FEASIBILITY STUDY OF A MITIGATION BANK FOR BOTH PRIMARY HEADWATER STREAMS AND WETLANDS AT THE PORTSMOUTH GASEOUS DIFFUSION PLANT IN PIKE COUNTY, OHIO

**Jennifer Bowman, Kelly Johnson, Gary Conley,
Rob Wiley, Natalie Kruse, Steve Porter**

June 2014

Sponsored by Ohio University's PORTSfuture Project

The PORTSfuture project is funded by a grant from the U.S. Department of Energy Office of Environmental Management Portsmouth/Paducah Project Office

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Acknowledgements:

I would like to acknowledge both graduate and undergraduate students who have assisted with this study project. For assistance with field data collection Bruce Underwood, graduate student in Environmental Studies and Aaron Coons undergraduate in Biological Sciences. For assistance with data report preparations of the appendices, Delaney Bolger, undergraduate in Honors Tutorial College with an emphasis on Geography.

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<u>List of Acronyms</u>

AM: Adaptive management
Ba: Basin area in square feet
C of C: Coefficient of Conservatism
CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act
Corps: the U.S. Army Corps of Engineers
CW: cold water
CWA: Clean Water Act
CWH: Cold water Habitat
D: Diversion of water
D&D: Decontaminate and Decommission
DEM: digital elevation model
DOE: Department of Energy
EPA: US Environmental Protection Agency
EPT: Ephemeroptera, Plecoptera, and Trichoptera
ET: Evapotranspiration
EWH: Exceptional Warmwater Habitat
FQAI: The Ohio Floristic Qualitative Assessment Index
G: Net export of ground water
GIS: Geographic Information Systems
GVS: Ohio University's Voinovich School of Leadership and Public Affairs
HHEI: Headwaters Habitat Evaluation Index
HMFEI: Headwater Macroinvertebrate Field Evaluation Index
I: Import of Water
LiDAR: Remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light.
LRW: Limited Resource Water
MWH: Modified Warmwater Habitat
NEH: National Engineering Handbook
NOAA: National Oceanic and Atmospheric Administration
OAC: Ohio Administrative Code
OEPA: Ohio Environmental Protection Agency
ORC: Ohio Revised Code
Pan: Pan Evaporation
PHWH: Primary headwaters habitat
PORTS: The Portsmouth Gaseous Diffusion Plant
Q: Water yield
RCRA: Resource Conservation and Recovery Act of 1976
ROE: Right of Entry
SAV: Submersed aquatic vegetation
TIN: Triangulated Irregular Network
USACE: United States Army Corps of Engineers
USDA: U.S. Department of Agriculture
VIBI-FQ: The Vegetation Index of Biotic Integrity "Floristic Quality"
Wa: Area of the wet pool in square feet
WWH: Warmwater Habitat
ΔS: Changes in moisture storage

1 INTRODUCTION

1.1 Project Description

The Portsmouth Gaseous Diffusion Plant (PORTS) facility is a United States Department of Energy (DOE) facility located in Pike County, near Piketon, Ohio. Located approximately 70 miles south of Columbus, north of Portsmouth, and east of the Scioto River (Figure 1.1). Normal conduct of the DOE's mission for decontamination and decommissioning (D&D) of the PORTS facilities may result in the unavoidable destruction of waters of the United States including wetlands and primary headwater streams. These technically definable landscape features, their loss and requirements for mitigation are regulated under the Clean Water Act Section 404 (33 CFR 328.3 and 40 CFR 230.3). Wetlands within PORTS are also regulated by Ohio Environmental Protection Agency under its 401 Water Quality Certification authority and by the authority provided by the Ohio Isolated Wetlands Law.

Figure 1.1 Location of PORTS in Ohio

Ohio University's Voinovich School of Leadership and Public Affairs (GVS), building on the previously completed Habitat Mapping and Site Characterization DOE Task from FY11/12 (Wiley et al. 2012), was commissioned to develop a feasibility plan to identify areas that may serve as a mitigation bank for both primary headwater streams and wetlands on the PORTS site. Identifying a mitigation bank in this way provides information that DOE, its contractors, and the public can use as D&D progresses. The mitigation bank may be needed to compensate for unavoidable impacts to existing primary headwater streams and wetlands that may occur from planned or future work at the site during operation and decommissioning of the PORTS facility.

Primary headwater streams field evaluations and data collection for wetland mitigation bank investigations were conducted June to October 2013 by Ohio University. Delineation of existing wetlands at PORTS was prepared by a third party consultant (Stantec 2013b). This feasibility study is divided into two parts; Part A: Primary Headwater Streams Mitigation Plan and Part B: Wetlands Mitigation Bank. This report is intended to be used now and in the future should the need to mitigate unavoidable losses to waters of the United States as D&D operations and repurposing of the PORTS facility continues.

1.2 Site Location

This study was conducted within the approximately 3,700 acre federally-owned area outside of the central high security zone and excluding the northeast corner of the facility, 'Study Area D'. Study Area D, was accessed separately by a third party consultant (Stantec 2013a). For off-site data collection pertinent to the primary headwaters streams adjacent to PORTS, right-of-entry access forms were obtained prior to entry from private landowners. Only properties where right-of entry access was granted were entered for data collection (Figure 1.2). Areas accessed for potential wetland investigations were strictly restricted to within DOE's property boundary.

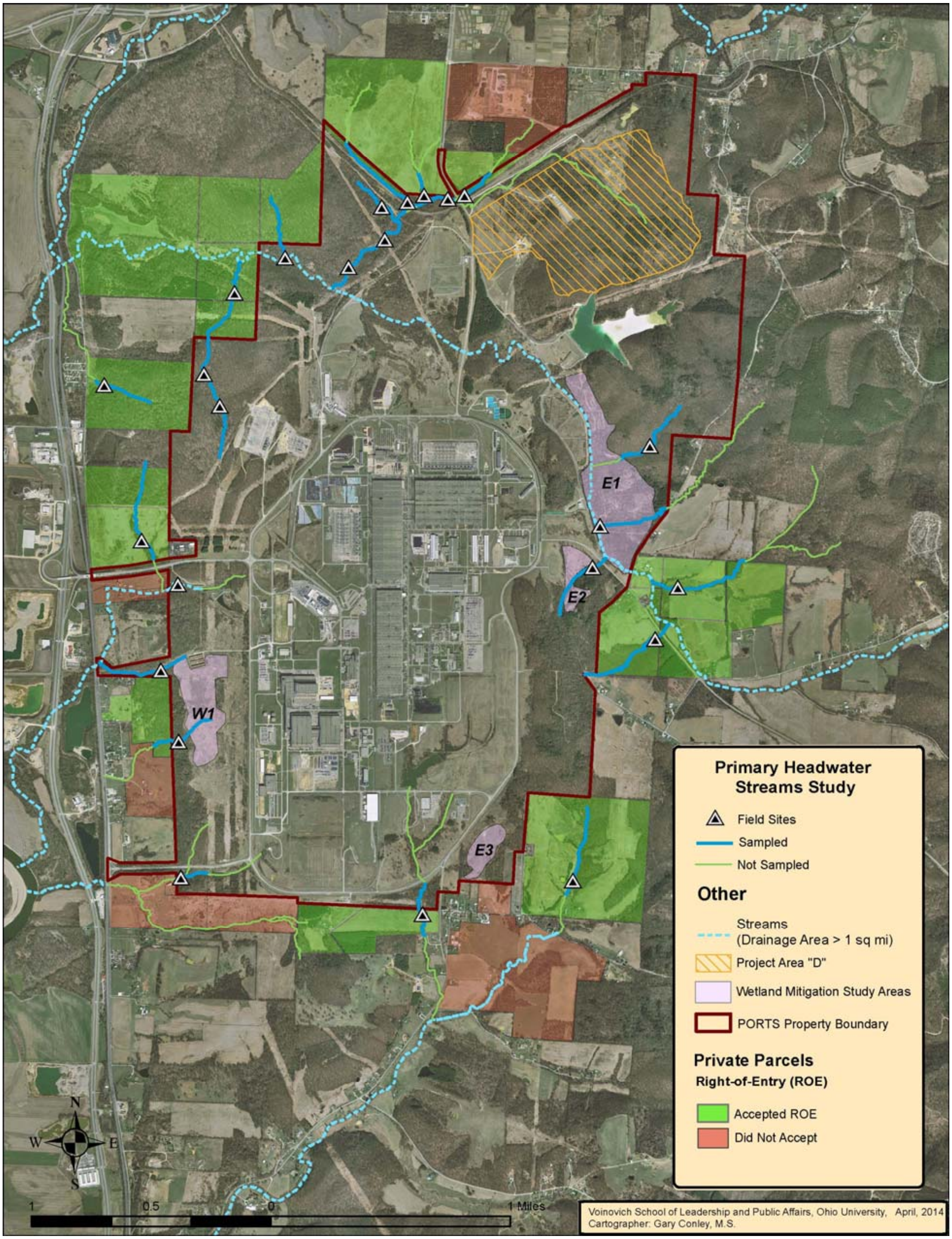


Figure 1.2 Primary headwater stream and wetland study areas on and adjacent to PORTS

1.3 Purpose of study

The purpose of the feasibility study of both primary headwater streams and wetlands is to provide data needed to develop a mitigation bank. GVS researchers provide site specific information to be utilized by DOE, its partners, and the public to use in the future to compensate for potential unavoidable losses to waters of the United States (Clean Water Act Section 404 jurisdictional wetlands and primary headwater streams as regulated by Ohio EPA). Generally, a formal primary headwater streams and/or wetlands mitigation bank is created as a contractual instrument between regulatory agencies such as State agencies such as Ohio EPA (and/or the US Army Corps of Engineers for wetlands) and an entity that due to its mission and an understanding of landscape configuration anticipates a probability that future impacts are unavoidable.

This document describes the process conducted to identify likely stream reaches and land areas where such practices such as preservation, conservation, and/or restoration can be effective. This is not a construction document. It is beyond the scope of this document to prepare construction details. Only sketches and functional discussions are provided herein to defend the choice of location. For primary headwaters streams, attributes such as the approximate length of stream reach, the stream classification based on biology, surface hydrology, land cover and in-stream habitat features are described and used in making site recommendations of primary headwater stream reaches for mitigation purposes. For wetlands, the site search for locations where physical factors suggest that hydrological conditions could be manipulated to support formation of sustainable wetlands were explored. This document details the findings of that search and an assessment of the physical factors that suggest that wetland conditions could be facilitated through topographic and hydrologic alterations. The size of the wetland created and the class of wetland likely to prevail under the average hydrological conditions achievable give the potential basin size, the local topography as generated from recent LiDAR and the soil conditions as defined by the USDA soil survey data for the locale. Should the areas herein recommended be selected for inclusion in a PORTS wetland mitigation bank, additional topographic and soil data would need to be collected and analyzed by engineers that would design and prepare construction drawings.

PART A: Feasibility Study of Primary Headwater Streams for Mitigation

2 BACKGROUND

Stream mitigation for impacts and disturbance is addressed by the anti-degradation provisions for surface waters of the state (OAC 3745-1, OAC 2011). Several categories of waters exist for the purposes of the anti-degradation provisions of the Ohio Administrative Code (OAC 2011) for stream mitigation: 'general high quality waters', 'superior high quality waters', 'outstanding state waters', 'outstanding national resource waters' and 'limited quality waters'. Unless a water body is specifically categorized as one of the superior, outstanding or limited quality designations, it is typically considered a 'general high quality water'.

While there are generally accepted guidelines, there are no specific rules governing stream mitigation in Ohio, and the requirements are determined on a case-by-case basis. Mitigation may include stream establishment, preservation, enhancement or restoration that addresses threats to the water body. A ratio of linear feet of mitigation to linear feet of impacted stream is negotiated with the OEPA based on the quality of the impacted stream and the proposed mitigation measures.

Suitable regulations or remediation efforts for activity and land use are important for resource conservation and can also significantly improve the quality of nearby streams or creeks (OEPA 2003). Land use impacts are more profound if a primary headwater stream is affected because first-order headwaters provide over half of the water volume in second-order streams (Alexander et al. 2007). Mitigation techniques preserve the aquatic resources to compensate for the unavoidable impacts from certain land use activities elsewhere (Harmon et al. 2012). Mitigation can occur through various methods: restoration (i.e. enhancement, establishment of a new site), conservation, or preservation (Department of Defense 2008).

Stream establishment, enhancement or restoration may take several forms, including relocation of an existing stream, creation of habitat features (e.g. riffles) within a stream, increasing shade through riparian plantings and removing chemical or physical (e.g. sedimentation) impairments. While these methods are often applied, stream restoration is an inexact science and often fails to meet the intended goals (e.g. Wohl et al 2005). For this reason, the preferred method for mitigation is stream preservation; through the perpetual protection of high quality streams.

Stream preservation may be accomplished using several legal and administrative methods. Environmental covenants can be established to protect ecological qualities of the land or to restore the site after use (Petts 1999). Environmental covenants are required to have a description of the remediation techniques and the activity and use limitations on the property (ORC 2004). The purpose of activity and use limitations is to define the category of land use, such as commercial and industrial use, in order to establish the regulations necessary for the activity (OEPA 2005). At a landowner's request, conservation easements may also be established in order to preserve certain aspects of the property. The landowner donates or sells a conservation easement restricting the activities that can occur on the property and enforces these restrictions for the specified time (ORC 2001). Conservation easements are a voluntary agreement between a landowner and a land trust or government agency that affords the landowner tax incentives for the sale or donation of the easement (ORC 5301.68, ORC 2005). A conservation easement would be held and maintained by a land trust and allows some land uses and limits others with an express conservation purpose. Conservation easements are granted in perpetuity and are tied to the real property through subsequent sales. Alternatively, the OEPA may enter into a Uniform Environmental Covenant, pursuant to the Uniform Environmental Covenants Act (ORC 5301.80 – 5301.92, ORC 2004). Environmental covenants are voluntary agreements between the landowner and OEPA that allow activity and use limitations to be placed on real property to protect ecological features associated with real property to fulfill the purposes of an environmental response project. Environmental response projects are defined as state and federal programs governing environmental cleanup primarily under either RCRA or CERCLA. The restrictions placed upon the activity and use of the property are recorded in land records and future landowners would purchase the property subject to the activity and use controls (ORC 2004).

Stream mitigation in Ohio is based upon the aquatic use designations that dictate the quality of water bodies. Primary headwaters streams (drainage area < 1 mi^2) have separate use designations than larger streams. Aquatic use designations for wadeable streams are defined in the State of Ohio Water Quality Standards (OAC 2011). Streams may be categorized as:

- Cold water Habitat (CWH) are waters that have natural cold water temperatures sufficient to support either a stocked trout population or native cold water fish.
- Exceptional Warmwater Habitat (EWH) are waters that support exceptional or unusual communities of aquatic organisms.
- Warmwater Habitat (WWH) are waters that support a “balanced, integrated adaptive community of warmwater aquatic organisms” (OAC 2011).
- Modified Warmwater Habitat (MWH) are waters that are not capable of supporting a “balanced integrated adaptive community of warmwater aquatic organisms” (OAC 2011), often due to channel modification, impoundment or sedimentation.
- Limited Resource Water (LRW) are waters that lack the capacity to support a community that reflects any of the other categories of use, often due to acid mine drainage or drainage way maintenance.

Primary headwater streams are defined in revisions to Rule 07 of Ohio’s water quality standards (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.

Primary headwaters habitat (PHWH) serves as a key source of both water and nutrients to a stream system. These streams are the smallest swales and stream origins of larger bodies of water. Primary headwater habitat stream classes are broken into four classifications.

Class I PHWH are ephemeral streams, providing water only seasonally for short periods of time, providing no significant habitat for aquatic fauna or aquatic wildlife use.

Class II PHWH are normally intermittent but may have perennial flow. They may support diverse warm water native fauna seasonally or year-round. Characterized by temperature facultative species of amphibians and pioneering fish. Water temperature conditions prevent establishment of class III biology and function

Class III PHWH are perennial streams in which flow and temperature conditions are influence by groundwater. They exhibit moderate to highly diverse communities of cold water taxa year-round. This classification is broken into two sub-classes:

Class IIIA PHWH are perennial streams exhibit diverse communities of native fauna characterized by one or more reproducing populations of the Northern Two-Lined Salamander, the Southern Two-Lined Salamander, the Northern Longtail Salamander or four or more cold water benthic macroinvertebrates taxa from table 7-2 of OAC Rule 3745-1-07 (Appendix A).

Class IIIB PHWH are perennial streams the exhibit superior species composition or diversity of native fauna characterized by one or more reproducing population of vertebrate species (cold water fish or salamander taxa) listed in Table 7-2 of OAC Rule 3745-1-07 or a macroinvertebrate community consisting of at least four cold water taxa found in Table 7-2 of OAC Rule 3745-1-07 (Appendix A) and having two or more of the following attributes:

- Six or more cold water macroinvertebrate taxa (Table 7-2 of OAC Rule 3745-1-07)
- Six or more EPT (Ephemeroptera, Plecoptera, and Trichoptera) macroinvertebrate taxa
- Six or more sensitive macroinvertebrate taxa

3 PREVIOUS STUDIES

In support of DOE's D&D efforts, Stantec assessed the streams in Study Area D (northeast corner of the DOE property) following Ohio EPA methods for Primary Headwaters Streams (OEPA 2012) and Ohio EPA methods for habitat assessment in streams (OEPA 2006). Stream survey sites were selected based on their representativeness of the surrounding stream habitat; additional survey sites were added where there were changes in physical conditions.

During Stantec's stream surveys, the field methodology undertook a tiered approach. All sites underwent a Level 1 physical habitat assessment. Further Level 2 biological assessment following standard methodology for the Headwater Macroinvertebrate Field Evaluation Index (HMFEI) were only completed if a site had flowing water, a natural or recovered channel, high quality substrate and a high enough

Headwaters Habitat Evaluation Index (HHEI) score (between 50 and 70) or were observed to have a community of larval salamanders. Level 3 assessments were performed at sites that exhibited Class III primary headwaters habitat characteristics based upon the Level 2 assessment; this includes the presence of salamanders during previous assessments. Level 3 assessments include both salamander surveys and lowest taxonomic level analysis for macroinvertebrates. The Level 2 or 3 assessments were conducted on different dates than the Level 1 (HHEI) assessments.

In contrast with only a couple exceptions, the Ohio University team conducted Level 1, 2 and 3 field assessments on all sites, regardless of characteristics, within a single day. Lowest taxonomic level analysis for macroinvertebrates was only conducted for sites which exhibited characteristics of Class III primary headwaters habitat.

The Stantec survey included 49 sites. Level 1 assessments were conducted in May 2013 while Level 2 and 3 assessments on a selection of sites were conducted in June 2013. Further surveys on three streams were conducted in August 2013. Of the initial 49 sites, ten were assessed using Level 2 methodology due to sufficient HHEI score or the presence of salamander larvae. Seven sites were observed to support salamander larvae during the Level 1 assessments and further Level 3 assessments were conducted at these sites.

Of the seven sites assessed to Level 3, no cold water taxa were found, however three sites did contain southern two-lined salamanders, a Class IIIA indicator species. Additional survey points were added on these three streams in August 2013 to gather more information.

The results of the headwater stream assessment indicate that within the study area, 678 ft of stream meet Warm Water Habitat (WWH), 5,103 ft meet Class IIIA Primary Headwater Habitat (PHWH), 2,842 ft meet Modified Class II PHWH, 19,236 ft meet Class II PHWH, 2,725 ft meet Modified Class I PHWH and 6,357 ft meet Class I PHWH. The study concluded that none of the streams assessed met the Ohio Administrative Code definition of cold water habitat. Of the 36,941 ft of streams assessed, 14,335 feet would be impacted by the On Site Disposal Cell grading area, including 49 ft of WWH, 2,419 ft of Class IIIA PHWH, 6,076 ft of Class II PHWH, 798 ft of Modified Class II PHWH, 3,956 ft of Class I PHWH and 1,037 ft of Modified Class I PHWH.

4 METHODS

4.1 Site Selection

Site selection for primary headwater stream data collection was based on drainage area (< 1 sq. mile) and the predominance of land cover and land use in a natural or semi-natural state. Evidence of previous/existing industrial use in the basin of streams draining the PORTS facility were excluded from this study due to existing influences on the stream. Catchment basins were delineated for streams located on PORTS and streams with a shared boundary between PORTS and adjacent landowners. All sites shown that drain less than one square mile were identified and included in this study unless otherwise stated

(Figure 4.1). Table 4.1 shows sample site names, locational information, into which basin the site drains, and land ownership.

Table 4.1 Primary headwater stream sample site locations within and adjacent to PORTS

Sample site	Latitude	Longitude	Drains to	Ownership
Trib 1a	39.03356	-83.00449	Little Beaver Creek	DOE
Trib 1b	39.03430	-83.00078	Little Beaver Creek	DOE
Trib 1c	39.0365	-82.99732	Little Beaver Creek	DOE
Trib 1d	39.03683	-82.99499	Little Beaver Creek	DOE
S1	39.03674	-82.99818	Little Beaver Creek	Private
Trib 2	39.03663	-83.00136	Little Beaver Creek	DOE
V1	39.03291	-83.00885	Little Beaver Creek	DOE
Trib 4a	39.024	-83.01379	Little Beaver Creek	DOE
Trib 4b	39.02597	-83.01514	Little Beaver Creek	DOE
Trib 4c	39.03102	-83.01294	Little Beaver Creek	Private
T1	39.02518	-83.02286	Little Beaver Creek	Private
O1A	39.01577	-83.01984	Scioto Run	Private
Trib 5	39.01319	-83.01781	Scioto Run	DOE
Trib 7	39.00786	-83.01855	Scioto Run	DOE
Trib 9	39.00347	-83.01702	Scioto Run	DOE
Trib 10	38.99429	-83.01482	Scioto Run	DOE
W1	38.99326	-82.99821	Big Run	Private
P1	38.99583	-82.98605	Big Run	Private
N1	39.0095	-82.98077	Little Beaver Creek	Private
B1	39.01291	-82.97884	Little Beaver Creek	Private
Trib 6	39.01427	-82.9849	Little Beaver Creek	DOE
Trib 8	39.01681	-82.98438	Little Beaver Creek	DOE
Trib 3	39.02164	-82.98026	Little Beaver Creek	DOE

Note: On-site locations are denoted with “Trib #”. Off-site locations are denoted with “Letter#”. The letters used for off-site locations are an abbreviation of landowner’s name to remain confidential.

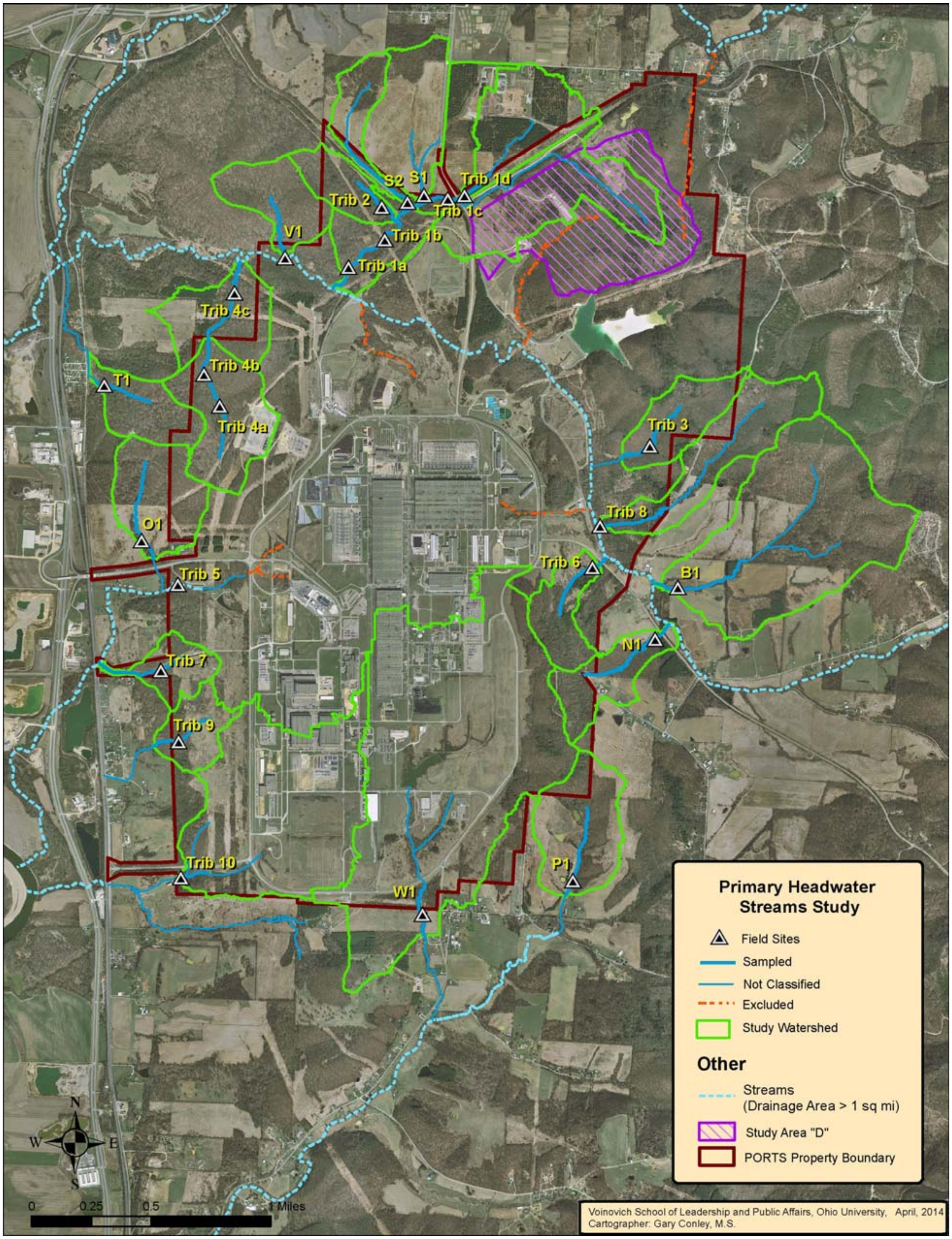


Figure 4.1 PHWH study sites with their associated catchment basin

4.2 Biological, Chemical, and Physical Field Data

At each sample site, a 200 ft reach was identified using a measuring tape. Temporary flags were inserted into the creek bed or bank at the boundaries of each reach. Within this 200 ft reach, the following physical data was collected at all sites: latitude, longitude, photos, and Headwaters Habitat Evaluation Index (HHEI) score. Appendix B contains a photo log and Appendix C contains HHEI forms for each site. Biological data was collected at all sites with flowing water, isolated pools, or moist channels. Macroinvertebrates were collected using dip nets and were handpicked from stream substrate within the 200 ft reach for at least 30 minutes until no new taxa were found. Appendix D contains the HMFEI forms for macroinvertebrates collected per site. Salamanders were collected using dip nets, strainers, fine mesh hand nets, and hand-picked from the stream channel and within 3 - 5 ft from wetted channel within a 30 ft section for 30 minutes, if none were found a second 30 ft section was identified within the 200 ft reach and sampled for an additional 30 minutes (Appendix E). If fish were present, fine mesh benthic invertebrate nets were used to collect fish for at least 15 minutes, targeting pools and undercut banks. At all streams with flowing water or isolated pools, surface water quality parameters were recorded using a calibrated Myron Ultrameter II 6Psi to measure pH, conductivity, oxidation/reduction potential, and temperature of the water (water quality data presented in Results section).

4.3 Biological Laboratory Analysis

There are three levels of PHWH assessments described in the Field Evaluation Manual for Ohio's Primary Headwater Streams (OEPA 2012):

- Level 1 assessment consists of a physical assessment of the headwater habitat generating a headwater habitat evaluation index (HHEI) score.
- Level 2 assessment combines the qualitative biological sampling results with the level 1 physical habitat (HHEI) 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.

HMFEI and HHEI multi-metric scores were determined following the Ohio EPA methods (OEPA 2012).

4.3.1 Macroinvertebrates

All macroinvertebrates collected in the field were retained and preserved in 70% ethanol. For the Level 2 PHWH assessment, macroinvertebrates were sorted, enumerated and identified to family under a dissecting scope. Identifications were performed by individuals with Ohio EPA Level 2 or higher credible data qualifications using Merritt, Cummins, and Berg (2008) and Bouchard (2004). For the Level 3 PHWH assessments, macroinvertebrates were identified to genus using compound and dissecting microscopes and Merritt, Cummins, and Berg (2008). Larval Chironomidae (Diptera) were mounted on microscope slides either as temporary wet mounts or under cover slips in Euparral, and identified using Wiederholm (1983) and Bolton (2012).

Cold water and sensitive headwater stream indicator taxa were categorized from the List of cold water indicator (Table 7-2 of OAC 3745-1-07) and sensitive (pollution intolerant) macroinvertebrate taxa listed in Attachment 3 of the PWHW Field manual (OEPA 2012).

Vouchered sample of all macroinvertebrates collected at each site are deposited in the Ohio University Department of Biological Sciences aquatic invertebrate collection.

4.3.2 Salamanders

Salamanders captured in the field were either identified and released (*Eurycea*, *Ambystoma* and *Plethodon* adults only) or returned to the laboratory and identified, euthanized and prepared for vouchering. Adult salamanders are easily identified by body shape and coloration. The adult *E. bislineata* shared the color pattern of the southern subspecies, *E. bislineata cirrigera* and based on the geographical distribution of the two subspecies, is also most likely to be *E. b. cirrigera*. However, the study sites are near the southern boundary of the northern subspecies, E. *b. bislineata* as well, and the two are known to hybridize. Without further investigation of subspecies, we refer to the two-lined salamanders from the study sites as *E. b. cirrigera,* which does not affect the Class II or III designations. We followed precedent of Petranka (1998) in recognizing the southern two-lined salamander as a subspecies of *E. bislineata* rather than elevating it to a separate species (*E. cirrigera*), as it is treated in some (but not all) sections of the PHWH field manual. Following the guidelines in the PHWH manual, the presence of larval two-lined salamanders was used as evidence of a reproducing population (even in the absence of juveniles or adults). In some cases this was the only justification for elevation to Class III headwater status (e.g. the HMFEI score indicated Class II).

Voucher salamanders were euthanized by immersion in a solution of MS-222 buffered to neutral pH with baking soda (Ohio University IUCUC Protocol number 12-L-024) for approximately 10 minutes while cessation of breathing was observed. Specimens were then transferred to a solution of one part buffered formalin and 9 parts water following methods described in the Ohio EPA PHWH manual (2012). After 3-4 weeks, specimens were transferred to 70% ethanol for permanent storage in the Department of Biological Sciences, Ohio University vertebrate collections museum along with labels with date, collector name, county, and site identification as listed on the HHEI field evaluation forms.

Larval salamanders were identified by Dr. Kelly S. Johnson in consultation with Dr. Carl R. Brune, Ohio University using the following taxonomic resources: Brandon (1964) and Petranka (1998).

4.3.3 Fish

Fish captured in the field were maintained in stream water in aerated buckets until end of day when they were identified, euthanized and prepared for vouchering. Fish were euthanized by immersion in a solution of MS-222 buffered to neutral pH with baking soda (Ohio University IUCUC Protocol number 12-L-024) for approximately 10 minutes while cessation of breathing was observed. Specimens were then transferred to a solution of one part buffered formalin and 9 parts water. After 3-4 weeks, specimens were transferred to 70% ethanol for permanent storage in the Department of Biological Sciences, Ohio University vertebrate collections museum along with labels with date, collector name, county, and site identification as listed on the HHEI field evaluation forms.

Fish were identified by Amy Mackey, Raccoon Creek Watershed Partnership and the Voinovich School of Leadership and Public Affairs, Ohio University.

4.4 Longitudinal Profiles

Longitudinal profiles were created using a GIS approach that relied on a combination of ArcGIS Linear Referencing and Spatial Analyst tools as well as R for plotting the resulting data. The linear referencing tools allow one to create route features. Route features can calculate and store the distance of other features along the route, similar to mile-markers on a highway. In this case the routes are actually streams and not roads or foot-paths. The process to create the vertical profiles involves creating points at regular intervals along a stream, getting the points' distances along the stream, and then sampling an elevation model to get the elevation at each point. In more detail:

1. Streams were digitized by hand to lie as close to the center of their channels using a digital elevation model (DEM) and aerial photography as references.
2. The lines were then densified so there is a vertex every 10 feet.
3. The stream lines were then converted to routes using ArcGIS's linear referencing tools so the length along the line can be calculated.
4. The line vertices were converted to point data.
5. The line vertex points were assigned a value from the DEM to obtain the elevation at each point along the line.
6. These elevation values, combined with the distance along the line from step 3 was then plotted using R and the ggplot2 package.

Other points of interest such as culverts and property lines were plotted by hand by placing a point on the map with the corresponding label and then using the linear referencing tools to find the distance of these points along the routes.

The DEM had a horizontal resolution of 2.5 feet and was generated from LiDAR data with a horizontal resolution of 5 feet. The LiDAR laser cannot reflect off of water surfaces. To get the closest elevation point, either sedimentary features or part of the channel would need to be captured next to the water surface in the creek. With a horizontal sampling resolution of 5 feet, the stream channel may not have been consistently captured for smaller streams. Therefore the profiles represent not the channel bed itself, but the flood plain or valley very near the channel. The scale is exaggerated at a ratio of 1:4 from x to y-axis, so elevation along the y-axis appears 4 times greater than reality.

4.5 Performance Criteria

The feasibility of each stream reach was evaluated for its mitigation potential. Multiple metrics such as: continuous length, HMFEI classification, HHEI classification, ownership, and its management strategy for mitigation (preservation, conservation, or restoration) were scored and totaled to rank the feasibility of reach stream reach for purposes of mitigation. HMFEI classification, ownership and continuous length were valued two times higher than other categories to give a scaled valuation of these key factors. The factors were determined using the following methods.

Drainage area was determined using GIS Arc Hydro, based on a digital elevation model (DEM). Representative continuous stream lengths were determined using the aerial maps and the previously created habitat layer (Wiley et al. 2012). Stream length upstream and downstream of the sampled site was extrapolated to form a representative reach to which the stream classification was applied. For example, the land cover and vegetative habitat type at site N1 are similar upstream and/or downstream of the 200 ft sample reach. The resulting stream classification (Class II) of the sampled reach was extended to those areas upstream and downstream, totaling 2,821 ft of Class II streams (Figures 5.18 and 5.19 and Table 5.18). Land ownership was plotted using publicly available data for Pike County's auditor's office. Stream length to drainage area ratios were calculated to determine the # of linear feet of stream to # of protected acres. The larger the number, the greater the length of stream gained for the amount of drainage area preserved.

4.5.1 Watershed Attributes

Watershed attributes such the Ohio Floristic Qualitative Assessment Index, % forested, and % palustrine habitat were derived from the previously generated GIS habitat layer (Wiley et al. 2012). These attributes are described below:

The Ohio Floristic Qualitative Assessment Index (FQAI) is a simple ordination method based on weighted averaging (Gauch 1982). It is calculated using species abundance and a weighting factor based on a species conservation value to derive a plant community rating that can be used to compare the relative state of ecosystem integrity between communities. Ecosystem integrity has been defined as "the capability of supporting and maintaining a balanced integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region" (Karr and Dudley 1981).

The selected weighting factor, identified as the Coefficient of Conservatism (C of C), is an ordinal number assigned to a plant species based on its ecological tolerances and its intolerance to external disturbances to a presumed "natural" condition. The C of C represents the degree of conservatism (fidelity to undisturbed conditions) that a species demonstrates by its occurrence within a particular habitat.

The FQAI for the j^{th} habitat is defined as:

$$FQAI_j = \frac{\sum_{i=1}^{n_j} C\ of\ C_i}{\sqrt{n_j}}$$

where $C\ of\ C_i$ is the coefficient of conservatism for a species and i is the number of species. This calculation is performed for all species as well as only for native species. The native-only calculation is the original FQAI calculation and one most often reported. This assessment prefers use of all species because the high importance of non-native species in most habitats truly reduces the floristic quality in spite of the occurrence of a relatively few highly rated individuals.

Percent forested is simply calculated as the percent of total area of any mature oak-hickory, mesic, bottomland hardwood, native coniferous, planted coniferous, or successional forest. Percent forest data was generated for the area of drainage catchment for each studied stream reach. Percent palustrine habitat is the percent of total area of any forested, scrub/shrub, or emergent palustrine habitat found in the catchment of each studied stream reach.

5 RESULTS

5.1 Sample site data

Data results are presented starting with sites on the north side of PORTS and moving counter clockwise around the facility ending on the east side (Study Area D located in the northeast section of the PORTS facility was excluded from this study) (Figure 4.1). In this section site-by-site information is presented including: site description, photo, water quality field parameters, longitudinal stream profile, macroinvertebrate data, salamander data, fish data, and a site summary.

5.1.1 Site Trib 1A

Class IIIB (Level 3 assessment + fish)

Site Description: Trib 1A is located on the north side of DOE property, and flows into Little Beaver Creek. The stream reach meanders through a mature bottomland hardwood forest with a wide riparian corridor on both sides (Photo 1). The reach is relatively low gradient (Figure 5.1), has high sinuosity, and 60% boulder and cobble substrate. It drains approximately 0.93 square miles (593 acres), of which 47 % is forested.

Water quality parameters: pH 7.77, temp 21.7^{oc}, conductivity 467.7 µS/cm, ORP 284 mv

Photo 1. Trib 1A. 6.24.2013

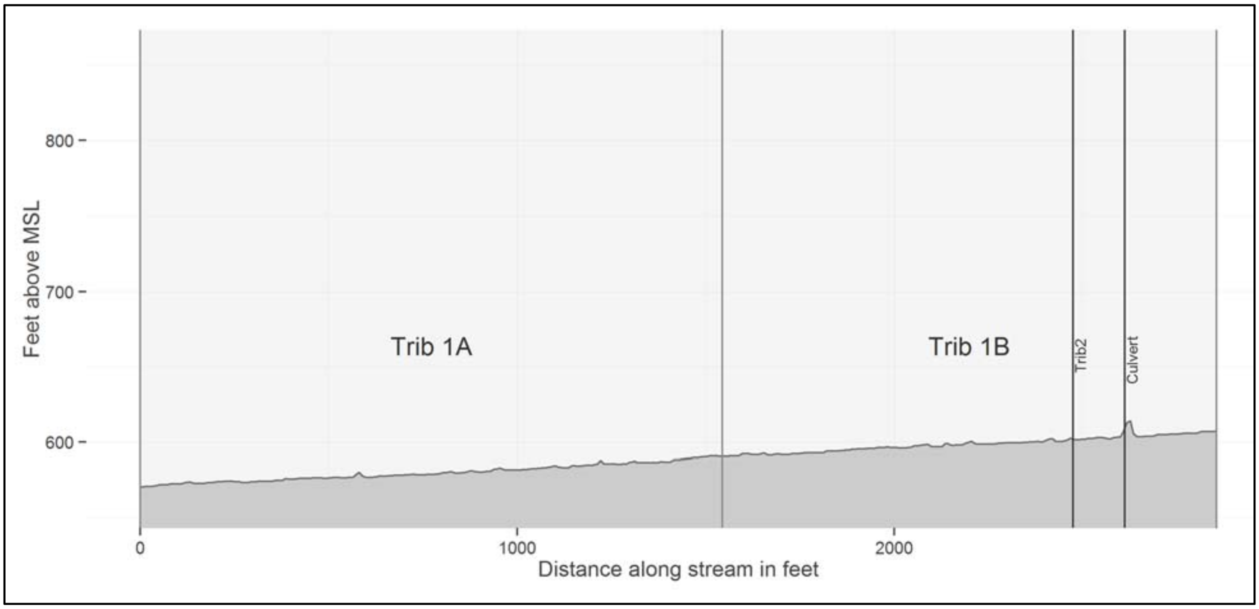


Figure 5.1 Longitudinal stream reach profile, sites Trib 1A and Trib 1B

Macroinvertebrates: HMFEI score (37). This reach supported a high quality macroinvertebrate community, with an HMFEI score well above the cut-off (>19) indicative of a Class III PHWH stream. A Level 3 assessment was performed, and although > 6 EPT taxa and 5 sensitive taxa were found only 1 cold water (CW) taxon (*Amphinemura* stonefly) was identified (Table 5.1). Thus, this stream is reported as Class IIIA.

Salamanders: Adult (N=1), juvenile (N=1) and larval stage (N=3) two lined salamanders were collected, but no reproducing population of cold water salamanders, further supporting the categorization of this stream as Class IIIA (rather than the higher quality IIIB).

Fish: (N=12) 1 Southern Red Bellied Dace, 6 Creek Chub, 1 Fantail Darter, and 4 unknown Cyprinidae. Southern Red Bellied Dace is a cold water adapted Class IIIB indicator species (table 7-2 of OAC Rule 3745-1-07: Ohio EPA 1989) a definitive indicator that this stream reach meets the definition of Class IIIB quality.

Table 5.1 List of macroinvertebrate taxa found at Trib 1A and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Diptera	Chironomidae	15				
Trichoptera	Hydropsychidae	1		1	1	*Ceratopsyche sp*
		2	0	1	1	*Macrostemum* sp
		10	0	1	0	*Cheumatopsyche sp*
		2		1	0	small unidentified
Decapoda	Cambaridae	8	0	0	0	
Ephemeroptera	Heptageniidae	5	0	1	0	*Stenonema femoratum*
Megaloptera	Corydalidae	3	0	0	0	*Nigronia serricornis*
Ephemeroptera	Caenidae	3	0	1	0	*Caenis* sp.
Odonata	Aeshnidae	2	0	0	0	*Boyeria vinosa*
Odonata	Libellulidae	2	0	0	0	
Megaloptera	Sialidae	1	0	0	0	*Sialis*
Ephemeroptera	Baetidae	1		1		unable to ID to genus
Coleoptera	Psephenidae	1	0	0	1	*Psephenus herricki*
Plecoptera	Perlodidae	1	0	1	0	*Beloneuria* sp.
Plecoptera	Nemouridae	1	1	1	1	*Amphinemura sp.*
Trichoptera	Polycentropodidae	1	0	1	1	*Polycentropus* sp.
Hemiptera	Gerridae	1	0	0	0	
Coleoptera	Elmidae	1	0	0	0	*Stenelmis sp.*
Diptera	Ceratopogonidae	1	0	0	0	
Gastropoda **(CLASS)**	Physidae	1	0	0	0	

Site Summary - This tributary is one of the higher quality streams within the study area, in a relatively large catchment that is well-forested (47 %), particularly in the riparian area. There is good physical habitat within the stream channel (HHEI score = 78, a Class III stream based on the initial habitat assessment) and hydrological characteristics of permanent flow. The reach has an added benefit of being contiguous with a second high quality section of stream (Trib 1B), and two additional upstream reaches (Trib 1C and Trib 1D).

5.1.2 Site Trib 1B

Class IIIA (Level 3 assessment)

Site description: Trib 1B located just upstream from Trib 1A is on the north side of DOE property, flowing into Little Beaver Creek. The stream reach flows through a mature bottomland hardwood forest with a wide riparian corridor on both sides (Photo 2). The upstream part of this reach is separated from reach Trib 1C by a large culvert that passes under the railroad. The reach is relatively low gradient (Figure 5.2), and has 55 % boulder and cobble substrate.

Water quality parameters: pH 7.88, temp 21.4^{oc}, conductivity 455.2 μS/cm, ORP 241 mv

Photo 2. Trib 1B. 6.24.2013

Macroinvertebrates: HMFEI score (37). This reach supported a high quality macroinvertebrate community, with an HMFEI score well above the cut-off (>19) indicative of a Class III PHWH stream. A Level 3 assessment was performed, revealing > 6 EPT taxa and two designated sensitive taxa but no confirmed cold water taxa (Table 5.2). This reach is given a designation of Class IIIA, which is consistent with the salamander indicators.

Salamanders: Adult (N=1), juvenile (N=1) and larval stage (N=6) two lined salamanders were collected, confirming the categorization of this stream as Class IIIA. No other salamanders were found.

Fish: (N=4) 2 Fantail Darter, 1 Creek Chub, and 1 unknown Cyprinidae, no cold water species.

Table 5.2 List of macroinvertebrate taxa found at Trib 1B and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Diptera	Chironomidae	47				
Trichoptera	Hydropsychidae	1		1	1	*Hydropsyche* sp.
		17		1	0	*Cheumatopsyche* sp.
		12				small, unidentified
Ephemeroptera	Heptageniidae	7	0	1	0	*Stenonema femoratum*
		1	0	1	0	*Stenacron* sp.
Gastropoda **(CLASS)**	Ancylidae	6	0	0	0	
Coleoptera	Psephenidae	4	0	0	1	*Psephenus herricki*
Megaloptera	Corydalidae	4	0	0	0	*Nigronia serricornis*
Odonata	Libellulidae	4	0	0	0	
Ephemeroptera	Caenidae	4	0	1	0	*Caenis sp.*
Hemiptera	Gerridae	3	0	0	0	
Decapoda	Cambaridae	2	0	0	0	
Ephemeroptera	Leptophlebiidae	2	0	1	0	*Paraleptophlebia* sp.
Gastropoda **(CLASS)**	Physidae	2	0	0	0	
Odonata	Gomphidae	2	0	0	0	
Ephemeroptera	Baetidae	2		1		too small to ID
Coleoptera	Elmidae	2	0	0	0	*Stenelmis* sp.
Odonata	Calopterygidae	1	0	0	0	*Calopteryx sp.*
Plecoptera	Perlidae	2	0	1	0	*Beloneuria* sp.
			0	1	0	*Hansonoperla* sp.
Hemiptera	Veliidae	1	0	0	0	
Megaloptera	Sialidae	1	0	0	0	*Sialis sp.*
Gastropoda **(CLASS)**	Planorbidae	1	0	0	0	
*Gastropod **(CLASS)**		1	*No operculum to determine family			

Site Summary - This reach is contiguous with the downstream Trib 1A section of the same tributary, and has nearly comparable biological quality, forest cover and physical habitat (HHEI score = 78, a Class III stream based on the initial habitat assessment). The fact that it is located upstream of a high quality reach (Trib 1A) and is contiguous with two other sections (Trib 1C and Trib 1D) is an added benefit.

5.1.3 Site Trib 1C

Class IIIA (Level 3 assessment)

Site description: Trib 1C is located upstream of the railroad culvert on the north side of DOE property, and flows into Little Beaver Creek. The stream reach meanders through a mature bottomland hardwood forest with a wide riparian corridor on both sides. The stream water was tinted black on site visit date, 6/24/2013 (Photo 3 & 3.1). The reach has a moderate gradient (Figure 5.2), and is 93% boulder and cobble substrate. It drains approximately 0.51 square miles (327 acres), of which 35 % is forested.

Water quality parameters: pH 7.49, temp 23.3^{oc}, conductivity 381.4 µS/cm, ORP 198 mv

Photo 3. Trib 1C. 6.24.2013

Photo 3.1. Trib 1 Black Water. 6.24.2013

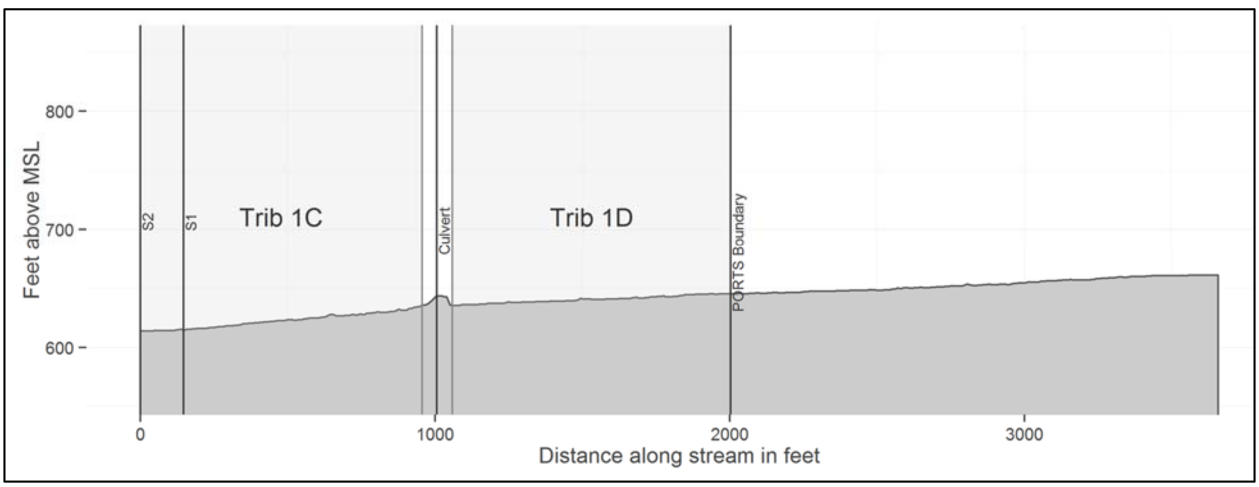


Figure 5.2 Longitudinal stream reach profile, site Trib 1C and Trib 1D

Macroinvertebrates: HMFEI score (30). This reach supported a high quality macroinvertebrate community, with an HMFEI score well above the cut-off (>19) indicative of a Class III PHWH stream. A Level 3 assessment was performed, and although > 6 EPT taxa were present, no cold water (CW) taxa were specifically identified and only 1 sensitive taxa (*Psephenus herricki*) was confirmed (Table 5.3).

Salamanders: Juvenile (N=1) and larval stage (N=8) two lined salamanders were collected, but no cold water salamanders were collected, supporting the categorization of this stream as Class IIIA PHWH.

Fish: (N=2) 2 Creek Chub, not a cold water species.

Table 5.3 List of macroinvertebrate taxa found at Trib 1C and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Ephemeroptera	Heptageniidae	27	0	1	0	*Stenonema femoratum*
Ephemeroptera	Heptageniidae	3	0	1	0	*Stenacron sp.*
Diptera	Chironomidae	25				
Ephemeroptera	Caenidae	15	0	1	0	*Caenis sp.*
Trichoptera	Hydropsychidae	14	0	1	0	*Cheumatopsyche sp.*
Decapoda	Cambaridae	12	0	0	0	
Megaloptera	Sialidae	7	0	0	0	*Sialis sp.*
Coleoptera	Psephenidae	6	0	0	1	*Psephenus herricki*
Megaloptera	Corydalidae	5	0	0	0	*Nigronia serricornis*
Plecoptera	Perlidae	5	0	1	0	*Beloneuria sp.*
Coleoptera	Elmidae	2	0	0	0	*Stenelmis sp.*
Coleoptera	Elmidae	1	0	0	0	*Dubiraphia sp.*
Odonata	Libellulidae	2	0	0	0	
Ephemeroptera	Baetidae	1		1		*no genus level ID*
Odonata	Calopterygidae	1	0	0	0	*Calopteryx sp.*
Odonata	Coenagrionidae	1	0	0	0	

Site Summary - Section Trib 1C supports a high quality biological assemblage and the in stream habitat of the channel is exceptionally good (HHEI score = 95, indicative of Class III based on physical habitat). However, this reach may suffer from a lack of connectivity with downstream reaches due to a large elevated culvert that presents a significant obstacle to fish passage upstream. This may explain the low fish diversity here compared to the downstream reaches of the same tributary (only one species collected in this section). The culvert is probably not a barrier to macroinvertebrate dispersal. The water at this site was observed on several occasions to be black. As no oily sheen or associated odor were present the most probable cause of the "black-water" was from very high tannin content. This reach is downstream of a lumber processing yard that is likely the source of concentrated organics that produce a tannin, "black water" effect. Regardless of the black-water present, the macroinvertebrate community appears to be unimpaired.

5.1.4 Site Trib 1D

Class IIIA (Level 3 assessment)

Site Description: Trib 1D the furthest upstream reach of tributary 1 is located on the north side of DOE property, east of the north entrance road, a tributary of Little Beaver Creek. The reach had intermittent flow with isolated pools, moderate riparian width characterized by palustrine emergent and scrub/shrub habitat in the floodplain. The stream flows from an off-site lumber processing facility that is heavily populated with planted pines. The stream lacked sinuosity and was heavily vegetated (Photo 4). The reach has a flat gradient (Figure 5.4), and has roughly 60% silt substrate. It drains approximately 0.16 square miles (102 acres), of which 36 % is forested.

Water quality parameters: pH 6.85, temp 20.7^{oc}, conductivity 383.5 μS/cm, ORP 239 mv

Photo 4. Trib 1D. 8.27.2013

Macroinvertebrates: HMFEI score (17). Although not as high quality as other sites of the same tributary (Tribs 1A, B, and C) this site supported two EPT taxa, Heptageniid and Caenid mayflies and was only two points from the HMFEI cutoff of 19 for Class III. Tolerant taxa, especially Asellidae, crayfish and chironomid midges, were numerically dominant. Genus level identifications indicated fewer than six cold water (CW) or sensitive taxa (Table 5.4). A Level 3 bioassessment was performed but no additional sensitive or cold water taxa were revealed. However, reproducing Class IIIA salamanders were found.

Salamanders: Larval stage (N=2) two lined salamanders were collected, supporting the elevation of this stream to Class IIIA, in spite of the modest macroinvertebrate community.

Fish: None

Table 5.4 List of macroinvertebrate taxa found at Trib 1D and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Isopoda	Asellidae	40	0	0	0	
Gastropoda **(CLASS)**	Physidae	19	0	0	0	
Decapoda	Cambaridae	8	0	0	0	
Diptera	Chironomidae	8		0		
Odonata	Libellulidae	3	0	0	0	
Diptera	Culicidae	3	0	0	0	
Odonata	Aeshnidae	2	0	0	0	*Boyeria vinosa*
Hirudinea **(CLASS)**		1	0	0	0	
Gastropoda **(CLASS)**	Planorbidae	1	0	0	0	
Odonata	Calopterygidae	1	0	0	0	
Ephemeroptera	Heptageniidae	1		1	1	*Maccaffertium* sp.
Hemiptera	Notonectidae	1	0	0	0	
Megaloptera	Sialidae	1	0	0	0	
Coleoptera	Dytiscidae	1	0	0	0	
Odonata	Coenagrionidae	1	0	0	0	
Ephemeroptera	Caenidae	1	0	1	0	*Caenis or Americaenis*
Coleoptera	Hydrophilidae	1	0	0	0	

Site Summary – Trib 1D, the uppermost section of Tributary 1 supports a much lower quality macroinvertebrate community compared to the downstream reaches. Even though the presence of larval two-lined salamander elevated the reach to Class IIIA, the channel has been modified and the physical habitat score (HHEI = 45) indicated a Class II stream, consistent with the macroinvertebrate score. There might be opportunity to implement specific restoration efforts to improve the physical habitat and thus the macroinvertebrate community. The presence of reproducing salamanders suggests the primary limitation is in-stream channel habitat, not water quality or intermittent flow.

5.1.5 Site Trib 2

Class I (Level 2 assessment)

Site description: Trib 2 is a small tributary that drains into stream reach Trib 1B located on the north side of DOE property. The stream reach flows from successional forest into mature bottomland hardwood and palustrine forest cover with a wide riparian corridor on both sides (Photo 5). The flow regime was intermittent with isolated pools. The reach has a moderate gradient (Figure 5.3), with minimal sinuosity. The substrate comprised of roughly 75% boulder and boulder slabs. It drains approximately 0.07 square miles (47 acres), of which 63 % is forested.

Water quality parameters: pH 6.08, temp 22.1^{oc}, conductivity 324.3 μS/cm, ORP 250 mv

Photo 5. Trib 2. 6.24.2013

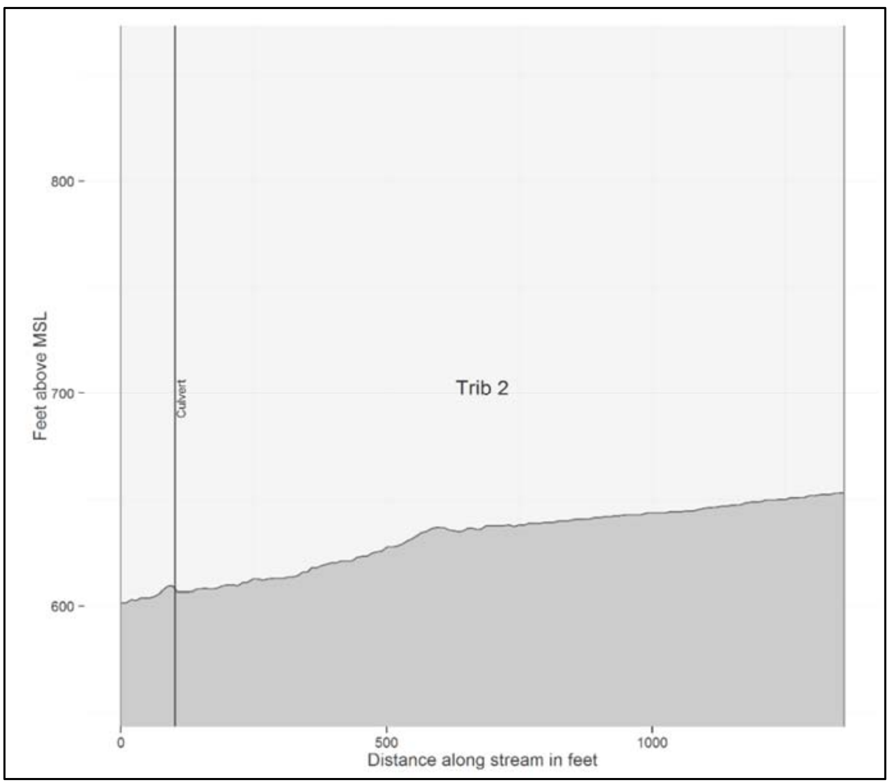


Figure 5.3 Longitudinal stream reach profile, site Trib2

Macroinvertebrates - (HMFEI=1) Very poor macroinvertebrate community.
Salamanders and Fish - none found

Site Summary - Although the physical channel earned an HHEI of 64, on the upper end of a Class II channel based on physical habitat, it does not support macroinvertebrates or salamanders. A mildly acidic field pH of 6.08 was recorded.

5.1.6 Site S1

Class I (Level 2 assessment)

Site description: S1 is a small ephemeral channel that drains into stream reach Trib 1C on the north side of DOE property. This stream shares ownership with off-site landowner and DOE. The reach surveyed was located partially on and partially off DOE property. The riparian corridor is narrow on left bank and moderate on the right bank; surrounded by open agricultural fields (Photo 6). The flow regime was dry with no water in channel. The reach has a flat to moderate gradient (Figure 5.4), with very little sinuosity. The substrate is comprised of roughly 71% boulder, boulder slabs, cobble, and bedrock. It drains approximately 0.17 square miles (109 acres), of which 21 % is forested.

Photo 6. S1. 8.27.2013

Water quality parameters: none-dry

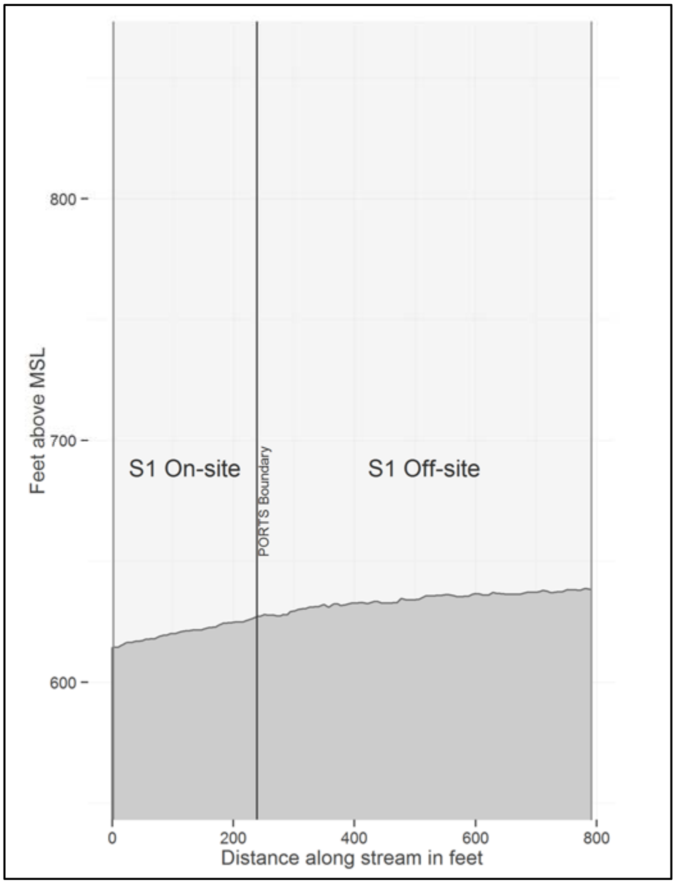


Figure 5.4 Longitudinal stream reach profile, site S1

Macroinvertebrates: HMFEI score (5) was low, only crayfish were found.

Salamanders: Adult two lined salamanders (N=2)

Fish: None

Site Summary: This reach is ephemeral and was dry when sampled (8-27-13). The channel appears to have been modified in the past and was recovering. No fish were present and the macroinvertebrate community was poor. Only adult two lined salamanders were collected.

5.1.7 Site S2

Modified Class II (Level 1 assessment –HHEI only)

Site Description: S2 located partially on DOE property also draining into stream reach Trib 1C on the north side. The reach surveyed lies on DOE property. The stream is an ephemeral dry channel (Photo 7) draining open agricultural fields. The channel appears to be modified due to railroad bed crossing further upstream. The substrate was comprised of approximately 75% boulder slabs, boulders, bedrock, and cobbles, yielding an HHEI score of 65. It drains approximately 0.07 square miles (47 acres), of which 19 % is forested. One tiny moist depression held about 1 cm of water, water quality parameters were measured and shown below. Macroinvertebrates and salamanders were not sampled.

Photo 7. S2. 8.27.2013

Water quality parameters: pH 7.53, temp 21.9^{oc}, conductivity 825.5 μS/cm, ORP 145 mv

5.1.8 Site V1

Class I (Level 2 assessment)

Site description: V1 is an ephemeral stream located on the northwest side of DOE property, a small tributary to Little Beaver Creek. The stream reach meanders through a mature bottomland hardwood forest with a wide riparian corridor on both sides (Photo 8). The reach is relatively high gradient (Figure 5.5), has good sinuosity, and 70% gravel and sand substrate. It drains approximately 0.11 square miles (71 acres), of which 100 % is forested. It was raining on the date surveyed (9/19/13); small pool of rain water sampled for water quality parameters.

Photo 8. V1. 8.27.2013

Water quality parameters: pH 6.53, temp 19^{oc}, conductivity 86 μS/cm, ORP 269 mv

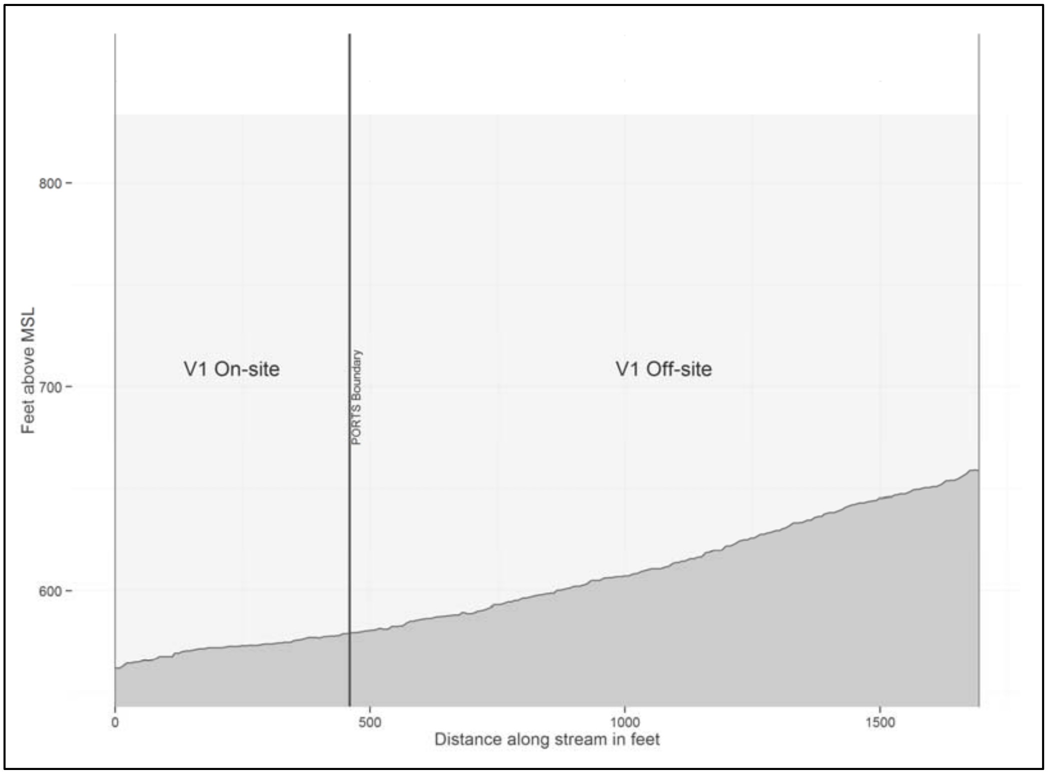


Figure 5.5 Longitudinal stream reach profile, site V1

Macroinvertebrates - The HMFEI score was very low (1) indicating poor macroinvertebrate community. Only one adult Hydrophilidae beetle was found.

Salamanders and Fish - None found

Site Summary: This reach is ephemeral, however had run-off with the recent rainfall on date sampled. Channel habitat quality scored HHEI = 36 (Class II). No fish were present and the macroinvertebrate community was poor. Only adult two lined salamanders were collected. Thus, this stream is classified as Class I.

5.1.9 Site Trib 4A

Class IIIA (Level 3 assessment)

Site description: Trib 4A is located on the northwest side of DOE property. This stream drains the Don Marquis area and is a tributary to Little Beaver Creek. Trib 4A is the headwaters of tributary 4, two section downstream of Trib 4A were also assessed. The stream reach meanders through a mature bottomland hardwood forest with a wide riparian corridor on both sides (Photo 9). This tributary's uplands are exceptionally diverse with trees aged 300+ years and riparian areas are equally rich. The reach has a moderate gradient (Figure 5.6) with its steeper section found in reach Trib 4C. Drainage from the Don Marquis to the headwaters of Trib 4A appears to have been modified resulting a new path for water to enter into Trib 4A. The headwaters of Trib 4A have experienced severe erosion with gully formation and stream entrenchment in the headwaters (Photo 9.1). Many trees were uprooted, blocking the stream path causing channel braiding in some areas. The stream has good sinuosity with the substrate made of mostly finer materials, not typical of a forested headwater stream, 70% gravel and sand substrate. The flow regime was interstitial drying in some places and reappearing with isolated pools. It drains approximately 0.13 square miles (81 acres), of which 68 % is forested.

Water quality parameters: pH 6.38, temp 20.7^{oc}, conductivity 726.4 μS/cm, ORP 68 mv

Photo 9. Trib 4A. 7.1.2013

Photo 9.1. Trib 4 Upstream. 7.01.2013

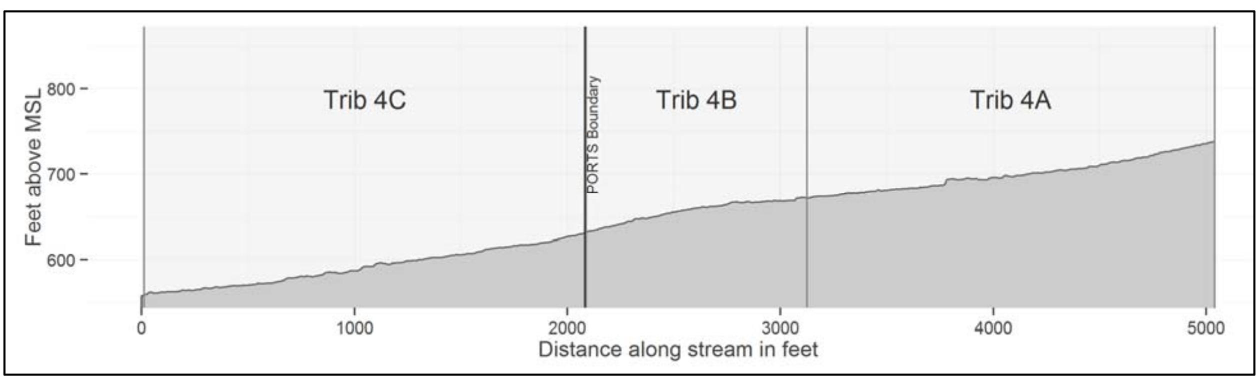


Figure 5.6 Longitudinal stream reach profile, sites Trib 4A, 4B, and 4C

Macroinvertebrates: HMFEI score (15). This reach supported an unremarkable macroinvertebrate community and was categorized as a Class II stream by the Level 2 macroinvertebrate assessment. Only a single EPT and sensitive taxa (1 Uenoid caddisfly case) was collected here and no cold water taxa (CW) were identified (Table X/x).

Salamanders: Larval two lined salamanders were collected (N= 9), but no juveniles or adults.
Fish: None

Table 5.5 List of macroinvertebrate taxa found at Trib 4A and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Decapoda	Cambaridae	2	0	0	0	
Turbellaria (CLASS)		23	0	0	0	*Dugesia* sp.
Isopoda	Asellidae	2	0	0	0	*Asellus* sp.
Coleoptera	Dytiscidae	7	0	0	0	
Coleoptera	Hydrophilidae	1	0	0	0	
Coleoptera	Dryopidae	2	0	0	0	
Diptera	Chironomidae	2		0		
Megaloptera	Sialidae	1	0	0	0	
Diptera	Tipulidae	2	0	0	0	*Tipula sp.*
Trichoptera	Uenoid? Pupal case	1	0	1	1	

Site Summary: Although the channel in this reach earned a reasonably good HHEI score for habitat (HHEI=68), it is also an extensively modified channel. An elevated water conductivity was recorded in the field (726 µS). The site earned a Class III designation largely due to the presence of larval two lined salamanders*).*

5.1.10 Site Trib 4B

Class IIIA (Level 2 assessment)

Site description: Trib 4B located downstream of Trib 4A on the northwest side of DOE property. Trib 4B is the middle reach sandwiched between Trib 4A in its headwaters and Trib 4C downstream. The stream reach meanders through a mature bottomland and oak-hickory forest with a wide riparian corridor on both sides (Photo 10). The severe erosional features found in the headwaters of Trib 4A have less of an impact on physical stream characteristics at reach Trib 4B. The stream has some sinuosity with the substrate made of mostly cobble and gravel (70%).

Photo 10. Trib 4B. 7.13.2013

Water quality parameters: pH 6.16, temp 22.3^{oc}, conductivity 406.8 µS/cm, ORP 172 mv

Macroinvertebrates: HMFEI score (8). This reaches supported a modest macroinvertebrate community and was categorized as a Class II stream by the Level 2 assessment. No EPT, cold water (CW) or sensitive taxa were identified from this site (Table 5.6).

Salamanders: Larval two lined salamanders (N= 4) were collected but no juveniles or adults.

Fish: None

Table 5.6 List of macroinvertebrate taxa found at Trib 4B and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Decapoda	Cambaridae	1	0	0	0	
Oligochaeta	Lumbriculidae	1	0	0	0	
Coleoptera	Dytiscidae	1	0	0	0	
Coleoptera	Hydrophilidae	1	0	0	0	
Diptera	Chironomidae	1				
Diptera	Tipulidae	3	0	0	0	*Tipula sp.*
Plecoptera	adult stonefly	1				

Site Summary - In spite of very nice in stream channel habitat (HHEI=85) that earned a Class III designation based on habitat alone, this section of stream did not support a good macroinvertebrate community. The presence of larval salamanders elevated the classification to Class III; however no juveniles or adults were collected.

5.1.11 Site Trib 4C

Class IIIA (Level 3 assessment)

Site description: Trib 4C is located on the northwest side of PORTS adjacent to DOE property and connects on-site sections, Trib 4A and Trib 4B, to Little Beaver Creek. The stream reach was interstitial with isolated pools. The stream meanders through a mature bottomland hardwood and mixed mesophytic forest with a wide riparian corridor on both sides (Photo 11). The reach has moderate gradient (Figure 5.6), high sinuosity, and 75% boulder, boulder slabs, and cobble substrate. All three stream reaches in Tributary 4 together, drain approximately 0.31 square miles (196 acres), of which 72 % is forested.

Photo 11. 4C. 8.27.2013

Water quality parameters: pH 7.18, temp 18.0^{oc}, conductivity 258 μS/cm, ORP 213 mv

Macroinvertebrates: HMFEI score (8). A single hydropsychid caddisfly was the only moderately sensitive taxa found at this site. The other macroinvertebrates present were tolerant taxa at very low abundances (Table 5.7). The stream was designed as Class II based on the macroinvertebrate community.

Salamanders: Larval two lined salamanders (N= 2) were collected, but no juvenile or adults.

Fish: None

Table 5.7 List of macroinvertebrate taxa found at Trib 4C and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Coleoptera	Dytiscidae	10	0	0	0	
Isopoda	Asellidae	2	0	0	0	
Decapoda	Cambaridae	1	0	0	0	
Amphipoda		1	0	0	0	
Trichoptera	Hydropsychidae	1		1		

Site Summary - This site was categorized as Class IIIA based on the presence of larval salamanders and a high habitat score (HHEI=89). However, the macroinvertebrate community here was poor, with low densities of fairly tolerant taxa.

5.1.12 Site T1

Class II (Level 1 assessment –HHEI only)

Site Description: T1 located off DOE property on the northwest side of PORTS, drains into the Little Beaver Creek. The stream is an ephemeral dry channel (Photo 12) that flows through a late-Wisconsinan (15-18 ka) outwash terrace comprised mostly of sand and gravel. The substrate was comprised of approximately 75% gravel and sand, yielding an HHEI score of 40. Macroinvertebrates (HMFEI =0), salamanders, and fish were not found. It drains approximately 0.08 square miles (54 acres), of which 94 % is forested. Water quality parameters not collected, dry stream.

Photo 12. T1. 9.10.2013

5.1.13 Site O1A

Class IIIA (Level 3 assessment)

Site Description: O1A located off DOE property on the west side of PORTS, flows into the Scioto River. The stream had a moist channel with one small isolated puddle. The stream flows from heavily forested uplands of mixed hardwoods into old field and palustrine habitat back into a successional forest on the right bank and shrub/scrub on the left bank with a wide to narrow riparian corridor, respectively (Photo 13). The reach has moderate gradient (Figure 5.7), minimal sinuosity, and 80% boulder, boulder slabs, and cobble substrate, yielding an HHEI score of 61 (Class II). It drains approximately 0.15 square miles (96 acres), of which 54 % is forested. Water quality parameters not collected, dry stream except for a small puddle.

Photo 13. O1. 9.10.2013

Water quality parameters: dry

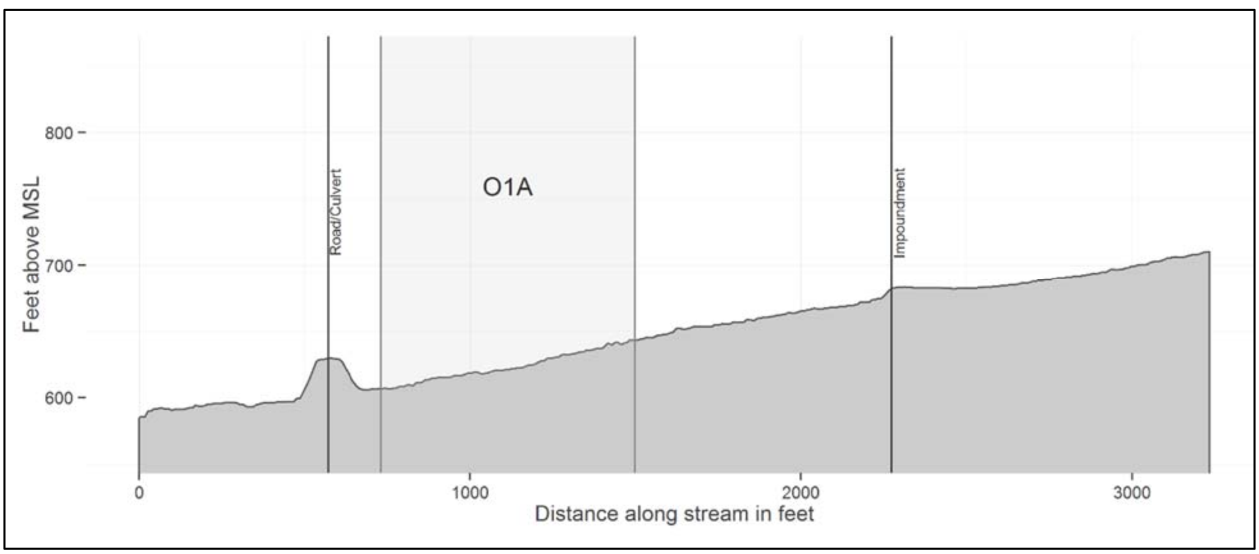


Figure 5.7 Longitudinal stream reach profile, site O1A

Macroinvertebrates: HMFEI score poor (3), with only a few crayfish, chironomids (N=2), mosquito larvae, and diving beetles (Dytiscidae).

Salamanders: Adult (N=3), juvenile (N=1) and larval (N=12) two lined salamanders were collected.

Fish: None

Site Summary: This stream reach was dry, with no surface flow, just a moist channel with one small puddle. This stream reach was elevated to Class IIIA designation solely based on the salamander population found.

5.1.14 Site Trib 7

Class II (Level 2 assessment)

Site description: Trib 7 is located on the west side of DOE property, part of a tributary to the Scioto River. The stream reach is modified and flows along the old west entrance road. There is a wide mixed hardwood forested riparian corridor on the left side and no corridor along the old entrance road covered with ruderal overgrowth on the right (Photo 15). The stream was flowing when sampled on 7-24-13, however there had been significant rainfall within 24 hours prior to sampling. The reach has a moderate gradient (Figure 5.8), no sinuosity, and 50% gravel and sand substrate. It drains approximately 0.07 square miles (44 acres), of which 49 % is forested.

Photo 15. Trib 7. 7.24.2013

Water quality parameters: pH 7.62, temp 21.3^{oc}, conductivity 444.2 μS/cm, ORP 207 mv

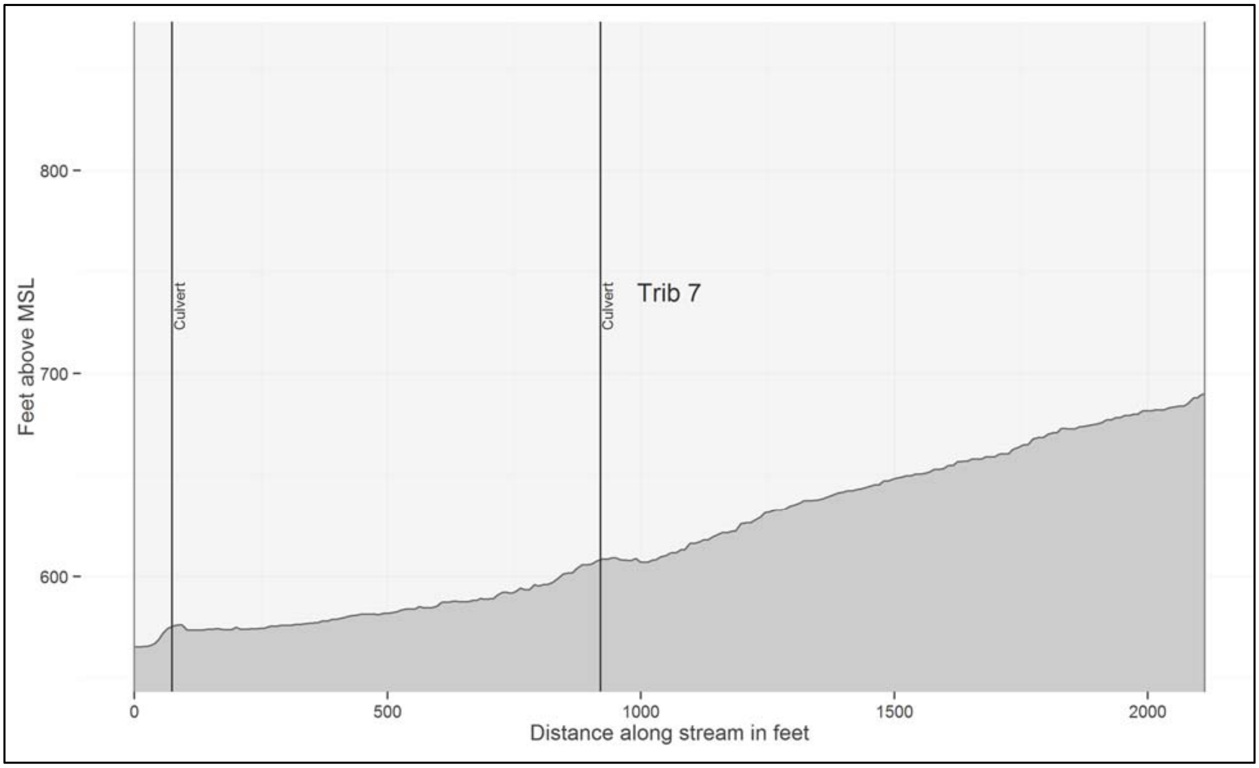


Figure 5.8 Longitudinal stream reach profile, site Trib 7

Macroinvertebrates: HMFEI score (9). The absence of any EPT taxa or moderately sensitive fishfly larvae, water penny beetles or craneflies placed this reach at the low scoring end of Class II, with an HFMEI score of 9 (only two points above the cutoff for Class I) (Table 5.8).

Salamander and Fish: None found

Table 5.8 List of macroinvertebrate taxa found at Trib 7 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Coleoptera	Dryopidae	6	0	0	0	
Amphipoda	Gammaridae	1	0	0	0	
Coleoptera	Elmidae	1	0	0	0	
Coleoptera	Dytiscidae	1	0	0	0	
Diptera	Chironomidae	2				
Diptera	Tabanidae	1	0	0	0	
Gastropoda (CLASS)	Planorbidae	3	0	0	0	
Odonata	Cordulegastridae	1	0	0	0	
Oligochaeta (CLASS)		1	0	0	0	

Site Summary - This reach has a modified channel (HHEI = 58, modified Class II), which probably accounts for the low scoring macroinvertebrate community. It appears to support neither salamanders nor fish.

5.1.15 Site Trib 9

Class IIIA (Level 3 Assessment)

Site description: Trib 9 is located on the west side of PORTS located partially on DOE property, and flows into a tributary of the Scioto River. The stream reach flows from a wetland headwater emerging from beneath aeolian sand dunes adjacent to a late-Wisconsinan outwash terrace. The stream then flows over the edge of the terrace into the alluvial plain and meanders through a mature mixed hardwood forest with a wide riparian corridor on both sides (photo=NA). The reach is relatively low gradient towards the mouth and appears to have an old breached impoundment in the headwaters (on-site) (Figure 5.9). The reach has fair sinuosity, and 75% boulder slabs, boulders, bedrock, and cobble substrate. The flow was interstitial along the outcropping bedrock. It drains approximately 0.08 square miles (48 acres), of which 21 % is forested.

Water quality parameters: pH 7.94, temp 13.8^{oc}, conductivity 1022 μS/cm, ORP 227 mv

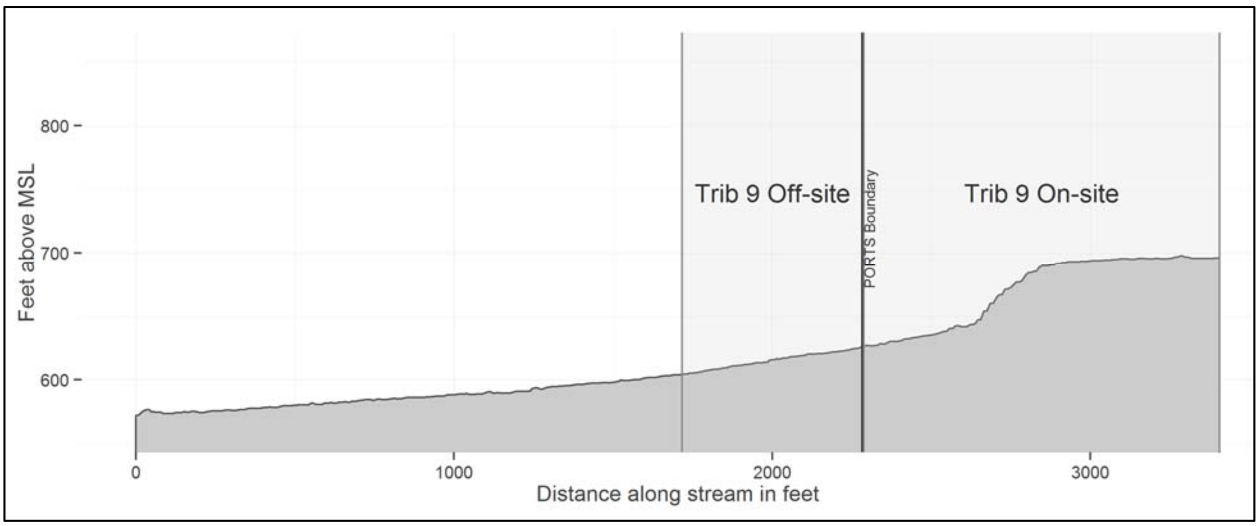


Figure 5.9 Longitudinal stream reach profile, site Trib 9

Macroinvertebrates: HMFEI score (9). A poor quality macroinvertebrate community. Tipulidae were the only moderately sensitive taxa found at this site, and they were unusually abundant (N=36). No EPT taxa, water penny beetles, fishflies or riffle beetles were found. The Level 3 bioassessment confirmed that the site did not meet the criteria of more than six cold water or sensitive genera, and the stream was designated as Class II based on the macroinvertebrates (Table 5.9).

Salamanders: Adult (N= 2) and larval (N= 3) two lined salamanders were collected, but no other salamanders*.*

Fish: None

Table 5.9 List of macroinvertebrate taxa found at Trib 9 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Oligochaeta	Lumbriculidae	1	0	0	0	
Megaloptera	Sialidae	1	0	0	0	Sialis sp.
Coleoptera	Dytiscidae	6	0	0	0	
Decapoda	Cambaridae	1	0	0	0	
Diptera	Culicidae	5	0	0	0	
Diptera	Chironomidae	2		0		
Diptera	Tipulidae	36	0	0	0	All *Tipula* sp.,
Hemiptera	Corixidae	30	0	0	0	
Hemiptera	Veliidae	4	0	0	0	

Site Summary - The presence of larval and adult two lined salamanders elevated this site to Class III even though the macroinvertebrate community was poor. The absence of EPT, sensitive or cold water macroinvertebrates, or any cold water salamanders, categorizes this stream as Class IIIA rather than B. The depauperate macroinvertebrate community was surprising given the relatively high quality instream habitat (HHEI = 78) and flow permanence as indicated by reproducing salamanders. There may be a water quality issue at this site, as the field conductivity reading was very high (1022 µS). The source of the high conductivity is unknown but may be negatively affecting the macroinvertebrate community.

5.1.16 Site Trib 10

Class IIIA (Level 3 assessment)

Site description: Trib 10 is located on the southwest side of PORTS located partially on DOE property, it flows into a tributary of the Scioto River. The stream reach flows from on-site through a control impoundment and descends into the alluvial plain and meanders through a diverse near-climax mixed hardwood forest with a wide riparian corridor on both sides (Photo 16). The reach is relatively flat, low gradient towards the mouth. However the headwaters cross a road through a culvert and flows through a treatment impoundment on DOE property (Figure 5.10). The reach has very little sinuosity, and is comprised of 75% boulder slabs, boulders, bedrock, and cobble substrate. The stream had a steady flow draining out of the upstream impoundment. The drainage basin drains the southwest corner of PORTS, approximately 0.50 square miles (320 acres), of which only 10% is forested.

Water quality parameters: pH 7.97, temp 16.9^{oc}, conductivity 451.7 µS/cm, ORP 222 mv

Photo 16. Trib 10. 10.10.2013

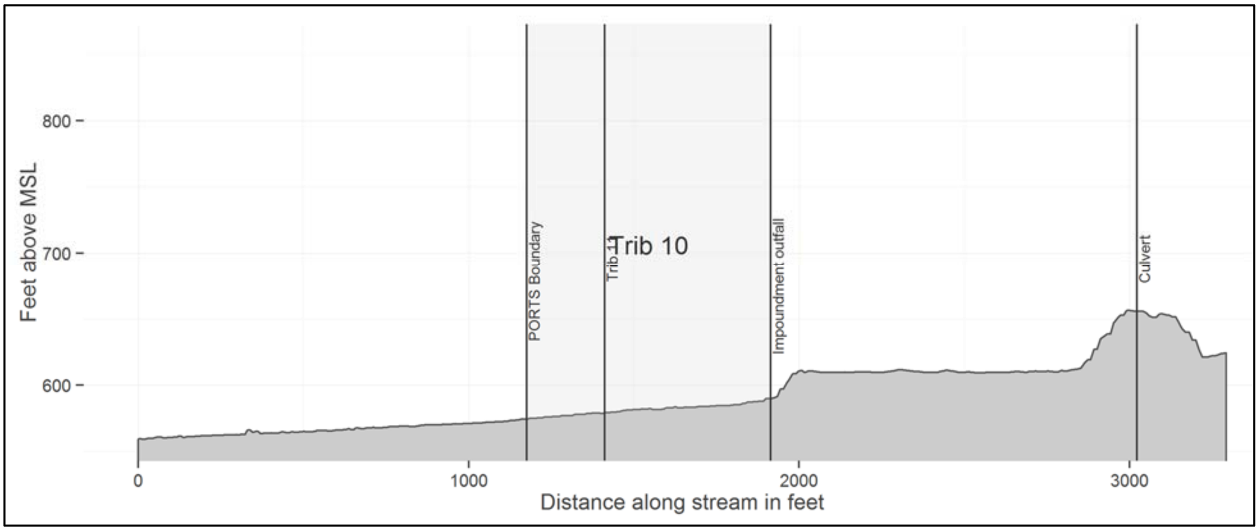


Figure 5.10 Longitudinal stream reach profile, site Trib 10

Macroinvertebrates: HMFEI score (28). This stream reach supported a high diversity of EPT taxa (four genera: *Chimarra*, *Ceratopsyche*, *Cheumatopsyche* and *Isonychia*), cranefly larvae, and water penny beetles. Elmid beetles and an abundance of Physid snails suggest rich periphyton resources. Dragonfly and damselfly diversity was high (five families). The HMFEI score >19 categorized this site as Class III PHWH. Genus level macroinvertebrate identifications indicated only 4 EPT, 4 sensitive taxa and < 6 CW taxa, consistent with a Class IIIA, rather than IIIB category (Table 5.10).

Salamanders: Reproducing two lined salamanders (N=2 juveniles, N= 1 larvae) were found, but no other salamanders, supporting the category of Class IIIA PHWH.

Fish: None

Table 5.10 List of macroinvertebrate taxa found at Trib 10 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Trichoptera	Hydropsychidae	5		1	1	N=5 *Ceratopsyche*
		22	0	1	0	N=22-24 *Cheumatopsyche* sp.
Isopoda	Asellidae	19	0	0	0	
Gastropoda	Physidae	12	0	0	0	
Odonata	Calopterygidae	12	0	0	0	
Odonata	Gomphidae	8	0	0	0	*Gomphus or Arigomphus*
Trichoptera	Philopotomidae	7	0	1	1	*Chimarra sp.*
Coleoptera	Psephenidae	6	0	0	1	*Psephenus sp.*
Coleoptera	Elmidae	6	0	0	0	*Stenelmis sp.*
Diptera	Tipulidae	3	0	0	0	*Tipula sp.*
Odonata	Coenagrionidae	3	0	0	0	

Megaloptera	Sialidae	2	0	0	0	*Sialis sp.*
Diptera	Culicidae	1	0	0	0	
Odonata	Libellulidae	1	0	0	0	
Ephemeroptera	Isonychiidae	1	0	1	1	*Isonychia* sp.
Diptera	Chironomidae	1		0		
Hemiptera	Veliidae	1	0	0	0	
Hemiptera	Gerridae	1	0	0	0	
Odonata	Aeshnidae	1		0		unID
Hemiptera	Corixidae	1	0	0	0	
						*Additionally, recorded 12 larval cases of sand, empty

Site Summary - This stream reach scored high on the physical habitat assessment (HHEI=81, Class III designation based on habitat alone) and supported high quality macroinvertebrate and salamander assemblages. All of the measures support a designation of Class IIIA designation, which was somewhat surprising given the low forest cover (10 %) of the catchment.

5.1.17 Site W1

Class IIIB (Level 3 assessment + fish)

Site description: Trib W1 is located on the south side of PORTS, partially on DOE property and is a tributary of Big Run. The stream reach flows from on-site and meanders through successional forest, and agricultural and maintained habitats with a narrow to moderate riparian corridor on right and left bank, respectively (photo 17). The reach is relatively flat, low gradient (Figure 5.11). The reach has high sinuosity and is comprised of 55% gravel and sand substrate. The stream was flowing and had good channel morphology. It drains approximately 0.99 square miles (634 acres), of which only 16% is forested.

Water quality parameters: pH 7.73, temp 25.1^{oc}, conductivity 808.3 μS/cm, ORP 121 mv

Photo 17. W1. 8.27.2013

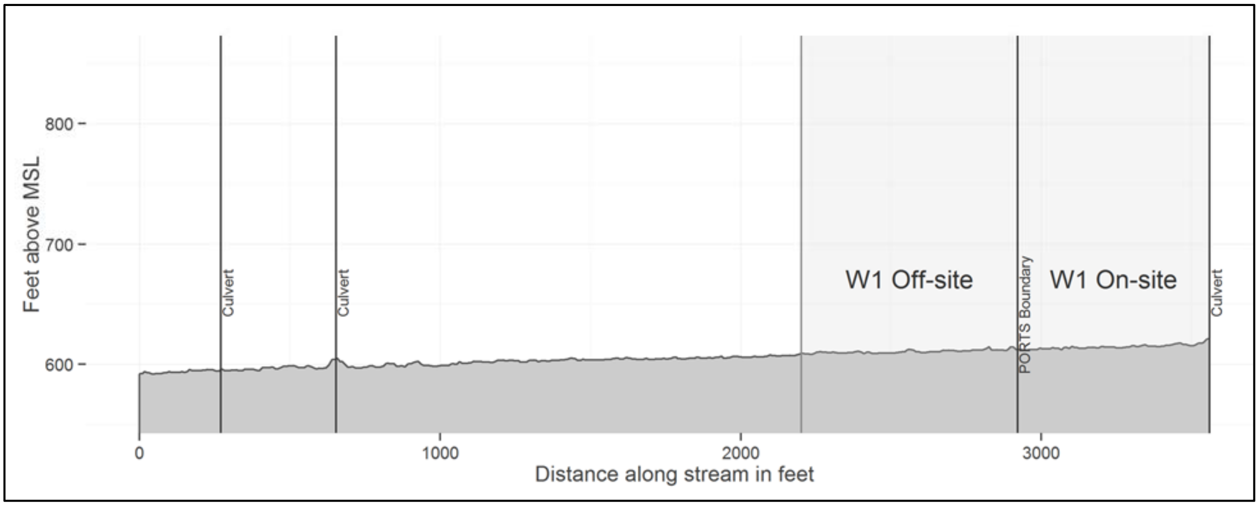


Figure 5.11 Longitudinal stream reach profile, site W1

Macroinvertebrates: HMFEI score (21). The presence of two EPT taxa (Hydropsychidae and Philopotamidae) and cranefly larvae, as well as the presence of riffle beetles, dryopid beetles and crayfish elevated the HMFEI score enough to place this stream in a Class III category. Macroinvertebrate abundances were high, with the most numerically dominant taxa being Chironomid midges, dragonfly and damselfly nymphs. Genus level identification, however confirmed presence of only two sensitive genera (*Macrostemum* and *Hexatoma*) and fewer than six EPT or cold water taxa, resulting in categorization of this site as Class IIIA (Table 5.11).

Salamanders: Larval two lined salamanders (N= 4) were collected. An adult *Plethodon electromorphus* was also collected near the stream; however these are woodland salamanders and are not indicators of flow permanence.

Fish: (N=8) 1 Fantail Darter, 5 Creek Chub, 1 Southern Red Bellied Dace, and 2 unknown Cyprinidae. Southern Red Bellied Dace is a cold water adapted Class IIIB indicator species (table 7-2 of OAC Rule 3745-1-07: Ohio EPA 1989) a definitive indicator that this stream reach meets the definition of Class IIIB quality.

Table 5.11 List of macroinvertebrate taxa found at Trib W1 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Diptera	Chironomidae	26				
Odonata	Calopterygidae	15	0	0	0	*Calopteryx sp.*
Odonata	Aeshnidae	14	0	0	0	*Boyeria vinosa*
Odonata	Coenagrionidae	12	0	0	0	
Trichoptera	Hydropsychidae	10	0	1	1	*Macrostemum sp.*
Coleoptera	Elmidae	1	0	0	0	*Dubiraphia sp.*
Coleoptera	Elmidae	17	0	0	0	*Stenelmis sp.*
Coleoptera	Elmidae	6	0	0	0	*Stenelmis sp. 'lumpy' black*
Coleoptera	Elmidae	2		0		larvae, unidentified
Trichoptera	Philopotamidae	7	0	1	0	*Chimarra sp.*
Decapoda	Cambaridae	5	0	0	0	

Odonata	Libellulidae	5	0	0	0	
Megaloptera	Sialidae	5	0	0	0	*Sialis* sp.
Diptera	Culicidae	5	0	0	0	
Coleoptera	Dytiscidae	3	0	0	0	
Diptera	Tabanidae	1	0	0	0	
Diptera	Tipulidae	1	0	0	1	*Hexatoma sp.*
Bivalve **(CLASS)***		1				** Corbicula or Sphaeriidae, 3mm*
Collembola**		1	0	0	0	*** Agrenia bidenticulata*
Coleoptera	Dryopidae	1	0	0	0	*Helichus sp.*
Turbellaria	flatworm	1	0	0	0	*Dugesia sp.*

Site Summary - This stream reach scored high on the physical habitat assessment (HHEI=77, Class III designation based on habitat alone) and supported high quality macroinvertebrate and salamander assemblages. All of the measures support a designation of Class IIIA designation, however the presence of the Southern Red Belly Dace fish elevates this stream reach to a Class IIIB. This highest categorical classification is somewhat surprising given the low forest cover (16 %) of the catchment and the residential land use presence within the stream reach surveyed.

5.1.18 Site P1

Class IIIA (Level 3 assessment)

Site description: Trib P1 is located on the southeast side of PORTS, off DOE property and is a tributary of Big Run. The stream reach flows through pasture and old field habitat (right) and mature oak-hickory forest (left) with a narrow to wide riparian corridor on right and left bank, respectively (photo 18). The reach has flat to moderate gradient (Figure 5.12). The reach lacked sinuosity with not much lateral movement and is comprised of 63% gravel and sand substrate. The stream flow was interstitial with bedrock outcropping with reach, found supplied most of water in channel. It drains approximately 0.17 square miles (109 acres), of which 27 % is forested. Note: conductivity was extremely high at this site, measured at the bedrock outcrop, primarily groundwater.

Water quality parameters: pH 6.94, temp 15.8^{oc}, conductivity 3095 µS/cm, ORP 128 mv

Photo 18. P1. 9.17.2013

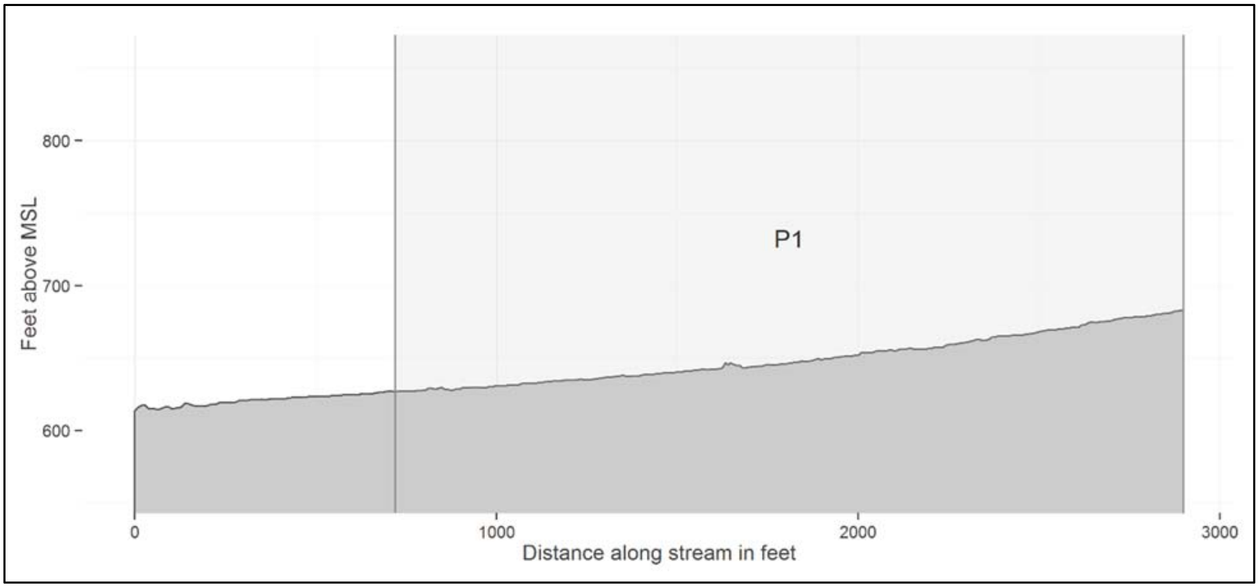


Figure 5.12 Longitudinal stream reach profile, site P1

Macroinvertebrates: HMFEI score (9), was very low. Tipulidae were the only moderately sensitive taxa found at this site. No EPT taxa, water penny beetles, fishflies or riffle beetles were found. Mosquitoes and crayfish were abundant. The modest macroinvertebrate community placed this stream in the Class II designation (Table 5.12).

Salamanders: Larval two lined salamanders (N= 27) were collected, which elevated the reach to Class IIIA. No juveniles or adult two lined salamanders were found.

Fish: None

Table 5.12 List of macroinvertebrate taxa found at Trib P1 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Diptera	Culicidae	9	0	0	0	
Decapoda	Cambaridae	8	0	0	0	
Odonata	Libellulidae	2	0	0	0	
Coleoptera	Dytiscidae	2	0	0	0	
Odonata	Aeshnidae	1	0	0	0	*Boyeria vinosa*
Odonata	Cordulegastridae	1	0	0	0	
Hemiptera	Corixidae	1	0	0	0	
Diptera	Tipulidae	1	0	0	0	
Gastropoda **(CLASS)**		1		0		right hand, operc missing
Coleoptera	Hydrophilidae	2	0	0	0	

Site summary - Physical habitat was good (HHEI = 64, Class III), however, this site had a very high specific conductivity reading (3095 µS) on the date sampled (9-17-13). The source is unknown but poor water quality may explain the absence of EPT taxa and fish. The higher designation of Class IIIA was justified only by the presence of two lined salamander larvae.

5.1.19 Site N1

Class II (Level 2 assessment)

Site description: Trib N1 is located on the east side of PORTS, off DOE property and is a tributary of the headwaters of Little Beaver Creek. The stream reach flows through pasture and successional old field habitat (left) and mature mixed hardwood forest (right) with a narrow to wide riparian corridor on left and right bank, respectively (Photo 19). The reach has flat to moderate gradient (Figure 5.13). The reach has very little sinuosity and is comprised of 60% gravel and sand substrate. The stream flow was intermittent, with one large pool located downstream of a 'head-cut', an erosional feature. It drains approximately 0.10 square miles (67 acres), of which 45 % is forested.

Photo 19. N1. 9.17.2013

Water quality parameters: pH 7.45, temp 17.2^{oc}, conductivity 234 µS/cm, ORP 174 mv

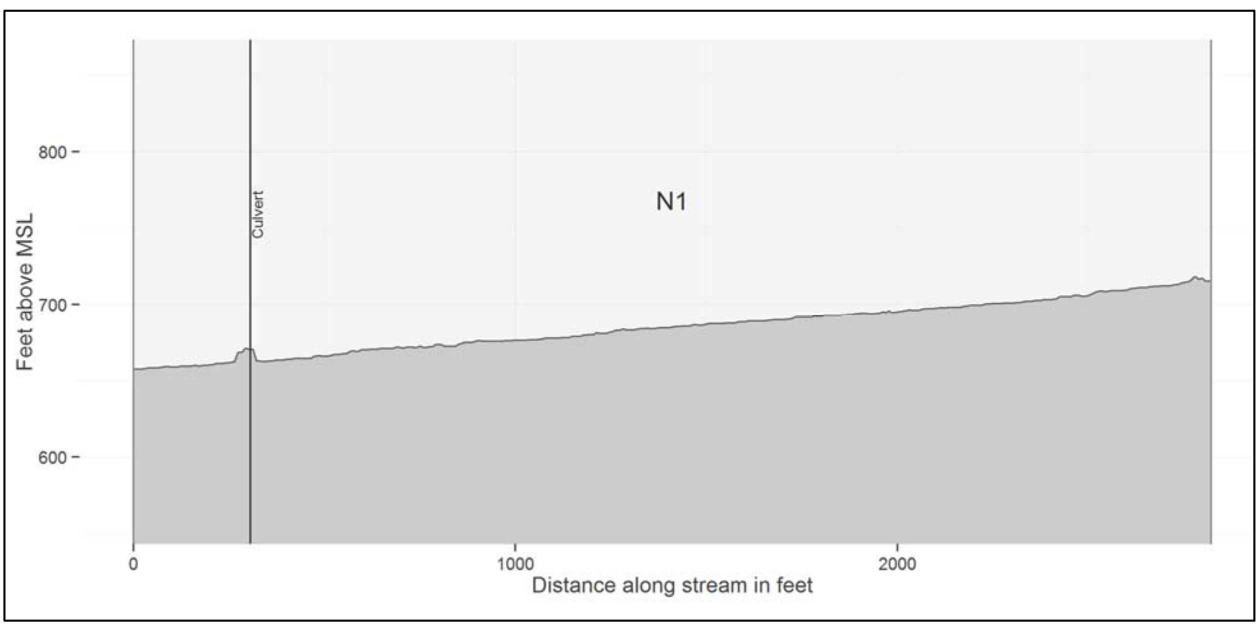


Figure 5.13 Longitudinal stream reach profile, site N1

Macroinvertebrates: HMFEI score (14). This site supported an abundance of dragonfly nymphs and mosquito larvae typical of slow, well-vegetated waters, but no EPT taxa and only one moderately sensitive headwater taxa (Corydalidae). It was categorized as a Class II stream based on the macroinvertebrates

Salamanders: One adult salamander was seen but escaped.

Fish: None

Site Summary - Although the physical habitat score of this reach was high (HHEI=73) and suggested a Class III designation, the macroinvertebrates, salamanders and fish all supported a lower (Class II) designation.

5.1.20 Site B1

Class IIIB (Level 3 assessment + fish)

Site description: Site B1 is located on the east side of PORTS, off DOE property and is a tributary of the headwaters of Little Beaver Creek. The stream reach flows from mature mixed hardwood uplands down through mostly agricultural lands with successional bottomland hardwoods and mixed shrub/scrub habitat along the stream corridor. The reach is relatively low gradient (Figure 5.14), slightly entrenched, and has minimal riparian corridor on either side (Photo 20). The reach lacks sinuosity and is comprised of 65% cobble and gravel substrate. The stream flow was intermittent, with pools throughout reach. It drains approximately 0.52 square miles (333 acres), of which 58 % is forested.

Water quality parameters: pH 7.03, temp 17.3^{oc}, conductivity 162.3 μS/cm, ORP 115 mv

Photo 20. B1. 9.17.2013

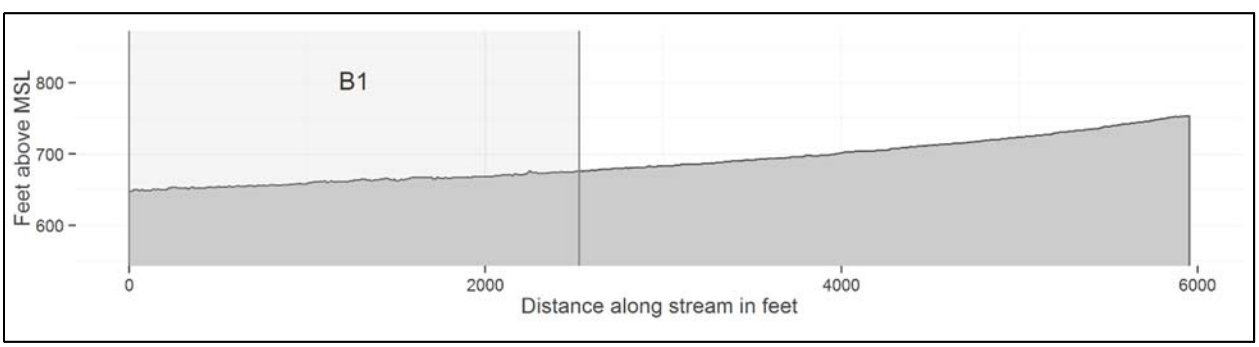


Figure 5.14 Longitudinal stream reach profile, site B1

Macroinvertebrates: HMFEI score (9). The macroinvertebrate community was dominated by tolerant taxa. No EPT, cold water or sensitive taxa were present at the time of sampling (Table 5.13).

Salamanders: Adult (N= 2) and larval (N= 11) two lined salamanders were collected.

Fish: (N=9) 1 Southern Red Bellied Dace, 6 Creek Chub, 2 Fantail Darters. Southern Red Bellied Dace is a cold water adapted Class IIIB indicator species (table 7-2 of OAC Rule 3745-1-07: Ohio EPA 1989) a definitive indicator that this stream reach meets the definition of Class IIIB quality.

Table 5.13 List of macroinvertebrate taxa found at Trib B1 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Gastropoda	Physidae	16	0	0	0	
Decapoda	Cambaridae	11	0	0	0	
Odonata	Libellulidae	7	0	0	0	
Diptera	Chironomidae	4				
Odonata	Aeshnidae	3	0	0	0	Boyeria vinosa
Bivalve (CLASS)		1	0	0	0	
Coleoptera	Dytiscidae	1	0	0	0	
Hemiptera	Hebridae	1	0	0	0	
Diptera	Dixidae	1	0	0	0	
Diptera	Culicidae	1	0	0	0	

Site Summary - The macroinvertebrate community was relatively poor, in spite of the presence of a diversity of fish and a reproducing population of two lined salamanders. The physical habitat of the stream reach was not high quality, with an HHEI score of 69 which would have designated the stream as Class II based on habitat alone. The presence of a reproducing population of salamanders elevated this stream classification to Class IIIA and the presence of the Southern Red Bellied Dace fish elevates the reach to Class IIIB.

5.1.21 Site Trib 6

Class IIIA (Level 3 assessment)

Site description: Trib 6 is located on the east side of DOE property and is a tributary of the headwaters of Little Beaver Creek. The stream reach flows from mature mixed hardwood forest uplands descending through a variety of successional habitats along its moderately wide stream corridor (Photo 21). Some exceptional forest habitat was found adjacent to this stream that hosts a number of plant species not previously reported from Pike County. The reach has flat to moderate gradient (Figure 5.15). The reach has high sinuosity and is comprised of 65% gravel and sand substrate. The stream was flowing when measured on 7-24-13. It drains approximately 0.09 square miles (55 acres), of which 63 % is forested.

Water quality parameters: pH 7.07, temp 21.3^{oc}, conductivity 200 μS/cm, ORP 228 mv

Photo 21. Trib 6. 7.24.2013

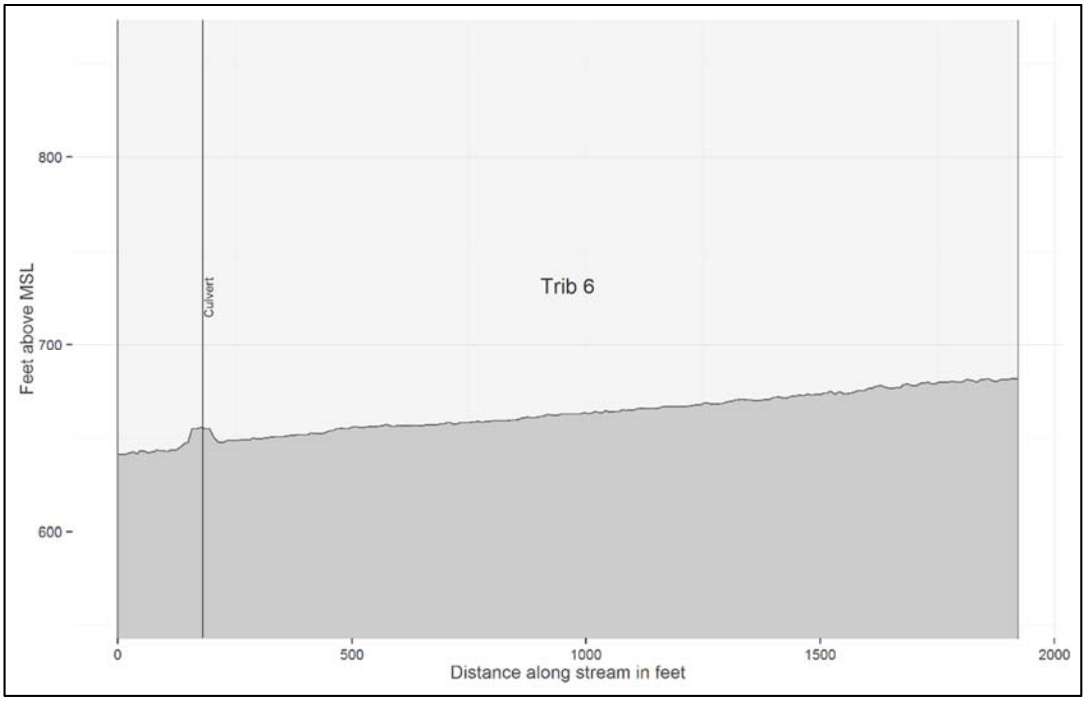


Figure 5.15 Longitudinal stream reach profile, site Trib 6

Macroinvertebrates: HMFEI score (11). The presence of only one EPT taxa (a single Baetidae mayfly) in the sample helped categorize this reach as a Class II PHWH stream. The numerical dominance of aquatic worms and fly larvae (Tabanidae, Ceratopogoniidae and Culicidae) further indicated a lesser quality biological community (Table 5.14).

Salamander: Larval two lined salamanders (N= 8) were collected, but no juveniles or adults.
Fish: None

Table 5.14 List of macroinvertebrate taxa found at Trib 6 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Oligochaeta **(CLASS)**		16	0	0	0	
Gastropoda **(CLASS)**	Physidae	8	0	0	0	
Isopoda	Asellidae	3	0	0	0	
Odonata	Cordulegastridae	2	0	0	0	
Diptera	Chironomidae	2		0		
Diptera	Culicidae	2	0	0	0	
Coleoptera	Hydrophilidae	2	0	0	0	
Decapoda	Cambaridae	1	0	0	0	
Odonata	Libellulidae	1	0	0	0	
Odonata	Aeshnidae	1	0	0	0	*Boyeria vinosa*
Ephemeroptera	Baetidae	1		1		
Hemiptera	Corixidae	1	0	0	0	
Diptera	Ceratopogonidae	1	0	0	0	
Diptera	Tabanidae	1	0	0	0	
Coleoptera	Dytiscidae	1	0	0	0	
Hemiptera	Veliidae	1	0	0	0	
*one right handed gastropoda with a missing operculum				0		

Site Summary - The physical channel earned a relatively high HHEI score (= 67, Class III based on habitat alone) and the catchment is well-forested (62%). The presence of larval salamanders elevated the site to Class III; however the macroinvertebrate community is more typical of Class II.

5.1.22 Site Trib 8

Class IIIA (Level 3 Assessment)

Site description: Trib 8 is located on the east side of PORTS, partially on DOE property. It is a tributary of Little Beaver Creek. The stream reach flows from mature mixed hardwood uplands then meanders slowly through a mixed bottomland hardwood forest with a wide riparian stream corridor (Photo 22). The reach has flat to moderate gradient (Figure 5.16). The reach has high sinuosity and is comprised of 52% cobble and gravel substrate. The stream was flowing when measured on 7-24-13. It drains approximately 0.19 square miles (119 acres), of which 48 % is forested (Forest cover determined from 2013 data, since then portions of the headwaters of this reach have been clear cut).

Water quality parameters: pH 7.06, temp 22^{oc}, conductivity 312 μS/cm, ORP 136 mv

Photo 22. Trib 8. 7.24.2013

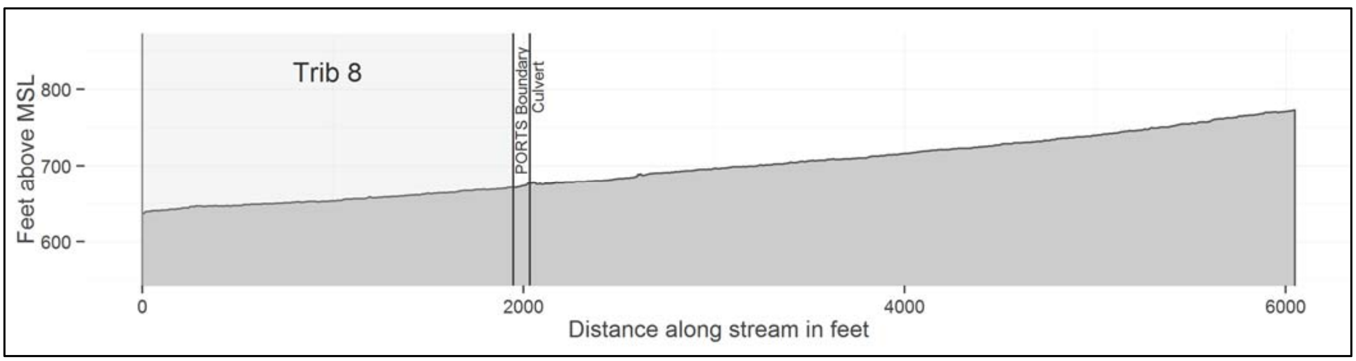


Figure 5.16 Longitudinal stream reach profile, site Trib 8

Macroinvertebrates: HMFEI score (22). The presence of tipulid craneflies, and three EPT taxa (Baetidae, Philopotamidae and Hydropsychidae) resulted in the designation of this site as a Class III PHWH stream during the Level 2 assessment. During the Level 3 assessment, fewer than 3 EPT or sensitive genera, and no CW specialists were identified in the sample, supporting the classification of this stream as Class IIIA (Table 5.15).

Salamanders: Five (N=5) larval two lined salamanders were collected, but no other species of cold water salamanders, further supporting the classification of this stream as Class IIIA.

Fish: (N=2) 1 Fantail Darter, 1 Creek Chub

Table 5.15 List of macroinvertebrate taxa found at Trib 8 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Hemiptera	Gerridae	4	0	0	0	
Odonata	Libellulidae	4	0	0	0	
Gastropoda **(CLASS)**	Physidae	3	0	0	0	
Coleoptera	Elmidae	3	0	0	0	*Stenelmis sp.*
Decapoda	Cambaridae	2	0	0	0	
Oligochaeta **(CLASS)**		2	0	0	0	
Megaloptera	Sialidae	1	0	0	0	*Sialis sp.*
Odonata	Cordulegastridae	1	0	0	0	
Ephemeroptera	Baetidae	1		1		Not ID to genus
Trichoptera	Hydropyschidae	1	0	1	1	*Macrostemum sp*
Trichoptera	Philapotomidae	1	0	1	1	*Chimarra sp.*
Diptera	Tabanidae	1	0	0	0	
Diptera	Tipulidae	1	0	0	0	

Site Summary - This reach supports a reasonably high quality macroinvertebrate and reproducing two lined salamander populations. The habitat of the channel was also relatively high (HMFEI = 77), consistent with Class III designation.

5.1.23 Site Trib 3

Class II (Level 3 assessment)

Site description: Trib 3 is located on the east side of DOE property. It is a tributary of Little Beaver Creek. The stream reach meanders through mature mixed hardwood forest and has wide riparian stream corridor (Photo 23). The mouth of this tributary contains extensive forested wetlands, these wetlands were not included in the reach surveyed. The sampled reach has moderate gradient (Figure 5.17) with good sinuosity and is comprised of 80% cobble and gravel substrate. The stream flow was interstitial with isolated pools. It drains approximately 0.11 square miles (69 acres), of which 98 % is forested.

Photo 23. Trib 3. 7.01.2013

Water quality parameters: pH 6.24, temp 20.5^{oc}, conductivity 648.4 µS/cm, ORP 176 mv

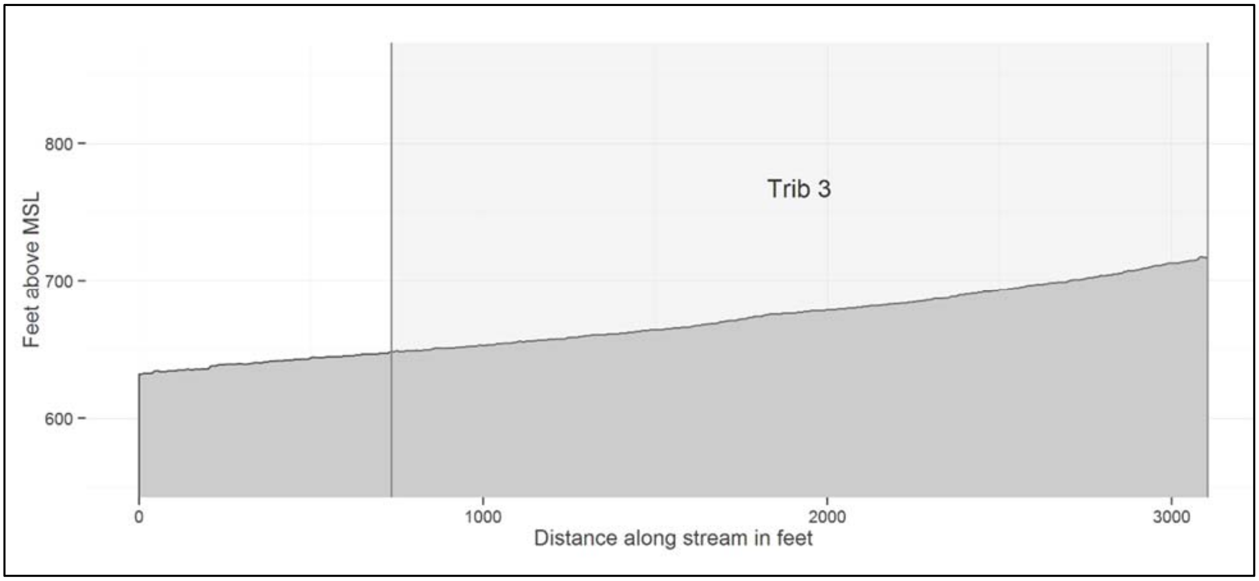


Figure 5.17 Longitudinal stream reach profile, site Trib 3

Macroinvertebrates: HMFEI score (12). The macroinvertebrate community, with no EPT taxa and only one moderately sensitive headwater taxa (Corydalidae), placed this site squarely into Class II designation. Dytiscid and hydrophilid beetles were the most numerically dominant taxa (Table 5.16).

Salamanders: Numerous (N=10) larval *Ambystoma* sp. salamanders were collected, but no headwater salamanders.

Fish: None

Table 5.16 List of macroinvertebrate taxa found at Trib 3 and their qualitative and quantitative data

Order	Family	Individuals	CW	EPT	Sensitive	Comments
Oligochaeta (CLASS)	Lumbriculidae	1	0	0	0	
Amphipoda (CLASS)	Gammaridae	2	0	0	0	
Coleoptera	Dytiscidae	12	0	0	0	
Coleoptera	Hydrophilidae	1	0	0	0	
Coleoptera	Dryopidae	1	0	0	0	
Diptera	Culicidae	1	0	0	0	
Diptera	Chironomidae	1	0	0	0	
Megaloptera	Corydalidae	2	0	0	0	*Nigronia serricornalis*
Decapoda	Cambaridae	6	0	0	0	
Hemiptera	Corixidae	1	0	0	0	

Site Summary - In spite of the fact that the catchment for Trib 3A is well-forested (98 %) and the physical channel is of good quality (HHEI=66, suggesting a possible Class III categorization) , it does not support a high quality macroinvertebrate community or reproducing salamanders indicative of permanent flow. Water conductivity was somewhat elevated (648 µS). The site was characterized by a moderate gradient and large limestone boulders, with very low flow and interstitial pools.

5.2 Summary of results

Site-by-site data was used to develop the following maps and tables. Figure 5.18 shows the primary headwater habitat sample site locations, its PHWH classification, and the stream reach highlighted in blue that represents the stream reach to which the classification applies. Table 5.17 summarizes the various levels of classification results from physical and biological data collected. Starting with the basic level 1 physical habitat (HHEI) score and classification, moving to the level 2 assessment of macroinvertebrate (HMFEI) score and classification, salamanders and fish identification. Level 3 assessment is the final arbiter of the PHWH classification process. The presence of certain cold water adapted species of salamander and fish found at numerous sites elevated nine sites to a higher classification, based on HHEI and HMFEI scores alone these sites had a lower classification.

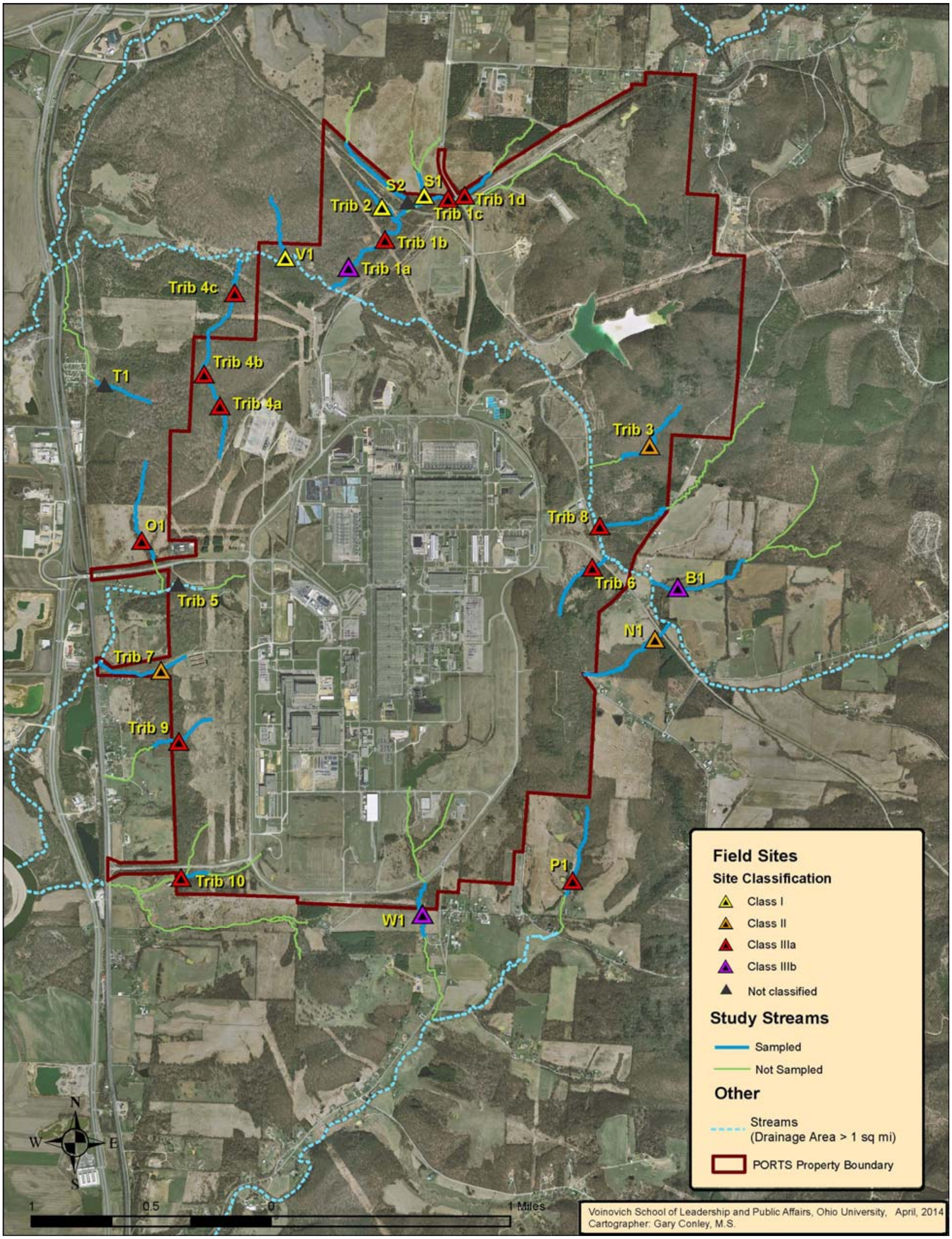


Figure 5.18 Map of field study sites and their PHWH classification at PORTS

Table 5.17 Summary table of primary headwater stream habitat classifications

Sample point	HHEI score	HHEI class	HMFEI score	HMFEI class	Class based on Salamander data	Class based on Fish data	Final PHWH class
trib 1a	78	III	37	III	IIIa	IIIb	IIIb
trib 1b	78	III	37	III	IIIa		IIIa
trib 1c	95	III	30	III	IIIa		IIIa
trib 1d	45	mod II	17	II	IIIa		IIIa
trib 2	64	II	1	I	I		I
S1	63	mod II	5	I	I		I
S2	65	mod II	NA	NA	NA		not classified
V1	36	II	1	I	I		I
Trib 4a	68	mod II	15	II	IIIa		IIIa
Trib 4b	85	III	8	II	IIIa		IIIa
Trib 4c	89	III	8	II	IIIa		IIIa
T1	40	II	NA	NA	NA		not classified
O1A	61	II	3	I	IIIa		IIIa
Trib 7	58	mod II	9	II	II		II
Trib 9	78	III	10	II	IIIa		IIIa
Trib 10	81	III	28	III	IIIa		IIIa
W1	77	III	21	III	IIIa	IIIb	IIIb
P1	64	III	9	II	IIIa		IIIa
N1	73	III	14	II	II		II
B1	69	II	9	I	IIIa	IIIb	IIIb
Trib 6	67	III	11	II	IIIa		IIIa
Trib 8	77	III	22	III	IIIa		IIIa
Trib 3	66	III	12	II	II		II

PHWH data for each site classification was extrapolated to include a representative length of stream. The classification was applied to these stream reaches (Figure 5.19). The extent of these reach classifications are based on best professional judgment taking into account the immediate land cover and habitat, physical barriers, and ownership (land use). Table 5.18 shows the length of each of these stream reaches and ownership. If the tributary has shared ownership with an adjacent landowner, it is indicated as 'partial'.

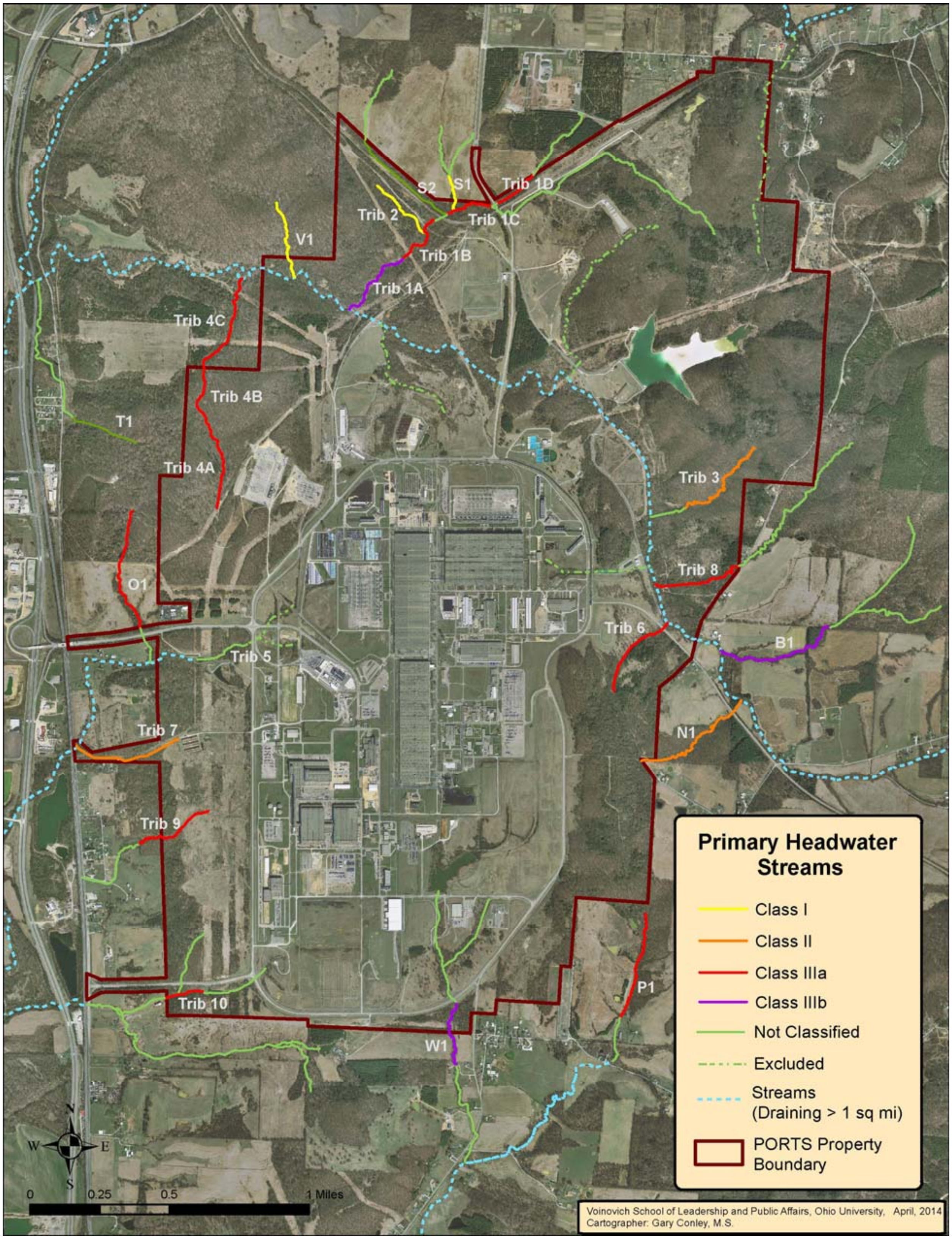


Figure 5.19 Primary headwaters stream reach classifications at PORTS

Table 5.18 List of PHWH stream reach lengths, PHWH classification, and ownership

Stream reach	Length (ft)	PHWH classification	Ownership
trib 1A-1B	2855	IIIb – IIIa	on-site
trib 1C	965	IIIa	on-site
trib 1D	944	IIIa	on-site
trib 2	1361	I	on-site
S1	791	I	partial
S2	2211	Not classified	partial
V1	1718	I	partial
Trib 4A	1914	IIIa	on-site
Trib 4B-4C	4840	IIIa	partial
T1	1369	Not classified	off-site
O1A	725	IIIa	off-site
Trib 7	2112	II	on-site
Trib 9	1690	IIIa	partial
Trib 10	738	IIIa	on-site
W1	1357	IIIb	partial
P1	2179	IIIa	off-site
N1	2821	II	off-site
B1	2489	IIIb	off-site
Trib 6	1922	IIIa	on-site
Trib 8	1948	IIIa	partial
Trib 3	2371	II	on-site

Together there are 3,870 ft of Class I streams, 7,305 ft of Class II streams, and 24,565 ft of Class III streams. Table 5.19 summarizes the length of streams within each of the PHWH stream classifications.

Table 5.19 Summary of total lengths of PHWH stream reach classifications

PHWH Classification	# of sites	Total length (ft)
Class I	3	3,870
Class II	3	7,305
Class III	13	24,565

6 Discussion

From the results of this study, the point data (extrapolated to represent the stream reach segments) are further expanded to include the drainage basin or catchment of the sampled reach segments. The area of land surrounding each reach segment is important because the management options discussed apply to areas of land in addition to the stream channel itself. The management options for the sites fall into three broad categories: preservation, conservation, and restoration. Preservation generally involves the least amount of active intervention, relying instead on *protection of high quality habitats against future degradation* by preserving (minimizing changes) to land surrounding stream segments. This is usually the recommended option for mitigation. Conservation typically involves minimal active management plus preservation, in that land use changes may occur but practices are put into place to minimize the impact on plant or animal populations. Some interventions may occur to *prevent further degradation* of the habitat; for example, removal of invasive species, implementation of practices to prevent further erosion, or maintaining existing hydrological features (i.e. ponds). Restoration is the most active management approach, and involves activities that address a goal of significantly *improving* habitat quality beyond its current state. Restoration activities include: channel restoration, channel stabilization, riparian planning, dam removal, establishing fishways, and/or culvert removal or replacement (NOAA ND). The management suggestions or recommendations for mitigation that are discussed in this section will need to be further refined at the time of mitigation to obtain the proper planning, engineering design, and costs of each management practice.

To assist in the discussion, the stream reach segments have been grouped into three rankings. Stream segments with desirable attributes for the highest performance for mitigation are colored 'red', 'fair' colored orange, and lower priority are colored 'yellow'. Desirable attributes include: on-site (DOE) ownership, high biological and physical stream quality, and the continuous length of stream available (Figure 5.18).

Catchment basins have also been divided into three groups based on their mitigation management preference. Catchments that are best suited for preservation are colored 'red', areas where biological outcomes could be sustained with minimal conservation practices are colored ' orange', and areas where stream, channel, or riparian restoration are needed to improve or sustain the biological quality of the streams are colored in 'yellow'. The most cost effective and efficient choice for mitigation is preservation, since simply preserving the land in its 'as-is' conditions to allow for natural succession yields the best results.

The mitigation management preference for each catchment basin and the stream performance rankings are shown in Figure 6.1. For example, a red stream segment and a red shaded catchment can be thought of in terms of mitigation as a top choice since the quality of stream is likely high, the site is most likely located on-site, or the length of the stream is relatively long and has mitigation options that are the most cost effective and efficient. A yellow stream and a yellow shaded catchment, is likely poorer quality stream, or one that has significant off-site segments, is a relatively shorter segment, or is in need of major restoration to improve its biological quality.

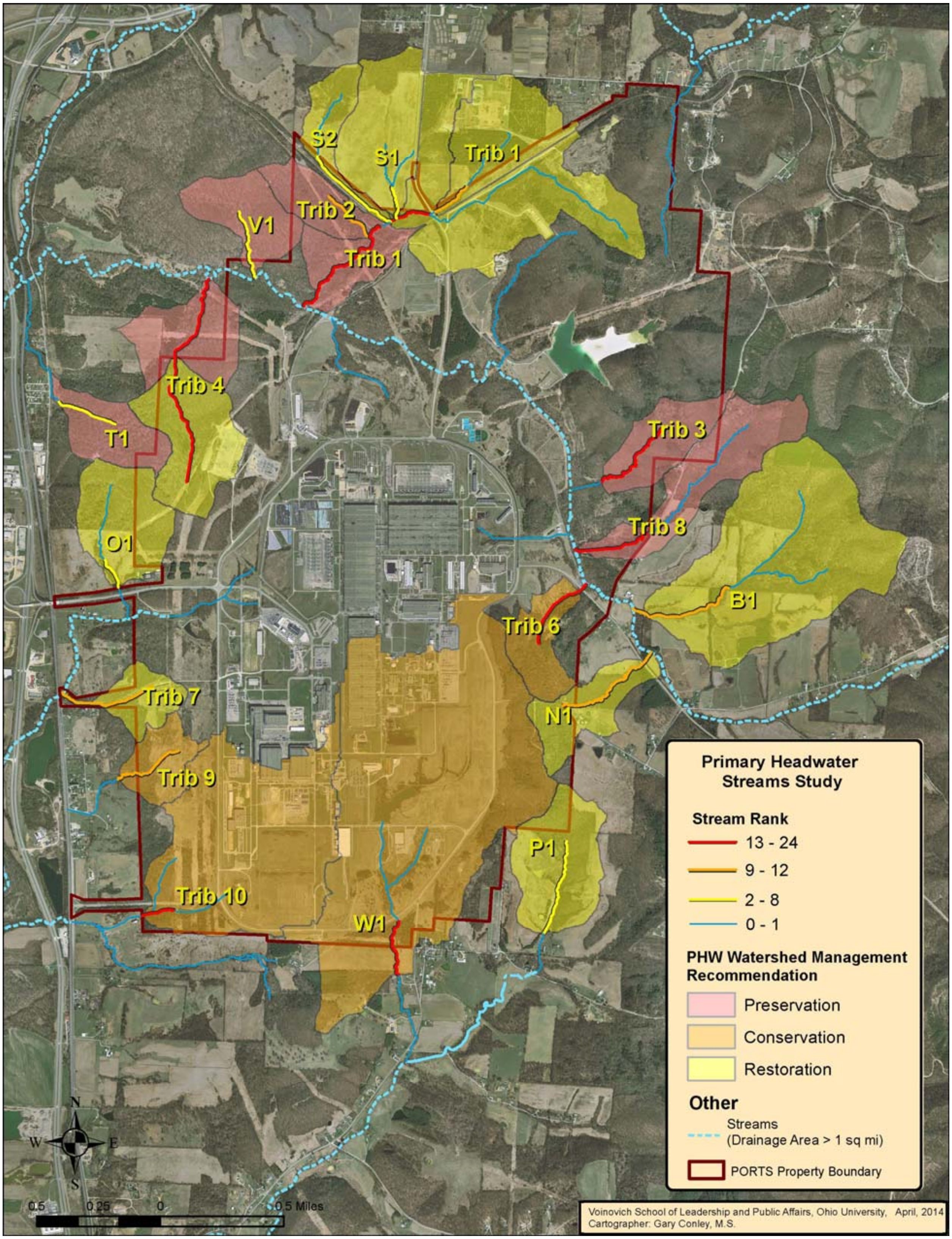


Figure 6.1 PHWH stream reach mitigation management recommendation and its performance rank

6.1 Preservation

Preservation is described as preserving the existing quality of the land surrounding a stream segment through the various legal avenues discussed in the Background (Section 2). Seven of the studied stream reaches fall into this category and are best suited for preservation options (Table 6.1). This section details the qualitative and quantitative features of these sites that were considered in determining the feasibility for mitigation.

Table 6.1 Lists physical attributes of study sites manageable for preservation mitigation options in ranked order

Site	Drainage area (acres)	Reach length (feet)	Ratio length/area (# ft : # ac)	FQAI Native	% Forested	% Palustrine	Performance score
Trib 1A-1B	593.2	2855	4.81	14.97	47.42	1.36	24
Trib 8	118.8	1947.5	16.39	16.91	48.12	0	16
Trib 3	68.8	2371.3	34.47	10.56	97.68	0.01	14
Trib 4B-4C	196	4839.5	24.69	16.94	72.49	0.07	13
Trib 2	46.8	1361	29.08	9.7	63.48	1.57	9
V1	70.5	1717.9	24.37	15.51	100	0	8
T1	54.3	1369.4	25.22	14.63	94.19	0	3

6.1.1 Site Trib 1A-1B

Stream reach Trib 1A – 1B totals 2,855 ft in length and ranks the highest of all stream segments for preservation. Its overall length, on-site location, high biological quality and high in-stream habitat (HMFEI) score makes this site a priority for preservation. Basin qualities include: 47 % forested, 1.36 % palustrine habitat, and an FQAI score of 14.97.

6.1.2 Trib 8

Stream reach Trib 8 totals 1,948 ft and ranks second highest for preservation. However, the headwaters of this site are not owned by DOE and parts have recently been clear-cut. The ability to control the quality of this stream reach into the future is therefore uncertain. Preservation is the preferred mitigation option however, on-going monitoring is recommended to track changes if there are land use changes offsite.

6.1.3 Trib 3

Stream reach Trib 3 is a late successional forest with a recovering watershed. The stream substrate is less stable, and has shifting and sorting sediments that yield a lower biological quality. It is not of the highest quality (Class II) but has a fairly long length; Trib 3 totals 2,371 ft of Class II stream habitat. The mouth of Trib 3 also contains forested wetlands of high quality and the preservation of this upstream stream segment and catchment are important for the quality of the downstream wetlands. The ratio of stream length to area of land is 34, meaning 34 ft of stream are gained for every acre preserved. This is a relatively high ratio compared to the other stream segments recommended for preservation. The upstream sections could be improved under the management of preservation to allow natural succession to occur. Portions of the headwater forest had previously been disturbed and are in a state of recovery.

6.1.4 Trib 4B - 4C

Stream segments Trib 4B - 4C represents a relatively long stream length of 4,839 ft. Partial ownership is not ideal for preservation options. The stream appears to have a limited amount of organic matter and may have reduced much nutrient cycling, however the streams are of high quality Class IIIA. The upstream headwater section Trib 4A is discussed in the restoration section and any improvements made to improve erosion and scouring in Trib 4A will likely improve downstream segments as well. The catchment is of high quality with 72% forested land cover and an FQAI score of 16.9.

6.1.5 Trib 2

Trib 2, representing 1,361 ft of relatively poor quality Class I stream habitat, drains into Trib 1A-1B. While not of high quality itself, its preservation could be important. This 47 acres of drainage area contribute to downstream segments Trib 1A-1B and should be considered for preservation along with Trib 1A and 1B. The upstream headwaters of Trib 2 contains 1.57 % palustrine habitat and in total is 65 % forested.

6.1.6 V1

Stream V1 is a Class I stream totaling 1,717 ft. While this basin is 100% forested, its PHWH quality is low and is located off-site. The catchment is of high quality with an FQAI score of 15.5, but its PHWH is Class I due to its lack of hydrology and connection to groundwater that would otherwise make it a higher quality primary headwater stream. No conservation or restoration actions are recommended, but preservation of the catchment would be of some value to Little Beaver Creek. Thus, management of this stream would fall into the preservation category and would be of low priority.

6.1.7 T1

Stream T1 totals 1,369 ft and is not classified. This site lacks the hydrology and connection to groundwater to make a higher quality primary headwater stream. Because no conservation or restoration actions are recommended, the stream falls into the preservation category of management and is of low priority.

6.2 Conservation

Conservation of habitat typically involves minimal active management elements compared to preservation, but is a management option when it is expected that some land use changes will occur. Conservation practices are implemented with the goal of minimizing the impact of those changes on plant or animal populations and/or ecological integrity. Interventions aim to *prevent further degradation* of the habitat; for example, the addition of minimal stabilizing features to stream channels, implementation of practices to prevent further erosion, maintaining existing hydrologic features, or removal of invasive species.

The following four sites were judged to be best suited for conservation options based on their performance criteria (Table 6.2). This section details the qualitative and quantitative information used to determine their value for mitigation.

Table 6.2 Lists physical attributes of study sites manageable for conservation mitigation options in ranked order

Site	Drainage area (acres)	Reach length (feet)	Ratio length/area (# ft : # ac)	FQAI Native	% Forested	% Palustrine	Performance score
Trib 10	320.6	738.4	2.30	12.44	9.79	0.17	17
Trib 6	55.4	1921.9	34.69	9.80	62.54	0.00	14
W1	632.6	1357.4	2.15	13.10	16.37	0.03	13
Trib 9	48.3	1689.6	34.98	NA	21.19	0.29	12

6.2.1 Trib 10

Stream 10, while a relatively short segment (738 ft), ranked high for conservation, with a Class IIIA classification. Interestingly, the catchment has little forest cover (9.7 %) and a moderate FQAI score (12.4). The headwaters of this stream lies on the industrial part of the PORTs facility in the southwest corner, which is not forested and is in a non-natural state. The likely reason Trib 10 performs well is due to a constant supply of water from an existing pond used to treat effluent water for the PORTs facility. This pond likely supplies this downstream stream reach with sufficient volume of water that allows for higher biodiversity. Under other circumstances, this stream would not likely perform as well given its lack of habitat features. With minimal conservation practices, such as maintaining the pond outflow, this section of stream could maintain its high quality.

6.2.2 Trib 6

Trib 6 totals 1,922 ft and earned a Class IIIA status based on the salamanders found during sampling. The macroinvertebrates found were of lesser value and constituted only a Class II. While the catchment is only 62 % forested, it yielded a low FQAI score (9.8). With minimal conservation practices, the in-stream habitat and stream morphology could be improved to allow the macroinvertebrate communities to increase.

6.2.3 W1

Site W1 located partially on-site totals 1,357 ft of Class IIIB stream. This site is similar to Trib 10 in on-site land use of its catchment with only 16 % forested cover and a moderate FQAI score (13.1). However, the stream segment scored very high likely due to on-site ponds that contribute process water to the streamflow. That source of water would likely need to be maintained to continue to supply water to this downstream segment and maintain its quality.

6.2.4 Trib 9

Trib 9 totals 1,689 ft and similar to Trib 6 earned a Class IIIA status based on the salamanders found during sampling. The headwaters of this site appears to have been impounded at one time. An earthen and brick dam breached many years ago has left eroded gullies and excess sediment. High conductivity water may need to be investigated at this site to assess its potential impact on water and/or biological quality. With minimal conservation efforts, the stream morphology could be stabilized and the source of high conductivity water addressed.

6.3 Restoration

Restoration represents a more active management approach that aims to significantly improve the quality of the stream through practices such as, but not limited to, reconstruction of the stream channel, stream re-location, major riparian plantings, culvert removal/replacement, or establishing fishways. While the outcome of restoration practices are inherently less predictable than preservation or conservation, in some instances modest alterations can result in substantial improvements of habitat quality and stream class designations.

The following ten sites were determined to be best suited for restoration options based on their performance criteria (Table 6.3). This section details the qualitative and quantitative features and potential restoration activities that could be utilized to improve the quality of these streams for mitigation purposes.

Table 6.3 Lists physical attributes of study sites manageable for restoration mitigation options in ranked order

Site	Drainage area (acres)	Reach length (feet)	Ratio length/area (# ft : # ac)	FQAI Native	% Forested	% Palustrine	Performance score
Trib 1C	327.3	964.5	2.95	12.58	34.98	1.75	16
Trib 4A	81.4	1914	23.51	13.98	67.58	0.00	13
Trib 7	43.6	2112.2	48.44	11.57	49.44	2.13	11
N1	67.1	2821.2	42.04	11.44	45.18	0.00	11
Trib 1D	102.6	944.3	9.20	12.58	36.28	0.11	9
B1	333.3	2489.2	7.47	17.83	58.24	1.37	9
P1	109.2	2178.6	19.95	15.19	26.65	0.05	8
S2	46.9	2211	47.14	Est. <10			6
O1	95.9	724.9	7.56	12.49	53.79	0.33	5
S1	109.3	791.4	7.24	Est. <10	21.33	0.50	4

6.3.1 Trib 1C

Trib 1C totals 965 ft and is classified as Class IIIA. This segment ranks very high for restoration given its high quality (HMFEI score 30) and connection to the high-priority preservation sections Trib 1A-1B. A large culvert passes the stream under the railroad bed between Trib 1B and Trib 1C with a substantial elevation drop from the end of pipe to the downstream segments. It becomes a significant barrier for fish disconnecting downstream and upstream stream reaches. Removal or replacement of this culvert to allow for fish passage could improve upstream segments Trib 1C and Trib 1D. Fish found at site Trib 1A, such as the Southern Red Bellied Dace, are of high quality, while fish found upstream in Trib 1C, such as the Creek Chub, are of low quality. Stream connectivity between these two segments could restore fish biodiversity to the entire stream and improve its overall mitigation potential.

6.3.2 Trib 4A

Trib 4A totals 1,914 ft of Class IIIA stream. The status is due to a marginal salamander population. The stream habitat in this section was extremely eroded and scoured. It appears that drainage off the Don Marquis area has been concentrated into a single drainage point and redirected from a previous outflow point further upstream, leaving upstream reaches abnormally dry. During storm run-off events the drainage appears to erode, scour, and entrench the receiving headwaters channel of site Trib 4A. Restoration of this section would include addressing drainage modifications at the Don Marquis site in a number of ways (i.e. returning the outflow to its original receiving channel, using impoundments, diffuse drainage systems, etc.). The source of high conductivity water should also to be investigated and remediated. Restoration in Trib 4A has the added benefit of improving downstream sections Trib 4B and 4C as well.

6.3.3 Trib 7

Trib 7 is a relatively long section of 2,112 ft of Class II stream. The catchment land cover is 49% forested, 2% palustrine habitat, and has a moderate FQAI score of 11.57. Stream restoration along the old west entrance road could improve stream morphology and biodiversity of this stream. However, considerable excavation would likely be needed to achieve any improvements in stream quality.

6.3.4 N1

Trib N1 is a relatively long section 2,821 ft of Class II stream. The catchment is comprised of 45 % forested cover and has a moderate FQAI score of 11.4. Restoration in this section is of a lower priority given that it is off-site. However, improving the current land use and investigating the legacy of excess sediment in this watershed could yield considerable improvements to its biodiversity and stream quality.

6.3.5 Trib 1D

Trib 1D, the uppermost section of Trib 1 sampled (944 ft), behaves like a wetland stream in this upper lower-gradient reach. The presence of salamander populations elevated its status from Class II (based on macroinvertebrates alone) to Class IIIA. This reach is downstream of a lumber processing yard that is likely the source of concentrated organics that produce a “black water” effect that is observable occasionally through the entire length of Trib 1. This segment could be managed either by preservation and left alone or restored to improve the stream hydrology. Drainage from tributaries to its south have been re-routed along the railroad bed and discharge into Trib 1 downstream of segment Trib 1D. Re-connecting the hydrology from these tributaries to segment Trib 1D could improve the supply of water and allowing for an increase in macroinvertebrate biodiversity.

6.3.6 B1

Site B1, totals 2,489 ft. PHWH classification of this site is Class IIIB however, this designation was determined from salamanders found during sampling. Based on the HMFEI score only, this site would have earned Class I. This stream catchment has a forest cover of 58 % with a relatively high average FQAI score of 17.8. The immediate riparian corridor along stream reach B1 was minimal, yet diverse. Restoration of this site is not a priority given it is located off-site. Riparian planting to improve land cover and land use in this section would benefit the macroinvertebrate biodiversity.

6.3.7 P1

Site P1, totals 2,178 ft is similar to other sites that received a high Class IIIA designation based on salamander population, but yielded a Class II based on macroinvertebrate alone. Restoration of this site is not a priority given it is located off-site, however, riparian planting to improve land cover and land use in this section and would benefit the macroinvertebrate biodiversity. Investigation of the extremely high conductivity water that discharges along the bedrock bedding planes in the creek substrate is needed to assess the potential use for mitigation purposes.

6.3.8 S2

Site S2 is a low priority site for restoration. It is located off-site and would require a complete stream restoration and channel re-location near the existing railroad bed. The headwaters are also in agricultural production.

6.3.9 O1

Site O1 is a low priority site for restoration, as it is located off-site and would require channel restoration and riparian plantings upstream of O1. However, this stream does exhibit higher quality habitat in the forested portions in the upper headwaters and there is some presence of wet meadow species immediately adjacent to the surveyed reach.

6.3.10 S1

Site S1 is a low priority site for restoration, it is located off-site and would require complete stream restoration and riparian planting to improve its land cover in the headwaters. It is similar and adjacent to stream S2 and represents similar challenges in restoring stream quality.

7 CONCLUSIONS

This feasibility study provides information for various options for mitigating impacts on primary headwater streams on the PORTS property through a variety of management options, including preservation (i.e. through environmental covenants or conservation easements), conservation, or active restoration of lower quality streams into higher class designations.

Of the primary headwater stream habitat assessed, 24,565 feet of streams are designated as Class III, 7,305 ft of stream are designated as Class II, and 3,879 ft of streams are designated as Class I. Information provided in this study will further inform DOE, its partners, and the public of the quality of primary headwater streams on and adjacent to DOE property. If mitigation of primary headwater stream are needed in the future, consultation and negotiations with regulatory agencies can refer to this plan for complete descriptions of the primary headwater streams including: location, photos, water quality parameters, HMFEI scores, HHEI scores, salamanders and fish obtained, taxa identification of cold water, sensitive, and EPT (high quality taxa), PHWH stream classification, longitudinal stream profile, length of representative stream reach extrapolated from the measured site, on-site and off-site land ownership, length of stream to drainage area ratios, and mitigation management strategies (preservation, conservation, restoration).

At the time a recommendation is needed for primary headwater stream mitigation, the multi-metrics used to determine the performance score (HMFEI biological scores, HHEI habitat scores, ownership, drainage area to steam length ratio, and mitigation management strategy), can be used to prioritize sites determining the best reach for each mitigation purpose. Further recommendations on the specific feasibility and cost-effectiveness of management options will depend on the costs and risks associated with specific preservation covenants or engineering designs.

PART B: Feasibility Study of Wetlands for Mitigation Banking

1 Introduction

The Ohio University Voinovich School of Leadership and Public Affairs (GVS) has been awarded a grant from DOE to help support the efficient and economical environmental restoration of the PORTS site. A specific task being performed by GVS for DOE is the preparation of a feasibility plan for developing a wetlands mitigation bank. The objective of this feasibility plan is to identify areas within the DOE PORTS lands that may serve as a wetlands mitigation bank to compensate for unavoidable impacts to existing wetlands that may occur from planned or future remediation of hazardous materials that have been released into the environment during decontamination and decommissioning (D&D) operations of the PORTS facility. A parallel objective of this plan is to provide informational support for PORTS managers and the public to use when considering wetlands impact and mitigation situations. The convergence of these objectives led to a site search for locations where physical factors suggest that hydrological conditions could be manipulated to support formation of sustainable wetlands. This document details the findings of that search and an assessment of the physical factors that suggest that wetland conditions could be facilitated through topographic and hydrologic alterations.

Generally, a formal wetland mitigation bank is created as a contractual instrument between wetland regulatory agencies such as the US Army Corps of Engineers, State agencies such as Ohio EPA and an entity that due to its mission and an understanding of landscape configuration anticipates a probability that future wetland impacts are unavoidable.

1.1 Wetland Mitigation Defined

The central objective of the Clean Water Act (CWA) is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. An important factor in the achievement of this goal is the prohibition of the discharge of dredged or fill material into *waters of the United States* unless a permit issued by the Army Corps of Engineers and/or approved by a State under CWA Section 404 and/or 401 authorizes such a discharge. *Waters of the United States* includes navigable rivers, lakes, wetlands, streams and other aquatic resources hydrologically connected to them by surface flow during some time during an average annual cycle. Impacts to waters of the United States including wetlands must be first avoided and then minimized to the extent practicable for the activity under consideration. For every authorized discharge to wetlands, the adverse effects from unavoidable impacts, compensatory mitigation is required to replace the loss of wetlands and the functions of the specific wetland within the watershed. Compensatory mitigation refers to the restoration, establishment, enhancement, or in certain circumstances preservation of wetlands, for the purpose of offsetting unavoidable adverse impacts.

Mitigation of wetlands is a last resort and must only be considered after the steps of avoidance and minimization have demonstrably occurred as part of the planning process for given activity. State and federal regulatory venues generally require a formal alternatives analysis as described under Section 404(b)(1) of the CWA. Mitigation banking means "the restoration, establishment, enhancement and, in exceptional circumstances, preservation of wetlands and/or other aquatic resources expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources". A wetlands mitigation bank is a wetland area that has been restored, established (created), enhanced or preserved, which is then set aside to compensate for future conversions of wetlands for development activities. Mitigation banking is one form of compensation for wetland loss that may also include *permittee-responsible wetland creation* after a discharge permit is issued and in-lieu fee mitigation, which entails the payment of a fee to a public or non-profit entity to preserve and protect off site wetlands. This assessment and feasibility plan is restricted to the mitigation banking approach because it is believed that adequate on-site opportunities exist.

This document describes the process conducted to identify likely land areas where such practices can be effective and the site-specific engineering and revegetation practices that would be applied to achieve the desired outcome for the selected areas. This is not a construction document. It is beyond the scope of this document to prepare construction details. Only sketches and functional discussions are provided herein to defend the choice of location, the approximate size of the wetland created and the class of wetland likely to prevail under the average hydrological conditions achievable give the potential basin size, the local topography as generated from recent LiDAR and the soil conditions as defined by the USDA soil survey data for the locale. Should the areas herein recommended be selected for inclusion in a PORTS wetland mitigation bank, additional topographic and soil data would need to be collected and analyzed by engineers that would design and prepare construction drawings.

2 Ecological Performance Standards

The acts of establishing, enhancing, rehabilitating or restoring wetlands under the rubric of a compensatory wetland mitigation bank requires a succinct definition of wetlands, leading to an understanding of how they function as unique habitats and the societal values that they provide, in order to articulate the physical design parameters needed to cause them to self-sustainably exist, which is closely linked to performance standards. Wetlands are defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (40 CFR 232.2(r)). Wetlands occur along a hydrological gradient between upland and aquatic sites. There are three mandatory technical criteria used to define wetlands (USACE 1987):

- **The presence of Wetland Hydrology**: All areas for which there is evidence that demonstrates at least periodic surface inundation or saturation during the growing season. The establishment of wetland hydrology is the central objective of engineering design of a mitigation bank wetland.

- **The presence of Hydric Soils**: Surface soils for which saturation or inundation prevails for a continuous period of 30 days or more during the growing season, creating oxygen-free conditions in the upper layers. While hydric soils may not exist at the time of mitigation wetland establishment, the establishment of wetland hydrology will foster the development of the resultant physiochemical changes over time.

- **The presence of Hydrophytic Vegetation**: More than 50% of the plant community is dominated by plants species rated to occur in wetlands at a frequency of greater than 33% of the time. Planting and seeding of wetland plant species is generally needed to establish desired native assemblages and suppress invasive weeds.

Jurisdictional wetlands -- those that are regulated by the U.S. Army Corps of Engineers (Corps) under Section 404 -- must exhibit all three characteristics: wetland hydrology, hydrophytic vegetation and hydric soils (USACE 1987). It is important to understand that some areas that function as wetlands ecologically, but exhibit only one or two of the three characteristics, do not currently qualify as jurisdictional wetlands and thus activities in these wetlands are not regulated under the Section 404 program. Such wetlands, however, may perform valuable functions. For example, the U.S. Fish and Wildlife Service defines wetlands as: lands that are transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water, and that have one or more of the following attributes:

- At least periodically, the land supports predominantly hydrophytes;
- The substrate is predominantly undrained hydric soil; and,
- The substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al. 1979).

This definition differs from the EPA and U.S. Army Corps of Engineers definition used for jurisdictional wetlands which requires that all three attributes (hydrophytes, hydric soils, and hydrology) be evident. The 1987 Corps of Engineers Manual on wetland delineation does not consider unvegetated aquatic sites such as mudflats and coral reefs or vegetated shallow water to be wetland areas, whereas the Cowardin Classification (Cowardin et al, 1979) does (USACE 1987).

While the Corps of Engineers Wetland Delineation Manual definition that includes the need for vegetation will generally prevail for this study, the Cowardin Classification is a highly useful hierarchical wetland classification, progressing from landscape scale hydrologic systems, to subsystems, classes, subclasses, to vegetation dominance types. The Cowardin system addresses all wetland and deep water habitats found in North America. This document will generally only address a relative few types as likely to be found on the PORTS reservation, including primarily palustrine wetlands (saturated soil to shallow still or slowly flowing systems), riparian systems will likely be encountered along the larger portions of the major creeks and lacustrine (lake fringes and clear water shallows) that may prevail along the shores of the mostly man-made lakes found throughout the PORTS facility.

Cowardin Classes generally encountered in the reservation are likely to be limited to four vegetation structural types:

Aquatic Beds: This includes both rooted submersed vegetation and floating aquatic vegetation. The depth of occupation by submersed aquatic vegetation (SAV) is limited by the depth of light penetration and will likely range from two to five feet below the elevation of the principal spillway of a pond or lake.

Emergent Vegetation: This includes the diverse array of herbaceous monocots and dicots that occupy saturated soils and shallow water to depths of generally less than 1-foot of depth. Wetlands identified as marshes, fens and bogs are generally included in this type.

Shrub-scrub Vegetation: This includes areas dominated by multi-stem woody perennials, generally less than 12 feet in height, that occupies shallow water and saturated soils. These may be called shrub swamps or may comprise significant portions of fens and bogs.

Forested Wetlands: This includes area dominated by trees occupying regions from near or just below water's edge to the upper edge of brief seasonal soil saturation. Type names may include swamps, bottomland hardwood forest, flood plain forest, riverine forests and forested vernal pool complexes.

Wetlands, as assessed and offered for inclusion in a mitigation bank include all vegetated habitats that range in hydroperiod from substrates that are briefly saturated during the growing season to permanently inundated pools of generally less than five in depth. Understanding the meaning of wetlands technical definitions and classifications as they are expressed by local species and the habitats formed from them are critical to the relevance and rationality of planning a wetland mitigation bank.

The creation of a wetland mitigation bank will include the preservation and the hydrological alteration from present conditions that can be variously characterized as rehabilitation, enhancement, expansion establishment (creation) and restoration. This document will use the term "creation" to define the full array of activities that would be employed to convert an area of land from its present condition to a functional wetland suitable for inclusion into the mitigation bank. The chief reason for this lies in the observation that the majority of sites found to available for set aside in a mitigation bank do not show signs of having ever been wetlands that could be subject to restoration or rehabilitation.

The major controlling physical factor in the establishment of wetlands is the manipulation of surface hydrology and hydraulics to increase the frequency and duration of soil saturation or inundation during the growing season. To restore wetland hydrology to an area of land is to "*create wetlands*". The restoration of wetland hydrology leads to oxygen depletion in soils, which allows for accrual of hydromorphic features that define "*hydric soil*": gleying, the formation of iron and manganese concretions, mottling and sulfur dioxide generation, however, the formation of these characteristics may require a long period. The stresses to plants caused by the depletion of oxygen in soils winnows those species from the affected vegetation community that lack physiologic compensation mechanisms, restoring dominance to those species that can endure periods of oxygen depletion, thus restoring "*hydrophytic vegetation*".

The manipulation of surface hydrology to create wetlands usually entails the manipulation of topography. Primarily an engineering function, the manipulation of surface topography includes inlet and outlet control, the designed alteration of soil shape (grade), increasing roughness, flow routing and permeability reduction; all designed to increase the duration and frequency of water presence at a location. These alterations can increase surface retention and detention time and rates through the diversion of water and routing over a landscape, physical introduction of additional surface flows from other locations (diversion), grading to create surface roughness, grading to create depressions, the installation of dams, the installation of level-control weirs and the reduction of soil percolation rate at key locations. The establishment of vegetation on a surface enhanced for retention and detention of water will further improve both surface roughness and absorptive abilities of surface soils. Thus, the establishment through engineering practices of conditions that result in the collection of water and its retention for long periods during the growing season is the chief design consideration for creation of a wetland mitigation bank. Table 2.1 summarizes plant community and hydroperiod relationships. Locations that can be made to sustain the presence of water at the depths and durations listed would be capable of sustaining plant communities suited to that condition; however there are additional considerations for the planning and implementation of successful wetlands.

Table 2.1 Assumed Relationships between Plant Communities and Hydroperiod Performance Standards

Plant Community	**Dominant Vegetation likely supported in this hydrologic regime**	**Water / Saturation Depth**	**Stage-Duration (days during growing season)**
Aquatic	Submergent rooted and floating leaved herbs; cow lily, lotus, waterweed, etc.	>1 to < 4 feet depth above surface	>/= 150 days
Deep Marsh	Emergent standing water hydrophytes; cattail, bur-reed, arrowhead, etc.	0-1 foot depth above surface	>/= 100 days
Emergent	Emergent moist soil to standing water hydrophytes; Sedges, rushes, many low and tall herbs and graminoids, etc.	Saturated soil from within 1.5 feet below the soil surface to 1.5 feet above surface inundation	>/= 60 days
Bottomland Hardwoods	Wet hydrophytic trees; willow, pin oak, elm, silver maple, green ash, boxelder, sycamore, etc.	0.5 feet above inundated surface to 1.5 feet below soil surface	>/= 30 days
Riparian Forest	Mesic hydrophytic trees; hackberry, swamp white oak, cottonwood, red maple, bitternut hickory; etc.	1.5 feet above inundated surface to 2.5 feet below soil surface	>/= 30 days
Upland Forest	Upland oak- hickory, maple-beech, flowering dogwood, Virginia pine forest	>2.5 feet above inundated surface	< 30 days

Chief among other considerations are activities applied to assure that the newly created favorable wetland hydrological conditions are not opportunistically occupied by locally problematic invasive plants such as reed canarygrass. The achievement of this condition requires both the rapid establishment of desired native vegetation and the occasional focused suppression of invasive species. Planting and seeding plans should be implemented during the first suitable period following the completion of soil-disturbing activities. Planted vegetation must be frequently monitored during the establishment period. Invasive species must be rapidly discovered and effectively eradicated.

Wetland performance; those characteristics of functionality that support concepts of wetland valuation, usually include consideration for water quality improvement through filtration of storm runoff, flood attenuation and habitat values. The opportunity for functionality of created mitigation wetlands to provide significant water filtration and flood attenuation may be relatively minor. The value and functionality as habitat for native plant and animal populations can however be very high in terms of the provision of locally scarce cover, shelter, nesting and foraging opportunities. The performance of created wetlands as high value habitat includes not only the array of native plant species established and preserved within them, but time for growth and development after establishment and the created wetlands position in the local landscape.

Once wetland hydrology is established and wetland plants installed, time is needed for full occupation of the wetland soils with the bacteria, fungi, flora and fauna that foster efficient nutrient cycling critical to support of macrophytes and subsequent animal populations. Once soil biota are established, macrophytes must have time to grow and diversify, creating increasing opportunities for faunal occupation. The longer the time between establishment of wetland hydrology and the use of the wetland as a recognized mitigation credit, the greater the trading value of that created wetland.

Use and usability of a given created mitigation wetland by wildlife is considered to be enhanced if the wetland habitat is both distant from sites of frequent human activity and connected via natural vegetated borders and corridors. The greater the distance from human activities and the more complete the connection to undisturbed habitat, the greater is the presumed wildlife value of the wetland. It is thus appropriate to try and locate migration wetlands adjacent to native mature habitat and to surround it with an upland habitat buffer of the greatest possible width, given other site operational necessities. Planning for the management, protection and preservation of the area surrounding a mitigation wetland is thus a performance enhancing consideration.

In summary, the performance standards for wetlands created for a wetland mitigation bank must demonstrate that five criteria are satisfied:

- Wetland hydrology would be established for the area defined as the wetland
- Native hydrophytic vegetation would be established in suitable hydrologic zones within the wetland
- Invasive species should be eliminated
- Wetlands should be integrated into the landscape by managing the immediate surrounding vegetation in a manner that provides cover and access to the wetland
- Wetlands should be established at locations as far as possible from present and anticipated concentrated human activity to maximize wildlife habitat values

3 Site Location and Site Selection Criteria

The selection of appropriate sites for creation as a wetland mitigation bank required 1) evaluation of the current and future land use for the locale, 2) an approximate and then a detailed assessment of the ability favorably alter the hydrologic regime of a particular site to create wetland conditions (which included consideration for drainage area yield, and 3) the ability to protect the land from future disturbance. Since the Department of Energy is both the designated land manager for the PORTS reservation and the intended single user of any mitigation bank credits that may be established, it is assumed that perpetual protection of the selected site(s) is assured. Such protection would in any event be a minimum requirement for a mitigation bank but does not need to be further addressed in the context of this report.

Site selection for the wetland mitigation bank began with an evaluation of both recent aerial imagery and the GIS mapping prepared as part of the Ohio University report, “Habitat Mapping of the Land and Vicinity of the United States Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (Ports) Pike County, Ohio Sponsored by Ohio University’s PORTSfuture Project” (Wiley et al 2011). The site image search objective excluded areas that are apparently actively used for any other support function (building sites, travel ways, landfills, parking areas and all area within the outer ring road). Recognizing that some uses may be abandoned in the future due to continued site decommissioning, the extent of potentially useful mitigation sites may expand. Forested, particularly older forested stands were excluded due to their high structural complexity and diversity, and thus their high value as wildlife habitat. Areas identified as wetlands were generally avoided; however sites displaying wetland conditions in disturbed areas were favored for assessment of the potential for expansion.

Tentative mitigation sites were identified in the late summer of 2013. Figure 3.1 shows three locations within the PORTS reservation that emerged from the initial selection process. Wetland bank sites are described as clusters and identified for discussion as the “western cluster”, the “eastern cluster” and the “southern cluster”. Each cluster is composed of several discrete wetland units. A wetland unit is a confined pool (*wet pool*) with a distinct drainage basin[1] from which it receives runoff and at least one outlet control structure. The outlet control structure is generally considered to be a low earthen dam that may be fitted with a primary and emergency outflow structure.

[1] A drainage basin is a topographic surface that receives atmospheric precipitation and generates runoff of excess water which flows to a single point that defines the downstream end of a designed wet pool.

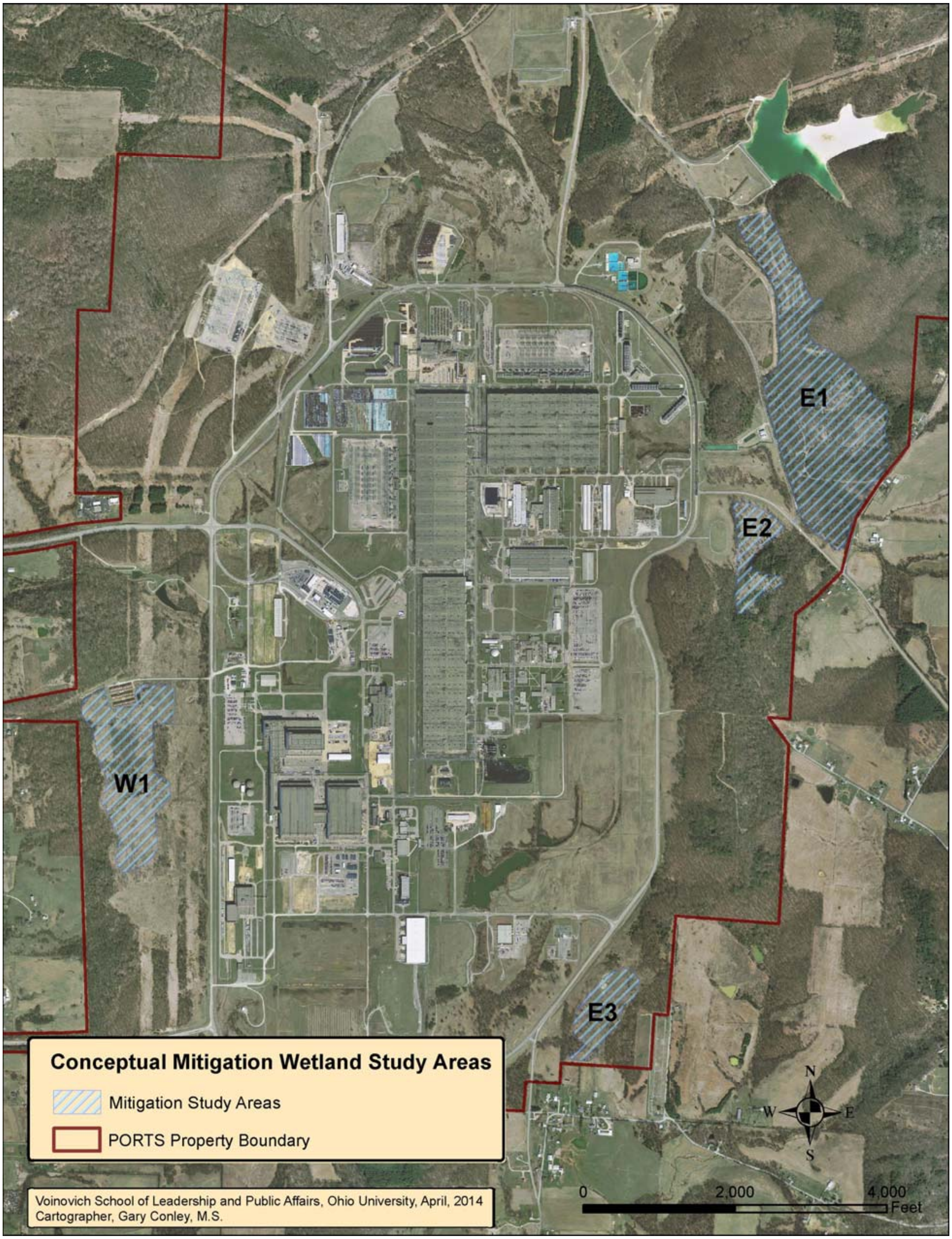


Figure 3.1 Conceptual mitigation study areas

These potential wetland mitigation sites are within mapped land use types identified as “Old field successional”, “ruderal successional”, “successional scrub” and “ruderal scrub-sapling”. All of these classifications describe vegetation communities that are either recovering from relatively recent vegetation and soil disturbance (i.e.; reestablishment by natural seeds dispersal mechanisms or root sprouting), or with ruderal types that experience disturbance (mowing, herbicides) on an annual or more frequent basis. Tentative sites were field inspected and characterized in May and July 2013.

Tentative mitigation bank sites were mapped and forwarded to other PORTS contractors for the conduct of formal jurisdictional wetlands delineation. The results of a wetlands delineation, provided as “Wetland Technical Memorandum Ohio University PORTS Mitigation Area Wetland Survey” (Stantec Consulting, 2013; included as Appendix F) was provided on November 4, 2013. The referenced report provided documentation of wetlands within the selected wetland mitigation bank sites. These wetlands are relatively small and of relatively low quality due to recent soil disturbance. The presence of small, low quality wetlands is not considered prohibitive to use of the selected sites for the intended use as wetland mitigation. For the most part there will be little or no fill material placed in the existing wetlands; however the average water level will be raised. Site by site details are discussed in the site description.

3.1 Western Cluster

The western cluster as shown on Figure 3.2 is a group of five wet pools that would be developed west of Perimeter Road and south of an east-west trending gravel access road, near a group of three metal warehouses. This is a ridge top plateau-like setting that is situated 20 to 45 feet higher than the industrial facilities inside Perimeter Road. Three powerline corridors occupy the eastern half of the site. Two available GIS data layers (USDA “Soils” and “soil_disturbed_area”) show that up to 95% of the area considered for use has been graded and filled within the last 30 years as shown in Figure 3.3. Shallow soil explorations reveal that a layer of medium sand covers most of the area. A prevalence of bottom land vegetation in an area that should be dominated by upland species suggests that the sand cover derived from the Scioto River flood plain to the west, which carried a burden of seeds normally found in bottomlands. The majority of the area is unmanaged and undergoing successional vegetation reestablishment, although some areas near the warehouses and under the powerlines appear to undergo less than annual mowing and possibly chemical suppression in the powerline corridors.

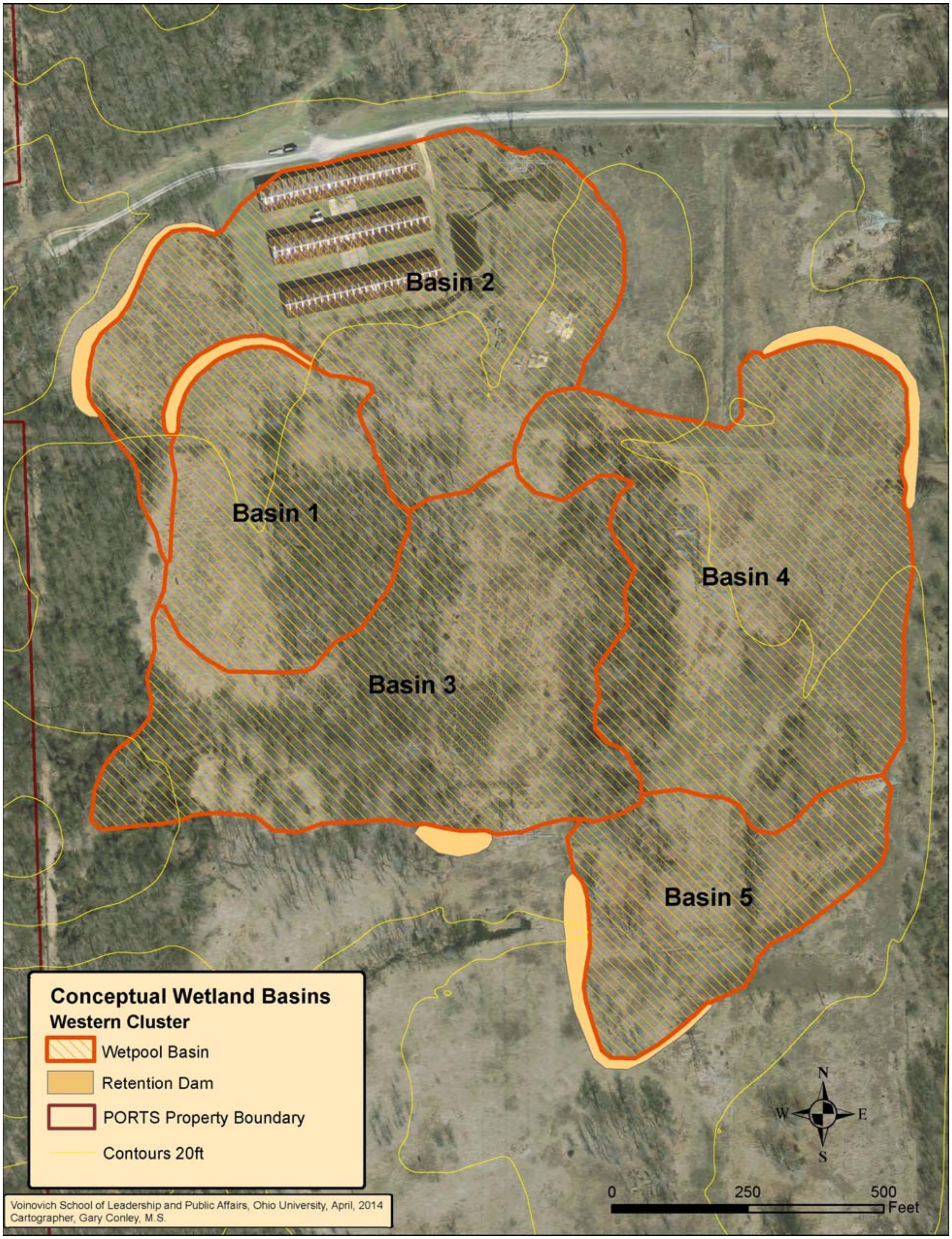


Figure 3.2 Western cluster of conceptual wetland basins

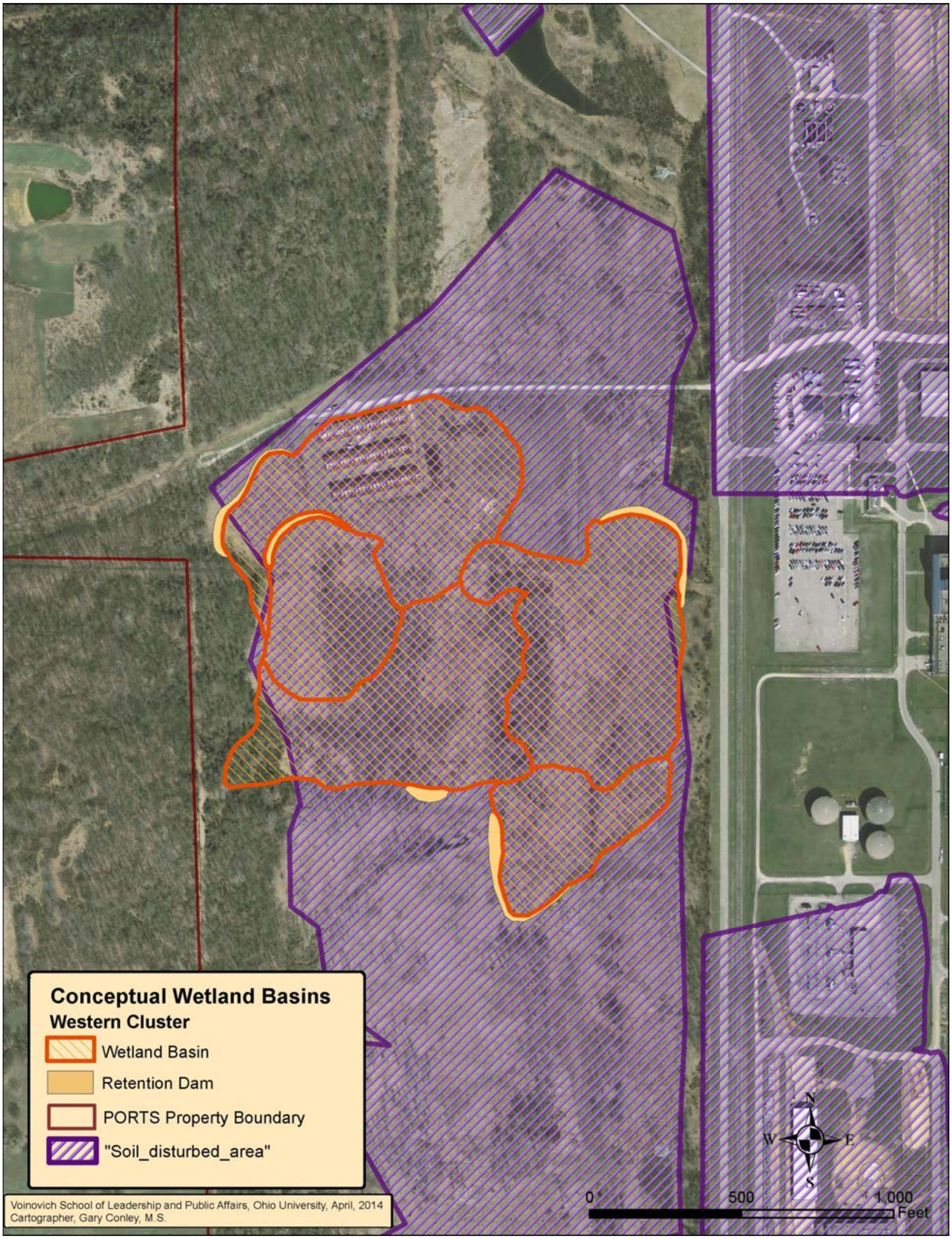


Figure 3.3 Disturbed soil underlying the western cluster basins

3.2 Eastern Cluster

The eastern cluster of potential wetland mitigation bank sites is a highly disturbed area resulting from use of the site for a borrow area. It appears that post excavation seeding took place due to the significant presence of *Lespedeza cuneata*. Most to the successional woody vegetation is composed of species with wind-delivered seed (sycamore, cottonwood) and much of the returning understory from bird delivered seed (red cedar, privet, honeysuckle). The potential work site is mapped as ruderal successional (the disturbed area) and ruderal shrub/sapling.

The site faces west with elevations ranging from 640 feet along the right descending bank of Little Beaver Creek to 675 at the approximate top of the old excavation cuts as shown in Figure 3.4. There are two main terraces created by the excavation. The lowest is a bench approximately 15 above the flow line of Little Beaver Creek. The second is nearly 40 feet higher. Both parallel the creek and generally follow the contour. The terraces offer opportunities to use a combination of excavation and earthen dams to retain runoff from wooded east slope and induce wetland hydrologic regimes.

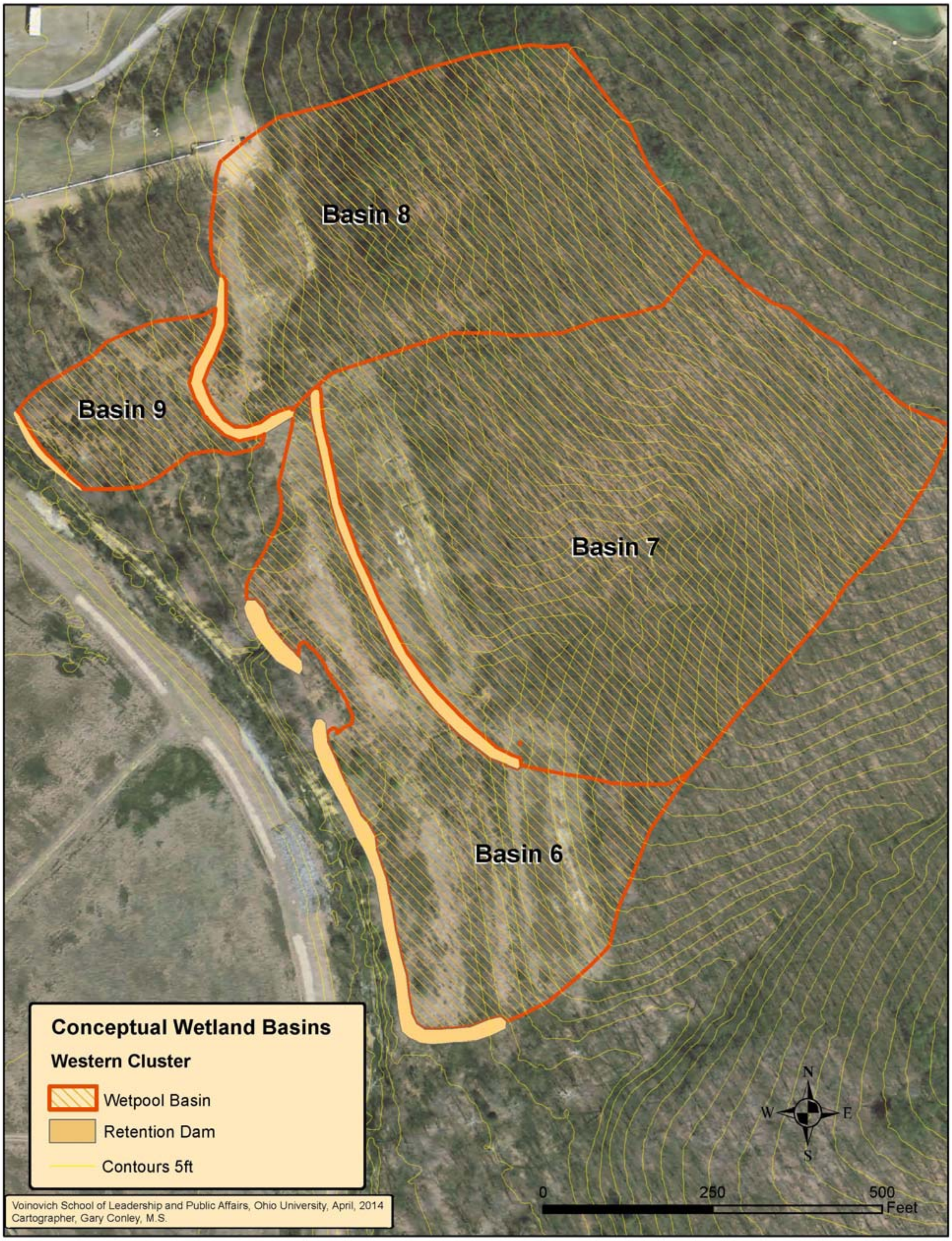


Figure 3.4 Eastern cluster of conceptual wetland basins

3.3 Southern Cluster

The southern cluster of potential mitigation wetlands is shown on Figure 3.5. This area was selected for investigation because there is little evidence that the area had been used for other operational purposes, it is free of native forest vegetation and there is surficial evidence of springs that could enhance the hydrologic inputs to created wetlands. A small borrow area exists on the north side of the site that offers potential as a source for earth materials for dam building.

Figure 3.5 Southern cluster of conceptual wetland basins

The site slopes at 5 to 10 percent toward the southwest. Total topographic relief throughout the potential construction area is approximately 65 feet and ranging from elevation 620 to 705 feet. The majority of the site is mowed at least annually and maintained in common pasture grasses. Eastern red cedar is beginning to occupy the site, suggesting the presence of a limestone layer near the surface. There is a small apparently seasonal spring near the center of the site near elevation 695.0 and a larger apparently perennial spring that emerges from the head of a deep channel near elevation 670.0

A wetland delineation conducted in 2013 (see Appendix F) identified five low quality early successional wetlands (w14, w15, w16, w17 and w18) becoming established in some of the low areas of the old pits. While not possible to create wetlands within existing wetlands, existing degraded wetlands can be restored, enhanced (expanded) or rehabilitated.

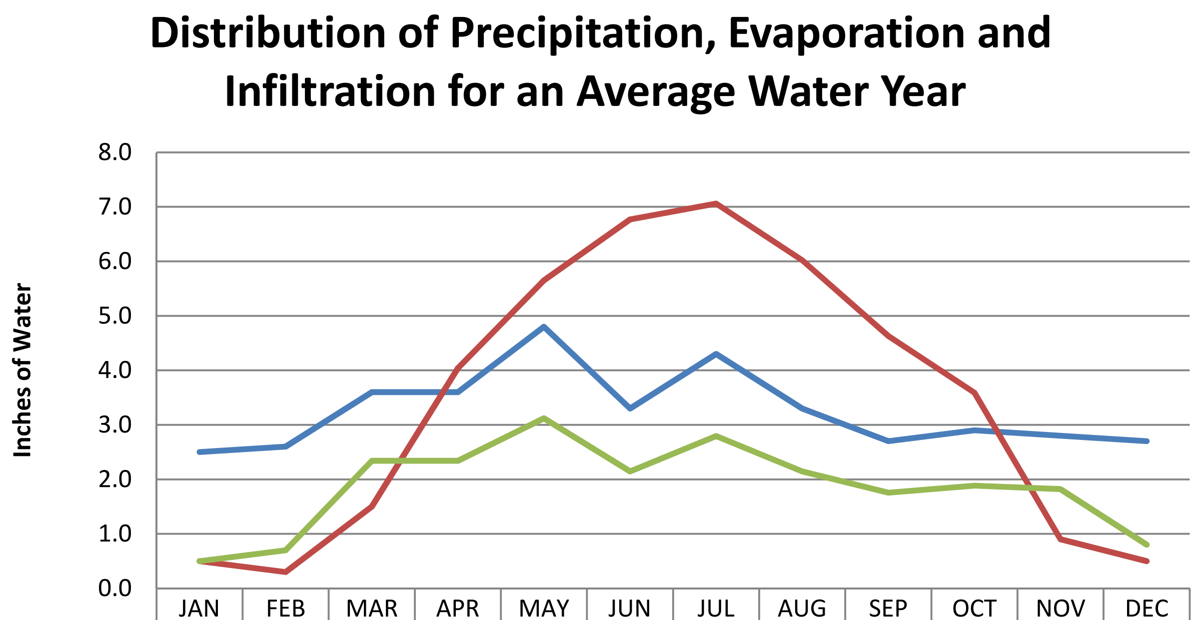
3.4 Water Component

Calculation of the water component is the most important part of demonstrating the potential for creating a wetland at a specified location and for determining the kind of wetland that could be sustained. The water component, or "water budget" is assessed to determine the water balance for the potential wetland site include:

- Water inputs from direct precipitation and runoff from the drainage basin
- Water losses due to infiltration, evapotranspiration and direct evaporation

The water budget necessary for satisfying the minimum "wetland hydrology" criteria is an amount of water that provides for the continuous inundation or soil saturation to the surface (upper 18 inches) for a period (hydroperiod) of at least 30 days (720 hours) during the growing season for the average water year. Areas that can maintain this minimum hydroperiod will, for example, likely support forest cover at maturity. Such areas generally occur along the wetland fringe, transitioning from trees that can tolerate long term inundation (willow) to trees favored in mesic conditions (red maple) to upland species (tulip poplar). Early in the successional process and lacking trees, the wetland fringe area would be occupied by emergent herbs and graminoids. As time passes and the hydroperiod increases, usually along with a water depth gradient, the type of vegetation sustained transitions from herbs to very tolerant trees (willow), to inundation tolerant shrubs (alder and buttonbush) at habitat maturity. Herbaceous vegetation may be either transitional over time to persistent emergent herbaceous vegetation, to persistent emergent, to floating leaved vegetation (i.e.; water lily) finally to submergent vegetation, as duration and water depth increase.

The extent of each vegetation type and wetland type thus depends on the actual basin water yield, minus the infiltration losses and the evapotranspiration losses as expressed over the course of the growing season. The typical relationship between inputs and losses for this latitude and precipitation zone is depicted in Figure 3.6.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Precip	2.5	2.6	3.6	3.6	4.8	3.3	4.3	3.3	2.7	2.9	2.8	2.7
Evap	0.5	0.3	1.5	4.0	5.7	6.8	7.1	6.0	4.6	3.6	0.9	0.5
Infilt	0.5	0.7	2.3	2.3	3.1	2.1	2.8	2.1	1.8	1.9	1.8	0.8

Figure 3.6 Typical distribution of precipitation, evaporation and infiltration for an average water year

Within a vegetated landscape, a large portion of evaporation is processed through living plants as transpiration and both are collectively referred to as evapotranspiration. The shading created by vegetation itself and the absorptive properties of an organic soil layer mitigate evaporative loses during the late summer and early fall, however this period is particularly stressful to plants. Water retained in soil generally sustains plants during this period. Concentrations of soil water in shallow aquifers caused by layer stratification and surface topography often contributes to sustenance of the wetland in the form of groundwater discharge during low precipitation periods.

3.4.1 Annual Precipitation Data

Precipitation values used for Ohio have traditionally been the 50-year record from 1931-1980 (Figure 3.7) provided in the Hydrologic Atlas for Ohio (Harstine, 1991). For purposes of spatial analysis in this study, precipitation data derived from the PRISM project were selected (Figure 3.8). GIS data layers developed by the PRISM model offer the "best current source for annual and monthly averages" (NEH, 2009). The 30-year normal was used to describe the average monthly and annual conditions for the past three decades of 1981-2010 (PRISM, 2004). The annual mean for this period was 40.64 inches as compared with the 40.48 inches reported by NOAA for the previous three decades. Monthly precipitation means are presented in Figure 3.9. The PRISM precipitation data provided the basis for the only hydrologic input to the study watersheds in the water balance equation.

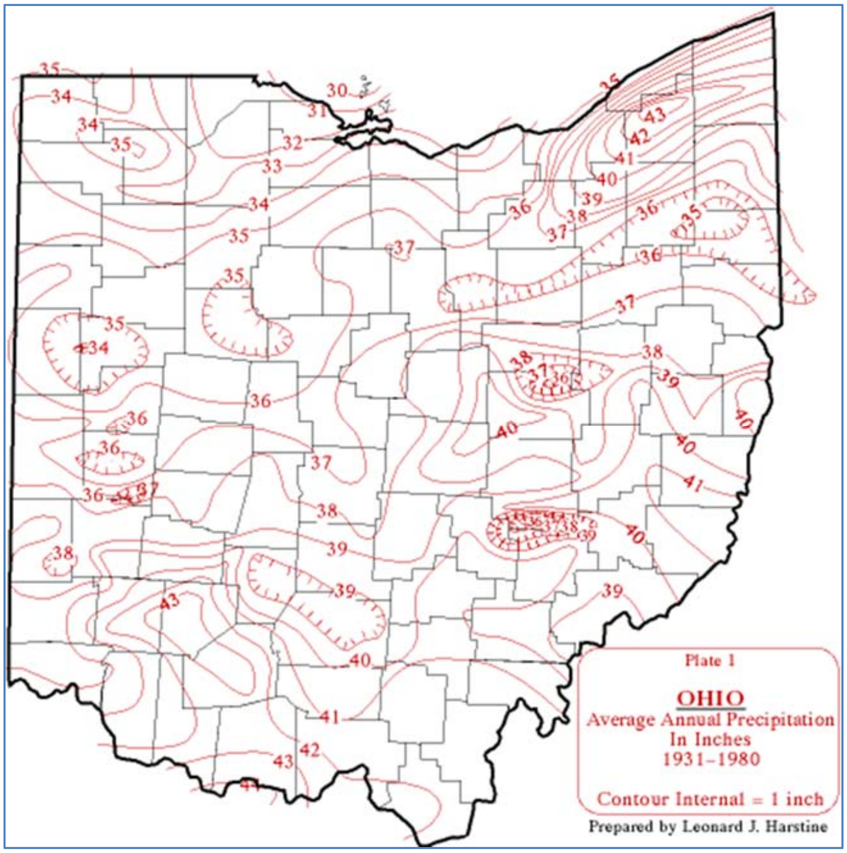


Figure 3.7 The 50-year record from the Hydrologic Atlas for Ohio for 1931-1980

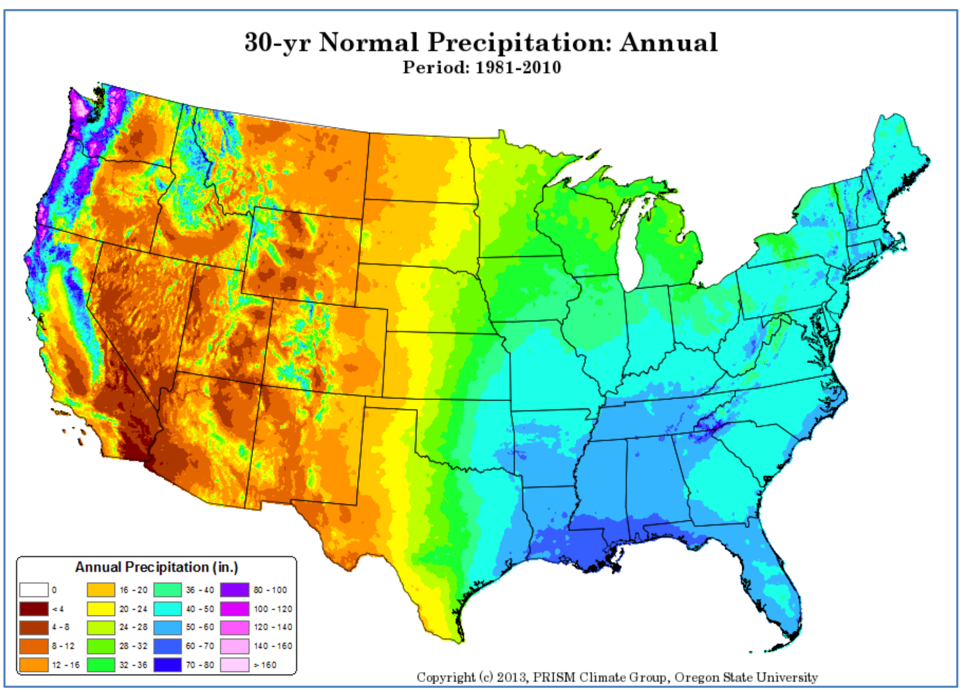


Figure 3.8 The PRISM data annual 30-year normal precipitation for 1981-2010

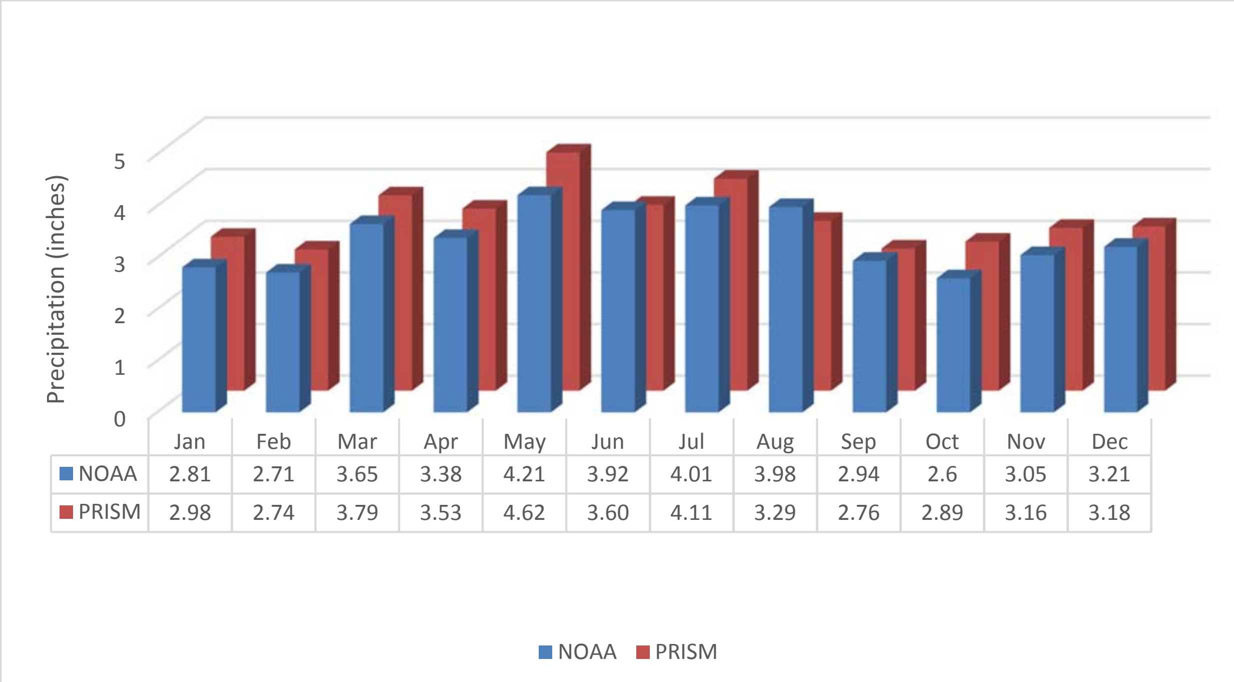


Figure 3.9 Comparison between the NOAA precipitation data and the PRISM data

3.4.2 Evapotranspiration Data

Evapotranspiration (ET) is the summary of all water losses that either evaporate from the watershed or lost to the atmosphere through the process of vegetal transpiration (the movement of water via capillarity through a plant vascular system and the release of water vapor through stomata in the leaves). While approximately 26% of all precipitation becomes direct runoff to the watershed, a small portion (~5%) of water loss occurs as direct evaporation from vegetation and soil surfaces during and after precipitation events (Fisher, et al., 1992). Generally, the remaining approximately 69% goes into the soil through infiltration and contributes to soil moisture, groundwater recharge, or returns to the surface in a lower part of the watershed. Most, if not all, of the soil moisture is lost back to the atmosphere by a combination of evaporation or transpiration and are accounted for in the ET values provided in the water balance equation.

The actual ET is difficult to calculate, but the potential ET can give a good estimate for the overall ET losses to a unit area where suitable pan evaporation data are available (NEH, 2009). Pan evaporation data (Table 3.1) from the station at the Tom Jenkins Dam at Burr Oak Lake were chosen as the most relevant station data for pan evaporation (Farnsworth, et al., 1982). Potential ET was calculated from pan evaporation values using the coefficient of 0.7 for months in which pan evaporation occurred (NEH, 2009). Pan evaporation values were also applied to water losses from the open water areas of the conceptual wet pools and adjusted for changes in pool area during volumetric declines in the drier parts of the season.

Table 3.1 Pan evaporation stations across Ohio

Station Location	Station Index No.	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	May-Oct **	Record Began Mo/Yr	Latest Data Mo/Yr
Charles Mill Lake (or Dam)	1466	3.59	4.98	5.90	6.21	5.48	4.01	2.65		29.23	4/39	10/79
40° 44', 82° 22'		39	41	41	41	41	41	41				
		19	16	9	10	8	12	17		7		
Columbus University Farm	1782	5	5.69	6.83	7.27	6.23	4.76	3.29		34.07	4/58	10/70
40° 00', 83° 03'		8	13	14	13	14	13	12				
		***	15	11	15	11	34	27		11		
Columbus (Ohio State Univ)	1788	3.33	4.45	5.29	5.66	4.79	3.53	2.14		25.86	6/18	11/55
40° 00', 83° 00'		35	36	37	38	38	37	38				
		***	***	***	***	***	***	***		***		
Coshocton Agric Rsch Station	1905	4.99	6.01	6.71	7.05	6.21	4.72	3.59		34.29	4/56	9/79
40° 22', 81° 48'		13	23	24	23	24	21	20				
		***	***	***	***	***	***	***		***		
Dayton	2067	4.04	5.65	6.77	7.06	6.20	4.63	2.86		33.17	4/37	10/69
39° 45', 84° 10'		32	31	32	32	32	32	32				
		18	15	7	11	10	9	16		6		
Deer Creek	2090	5	6	7	6.63	6	3.67	3		32	6/70	11/79
39° 30', 83° 13'		7	9	9	10	9	10	10				
		***	***	***	***	***	***	***		***		
Senecaville Lake (or Dam)	7559	4.35	5.52	6.32	6.35	5.73	4.30	2.99		31.21	4/39	10/79
39° 55', 81° 26'		34	38	38	38	39	39	37				
		20	14	10	24	7	15	38		8		
Tom Jenkins Lake	8378	4	5.08	5.39	5.45	4.72	3.61	2.52	1	26.77	7/53	11/79
39° 33', 82° 04'		9	26	26	27	27	27	26	7			
		***	12	9	11	10	11	15	***	6		
Wooster Exp Station	9312	4.03	5.23	6.31	6.80	5.81	4.35	2.71		31.21	7/16	10/79
40° 47', 81° 36'		36	48	48	49	49	51	50				
		19	17	10	12	10	12	21		8		

* First line of data in the table for each station is mean evaporation in inches; second line is the number of years of record per month; third line is the coefficient of variation in percent (computed only where there are 10 years or more of record during 1956-1970).

** Sum of monthly means

*** Insufficient data between 1956 and 1970 to compute the coefficient of variation

3.5 Soils Component

Water losses through infiltration account for a large part of the total water losses within a watershed. The rate of soil infiltration is regulated by the ability of water to permeate different soil types within the watershed basin. The conceptual wetland clusters exhibit similar soil types and hydrologic properties. Table 3.2 shows the diversity and types of soils characteristic of each cluster area. The water infiltration rate is likely to be slow due to the fairly low permeability of the soils common to Pike County and the study areas. The soils within the conceptual wetland clusters are dominated by hydrologic soil group C, except the eastern cluster. The eastern cluster has a slightly greater area comprised of hydrologic soil group D which exhibits even less permeability.

While approximately 69% of all precipitation goes into the soil through infiltration, much of the water lost to soil infiltration escapes back to the atmosphere as discussed in the previous section. Of the remaining portion left in the soil, about 15% or less of the total precipitation is lost to groundwater recharge and transported out of the watershed. Therefore, groundwater losses and potential ET losses are the principle losses to watershed yield.

Table 3.2 Character of hydrological soil conditions with each study cluster based on soil properties

	Hydrologic Soil Group		
Wetland Design Area	**% B**	**% C**	**% D**
Eastern Cluster	**0.00**	**44.14**	**55.86**
Western Cluster	**2.14**	**97.86**	**0.00**
Southern Cluster	**0.00**	**100.00**	**0.00**

3.6 Water Balance

Watershed yield is the net amount of water that flows past or accumulates at a given point within a watershed over a given period of time. In this case we are considering the long-term monthly average water flow for the study watersheds. Average watershed yields are considered to provide sufficient information to determine the representative conditions without consideration of the expected variation in the record. For planning and design purposes, the flows of certain variable events or exceeding probabilities should be considered.

The following water balance equation is given to provide the basis for calculating watershed yield:

$\boldsymbol{Equation\ 3.1}: Q = P + I - ET - G - \Delta S - D$

Where:

Q = Streamflow (water yield)

P = Precipitation

I = Import of water into the watershed

ET = Evapotranspiration

G = Net export of ground water

ΔS = Change in moisture storage

D = Diversions out of the watershed

In this study, we were concerned with the water yield (Q) as it would concentrate at a specified point in the watershed to sustain wetland hydrology. The water yield represents the flow of water from runoff of precipitation and ground water contribution to any lower portion of a watershed. In order to calculate the water yield for each conceptual wetland basin, data values needed to be converted to a useful unit of measure. Before a suitable water balance equation could be calculated, all water measures were converted to cubic feet and all area measures were converted to square feet.

The actual runoff is estimated as the product of the total rainfall and import of water, minus all water losses within or out of the watershed. For the purposes of this study, import of water (I) and diversion of water (D) are not considered in the final calculations, as the watersheds have seemingly not been hydrologically manipulated. Changes in moisture storage (ΔS) are also not considered due to the small extent of the study watersheds and the fact that these losses are essentially zero over longer periods of time, as in this study. The only import considered was the outflow of an upstream wet pool to a lower wet pool within the same basin. Thus, considering all relevant gains and losses of water in each watershed the final water yield equation is:

Equation 3.2: $Q = P + I - ET - G$

3.6.1 Basin Size and Wet Pool Volumes

The potential mitigation areas were analyzed using spatial analysis techniques to define and characterize the conceptual wetlands for mitigation uses. The 2010 LIDAR imagery was used to generate a surface digital elevation model (DEM). The DEM was used to delineate individual watersheds and to generate 20-foot, 5-foot, and 1-foot contours of the study areas. Field data, mapped features already available, and the contours were used to identify areas of potential watershed accumulation for conceptual wetland development.

Conceptual impoundments were digitized across drainages to retain watershed yields within the catchments. The contour lines were used as a guide to place impoundments and to assure uniform water surface elevations in constructed pools. The overall height of impoundments was maximized within engineering limits to capture and calculate the full hydrologic potential of each catchment. The maximum elevation of each impounded wet pool was determined to be at least 1.5 feet below the top of the dam. The area of each wet pool and the types of wetland habitats possible were then determined and digitized using the 1-foot contour lines.

In order to determine the amount of water necessary to fill the wet pools, the volume of each pool had to be determined. To accomplish this, the DEM was converted to a TIN (Triangulated Irregular Network). The TIN was then modified to include the conceptual impoundments previously created. The maximum surface elevation of the conceptual wet pool was then included in a separate TIN. The surface difference tool was used to calculate the area and volume from the maximum of each pool elevation descending at intervals of 0.5 feet until the volume was zero or less. The resulting data provided an area-volume curve Figure 3.10 that could be used to apply the watershed yield and create a predicted mean hydrologic regime.

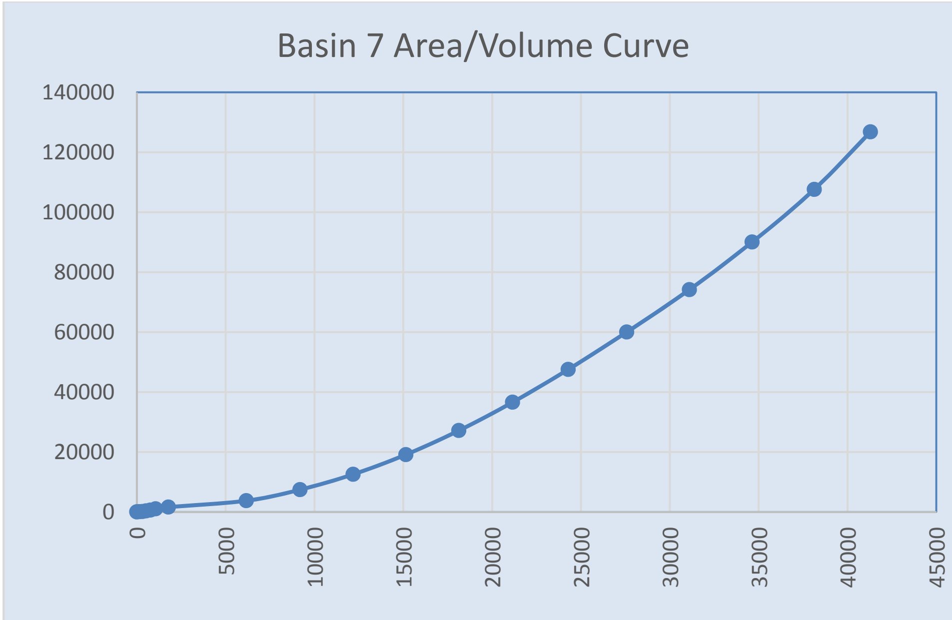


Figure 3.10 Typical Area / Volume curve for wetland basins

3.6.2 Predicted Mean Hydrologic Regime

The final calculation required an application of all factors relevant to the water yield of each watershed using Equation 3.2, such that the following equation emerged:

Equation 3.3: $Q = (P\ x\ Ba) + I - ((Pan\ x\ 0.7)\ x\ (Ba - Wa) + (Wa\ x\ Pan)) - (P\ x\ 0.85)$

Where:

Ba = Basin area in square feet

Wa = Area of the wet pool in square feet

Pan = Pan evaporation

The result of these calculations returned a mean hydrologic regime for each conceptual wet pool for the first and second hydro-year after development. The resultant watershed yields and wet pool hydrographs are presented in Appendix G. Section 4 of this document summarizes the findings in terms of area of total wetlands that could be created, and a breakdown by wetland class (e.g.; emergent, shrub-scrub or forested wetlands).

4 Preliminary Design for Four Wetland Bank Sites

This section describes in general terms how the selected sites might be either converted to wetlands or how the existing wetlands may be expanded. Although preliminary calculations for water budgets are included in Appendix G, this is not an engineering document. The necessary engineering calculations and designs would be prepared after the completion of detailed topographic surveys, actual soil classifications and a comprehensive tracing of constructed drainage features on this highly modified site. The following discussions and attendant calculations are intended to demonstrate feasibility to create wetland hydrology and to describe the likely outcome for extent and wetland class that would be sustainable for the average water year after hydrologic controls would have been constructed.

The frequency and duration of water near the surface is the primary factor in controlling whether an extent of land would be a wetland. The development of wetland hydrology is controlled by either manipulating inflow (increasing the wet basin capture) or outflow (controlling the outlet), or both. Inflow can be managed (increased) by diverting runoff from portions of the land surface not initially flowing to a particular outlet control point. The duration of inundation, depth and frequency of soil saturation control the composition and extent of wetland plant species groupings. Outlet elevations could be modified to maximize the desired wetland type and plant community. This section discusses how wetland hydrology would be created and the probable plant community that would likely thrive for each of the 11 wet pools identified. Table 4.1 lists the features of mitigation wetland units, dams and drainage basins by cluster. Table 4.2 summarizes wetland unit features by cluster. These estimates are approximate until additional topographic survey data are obtained.

Table 4.1 Mitigation Wetland Units

Feature	Acres	Unit	Location
Basin 1	4.76	Basin	Western Cluster
Wet pool 1	0.87	Wet pool	Western Cluster
Earthen Dam 1	0.20	Dam	Western Cluster
Basin 2	9.35	Basin	Western Cluster
Wet pool 2	0.71	Wet pool	Western Cluster
Earthen Dam 2	0.23	Dam	Western Cluster
Basin 3	9.46	Basin	Western Cluster
Wet pool 3	1.49	Wet pool	Western Cluster
Earthen Dam 3	0.13	Dam	Western Cluster
Basin 4	10.07	Basin	Western Cluster
Wet pool 4	1.69	Wet pool	Western Cluster
Earthen Dam 4	0.30	Dam	Western Cluster
Basin 5	4.10	Basin	Western Cluster
Wet pool 5	1.44	Wet pool	Western Cluster
Earthen Dam 5	0.35	Dam	Western Cluster
Basin 6	4.40	Basin	Eastern Cluster
Wet pool 6	1.76	Wet pool	Eastern Cluster
Earthen Dam 6A	0.07	Dam	Eastern Cluster
Earthen Dam 6B	0.28	Dam	Eastern Cluster
Basin 7	10.50	Basin	Eastern Cluster
Wet pool 7	0.96	Wet pool	Eastern Cluster

Earthen Dam 7	0.24	Dam	Eastern Cluster
Basin 8	6.01	Basin	Eastern Cluster
Wet pool 8	0.42	Wet pool	Eastern Cluster
Earthen Dam 8	0.15	Dam	Eastern Cluster
Basin 9	1.16	Basin	Eastern Cluster
Wet pool 9	0.08	Wet pool	Eastern Cluster
Earthen Dam 9	0.04	Dam	Eastern Cluster
Basin 10	4.24	Basin	Southern Cluster
Wet pool 10	0.53	Wet pool	Southern Cluster
Earthen Dam 10	0.16	Dam	Southern Cluster
Basin 11	3.99	Basin	Southern Cluster
Wet pool 11	0.25	Wet pool	Southern Cluster
Earthen Dam 11	0.14	Dam	Southern Cluster

Table 4.2 Acreages by Cluster and Features

	FEATURE			
SITE	**Basin (acres)**	**Dam (acres)**	**Wet pool (acres)**	**Wetland (acres)**
Eastern Cluster	22.06	0.78	3.23	15.23
Southern Cluster	8.23	0.30	0.79	1.63
Western Cluster	37.74	1.20	6.18	4.31
Grand Total	**68.03**	**2.28**	**10.20**	**21.16**

The development of wetland hydrologic regime for all of the sites relies principally on outlet control established by the emergency spillway of low earthen dams. Dams would typically be constructed using standard engineer practices including properly installed clay cores, broad crested weir primary spillways and additional emergency spillways to safely conduct the 10 year 24-hour storm. Rip-rap would be used for core armoring of spillway bottoms and an outlet apron, but most of the spillways would be re-soiled and vegetated. Downstream dam heights would be as low as possible, generally maintaining maximum pool depths of less than 4-feet at the primary spillway and designed as low risk shallow pools. Slopes on dams and berms would generally be held at 4:1 and flatter. Overall pool depth within wet pools would average less than 1-foot, with much of the wet pool area only saturated by soil capillary action along the pool fringe. Soil capillary action should raise the area of extended soil saturation to the surface 1 to 2 feet above the standing pool elevation during the wetter portions of the growing season, and to within 18-inches of the surface within a greater distance.

To the extent possible, activities associated with construction of low dams and outlet control structures should avoid deposition of earth material, grading or vegetation removal in areas that have been identified as wetlands (Appendix F). It appears that such avoidance is feasible for most of the mitigation wetlands sites. There should be no removal of vegetation of any kind in wet pool areas, it is expected that changes in hydrologic regime will induce mortality in some individuals, as other newly planted individuals are favored. Mortality of woody species can be generally beneficial for several years follow hydrologic alternation because of the habitat values provided for many wildlife species.

All sites would be planted and seeded with wetland species suited to the established hydrologic regime. The typical species selected for planting and seeding would be regional natives. Table 4.3 provides the characteristics of hydrologic planting zones. Table 4.4 lists recommended native plant species by generalized hydrologic regime zone.

Table 4.3 Hydrological planting zones

Plant Community	Dominant Vegetation likely supported in this hydrologic regime	Water/ Saturation Depth	Hydrologic Regime Zone
Aquatic	Submergent rooted and floating leaved herbs; cow lily, lotus, waterweed, etc.	>1 to < 4 feet depth below water surface	**1**
Deep Marsh	Emergent standing water hydrophytes; cattail, bur-reed, arrowhead, etc.	0-1 foot depth below standing water	**2**
Emergent	Emergent moist soil to standing water hydrophytes; sedges, rushes, many low and tall herbs and graminoids, etc.	Saturated soil from within 1 feet below the water surface to 1.5 feet above surface inundation	**3**
Wet Forest	Wet hydrophytic trees; willow, alder, pin oak, elm, silver maple, green ash, boxelder, sycamore, etc.	0.5 feet above inundated surface to 1.5 feet below soil surface	**4**
Mesic Forest	Mesic hydrophytic trees; hackberry, swamp white oak, cottonwood, red maple, bitternut hickory; etc.	1.5 feet above inundated surface to 2.5 feet below soil surface	**5**
Upland Forest	Upland oak- hickory, maple-beech, flowering dogwood, Virginia pine forest	>2.5 feet above inundated surface	**6**

Table 4.4 Suggested species list by hydrologic zone

WOODY SPECIES PLANTING			
Species	**Author**	**Common Name**	**Hydrologic Zone**
Acer negundo	L.	boxelder	4
Acer rubrum	L.	red maple	4, 5
Acer saccharinum	L.	silver maple	4
Cephalanthus occidentalis	L.	buttonbush	2
Platanus occidentalis	L.	American sycamore	3
Quercus palustris	Münchh.	pin oak	3, 4
Ulmus americana	L.	American elm	3, 4

Fraxinus pennsylvanica	Marsh.	green ash	3, 4
Quercus bicolor	Willd.	swamp white oak	4, 5
Salix Nigra		Black willow	3, 4
Carya ovata	(Mill.) K. Koch	shagbark hickory	4, 5, 6
Celtis occidentalis	L.	common hackberry	5, 6
Juglans nigra	L.	black walnut	5, 6
Populus deltoides	Bartram ex Marsh.	eastern cottonwood	3, 4, 5
Betula nigra	L.	river Birch	3, 4, 5
Alnus serrulata	(Aiton) Willd.	smooth alder	2, 3

POTENTIAL HERBACEOUS SPECIES PLANTING & SEEDING			
Species	**Author**	**Common Name**	**Hydrologic Zone**
Acorus americanus	(Raf.) Raf.	sweet flag	2
Agrimonia gryposepala	Wallr.	tall hairy agrimony	5, 6
Alisma subcordatum	Raf.	American water plantain	2
Andropogon gerardii	Vitman	big bluestem	4, 5, 6
Apios americana	Medik.	groundnut	3, 4
Apocynum cannabinum	L.	Indianhemp	5, 6
Argentina anserina	(L.) Rydb.	silverweed cinquefoil	5, 6
Arisaema dracontium	(L.) Schott	green dragon	3, 4
Arisaema triphyllum	(L.) Schott	Jack in the pulpit	3, 4
Asclepias incarnata	L.	swamp milkweed	3, 4
Asclepias speciosa	Torr.	showy milkweed	5, 6
Bidens aristosa	(Michx.) Britton	bearded beggarticks	5, 6
Bidens cernua	L.	nodding beggartick	5, 6
Bidens frondosa	L.	devil's beggartick	5, 6
Boehmeria cylindrica	(L.) Sw.	smallspike false nettle	3, 4
Carex aquatilis	Wahlenb.	water sedge	2
Carex bebbii	Olney ex Fernald	Bebb's sedge	3
Carex blanda	Dewey	eastern woodland sedge	3
Carex cephalophora	Muhl. ex Willd.	oval-leaf sedge	3, 4
Carex crinita	Lam.	fringed sedge	3
Carex cristatella	Britton	crested sedge	3, 4
Carex hystericina	Muhl. ex Willd.	bottlebrush sedge	3
Carex interior	L.H. Bailey	inland sedge	3, 4
Carex intumescens	Rudge	greater bladder sedge	3, 4
Carex laevivaginata	(Kük.) Mack.	smoothsheath sedge	3, 4
Carex lupuliformis	Sartwell ex Dewey	false hop sedge	3
Carex lupulina	Muhl. ex Willd.	hop sedge	2, 3
Carex lurida	Wahlenb.	shallow sedge	3, 4

Carex scoparia	Schkuhr ex Willd.	broom sedge	3, 4
Carex squarrosa	L.	squarrose sedge	3, 4
Carex stipata	Muhl. ex Willd.	awlfruit sedge	3, 4
Carex stricta	Lam.	upright sedge	3, 4
Carex tribuloides	Wahlenb.	blunt broom sedge	3, 4
Carex typhina	Michx.	cattail sedge	3, 4
Carex vulpinoidea	Michx.	fox sedge	3, 4
Carex woodii	Dewey	pretty sedge	3, 4
Chelone glabra	L.	white turtlehead	3, 4
Cicuta maculata	L.	spotted water hemlock	3, 4
Coreopsis lanceolata	L.	lanceleaf tickseed	4, 5, 6
Cyperus strigosus	L.	strawcolored flatsedge	3, 4, 5
Desmodium canadense	(L.) DC.	showy ticktrefoil	5, 6
Dichanthelium clandestinum	(L.) Gould	deertongue	3, 4
Eleocharis acicularis	(L.) Roem. & Schult.	needle spikerush	2, 3, 4
Eleocharis engelmannii	Steud.	Engelmann's spikerush	2, 3, 4
Eleocharis obtusa	(Willd.) Schult.	blunt spikerush	2, 3, 4
Eleocharis palustris	(L.) Roem. & Schult.	common spikerush	2, 3, 4
Elodea canadensis	Michx.	Canadian waterweed	1, 2
Elymus canadensis	L.	Canada wildrye	3, 4
Elymus riparius	Wiegand	riverbank wildrye	3, 4
Epilobium coloratum	Biehler	purpleleaf willowherb	3, 4
Eupatorium perfoliatum	L.	common boneset	3, 4
Eupatorium purpureum var. purpureum	L.	sweetscented joe pye weed	3, 4
Euthamia graminifolia	(L.) Nutt.	flat-top goldentop	3, 4
Glyceria striata	(Lam.) Hitchc.	fowl mannagrass	3, 4
Helianthus annuus	L.	common sunflower	5, 6
Helianthus giganteus	L.	giant sunflower	5, 6
Heracleum maximum	Bartram	common cowparsnip	3, 4
Juncus acuminatus	Michx.	tapertip rush	3, 4
Juncus bufonius	L.	toad rush	3, 4
Juncus canadensis	J. Gay ex Laharpe	Canadian rush	3, 4
Juncus effusus	L.	common rush	3, 4
Juncus interior	Wiegand	inland rush	3, 4
Juncus tenuis	Willd.	poverty rush	5, 6
Leersia oryzoides	(L.) Sw.	rice cutgrass	2, 3
Lobelia cardinalis	L.	cardinalflower	3, 4
Lobelia siphilitica	L.	great blue lobelia	4, 5
Mimulus ringens	L.	Allegheny monkeyflower	3, 4
Mirabilis nyctaginea	(Michx.) MacMill.	heartleaf four o'clock	5, 6
Monarda fistulosa	L.	wild bergamot	5, 6

Nelumbo lutea	Willd.	American lotus	1
Nuphar lutea	(L.) Sm.	yellow pond-lily	1
Nymphaea odorata	Aiton	American white waterlily	1
Panicum capillare	L.	witchgrass	5, 6
Panicum dichotomiflorum	Michx.	fall panicgrass	5, 6
Panicum virgatum	L.	switchgrass	5, 6
Penthorum sedoides	L.	ditch stonecrop	3, 4
Poa palustris	L.	fowl bluegrass	3, 4
Polygonum amphibium	L.	water knotweed	1
Polygonum cespitosum	Blume, nom. inq.	Oriental lady's thumb	3, 4
Polygonum hydropiper	L.	marshpepper knotweed	3, 4
Polygonum hydropiperoides	Michx.	swamp smartweed	3, 4
Polygonum lapathifolium	L.	curlytop knotweed	3, 4
Polygonum pensylvanicum	L.	Pennsylvania smartweed	2, 3
Polygonum sagittatum	L.	arrowleaf tearthumb	3, 4
Potamogeton crispus	L.	curly pondweed	1
Potamogeton natans	L.	floating pondweed	1
Potentilla argentea	L.	silver cinquefoil	5, 6
Pycnanthemum tenuifolium	Schrad.	narrowleaf mountainmint	5, 6
Rudbeckia hirta	L.	blackeyed Susan	5, 6
Rudbeckia laciniata	L.	cutleaf coneflower	
Ruellia humilis	Nutt.	fringeleaf wild petunia	5, 6
Sagittaria latifolia	Willd.	broadleaf arrowhead	1, 2, 3
Schizachyrium scoparium	(Michx.) Nash	little bluestem	5, 6
Schoenoplectus tabernaemontani	(C.C. Gmel.) Palla	softstem bulrush	1, 2 ,3
Scirpus atrovirens	Willd.	green bulrush	2, 3
Scirpus cyperinus	(L.) Kunth	woolgrass	2, 3
Sicyos angulatus	L.	oneseed bur cucumber	3, 4, 5
Silphium perfoliatum	L.	cup plant	5, 6
Sisyrinchium angustifolium	Mill.	narrowleaf blue-eyed grass	5, 6
Sium suave	Walter	hemlock waterparsnip	
Solidago altissima	L.	Canada goldenrod	5, 6
Solidago canadensis	L.	Canada goldenrod	5, 6
Solidago gigantea	Aiton	giant goldenrod	5, 6
Sorghastrum nutans	(L.) Nash	Indiangrass	5, 6
Sparganium americanum	Nutt.	American bur-reed	1, 2, 3
Sparganium eurycarpum	Engelm.	broadfruit bur-reed	1, 2, 3
Strophostyles helvola	(L.) Elliott	amberique-bean	5, 6
Symphyotrichum lanceolatum ssp. hesperium var. hesperium	(Willd.) G.L. Nesom	white panicle aster	5, 6
Symphyotrichum novae-angliae	(L.) G.L. Nesom	New England aster	5, 6

Symphyotrichum pilosum var. pilosum	(Willd.) G.L. Nesom	hairy white oldfield aster	5, 6
Symphyotrichum puniceum var. puniceum	(L.) Á. Löve & D. Löve	purplestem aster	3, 4
Typha angustifolia	L.	narrowleaf cattail	1, 2, 3
Typha latifolia	L.	broadleaf cattail	1, 2, 3
Verbena hastata	L.	swamp verbena	2, 3
Verbena urticifolia	L.	white vervain	5, 6
Verbesina alternifolia	(L.) Britton ex Kearney	wingstem	5, 6
Vernonia gigantea	(Walter) Trel.	giant ironweed	5, 6
Zizia aptera	(A. Gray) Fernald	meadow zizia	5, 6
Zizia aurea	(L.) W.D.J. Koch	golden zizia	5, 6

Planting and seeding of the wet pool would occur during the first growing season following grading and establishment of the outlet control. Woody species would be planted as 2-4 year old saplings. Plants used in hydrologic zones 1 and 2 would likely be planted potted stock, whips, stakes, or sprigs. Many of the herbs may be only available as seed. Areas adjacent to the wet pool that do not presently support forest cover

4.1.1 Western Cluster

The western cluster of mitigation wetlands is composed of five wet pools, numbers 1 through 5. The physical alterations required for each to establish wetland hydrology and the location and extent of resulting hydrologic planting zones is discussed for each wet pool. Figure 4.1 shows the extent of the western mitigation wetland cluster, the approximate locations and extents of earthen dams, the extent of contributing drainage basins and the routing of water through the features.

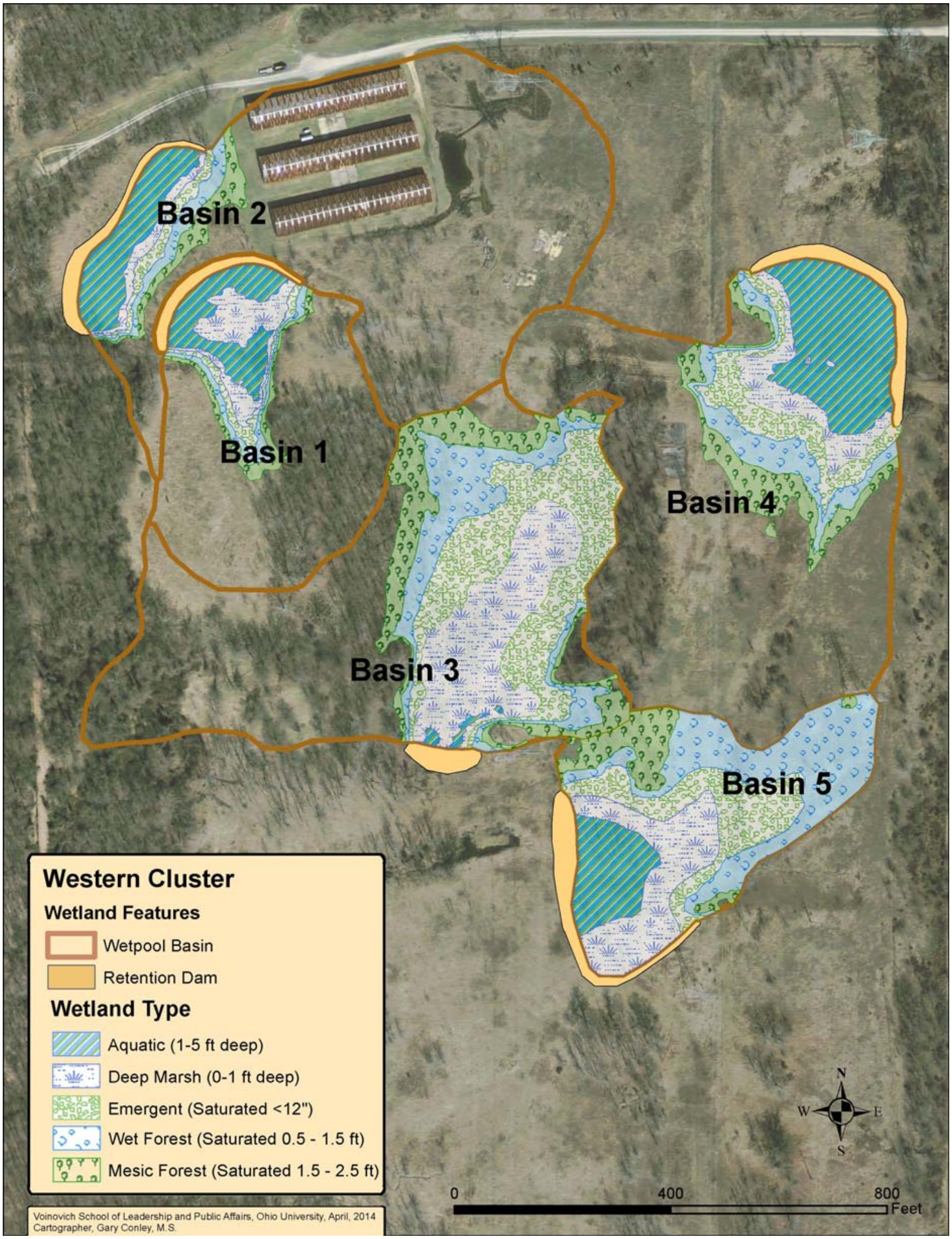


Figure 4.1 The Western cluster conceptual wetland design layout

4.1.1.1 Wet Pool 1

Figure 4.2 shows the extent of wet pool 1. This area currently drains to the west by way of an approximately 8-foot top width, 4 foot deep channel that appears to be at the edge of areas identified in various GIS coverages as fill material. There would need to be little excavation needed for the excavation of this wet pool, except for the installation of the core trench.

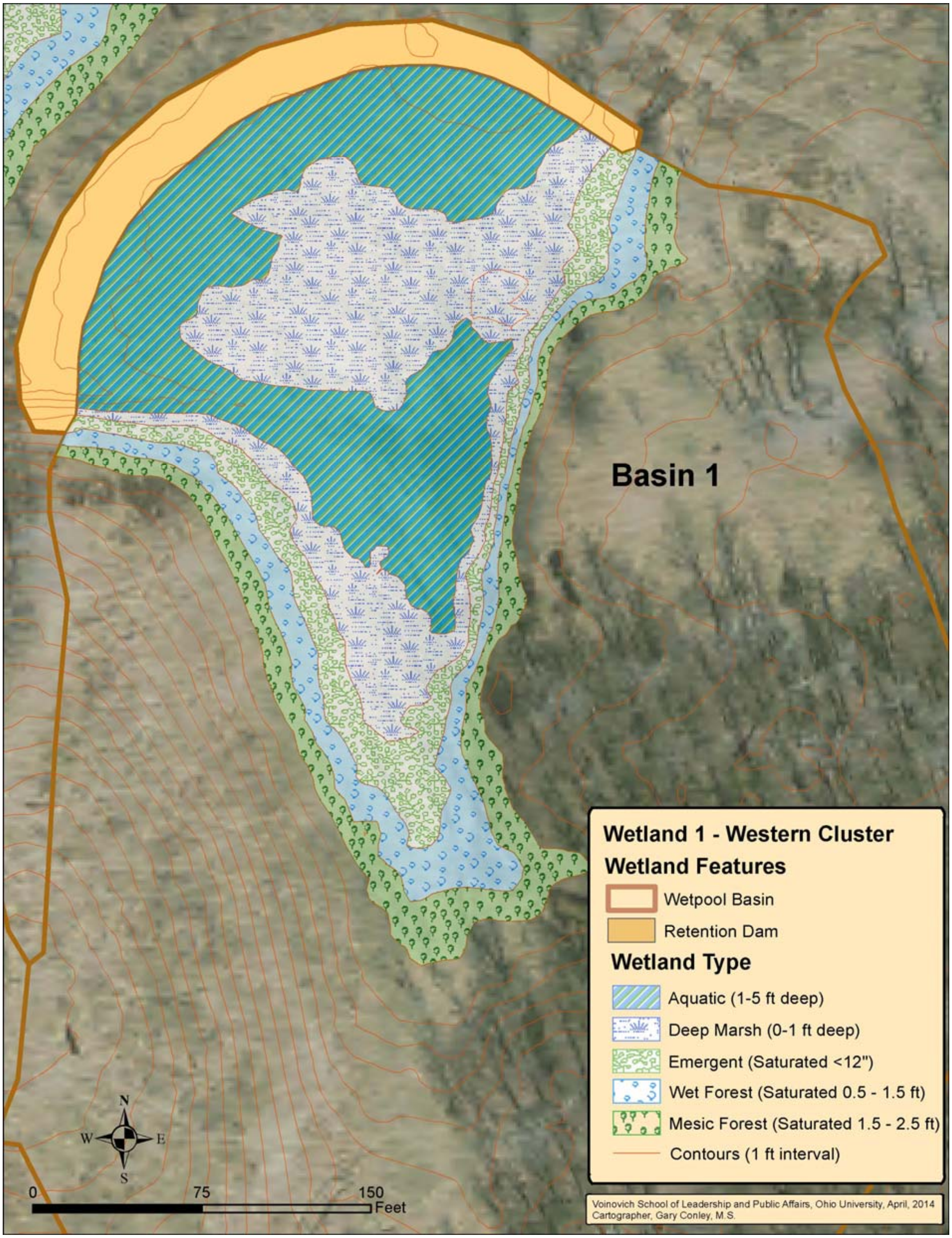


Figure 4.2 Conceptual wetland plant community for wetland 1

Shallow excavations with a soil auger show that most of the wet basin is underlain by loose, medium to coarse sand and clearly not an in situ formation. The outlet channel at the western edge of the sand deepens into an erosion channel as the slope steepens and flows over native silty clay loam soils. It is at this transition point that the earthen dam would be constructed. The dam would need to be approximately 6-feet above the downstream channel bottom, with an approximate top elevation of 704.0. There would be no outlet through this structure. The discharge point would be placed at the north end and designed to discharge through an improved channel to wet pool number 2. The crest of the outlet channel would thus be approximately elevation 702.0. The spillway would drop water to an outlet channel at elevation 697.0, which would deliver excess runoff to wet pool 2 at approximate elevation of 686.0. The resulting wet pool 1 area at elevation 702.0 would maintain a surface saturated or inundated area of approximately XX acres. The wetted fringe at approximately upstream of the maximum pool area would potentially extend to 703.5, define the extent of hydrologic planting zone 4. The estimated extent of the various hydrological zones induced for wet pool 1 is presented in Table 4.5.

Table 4.5 Hydraulic Zones for Wet Pool 1

Hydrologic Zone	Area (acres)
1	0.48
2	0.39
3	0.14
4	0.15
5	0.17
Total	**1.32**

4.1.1.2 Wet Pool 2

Wet pool 2 would be established by excavation into native silty clay loam soil and the construction of a 4-foot high berm with the excavated materials. Alignment would more or less follow along the contour of elevation 684.0. This would result in a berm maximum top elevation of 688.0 and a wet pool elevation of approximately 686.0; extended the wetted fringe area above the pool to approximately 688.0. The outlet for this wet pool would be located at the northern end of the berm and discharge to an existing, westward-flowing channel just south of an access road to the north. Figure 4.3 shows the layout of this wet pool. Table 4.6 shows the areas of induced hydrologic zones.

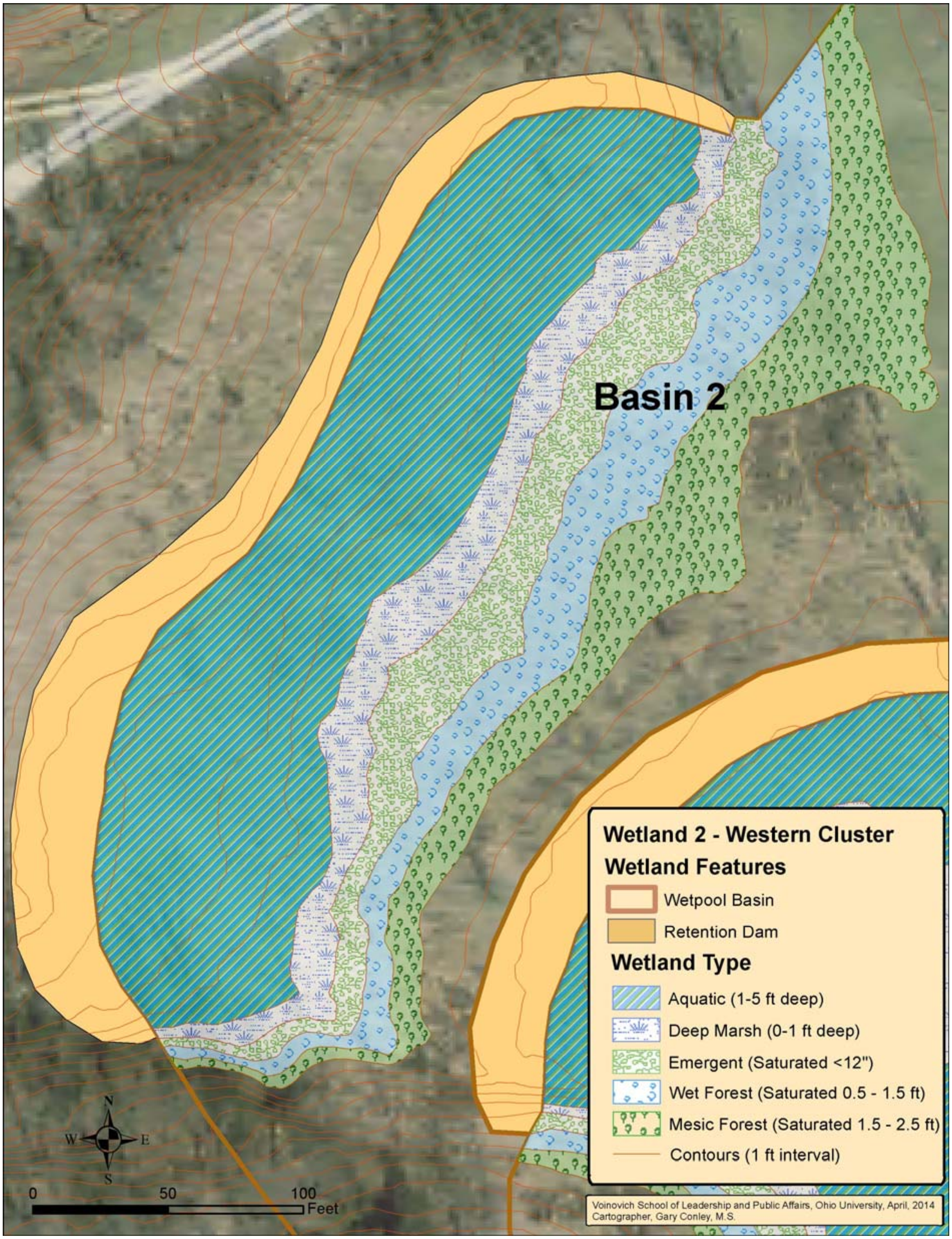


Figure 4.3 Conceptual wetland plant community for wetland 2

Table 4.6 Hydraulic Zones for Wet Pool 2

Hydrologic Zone	Area (acres)
1	0.57
2	0.14
3	0.16
4	0.20
5	0.25
Total	**1.31**

4.1.1.3 Wet Pool 3

Wet pool 3 (Figure 4.4) would be created by the construction of an earthen dam at the south end of a south-flowing swale. This feature would appear to be in the same sandy fill as wet pool 1, with the dam similarly located at the transition to native soils. The approximate top of a 4-foot high dam would be at elevation 705.0. The spillway would sustain a wet pool elevation of 703.0 and a wetted fringe at approximately 704.5. The dam would be placed across a 15-wide ephemeral channel that discharges to a westward flooring intermittent channel. Table 4.7 summarizes the induced hydrologic zones for this created wetland.

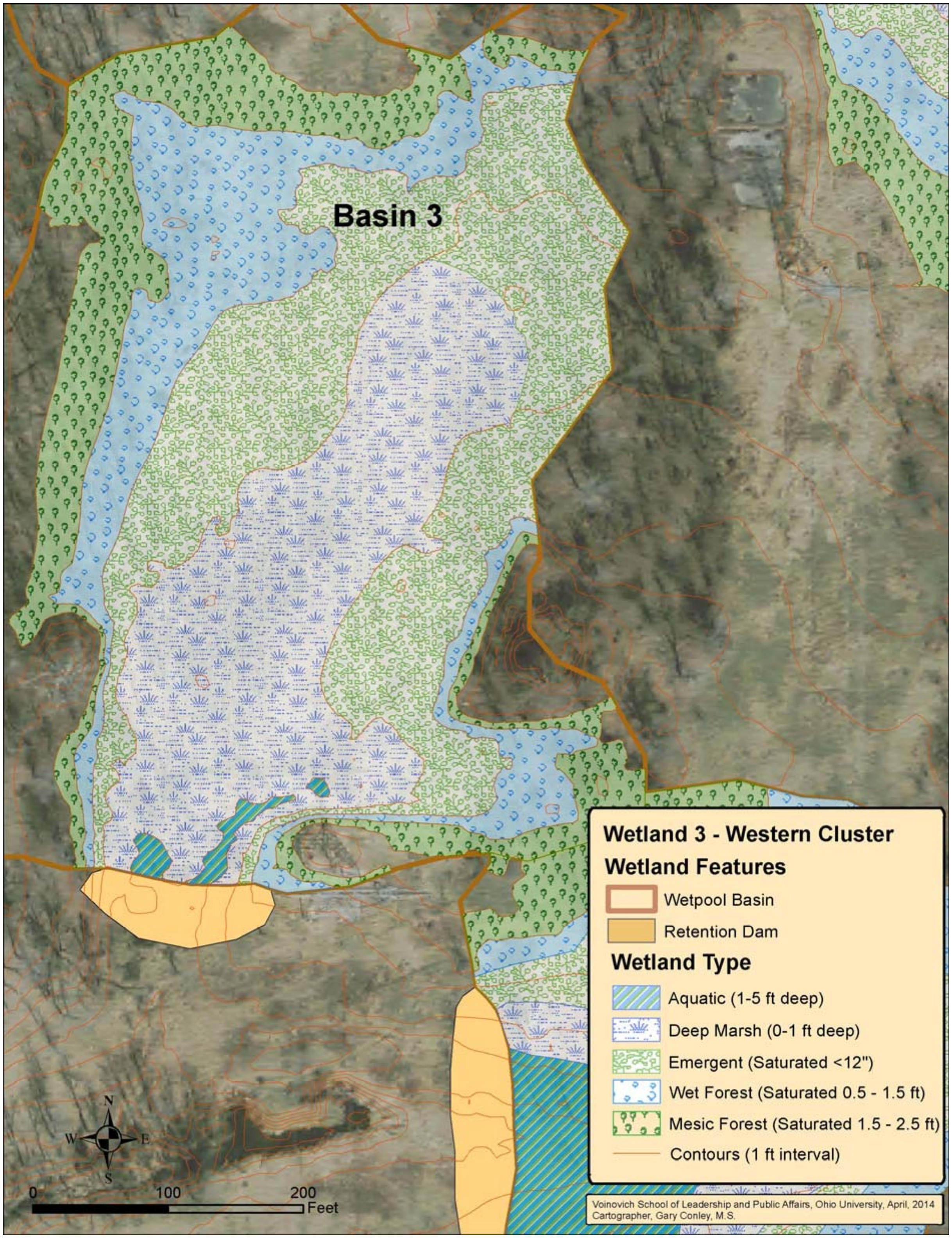


Figure 4.4 Conceptual wetland plant community for wetland 3

Table 4.7 Hydraulic Zones for Wet Pool 3

Hydrologic Zone	Area (acres)
1	0.04
2	1.44
3	1.72
4	0.96
5	0.96
Total	**5.13**

4.1.1.4 Wet Pool 4

The creation of wet pool 4 (Figure 4.5) would require an above-grade earthen dam approximately 4-feet in height and a top elevation of approximately 695.0. The permanent pool elevation would be at 693.0 and the upper elevation of the wetted fringe at approximately 694.5. Below-grade excavation within the wet pool area to obtain fill material for the dam would in some areas of total water depth of 5 to 6 feet. The discharge from wet pool 4 would be via an earthen spillway near the northwest end of the dam that would discharge to a north-flowing channel, which flows into a treatment pond located approximately 1500 feet to the north. Table 4.8 lists the areas of the various hydrologic zones in this feature.

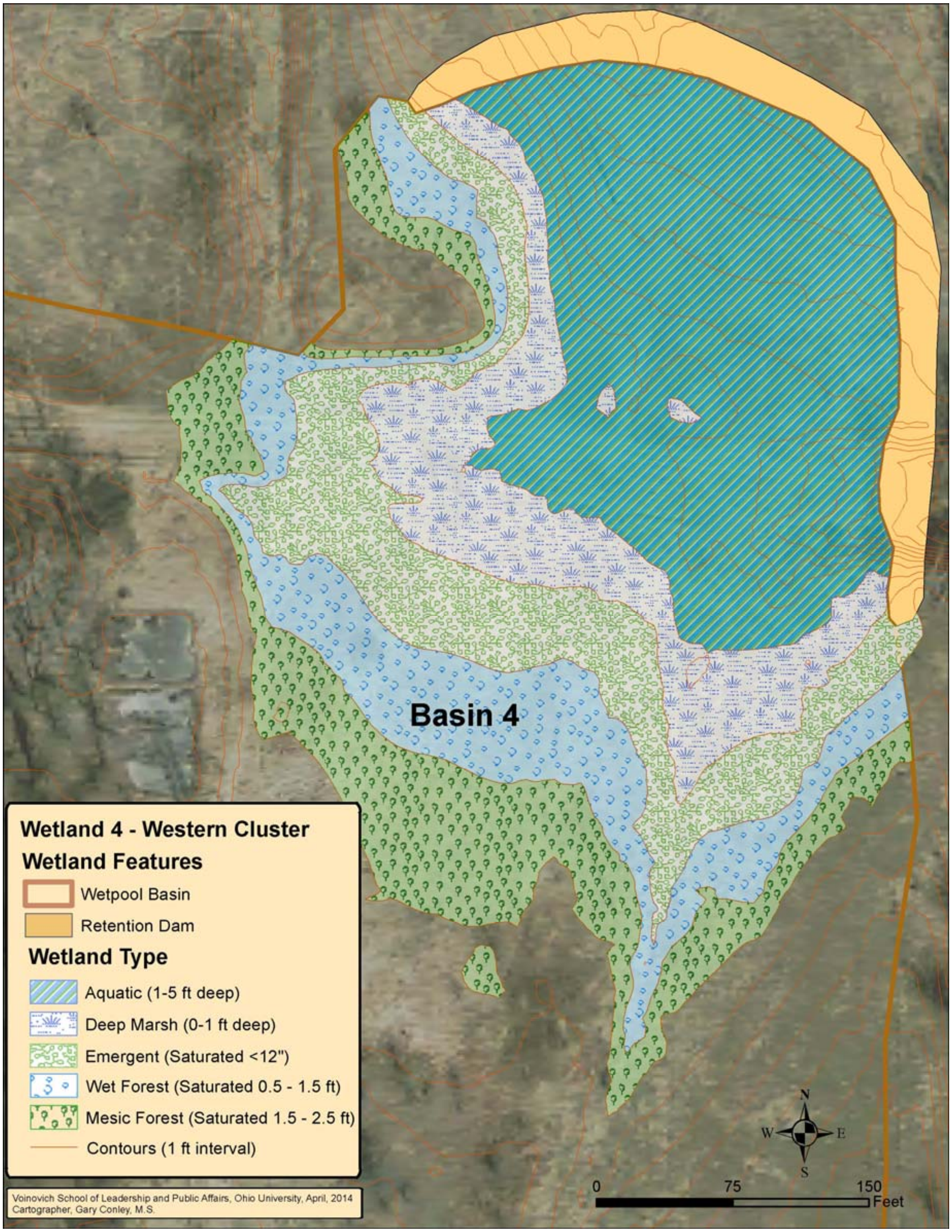


Figure 4.5 Conceptual wetland plant community for wetland 4

Table 4.8 Hydraulic Zones for Wet Pool 4

Hydrologic Zone	Area (acres)
1	1.23
2	0.46
3	0.56
4	0.54
5	0.61
Total	**3.39**

4.1.1.5 Wet Pool 5

Wet pool 5, as shown by Figure 4.6, would be created by the construction of a north-south trending earthen dam located across the upper portion of the westward-flowing swale that contains wetland w02 (Appendix F). Dam top elevation would be at approximately 705.0, with a maximum spillway controlled pool elevation of 703.0. This pool elevation would inundate or saturate an area extending 600 feet to the east. Table 4.9 summarizes the induced hydrologic zones with this wet pool.

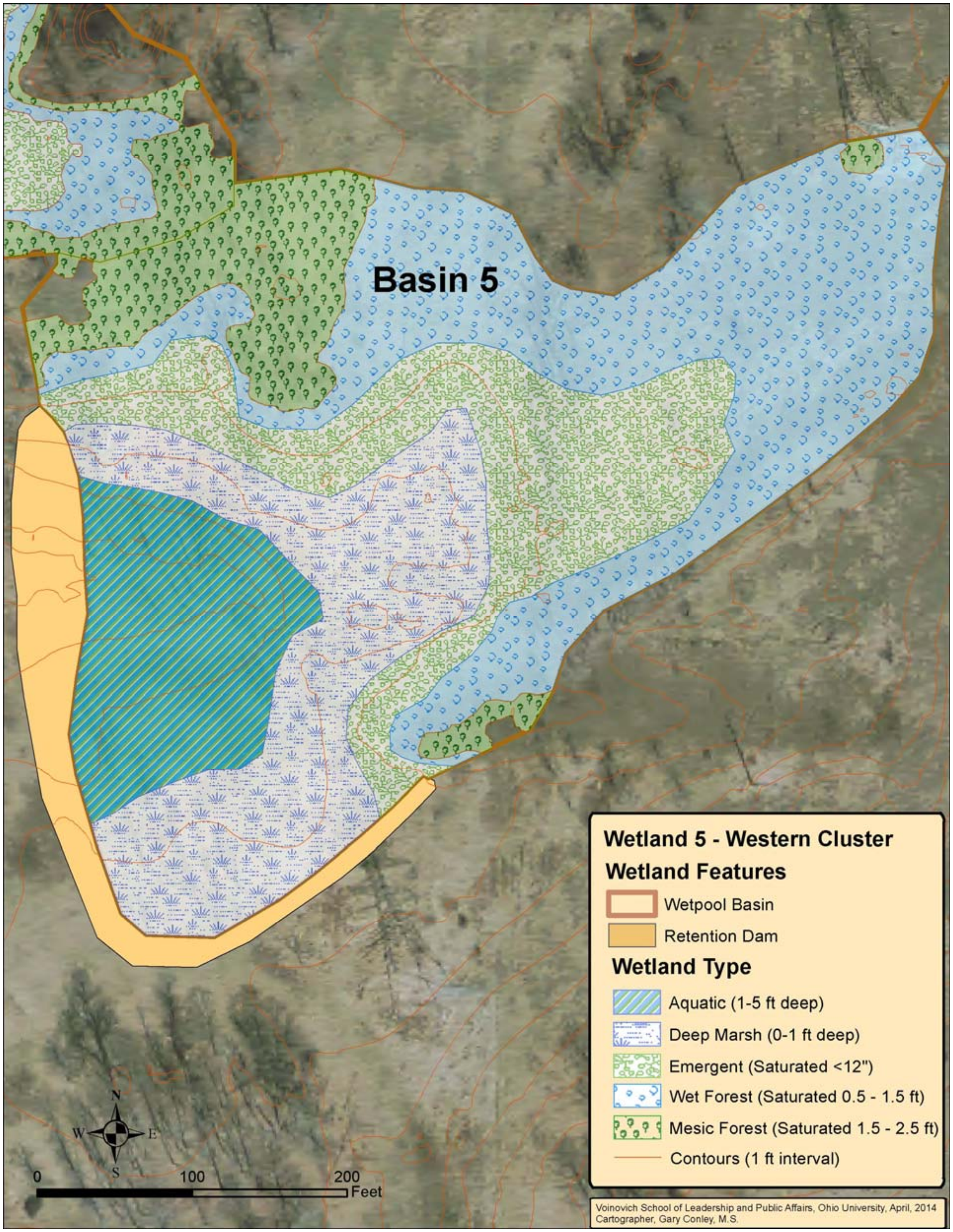


Figure 4.6 Conceptual wetland plant community for wetland 5

Table 4.9 Hydraulic Zones for Wet Pool 5

Hydrologic Zone	Area (acres)
1	0.55
2	0.88
3	0.83
4	1.38
5	0.42
Total	**4.07**

4.1.2 Eastern Cluster

The eastern cluster of mitigation bank wetlands would be created by utilization of excavation pits resulting from a fill material borrow operation that, based on the size/age of the occupying trees, appears to have occurred 20-30 years ago. Given the proximity, the excavated material may have been used to construct the dam for the lime collection pond to the north. (Figure 4.7) The linearity of the four excavation pits suggest that the borrow operation proceeded from south to the north and may have been performed using a pan scraper. It appears as though 2 to 6 feet of earth material was removed generally along the contour, leaving undisturbed strips of earth along the western sides of the excavations that could be made to serve as a berm to retain shallow pools. Several outlet control structures and some relatively small low-head dams and berms needed to seal breaches in the western excavation relict edges could convert these borrow pits into mitigation wetlands. The wetland delineation (Appendix F) indicates that small, annual to perennial successional herb-dominated wetlands have accrued near erosional outlets. Dam construction would be likely to cause temporary loss of these features.

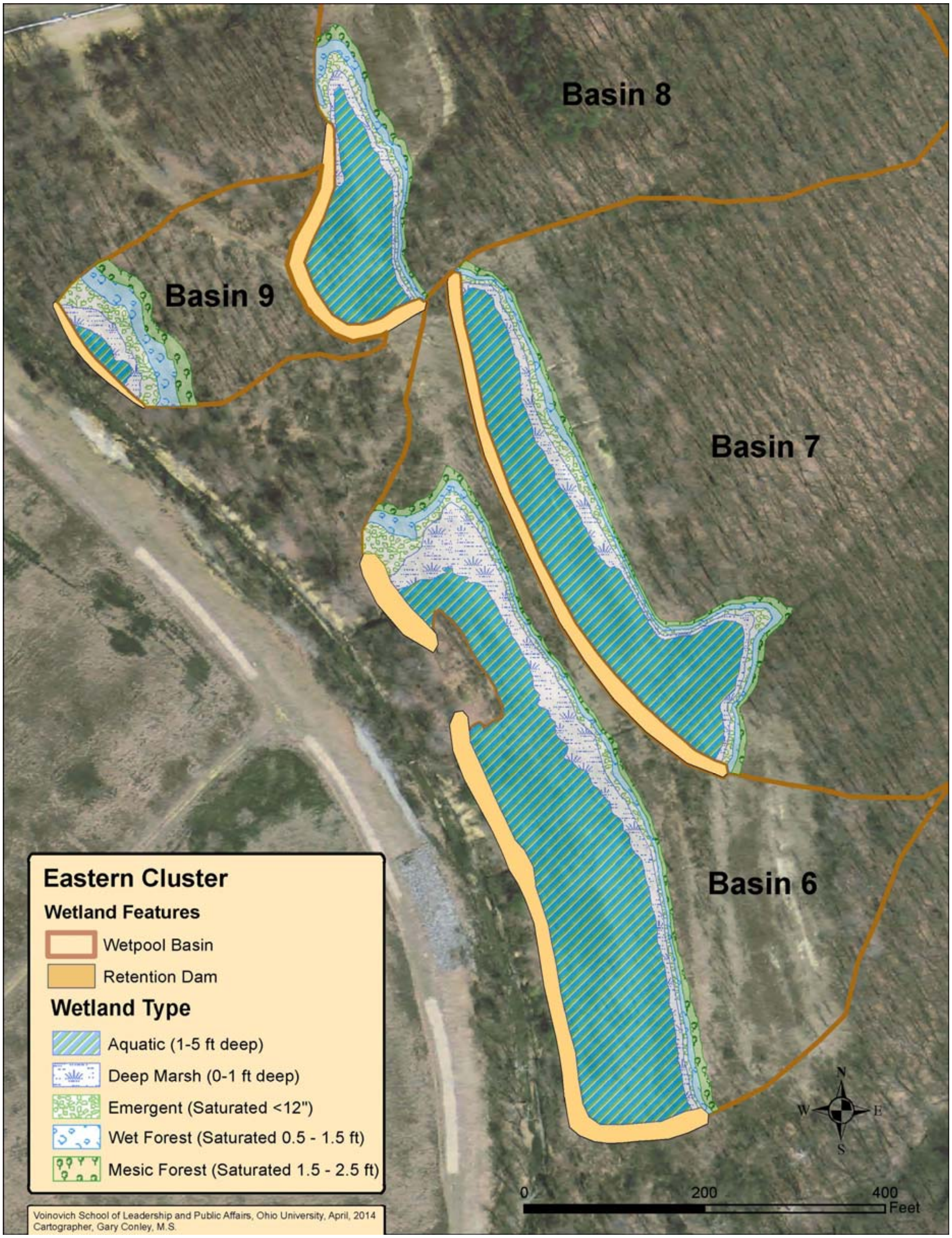


Figure 4.7 The Eastern cluster conceptual wetland design layout

4.1.2.1 Wet pool 6

Wet pool 6 would require two separate earthen dams as shown in Figure 4.8. The top elevation of both would be approximately elevation 647.0, resulting in a spillway elevation of 645.5. Earthen dam 6A would close an erosion channel and would have no spillway. The spillway would be located at earthen dam 6B and would require a south flowing discharge channel that would direct outflow to a natural channel approximately 300 feet to the south. Dam 6B would be an above grade berm approximately 4 feet at its highest point along the southwestern side. There are three low quality wetlands that would be located within the wet pool (w16, w17, w18). There would be no fill placed in these wetlands, however their hydroperiod would likely increase changing them from a hydrologic zone 4 to a zone 1 or 2. Table 4.10 lists the areas of the various hydrologic zones in wet pool 6.

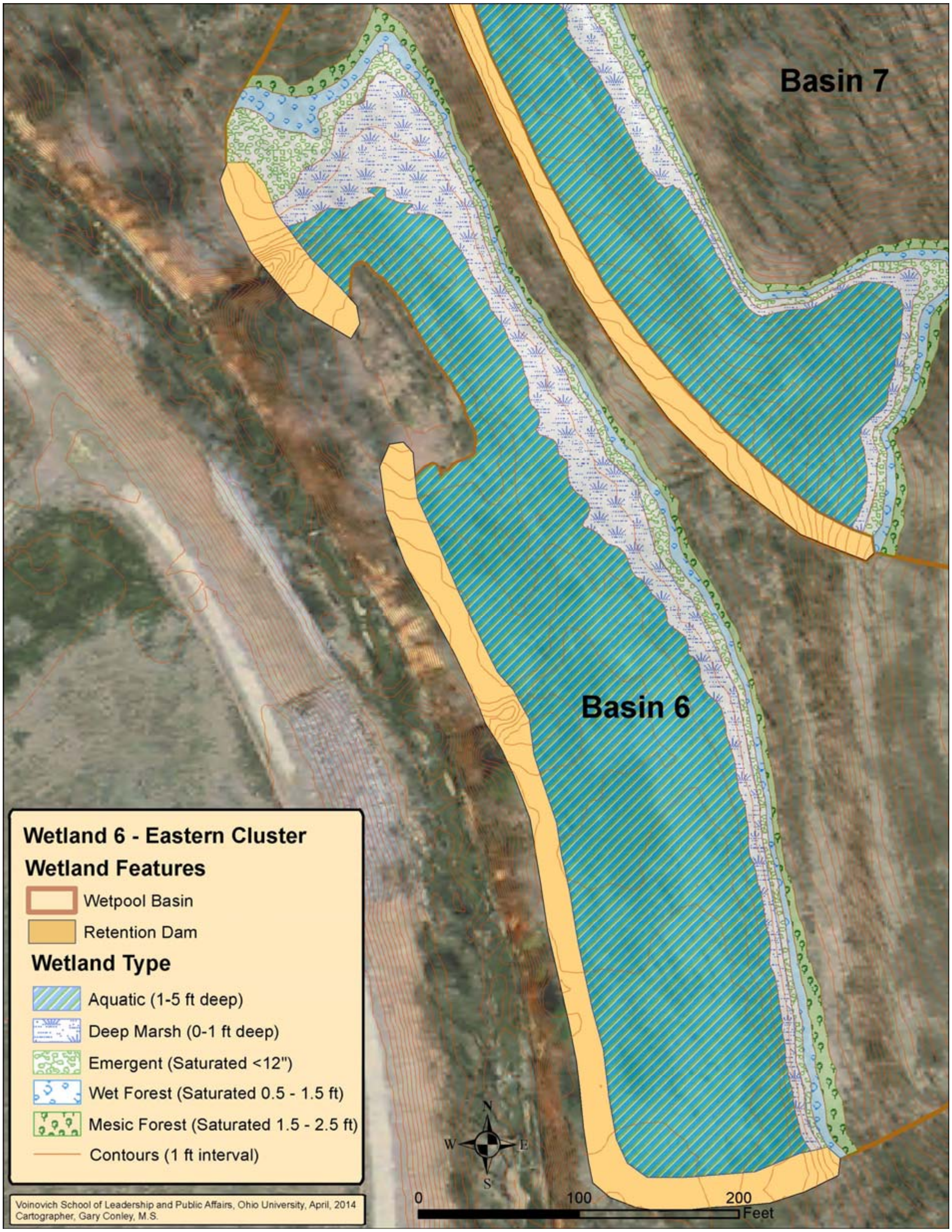


Figure 4.8 Conceptual wetland plant community for wetland 6

Table 4.10 Hydraulic Zones for Wet Pool 6

Hydrologic Zone	Area (acres)
1	1.41
2	0.36
3	0.15
4	0.12
5	0.11
Total	**2.15**

4.1.2.2 Wet pool 7

The conversion of the upper borrow pit to a mitigation bank wetland would require additional excavation, particularly along the south half of the wet pool, to an elevation of approximately 660.0 and the creation of an earthen dam at elevation 664.0. Spillway elevation would impound up to 2 feet of water at elevation 662.0. As depicted in Figure 4.9, the dam would block a southwest flowing natural channel and retain runoff from this channel and an adjacent wooded hillside in a basin that would be graded along the contour. The spillway would discharge again into the natural channel, which would conduct excess runoff to wet pool 6. Table 4.11 shows the distribution of hydrologic zones in this wet pool.

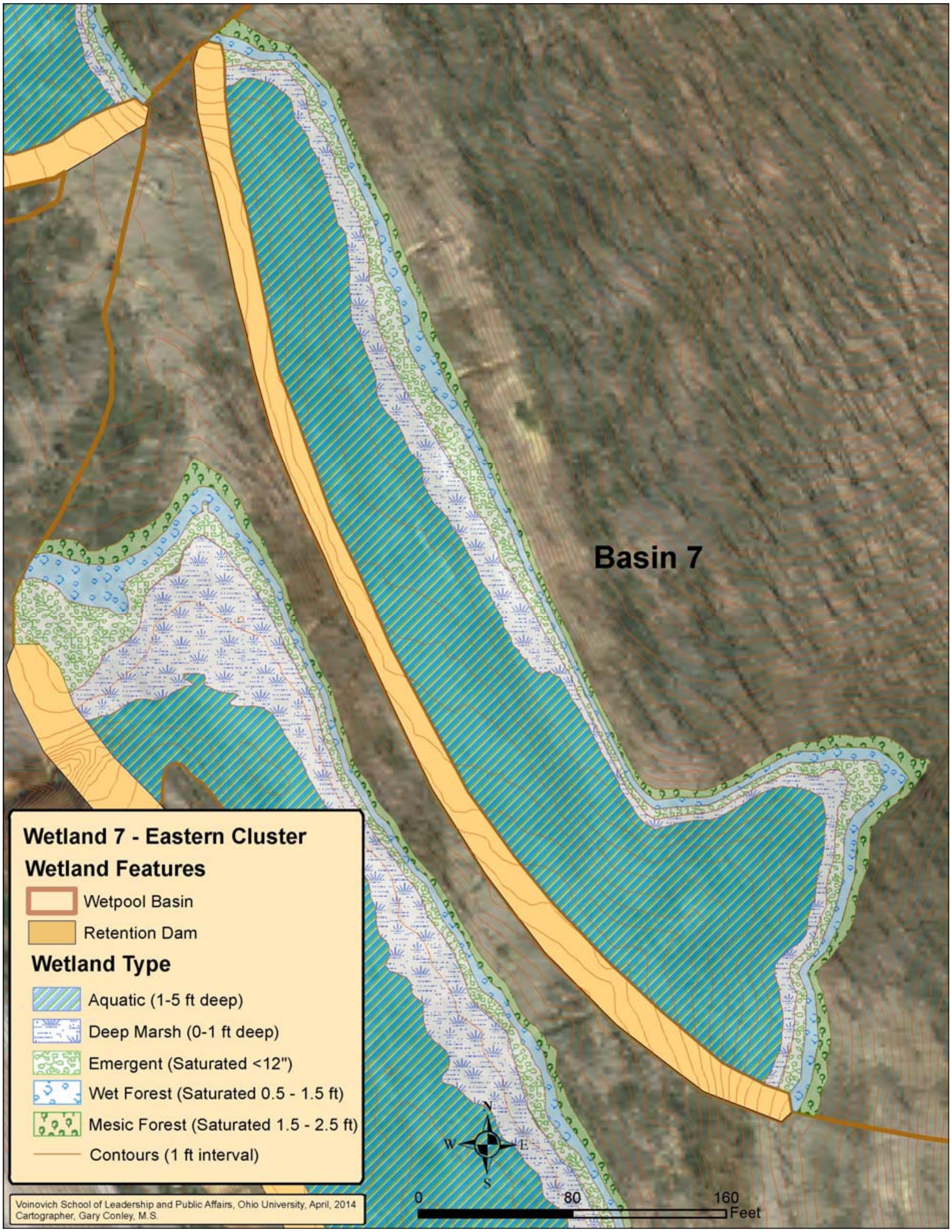


Figure 4.9 Conceptual wetland plant community for wetland 7

Table 4.11 Hydraulic Zones for Wet Pool 7

Hydrologic Zone	Area (acres)
1	0.82
2	0.15
3	0.12
4	0.10
5	0.08
Total	**1.27**

4.1.2.3 Wet pool 8

Wet pool 8 (Figure 4.10) would result from the placement of an earthen dam across an existing excavation pit at the approximate elevation 652.0. The wet pool elevation as controlled by the principal spillway would retain surface water at elevation 650.0, increasing the hydroperiod for an existing but recent in origin, low quality wetland (w14). Materials for the dam would be derived from excavation along the northeastern perimeter, widening the pit bottom and in dong temporarily disturbing the surface grad of the existing wetland. The spill way for dam 8 would direct flow to wet pool 9. Table 4.12 shows the distribution of hydrologic zones in this wet pool.

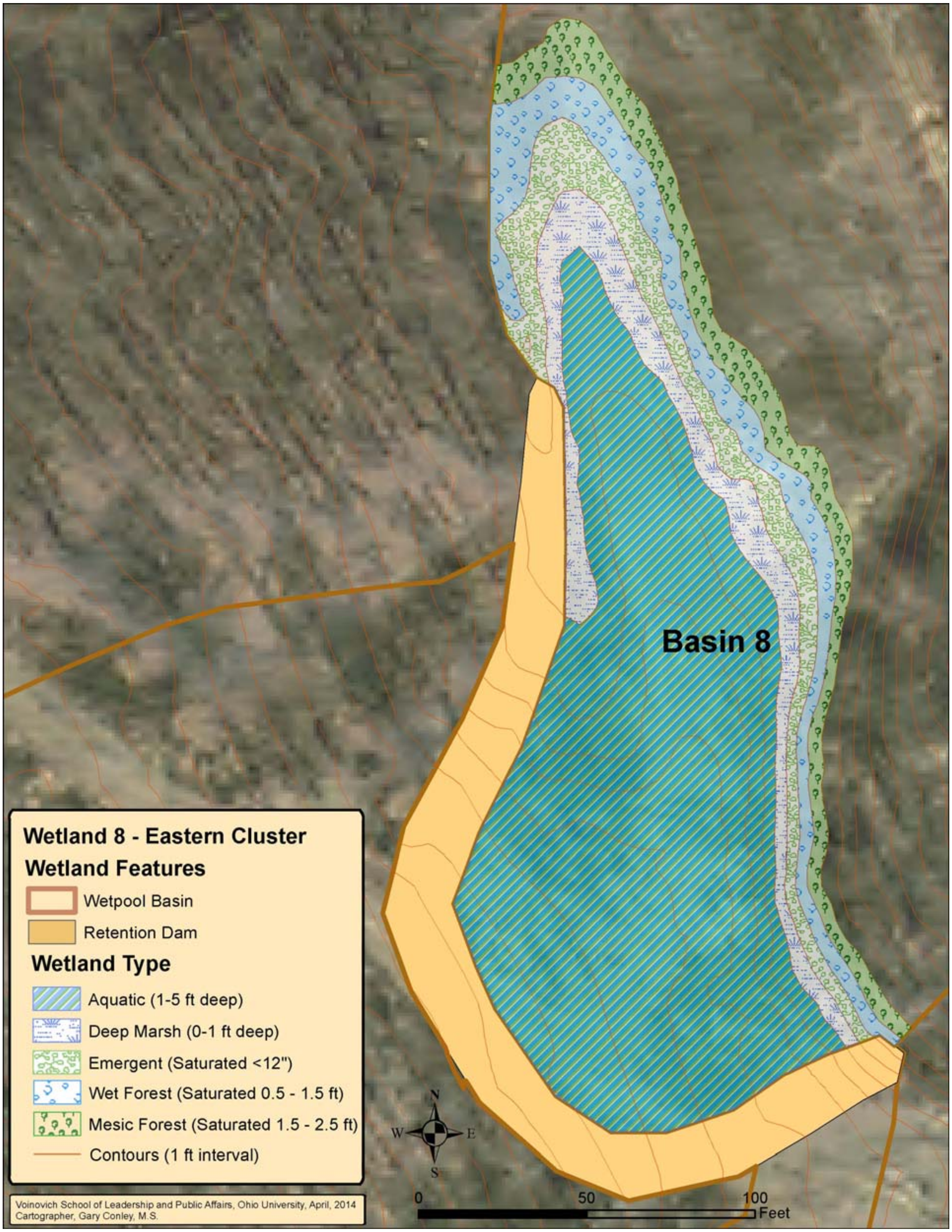


Figure 4.10 Conceptual wetland plant community for wetland 8

Table 4.12 Hydraulic Zones for Wet Pool 8

Hydrologic Zone	Area (acres)
1	0.36
2	0.06
3	0.06
4	0.06
5	0.05
Total	**0.58**

4.1.2.4 Wet pool 9

Wet pool 9 (Figure 4.11)could be created within another borrow pit by the construction of an earthen dam across an erosion channel that presently discharges to Little Beaver Creek over a 12-15 foot high rocky ledge. The dam, with a top elevation at approximately 634.0 would have a maximum impoundment elevation of 632.0. This would inundate an existing low quality wetland (w15) that could experience minor disturbance during dam construction. Table 4.13 shows the areas of hydrologic planting zones that would result.

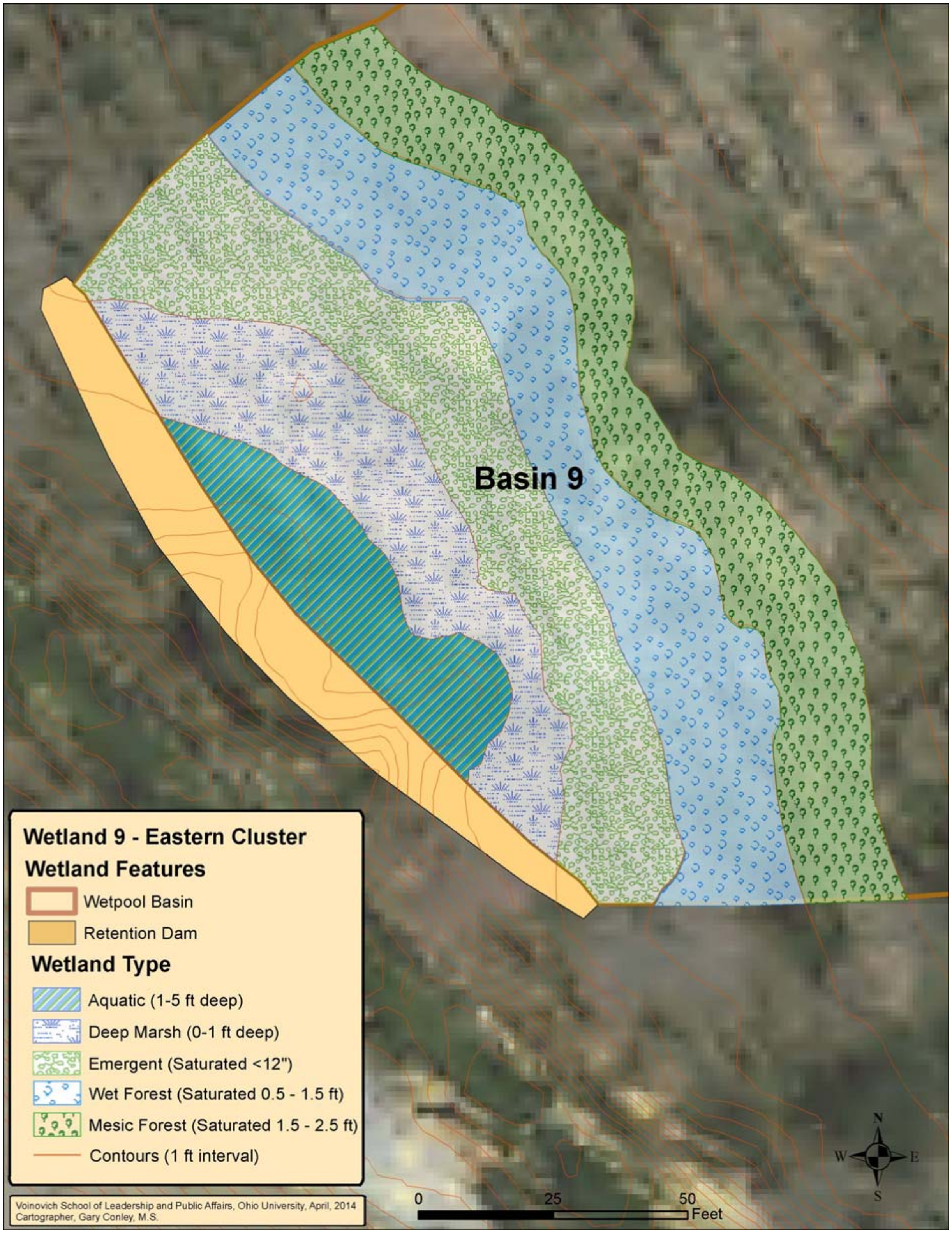


Figure 4.11 Conceptual wetland plant community for wetland 9

Table 4.13 Hydraulic Zones for Wet Pool 9

Hydrologic Zone	Area (acres)
1	0.03
2	0.05
3	0.08
4	0.08
5	0.07
Total	**0.31**

4.1.3 Southern Cluster

The southern created wetland cluster includes only two locations along a southwestern-facing slope (Figure 4.12). This general site has not, unlike the other mitigation wetland clusters, been profoundly disturbed or filled. It appears that some borrow has occurred, but the majority of the sites are merely maintained in a low seral stage by frequent mowing. Springs emerge within both features that suggest the locations of impounding dams, the lower of which may be perennial in discharge.

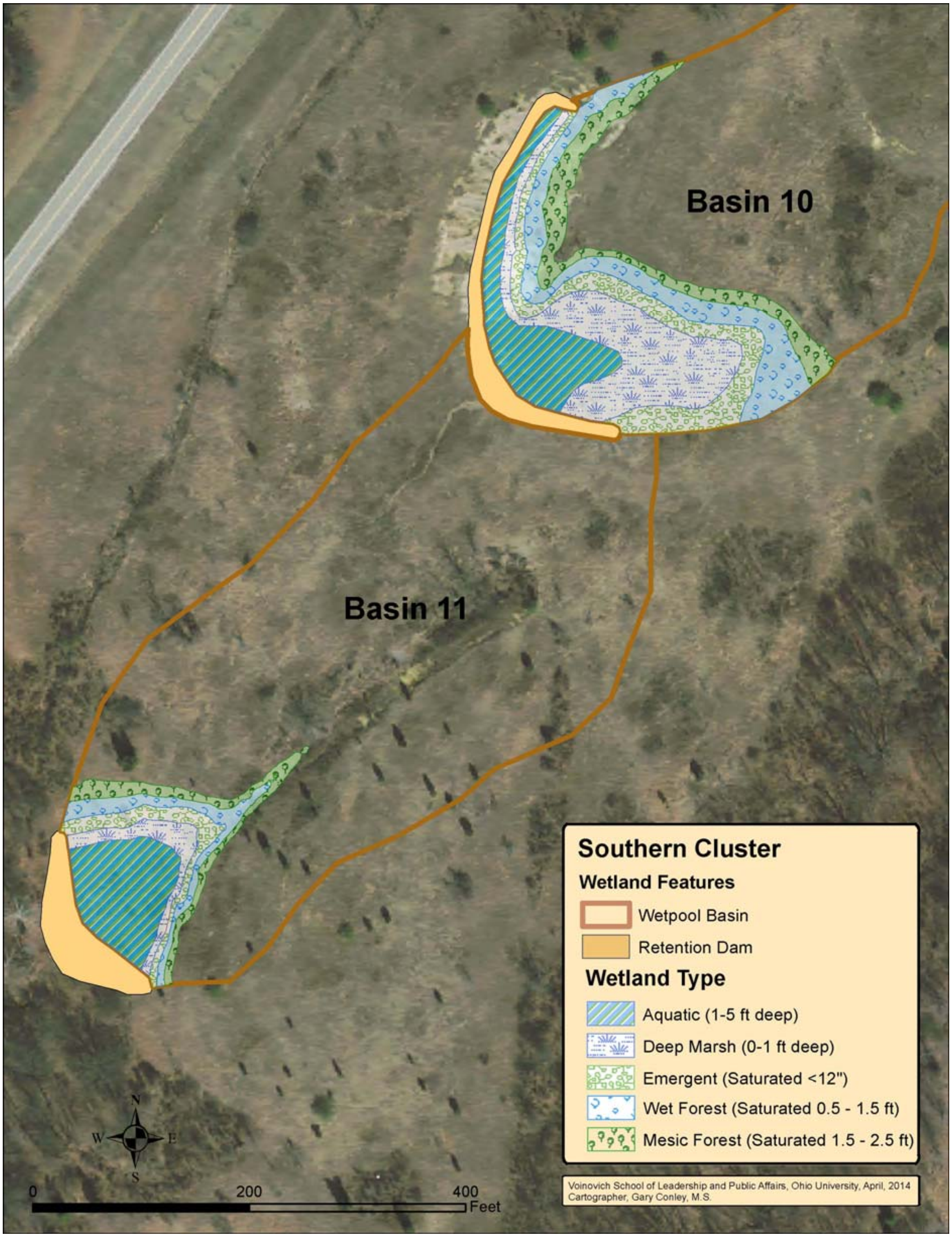


Figure 4.12 The Southern cluster conceptual wetland design layout

4.1.4 Wet pool 10

Figure 4.13 shows the proposed earthen dam with a top elevation of approximately 696.0, which will create a maximum pool at elevation 694.0. The northern part of this feature would take advantage of a shallow borrow pit. The southern portion would take advantage of a natural hillside depression. The spillway for this basin would direct overflow to an existing natural channel and then to wet pool 11. Table 4.14 displays the distribution of hydrologic planting zones.

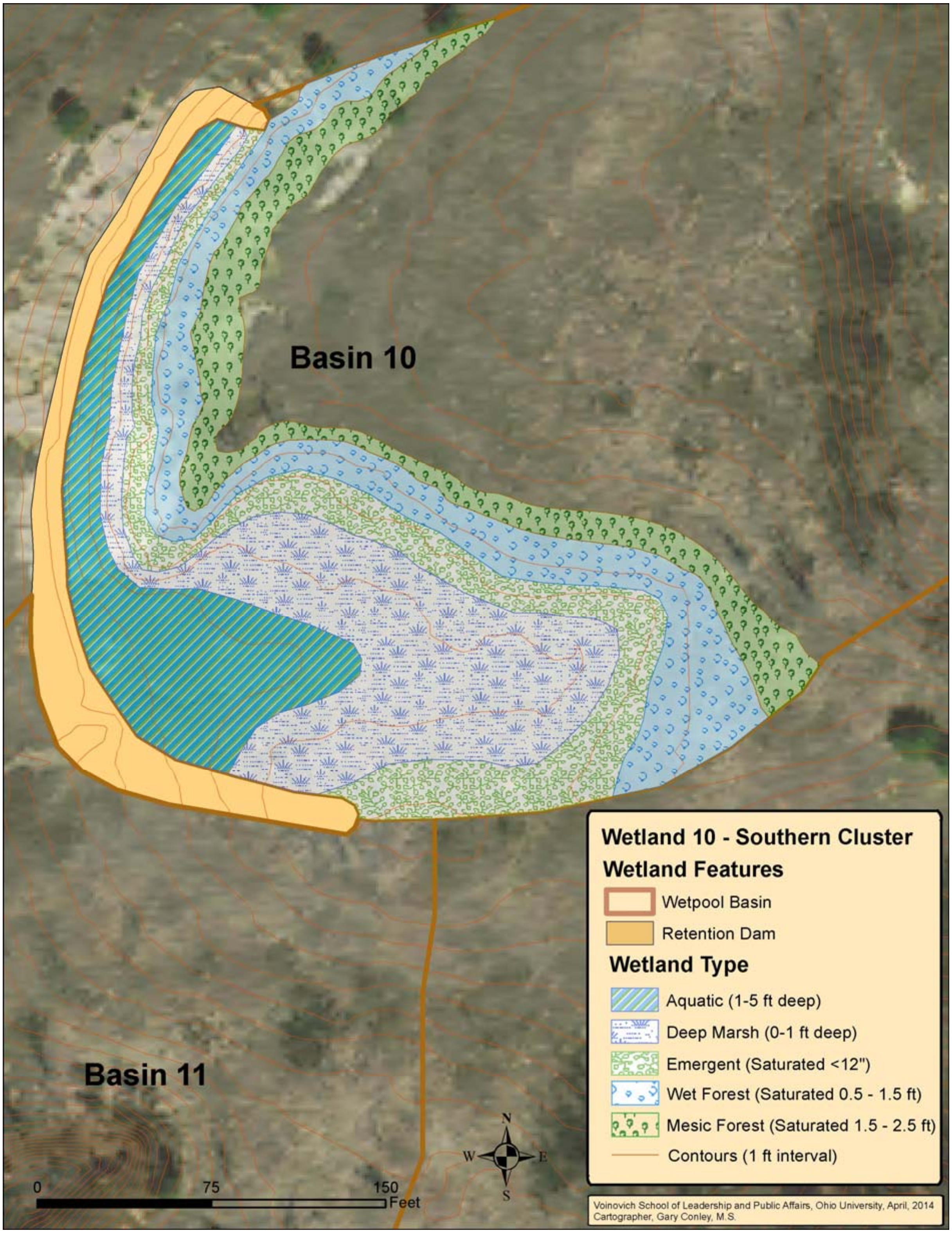


Figure 4.13 Conceptual wetland plant community for wetland 10

Table 4.14 Hydraulic Zones for Wet Pool 10

Hydrologic Zone	Area (acres)
1	0.21
2	0.32
3	0.20
4	0.24
5	0.17
Total	**1.15**

4.1.5 Wet pool 11

Wet pool 11 as depicted in Figure 4.14 would be induced by an earthen dam placed across a natural channel at approximate elevation 663.0, which would establish a maximum pool elevation of 661.0. There is a natural topographic basin that would be inundated or saturated and result in hydrologic planting zones listed in Table 4.15. A natural wetland, likely caused by a perennial spring, existing along the inflow channel to this basin (w06) would not likely be disturbed by the dam construction or increased extent of surface saturation. Discharge for this wet pool is likely to be perennial suggesting the need for some portion of the principal discharge channel to be hardened. Due to the distance and steepness of drop from this structure, the discharge point to the natural channel would also likely require hardening to prevent erosion. It is suggested that due to the steep slopes and perennial spring flow that this structure may be the most expensive to build per unit area of mitigation wetland.

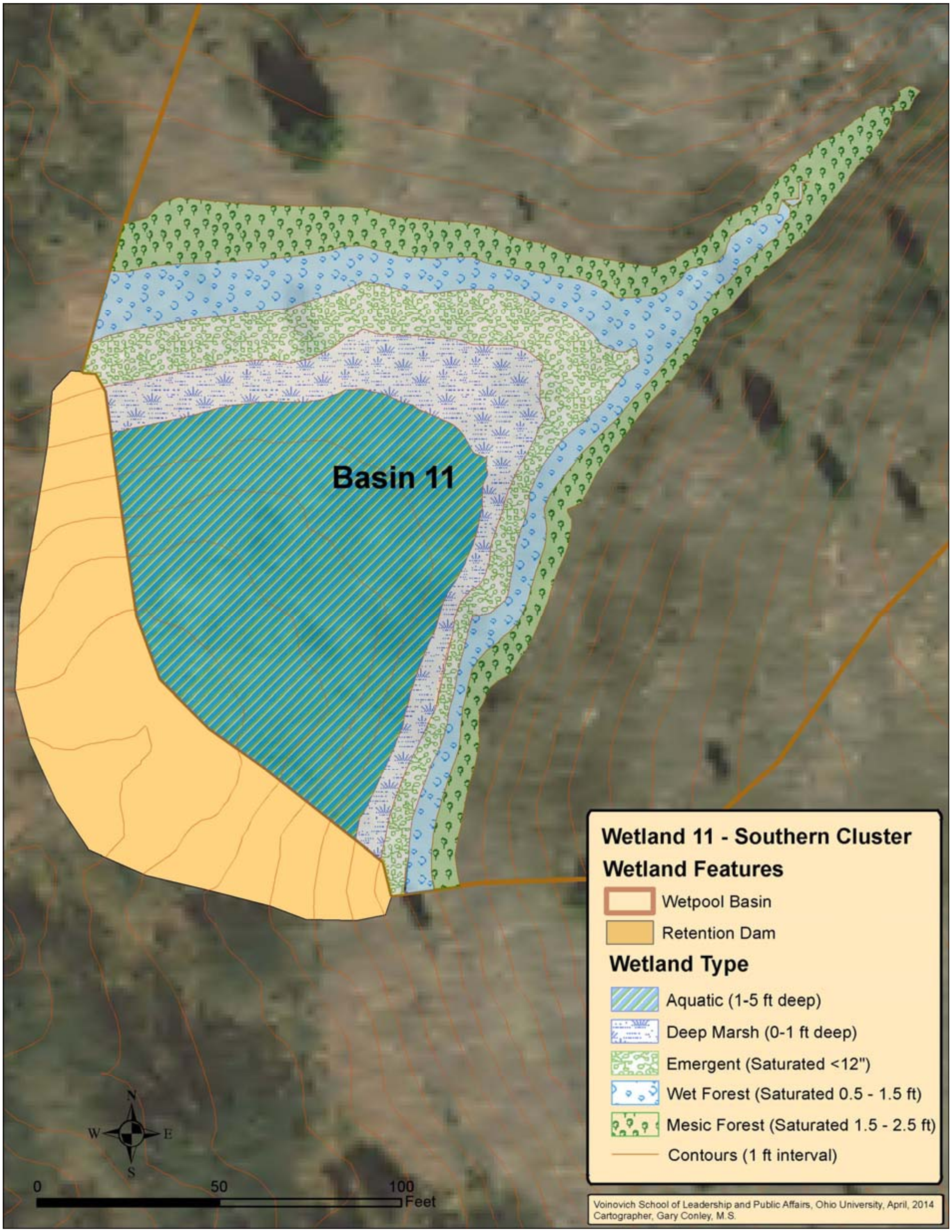


Figure 4.14 Conceptual wetland plant community for wetland 11

Table 4.15 Hydraulic Zones for Wet Pool 11

Hydrologic Zone	Area (acres)
1	0.19
2	0.06
3	0.07
4	0.08
5	0.08
Total	0.49

4.2 Summary of Mitigation Wetlands

The construction of earthen dams, minor excavation, ditches, diversions and spillways for all eleven wet pools would collectively create approximately 21.16 acres of wetlands. Any part or all of these conceptual mitigation site options could serve as a mitigation bank to fulfill future wetland mitigation needs. Table 4.16 summarizes the extent of various induced hydrologic vegetation zones.

Table 4.16 Summary of Wetland Hydrologic Vegetation Zones for the PORTS Wetland Mitigation Bank

Wet pool	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total
1	0.48	0.39	0.14	0.15	0.17	1.32
2	0.57	0.14	0.16	0.20	0.25	1.31
3	0.04	1.44	1.72	0.96	0.96	5.13
4	1.23	0.46	0.56	0.54	0.61	3.39
5	0.55	0.88	0.83	1.38	0.42	4.07
6	1.41	0.36	0.15	0.12	0.11	2.15
7	0.82	0.15	0.12	0.10	0.08	1.27
8	0.36	0.06	0.06	0.06	0.05	0.58
9	0.03	0.05	0.08	0.08	0.07	0.31
10	0.21	0.32	0.20	0.24	0.17	1.15
11	0.19	0.06	0.07	0.08	0.08	0.49
TOTALS	**5.90**	**4.30**	**4.10**	**3.90**	**2.97**	**21.16**

5 Adaptive Management

Adaptive management (AM) is a systematic approach for improving resource management by learning from management outcomes. Various perspectives on adaptive management are rooted in parallel concepts found in business such as total quality management and learning organizations, in experimental science as hypothesis testing and in systems theory as feedback control (Williams et al 2009). AM is at its root the obtaining of targeted information concerning the existing conditions of a management element, comparing that condition to a self-established set of minimum thresholds for that management element and then developing and implementing a plan to modify the management element in a way that brings its condition into the realm of established threshold conditions. Wetlands by definition are restricted to conditional thresholds as they are required to exhibit hydric soils, dominant hydrophytic vegetation, and adequate hydrology for a minimum period of time during each growing season. As applied to wetlands intentionally created as a mitigation bank, the components of adaptive management include:

- Monitoring the condition of the created wetlands to satisfy the minimum thresholds
- The preparation and submittal of a report to a designated oversight authority
- An action/Implementation plan to address the findings of monitoring and any concerns identified by the oversight authority.

The conditions of interest and for which minimum thresholds might be established within a created wetland include:

- Vegetation success, and particularly mortality and survival
- Vegetation composition and structure
- The presence of invasive weed species
- Evidence of wetland hydrology
- Use of the wetland habitat by native wildlife

The quantitative assessment of these characteristics constitute the feedback loop needed for the system designer, builder and manager to understand the cause and effect relationships between design decisions and management action needed for effective establishment and management of a desired outcome. As importantly, these kinds of measurements, analyses and findings demonstrate to an external mitigation plan authority that the creation effort was not only successful but serve as the basis for negotiation of the mitigation ratios when unavoidable wetland impacts must occur and the mitigation bank wetland credits would be allotted. A well-designed, properly installed and well-managed wetland may demonstrate significantly better quality wetlands than those that may be disturbed by a needed activity, allowing for the negotiation of a less than 1:1 mitigation ratio.

5.1 Monitoring Plan

A monitoring plan is a method for measuring and analyzing the condition of the wetland bank. Such a plan would include the implantation of method to measure plant communities and an inspection routine for hydrologic control structures. There have been many methods developed for the measurement of and the valuation of various aspects of plant communities. A method that is both locally appropriate and scientifically defensible is a set of protocols developed in part by Brian Gara (Ohio EPA, 2013), John Mack

(Ohio EPA, 2004, 2006), Andreas et al 2004 and many others is The Vegetation Index of Biotic Integrity "Floristic Quality" (VIBI-FQ) (Gara 2013). This method employs plot sampling similar to the Braun-Blanquet releve', wherein a fix set of sampling plots is established and resampled over time to measure and quantify changes in plant communities. This method is recommended by Ohio EPA for the sampling of mitigation wetlands (those required to be constructed as condition of a permit to impact natural wetlands). The method has two components; 1) a detailed sampling protocol that allows for high repeatability and 2) an analytical method that is consistent and easy to apply. Analysis results in a valuation of the plant community by calculation of a weighted geometric mean based on an established "coefficient of conservatism" (C of C) ratings for all plant species with "0" to "10" and a calculation of species importance value from collected field data. C of C is an expression of plant species tolerance and fidelity to a particular habitat. Species rated as "0" are usually invasive rural weeds. Plants rated as "10" are usually rare species that thrive in unique environmental conditions that have reached a sustained climatic climax state. The weighed C of C value and a measure of "diversity" (the number and relative abundance of species within a fixed area) can be consistently applied to identify both present condition and trends in a plant community.

VIBI-FQ sampling plots would be established once hydrologic modifications have been completed and the planting zones planted and seeded. Monitoring would be conducted on a yearly basis for the first five years in order quickly observe early mortality and weed invasion. A reduction of the frequency of monitoring using quantitative methods might be reduced to three to five year periods if clear trends can be established in the first five years. Frequent inspection would be conducted on a less than annual basis to identify problems such as weed infestation and spillway erosion.

5.2 Report Preparation

Annual reporting to an authorizing authority is generally required if and/or when a mitigation bank is established. Specifying the terms of the wetland bank establishment plan and reviewing annual reports are likely to be the negotiated roles of the reviewing authority. Data collected from the monitoring plan would be analyzed to yield a valuation of the conditions against some set of established values. The report serves the functions of:

- Informing reviewing authorities of progress and reinforcing the commitment to continue observation and management of the wetland bank
- Building of a record of changes in wetland and demonstration of increasing wetland quality
- To serve as the basis for management action by demonstrating the distance between a repeatedly measureable condition and an initially established quality threshold
- To serve as a basis for establishing an operating budget line items that assures the appropriate management activities are fully funded.

5.3 Adaptive Management Action

A wetland mitigation bank is, like any other constructed feature, set of conditions or item, something that must be observed and maintained to achieve its usefulness or intend value. Many wetland mitigation efforts fail directly because of an absence of follow-up monitoring and maintenance. Once monitoring data collected and analyzed and often before a report is submitted and reviewed, the characteristics observed can lead to corrective actions. An action plan should initially conceive the conditions or things that could go wrong and prepare the plans and organize the tools to make rapid corrections. The components of a wetland management plan would include:

- A prepared operations plan that identifies functional thresholds for the wetland vegetation (e.g. 95% survival after 2 years by planted woody vegetation, less than 15% barren area in herbaceous vegetation, 1% weed infestation) and specifies practices and needed equipment,
- The tools, chemicals, supplies that might be needed and a place to store and maintain them,
- An assigned supervisor aware of the mission, and delegated the authority and budget to carry it forward,
- A level of training needed by a crew assigned to perform the needed maintenance.

6 Site Protection

The factors that characterize and define a wetland (i.e. hydrology, hydric soils, and hydrophytic vegetation) are susceptible to disturbance. EPA guidelines require that a site authorized to function and be usable as a wetland mitigation bank must be protected forever. Regulations found in the Federal Register / Vol. 73, No. 70 / Thursday, April 10, 2008 / Rules and Regulations specifies that site protection generally consists of three considerations:

- Protection of the real estate through easements
- Budgetary commitment to monitoring and maintenance (financial assurances)
- Identification of Responsible Party

The manner in which DOE addresses these issues would seem to be through the development of specific policy that may take the form of an interagency memorandum of agreement. Such an agreement might consider the following:

- It is uncertain whether DOE can attach easements to lands under its authority. A specific use designation for the areas needed for the wetland mitigation, including a land survey might satisfy this typical mitigation banking requirement
- A critical element for assuring that a wetland mitigation bank is maintained and protected is the assignment of an annual operating budget as part of the overall sites budgeting process
- While DOE would be the responsible party for the maintenance of the mitigation bank wetlands, the manner by which such responsibilities obligate a new owner, should DOE transfer some or all of the bank lands to a third party should be specified

7 Summary Recommendations

This study suggests that it would be feasible to establish a wetland mitigation bank by creating wetlands at least three locations within the DOE PORTS lands. Approximately 21.16 acres of wetlands could be created to offset future unavoidable impacts to existing wetlands as the need arises. The information contained in this report serves to support the decision-making process when considering wetland mitigation projects on-site at PORTS.

The value of created wetlands in terms of plant community structure, species composition and wildlife habitat increase with the passage of time. The greater the demonstrated value of a mitigation wetland at the time of its commitment to a specific regulatory compensatory mitigation requirement, the lower the compensation ratio may be. Minimizing the compensation ratio (i.e., reducing it to 1:1 or less) maximizes the cost effectiveness of the initial construction.

It may be necessary to collect high-quality topographic data and local soil data to assess infiltration rates and structural uses as the basis for engineering design and the preparation of construction documents. The optimal construction period of mitigation wetlands is late spring, with all grading and resoiling completed by the fall planting season of that same year. Seeding and planting of root perennials should be completed in early spring the following year. Prior to commencement of earth moving activity, the area within 200 feet around the site should be inspected for invasive plants and these suppressed using mechanical and chemical means.

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