts = 2)	Water Penny Beetles (**Psephenidae**) (HMFEI pts = 3)
Sow Bugs (**Isopoda**) (HMFEI pts = 1)	Riffle Beetles (**Dryopidae, Elimidae, Ptilodactylidae**) (HMFEI pts = 2)	Cranefly Larvae (**Tipulidae**) (HMFEI pts = 3)
Scuds (**Amphipoda**) (HMFEI pts = 1)	Larvae of other Flies (**Diptera**) Name: (HMFEI pts = 1)	**EPT TAXA*** Total No. EPT Taxa = _____
Water Mites (**Hydracarina**) (HMFEI pts = 1)	Midges (**Chironomidae**) (HMFEI pts = 1)	Mayfly Nymphs (**Ephemeroptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3]
Damselfly Nymphs (**Zygoptera**) (HMFEI pts = 1)	Snails (**Gastropoda**) (HMFEI pts = 1)	
Alderfly Larvae (**Sialidae**) (HMFEI pts = 1)	Clams (**Bivalvia**) (HMFEI pts = 1)	Stonefly Nymphs (**Plecoptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3]
Other Beetles (**Coleoptera**) (HMFEI pts = 1)	Other Taxa :	
Other Taxa:	Other Taxa:	Caddisfly Larvae (**Trichoptera**) Taxa Present: [HMFEI pts = No. Taxa (x) 3]
Other Taxa:	Other Taxa	

*Note: EPT identification based upon Family or Genus level of taxonomy

Voucher Sample ID_____ Time Spent (minutes):_____

Notes on Macroinvertebrates: (Predominant Organisms; Other Common Organisms; Diversity Estimate)

_____

_____

_____

Final HMFEI Calculated Score (Sum of All White Box Scores) =

IF Final HMFEI Score is > 19, Then CLASS III PHWH STREAM
IF Final HMFEI Score is 7 to 19, Then CLASS II PHWH STREAM
IF Final HMFEI Score is < 7, Then CLASS I PHWH STREAM

Attachment 2

Field Check List for Primary Headwater Stream Sampling

Physical-Chemical Sampling:

Attachment 1 PHWH field data form from HWH manual with clip board, pencil
100 foot tape measure, cloth
Ruler (in cm)
3 color flag markers (to mark ends and mid-point of sample zone)
30 ft of string to measure bankfull width, with two metal stakes
Bubble type carpenter's line level or carpenter's laser level
Stop watch
Camera
Clip board, pencils
Carry bag
Guarded thermometer or field meter(s) [temperature, dissolved oxygen, pH, conductivity]
Containers for potential water samples for nutrients, coliform bacteria, and/or metals
Mosquito repellant
Optional: GPS unit for lat./long.

Biological Sampling:

Hip waders or chest waders (knee boots not recommended)
Fine mesh kick net for invertebrate sampling
White sorting pans (2)
Fine tip forceps
Specimen jars: 70% alcohol for invertebrates, and formalin solution for fish voucher samples
Large tea strainer or fine mesh small handle invertebrate net for salamanders
Hard plastic container with air holes in lid for salamander collection
Heavy duty plastic bags (4) for transport of salamanders to lab
Small cooler with ice or block ice for salamander transport and water samples
Marker flags (2) to mark ends of sample zone
30 foot line to measure length of salamander sample zones
10 foot fish seine
Optional: High intensity head lamp

THIS PAGE INTENTIONALLY LEFT BLANK

Attachment 3. List of cold water indicator (Table 7-2 of OAC 3745-1-07) and sensitive (pollution intolerant) macroinvertebrate taxa used to classify Class III PHWH streams.

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Phylum Ectoprocta				(Bryozoa, Moss Animals)
Lophopodidae				
	Lophopodella carteri		X	
Paludicellidae				
	Paludicella articulata		X	
Plumatellidae				
	Hyalinella punctata		X	
Phylum Entoprocta				(Banded Moss Animals)
Barentsiidae				
	Urnatella gracilis		X	
Phylum Arthropoda				
Class Crustacea				
Order Amphipoda				(Scuds, Amphipods)
Gammaridae				
	Gammarus minus	X		
Order Decapoda				
Cambaridae				(Crayfish)
	Cambarus (Cambarus) sciotensis		X	
Class Insecta				(Insects)
Order Ephemeroptera				(Mayflies)
Ameletidae				(Ameletid Minnow Mayflies)
	Ameletus sp.	X	X	
Baetidae				(Small Minnow Mayflies)
	Acentrella sp.		X	
	Acentrella nadineae		X	
	Acentrella turbida		X	
	Acerpenna sp.		X	
	Acerpenna macdunnoughi		X	
	Acerpenna pygmaea		X	
	Plauditus sp.		X	
	Acentrella parvula		X	
	Baetis brunneicolor	X		
	Baetis tricaudatus	X	X	
	Iswaeon anoka		X	
	Labiobaetis sp.		X	
	Labiobaetis dardanum		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Baetidae (cont)				
	Labiobaetis frondale		X	
	Labiobaetis propinquum		X	
	Plauditus cestus		X	
	Plauditus dubius		X	
	Plauditus dubius or P. virilis		X	
	Plauditus gloveri		X	
	Plauditus virilis		X	
	Centroptilum sp. (w/o hindwing pads)		X	
	Procloeon sp (formerly in Centroptilum)		X	
	Diphetor hageni		X	
	Heterocloeon (H.) sp.		X	
	Paracloeodes sp.		X	
	Paracloeodes fleeki		X	
	Paracloeodes minutus		X	
	Procloeon sp.		X	
	Procloeon sp. (w/ hindwing pads)		X	
	Procloeon sp. (w/o hindwing pads)		X	
	Procloeon viridoculare		X	
	Acentrella sp. or Plauditus sp. (formerly in Pseudocloeon)		X	
Isonychiidae				(Brushlegged Mayflies)
	Isonychia sp.		X	
Heptageniidae				(Flatheaded Mayflies)
	Epeorus sp.	X	X	
	Heptagenia flavescens		X	
	Heptagenia marginalis		X	
	Leucrocuta sp.		X	
	Leucrocuta hebe		X	
	Leucrocuta maculipennis		X	
	Nixe sp.		X	
	Nixe inconspicua		X	
	Nixe perfida		X	
	Rhithrogena manifesta		X	
	Maccaffertium sp.		X	
	Maccaffertium exiguum		X	
	Maccaffertium ithaca	X	X	
	Maccaffertium mediopunctatum		X	
	Maccaffertium mexicanum integrum		X	
	Maccaffertium modestum	X	X	
	Maccaffertium pulchellum group		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Heptageniidae (cont)				
	Maccaffertium pulchellum		X	
	Maccaffertium terminatum		X	
	Maccaffertium vicarium		X	
Leptophlebiidae				(Pronggilled Mayflies)
	Choroterpes sp.		X	
	Habrophlebia vibrans	X	X	
	Habrophlebiodes sp.	X	X	
Ephemerellidae				(Spiny Crawler Mayflies)
	Ephemerellidae		X	
	Dannella simplex	X	X	
	Eurylophella sp.		X	
	Teloganopsis sp.		X	
	Teloganopsis deficiens		X	
Tricorythidae				(Little Stout Crawler Mayflies)
	Tricorythodes sp.		X	
Caenidae				(Small Squaregill Mayflies)
	Sparbarus sp.		X	
	Sparbarus lacustris		X	
Baetiscidae				(Armored Mayflies)
	Baetisca sp.		X	
	Baetisca lacustris		X	
Potamanthidae				(Hacklegill Mayflies)
	Anthopotamus sp.		X	
Ephemeridae				(Common Burrower Mayflies)
	Ephemera sp.		X	
	Ephemera simulans		X	
	Ephemera varia		X	
	Litobrancha recurvata	X	X	
Polymitarcyidae				(Pale Burrower Mayflies)
	Ephoron sp.		X	
	Ephoron album		X	
	Ephoron leukon		X	
Order Odonata				
Anisoptera				(Dragonflies)
Aeshnidae				(Darner Dragonflies)
	Boyeria grafiana	X	X	
Gomphidae				(Clubtail Dragonflies)
	Gomphurus sp.		X	
	Gomphurus externus		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Gomphidae (cont)				(Clubtail Dragonflies)
	Lanthus sp.	X	X	
	Lanthus parvulus	X	X	
	Ophiogomphus sp.		X	
	Ophiogomphus rupinsulensis		X	
	Ophiogomphus carolus		X	
	Stylogomphus albistylus		X	
	Stylurus sp.		X	
	Stylurus notatus		X	
	Stylurus spiniceps		X	
Corduliidae				(Emerald Dragonflies)
	Neurocordulia obsoleta		X	
	Neurocordulia yamaskanensis		X	
Macromiidae				(River and Stream Cruiser Dragonflies)
	Macromia sp.		X	
Order Plecoptera				(Stoneflies)
Pteronarcyidae				(Giant Stoneflies)
	Pteronarcys sp.		X	
	Pteronarcys biloba		X	
Peltoperlidae				(Roachlike Stoneflies)
	Peltoperla sp.	X	X	
Nemouridae				(Nemourid Stoneflies)
	Amphinemura sp.	X	X	
	Ostrocerca sp.		X	
	Prostoia sp.		X	
	Soyedina sp.	X	X	
Leuctridae				(Rolledwinged Stoneflies)
	Leuctra sp.	X	X	
	Paraleuctra sp.		X	
Perlidae				(Common Stoneflies)
	Acroneuria sp.		X	
	Acroneuria abnormis		X	
	Acroneuria carolinensis		X	
	Acroneuria frisoni		X	
	Acroneuria internata		X	
	Acroneuria lycorias		X	
	Eccoptura xanthenes	X	X	
	Neoperla clymene complex		X	
	Paragnetina sp.		X	
	Paragnetina media		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Perlidae (cont)				(Common Stoneflies)
	Perlinella sp.		X	
	Perlinella drymo		X	
	Agnetina capitata complex		X	
	Agnetina capitata		X	
	Agnetina flavescens		X	
Perlodidae				(Perlodid Stoneflies)
	Clioperla clio		X	
	Cultus sp.		X	
	Cultus decisus complex		X	
	Diploperla sp.		X	
	Diploperla robusta		X	
	Isoperla sp.		X	
	Isoperla namata		X	
	Isoperla similis		X	
	Isoperla transmarina		X	
	Malirekus iroquois		X	
Chloroperlidae				(Green Stoneflies)
	Alloperla sp.		X	
	Haploperla brevis	X	X	
	Sweltsa sp.	X	X	
Order Megaloptera				(Dobsonflies, Hellgrammites)
Corydalidae				
	Corydalus cornutus		X	
	Nigronia fasciatus	X	X	
Order Trichoptera				(Caddisflies)
Philopotamidae				(Fingernet Caddisflies)
	Chimarra sp.		X	
	Chimarra aterrima		X	
	Chimarra obscura		X	
	Chimarra socia		X	
	Dolophilodes sp.	X	X	
	Dolophilodes distinctus	X	X	
	Wormaldia sp.	X	X	
	Wormaldia moesta	X	X	
	Wormaldia shawnee	X	X	
Psychomyiidae				(Tube-making Caddisflies)
	Lype diversa		X	
	Psychomyia flavida		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Polycentropodidae			(Trumpet-net	Caddisflies)
	poss. Cernotina sp. or Polycentropus sp.		X	
	Neureclipsis sp.		X	
	Nyctiophylax sp.		X	
	Polycentropus sp.		X	
Hydropsychidae			(Common Netspinner Caddisflies)	
	Diplectrona sp.	X		
	Diplectrona metaqui	X	X	
	Diplectrona modesta	X		
	Ceratopsyche sp.		X	
	Ceratopsyche morosa group		X	
	Ceratopsyche morosa		X	
	Ceratopsyche slossonae	X	X	
	Ceratopsyche ventura	X	X	
	Hydropsyche aerata		X	
	Hydropsyche bidens		X	
	Hydropsyche bidens or H. orris		X	
	Hydropsyche dicantha		X	
	Hydropsyche frisoni		X	
	Hydropsyche hageni		X	
	Hydropsyche orris		X	
	Hydropsyche simulans		X	
	Hydropsyche valanis		X	
	Hydropsyche venularis		X	
	Macrostemum sp.		X	
	Macrostemum zebratum		X	
Hydropsychidae (cont)				
	Parapsyche sp.	X	X	
	Parapsyche apicalis	X	X	
	Potamyia flava		X	
Rhyacophilidae			(Primitive, Free-living Caddisflies)	
	Rhyacophila sp. (excluding R. lobifera)	X	X	
	Rhyacophila minor	X	X	
	Rhyacophila carolina	X	X	
	Rhyacophila fenestra or R. ledra	X	X	
	Rhyacophila glaberrima	X	X	
	Rhyacophila torva	X	X	
	Rhyacophila invaria complex	X	X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Glossosomatidae				(Saddlecase Maker Caddisflies)
	Agapetus sp.	X	X	
	Glossosoma sp.	X	X	
	Protoptila sp.		X	
Hydroptilidae				(Micro Caddisflies)
	Leucotrichia pictipes		X	
	Mayatrichia ayama		X	
	Ochrotrichia sp.		X	
	Ochrotrichia confusa group		X	
	Stactobiella sp.		X	
Phyrganeidae				(Giant Case Maker Caddisflies)
	Oligostomis sp.	X		
Brachycentridae				(Humpless Case Maker Caddisflies)
	Brachycentrus sp.		X	
	Brachycentrus numerosus		X	
Goeridae				
	Goera sp.	X	X	
	Goera stylata	X	X	
Limnephilidae				(Northern Case Maker Caddisflies)
	Frenesia sp.	X	X	
	Hydatophylax sp.		X	
	Hydatophylax argus		X	
	Limnephilus sp.		X	
	Pycnopsyche sp.		X	
Uenoidae				(Uenoid Case Maker Caddisflies)
	Neophylax sp.		X	
Lepidostomatidae				(Lepidostomid Case Maker Caddisflies)
	Lepidostoma sp.	X	X	
Odontoceridae				(Strongcase Maker Caddisflies)
	Psilotreta indecisa	X	X	
	Psilotreta rufa	X	X	
Molannidae				
	Molanna sp.	X	X	
Helicopsychidae				(Snailcase Maker Caddisflies)
	Helicopsyche borealis		X	
Leptoceridae				(Longhorned Case Maker Caddisflies)
	Ceraclea sp.		X	
	Ceraclea ancylus		X	
	Ceraclea flava complex		X	
	Ceraclea maculata		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Leptoceridae (cont)				(Longhorned Case Maker Caddisflies)
	Ceraclea spongillovorax		X	
	Mystacides sp.		X	
	Mystacides sepulchralis		X	
	Nectopsyche sp.		X	
	Nectopsyche candida		X	
	Nectopsyche diarina		X	
	Nectopsyche exquisita		X	
	Nectopsyche pavida		X	
	Oecetis avara		X	
	Oecetis persimilis		X	
	Triaenodes sp.		X	
	Triaenodes ignitus		X	
	Triaenodes injustus		X	
	Triaenodes melaca		X	
	Triaenodes perna		X	
Order Lepidoptera				(Butterflies and Moths)
Crambidae				(Aquatic Moths)
	Parapoynx sp.		X	
	Petrophila sp.		X	
Order Coleoptera				(Beetles)
Psephenidae				(Water Pennies)
	Psephenus herricki		X	
Elmidae				(Riffle Beetles)
	Microcylloepus pusillus		X	
	Optioservus sp.		X	
	Optioservus ampliatus		X	
	Optioservus fastiditus		X	
	Optioservus trivittatus		X	
Ptilodactylidae				(Toe-winged Beetles)
	Anchytarsus sp.		X	
Lutrochidae				(Travertine Beetles)
	Lutrochus laticeps		X	
Order Diptera				(True Flies)
Tanyderidae				(Primitive Crane Flies)
	Protoplasa fitchii		X	
Tipulidae				(Crane Flies)
	Antocha sp.		X	
	Dicranota sp.	X	X	
	Hexatoma sp.		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Tipulidae (cont)				(Crane Flies)
	Hexatoma cinerea		X	
	Limnophila sp.		X	
	Molophilus sp.		X	
	Pedicia sp.	X		
	Pseudolimnophila sp.		X	
Psychodidae				(Moth Flies/Sand Flies)
	Pericoma albitarsis		X	
Ptychopteridae				(Phantom Crane Flies)
	Ptychoptera sp.		X	
Thaumaleidae				(Solitary Midges)
	Thaumalea americana	X	X	
Simuliidae				(Black Flies)
	Prosimulium sp.		X	
Chironomidae				(Non-biting Midges)
Tanypodinae				
	Apsectrotanypus johnsoni	X	X	
	Brundiniella eumorpha	X	X	
	Krenopelopia sp.		X	
	Macropelopia sp.	X	X	
	Meropelopia sp.	X		
	Paramerina sp 1		X	
	Radotanypus florens	X	X	
	Rheopelopia acra		X	
	Rheopelopia paramaculipennis		X	
	Telopelopia okoboji		X	
	Trissopelopia ogemawi	X	X	
	Zavrelimyia sp.	X		
Diamesinae				
	Diamesa sp.	X		
	Pagastia orthogonia	X		
	Potthastia gaedii group		X	
	Potthastia longimanus		X	
	Sympotthastia sp.		X	
Prodiamesinae				
	Odontomesa ferringtoni	X		
	Prodiamesa olivacea	X		
Orthocladiinae				
	Brillia parva	X	X	
	Cardiocladius obscurus		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Chironomidae (cont)				
Orthocladiinae (cont)				
	Chaetocladius piger	X	X	
	Corynoneura sp. 5	X	X	
	Corynoneura "celeripes" (sensu Simpson & Bode, 1980)		X	
	Corynoneura sp. 12		X	
	Cricotopus (Isocladius) absurdus		X	
	Cricotopus (C.) politus		X	
	Epoicocladius sp. 3 (sensu Jacobsen, 1992)		X	
	Eukiefferiella brehmi group		X	
	Eukiefferiella devonica group	X		
	Eukiefferiella gracei group		X	
	Heleniella sp.	X	X	
	Heterotrissocladius sp.		X	
	Heterotrissocladius marcidus	X	X	
	Lopescladius sp.		X	
	Metriocnemus sp.	X	X	
	Metriocnemus eurynotus	X	X	
	Nanocladius (Plecopteracoluthus) downesi		X	
	Neozavrelia sp. 1	X	X	
	Orthocladius (Symposiocladius) lignicola		X	
	Parachaetocladius sp.	X	X	
	Parakiefferiella n.sp. 5		X	
	Parametriocnemus sp.	X		
	Parametriocnemus sp. A (sensu Sæther, 1969)		X	
	Paratrichocladius sp.		X	
	Psilometriocnemus triannulatus	X	X	
	Rheocricotopus (R.) eminellobus	X	X	
	Thienemanniella taurocapita		X	
	Thienemanniella boltoni	X	X	
	Thienemanniella similis		X	
	Tvetenia bavarica group		X	
	Tvetenia sp.		X	
	Tvetenia discoloripes group		X	
	Xylotopus par		X	
Chironominae				
	Demicryptochironomus sp.		X	
	Gillotia alboviridis		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Chironomidae (cont)				
Chironominae (cont)				
	Glyptotendipes (Heynotendipes) amplus		X	
	Lipiniella sp.		X	
	Microtendipes "caelum" (sensu Simpson & Bode, 1980)		X	
	Microtendipes rydalensis		X	
	Parachironomus pectinatellae		X	
	Paracladopelma nais		X	
	Paracladopelma undine		X	
	Polypedilum (P.) n.sp. 1		X	
	Polypedilum (P.) albicorne	X		
	Polypedilum (Uresipedilum) aviceps	X	X	
	Polypedilum (P.) laetum group		X	
	Polypedilum (Cerobregma) ontario		X	
	Robackia demeijerei		X	
	Cladotanytarsus species group B		X	
	Cladotanytarsus vanderwulpi group sp. 1		X	
	Cladotanytarsus vanderwulpi group sp. 3		X	
	Cladotanytarsus vanderwulpi group sp. 4		X	
	Cladotanytarsus vanderwulpi group sp. 5		X	
	Micropsectra sp.	X		
	Paratanytarsus longistilus	X	X	
	Rheotanytarsus pellucidus		X	
	Stempellina sp.		X	
	Stempellina sp. 2		X	
	Stempellina poss. subglabripennis		X	
	Stempellinella sp.		X	
	Stempellinella leptocelloides		X	
	Stempellinella boltoni	X	X	
	Stempellinella fimbriata		X	
	Sublettea coffmani		X	
	Neostempellina reissi	X	X	
	"Constempellina" n. sp. 1	X	X	
	Zavrelia aristata	X	X	
Athericidae				(Aquatic Snipe Flies)
	Atherix lantha		X	
Empididae				(Dance Flies)
	Neoplasta sp.	X	X	
	Clinocera (C.) sp.	X	X	
	Clinocera (Hydrodromia) sp.		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Phylum Mollusca				
Class Gastropoda				(Snails)
Pleuroceridae				
	Elimia sp.		X	
	Pleurocera sp.		X	
Class Bivalvia				(Mussels, Clams)
Unionidae				(Freshwater Mussels)
	Utterbackia imbecillis		X	
	Strophitus undulatus undulatus		X	
	Alasmidonta marginata		X	
	Alasmidonta viridis		X	
	Lasmigona complanata		X	
	Lasmigona compressa		X	
	Lasmigona costata		X	
	Megalonaias nervosa		X	
	Tritogonia verrucosa		X	
	Quadrula cylindrica cylindrica		X	
	Quadrula metanevra		X	
	Quadrula pustulosa pustulosa		X	
	Quadrula quadrula		X	
	Amblema plicata plicata		X	
	Fusconaia flava		X	
	Cyclonaias tuberculata		X	
	Pleurobema clava		X	
	Pleurobema cordatum		X	
	Pleurobema sintoxia		X	
	Elliptio dilatata		X	
	Ptychobranchus fasciolaris		X	
	Obliquaria reflexa		X	
	Cyprogenia stegaria		X	
	Actinonaias ligamentina carinata		X	
	Ellipsaria lineolata		X	
	Obovaria subrotunda		X	
	Truncilla donaciformis		X	
	Truncilla truncata		X	
	Leptodea fragilis		X	
	Potamilus alatus		X	
	Potamilus ohiensis		X	
	Ligumia nasuta		X	
	Ligumia recta		X	

Family/ Subfamily	Taxon Name	Cold Water Taxon	Sensitive Taxon	Common Name
Unionidae (cont)				
	Villosa fabalis		X	
	Villosa iris iris		X	
	Lampsilis fasciola		X	
	Lampsilis radiata luteola		X	
	Lampsilis cardium		X	
	Epioblasma triquetra		X	

NOTE TO USERS: the taxa list presented above represents a complete list of macroinvertebrate taxa identified as cold water indicator or sensitive taxa (pollution intolerant or moderately pollution intolerant) by the Ohio EPA at the time of publication of this manual (December 2011). Where genera are listed in the table (e.g. "*genus sp.*") as meeting one or both of these categories, it should be assumed that the applicable categorizations apply to any new species from that genus encountered in PHWH macroinvertebrate collections.

Definitions:

Cold water macroinvertebrates are taxa that primarily inhabit streams that generally maintain average summer water temperatures below approximately 20 °C. Cold water taxa have been in part chosen by analysis of the 50th percentile statistic of the number of cold water taxa at a taxon's collection sites during the summer collection period (June 15 to September 30). Cold water taxa are identified as those present in circumstances where the 50th percentile of the number of known cold water taxa cohabitating sites where a taxon is found is greater than or equal to three. Information in the published scientific literature was also considered when assigning taxa to the cold water list found in Table 7-2 of OAC Rule 3745-1-07.

Some species emerge in the spring and their larvae are not present during the summer collection period. For these taxa, the nature of the collection sites were taken into account along with an analysis of the associated taxa and a review of the scientific literature to determine if a particular taxon should be included on the cold water taxa list. Percentile breakdowns for each cool water taxon and literature references relevant to the assessment process noted above are available upon request from the Ohio EPA.

Sensitive macroinvertebrate taxa are defined as taxa that are considered by the Ohio EPA to be pollution intolerant or moderately pollution intolerant. These taxa are primarily found at stream monitoring stations that have minimal anthropogenic pollution or physical habitat alterations. This condition is usually associated with relatively high qualitative sample diversity for taxa from the Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa). Therefore, the number of qualitative EPT taxa present at stream monitoring stations is used as the surrogate for anthropogenic disturbance. Pollution tolerance categories are based upon a statistical evaluation of the occurrence of qualitative EPT taxa cohabiting stations where each macroinvertebrate taxon has been found. The results of this analysis for each sensitive taxon and data relevant to the assessment process noted above are available upon request from the Ohio EPA.

THIS PAGE INTENTIONALLY LEFT BLANK

Attachment 4 – PHWH Manual Version 3.0

River Code:_____ River/Stream:_____ RM:_____
Date:_____ Location:_____
Investigator:_____ Rosgen Channel Type: _____

Zig/Zag Pebble Count

Particle Size Range (mm)	Total (Dry) Channel	Total (Wetted Channel) Riffle	Run	Pool	Glide	%	Cum%
Silt							
Sand (< 2)							
V Fine Gravel (2-3.9)							
Fine Gravel (4-7.9)							
Medium Gravel (8-15)							
Coarse Gravel (16-31)							
V Coarse Gravel (32-63)							
Small Cobble (64-127)							
Large Cobble (128-255)							
Small Boulder (256-511)							
Medium Boulder (512-1023)							
Large Boulder (> 1024)							
Bedrock							
Clay Hardpan							

Bank Full Width: _____ Bankfull Max Depth: _____ Channel Slope _____

Bank Full Mean Depth _____ Flood Prone Area Width:_____ Valley Slope: _____

Width/Depth Ratio _____ Entrenchment Ratio _____ Sinuosity _____

THIS PAGE INTENTIONALLY LEFT BLANK

Attachment 5: Qualitative Substrate Evaluation Form

Site:_____ **Date:**_____ **Evaluator:**_____

Stream Drawing: use the grid below to draw the stream channel. Note habitat features and reference points for notes. Include landmarks.

Scale = 5 ft grid.

Place North Arrow in circle:

Use the following codes to complete the station chart below:

Substrate Types:

Bedrock:	BD	Silt:	ST
Boulder Slab:	BS	Leaf Pack/Woody Debris:	W
Boulder:	B	Fine Detritus:	D
Cobble:	C	Muck:	M
Gravel:	G	Clay/Hardpan:	H
Sand:	S	Artificial:	A

Substrate Prevalence Codes (at station):

Absent:	blank	Trace (functional)	X
<10%	1	10%-25%	2
25%-49%:	3	50%-75%::	4
75%-99%:	5	100%:	6

Habitat Types:

Pool:	P	Run:	RN
Riffle:	R	Glide:	G
Dry:	D	Stagnant:	S

	Substrate Types (enter code)							
Station/ Habitat								
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
Tally:								

Use back of form for notes.

Bedrock Exposed? Y / N Type:_____

Attachment 5: Qualitative Substrate Evaluation Form Instructions

1) In the grid provided on attachment make a drawing of the evaluated PHWH stream reach. A scale of 5 ft per grid unit is assumed unless an alternative scale is noted on the form.

   Include the following information on the map
   (note that suggested abbreviations for notations are provided on the form for habitat and substrate types):

   - important landmarks,
   - habitat features,
   - notations regarding substrate distribution
   - bankfull width measurement locations,
   - pools and pool depths,
   - riffles,
   - the direction of water flow,
   - a north arrow, and
   - any other features of interest.

   Also include information regarding any road crossings or points for access.
   The drawing should include comments on the type of riparian zone and land use adjacent to the stream reach, and any observations regarding seepage areas or confluences with other tributary channels. The stream drawing is a critical component of the assessment process and is extremely useful to document the condition of the evaluated reach on the day of the site evaluation.

2) To semi-quantitatively assess the percentages of the substrate types present, a tally table is provided to record both the types of substrate present and the relative prevalence of each substrate type at various points within the PHWH reach. It is helpful to identify each assessment point on the stream map by numbering them with the corresponding number on the tally sheet.
   - Note that the prevalence ratings use percent ranges that apply for a particular assessment point within the reach.
   - For stream reaches with normal substrate heterogeneity, it is recommended that at least 20 points be assessed for relative substrate distribution. For complex sites, additional assessment points may be needed. For sites with simple or monotonic substrate distribution patterns, fewer points may be sufficient.

3) Use an averaging approach (total tally ÷ number of assessment points) to determine the relative distribution of each of the substrate types. The relative scores can then be used to estimate the percent distribution for entry onto the HHEI form. A count of all of the substrate types observed within the stream reach can also be tallied to score sub-metric B for the substrate metric on the HHEI form.

NOTES: _____

_____

_____

Collection ID #: _____

Ohio EPA
Headwater Stream Salamander Voucher Data Sheet

Date Collected: _____ Time: _____
Site Name: _____
Location: _____
Tributary of: _____
County: _____; Township: _____
County Soil Map Page: _____; USGS Topo Map: _____
Road/Bridge: _____
Latitude: _____ N; Longitude _____ W
Average Bankfull Width (meters): _____; Maximum Pool Depth (cm): _____
Two Dominant Stream Bed Substrate Types: _____; _____
Riparian Vegetation Description: _____
_____
Temp (°C) _____; DO (mg/l) _____; pH _____; Cond (umhos/cm)_____
Stream Gradient Estimate (% Slope in ft/100 ft): _____ within 200 ft stream reach
Watershed Area: (sq mi) _____; (km) _____; (ha) _____
Were fish present? (Y) _____; (N) _____; Species: _____, _____,
_____, _____, _____, _____
Water Type: Spring-seep near source_____ ; Headwater Stream _____; Other: _____
Type of Flow: Complete Surface Flow _____; Interstitial Flow _____; Isolated Pools-Moist Soil but not Flowing (Intermittent)_____; Dry Channel Entire Length: _____

Collectors: _____

Salamander Species Collected:	Age Class:	
_____	_____	Number ( )
_____	_____	Number ( )
_____	_____	Number ( )
_____	_____	Number ( )
_____	_____	Number ( )
_____	_____	Number ( )
_____	_____	Number ( )

Tentative Identifications by: _____

***** Upon completion, this form can be copy reduced to fit inside the voucher container *****