A STUDY OF SEEPAGE WETLANDS IN PENNSYLVANIA

Report To:

The United States Environmental Protection Agency
and
The Pennsylvania Department of Conservation and Natural Resources
Bureau of Forestry
Forestry Advisory Services

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INTRODUCTION

In the Northeast, wetlands that occur in topographic depressions and at the base of slopes represent a transition from more upland communities to those associated with permanent water, including lakes and streams (Novitzki 1989). Topographic position and geology determine the mix of ground and surface water available to a given wetland and for all but the most ombrotrophic bogs, groundwater input conveys some portion of the hydrologic budget to wetlands. Wetlands associated with depressions such as swamps and marshes receive a mixture of ground and surface water. Wetlands on slopes, beyond the influence of stream or lake flooding, are fed largely by groundwater discharge. These wetlands are generally small and depend on the following water sources: seepage from fractures that break the continuity of unconfined aquifers (water table); the presence of perched water tables; or seepage from the exposure of confined aquifers (artesian conditions) (Bushnell 1989, Podniesinski, 1998).

In Pennsylvania, non-basin wetland communities dependent primarily on groundwater discharge include: springs, basin and hillside fens, (northern Appalachian) seeps and riverside seeps (Smith 1991). Peat accumulating wetlands associated with the discharge of high pH groundwater are among the rarest communities in the state (PNDI 1998) and have been considered in detail for both state and regional inventory and classification (WPC 1995). Non-basin wetlands on mineral soils with a broader range of pH values have not received the same attention. However, non-basin seepage wetlands serve valuable functions and furnish habitat to numerous taxonomic groups. For example, seeps and springs provide both a food source and breeding habitat for the Red Salamander (Pseudotriton ruber) and the Spring Salamander (Gyrinphilus porphyviticus). Wet meadows and swales furnish habitat to Kirtlands Snake (Clonophis kirtlandii) and to the Pennsylvania endangered Eastern Massasauga Rattlesnake (Sistrurus catenatus) (McCoy 1989). Wetlands associated with groundwater seepage support Water Shrew (Sorex palustris) and the Star-nosed Mole (Condylura cristata) which exploit marshy areas surrounding streams (Kirkland and Serfass 1989).

Seepage wetlands often occur in association with larger palustrine complexes. Levels of distinction between seepage areas and the surrounding communities vary from state to state. Forested seepage wetlands are frequently considered part of larger communities while more open, shrub-, graminoid- or forb-dominated seepage wetlands are treated as individual communities. For example, New York includes forested seepage wetlands in either the Hemlock-hardwood Swamp community type or the Rich Hemlock-hardwood Peat Swamp community type while distinguishing between seven types of open fen communities (Reschke 1990). Pennsylvania's past classification followed a similar pattern, recognizing an Eastern Calcareous Seepage Swamp and a Circumneutral Broadleaf Swamp as the primary forested groundwater wetlands while distinguishing between four types of open or shrub dominated fen communities and four types of seep communities (Smith 1991).

Some classifications rely on vegetation to draw distinctions in the classification while others combine a number of topographic, physiognomic and vegetative characteristics to define community types. The current direction in community classification relies on floristics to define communities. The Nature Conservancy and the State Natural Heritage Programs completed a draft of a vegetation alliance-level classification based on vegetation (Sneddon, Anderson and

Metzler 1994). This classification and the current draft of the Community Alliances and Elements of the Eastern Region (Sneddon, Anderson and Metzler 1996) have helped to cross-reference community types among the states and will provide a range-wide vocabulary for sampling and classifying natural communities to states currently updating their community classifications.

PURPOSE

The purpose of this study is to develop a more complete understanding of calcareous and circumneutral seepage wetlands in Pennsylvania and to apply the data we collect to ongoing natural community classification efforts in Pennsylvania and in the Northeast. We designed this seepage wetland study to complement the calcareous fen study completed in 1995 (Western Pennsylvania Conservancy 1995).

METHODS

The general procedures follow those used in the study of calcareous fens. We obtained landowner permission before visiting seeps on private property. Permits necessary to collect plants on state lands and to collect Chapter 82 listed species were obtained from DCNR.

We established 61plots representing 46 sites during 1996-1997. **Figure 1** shows the distribution of sites across Pennsylvania. Twenty-six sites are in the glaciated northeast and northwest, while 20 sites are located south of the Wisconsinan glacial border. Detailed location information and general descriptions of the plots sampled as part of this study are found in **Appendix I**.

We collected vegetation and soils data for each plot within a single field season. At the end of the second year (September/October 1997), we revisited all plots to collect water samples and describe landscape context and site hydrology. Hydrologic models were produced for the seepage wetland sites (Podniesinski 1998), and detailed analyses of water samples were provided by Syracuse University.

Site Selection

The selection of sites for study involved assembling a portfolio of potential sites from various sources of information and visiting those sites to assess their quality and appropriateness for inclusion the intended research.

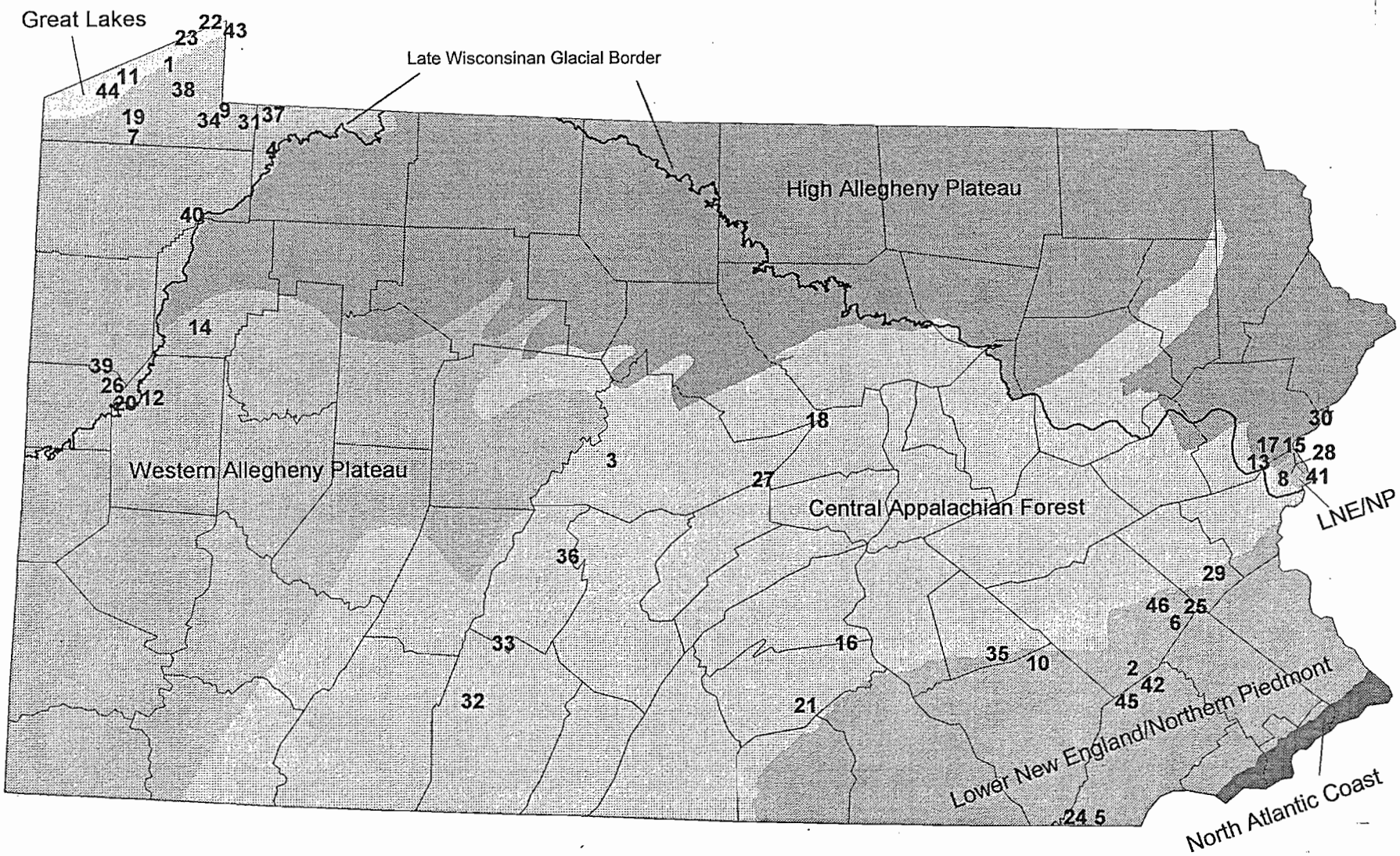

Figure 1. Map of Pennsylvania, showing 46 research sites and six ecoregions.

Sources
Ecoregion boundaries from The Nature Conservancy Eastern Regional Office, Boston, MA
Glacial border derived from Map 13, Physiographic Provinces of Pennsylvania, Commonwealth of Pennsylvania, Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey, 1995
County boundaries from Environmental Systems Research Institute, Inc., 1996

Map prepared by Susan Klugman and Andra Leimanis, The Nature Conservancy, Pennsylvania Science Office, and Jeffrey Wagner, Western Pennsylvania Conservancy

Pennsylvania Seepage Wetland Site Names, Abbreviations and Map Numbers

Site Name	Abbreviation	Map No.
Behrend Slumps 1	Behrend 1	1
Behrend Slumps 2	Behrend 2	1
Birdsboro Reservoir Seeps	Birdsboro	2
Black Moshannon Seeps	Black Moshannon	3
Carlisle Farm Seeps 1	Carlisle 1	4
Carlisle Farm Seeps 2	Carlisle 2	4
Carlisle Farm Seeps 3	Carlisle 3	4
Carlisle Farm Seeps 4	Carlisle 4	4
Chrome Serpentine Barrens Seep 1	Chrome 1	5
Chrome Serpentine Barrens Seep 2	Chrome 2	5
Dale Seeps 1	Dale 1	6
Dale Seeps 2	Dale 2	6
Edinboro Lake Seeps	Edinboro	7
Getz Swamp	Getz	8
Hubbel Run Seeps 1	Hubbel Run 1	9
Hubbel Run Seeps 2	Hubbel Run 2	9
Indian Run Seeps	Indian Run	10
James Preserve Seeps 1	James Preserve 1	11
James Preserve Seeps 2	James Preserve 2	11
Jennings Praire Seeps	Jennings	12
Kemmererville Seeps 1	Kemmererville 1	13
Kemmererville Seeps 2	Kemmererville 2	13
Kennerdell Seeps	Kennerdell	14
Lake Poco Seep	Lake Poco	15
Lambs Gap Seeps	Lambs Gap	16
Mansfield Seep	Mansfield	17
McCall Dam Seeps 1	McCall Dam 1	18
McCall Dam Seeps 2	McCall Dam 2	18
McLane Seepage Swamp	McLane	19
Moores Corners Seeps 1	Moores Corners 1	20
Moores Corners Seeps 2	Moores Corners 2	20

Site Name	Abbreviation	Map No.
Mt. Holly Preserve	Mt. Holly	21
North East Slumps - West 1	NE Slumps - W1	23
North East Slumps - West 2	NE Slumps - W2	23
North East Slumps - East	NE Slumps -E	22
Nottingham Serpentine Barrens Seeps	Nottingham 1	24
Nottingham Serpentine Barrens Seeps	Nottingham 2	24
Perkiomen Tributary Seeps	Perkiomen	25
West Branch Pine Creek Tributary Seep	Pine Creek	46
Plain Grove Fens - Island Fen	Plain Grove	26
Poe Paddy Seep	Poe Paddy	27
Raesly Woods	Raesly	28
Robert Rodale Reserve	Rodale	29
State Game Lands #69	SGL #69	40
State Game Lands #102	SGL #102	34
State Game Lands #156	SGL #156	35
State Game Lands #166	SGL #166	36
State Game Lands #197	SGL #197	37
State Game Lands #218	SGL #218	38
State Game Lands #284	SGL #284	39
Shoemakers Swamp	Shoemakers	30
Spencer-Plank Road Seeps	SP Road	31
Springhope Seep	Springhope	32
Sproul Seeps	Sproul	33
Taylor East Seep	Taylor	41
Trythall Woods Seeps	Trythall	42
Twentymile Creek Seeps 1	Twentymile 1	43
Twentymile Creek Seeps 2	Twentymile 2	43
Walnut Creek Seeps 1	Walnut Creek 1	44
Walnut Creek Seeps 2	Walnut Creek 2	44
Warwick Seeps	Warwick	45

Selection of Potential Sites

A number of seepage areas in Pennsylvania were already known through the PNDI database and the cooperators involved in the project. The amount of information available for specific sites varied and, in some cases, was applicable to only small sections of more extensive areas. Sites with descriptions of communities that included references to seepage and sites with records for plant species of special concern that are indicative of alkaline or circumneutral groundwater chemistry (**Table 1**) were included on the list for reconnaissance. We inspected aerial photographs (B&W and color IR) of some of the more extensive areas with potential for groundwater seepage and selected for reconnaissance sections that appeared to contain seepage wetlands.

One of our goals was to represent several ecoregions and bedrock types within Pennsylvania by our selection of sites. Ecoregions represented in the study are the Great Lakes Plain, Western Allegheny Plateau, Central Appalachians (sandstone ridge/limestone valley geology), High Allegheny Plateau and Lower New England-Northern Piedmont (serpentinite and diabase bedrock). The northern section of the High Allegheny Plateau and the southern and eastern portions of the Western Allegheny Plateau are typically underlain by bedrock that provides more acidic groundwater chemistry and were not scrutinized as closely as the regions more likely to contain circumneutral or alkaline groundwater discharge.

Table 1: Pennsylvania Species of Concern occurring in Alkaline and Circumneutral Seepage Wetlands

Carex prairea	Cypripedium parviflorum	Platanthera hyperborea
Carex buxbaumii	Cypripedium reginae	Parnassia glauca
Carex flava	Euphorbia purpurea	Rhamnus alnifolia
Carex tetanica	Lobelia kalmii	Spiranthes romanzoffiana
Carex diandra	Conioselinum chinense	Platanthera dilatata
Carex aurea	Epilobium strictum	Poa paludigena
Carex bebbii	Juncus alpinus	Salix candida
Rhynchospora alba	Juncus brachycephalus	Trollius laxus
Rhynchospora capillacea	Juncus balticus	

Reconnaissance

We visited potential seepage sites to determine whether they fit our criteria. We noted obvious disturbances, assessed recent anthropogenic disturbance, and applyied the following criteria derived from the definition of seeps in Anderson (1993): **1)** the site must contain or be integral with water discharge areas on slopes of greater than one degree; **2)** the site must have substrate containing some mineral soil and have minimal peat accumulation (generally under 40 cm); **3)** the water discharging or flowing into the site must have pH of 5.5 or greater; **4)** the physiognomic patch representing the community of interest must be of sufficient size to allow plot establishment and releve sampling. During the reconnaissance visit we marked plot

locations with biodegradable flagging, sketched the wetland and the landscape setting, and took a representative photograph of each seep.

Data Collection

Initial Sampling

We coordinated sampling to allow all sites to be sampled during the last three weeks in June during both 1996 and 1997. We began sampling the southern sites and worked toward the northern ones. We established plots in relatively homogeneous patches (in terms of physiognomy and species composition), added more plots to represent the diversity of more complex sites as needed, and avoided obvious edge or transition areas. We used the following guidelines for selecting plot size: $25m^2$ plots on open seeps, 100 m^2 meter plots in shrub-dominated seeps, and $625m^2$ in forested wetlands. Plot dimensions were allowed to vary to allow sampling a representative area and avoid edges and transition zones. For most sites, establishment of one plot per patch was sufficient to represent the seep community.

We estimated vascular plant cover within each height strata for each plot. Species that occurred within the community but not within the sampling plot were recorded separately. Species percent cover was estimated, and species not identifiable in the field were collected for later identification.

We sampled bryophytes in three to six $1m^2$ quadrats (number based on plot size) located in the corners of the larger plot, using a collapsible PVC pipe frame to delineate the bryophyte sampling plots. We collected specimens of all bryophyte species and sent them to a bryologist for identification.

We recorded the temperature, pH and specific conductivity of surface water within each of the plots by choosing a spot (avoiding hummocks and standing pools) with a sufficient depth of flowing water for measurement. When flowing water was not present at the surface, we formed a small depression in the substrate and allowed it to fill with water. Readings were taken using portable "pen" style (Omega PHH-3X combination pH meter and thermometer/Omega CDH-2X conductivity meter) pH/conductivity meters. These measurements were taken during each visit to the plot in order to calculate a mean for the growing season.

Follow-up Sampling

We revisited each plot in late summer or early fall to check for changes in species cover, add late season plants to the species list, and identify and collect species that had not been identifiable or collected in flower or fruit earlier in the season. We noted marked changes in the cover of dominant species but did not re-estimate percent cover for all species.

We described the soil profile at each plot. Our goal was to describe soils to a depth of one meter, but the underlying substrate (bedrock, unconsolidated rock deposits or very dense clay)

occasionally prevented reaching that depth. Dr. Greg Podniesinski accompanied us to collect hydrology, geology, soil, and water chemistry data for use in hydrologic models of the seepage sites and to collect water samples for analysis of the major cations and anions. We tested the discharging groundwater at our plots for elevated levels of nitrate and ammonium to reveal possible contamination of seep water sources and recharge zones by domestic or agricultural activities.

Data analysis

Vegetation data were analyzed using several hierarchical classification techniques. Hierarchical classification techniques group similar entities into classes, arrange the classes into a hierarchy, and thus reveal relationships in the data (Gauch 1982). Two-way indicator species analysis (TWINSPAN) and detrended correspondence analysis (DCA) are polythetic divisive classification techniques that are designed to analyze data on the occurrence of species in plots. Both TWINSPAN and DCA begin with all plots grouped together in a single cluster and divide plots, based on the percent cover of species, into a hierarchy of smaller clusters until a pre-specified number of plots per cluster is reached. TWINSPAN first uses reciprocal averaging to construct a primary classification of plots (Hill 1979). The primary plot classification is used to classify species according to ecological preferences, and both plot and species classifications are then used to obtain an ordered two-way table that expresses plot and species relationships as clearly as possible with most similar plots placed together. DCA ordinates both species and samples at the same time (McCune and Mefford 1995), and the breaking of the plots into clusters is done subjectively by hand (Gauch 1982). DCA can be useful in identifying plots that clearly and strongly differ from the rest. The presence of very different plots (outliers) compresses the remaining data. Removal of these plots may allow subsequent analyses of the remaining, more similar plots to reveal patterns previously obscured by the presence of outliers.

We ran TWINSPAN and DCA using PC-ORD software (McCune and Mefford 1995). To determine whether variations in setup parameters and various subsets of the data effected the TWINSPAN groupings, we ran analyses a number of different ways. We analyzed the data using presence/absence of species and repeated the analyses using five cutoff levels (0, 2, 5, 10, 20) to define species cover classes. After some initial experimentation, the remaining setup parameters were left at default settings: maximum number of indicators per division = 5 and minimum group size for division = 5.

We ran TWINSPAN on various subsets of the full data set including: all vascular and bryophyte species, vascular species only, bryophyte species only, vascular and bryophyte species excluding trees, tree and shrub species only, and vascular and bryophyte species excluding exotics. If a specific group of plots was divided from the rest based on the presence of a single exotic species, that species was removed, and the analysis was rerun to determine whether the division would be repeated based on other species in the plots. We repeated the analyses listed above eliminating the rarest species (those present in only one plot or present in only two plots). We ran DCA on various subsets of the data with setup parameters remaining at default levels. DCA of all 61 plots showed an undifferentiated cluster of 40 plots. We ran further DCA and TWINSPAN trials on the 40 plots to try to get better separation.

We expected percent cover of calciphiles to be a factor in the splitting of plots. Due to the fact that many of the calciphiles were present in only a few plots, we created the variable CALCIALL to retain calciphiles in the data set when running analyses leaving out species that occurred in only one or two plots. CALCIALL equals the sum of percent cover values of the following species described as occurring in calcareous habitats (Gleason and Cronquist 1991, Voss 1996): *Carex aurea, Carex flava, Carex prairea, Carex sterilis, Carex tetanica, Conioselinum chinense, Eriophorum viridicarinatum, Equisetum variegatum, Gentianopsis crinita, Lobelia kalmii, Muhlenbergia glomerata, Parnassia glauca, Rhynchospora capillacea, Salix myricoides, Trollius laxus, Campylium stellatum*, and *Chara* species.

Vegetation and environmental data were analyzed together using canonical correspondence analysis (CCA). CCA is an ordination technique that directly incorporates environmental data into the ordination by combining reciprocal averaging and multiple regression (McCune and Mefford 1995). To determine whether species composition and cover in our plots respond to the set of environmental and water chemistry variables we measured, we ran several iterations of CCA with different subsets of the environmental data.

RESULTS

Site Characteristics

All sites are located on slopes greater than one degree with all but 11 plots out of 61 having slopes greater than two degrees. Most sites occur on shallow to moderate slopes (2 to 15 degrees) except those associated with the Lake Erie Shoreline and the tributary gorges to the lake which occur on steep to very steep slopes of 20 degrees or greater (**Table 2**).

Surface substrate characteristics are various with the bulk of the plots having soil, muck, sand or gravel as the dominant substrate. Only 11 plots show some peat accumulation with four of those having significant accumulation of over 40 cm (above our suggested cutoff level).

Most (46 out of the 61) plots exhibit perennial water flow. Out of the 15 plots described as having ephemeral flow, five (Raesly Woods, Springhope, Shoemakers, Warwick, and SGL #69) have dramatically lowered water tables by early autumn.

One half (31) of the plots are classified as open while 18 are forested and 12 are shrub dominated. Physiognomy alone does not always capture the character of the plots, particularly in relation to the amount of light received (e.g. a plot classified as open may be within a forest and receive relatively little light compared to a plot at the edge of a shrub lowland). Therefore, we included an additional class called cover to better illustrate the canopy cover and light conditions for each plot.

Table 2: Site Characteristics of Pennsylvania Seepage Wetlands

Site Name	Slope (deg.)	Waterflow	[1]Temperature (°C)	Surface	Peat depth (cm)	Physiogomy	Cover	Latitude	Longitude
Chrome 1	3.0	PD	19	M	0	O	O	394427	755641
Chrome 2	3.5	ED	19	P	15	O	O	394357	755712
Nottingham 1	1.0	PD	15	M	0	O	O	394350	760242
Nothingham 2	2.0	PD	20	P	65	O	O	394402	760250
Warwick	1.5	ED	18	SO	0	F	S	400953	754742
Trythall	4.0	PS	14	SO	0	O	S	401053	754527
Pine Creek	5.0	PS	13	R	0	S	S	402555	754408
Dale 1	12.0	PS	13	MS	0	F	S	402519	753626
Dale 2	6.5	PD	14	S	0	S	S	402515	753627
Perkiomen	7.0	PD	13	R	0	O	S	402621	753446
Rodale	4.0	PS	18	G	0	O	S	403323	752748
Getz	1.0	ED	18	M	0	F	S	405334	750840
Lake Poco	2.0	PS	13	MG	0	F	S	405533	750747
Taylor	4.0	PS	18	MP	27	O	O	405416	750701
Raesly	1.5	ES	10	SO	0	F	S	405514	750657
Mansfield	5.5	PD	17	SO	0	S	S	405652	751318
Kemmererville1	7.0	PS	20	MR	0	O	O	405531	751448
Kemmererville 2	6.0	PS	17	MR	0	S	S	405530	751447
Shoemaker	3.5	ED	17	SOM	0	FS	S	410347	750144
Birdsboro	4.0	PS	13	S	0	O	S	401417	754903
Indian Run	5.0	PS	12	R	0	FS	S	401531	761255
SGL #156	4.0	PD	15	SG	0	FS	S	401603	762154
Lambs Gap	3.0	PD	14	SOM	0	F	S	401840	770057
Poe Paddy	1.0	PS	11	M	0	S	O	405011	772455
Mt. Holly	1.5	PS	13	SM	0	FS	S	400547	771118
Carlisle 1	1.0	PD	14	M	0	O	O	415132	793217
Carlisle 2	1.0	PD	19	P	100	F	S	415132	793150
Carlisle 3	11.0	ES	19	SO	0	F	S	415103	793240
Carlisle 4	2.0	PS	15	SO	0	F	S	415157	793158
SGL #197	3.0	PD	14	P	30	F	S	415825	793502
SGL #69	6.5	ED	18	SO	0	F	S	413723	795329
Kennerdell	4.5	PS	20	R	0	O	O	411548	794939
McLane	9.0	PD	13	P	20	O	O	415616	800754

Table 2 (cont.)

Site Name	Slope (deg.)	Waterflow	[1]Temperature (°C)	Surface	Peat depth (cm)	Physiogomy	Cover	Latitude	Longitude
Edinboro	6.0	ED	14	SO	0	S	S	415325	800757
SGL#102	7.5	PS	13	G	0	O	S	415624	794838
NE Slumps - W1	8.0	PS	15	S	0	F	S	421618	795324
NE Slumps - W2	23.0	PD	18	SO	0	O	O	421318	795324
Hubbel Run 1	7.0	PS	19	M	0	F	S	415751	794553
Hubbel Run 2	1.0	PD	17	P	45	F	S	415833	794610
Springhope	4.0	ED	19	SO	0	O	O	400538	783550
Sproul	4.0	ED	20	SO	0	O	O	401659	782756
Black Moshannon	2.0	ED	15	M	0	S	O	405329	480243
SGL #166	1.5	ED	18	SO	0	S	S	403402	781244
McCall Dam 1	1.5	PS	16	SO	0	O	S	410155	771109
McCall Dam 2	3.0	PD	15	SO	0	S	O	410158	771050
NE Slumps - E	33.0	PD	17	S	0	O	O	421406	795040
Walnut Creek 2	56.0	PS	18	B	0	O	O	420310	801145
Walnut Creek 1	20.0	PS	21	B	0	O	S	420303	801201
James Preserve 1	7.0	PD	24	P	60	S	O	420333	801058
James Preserve 2	4.0	PS	31	P	10	O	O	420333	801058
Behrend 2	47.0	PS	19	SO	0	O	S	420655	795921
Behrend 1	11.0	PD	17	P	20	S	S	420652	795921
Twentymile 1	53.0	PS	28	B	0	O	O	424353	794548
Twentymile 2	60.0	PD	19	B	0	O	S	421352	794548
SP Road	2.0	PS	15	M	0	O	S	415807	793607
Moores Corners 2	7.0	PS	16	S	0	O	S	410208	800630
Moores Corners 1	7.5	PS	13	S	0	O	S	410208	800630
SGL #218	3.0	ED	18	P	12	O	S	420240	795457
Jennings	2.5	ED	23	P	20	S	O	410044	800023
Plain Grove	3.0	PS	18	G	0	O	O	410327	800915
SGL #284	3.0	ED	23	P	10	O	O	410752	501248

[1] Average of all measurements taken during growing season

Key:

Waterflow
PS=perennial, strong
PD=perennial, diffuse
ES=ephemeral, strong
ED=ephemeral, diffuse

Surface
M=muck
P=peat
R=rocky
S=sand
G=gravel
SO=soil
B=bedrock

Physiognomy
O=open
S=shrub
F=forest

Cover
O=open
S=shaded

Vegetation

A total of 446 species of vascular plants representing 206 genera and 80 families were recorded within seeps over the course of this study (**Table 3**). Four families (Asteraceae, Cyperaceae, Poacea, and Rosaceae) account for 167 species (37%) of the total species identified. Pennsylvania species of special concern comprise 18 of the total species with 10 endangered (PE), 7 threatened (PT) and one tentatively undetermined (TU). The most frequently occurring species, present in at least half of the plots, include: *Acer rubrum* (37 plots), *Arisaema triphyllum* (33), *Glyceria striata* (39), *Impatiens capensis* (42), *Lindera benzoin* (31), *Osmunda cinnamomea* (32) and *Symplocarpus foetidus* (40). Additional frequently occurring species, present in at least one third of the plots, include: *Aster puniceus* (20), *Betula alleghaniensis* (25), *Chelone glabra* (26), *Chrysosplenium americanum* (24), *Galium triflorum* (22), *Lycopus uniflorus* (20), *Onoclea sensibilis* (24), *Pilea pumila* (20), *Polygonum sagittatum* (24), and *Viola cucullata* (28). Taxonomy for vascular flora follow Gleason and Cronquist (1991) except for *Eleocharis elliptica* and *Viburnum recognitum* which follow Rhoads and Klein (1992).

A total of 118 species of non-vascular plants representing 63 genera, 34 families, and 3 kingdoms were recorded for the seeps sampled as part of this study (**Table 4**). Of those species, only one – *Thuidium delicatulum* – is present in a majority of the plots (41). The next highest in frequency include: *Amblystegium tenax* (13), *Brachythecium rivulare* (22), *Bryhnia novae-angliae* (10), *Campylium polygamum* (10), *Rhizomnium punctatum* (16), and *Rhynchostegium serrulatum* (15). The non-vascular plants currently have no legal status in Pennsylvania, but the Bryophyte Technical Committee of the Pennsylvania Biological Survey will recommend status for bryophytes and lichens at some point in the future. Taxonomy for bryophytes follows Crum and Anderson (1981). Species composition and cover are listed by plot in **Appendix II**.

Geology, Hydrology and Water Chemistry

The plots in this study occur in seven general hydrogeological settings. **Figures 2 - 8** show the cross-sectional geology and water flow patterns for each of the settings (Podniesinski 1998).

Thirty-two of 61 plots sampled in this study are located in northeastern and northwestern glaciated sections of the state. Of the plots located in glaciated areas, 15 are associated with kame deposits, 9 with lacustrine deposits over weathered shale/sandstone bedrock, 1 with lacustrine deposits over gravel and glacial till, 4 with ground moraines, 2 with end moraines, and 1 with a glacial outwash plain. Of the plots located in non-glaciated portions of the state, 11 are associated with crystalline bedrock (diabase, granitic gneiss, and serpentine bedrock found in the southeastern section of the state), 14 are associated with the sandstone bedrock of the central Pennsylvania ridgelines, and 2 are associated with shale bedrock hills and slopes of central Pennsylvania (**Table 5**).

We measured the water chemistry of discharging groundwater for each plot in order to better understand environmental conditions at each site, including anthropogenic influences, and to investigate the effects of specific variables on species presence and distribution.

Table 3: Vascular Plant Species from Pennsylvania Seepage Wetlands

Family	Species	PA Status
Aceraceae	Acer pensylvanicum	
	Acer rubrum	
	Acer saccharum	
	Acer spicatum	
Anacardiaceae	Toxicodendron radicans	
	Toxicodendron vernix	
Apiaceae	Angelica atropurpurea	
	Cicuta maculata	
	Conioselinum chinense	PE
	Cryptotaenia canadensis	
	Daucus carota	
	Hydrocotyle americana	
	Osmorhiza sp.	
	Sanicula sp.	
	Zizia aurea	
Apocynaceae	Apocynum cannabinum	
Aquifoliaceae	Ilex verticillata	
Araceae	Arisaema triphyllum	
	Symplocarpus foetidus	
Araliaceae	Panax trifolius	
Aristolochiaceae	Asarum canadense	
Asclepiadaceae	Asclepias incarnata	
Aspleniaceae	Athyrium filix-femina	
	Athyrium thelypterioides	
	Dryopteris carthusiana	
	Dryopteris clintoniana	PT
	Dryopteris cristata	
	Dryopteris intermedia	
	Gymnocarpium dryopteris	
	Polystichum acrostichoides	
	Thelypteris hexagonoptera	
	Thelypteris noveboracensis	
	Thelypteris palustris	
Asteraceae	Achillea millefolium	
	Ambrosia artemisiifolia	
	Aster cordifolius	
	Aster divaricatus	
	Aster lateriflorus	
	Aster prenanthoides	
	Aster puniceus	
	Aster sagittifolius	
	Aster sp.	
	Aster umbellatus	
	Bidens cernua	
	Bidens connata	
	Bidens frondosa	
	Bidens sp.	
	Cirsium muticum	
	Cirsium vulgare	
	Erigeron philadelphicus	
	Eupatorium fistulosum	
Asteraceae (cont.)	Eupatorium maculatum	
	Eupatorium perfoliatum	
	Eupatorium rugosum	
	Euthamia graminifolia	
	Helenium autumnale	
	Helianthus decapetalus	
	Helianthus giganteus	
	Krigia biflora	
	Lactuca sp.	
	Mikania scandens	
	Prenanthes sp.	
	Senecio aureus	
	Solidago caesia	
	Solidago canadensis	
	Solidago flexicaulis	
	Solidago gigantea	
	Solidago patula	
	Solidago rugosa	
	Solidago uliginosa	
	Taraxacum officinale	
	Tussilago farfara	
	Vernonia noveboracensis	
Balsaminaceae	Impatiens capensis	
	Impatiens pallida	
	Impatiens sp.	
Berberidaceae	Berberis thunbergii	
	Podophyllum peltatum	
Betulaceae	Alnus incana	
	Alnus serrulata	
	Betula alleghaniensis	
	Betula lenta	
	Betula sp.	
	Carpinus caroliniana	
	Corylus americana	
	Ostrya virginiana	
Boraginaceae	Myosotis laxa	
	Myosotis scorpioides	
Brassicaceae	Alliaria petiolata	
	Arabis sp.	
	Cardamine concatenata	
	Cardamine diphylla	
	Cardamine pensylvanica	
	Cardamine rhomboidea	
	Rorippa nasturtium-aquaticum	
Campanulaceae	Lobelia kalmii	PE
	Lobelia siphilitica	
Caprifoliaceae	Lonicera canadensis	
	Lonicera dioica	
	Lonicera japonica	
	Lonicera morrowii	
	Sambucus canadensis	
	Sambucus pubens	
	Viburnum dentatum	
	Viburnum lentago	
	Viburnum prunifolium	
	Viburnum recognitum	

Table 3: Vascular Plant Species from Pennsylvania Seepage Wetlands (cont.)

Family	Species	PA Status
Caryophyllaceae	Cerastium arvense	
	Cerastium vulgatum	
	Stellaria alsine	
	Stellaria graminea	
	Stellaria longifolia	
Celastraceae	Euonymus obovatus	
Clusiaceae	Hypericum mutilum	
	Hypericum perforatum	
	Hypericum prolificum	
	Hypericum punctatum	
	Hypericum sp.	
	Triadenum fraseri	
Cornaceae	Cornus alternifolia	
	Cornus amomom	
	Cornus racemosa	
	Cornus sericea	
	Nyssa sylvatica	
Cupressaceae	Juniperus virginiana	
Cyperaceae	Carex amphibola	
	Carex atlantica	
	Carex aurea	PE
	Carex baileyi	
	Carex blanda	
	Carex bromoides	
	Carex brunnescens	
	Carex crinita	
	Carex eburnea	PE
	Carex echinata	
	Carex flava	PT
	Carex folliculata	
	Carex frankii	
	Carex gracilescens	
	Carex gracillima	
	Carex granularis	
	Carex gynandra	
	Carex hystericina	
	Carex interior	
	Carex laevivaginata	
	Carex laxiculmis	
	Carex leptalea	
	Carex leptonervia	
	Carex lurida	
	Carex pedunculata	
	Carex pellita	
	Carex prairea	PT
	Carex prasina	
	Carex radiata	
	Carex scabrata	
	Carex scoparia	
	Carex seorsa	
	Carex sterilis	
	Carex stipata	
	Carex stricta	
	Carex tetanica	
	Carex trisperma	
	Carex vulpinoidea	
	Cyperus bipartitus	
	Carex sp.	
	Carex sp. 1	
	Carex sp. 2	
	Carex sp. 3	
Cyperaceae (cont.)	Cyperus strigosus	
	Eleocharis elliptica	PE
	Eleocharis erythropoda	
	Eleocharis sp.	
	Eleocharis tenuis	
	Eriophorum viridicarinatum	PT
	Rhynchospora alba	
	Rhynchospora capillacea	PE
	Scirpus americanus	
	Scirpus atrovirens	
	Scirpus polyphyllus	
	Scirpus validus	
	Scirpus sp.	
Dioscoreaceae	Dioscorea villosa	
Droseraceae	Drosera rotundifolia	
Equisetaceae	Equisetum arvense	
	Equisetum hyemale	
	Equisetum sylvaticum	
	Equisetum variegatum	PE
Ericaceae	Gaylussacia frondosa	
	Kalmia latifolia	
	Lyonia ligustrina	
	Rhododendron viscosum	
	Vaccinium angustifolium	
	Vaccinium corymbosum	
Euphorbiaceae	Euphorbia purpurea	PE
Fabaceae	Amphicarpaea bracteata	
	Apios americana	
	Robinia pseudoacacia	
Fagaceae	Fagus grandifolia	
	Quercus alba	
	Quercus bicolor	
	Quercus rubra	
Gentianaceae	Gentianopsis crinita	
Geraniaceae	Geranium maculatum	
	Geranium robertianum	
Grossulariaceae	Ribes americana	
	Ribes cynosbati	
	Ribes sp.	
Hamamelidaceae	Hamamelis virginiana	
Hydrophyllaceae	Hydrophyllum virginianum	
Iridaceae	Iris versicolor	
Juglandaceae	Carya cordiformis	
	Carya ovata	
Juncaceae	Juncus acuminatus	
	Juncus alpinoarticulatus	
	Juncus brachycephalus	PT
	Juncus brevicaudatus	
	Juncus effusus	
	Juncus marginatus	
	Juncus nodosus	

Table 3: Vascular Plant Species from Pennsylvania Seepage Wetlands (cont.)

Family	Species	PA Status
Juncaceae (cont.)	Juncus subcaudatus	
	Juncus tenuis	
	Luzula multiflora	
	Juncus sp. 1	
	Juncus sp. 2	
	Juncus sp. 3	
Lamiaceae	Collinsonia canadensis	
	Glechoma hederacea	
	Lycopus americanus	
	Lycopus uniflorus	
	Lycopus sp.	
	Mentha arvensis	
	Mentha X citrata	
	Mentha X piperita	
	Prunella vulgaris	
	Pycnanthemum virginianum	
	Scutellaria lateriflora	
Lauraceae	Lindera benzoin	
	Sassafras albidum	
Lemnaceae	Lemna sp.	
	Wolffia sp.	
Liliaceae	Allium sp.	
	Clintonia borealis	
	Lilium sp.	
	Maianthemum canadense	
	Medeola virginiana	
	Polygonatum pubescens	
	Smilacina racemosa	
	Veratrum viride	
Limnanthaceae	Floerkea proserpinacoides	
Linaceae	Linum striatum	
Lycopodiaceae	Lycopodium lucidulum	
Lythraceae	Lythrum salicaria	
Magnoliaceae	Liriodendron tulipifera	
	Magnolia acuminata	
Myricaceae	Myrica pensylvanica	
Oleaceae	Fraxinus americana	
	Fraxinus nigra	
	Fraxinus pennsylvanica	
	Fraxinus sp.	
Onagraceae	Circaea alpina	
	Circaea lutetiana	
	Epilobium ciliatum	
	Epilobium coloratum	
	Epilobium glandulosum	
	Epilobium strictum	
	Epilobium sp.	PE
	Ludwigia alternifolia	
	Ludwigia palustris	
	Oenothera biennis	
Onocleaceae	Onoclea sensibilis	
Ophioglossaceae	Botrychium virginianum	
Orchidaceae	Calopogon tuberosus	
	Epipactis helleborine	
	Goodyera pubescens	
	Platanthera sp.	
	Spiranthes cernua	
	Spiranthes lucida	
	Spiranthes sp.	
Osmundaceae	Osmunda cinnamomea	
	Osmunda regalis	
Oxalidaceae	Oxalis acetosella	
	Oxalis stricta	
Pinaceae	Picea glauca	
	Pinus strobus	
	Tsuga canadensis	
Poaceae	Agrostis gigantea	
	Agrostis hyemalis	
	Agrostis perennans	
	Agrostis stolonifera	
	Anthoxanthum odoratum	
	Brachyelytrum erectum	
	Bromus ciliatus	
	Bromus inermis	
	Cinna arundinacea	
	Cinna latifolia	
	Deschampsia cespitosa	
	Elymus virginicus	
	Festuca pratensis	
	Festuca subverticillata	
	Glyceria grandis	
	Glyceria melicaria	
	Glyceria striata	
	Holcus lanatus	
	Hystrix patula	
	Leersia oryzoides	
	Leersia virginica	
	Microstegium vimineum	
	Muhlenbergia frondosa	
	Muhlenbergia glomerata	
	Muhlenbergia mexicana	
	Muhlenbergia sylvatica	
	Panicum clandestinum	
	Panicum dichotomum	
	Panicum lanuginosum	
	Panicum philadelphicum	
	Phragmites australis	
	Poa alsodes	
	Poa compressa	
	Poa paludigena	PT
	Poa palustris	
	Poa trivialis	
	Poa sp.	
	Sorghastrum nutans	
	Sphenopholis nitida	
	Sphenopholis obtusata	
	Sphenopholis pensylvanica	
Polemoniaceae	Polemonium reptans	
Polygonaceae	Polygonum amphibium	
	Polygonum arifolium	
	Polygonum caespitosum	
	Polygonum hydropiper	

Table 3: Vascular Plant Species from Pennsylvania Seepage Wetlands (cont.)

Family	Species	PA Status
Polygonaceae (cont.)	Polygonum punctatum	
	Polygonum sagittatum	
	Polygonum sp.	
	Polygonum virginianum	
	Rumex obtusifolius	
Primulaceae	Lysimachia ciliata	
	Lysimachia nummularis	
	Lysimachia terrestris	
	Lysimachia vulgaris	
	Trientalis borealis	
Ranunculaceae	Anemone quinquefolia	
	Anemone sp.	
	Anemonella thalictroides	
	Caltha palustris	
	Clematis virginiana	
	Coptis trifolia	
	Ranunculus abortivus	
	Ranunculus acris	
	Ranunculus hispidus	
	Ranunculus pensylvanicus	
	Ranunculus recurvatus	
	Ranunculus sp.	
	Thalictrum pubescens	
	Trollius laxus	PE
Rhamnaceae	Rhamnus alnifolia	
	Rhamnus frangula	
Rosaceae	Agrimonia gryposepala	
	Agrimonia parviflora	
	Amelanchier arborea	
	Amelanchier sp.	
	Aronia sp.	
	Crataegus sp.	
	Dalibarda repens	
	Duchesnea indica	
	Fragaria vesca	
	Fragaria virginiana	
	Geum canadense	
	Geum laciniatum	
	Geum rivale	
	Geum sp.	
	Physocarpus opulifolius	
	Potentilla simplex	
	Prunus serotina	
	Prunus virginiana	
	Rosa multiflora	
	Rosa palustris	
	Rubus alleghaniensis	
	Rubus hispidus	
	Rubus idaeus	
	Rubus occidentalis	
	Rubus odoratus	
	Rubus phoenicolasius	
	Rubus pubescens	
	Sanguisorba canadensis	
	Spiraea alba	
	Spiraea tomentosa	
Rubiaceae	Galium aparine	
	Galium asprellum	
	Galium circaezans	
	Galium concinnum	
	Galium lanceolatum	
Rubiaceae (cont.)	Galium obtusum	
	Galium palustre	
	Galium pilosum	
	Galium tinctorium	
	Galium trifidum	
	Galium triflorum	
	Mitchella repens	
Salicaceae	Populus grandidentata	
	Populus tremuloides	
	Salix alba	
	Salix discolor	
	Salix myricoides	
	Salix sericea	
	Salix myricoides	TU
	Salix sp.1	
Saxifragaceae	Chrysosplenium americanum	
	Mitella diphylla	
	Parnassia glauca	PT
	Penthorum sedoides	
	Saxifraga pensylvanica	
	Tiarella cordifolia	
Scrophulariaceae	Agalinis purpurea	
	Chelone glabra	
	Mimulus moschatus	
	Mimulus ringens	
	Veronica americana	
	Veronica officinalis	
Selaginellaceae	Selaginella apoda	
Smilacaceae	Smilax rotundifolia	
Solanaceae	Solanum dulcamara	
Taxaceae	Taxus canadensis	
Thymelaeaceae	Dirca palustris	
Tiliaceae	Tilia americana	
Typhaceae	Typha latifolia	
Ulmaceae	Ulmus americana	
	Ulmus rubra	
Urticaceae	Boehmeria cylindrica	
	Laportea canadensis	
	Pilea pumila	
Verbenaceae	Verbena hastata	
Violaceae	Viola blanda	
	Viola conspersa	
	Viola cucullata	
	Viola pallens	
	Viola primulifolia	
	Viola pubescens	
	Viola striata	
	Viola sp. 1	
	Viola sp. 2	
	Viola sp. 3	
Vitaceae	Parthenocissus inserta	
	Parthenocissus quinquefolia	
	Vitis labrusca	
	Vitis sp.	

Table 4: Nonvascular Plant Families and Species from Pennsylvania Seepage Wetlands

Family	species
MOSSES	
Sphagnopsida	Sphagnum capillifolium
	Sphagnum fimbriatum
	Sphagnum flexuosum
	Sphagnum imbricatum
	Sphagnum palustre
	Sphagnum teres
Amblystegiaceae	Amblystegium noterophilum
	Amblystegium riparium
	Amblystegium serpens
	Amblystegium tenax
	Amblystegium trichopodium
	Calliergon cordifolium
	Calliergon stramineum
	Calliergonella cuspidata
	Campylium chrysophyllum
	Campylium hispidulum
	Campylium polygamum
	Campylium radicale
	Campylium sp.
	Campylium stellatum
	Cratoneuron commutatum
	Cratoneuron filicinum
	Drepanocladus aduncus
	Hygrohypnum luridum
Aulacomniaceae	Aulacomnium palustre
Bartramiaceae	Philonotis capillaris
	Philonotis fontana
	Philonotis muhlenbergii
Brachytheciaceae	Brachythecium campestre
	Brachythecium oxycladon
	Brachythecium rivulare
	Brachythecium rutabulum
	Brachythecium salebrosum
	Brachythecium sp.
	Bryhnia novae-angliae
	Bryhnia sp.
	Cirriphyllum piliferum
	Eurhynchium pulchellum
	Eurhynchium riparioides
	Rhynchostegium serrulatum
	Tomenthypnum nitens
Bryaceae	Bryum pseudotriquetrum
	Bryum sp.
	Bryum uliginosum
	Pohlia sp.
Climaciaceae	Climacium americanum
Dicranaceae	Dicranella cerviculata
	Dicranella heteromalla
	Dicranum fuscescens
	Dicranum scoparium
Ditrichaceae	Ceratodon purpureus
	Distichium capillaceum
	Ditrichum pusillum
Fissidentaceae	Fissidens adianthoides
	Fissidens bryoides
	Fissidens cristatus
Hypnaceae	Homomallium adnatum
	Hypnum fertile
	Hypnum imponens
	Hypnum lindbergii
	Hypnum pratense
	Isopterygium distichaceum
	Pylaisiella polyantha
	Taxiphyllum deplanatum
Leucobryaceae	Leucobryum glaucum
Mniaceae	Cinclidium stygium
	Mnium lycopodioides
	Plagiomnium affine
	Plagiomnium ciliare
	Plagiomnium cuspidatum
	Plagiomnium rostratum
	Plagiomnium rugicum
	Rhizomnium appalachianum
	Rhizomnium ciliare
	Rhizomnium gracile
	Rhizomnium pseudopunctatum
	Rhizomnium punctatum
	Atrichum oerstedianum
	Atrichum undulatum
	Polytrichum commune
	Polytrichum juniperinum
	Polytrichum lingisetum
Pottiaceae	Barbula fallax
	Tortella tortuosa
Sematophyllaceae	Brotherella recurvans
	Brotherella tenuirostris
	Didymodon tophaceus
	Sematophyllum demissum
Tetraphidaceae	Tetraphis pellucida
Thuidiaceae	Helodium blandowii
	Helodium paludosum
	Thuidium delicatulum
	Thuidium recognitum
LIVERWORTS	
Aneuraceae	Aneura pinguis
	Riccardia multifida
	Riccardia palmata
Anthrocerotae	Anthoceros laevis
Aytoniaceae	Asterella tenella
Blasiaceae	Blasia pusilla
Calypogeiaceae	Calypogeia fissa
	Calypogeia muelleriana
Cephaloziaceae	Cephalozia bicuspidata
	Cephalozia lunulifolia
	Nowellia curvifolia
Codoniaceae	Fossombronia wondraczekii
Conocephalaceae	Conocephalum conicum
Jungermanniaceae	Lophozia attenuata
Lepidoziaceae	Bazzania trilobata
Lophocoleaceae	Chiloscyphus cuspidatus
	Chiloscyphus polyanthus
	Chiloscyphus profundus
Pallaviciniaceae	Pallivicinia lyellii
Pelliaceae	Pellia epiphylla
Trichocoleaceae	Trichocolea tomentella
LICHENS	
Cladoniaceae	Cladonia conlocrea
	Cladonia sp.
Parmeliaceae	Parmelia sulcata
ALGAE	
Characeae	Chara sp.

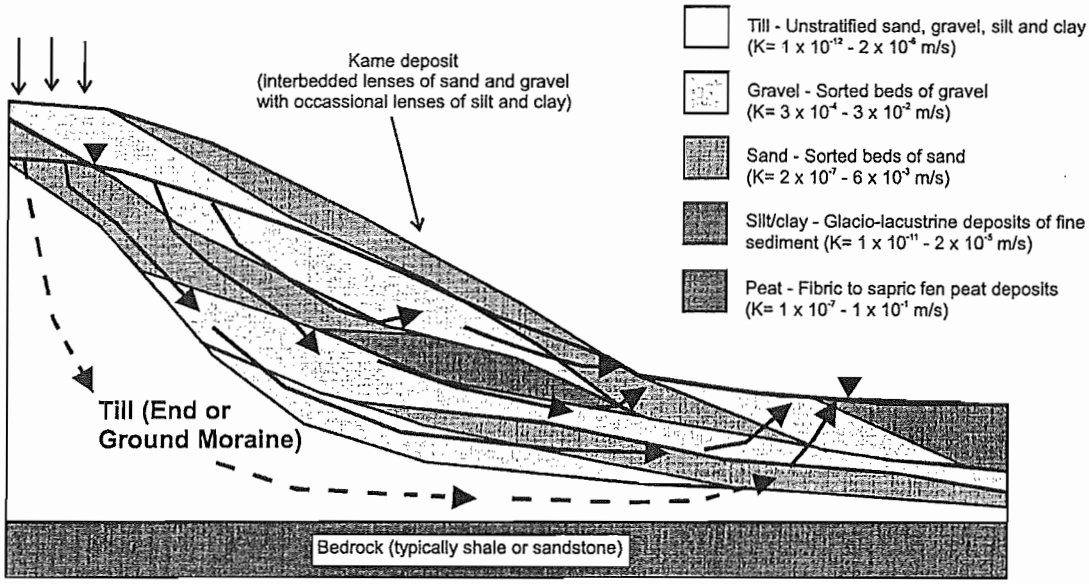

Figure 2. A general cross-sectional model of groundwater flow through a kame deposit. Underlying till deposits act as an impermable layer (no-flow boundary), though a very small volume of water may move through till. As a general rule the water table in sand and gravel kame deposits is 15 to 25 feet below the surface in the upper and mid slope positions. Groundwater discharge tends to occur at the toe-of-slope, where finer sediments, shallow slopes and poorly developed drainage cause the water table to intersect the surface.

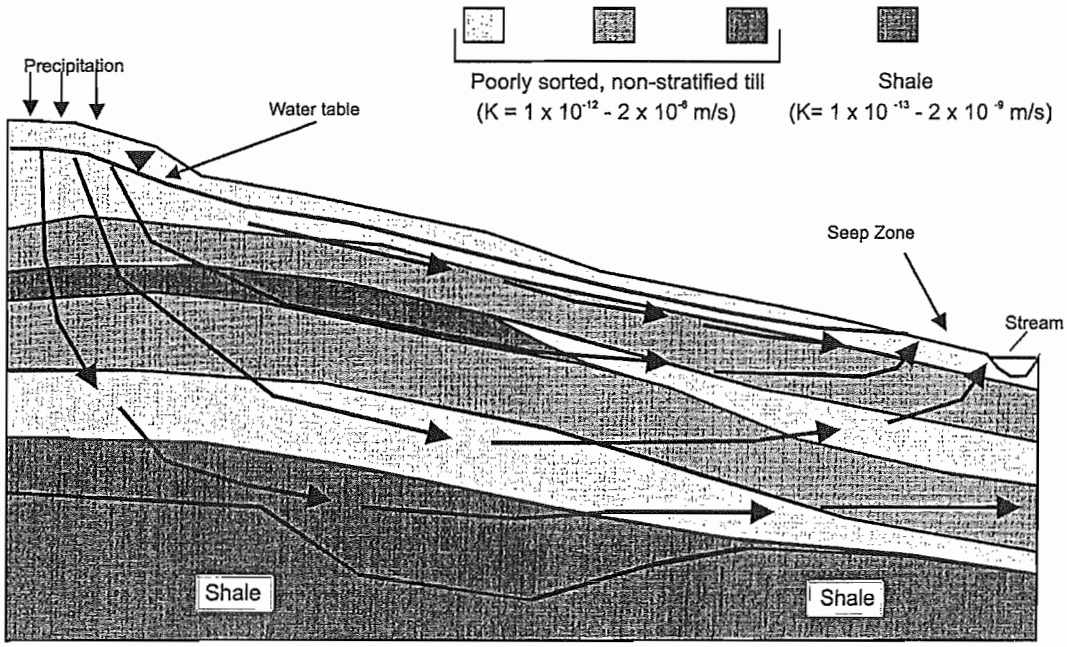

Figure 3. A general cross-sectional model of groundwater flow in glacial moraine deposits. Groundwater flow in till can vary greatly, depending upon relative proportions of sand, gravel, silt, and clay in till layers. In general, till deposits have a greater percentage of sand and gravel near glacial borders and increase in silt and clay content away from the glacial border. The increase in silt and clay content away from the glacial border reflects the reworking of previous till deposits during glacial re-advances. Variations in seep flow volume tend to increase as silt and clay content increases. Silt and clay dominated till deposits will tend to resist infiltration and water recharge and will store less groundwater than till deposits with high sand and gravel content. Moraine seeps tend to experience strong seasonal variations in groundwater flow volume as a result of limited groundwater storage.

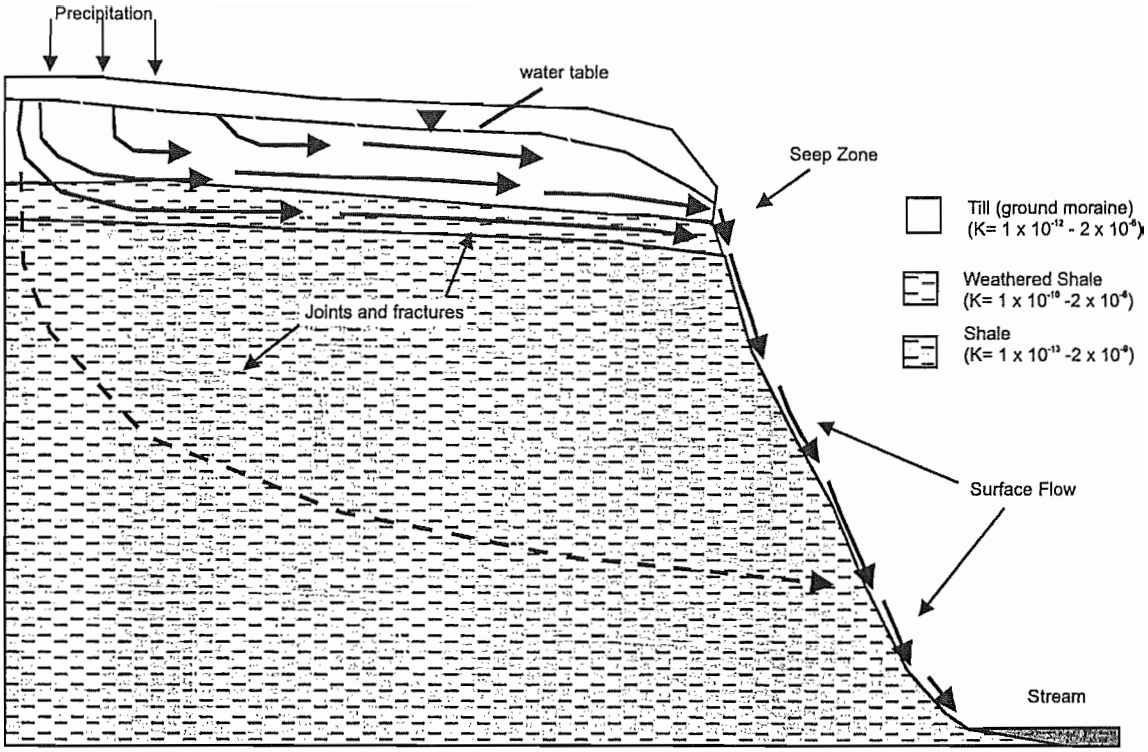

Figure 4. General cross-sectional model of groundwater flow in gorge seeps. The majority of flow occurs in overlying till deposits and in weathered bedrock at the top of the shale formation. Some groundwater may move through the underlying shale, but the volume is typically one or more orders of magnitude smaller than seepage through ovelying till and weathered shale. Seep wetlands occur at some point along exposed bedrock face (often mid- to toe-of-slope position).

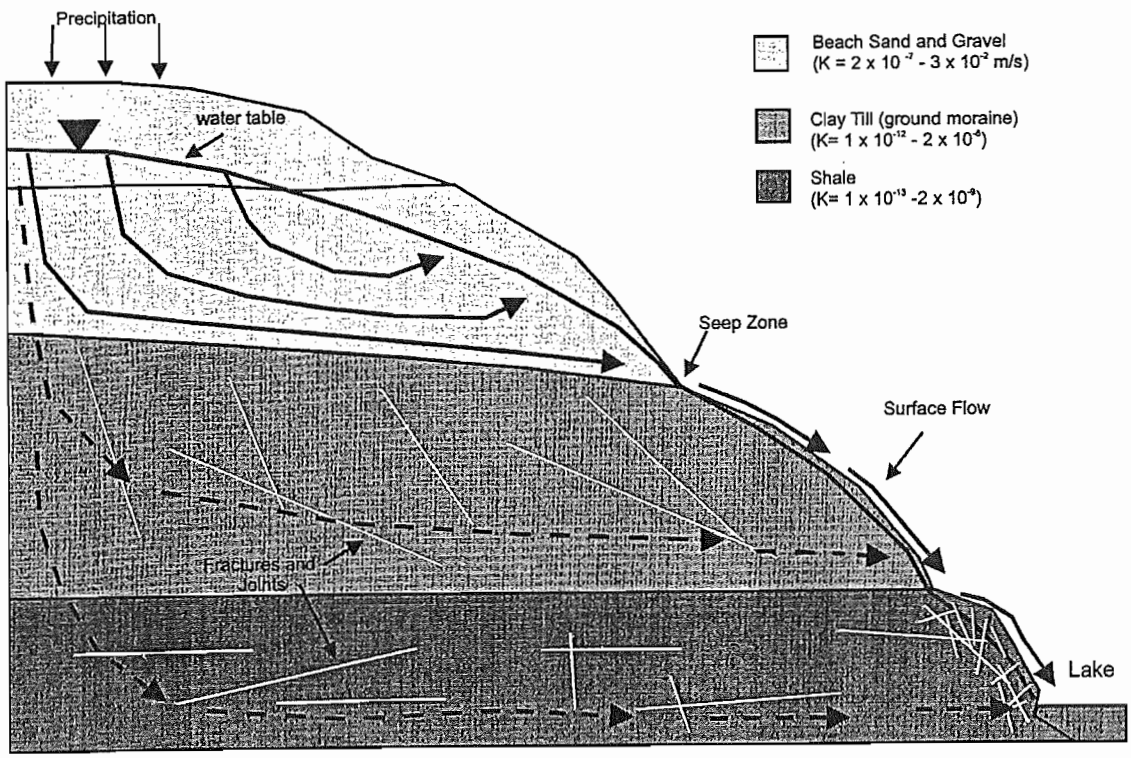

Figure 5. A general cross-sectional model of groundwater flow in Lake Erie lake bluff seeps. The majority of groundwater flow occurs through sand and gravel beach deposits at the top of the bluff. Groundwater discharges at the base of the beach deposits at the contact with underlying clay till deposits. Seep wetlands occur over the exposed till outcrop as the overlying beach deposits are not sufficiently stable. A small amount of flow may occur through the underlying till, but is insignificant relative flow through beach deposits. Flow through shale bedrock is also likely very low.

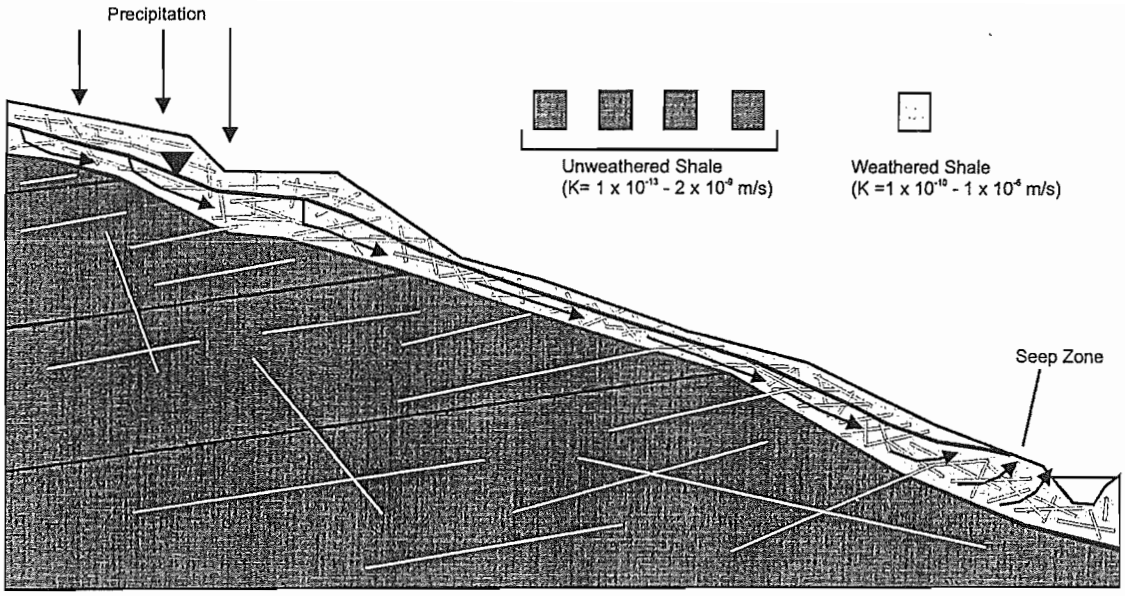

Figure 6. A general cross-sectional model of groundwater flow in shale bedrock. Groundwater flow is greatest in the weathered shale near the surface were the shale is fractured and jointed. Groundwater flow is greatly reduced in unweathered shale where fractures tend to seal off due to the pressure of the overlying rock and the relatively weak structure of shale beds. The limited depth of the weathered shale layer allows only a small amount of groundwater storage, resulting in strong seasonal variation in seep flow volume. Shale seeps tend to go dry during drought periods (i.e., late summer and early fall).

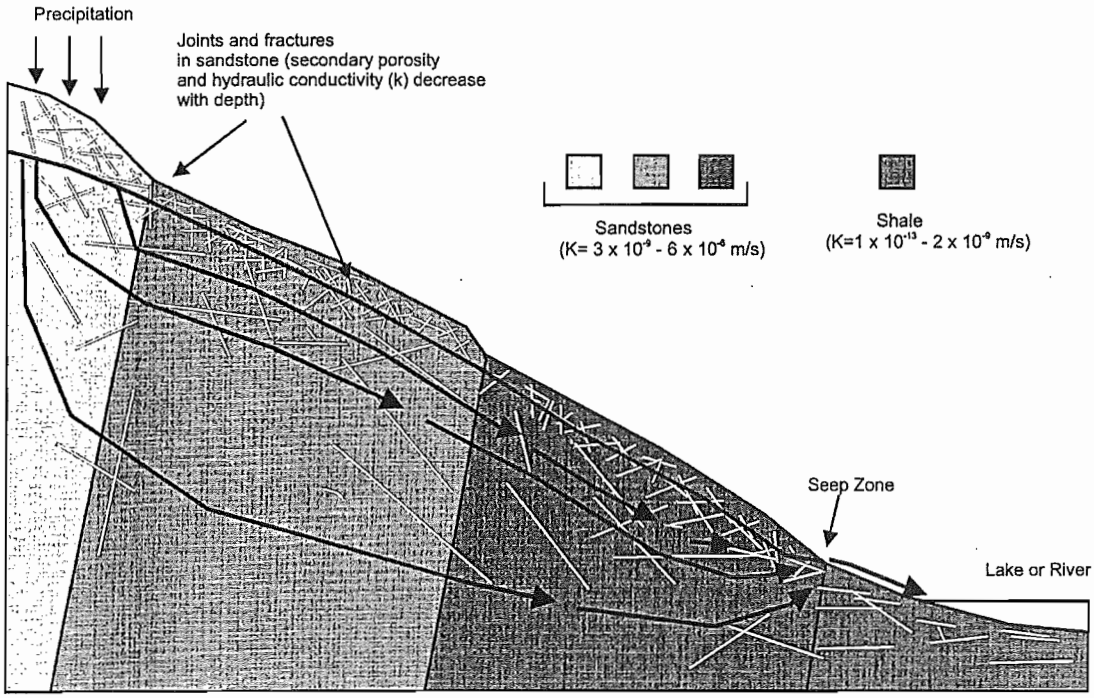

Figure 7. A general cross-sectional model of groundwater flow through a sandstone ridge (ascending limb of an anticline). Groundwater seepage occurs where the water table intersects the ground surface. Seepage zones typically occur at the toe of slope or where a less permeable strata is encountered (shale in the above figure).

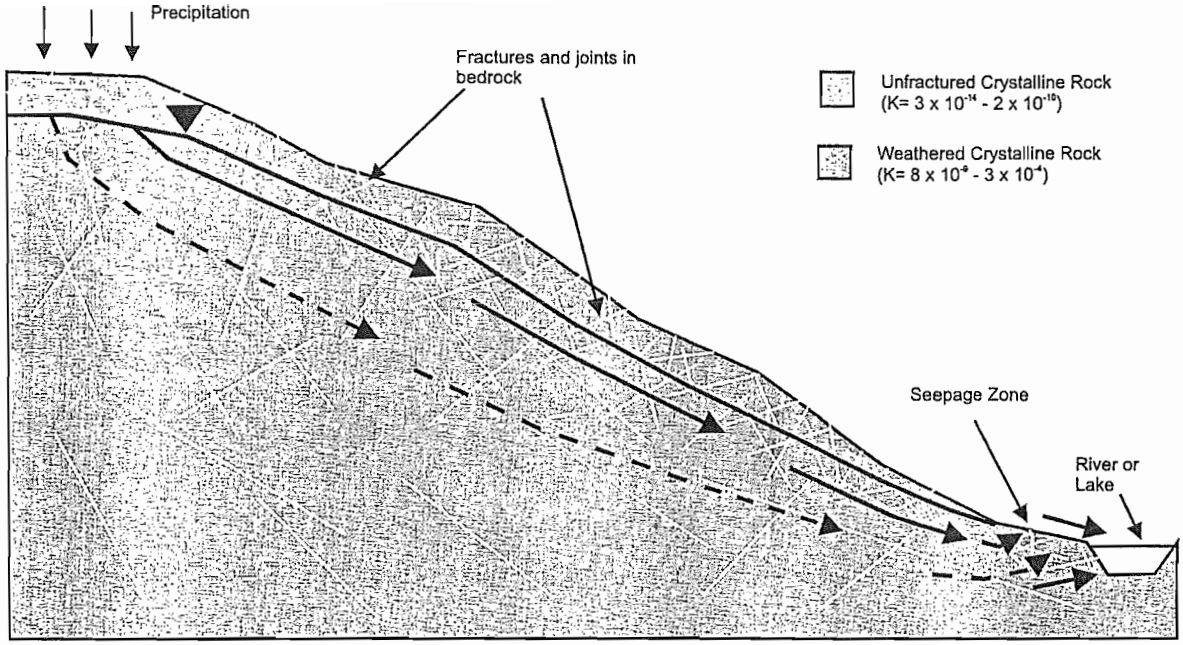

Figure 8. A general cross-sectional model of groundwater flow in crystalline rock (including granitic gneiss, serpentinite, and diabase). The majority of groundwater flow is limited to a thin mantle of weathered rock, with little or no flow in the underlying unweathered bedrock. Primary porosity is very low and flow is limited to secondary porosity in fractures, joints and along faults. Density of connected fractures and joints decreases with depth. The shallow depth of the weathered layer allows only limited groundwater storage, resulting in strongly seasonal variations in seep flow volumes. Seeps will often go dry during drought periods (i.e., late summer and early fall).

Table 5: Geology and Water Chemistry Data for Pennsylvania Seepage Wetlands

Site	Geologic Setting	Mean pH	Mean Sp.Cond.(uS)	Mean Temp. (0C)	TDS (mg/l)	Cations (mg/l)										Anions (mg/l)			
						Ca	Mg	Na	K	Fe	Sr	Si	Al	field NH4	field NO3	alkalinity	HCO3	Cl	SO4
Behrend Slumps 1	Lacustrine/Shales	8.2	600	17.4	458.5	82.8	6.4	27.9	3.8	0.0	0.1	0.4	0.4	0	0.4	380.6	312.2	24.2	0.0
Behrend Slumps 2	Lacustrine/Shales	8.5	700	19.4	343.0	86.1	4.6	27.4	4.6	0.0	0.1	0.4	0.3	0	0.4	230.5	189.0	30.0	0.0
Birdsboro	Sandstone	6.4	30	13.3	11.4	1.3	0.2	1.0	0.2	0.0	0.0	0.3	0.0	0.02	0	9.2	7.6	0.8	0.0
Black Moshannon	Sandstone	6.6	50	13.0	43.0	6.9	0.3	1.0	6.9	1.7	0.0	0.3	0.2	0.4	0.05	21.6	17.7	7.6	0.0
Carlisle Farm 1	Kame	7.6	163	13.6	313.2	15.4	0.6	2.9	0.6	0.0	0.0	0.2	0.0	0	0.35	37.2	30.5	0.0	0.0
Carlisle Farm 2	Kame	7.5	217	18.3	130.5	22.4	2.7	4.1	0.7	1.1	0.0	0.4	0.1	0.3	4	115.5	94.7	0.0	0.0
Carlisle Farm 3	End Moraine	6.4	50	17.0	50.6	5.8	1.8	3.3	0.2	0.0	0.0	0.4	0.0	0	0.5	231.9	190.2	0.0	110.9
Carlisle Farm 4	Kame	7.7	170	13.0	132.7	32.5	4.6	2.6	0.3	0.0	0.0	0.4	0.1	0	0.25	111.5	91.5	0.4	0.0
Chrome 1	Crystalline	7.5	320	19.1	98.6	6.9	14.4	2.1	5.0	0.0	0.0	2.1	0.1	0.11	0	81.8	67.1	0.8	0.0
Chrome 2	Crystalline	7.6	275	19.0	34.4	2.8	6.8	0.8	0.0	0.0	0.0	1.5	0.0	0.02	1	21.6	17.7	3.8	0.0
Dale 1	Crystalline	6.2	100	13.0	71.7	7.6	3.4	4.9	0.0	0.0	0.0	0.8	0.0	0	3.25	60.0	49.2	2.5	0.0
Dale 2	Crystalline	6.3	90	14.0	59.4	6.1	2.6	4.1	0.7	0.1	0.0	0.8	0.1	0	2.5	47.0	38.5	3.9	0.0
Edinboro	Outwash	7.9	330	16.0	217.1	47.8	10.3	9.7	9.9	0.0	0.1	0.4	0.4	0	2.5	156.1	128.1	8.0	0.0
Getz	Kame	7.7	398	18.3	315.6	44.7	15.7	13.6	3.3	0.0	0.1	0.4	0.1	0.04	0	281.0	230.5	7.3	0.0
Hubbel Run 1	Kame	7.9	240	18.0	121.1	37.5	5.9	1.4	3.5	0.0	0.0	0.4	0.1	0.03	0.02	81.8	67.1	5.2	0.0
Hubbel Run 2	Kame	7.0	150	17.0	176.4	33.1	6.5	2.4	0.4	7.8	0.0	0.5	0.3	1	0	148.7	122.0	2.5	0.0
Indian Run	Sandstone	6.5	45	12.5	21.9	2.3	1.3	2.4	0.0	0.0	0.0	0.4	0.0	0.03	0.2	14.9	12.2	3.1	0.0
James Preserve 1&2	End Moraine	7.6	600	24.7	383.1	68.4	14.7	7.8	4.4	1.3	0.1	0.9	0.3	0.17	0.1	334.5	274.4	10.6	0.0
Jennings	Lacustrine/Gravel	7.7	715	19.2	369.6	96.1	11.7	5.5	4.1	2.5	0.3	0.4	0.5	0.4	0.05	289.9	237.8	10.3	0.0
Kemmererville 2	Sandstone	7.1	150	17.0	151.0	17.6	2.6	2.3	0.0	0.0	0.1	0.3	0.0	0.17	0	156.1	128.1	0.0	0.0
Kemmererville1	Sandstone	7.2	230	20.0	137.0	40.9	1.9	2.0	0.0	0.0	0.1	0.3	0.2	0.17	0	111.5	91.5	0.0	0.0
Kennerdell	Sandstone	6.3	65	20.0	21.5	1.2	2.8	4.5	0.0	0.1	0.0	0.3	0.1	0.1	0.2	14.9	12.2	0.0	0.0
Lake Poco	Ground Moraine	7.4	315	13.0	205.6	46.3	9.8	4.9	5.0	0.0	0.1	0.5	0.2	0.03	0.9	163.6	134.2	3.7	0.0
Lambs Gap	Sandstone	7.2	173	13.7	129.1	28.8	3.1	3.5	4.6	0.2	0.5	0.5	0.1	0.14	0.05	104.1	85.4	2.2	0.0
Mansfield	Kame	7.8	148	17.0	93.9	25.2	1.2	3.1	0.7	0.1	0.0	0.3	0.1	0.08	0.05	74.3	61.0	2.1	0.0
McCall Dam 1	Sandstone	6.7	10	16.0	20.9	1.4	0.3	3.4	0.2	0.1	0.0	0.2	0.2	0.3	0.9	12.8	10.5	3.4	0.0
McCall Dam 2	Sandstone	6.2	10	15.0	17.2	2.1	0.3	2.1	3.8	0.2	0.0	0.2	0.2	0.4	0.3	9.2	7.6	0.0	0.0
McLane	Kame	8.6	300	14.0	250.9	45.3	9.4	2.0	0.1	0.0	0.1	0.5	0.2	0	0.2	233.5	191.5	1.5	0.0
Moores Corners 1&2	Kame	7.7	145	12.2	50.4	19.0	0.9	1.4	0.7	0.0	0.0	0.4	0.1	0.06	0.2	32.7	26.8	0.9	0.0
Mt. Holly	Sandstone	5.9	30	15.6	20.2	1.8	0.7	1.1	1.1	0.3	0.0	0.5	0.0	0.06	0	14.4	11.8	2.8	0.0
NE Slumps - E	Lacustrine/Shales	8.7	603	17.8	254.1	74.4	2.5	24.6	4.6	0.0	0.1	0.5	0.4	0	5	173.2	142.1	0.0	0.0
NE Slumps - W1	Lacustrine/Shales	8.2	560	15.0	255.9	76.2	4.9	21.8	0.3	0.0	0.1	0.4	0.4	0	2.5	170.2	139.6	9.7	0.0
NE Slumps - W2	Lacustrine/Shales	8.2	925	17.5	568.7	140.0	20.5	14.9	3.8	0.0	0.2	0.3	0.5	0	0.1	460.9	378.1	10.3	0.0
Nothingham 2	Crystalline Bedrock	7.7	413	20.8	80.4	3.1	14.4	1.2	1.8	10.7	0.0	1.5	0.0	0.06	0	58.0	47.6	0.0	0.0
Nottingham 1	Crystalline Bedrock	8.0	290.	16.2	182.0	0.1	36.1	1.2	0.0	5.6	0.0	1.8	0.0	0.3	0	165.0	135.4	1.5	0.0
Perkiomen	Crystalline Bedrock	6.6	60	13.3	34.7	3.2	0.9	3.3	0.1	0.1	0.0	0.9	0.0	0.3	0.1	29.2	23.9	1.9	0.0
Pine Creek	Crystalline Bedrock	6.6	97	13.0	62.6	5.5	2.3	6.0	0.0	0.1	0.0	1.1	0.0	0.11	1.25	53.5	43.9	2.4	0.0
Plain Grove	Kame	8.3	327	20.9	190.6	49.0	9.6	3.3	1.0	0.0	0.1	0.5	0.1	0.06	0.1	141.2	115.9	11.1	0.0
Poe Paddy	Sandstone	6.7	40	10.0	42.7	6.4	1.9	0.4	0.9	0.2	0.0	0.3	0.0	0.11	0	39.2	32.1	0.4	0.0
Raesly	Ground Moraine	6.8	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
Rodale	Crystalline Bedrock	5.9	80	18.0	42.9	3.4	0.4	5.0	1.5	0.2	0.0	0.8	0.1	0.03	0.2	36.0	29.6	1.5	0.1
SGL #156	Sandstone	6.3	35	15.0	29.2	6.0	1.4	1.2	0.0	0.3	0.0	0.9	0.0	0.2	0.05	22.3	18.3	0.8	0.0
SGL #166	Sandstone	5.6	30	20.0	18.1	2.4	0.5	0.5	0.4	0.1	0.0	0.2	0.1	0.03	0.2	14.9	12.2	1.5	0.0
SGL #197	Kame	8.3	175	13.5	136.7	26.2	5.0	3.4	2.6	0.0	0.0	0.3	0.0	0	0.25	118.9	97.6	1.4	0.0
SGL #218	Kame	7.8	305	18.3	134.4	39.6	7.2	2.1	0.0	0.0	0.1	0.4	0.1	0	0.4	98.9	81.1	3.5	0.0
SGL #284	Kame	8.1	720	22.2	341.4	93.7	14.8	12.3	5.4	1.3	0.2	0.5	0.5	0.3	0.05	245.3	201.2	11.1	0.0
SGL #69	Ground Moraine	6.5	60	21.0	63.8	8.6	2.1	2.4	0.2	0.3	0.0	0.5	0.2	0	0.9	59.5	48.8	0.0	0.0
SGL#102	Kame	8.4	280	12.0	147.0	46.7	2.8	2.3	0.0	0.0	0.1	0.5	0.2	0	2	111.5	91.5	1.1	0.0
Shoemakers	Sandstone	6.7	125	17.1	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***
SP Road	Kame	8.0	402	15.2	265.5	57.3	12.3	6.8	3.7	0.0	0.1	0.4	0.3	0	4.25	148.7	122.0	7.5	50.9
Springhope	Shale	5.8	90	19.0	55.5	9.3	2.3	6.6	8.3	0.2	0.0	0.5	0.0	0.2	0.3	24.5	20.1	1.4	6.1
Sproul	Shale	6.0	53	21.0	57.8	6.4	2.1	1.8	1.2	1.9	0.0	0.5	0.1	0.3	0	51.8	42.5	0.9	0.0
Taylor	Ground Moraine	8.1	658	17.9	482.5	72.5	28.1	23.2	1.7	0.1	0.1	0.5	0.3	0.08	0.8	396.7	325.4	18.6	11.2
Trythall	Crystalline	6.9	142	13.8	41.5	10.2	1.3	4.5	0.0	0.0	0.0	1.3	0.0	0.02	0.8	20.8	17.1	6.2	0.0
Twentymile 1	Lacustrine/Shales	8.5	423	25.7	149.8	39.8	2.1	4.3	1.9	0.0	0.1	0.4	0.2	0	2.25	116.0	95.1	3.7	0.0
Twentymile 2	Lacustrine/Shales	8.1	185	19.4	53.1	11.5	2.8	3.1	0.1	0.0	0.0	0.3	0.4	0	0.8	37.2	30.5	3.6	0.0
Walnut Creek 1	Lacustrine/Shales	8.9	410	20.6	198.4	45.4	2.7	4.0	2.5	0.0	0.1	0.5	0.1	0.03	0	173.0	141.9	1.2	0.0
Walnut Creek 2	Lacustrine/Shales	9.0	334	17.9	103.8	35.7	1.6	2.1	1.6	0.0	0.0	0.4	0.2	0	0.2	74.3	61.0	1.0	0.0
Warwick	Crystalline	6.9	157	18.5	***	***	***	***	***	***	***	***	***	***	***	***	***	***	***

The average of pH values taken in the field over the course of the season ranges from a low of 5.3 to a high of 8.9 (**Table 5**). Slightly less than one half of the 61 plots have values within the 7.0 to 8.0 range with 21 having pH values less than 7.0 and 16 having pH values over 8.0. Specific conductivity values range from 20 μs to 850 μs with slightly over one third of the plots having values between 100 and 300 μs. Out of the 61 total plots, 19 had specific conductivity values less than 100 μs and 20 had conductivity values over 300 μs.

Measurements of pH and specific conductivity are closely related to geologic setting. Plots associated with glacial deposits tend to have high pH and conductivity values reflecting the rapid weathering and subsequent high base metal content of the groundwater in these areas. Plots associated with a non-glacial landscape tend to have lower pH and specific conductivity values reflecting the more slowly weathering sandstone bedrock, lower base metal content, and lower buffering capacity of the groundwater in these areas. Plots associated with serpentinite bedrock have high conductivity values, possibly reflecting higher magnesium content of this bedrock type. In general, plots associated with lacustrine shales have the highest pH values. Next, from highest to lowest, are plots associated with kames and outwash, plots on moraines, plots on crystalline bedrock and plots on sandstone and shale.

The concentrations of the major cation, calcium (Ca), correlate well with geologic setting. Calcium concentration varies from 0.1 to 140.0 mg/ml. Plots in non-glacial landscapes have weakly calcareous groundwater (< 10 mg/ml Ca), and plots from glacial landscapes have highly calcareous groundwater (> 25 mg/ml Ca). Only two of the non-glacial seep plots have relatively elevated [Ca]: Kemmererville 1 and Lambs Gap. The presence of interbedded calcareous shales and limestone in the predominately sandstone region could explain the elevated values.

Other cation concentrations also reflect geologic setting. The majority of plots within glacial settings have higher magnesium levels as well as high [Ca]; those in non-glacial bedrock settings have generally low [Mg]. Plots on serpentinite bedrock have higher [Mg] than [Ca] as expected based on serpentinite $\{(Mg, Fe)_3Si_2O_5(OH)_4\}$ parent material.

Elevations in sodium (Na) levels, particularly when coupled with high chloride levels, may indicate contamination from road salt or septic leachate (Poth 1972). High sulfate levels would also be expected with leachate contamination. Five of the plots have relatively elevated [Na] but not beyond the values that would be expected if contamination were present (**Figure 9**). In contrast, two plots do have significantly elevated sulfate levels (SP Road and Carlisle 3), indicating likely contamination. For SP Road, a dairy farm situated upslope could be the source of sulfate. A source of potential sulfate contamination was not apparent in the recharge area of the Carlisle 3, and an error in collection of water samples or in analysis is suspected.

Nitrate levels greater than 0.45 to 6.75 mg/l can be considered an indicator of contamination in groundwater (Poth 1972). Nitrate in ammonia form is the prevalent form of naturally occurring nitrogen in forested systems and may be released through disturbance. Results show that seeps located in agricultural settings, particularly where groundwater recharge areas are

A - dolomite, limestone, sandstone

B - crystalline bedrock

C - shale

D - gypsum, pyrite

E - salt

F - leachate

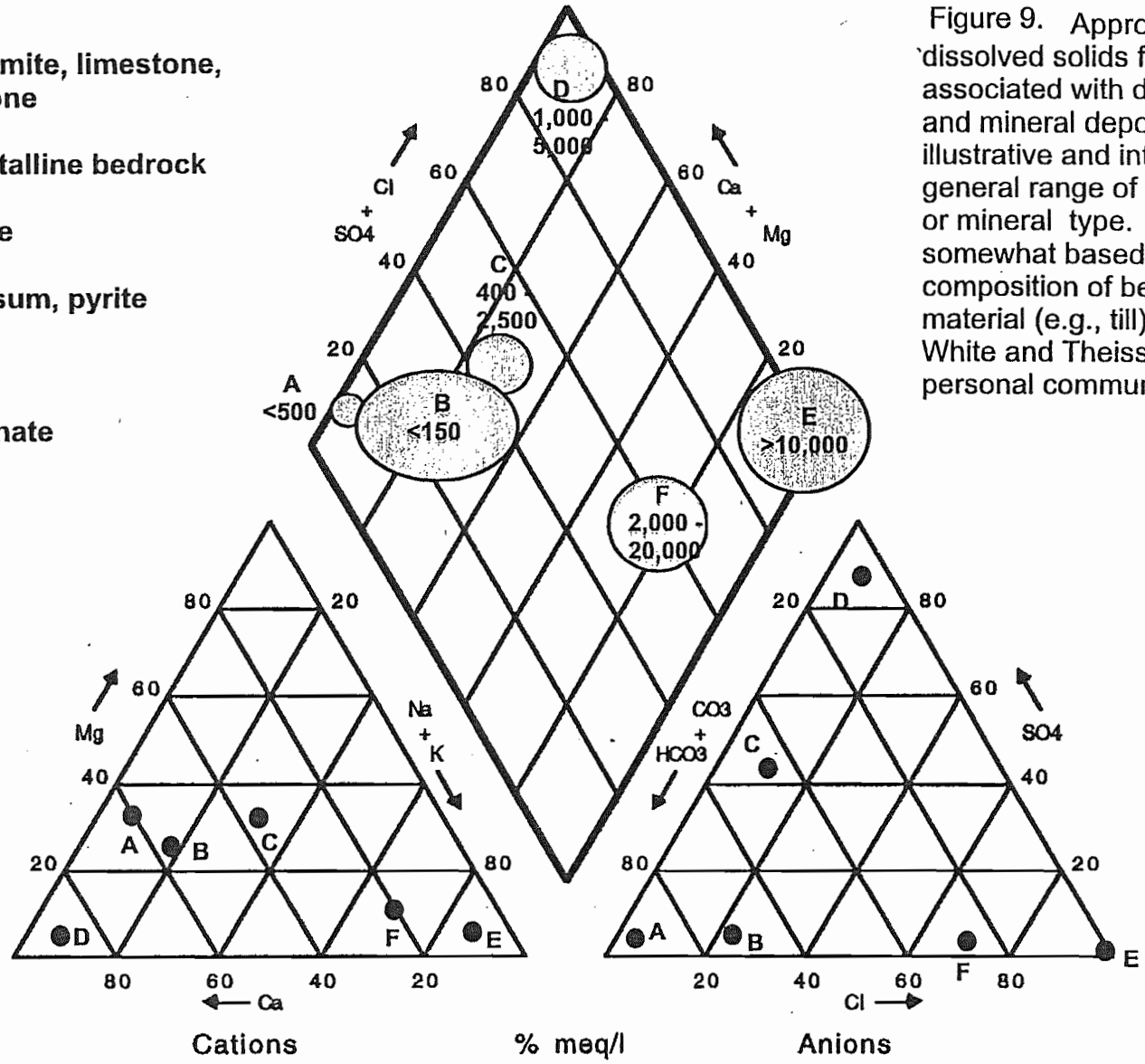

Figure 9. Approximate range of total dissolved solids found in groundwater associated with different types of bedrock and mineral deposits. This figure is illustrative and intended to show the general range of values for each bedrock or mineral type. Actual values may differ somewhat based on the specific mineral composition of bedrock or other parent material (e.g., till). Values are mg/l. (from White and Theiss 1963, and Siegel, D. I., personal communication).

part of the active farming operation, have elevated nitrate levels and low levels of ammonia. Groundwater in seeps associated with undeveloped or (moderately) developed landscapes has higher ammonia levels and relatively low nitrate levels (**Figure 10**).

Soils

A majority of the plots contain little or no peat (**Figure 11**). The organic layer present in most of these plots is well decomposed peat or muck. Typically, plots having sandy or gravelly upper profiles are likely to have large cobble or stone layers within 1 m of the surface. Plots with loam or clay-loam in the upper profile are more likely to have dense clay within 1 m of the surface. Four plots were located directly on bedrock (Twentymile Creek 1 and 2, Walnut Creek 1 and 2).

ANALYSIS

The 61 seepage wetland plots are separated into four general groups by TWINSPAN (**Figure 12**). Most of the TWINSPAN runs produced very similar results regardless of setup parameter cover cutoff level choice or subset of the species data. DCA produced results that support the TWINSPAN divisions (**Figure 13**). **Table 6** is a representative of the 28 TWINSPAN analyses run. The first division separates open canopy plots from plots with cover greater than 20 - 25% in the tree canopy, subcanopy or tall shrub layers. This division persists even when trees are left out of the analysis. Open canopy seeps include those on steep rock faces of lake bluffs and creek gorges (scarps), in serpentine barrens, and in the scour zone of a river. Also included are seeps occurring on glacial deposits and exhibiting similarities to fens.

The four serpentine barrens seeps (Chrome 1, Chrome 2, Nottingham 1 and Nottingham 2) and one riverside seep (Kennerdell) split from the rest of the open canopy seeps early in the analysis. Although Kennerdell and the serpentine seeps split from the rest of the open ones based on the presence of *Polygonum sagittatum* and the lack of calciphiles, they have only seven of 248 species in common.

Both Kennerdell and the serpentine seeps occur in areas periodically influenced by disturbance. Kennerdell experiences yearly scouring by floods and ice, while the serpentine seeps occur within a barrens system maintained by fire, grazing and the erosion occurring as a result of those disturbances. Kennerdell briefly groups with serpentine seeps because it shares even less with any other set of plots. Kennerdell was the only riverside seep sampled for this study. Other state Heritage Programs have sampled riverside seeps, and this site may be more appropriately understood within the regional context than through its relationship to the other Pennsylvania seeps with which it shares little.

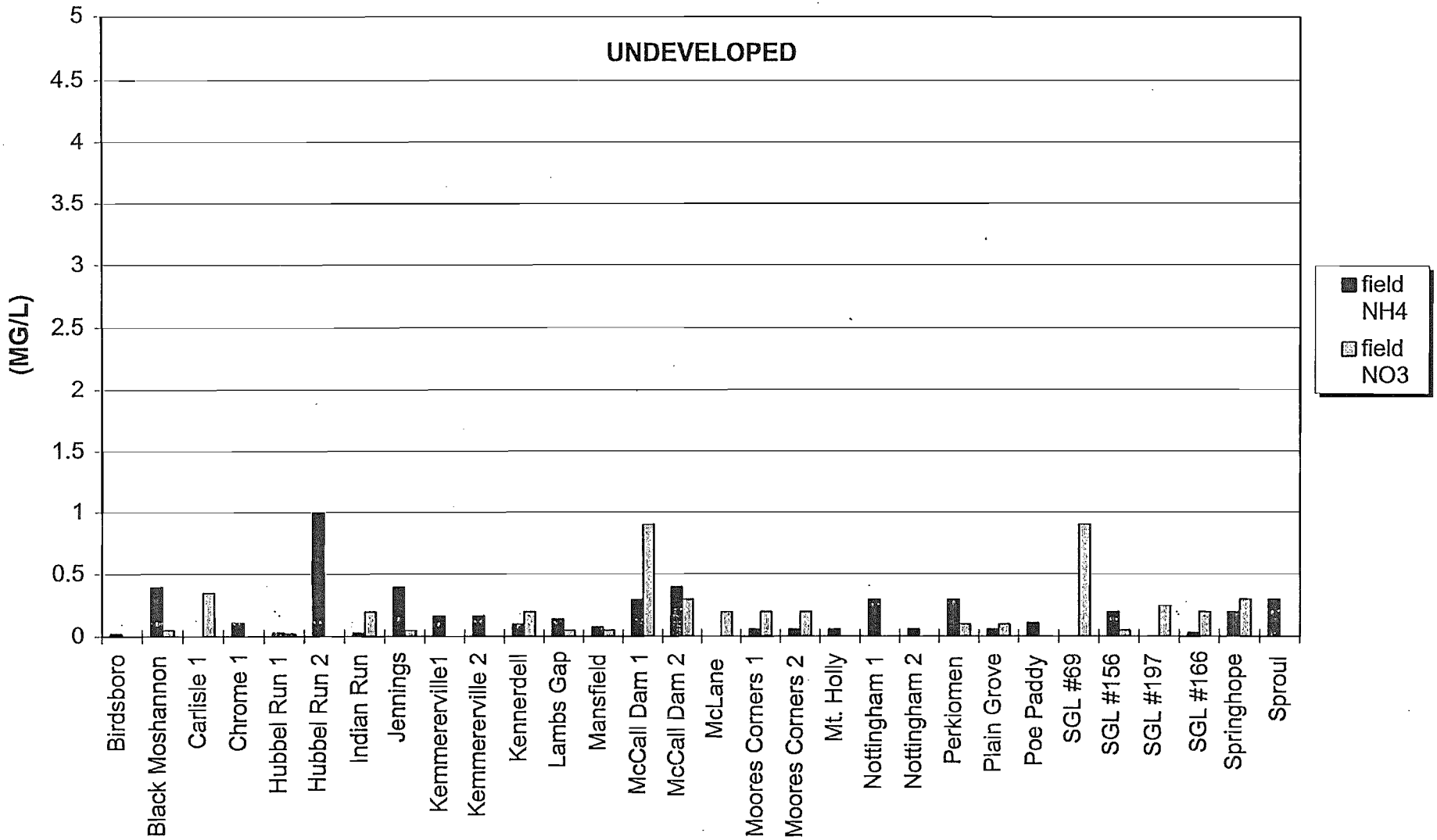

Figure 10. Field measurements of NH4 and NO3. Plots are categorized by landscape setting: undeveloped, agricultural, and developed (residential).

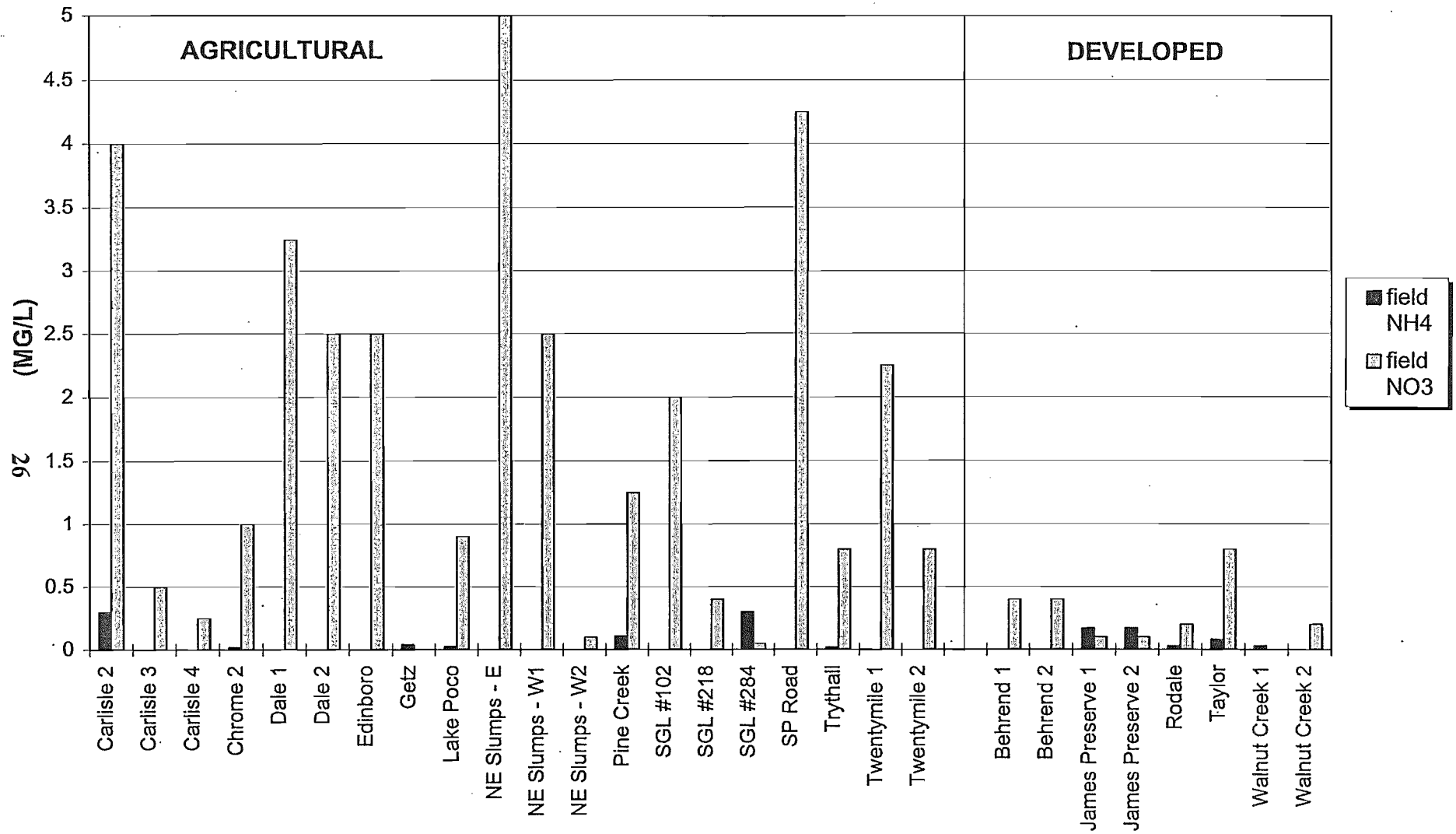

Figure 10. (cont.)

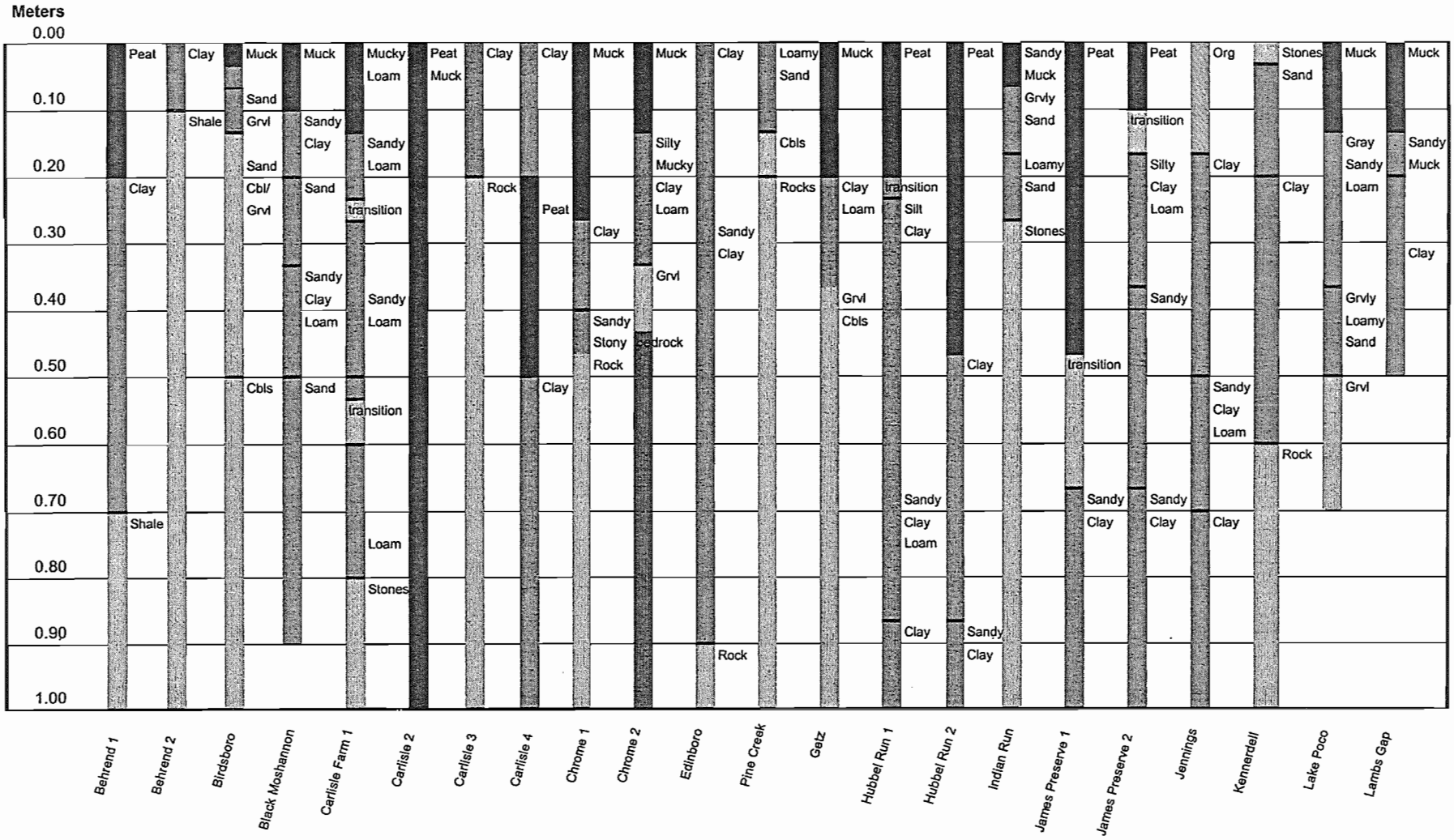

Figure 11a. Soil profiles of Pennsylvania seepage wetlands.

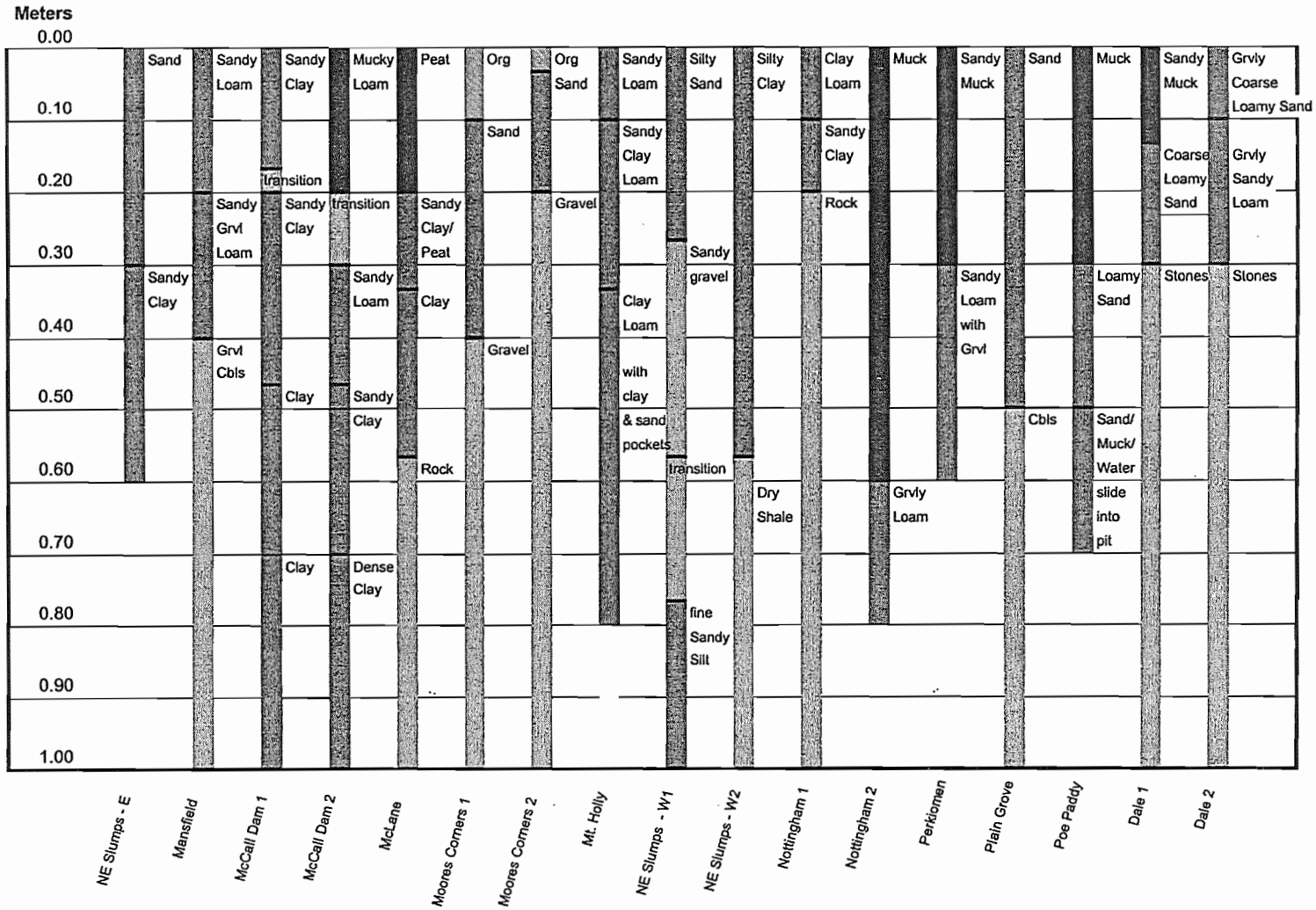

Figure 11b. Soil profiles (cont.)

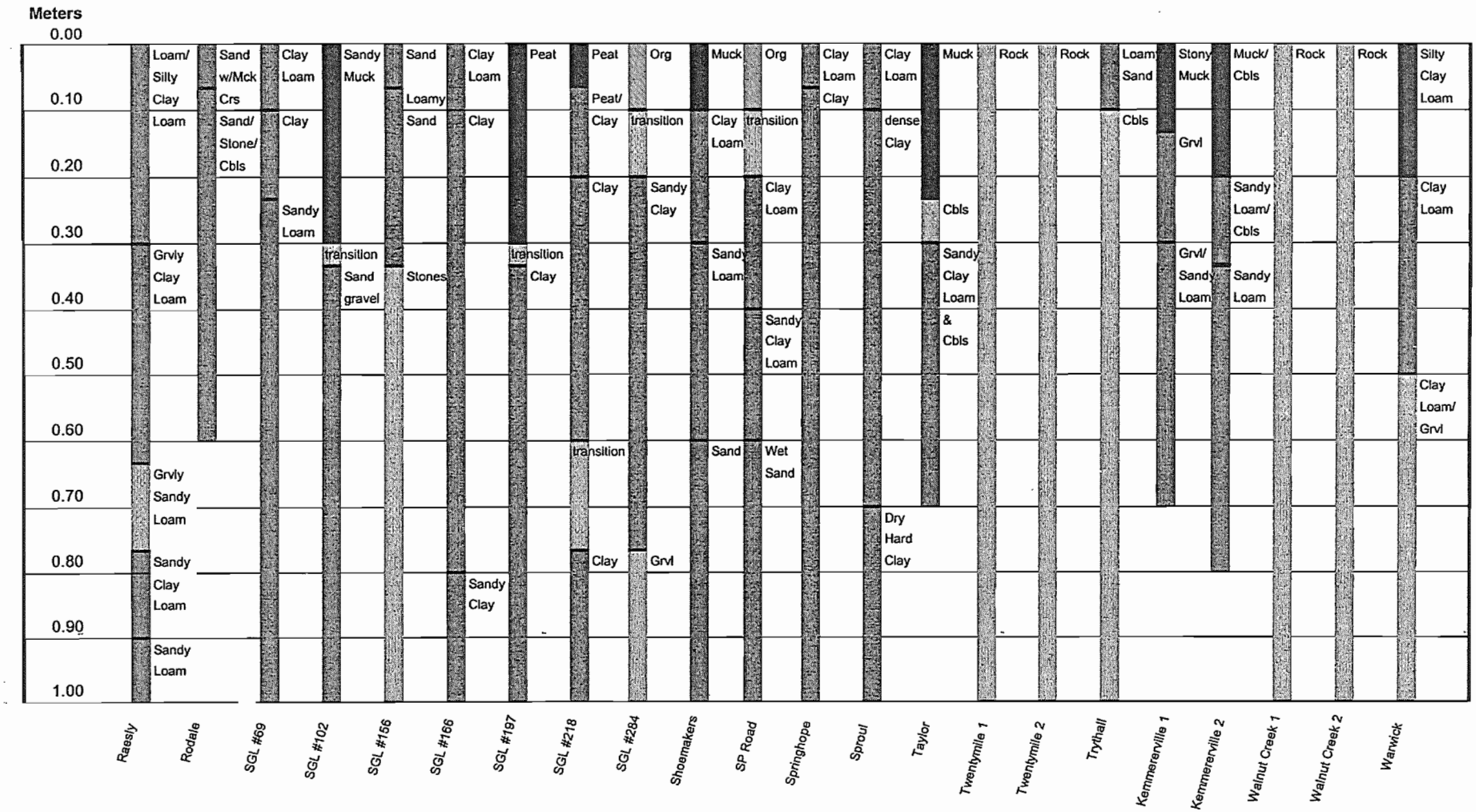

Figure 11c. Soil profiles (cont.)

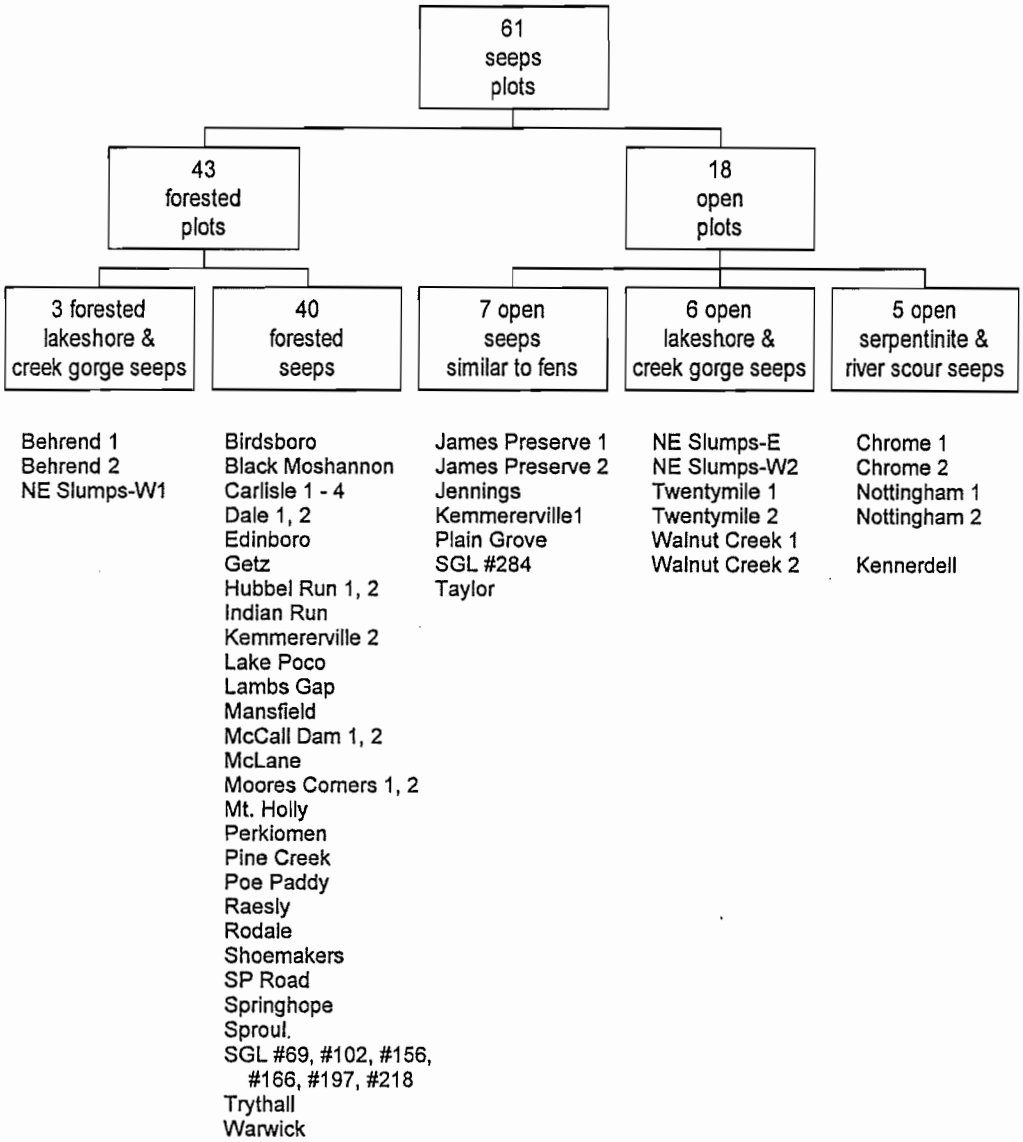

Figure 12. TWINSPAN division of 61 seeps plots into four general groups: lakeshore and creek gorge seeps, forested seeps, open seeps similar to fens and serpentinite and river scour seeps. Note that lakeshore and creek gorge seeps occur under both forested and open categories but are treated as one group.

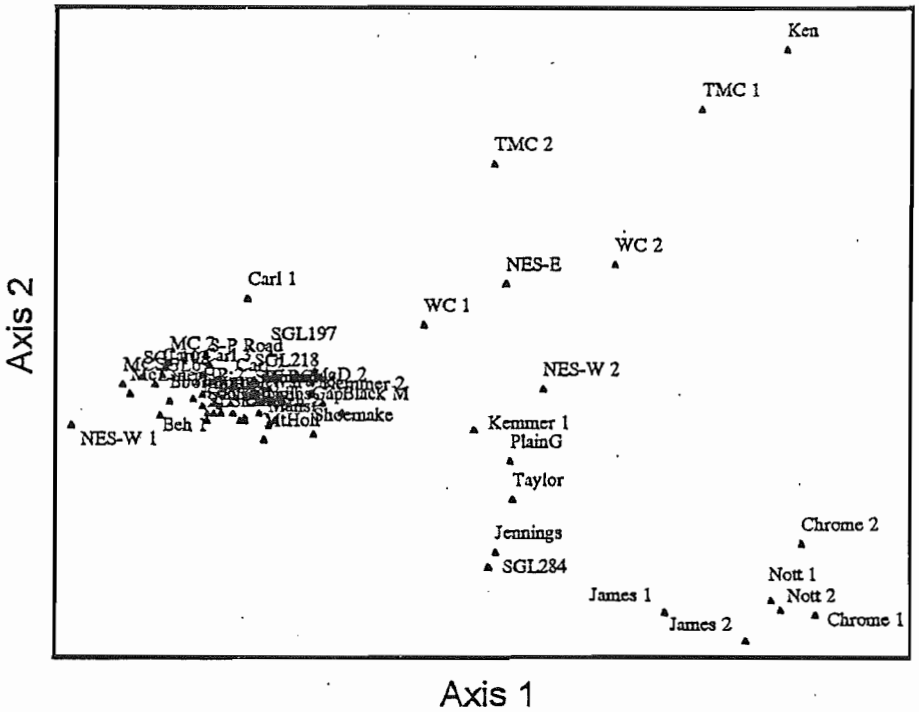

Figure 13. Axes 1 and 2 of DCA run on 198 vascular and bryophyte species occurring in 4 or more seeps plots.

Eigenvalues of Axis 1 and Axis 2 are 0.80 and 0.60, respectively. Species associated with the positive end of Axis 1 are *Philonotis capillaris, Leersia oryzoides, Deschampsia cespitosa, Cyperus strigosus, Eleocharis tenuis, Eleocharis elliptica, Scirpus validus, Polygonum punctatum, Juncus tenuis, Muhlenbergia mexicana, Cirsium muticum, Eupatorium perfoliatum, Carex hystericina.* Species associated with the negative end of Axis 1 are *Acer saccharum, Carex scabrata, Fagus grandifolia, Fraxinus americana, Bryhnia novae-angliae, Laportea canadensis, Pilea pumila, Rhynchostegium serrulatum, Chrysosplenium americanum, Cardamine diphylla, Athyrium thelypterioides, Hypnum imponens.* Species associated with the negative end of Axis 2 are *Juncus brevicaudatus, Eleocharis elliptica, Carex hystericina, Typha latifolia, Viola pallens, Deschampsia cespitosa, Cyperus strigosus, Philonotis capillaris, Polygonum punctatum, Fissidens adiantoides, Asclepias incarnata, Cirsium muticum, Euthamia graminifolia, Scirpus validus, Vernonia noveboracensis, Thelypteris palustris, Campylium stellatum, Pycnanthemum virginianum.* Species associated with the positive end of Axis 2 are *Juncus tenuis, Cirriphyllum piliferum, Panicum lanuginosum, Eupatorium rugosum, Solidago canadensis, Lycopus americanus, Salix sp., Lobelia siphilitica, Senecio aureus, Veronica americana, Poa palustris, Rubus alleghaniensis, Carex aurea.*

Table 6. TWINSPAN output for Pennsylvania's seepage wetland plot data *. Analysis was run on the 248 vascular and bryophyte species that occur in three or more of the 61 plots. Invasive non-natives are excluded from this run.

```
                 3554224444423333335522355   22223 1111112 111145656445534    3
                 6122460134570358958891767890125460132563598749009178347612342

  2 Acer  sac    525----------511-----4----------3---1-1--11-----------11-----
 78 Fagu  gra    12-----1---1-45-1--111-----42-----------------------1---------
146 Quer  rub    -33---1----1-------2--1--------------1----1--------1---------
217 Bryu  pse    -1-----------------------------------2----23---13----1-------
 62 Dali  rep    1--1-------1-------------------------------------------------
 90 Geum  can    1----------1---------1-3------------1-----11-----------------
167 Sola  dul    23----------1-1-11------------1------1----------------------
219 Camp  rad    -1-----1---------1-------------1-------------------------
  5 Alnu  inc    ---254----5-----------------------2------------1-------------
 13 Aste  pre    -----412----1-------1--------1-----------1-------------------
 23 Card  dip    1-------------11-1121----------1-----------------------------
 28 Care  bru    ------------1------11-----------------------------------------
 29 Care  cri    -----1--32------------------------------------------------
 44 Care  tri    ---------111-----------------------------------------------
 50 Circ  alp    ------------11--1---11-------------------1---------------------
 67 Dryo  cri    ---1---1--1-1-----------------------1-------------------------
 87 Gali  tin    ---1-----1--------1-----------------------------------------
 91 Glyc  mel    ----3--3442-----1--111-----1-11----------1-------------------
100 Junc  eff    ---2231-313-1--1--------1-----------------------------------1
103 Lapo  can    -------------1--1--11------------1-----------------------
125 Oxal  ace    ---1-------2---1---11-----------------------------------------
132 Pinu  str    -----5----235--------------1-----------------------------
176 Spir  alb    ---1--------1-----------------------------------2------------
184 Tiar  cor    -----------22-111-2111----------------1----------------------
192 Vacc  ang    ---1------11------------------------------------------------
200 Viol  bla    --------3-----------------1----------------1-----------------
212 Bazz  tri    -----------2----1---1-----------------------------------------
230 Hypn  imp    ----1---1-----1-1----1-----------------------------------
242 Spha  fim    -----------3----2-------------------1-----------------------
243 Spha  imb    ---------15----------------------------1----------------------
  7 Amel  arb    -5---5-----------2------------------------------------------
 18 Betu  all    -2--34--54-4--424-2555-3--1-51-----51-2--3321---------1------
 22 Calt  pal    ---21------4-----------------------111-----------------------
 25 Care  atl    ---12---1-5-----------------1-1--------1----------------------
 41 Care  sca    --3--------12414---11255----------1-2-------------------------
 55 Copt  tri    ----------121---1--21--------------1------2-------------------
 72 Epil  col    ----1-------------------------------------11------------------
 95 Hydr  ame    ----31--11--------1---------1---1---------11------------------
122 Onoc  sen    ---115---2313--111-321------1--1-1--11111-11---------1-------
123 Osmu  cin    ---544--3--5311542422---1112414311211-441-42------------------
143 Prun  ser    ---3-2-----12121-5-1--45-------3-----------------------------
149 Ranu  his    ----13-----11---2------3-----------111-----------------------
154 Rubu  his    ---2----2-3-1--1--------------3-----1-----------------------
162 Scut  lat    ------1--1-1-1--1121----1-1-1----1--1---111-----------------
189 Tsug  can    -55-4--435-514445-433--------------------151----------1------
194 Vera  vir    ---4-----------------4--1-------2-1--1---1-------------------
206 Ambl  ser    ----2----2---2-1-----------1------2----1------4-------------
213 Brac  riv    ----14----3-312221-5-23---1-1------3111-33-1----3------------
215 Bryh  nov    1------------1--1---53----------2-1-1-11----------------------
244 Spha  pal    ---41---3---1--1-------------12-----------12------------------
  1 Acer  rub    ---1--1-4234-4-555-11-4-55145555324555315112 1-----------1-11-
 45 Carp  car    ------------1-2---5-5--5----------1--1121-2---------2---------
 81 Frax  nig    ----4--1--4-----2-3------12---1-5--2-2-5-5--1------1---------
179 Symp  foe    ---45515---45-3553521-5555555555545454551421 4--14----------2-
246 Thui  del    --112211-215321522211-13333-213-3-31324232212--121-----------
 16 Athy  fil    ---1-------1---2---11--211-11----11---1--21------------------
 24 Card  pen    -------1------1-1--21-111-1-11--1-1111----11-----------------
 27 Care  bro    ----1-----------3---------------3----4-2--------5------------
 39 Care  prs    -----3514----------2-3-41-2------31--5411----------------------
 47 Chel  gla    ----13---1-1112-13----1511111111-1-11-11--1----------4-------
 48 Chry  ame    ---13--4-121-2--5--213422-2422---532--11--1------------------
 66 Dryo  car    ---2-1--1-12------------21-2-1--2----1-111------------------
 68 Dryo  int    ----1--------11-1--22223-1-11---1-211----3-------------------
 79 Floe  pro    1-------------------1--4-----------------------------------
 80 Frax  ame    122---------------3---531--1---4-----------2-----------------
 83 Gali  apa    ------------1--2------1---------1------1----------------------
```

```
                 3554224444423333335522355   22223 1111112 111145656445534    3
                 6122460134570358958891767890125460132563598749009178347612342

 84 Gali  asp    ----1-----------------1--------------1---------1------------
 85 Gali  obt    ----111-------------------------------1-11-------------------
 88 Gali  trm    -----------111----1111-3-1--1--1-11111111111-----------------
 93 Hama  vir    -11--------4431---45---3----2521--15--3--132-----------------
 97 Impa  cap    ---155553-1425135155455455255 5-1155255111221--------12---1---
121 Nyss  syl    ----2--------------------2---1---------1----------------------
137 Poly  ari    ----1---1--1------1-----3-----------1----1--------------------
160 Saxi  pen    ----------------1-1--------------1-111----11-----------------
175 Sphe  pen    ----------------------------1-------------11-----------------
182 Thel  nov    ---1-----3---------11------1111-1------1----------------------
209 Atri  cri    ----------------1------------1-----1----------------------
221 Chil  cus    --------------1------------11-----------------------------
238 Rhiz  pse    --------------1-----1------5-----------------------------
239 Rhiz  pun    ---1----24---1-12-1---1----3342-1--1-----11-----------------
241 Ricc  mul    ---------1--1---------------2-----------------------------
248 Tric  tom    -----------2-----------------------2---2----------------------
  3 Agri  gry    ------------------------------------111----------------------
 17 Athy  the    --------------1-1--11-----1-1---313----2----------------------
 40 Care  rad    ------------------------------------1-1-1--1-----------------
 49 Cinn  aru    ------------------------1-11----------1-11-----------------
 51 Circ  lut    -------------------------1-1-1---------111-----------------
 54 Coll  can    ------------------------------------1-1-1-2-----------------
 59 Cryp  can    ------1----------------1--------1--21-1-1-----------------
 64 Dios  vil    ---------------------------1-----1-1--11-----------------
 82 Frax  pen    ---------------------------14--4422354-4-12-----------------
 89 Gera  mac    ------------------------------------11-111-----------------
 96 Ilex  ver    ----2-------------------4-311445-11-11-11-----------------
106 Lili  spl    ------------------------------1-------11-----------------
110 Luzu  mul    ---------------------------1------1---1-----------------
112 Lyco  luc    -----------1----------------11--------1-----------------
115 Maia  can    -----------1---------------1111----11-----11-----------------
117 Mitc  rep    ---------------------------1------11-----1-----------------
131 Pile  pum    ----1-1------------11-542114----13132211-11-----------------
135 Podo  pel    ----------------------4-1--1----------114-----------------
136 Poly  acr    ------------------------------111----1-21-----------------
138 Poly  pub    ------------------------------1---1--11-1-1-----------------
141 Poly  vir    ----------------------12--------11---2--11-----------------
142 Pren  spl    ------------------------1--------111-----------------------
147 Ranu  abo    ------------------------1-----1--11--1-----------------
150 Ranu  rec    -------------1--------1211111---1111111-1-11-----------------
152 Rhod  vis    ---------------------------212---12------1-----------------
159 Samb  can    ----------------1-------1-1111-132111-1---1-----------------
165 Smil  rac    -----------1-------------11-1----1111-11-1-----------------
181 Thel  hex    ---------------------------1----------1-1-----------------
188 Trol  lax    ------------------------------------111-----------------
197 Vibu  den    -----1-3----------------------122----4-3-3-1-----------------
198 Vibu  pru    ---------------------------1---3--11---2-----------------
203 Viti  lab    ---------------------------11-2---1-1-----------------
207 Ambl  ten    --------------2-1-2---1-3---1---3113--1---31-----------------
210 Atri  oer    ----------------2------------12---------2-----------------
214 Brac  rut    ---2----------------------11-2---3------1-----------------
216 Bryh  sp.    ----------------------4------------2----1-----------------
224 Clim  ame    ----------------2------------------14-134-----------------
236 Plag  cus    ----1------1----------------------11--41-----------------
240 Rhyn  ser    ----1-1----2-1--1------3133412---3--21-----------------
245 Tetr  pel    ------------1-------1--1-----------1-2----1-----------------
247 Thui  rec    --------2-------2----1--21--2---244221-11-11-----------------
  9 Aris  tri    1-3-1---1112-2-1--1111--1111412-11331124321-----1--1---------
107 Lind  ben    -25-4--35--2-1--1------3553144314435544535 42-------1------1--
228 Eurh  pul    1-----------------------------------24-----------------
  8 Amph  bra    ------------------------------1--1111142----------1--
124 Osmu  reg    ---------------------------1--4-----143----1-----------------
105 Leer  vir    -------1--------1--------1111---111-111-11-11-----------------
186 Toxi  rad    -------1---1----------------111111121211-----------------
193 Vacc  cor    ---3----------------------1-31---2--231----------1--
235 Plag  cil    --------1-1----------------3----1---11-1-2----------1------
```

```
                 355422444442333335522355    22223 1111112 111145656445534    3
                 612246013457035895889176789012546013256359874900917834761234 2
 11 Aste  div  112----------------1-1--12-11---11-111--21---------1-1-------
 30 Care  grc  -----1------2------11---------------11-111-----1-----------
118 Mite  dip  -----------2-----------2-----------11----2-1-----1----------
153 Rubu  all  -----1-------------------11----------1------1--------2------
201 Viol  cuc  ---3--11-11111--1-121---323-23---42211-211-22--4------------
  6 Alnu  ser  ---------------------------4---2-----1-2-----------------1-1-
 21 Boeh  cyl  ----1--------1----------1--------1--11-11------------1----1--
 35 Care  lae  -----------1-1--------------------1--1-1---1--------1---------
130 Part  qui  -----------1---2----------1-----1111111151112------1---------
180 Thal  pub  -------------------------1--121--1-11-1----2---1------------
237 Plag  lae  --------------------1----------11---3---2--------------1-----
108 Liri  tul  ----------------------------5-----5-5-441-4-3----1-1---------
166 Smil  rot  -------------------------2--1-------11--------------------1--
134 Poa   pal  -------11--1--1-1--11--3-------------------------1-----------1
  4 Agro  per  ---11----11--------11-----------------1--1---1----1--1-------
 32 Care  gyn  ---4------1---------------------------1---1-------------1----
 36 Care  lea  ----3------1---1---11----1--1-1--1-----1--152----------------
156 Rubu  pub  -----2------1------2-----------------1----1--1----------------
 37 Care  lep  ---1------111-----------------------------------1------------
 57 Corn  rac  ------1---------------------------1-----------21-----------
 86 Gali  pal  -----4-----1-------------------------------------------------1
 42 Care  sti  ---12-2221--1---1-3-----------------1--------------------121-1
140 Poly  sag  ---1121111111---1-111----------------11--111------------21121
196 Vero  ame  -----4------2-----------------------------11-------1--------1
211 Aula  pal  --------2-----------------------------------1------------1----
 14 Aste  pun  --11--12----1-1--2------1-1-1--1---1111---1211---1-----------
 92 Glyc  str  --114121431-1--1-1131--31--1111-21--1-1131111---1--311--1111-
231 Hypn  pra  -----2-------------------------2---------1-----------11------
 53 Clem  vir  ------------1-----------------1-----1-1--------1-----------
191 Ulmu  ame  -------4---------------------413351-1----12-4---------
155 Rubu  occ  1-----------1-------------------11----------------1-----
227 Dicr  cer  -----------1----1------1-22-------------------------2--------
232 Leuc  gla  -12-------------------------2--2---1--------2---------------
114 Lysi  cil  -----1---------------2-------------1-----------2-----------
127 Pani  dic  ------------------------------1--------1----1---------------
187 Toxi  ver  ------------------------------2----11-2---324----------------
202 Viol  pal  -----------------1----------3--------1-----------------4-
 15 Aste  umb  ---1-----------------------------------1-------1--------------
172 Soli  rug  ---2---1-------1---11---1----1------111-111111--14----------
233 Pell  epi  ---1-----------------------------------------1-----1-----1-------
 10 Ascl  inc  ------------------------------------------11--1-11----------
185 Tili  ame  ---------------------4----------3-----------------4---------
 76 Eupa  rug  -11--------1------1-----------------1---33-------1-315-1-----
109 Lobe  sip  -2-----------------------------------1-11--111------1-4-1-----
169 Soli  fle  253-----------------------11-----------------------5----------
 12 Aste  lat  --1---------1-----1---------1------1--1-1---1--2--211--2--1-1
 26 Care  aur  ------------------------------------------1----1-1-1------
 31 Care  grn  ------------------------------------------1-----21---------
 58 Corn  ser  ------------------------------5-------------4-----2---------
 99 Junc  bre  ------------------------------------------151--1----2-----
119 Muhl  glo  ------------------------------------------1--2-------1-----
128 Pani  lan  ------------------------------------------11-1-----4--------
129 Parn  gla  ------------------------------------------132--1--42--5------
133 Poa   com  ------------------------------------------1------11---1-----
164 Sene  aur  ----1------11---1-11---------------1-------1-111--5242------
168 Soli  can  ------------------------------------------1------1---2--1-----
173 Soli  uli  ------------------------------------------1--3-1----------
177 Spir  cer  ------------------------------------------1--1-1----------
190 Typh  lat  ---11------------------------------------131--------2-----
205 calc  iall ----------------------------------2111---135224-3422-52-----
220 Camp  ste  ------------------------------------------1521-------2------
226 Crat  com  ------------------------------------------2-51---------
229 Fiss  adi  -11----------------------------------1-----13-1----------
 33 Care  hys  -----------1-----------------------1---1-1-21------1-211--
 38 Care  lur  ----------------------1-------------------1--------------1
```

```
                 355422444442333335522355    22223 1111112 111145656445534    3
                 612246013457035895889176789012546013256359874900917834761234 2
 69 Eleo  ell  ------------------------------------------1421--------2-15-
 74 Eupa  mac  ----------------------------1-------1---1115---2---12---11-
 75 Eupa  per  ---------------1--1-----------------------111--3-112---1-132
102 Junc  ten  ------------------------------------------111-------41--111-5
116 Ment  arv  ----1-----------------------------------------------2---------1
158 Sali  sp.  ------------------------------------------------11---4----1
 94 Hele  aut  ------------------------------------------1---1----------1
111 Lyco  ame  -----1-----------------------------------1---12----------1
120 Muhl  mex  ------------------1-----------------------1----1---1---111--
145 Pycn  vir  ------------------------------------------1--23-------11---
195 Vern  nov  ------1-----------------------------------111---41-------132-
 46 Cera  arv  ------------------------------------------------------221--
 52 Cirs  mut  ----------------------------------1------11----------1-11-
 61 Cype  str  ------------------------------------------------------1111-
 63 Desc  ces  ------------------------------------------------------5555-
 70 Eleo  ten  ------------------------------------------11-------------3--5
104 Leer  ory  ----1-----------------------------------111-----------5514-
126 Pani  cla  ------------------------------------------------------151-
139 Poly  pun  ---------1-----------------------------1-----------2112-
161 Scir  val  ------------------------------------------1----------1--31
234 Phil  cap  ------------------------------------------------------2111-
 60 Cype  bip  ------------------------------------------1---1----1--------
 77 Euth  gra  ---1--2-----------------------------------3------1--------
199 Vibu  rec  ----------------2---------------------2---1----------
208 Aneu  pin  ----------------1-----------------------11---------------
 98 Impa  pal  5-----------------------------------------------4-4-------
222 Cirr  pil  ------------------------------1----1-2-----------53------
225 Cono  con  ------------------------------------1---22----------13-----
 43 Care  str  ------------------------------1-1--------155----------
 73 Equi  arv  ---4--------2-12-42----------------1-----3312-1---11-55-----
171 Soli  pat  ------------1----1-1----------1-----11----124--14-11--------
183 Thel  pal  ----1-----3-1---------------1-------1-2---245411-------------
204 Viti  sp.  ---------------2-----------------------------1---1-----
 19 Bide  cer  ----1-----------------------------------------------1------1
 34 Care  int  ---3-----11-------------------------------4-111---------221-
113 Lyco  uni  ----2-1-32-11-----1-----------------1-1---111---1-11-4--2113-
178 Stel  als  ----1-----------------------1-----------------------------1
 56 Corn  alt  --------------11-----------------------------------1--------
 71 Epil  cil  -------------------11-----------------------------------1
174 Sphe  obt  -----2-----------------------------------11----------------
218 Camp  pol  -----1-21-1-2----2-----------------------3-----------2-11-
101 Junc  sub  ---1-----------------------------------1-------------1----
151 Ranu  sp.  1-------------1-----------------------------------------1
 20 Bide  fro  ------------------------------------121----------------
 65 Dros  rot  ---1-----------------------------------111--1----------
144 Prun  vul  ------------1--1--------------------1-1---1211-1---1---------
157 Sali  dis  ------------------------------------11---1-------------
163 Sela  apo  ------------------------------------1--253--21----------
148 Ranu  acr  -----2------------1-----------------1--2----------------
223 Clad  sp.  ---------------1------1----------------------1-------------
170 Soli  gig  1-----4-----------------------------11-----------------2-----

               000000000000000000000000000000000000000000111111111111111111
               000111111111111111111111111111111111111111100000000000000011111
                  00000000000000000000111111111111111111111000000011111100001
```

* Plots are listed according to their order in the table (left to right): 36 - NE Slumps – W1; 51 – Behrend 2; 52 – Behrend 1; 42 - Black Moshannon; 24 – Poe Paddy; 26 – Carlisle 1; 40 – Springhope; 41 - Sproul; 43 – SGL #166; 44 – McCall Dam 1; 45 – McCall Dam 2; 27 – Carlisle 2; 30 – SGL #197; 33 - McLane; 35 – SGL #102; 38 – Hubbel Run 1; 39 – Hubbel Run 2; 55 – SP Road; 58 – SGL #218; 28 – Carlisle 3; 29 – Carlisle 4; 31 – SGL #69; 57 – Moores Corners 1; 56 – Moores Corners 2; 7 – Pine Creek; 8 – Dale 1; 9 – Dale 2; 20 - Birdsboro; 21 – Indian Run; 22 – SGL #156; 25 – Mt. Holly; 34 - Edinboro; 6 - Trythall; 10 - Perkiomen; 11 - Rodale; 13 – Lake Poco; 12 - Getz; 15 - Raesly; 16 - Mansfield; 23 – Lambs Gap; 5 - Warwick; 19 - Shoemakers; 18 – Kemmererville 2; 17 – Kemmererville 1; 14 - Taylor; 49 – James Preserve 1; 50 – James Preserve 2; 60 – Plain Grove; 59 - Jennings; 61 – SGL #284; 47 – Walnut Creek 2; 48 – Walnut Creek 1; 53 – Twentymile 1; 54 – Twentymile 2; 37 – NE Slumps – W2; 46 – NE Slumps - E; 1 – Chrome 1; 2 – Chrome 2; 3 – Nottingham 1; 4 – Nottingham 2; 32 - Kennerdell.

The four serpentine barrens seeps are distinguished from the rest of the seeps sampled by the presence of *Deschampsia cespitosa*, *Cyperus strigosus* and *Philonotis capillaris*. *Cerastium arvense* and *Panicum clandestinum* occur in three of the four. Serpentine seeps are characterized by pH between 7.7 and 8.1, total dissolved solids between 30 and 180, and [Ca] less than 7 mg/l. The four seeps sampled occur on gentle 1 to 3.5 degree slopes adjacent to streams. This group, **Serpentine seepage wetland**, is described in the classification section that follows the analysis section.

Lakeshore (NE Slumps - E, NE Slumps - W1, NE Slumps - W2) and creek gorge (Behrend 1 and 2, Twentymile 1 and 2, Walnut Creek 1 and 2) scarp seeps split from the remaining open seeps based on the absence of both *Thuidium delicatulum* and *Thelypteris palustris* in the scarp seeps. Included in this group are three plots (NE Slumps - W1, Behrend 1, Behrend 2) that group with forested plots in the first open - forested split but break apart from the core of the forested group at the next level. This subset of scarp plots occurs in coves or on shelves where surrounding and overhanging canopy cover greater than 50%. The understory is dominated by forbs and tends to be patchy. *Solidago flexicaulis, Aster divaricatus, Eupatorium rugosum, Impatiens pallida* and *Arisaema triphyllum* are common in the examples of this subset of scarp seeps. Although it is not shaded by a tree canopy, Twentymile 2 is similar to this group based on floristics likely because of its position on a steep, north-facing slope.

Unlike the forested subset, the open lakeshore and creek gorge scarp seeps have a denser layer of forbs and graminoids. The more common species are *Carex* spp., *Juncus tenuis, Senecio aureus, Lobelia siphilitica*, *Impatiens* spp. and *Tussilago farfara*. These open scarp seeps usually contain one or two of the following calciphilic species: *Carex aurea, Equisetum variegatum, Gentianopsis crinita, Lobelia kalmii, Muhlenbergia glomerata*, *Parnassia glauca* and *Campylium stellatum.*

The scarp seeps are characterized by steep slopes (between 23 - 60 degrees for the open plots and between 7 and 47 degrees for the forested subset); groundwater with high specific conductivity (other than Twentymile 2, mean conductivity levels were between 330 and 925 μS) and pH values greater than 8.0. Five of the nine sites in this group contain calciphilic species, and all but Twentymile 2 (12 mg/l [Ca]) have strongly calcareous (> 25 mg/l [Ca]) water chemistry. These sites occur within a dynamic setting of saturated, slumping substrates that serve to arrest succession at pre-forest levels. The cycle begins when an area of freshly slumped substrate is colonized by bryophytes and *Equisetum*. Graminoids and forbs begin to establish and provide greater stability (and mass) to the substrate. Shrubs and trees invade, consolidating the section of substrate and adding more mass. The mass eventually leads to the sliding of the upper sandy deposits across the underlying and saturated shales (slumping). The cove and shelf (forested) areas differ from the more exposed ones because they receive some protection from wind and water erosion and may occur on formerly slumped material that is stabilized by surrounding forest. This group, **Great Lakes region scarp seep**, is described in the classification section that follows the analysis section.

The remaining group of open canopy seeps includes: Taylor East, Kemmererville 1, James Preserve 1 and 2, Jennings Prairie, Plain Grove and SGL #284. These seeps share similarities with fens. All are dominated by dense cover of graminoids and forbs. All have an organic A-

horizon (either peat or muck) between 10 and 60 cm deep, although the areas of peat accumulation at Plain Grove lie outside the sampled area. Specific conductivity of the groundwater discharging into these seeps ranges from 250 to 670 μS, and pH ranges from 7.6 to 8.3. These plots occur on 2.5 to 7 degree slopes.

Forty plots are located in seeps that contain more than 25% cover from a tree canopy, tree subcanopy or tall shrub layer. The plots with canopy cover split apart from open seeps at the first level of TWINSPAN based on the presence of *Impatiens capensis*, *Osmunda cinnamomea, Arisaema triphyllum*, *Thuidium delicatulum*, moderate cover of *Symplocarpus foetidus* and the lack of *Eupatorium perfoliatum* in the shaded seeps. The species of forested plots that did not occur in any of the open plots include: *Carex prasina, Carex scabrata, Glyceria melicaria* and *Rhizomnium punctatum.*

Further divisions split this broad group of 40 plots into two subgroups approximately correlating with the presence/absence of *Tsuga canadensis*. However, there is no set of indicator species that clearly and consistently split these two subgroups. The *Tsuga* plots tend to contain *Prunus serotina, Tiarella cordifolia, Fagus grandifolia, Poa palustris, Cardamine diphylla, Oxalis acetosella, Circaea alpina* and *Hypnum imponens*. The flora of these plots tends to have a more northern affinity, and the plots tend to be in a landscape context with more extensive conifer-dominated wetlands. The forested plots without *Tsuga* have a deciduous canopy and are more likely to contain *Fraxinus pennsylvanica, Ilex verticillata, Rosa multiflora, Berberis thunbergii, Sambucus canadensis, Toxicodendron radicans, Rhododendron viscosum, Ranunculus recurvatus* and *Smilacina racemosa*. The forested plots without *Tsuga* tend to occur within and close to the Lower New England – Northern Piedmont ecoregion while *Tsuga* plots occur outside (to the north and west) of the ecoregion (Moores Corners and Edinboro tend to group with non-*Tsuga* plots although they are geographically closer to the *Tsuga* plots).

Further TWINSPAN analyses of this broad group of 40 forest seeps did not provide any additional, useful separation. The data sets used include: all vascular and bryophyte species; vascular and bryophyte species excluding trees; trees and shrubs only; bryophytes only; and trees, shrubs and bryophytes. DCA run on the 40 plots with canopy cover did not reveal any additional separation and does not support the trend toward the *Tsuga* and non-*Tsuga* subgroups. The ***Symplocarpus foetidus/Chrysosplenium americanum* forest seep** is described in the classification section that follows the analysis section.

Various iterations of CCA were run on all 61 plots and on the subset of 40 forested plots in order to investigate whether species composition and cover respond to the environmental and water chemistry data we collected. Results repeat the general grouping patterns resulting from TWINSPAN and DCA, both of which use only vegetation data. However, environmental and water chemistry variables account for very little variation. Three to ten environmental and/or water chemistry variables were selected for each run of CCA from the following: geologic setting (bedrock), specific conductivity, pH, canopy cover, slope, peat depth, number of calciphiles, latitude, longitude, [Ca], water flow, total dissolved solids, and alkalinity. We selected the subsets so as to avoid including several highly correlated variables in the same run. The total percent of variance in species data explained by the selected subset of variables ranged from 9.9 to 15.0 %. Although some plots that are grouped together tend to share characteristics

such as high specific conductivity or steep slopes, in general environmental and water chemistry variables do not explain the plot groupings.

In order to investigate the relationship between Pennsylvania's seeps and fens, we combined the two data sets for TWINSPAN. When the 61 seep plots from this study are analyzed with the 56 plots from Pennsylvania's fen study, the major groupings remain consistent with results described above when seeps are analyzed alone. However, the seven seeps exhibiting similarities to fens further divide into three fen groups.

The plots at Kemmererville 1 and Taylor East group with a fen type that occurs in northeastern Pennsylvania and western New Jersey. Taylor East is located in an active discharge area in a complex of fens located within a ground moraine. The fens have areas of active, perennial water flow over gravel substrate and also contain areas of deeper (up to 1 m) peat deposits. Kemmererville 1 is located on glacial terminal moraine deposits over sandstone where sedge peat has accumulated to a depth of 20 cm. Groundwater discharging directly above the plot flows along gravelly channels within and alongside the peat. ***Toxicodendron vernix/ Juniperus virginiana/ Myrica pensylvanica*** fen is described in the classification section that follows the analysis section.

Jennings Prairie and State Game Lands #284 group with open sedge fens. Dominated by dense graminoids and forbs, these sites accumulate peat and exhibit drier conditions in the later part of the growing season. **Open sedge (Carex stricta/Carex prairea/Carex lacustris) fen** is described in the classification section that follows the analysis section. Many of the sites within this group are associated with floodplains of smaller streams and with past or present agricultural land-use.

Plain Grove and James Preserve 1 and 2 group with Rhamnus alnifolia/Carex interior/Senecio aureus fens. Both of these sites have areas of active, perennial water flow over gravelly, sandy substrate and also areas of peat-forming diffuse flow. Both occur on slopes greater than 5 degrees and are surrounded by extensive shrub growth. The **Rhamnus alnifolia/Carex interior/Senecio aureus fen** is described in the classification section that follows the analysis section.

CLASSIFICATION

The Pennsylvania community classification is currently in draft, and the types described below may change before the classification is finalized. The classification will be available from the Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry, Forestry Advisory Services when completed.

Serpentine seepage wetland This community type is an herbaceous wetland restricted to areas underlain by serpentinite bedrock. Seeps are found on gentle slopes at the bases of low hills and adjacent to streams. Groundwater saturates the surface for a significant portion of the growing season. Graminoids dominate, with *Deschampsia cespitosa*, *Leersia oryzoides*, *Eleocharis tenuis* or *Panicum clandestinum* often dominant. Other species characteristic of these seeps

include: *Cerastium arvense, Cyperus strigosus, Muhlenbergia mexicana, Cirsium muticum, Polygonum sagittatum, Sorghastrum nutans, Lycopus uniflorus, Agalinis purpurea, Sanguisorba canadensis, Eupatorium perfoliatum* and *Philonotis capillaris.*

Great Lakes region scarp seep This community occurs on glacial and glacial lacustrine deposits over exposed, eroded shales and sandstone. This community includes seeps on lakeshore bluffs, where groundwater seepage occurs at the interface of old beach deposits of sand/gravel and dense till, and creek gorge seeps, which occur where a ledge or shelf is fed by groundwater discharging from surficial glacial deposits and the directly underlying weathered shale. These seeps occur on steep, saturated, unstable substrate and share a common disturbance cycle. The cycle begins when an area of slumped substrate is colonized by bryophytes and *Equisetum* species. The substrate is stabilized by vegetation, organic matter begins to accumulate, and graminoids, forbs, and shrubs colonize the seep. More exposed seeps closer to the scarp face undergo more frequent slumping cycles as the weight of vegetation and saturated soil/gravel substrate cause the community to slide off the bedrock. More sheltered areas in coves and on shelves are protected from the full force of wind and/or water, and the substrate is not as active. The seeps in the protected areas undergo a less frequent slumping cycle, and this allows forest cover to develop around the seeps. The tree canopy tends to be dominated by *Acer saccharum* and *Tsuga canadensis*. *Amelanchier arborea* and *Lindera benzoin* occur in the subcanopy and shrub layers. Forested scarp seeps tend to have a patchy, forb-dominated understory. Characteristic species include: *Solidago flexicaulis, Aster divaricatus, Eupatorium rugosum, Impatiens pallida, Equisetum arvense* and *Arisaema triphyllum*. Seeps in more exposed areas have no forest canopy and are dominated by *Equisetum arvense, Tussilago farfara, Senecio aureus* and a mix of graminoids in addition to the forest forbs listed above. *Carex aurea, Parnassia glauca, Lobelia kalmii, Equisetum variegatum* and *Gentianopsis crinita* are calciphilic species characteristic of but not restricted to the lake plain scarp seeps. Calciphiles, when present, can provide a significant amount of cover (15 – 20%).

***Toxicodendron vernix/Myrica pensylvanica/Juniperus virginiana* fen** This community is a type of fen that occurs in northeastern Pennsylvania and western New Jersey. Depth of organic material may vary from none in actively seeping areas to a meter or more in basins. These wetlands have developed under the influence of base-rich groundwater. During the growing season, pH of surface water ranges from 7.0 to 8.1. These fens are dominated by a mixture of shrubs and herbaceous plants (predominantly sedges) although the shrub layer may be sparse or missing on some sites. Most of the sites that are dominated by shrubs have active groundwater discharge areas that lack woody vegetation. Characteristic shrubs include: *Toxicodendron vernix, Myrica pensylvanica, Juniperus virginiana.* Other common shrubs are *Salix* spp., *Cornus racemosa* and *Rhamnus alnifolia*. Herbaceous species include: *Carex sterilis, Carex flava, Carex stricta, Muhlenbergia glomerata, Rhynchospora alba, Rhynchospora capillacea, Thelypteris palustris, Lobelia kalmii, Parnassia glauca, Drosera rotundifolia, Pycnanthemum virginianum, Aster lateriflorus, Vernonia noveboracensis* and *Selaginella apoda*. Characteristic bryophytes include: *Campylium stellatum, Aulacomnium palustre, Fissidens adiantoides* and *Bryum pseudotriquetrum.*

Open sedge (Carex stricta/Carex prairea/Carex lacustris) fen These are open, sedge-dominated wetlands that usually occur on organic soil (sedge peat) saturated through most of the

year by base-rich groundwater. These fens typically lack areas of active seepage and do accumulate peat. PH is generally between 7.0 and 7.5 during the growing season. Sedges dominate, usually by some combination of *Carex stricta, Carex prairea, Carex lacustris, Carex tetanica* and *Carex aquatilis*. Additional characteristic herbs include: *Typha latifolia, Impatiens capensis, Onoclea sensibilis, Verbena hastata, Pycnanthemum virginianum, Thelypteris palustris, Epilobium leptophyllum* and *Galium tinctorium*. Typical bryophytes include *Campylium stellatum, Fissidens cristatus, Sphagnum teres* and *Thuidium delicatulum*. On some sites the lack of a significant shrub layer may be due to excessive moisture, but in many cases disturbance (cattle grazing, repeated fire) keeps these sites open.

***Rhamnus alnifolia – Carex interior – Senecio aureus* fen** These wetlands developed under the influence of base-rich groundwater. Depth of organic material may vary from none in actively seeping areas to a meter or more in basins. During the growing season, pH of surface water ranges from 6.9 to 7.9. This type of fen is dominated by a mixture of shrubs and herbaceous plants (predominantly sedges). Most sites have an area of active groundwater discharge that is without woody growth. Characteristic shrubs are *Rhamnus alnifolia, Salix spp., Rubus pubescens, Alnus incana, Viburnum recognitum* and *Cornus sericea*. Herbaceous species vary greatly from site to site. Some typical representatives are *Carex interior, Senecio aureus, Equisetum arvense, Carex hystericina, Thelypteris palustris, Chelone glabra, Geum rivale, Symplocarpus foetidus, Solidago patula, Typha latifolia* and *Eupatorium perfoliatum*. Some sites may contain calciphilic species such as *Carex aurea, Carex flava, Carex prairea, Carex sterilis, Carex tetanica, Eriophorum viridicarinatum, Muhlenbergia glomerata* or *Parnassia glauca*. Characteristic bryophytes include *Campylium stellatum, Plagiomnium ellipticum, Sphagnum palustre, Bryum pseudotriquetrum* and *Climacium americanum*. On many of these sites, microtopography creates a tight mosaic of locally different substrate chemistry. Mounds of mosses, especially *Sphagnum* spp., form at the base of shrubs and stumps and provide more acidic conditions for species otherwise not usually associated with alkaline wetlands (*Vaccinium corymbosum, Vaccinium myrtilloides, Gaultheria procumbens, Clintonia* spp., *Tsuga canadensis*).

***Symplocarpus foetidus/Chrysosplenium americanum* forest seep** These are wetlands which occur where circumneutral to alkaline groundwater discharges to the surface and saturates the substrate. At most sites the substrate is saturated for much of the growing season in most years, while at other sites, where the recharge area is smaller, the water table is at the surface only during spring. These wetlands are typically small (<0.1 ha) but also include some that are larger (10 ha). Frequently several small seeps occur along one hill or slope. There may be an accumulation of organic material (peat or muck), but it is seldom more than 50 cm deep. Canopy cover ranges from 25 to 80 % and may be provided by woody species either rooted within the seep or by overhanging foliage from woody plants rooted in the upland adjacent to the seep. Included in this community are species tolerant of a wide amplitude of pH. Some wetlands fed by moderately to strongly calcareous groundwater ([Ca] > 15 mg/l) may occasionally contain calciphilic herbaceous species in the understory. Sites with less canopy cover tend to have greater cover of graminoids, while those with greater canopy cover typically have more forbs. Species composition is highly variable but usually includes several of the following: *Symplocarpus foetidus, Chrysosplenium americanum, Chelone glabra, Osmunda cinnamomea, Impatiens capensis, Acer rubrum, Arisaema triphyllum, Athyrium filix-femina, Athyrium*

thelypterioides, Cardamine pennsylvanica, Carex prasina, Carex scabrata, Carpinus caroliniana, Dryopteris carthusiana, Dryopteris intermedia, Galium triflorum, Glyceria melicaria, Ilex verticillata, Lindera benzoin, Onoclea sensibilis, Pilea pumila, Sambucus canadensis, Scutellaria lateriflora, Smilacina racemosa, Thelypteris noveboracensis, Tiarella cordifolia, Saxifraga pensylvanica , Viburnum dentatum, Brachythecium rivulare, Bryhnia novae-angliae, Rhizomnium punctatum, Rhynchostegium serrulatum and *Thuidium delicatulum.*

DISCUSSION

Sites for this study were selected based on the expectation that flora would reflect geography, site hydrogeology and water chemistry. The expectation that floristics would track abiotic factors originated from field observations, inspection of available data on Pennsylvania's seepage wetlands, and readings of past classifications (e.g. Smith 1991) which were often based on specific, classic examples of communities.

We expected that sampling seepage wetlands at this level of detail would reveal strong floristic patterns. Analyses reveal that the seeps do split into reasonable and explainable groups based on vascular and non-vascular plants. However, these groups can not always be distinguished from each other on the basis of floristics alone, and the floristic groupings do not strongly correlate with most environmental and chemical variables measured. Additionally, some groups (forested seeps) are not floristically distinct from other related communities. For example, acidic seeps that occur in forest settings commonly have as dominant species *Osmunda cinnamomea* and *Symplocarpus foetidus* – two of the most prevalent species within their more alkaline counterparts sampled in this study. Other species are also commonly dominant across the pH range of sustaining groundwater; *Acer rubrum* and *Lindera benzoin* have wide ecological amplitude and occur in uplands as well as wetlands and in moderately acidic as well as circumneutral or alkaline areas. This suggests that additional descriptive information, beyond floristic composition, may be required to represent the variation of communities on the landscape.

One variable strongly associated with floristic composition is canopy cover. Open seeps are generally associated with one or more of the following: periodic disturbances (such as fire or grazing) that keep them open but do not alter the hydrology of the site; steep, unstable slopes or shallow, eroding soils; thin saturated soils over rock or near active discharge areas where trees develop shallow root systems that contribute to frequent wind-throw. Open seeps fed by moderately to strongly calcareous groundwater often contain a set of calciphilic species which includes many of the species of special concern in Pennsylvania occurring in high pH wetlands. Competition for light may be the major regulating factor in the distribution of these rare species. The conditions and disturbances at these sites slow invasion by woody species and maintain the high light levels that appear important for many uncommon species.

In forested seeps, other factors beyond light intensity combine to dilute the influences of groundwater chemistry. Forest seeps provide a variety of microhabitats. Hummocks on root mounds and coarse woody debris provide variations in microtopography that remove a plant

from direct contact with groundwater or give a plant access to unsaturated soils. Upland plants can occur at edges of wetlands or within wetlands on hummocks. Hummocks may also support plants typically associated with more acidic sites.

Periodic disturbances together with a number of abiotic factors (such as high light levels, highly mineralized groundwater, active groundwater discharge) create patches of rare and unique habitat. This characterizes most of the open category of seepage wetlands and fens. The physiognomy and species composition of fens and open seeps are as much a result of prior land-use as of the abiotic factors currently present at the site. Disturbances initially responsible for altering the landscape in such a way that resulted in the development of open fens and seeps include beaver flooding and subsequent draining, windthrow of large trees or groups of trees during violent weather events, fire, and, more recently, clearing for agriculture (grazing) and subsequent abandonment. Current physiognomic structure and species composition of many open wetland sites is likely to change; some fens are losing their open aspect as woody vegetation cover increases. The successional relationship between open wetlands and their forested counterparts is poorly understood and requires further study. Until we understand the factors that molded the landscape of which these communities are a part, we will be left managing small, isolated patches and miss the opportunity to allow large scale natural processes to function successfully.

CONSERVATION IMPLICATIONS

The setting of conservation priorities relies on our ability to distinguish high biodiversity from lower biodiversity sites. Species-level data often serves as the basis for ranking sites and developing priorities. However, community-level data can play a much broader role by linking habitat and process information to (specific) species requirements. Communities, if well understood and documented accurately, can serve as predictors of particular species and the processes that maintain those species. The collection of quantitative data provides the opportunity for comparison of communities across broad geographical areas. Community-level data can furnish the foundation on which other research may build.

Communities themselves should be targets of conservation. Plants of special concern frequently survive in fragmented, disturbed and unnatural settings, and protecting each fragment does not ensure the continued long-term existence of the species or further biodiversity conservation on a landscape scale. Maintaining a viable community imbedded in a relatively undisturbed landscape with ecological processes in place is a long-term strategy for ensuring biodiversity conservation.

This study indicates the need for further research for both basic biological inventory and community classification. The lack of floristic distinction among many of the wetlands studied highlights the importance of studying other taxa present in seepage wetlands. Invertebrate, reptile and amphibian inventories are particularly appropriate research targets when coupled with existing vegetation and hydrology data. Faunal groups may respond to geographic and environmental factors more selectively than vegetation and may allow wetland groups such as

forested seepage wetlands (*Symplocarpus foetidus/Chrysosplenium americanum*) described above to be further divided and more finely classified.

The hydrological component of this study provides site-specific data on water flow characteristics and recharge zones to the Pennsylvania Natural Diversity Inventory. Protecting a wetland community frequently involves more than protecting the area delineated as wetland. Protecting the recharge area that is the water source for the wetland is equally, if not more, important. Site-specific hydrologic information allows a more selective approach to protection and provides a critical piece of information for the assessment of our ability to ensure long-term viability of a wetland.

As part of this project, we are sharing our data with the Eastern Regional Office of The Nature Conservancy. Progress is being made in unifying data sets from across the eleven states of the eastern region and analyzing communities on a regional basis. Information from other states includes extensive fen data and some seepage wetland data (especially riverside seeps). Maryland is currently completing a wetland study similar to ours, and their data will be available to the region within the coming year. As the region-wide data set grows, the ability of individual states to recognize meaningful patterns and make classification decisions will increase. The result should be an improved context for making conservation and management decisions over a large and comprehensive landscape on the scale of natural community and species ranges. Programs or individuals requiring more information concerning the process of assembling and sharing data should contact the regional ecologists at the Eastern Regional Office of the Nature Conservancy as well as the individual states which have contributed data to that office.

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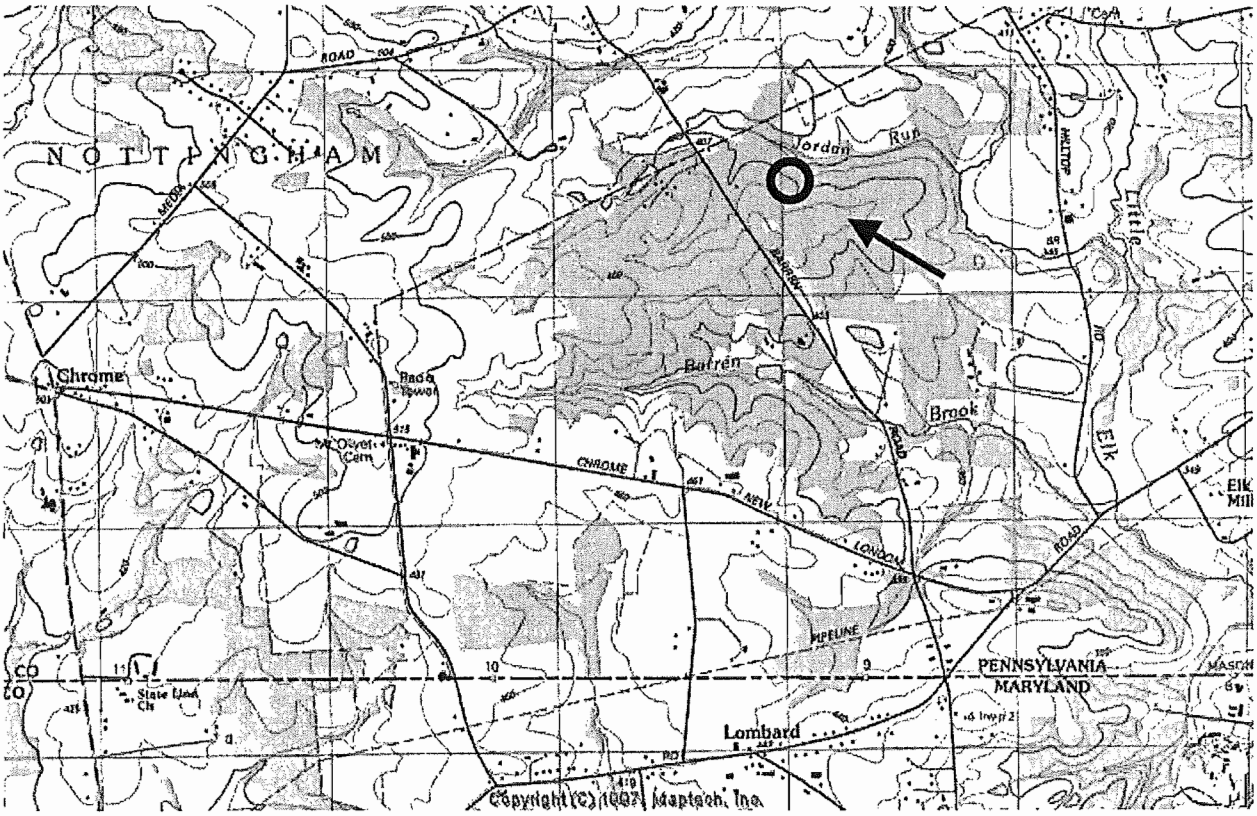
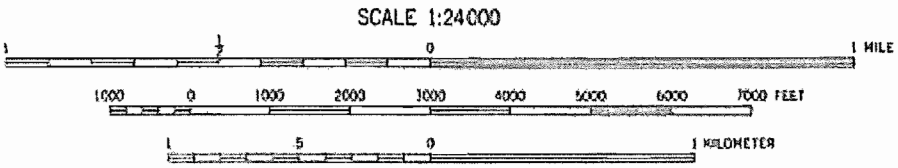
APPENDICES

Site: Chrome Serpentine Barrens Seep 1

USGS 7.5' Quadrangle: Bay View, MD - PA		Latitude:	394427
Chester County, Elk Twp.		Longitude:	755641
Location: Chrome, 3.4 km ENE		Elevation:	122 m

Chrome Serpentine Barrens Seeps 1 and 2 are located at the ends of two rather gently sloping serpentinite ridges. Recharge areas for both seeps are restricted to the serpentinite formation. Land use in the recharge zone of Seep 1 is scrub forest. Land use in the recharge zone for Seep 2 is primarily agriculture, low density residential housing and scrub forest. The diffuse groundwater flow feeding both seeps is strongly seasonal. Both seeps are open and dominated by graminoids (*Deschampsia cespitosa*, *Leersia oryzoides*).

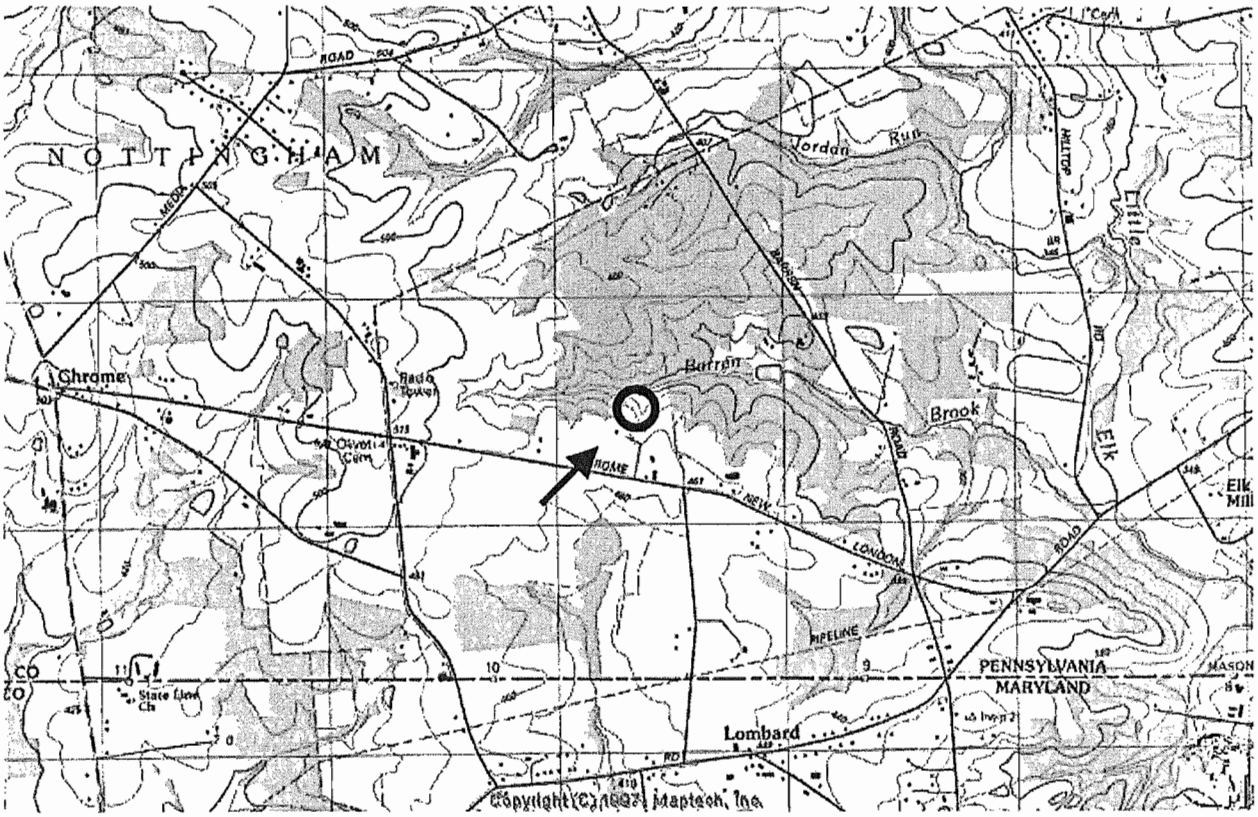


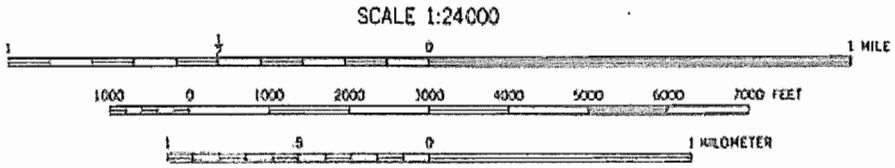


Site: Chrome Serpentine Barrens Seep 2

USGS 7.5' Quadrangle: Bay View, MD - PA		Latitude:	394357
Chester County, Elk Twp.		Longitude:	755712
Location: Chrome, 2.55 km E		Elevation:	127 m

Chrome Serpentine Barrens Seeps 1 and 2 are located at the ends of two rather gently sloping serpentinite ridges. Recharge areas for both seeps are restricted to the serpentinite formation. Land use in the recharge zone of Seep 1 is scrub forest. Land use in the recharge zone for Seep 2 is primarily agriculture, low density residential housing and scrub forest. The diffuse groundwater flow feeding both seeps is strongly seasonal. Both seeps are open and dominated by graminoids (*Deschampsia cespitosa*, *Leersia oryzoides*).

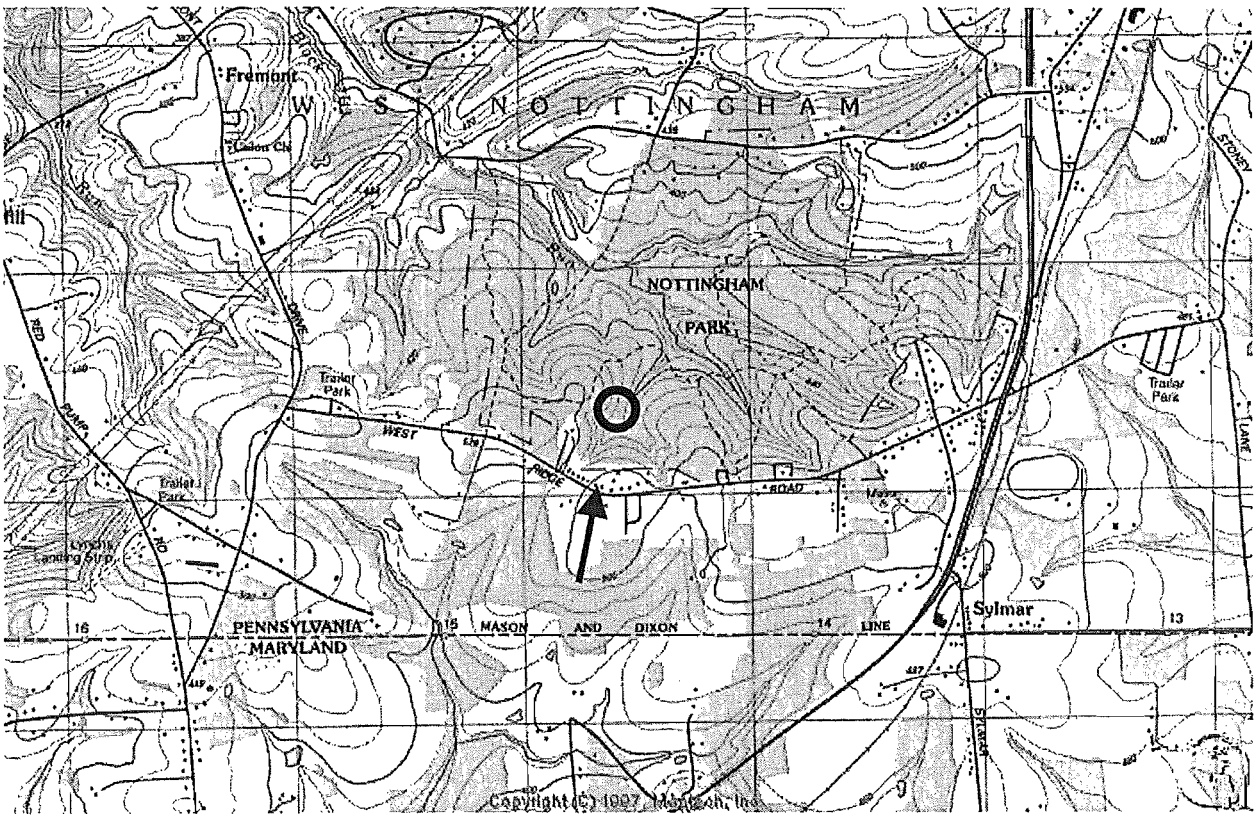




Site: Nottingham Serpentine Barrens Seep 1

USGS 7.5' Quadrangle: Rising Sun, MD - PA		Latitude:	394350
Chester County, West Nottingham Twp.		Longitude:	760242
Location: Nottingham, 3.1 km SW		Elevation:	122 m

Nottingham Serpentine Barrens Seeps 1 and 2 are located at the base of a low hill of serpentinite. The entire recharge zone for both seeps lies within the serpentinite formation. Land use in the recharge zone for both seeps is mainly scrub forest although Seep 1 may receive additional groundwater from another ridge that has moderate density residential development. Both seeps show minor seasonal fluctuations in groundwater discharge. Seep 2 is fed by water from a nearby stream. Groundwater discharges into the stream and then seeps into the peaty soils of "Seep" 2. Both seeps are open and dominated by graminoids (*Deschampsia cespitosa, Eleocharis elliptica, Panicum clandestinum, Leersia oryzoides*).



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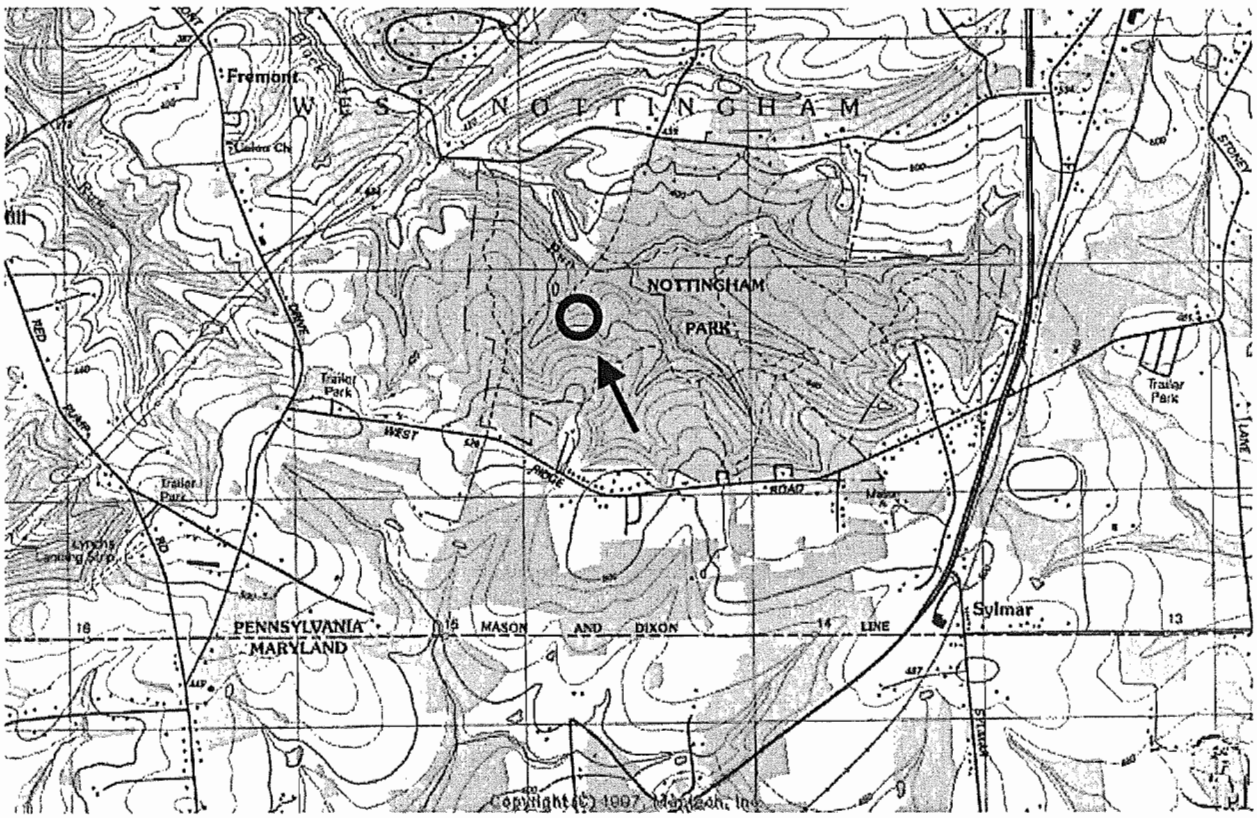
Site: Nottingham Serpentine Barrens Seep 2

USGS 7.5' Quadrangle: Rising Sun, MD - PA		Latitude:	394402
Chester County, West Nottingham Twp.		Longitude:	760250
Location: Nottingham, 2.9 km SW		Elevation:	107 m

Nottingham Serpentine Barrens Seeps 1 and 2 are located at the base of a low hill of serpentinite. The entire recharge zone for both seeps lies within the serpentinite formation. Land use in the recharge zone for both seeps is mainly scrub forest although Seep 1 may receive additional groundwater from another ridge that has moderate density residential development. Both seeps show minor seasonal fluctuations in groundwater discharge. Seep 2 is fed by water from a nearby stream. Groundwater discharges into the stream and then seeps into the peaty soils of "Seep" 2. Both seeps are open and dominated by graminoids (*Deschampsia cespitosa, Eleocharis elliptica, Panicum clandestinum*, *Leersia oryzoides*).



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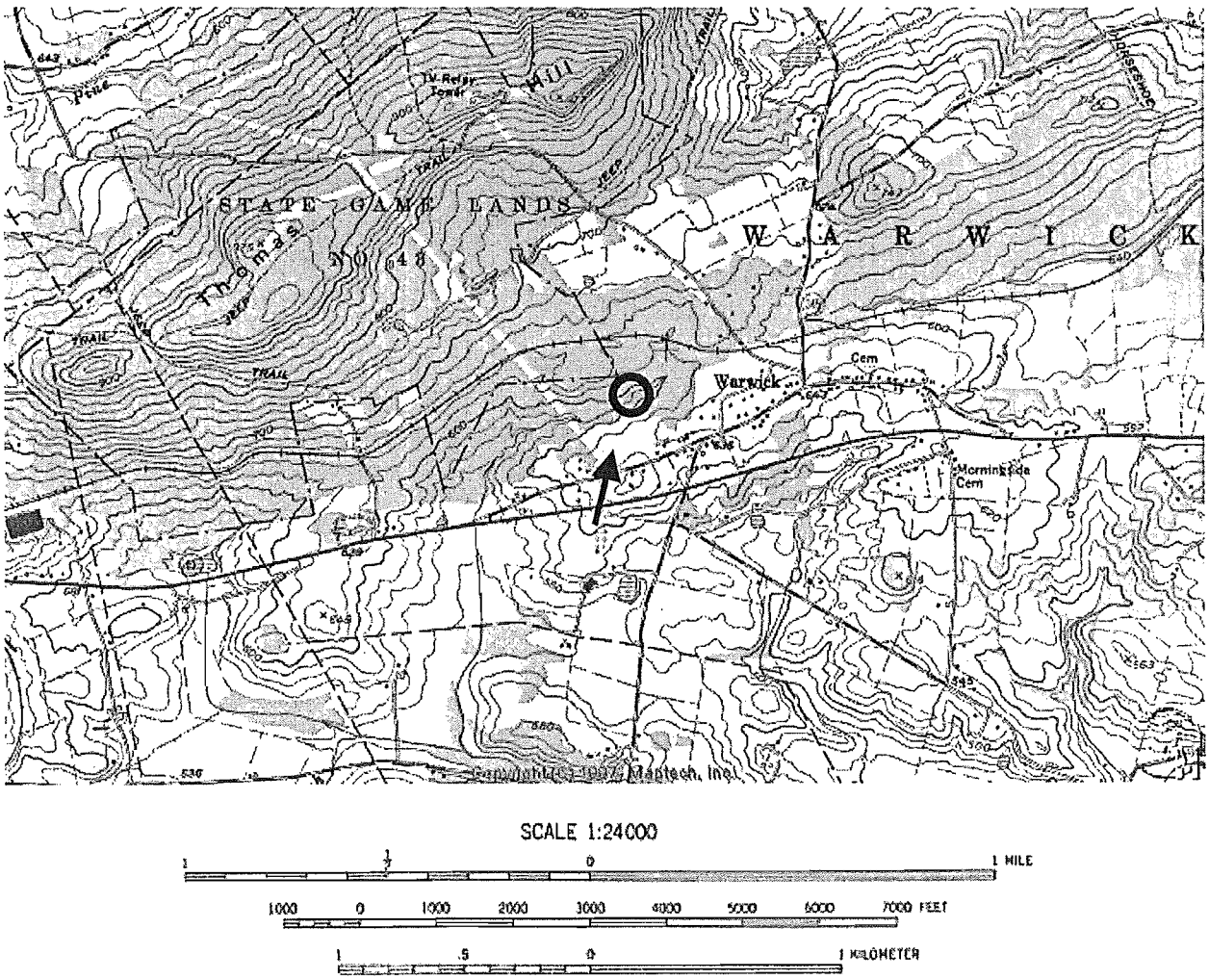
Site: Warwick Seeps

USGS 7.5' Quadrangle: Elverson, PA		Latitude:	400953
Chester County, Warwick Twp.		Longitude:	754742
Location: Warwick, 0.8 km W		Elevation:	183 m

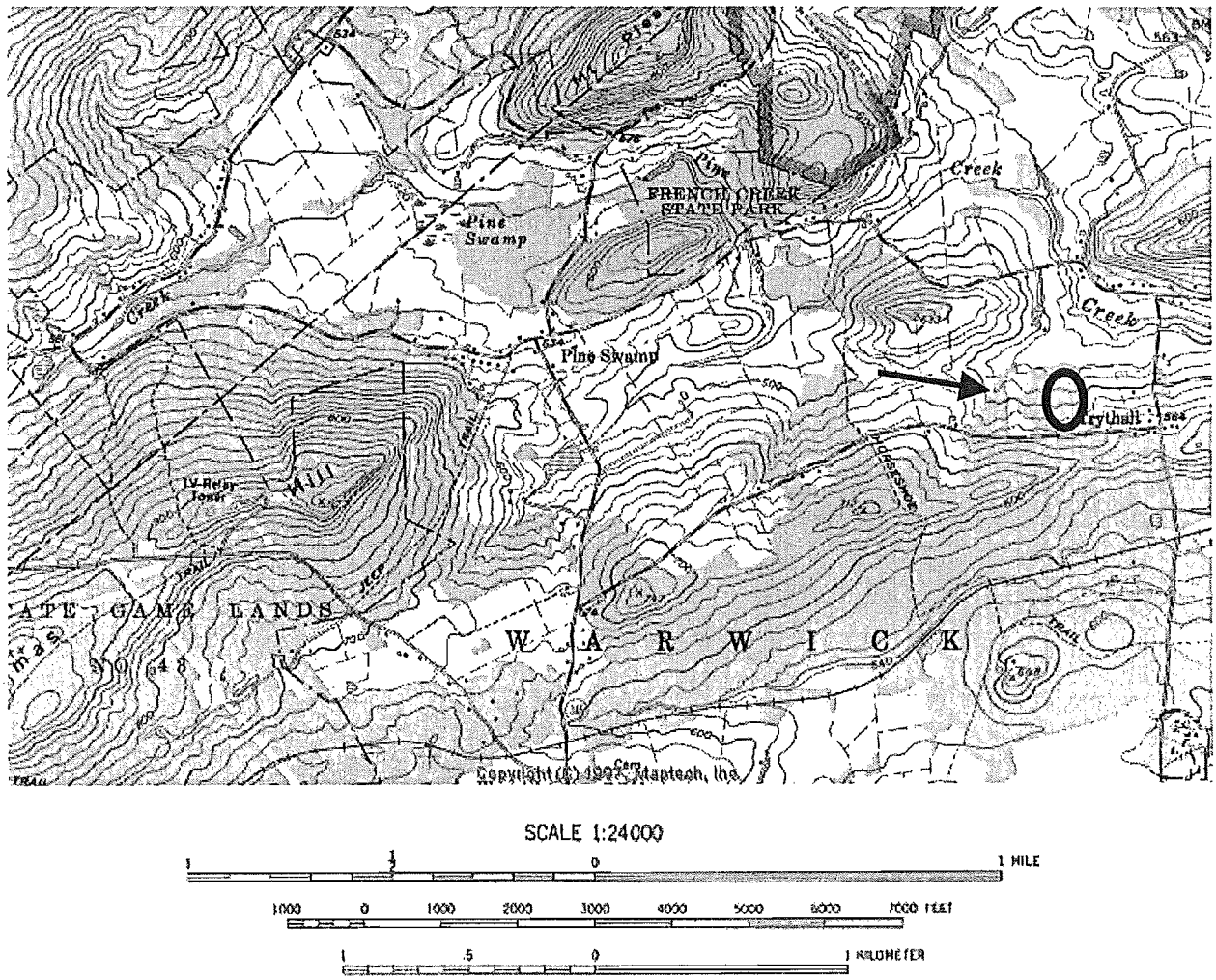
Warwick Seep is located at the base of a very gentle slope. The large recharge zone contains quartzite, quartz monzonite and quartz monzonite gneiss, and diabase. Land use in the recharge zone is successional forest on state game lands. The water table is strongly seasonal. Groundwater may discharge only in spring when water levels are high in all three bedrock formations or water observed at the surface in early spring may have been ponded water or sheet flow over impervious clayey soil derived from weathered diabase. Full tree canopy cover is provided by *Quercus bicolor*, *Acer rubrum* and *Fraxinus pennsylvanica* with *Ulmus americana* and *Acer rubrum* dominating the subcanopy. Occasional boulders are found at the surface.



Site: Trythall Woods Seep

USGS 7.5' Quadrangle: Elverson, PA		Latitude:	401053
Chester County, Warwick Twp.		Longitude:	754527
Location: Trythall, 0.4 km WNW		Elevation:	152 m

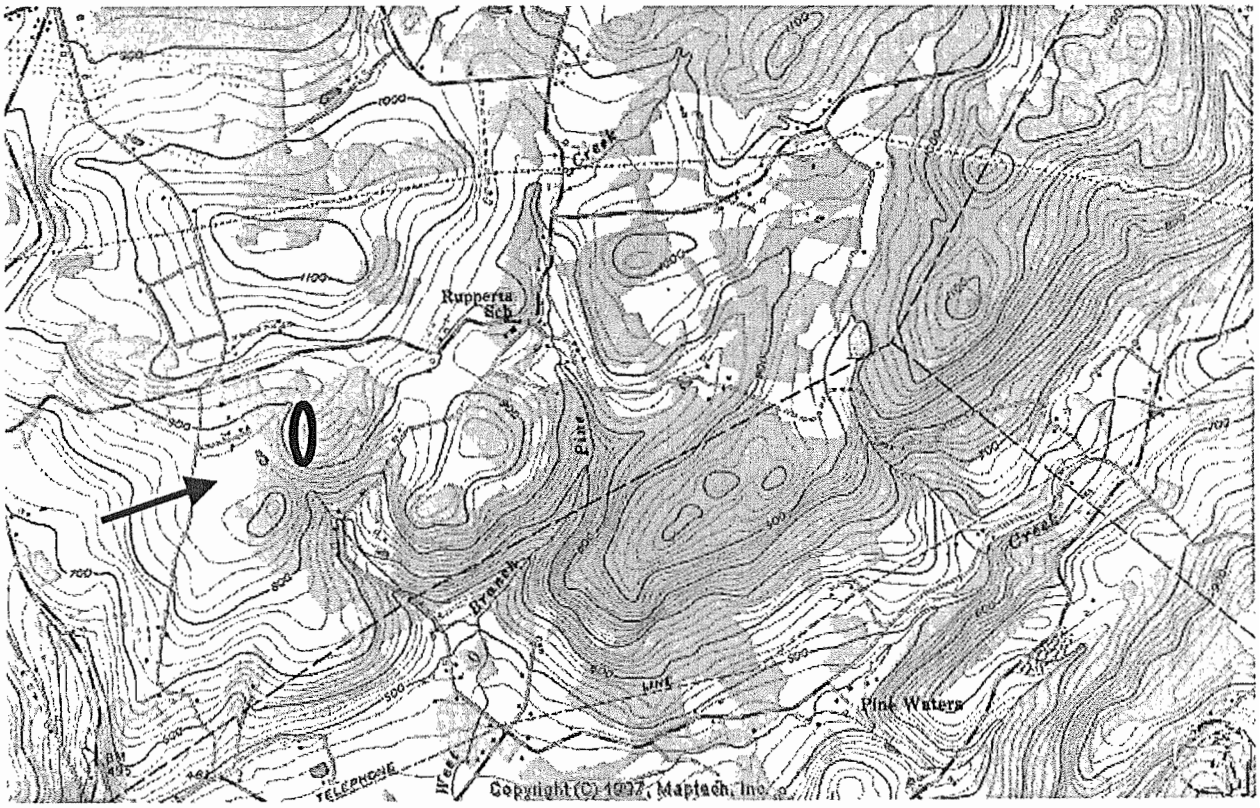
Trythall Woods Seep occurs on the lower slope of a low ridge composed of intruded diabase. Adjacent to the seep is a small lobe of quartz monzonite. While most of the recharge comes from the diabase, a small portion may come from the monzonite. Land use on the diabase is successional forest with a paved road crossing the ridge halfway up. The area directly adjacent to the seep is used for row crops. Groundwater flow in the seep remains fairly constant during the growing season. Partial canopy cover is provided by trees rooted outside the seep or on large dry hummocks extending into the seep (*Fraxinus nigra*, *Fraxinus pennsylvanica*, *Acer rubrum*, *Acer saccharum*, *Tilia americana*).

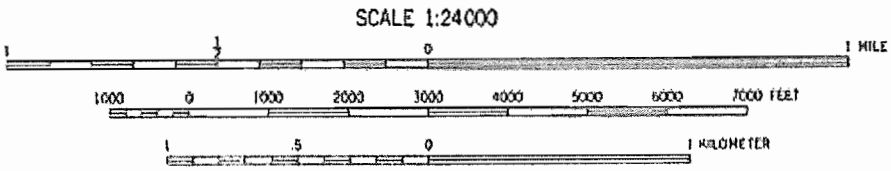


Site: West Branch Pine Creek Tributary Seep

USGS 7.5' Quadrangle: Manatawny, PA		Latitude:	402555
Berks County, Rockland Twp.		Longitude:	754408
Location: New Jerusalem, 2.1 km SE		Elevation:	274 m

West Branch Pine Creek Tributary Seep lies at the base of a small hill. The seep and nearly the entire recharge zone are located on granitic gneiss. Land use in the recharge zone includes successional forest and agriculture. Groundwater discharge volume remains relatively constant throughout the year. The seep is forested with *Acer rubrum* the dominant species rooted in the seep. Tree canopy cover is also provided by *Betula lenta* and *Quercus montana* (both rooted on the hillside above the seep). *Ilex verticillata* and *Lindera benzoin* dominate the shrub layer that covers about a third of the seep. The dominant herbaceous layer species are *Symplocarpus foetidus* and *Impatiens capensis*. The seep surface is covered by patches of loamy sand among cobbles and small boulders.

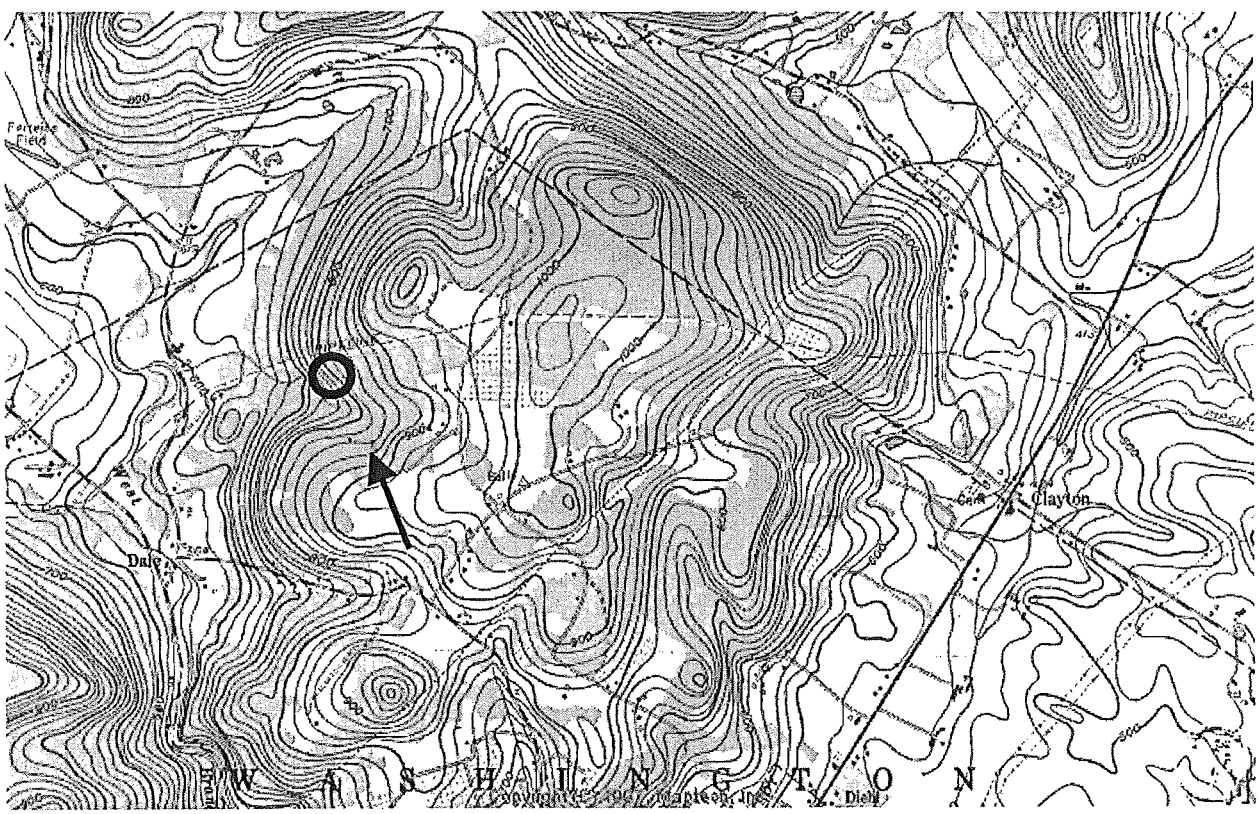


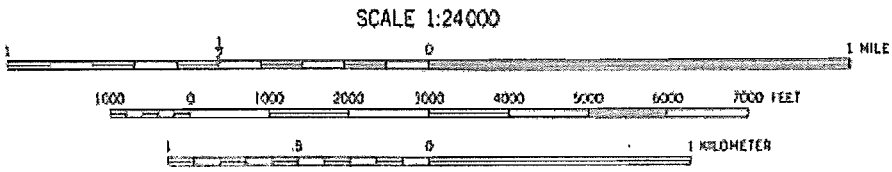


Site: Dale Seep 1

USGS 7.5' Quadrangle: East Greenville, PA		Latitude:	402519
Berks County, Washington Twp.		Longitude:	753626
Location: Bally, 2.85 km NW		Elevation:	256 m

Dale Seeps 1 and 2 occur mid-slope on a large hill of granitic gneiss. Land use in the recharge zone includes mature and successional forest, low density residential development, row crops and pasture. The volume of strong groundwater flow at Seep 1 is nearly constant throughout the year while the more diffuse flow at Seep 2 experiences strong seasonal fluctuations. Tree canopy cover above both seeps is provided by trees rooted in the uplands adjacent to the seeps (*Quercus alba*, *Fraxinus americana* and *Liriodendron tulipifera*). In Seep 1 *Acer rubrum* rooted on hummocks within the seep provides nearly full subcanopy cover. In Seep 2 *Alnus serrulata* and *Ilex verticillata* (and *Hamamelis virginiana* rooted in the upland) cover about a third of the seep. Dominant herbs in both seeps are *Symplocarpus foetidus* and *Impatiens capensis*. The ground surface is exceedingly stony. Gravel, cobbles and boulders are common.

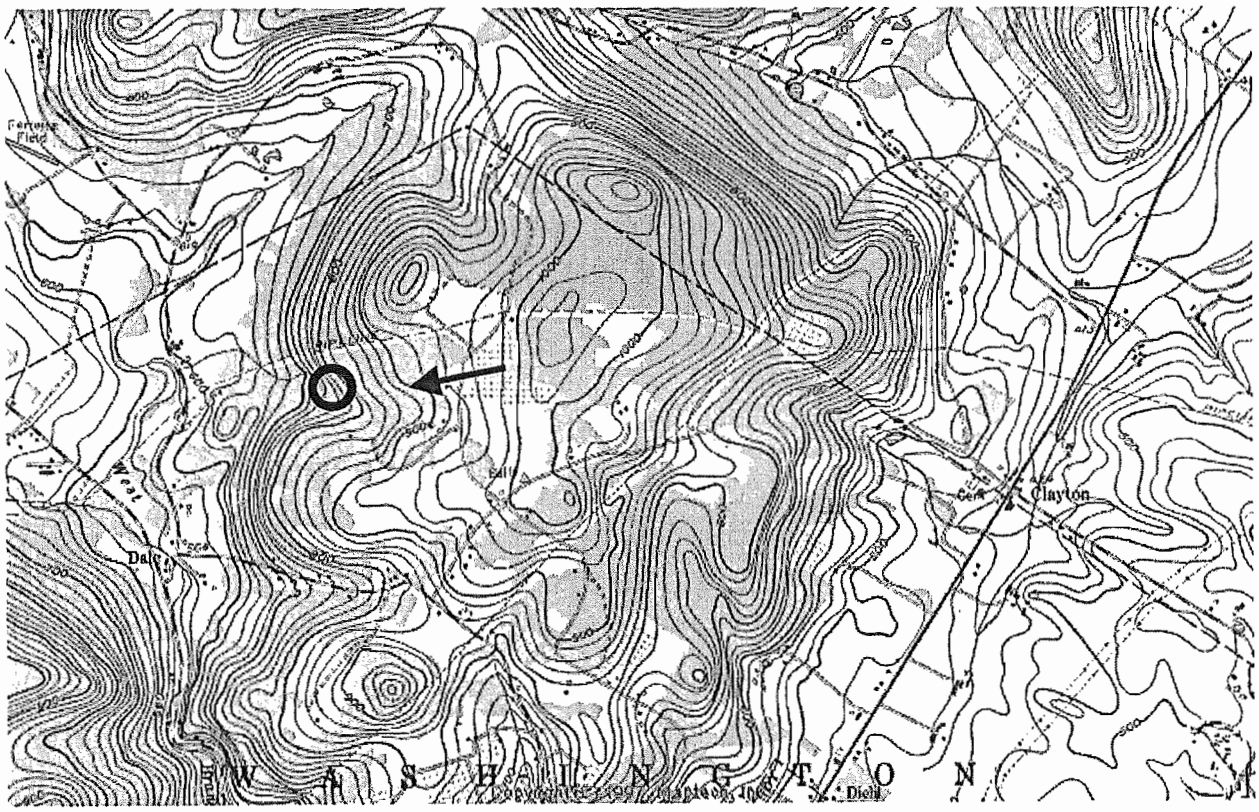


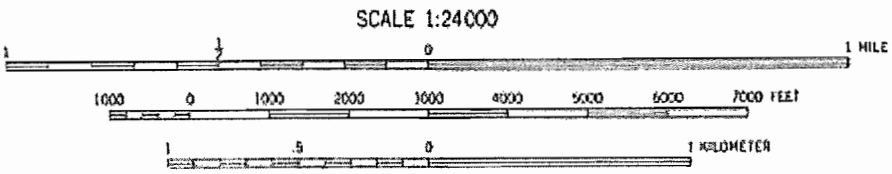


Site: Dale Seep 2

USGS 7.5' Quadrangle: East Greenville, PA		Latitude:	402515
Berks County, Washington Twp.		Longitude:	753627
Location: Bally, 2.75 NW		Elevation:	238 m

Dale Seeps 1 and 2 occur mid-slope on a large hill of granitic gneiss. Land use in the recharge zone includes mature and successional forest, low density residential development, row crops and pasture. The volume of strong groundwater flow at Seep 1 is nearly constant throughout the year while the more diffuse flow at Seep 2 experiences strong seasonal fluctuations. Tree canopy cover above both seeps is provided by trees rooted in the uplands adjacent to the seeps (*Quercus alba*, *Fraxinus americana* and *Liriodendron tulipifera*). In Seep 1 *Acer rubrum* rooted on hummocks within the seep provides nearly full subcanopy cover. In Seep 2 *Alnus serrulata* and *Ilex verticillata* (and *Hamamelis virginiana* rooted in the upland) cover about a third of the seep. Dominant herbs in both seeps are *Symplocarpus foetidus* and *Impatiens capensis*. The ground surface is exceedingly stony. Gravel, cobbles and boulders are common.

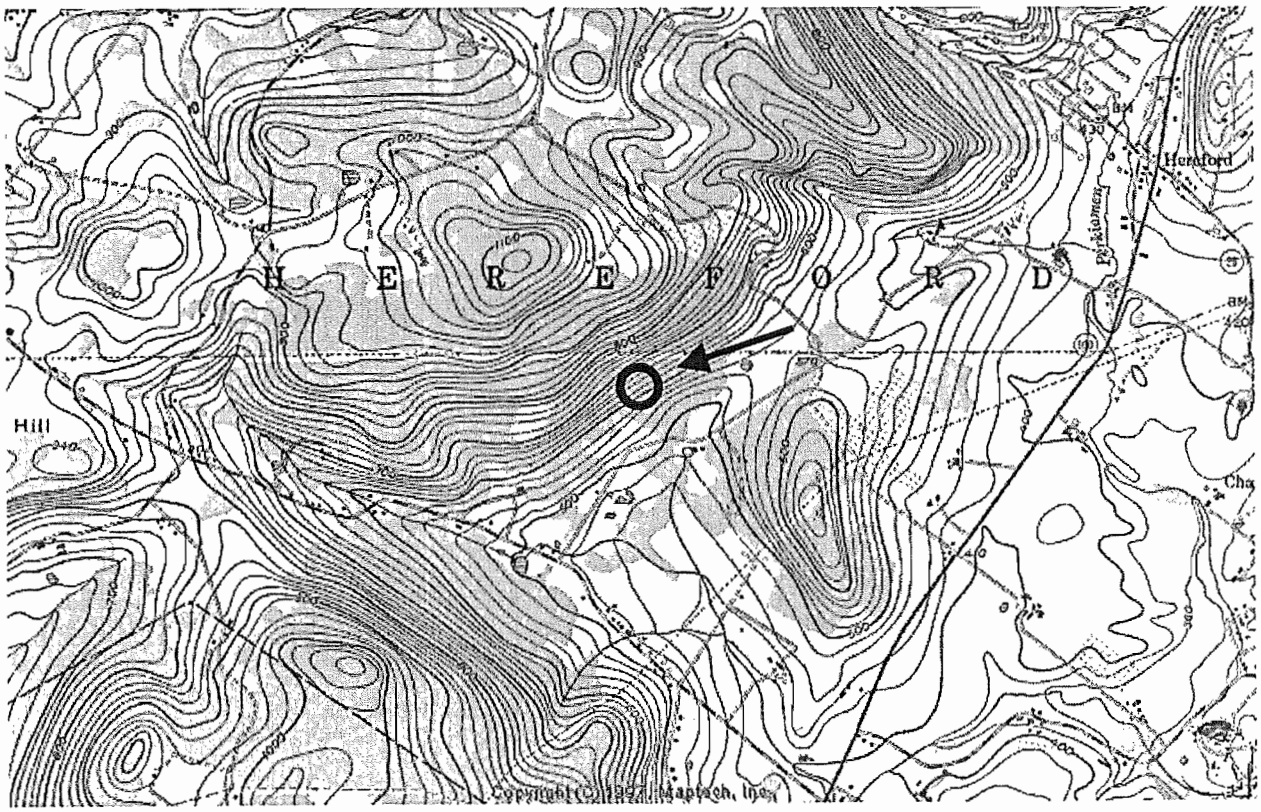


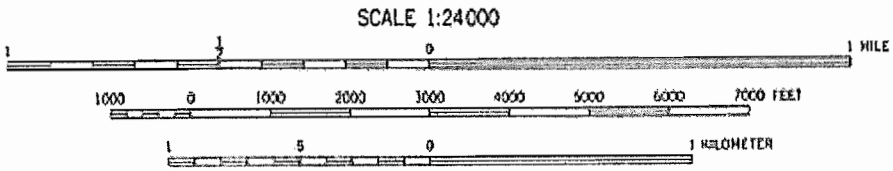


Site: Perkiomen Tributary Seeps

USGS 7.5' Quadrangle: East Greenville, PA		Latitude:	402621
Berks County, Hereford Twp.		Longitude:	753446
Location: Bally, 4.3 km N		Elevation:	183 m

Perkiomen Tributary Seep occurs at the base of a steep slope. The entire recharge zone consists of granitic gneiss. Land use in the recharge zone is primarily mature forest with a powerline right-of-way crossing the upper slope and some residences near the crest of the hill. Groundwater discharge is strongly seasonal in the seep sampled for this study. Several other seeps on this hillside exhibit a more constant flow volume throughout the year. Full forest cover by *Liriodendron tulipifera* is present from outside the seep. Within the seep *Fraxinus pennsylvanica* provides a sparse subcanopy and *Lindera benzoin* dominates the sparse shrub layer.

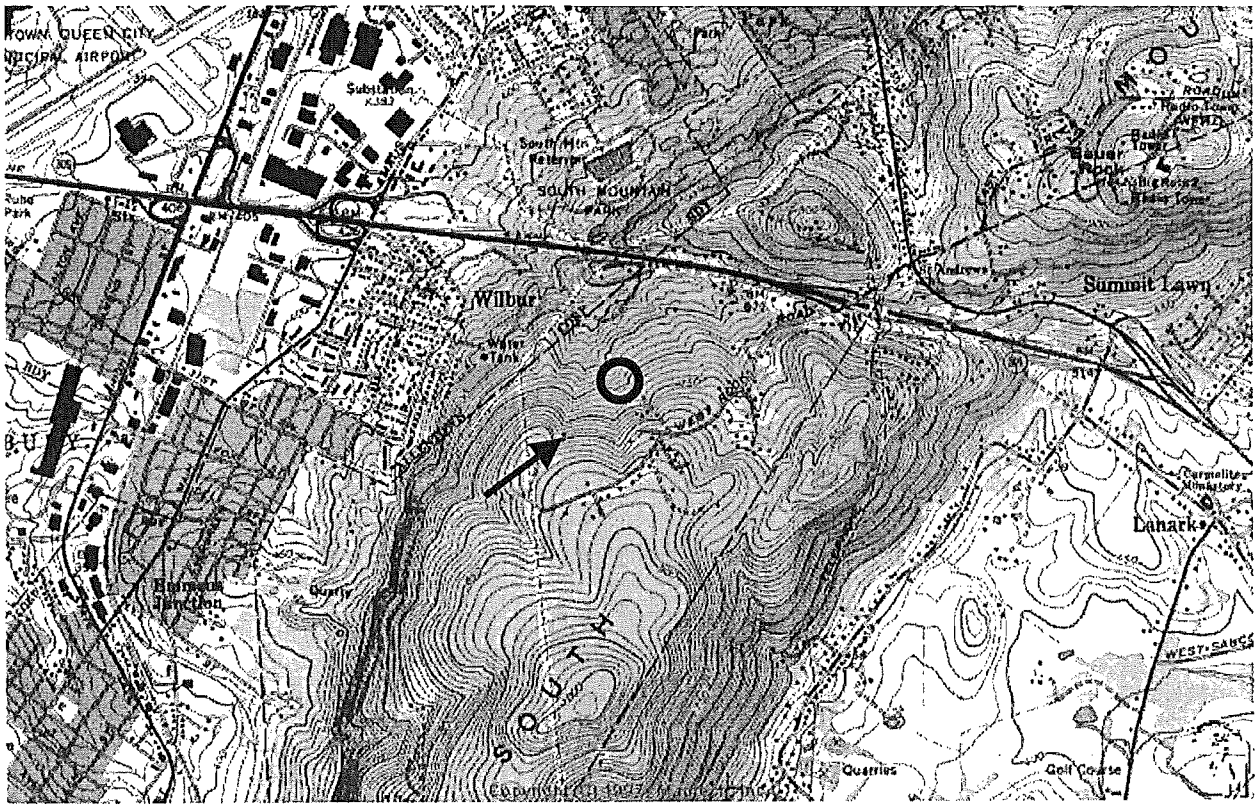


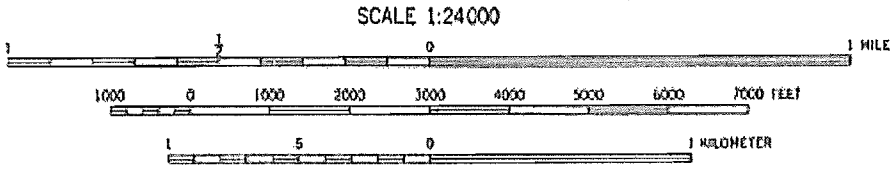


Site: Robert Rodale Reserve Seeps

USGS 7.5' Quadrangle: Allentown East, PA		Latitude:	403323
Lehigh County, Salisbury Twp.		Longitude:	752748
Location: Wilbur, 1.1 km ESE		Elevation:	226 m

Robert Rodale Reserve Seep occurs at mid-slope on the side of South Mountain. The entire recharge zone, from the seep to the summit, consists of granitic gneiss. Land use in the recharge zone is mature forest and moderate density residential development. Groundwater flow shows only minor seasonal variation. *Liriodendron tulipifera* rooted on the larger hummocks within the seep provides partial forest. Within the seep *Acer rubrum* provides a sparse subcanopy and *Lindera benzoin* and *Alnus rugosa* provide a sparse shrub layer. Dominant herbaceous layer species are *Symplocarpus foetidus* and *Impatiens capensis*.

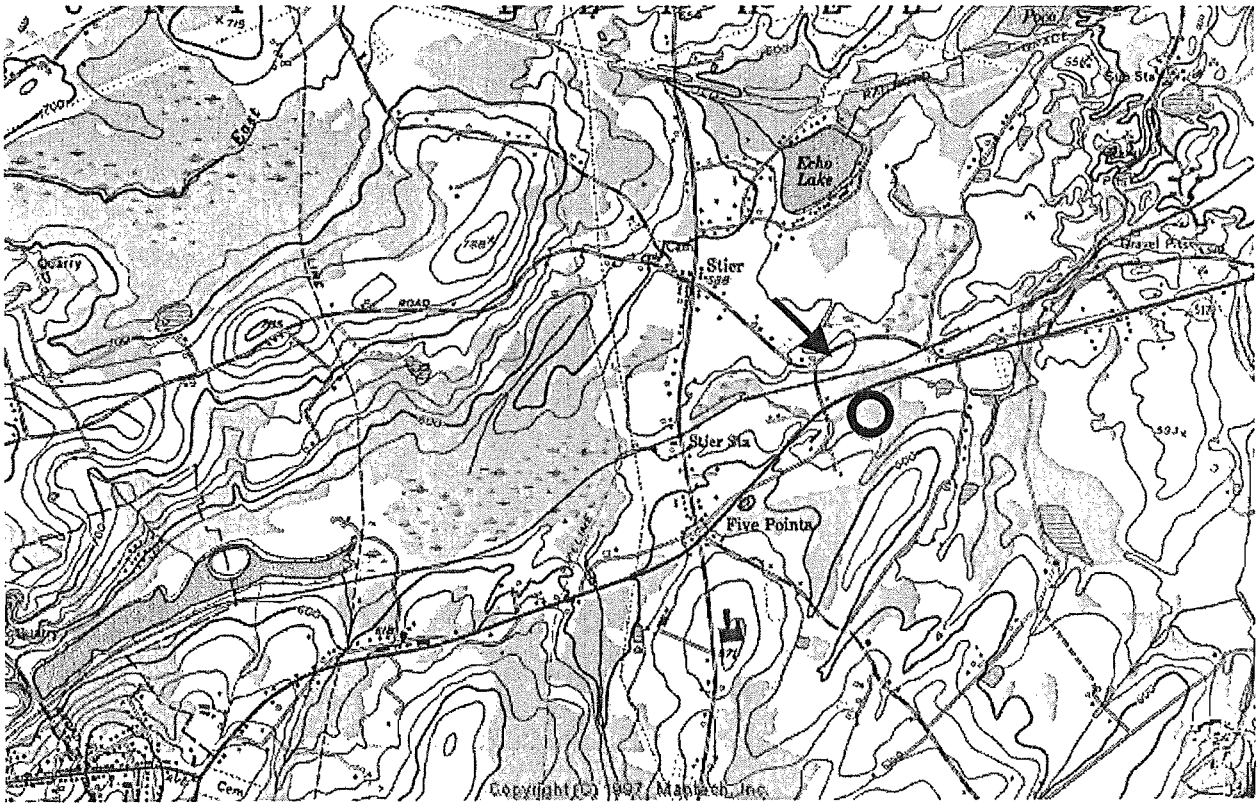


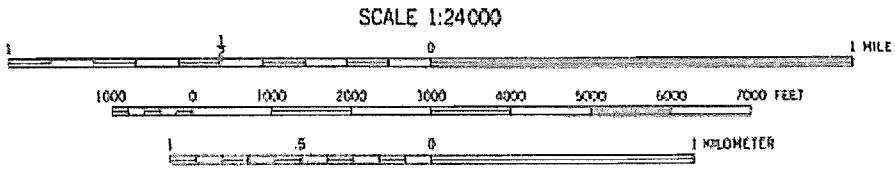


Site: Getz Swamp Seep

USGS 7.5' Quadrangle: Stroudsburg, PA - NJ		Latitude:	405334
Northampton County, Upper Mount Bethel Twp.		Longitude:	750840
Location: Five Points, 0.9 km NE		Elevation:	171 m

Getz Swamp Seep occurs in an area of very gentle slope and is not associated with a clear topographic break. Seepage occurs over a broad area, has a strong seasonal variation in flow, and is evident only when the water table is very high in spring. Surrounding land use is primarily agriculture (row crops) and light residential. Parts of Getz were used as pasture in the past. The seep is forested with full canopy cover. *Acer rubrum* is dominant though *Ulmus americana* and *Liriodendron tulipifera* are also common.

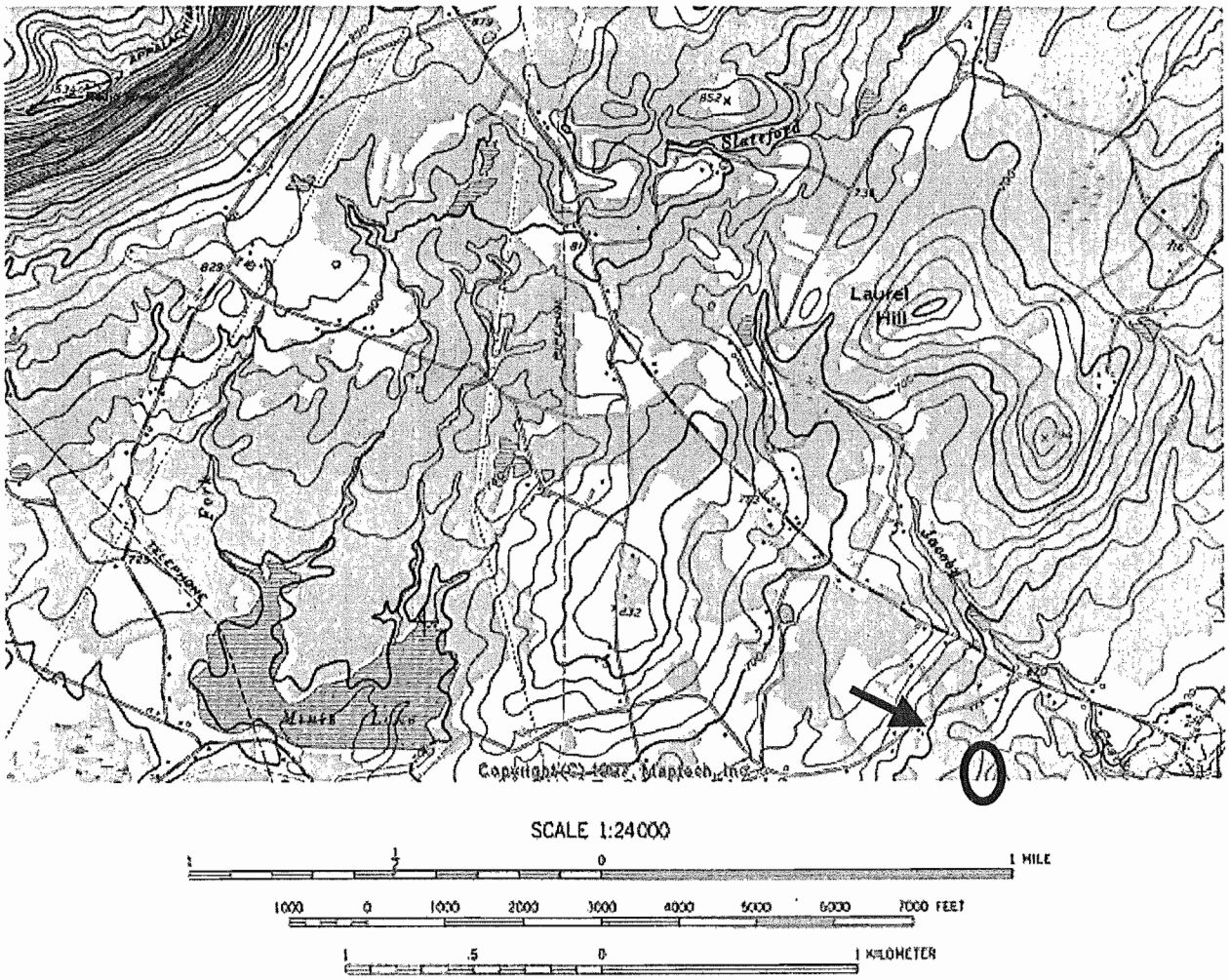




Site: Lake Poco Seep

USGS 7.5' Quadrangle: Stroudsburg, PA - NJ		Latitude:	405533
Northampton County, Upper Mount Bethel Twp.		Longitude:	750747
Location: Five Points, 2.7 km NNE		Elevation:	159 m

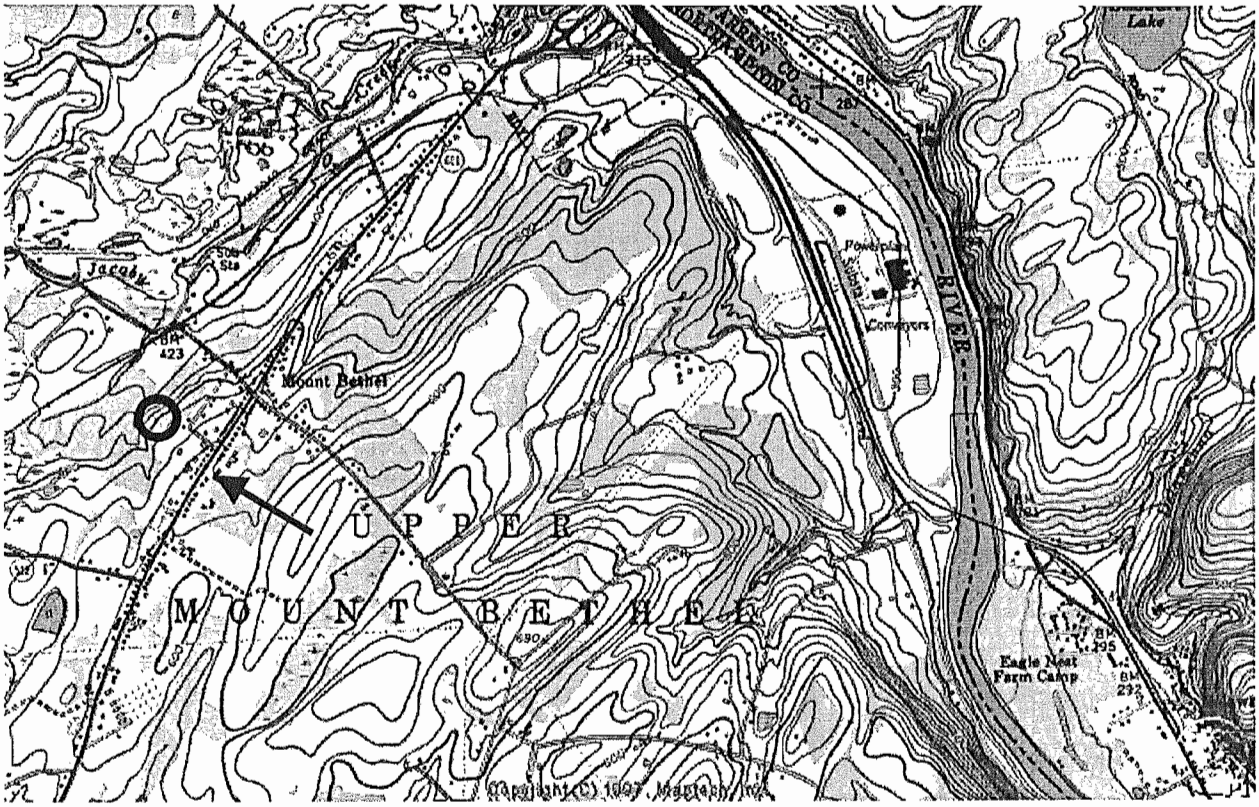
Lake Poco Seep is located at the edge of extensive ground moraine deposits, at the base of a gentle slope. Land use within the large recharge zone consists of agriculture, low density residential development and successional forest on abandoned farmland. Groundwater flow into the seep is nearly constant throughout the year with only minor seasonal fluctuations. The seep is forested with full tree canopy cover dominated by *Acer rubrum* with some *Betula alleghaniensis*. *Liriodendron tulipifera* and *Hamamelis virginiana* provide cover along seep edges and on larger, drier hummocks within the seep.



Site: Taylor East Seep

USGS 7.5' Quadrangle: Portland, PA - NJ		Latitude:	405416
Northampton County, Upper Mount Bethel Twp.		Longitude:	750701
Location: Mount Bethel, 0.3 km W		Elevation:	134 m

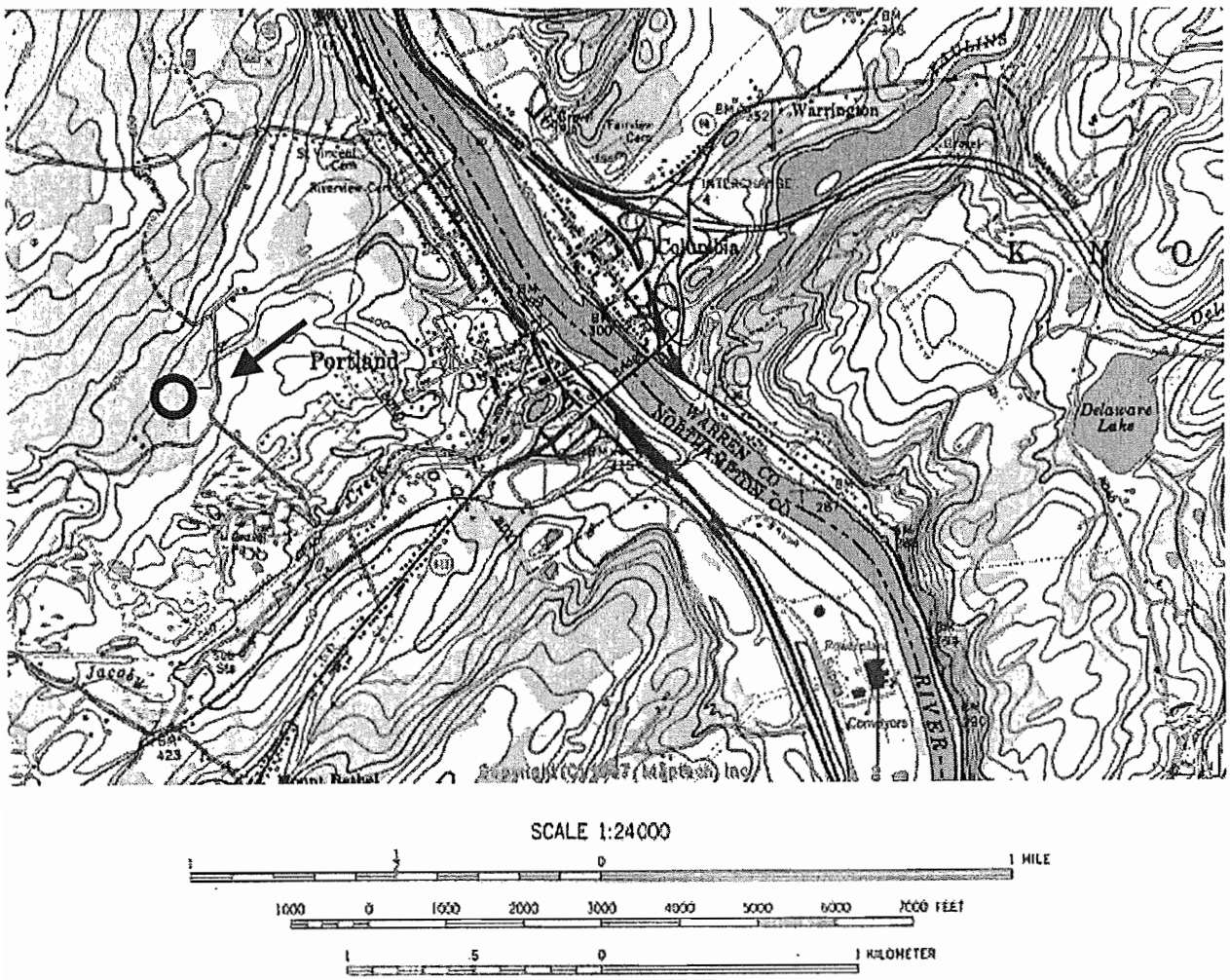
Taylor East Seep occurs within a ground moraine in a landscape characterized by gentle topographic relief and increasing residential and commercial density across its recharge area of post-pasturing and post-agricultural successional vegetation. Several strong seepage sources feed the seep, and flow volume is nearly constant throughout the year with only minor seasonal fluctuations. Taylor East is dominated by a blend of graminoids (*Carex* spp.) and forbs (*Thelypteris palustris*, *Solidago patula*, *Symplocarpus foetidus*, *Parnassia glauca*). Sparse (15% cover) shrub layer is dominated by *Toxicodendron vernix*.



Site: Raesly Woods

USGS 7.5' Quadrangle: Portland, PA - NJ		Latitude:	405514
Northampton County, Upper Mount Bethel Twp.		Longitude:	750657
Location: Mount Bethel, 1.8 km NNW		Elevation:	140 m

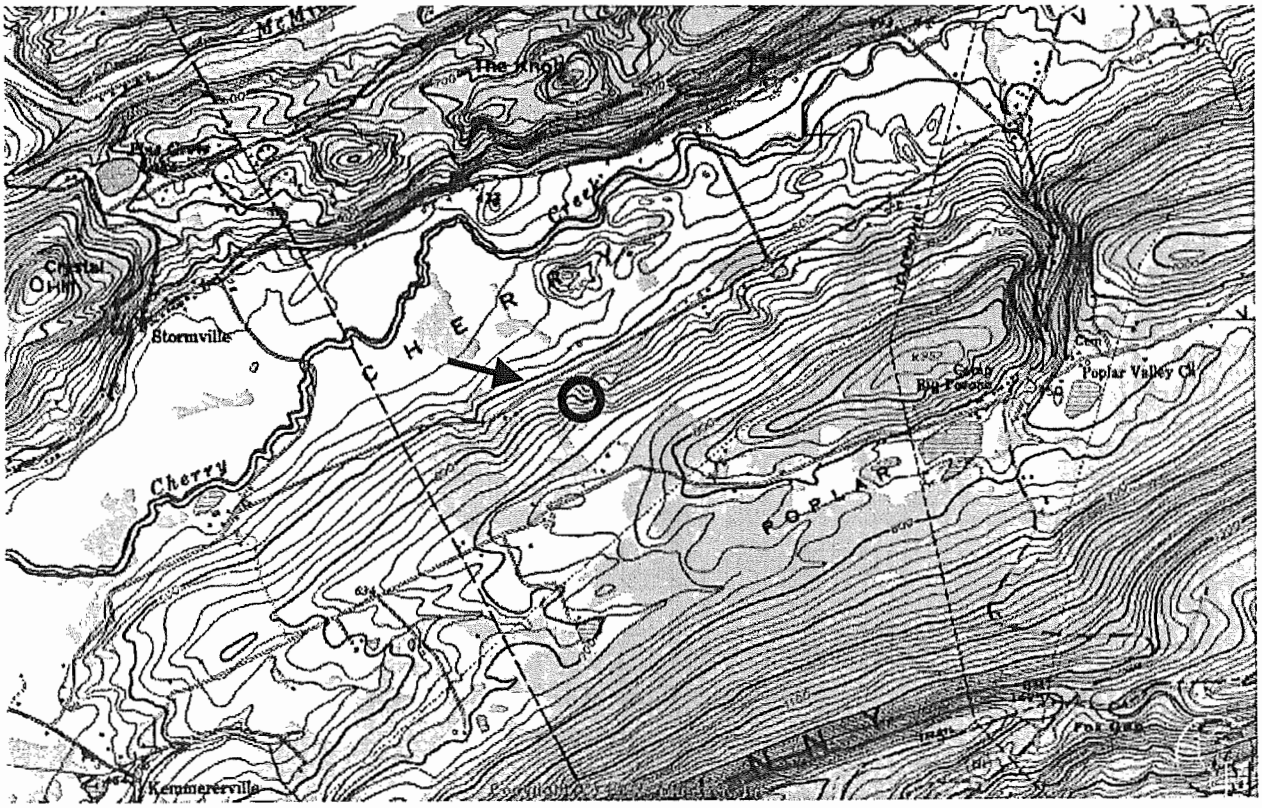
Raesly Woods Seep lies at the base of a long gentle slope at the edge of a floodplain of a small stream. The entire seep recharge zone is covered with Wisconsin ground moraine deposits. Water flow is diffuse and strongly seasonal with flow present only in spring. Land use within the recharge zone is primarily successional and mature forest. Raesly Woods was used as pasture in the past, but it is now forested with a full tree canopy dominated by *Acer rubrum* and *Fraxinus pennsylvanica*.

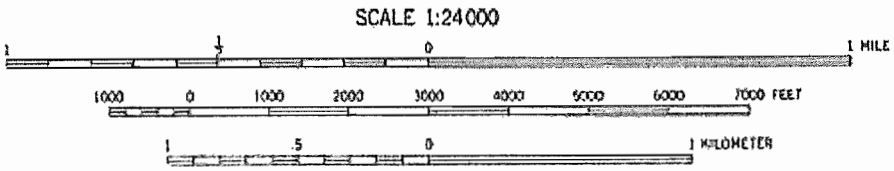


Site: Mansfield Seep

USGS 7.5' Quadrangle: Stroudsburg, PA - NJ		Latitude:	405652
Monroe County, Stroud Twp.		Longitude:	751318
Location: Kemmererville (Kemmertown), 2.53 km NE		Elevation:	171 m

Mansfield Seep is located in a small kame deposit on the lower slope of a steep sandstone ridge that is covered by ground moraine deposits on its lower slope. Groundwater flow is nearly constant throughout the year. Surrounding land use is mostly undeveloped forest with low density residential use along the crest of the ridge. *Fraxinus pennsylvanica*, *Acer rubrum*, *Liriodendron tulipifera* and *Ulmus americana* provide partial tree canopy cover, and *Lindera benzoin* and *Viburnum dentatum* dominate the shrub layer which provides about 50% cover.

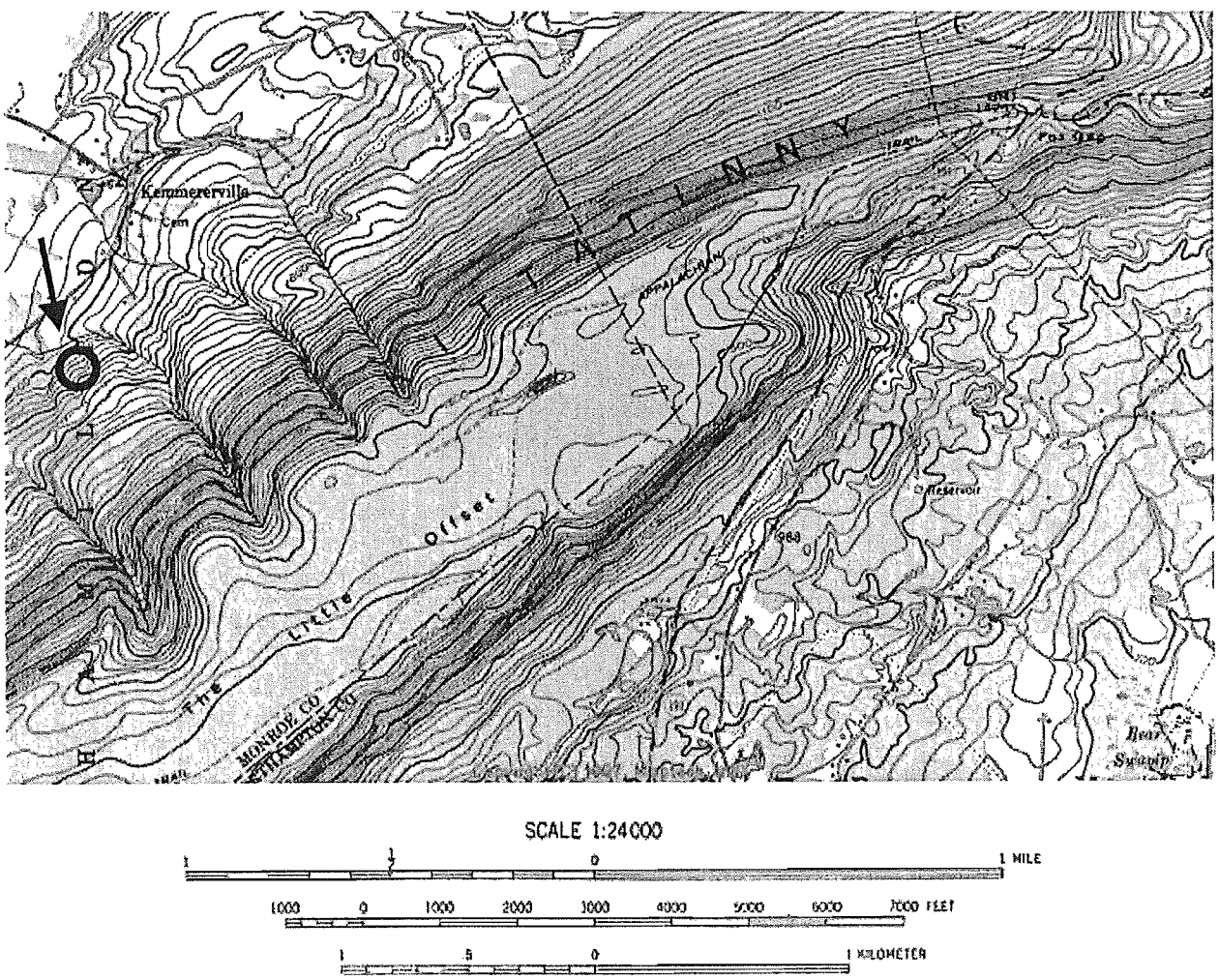




Site: Kemmererville Seeps 1

USGS 7.5' Quadrangle: Stroudsburg, PA - NJ		Latitude:	405531
Monroe County, Hamilton Twp.		Longitude:	751448
Location: Kemmererville (Kemmertown), 0.78 km SSW		Elevation:	159 m

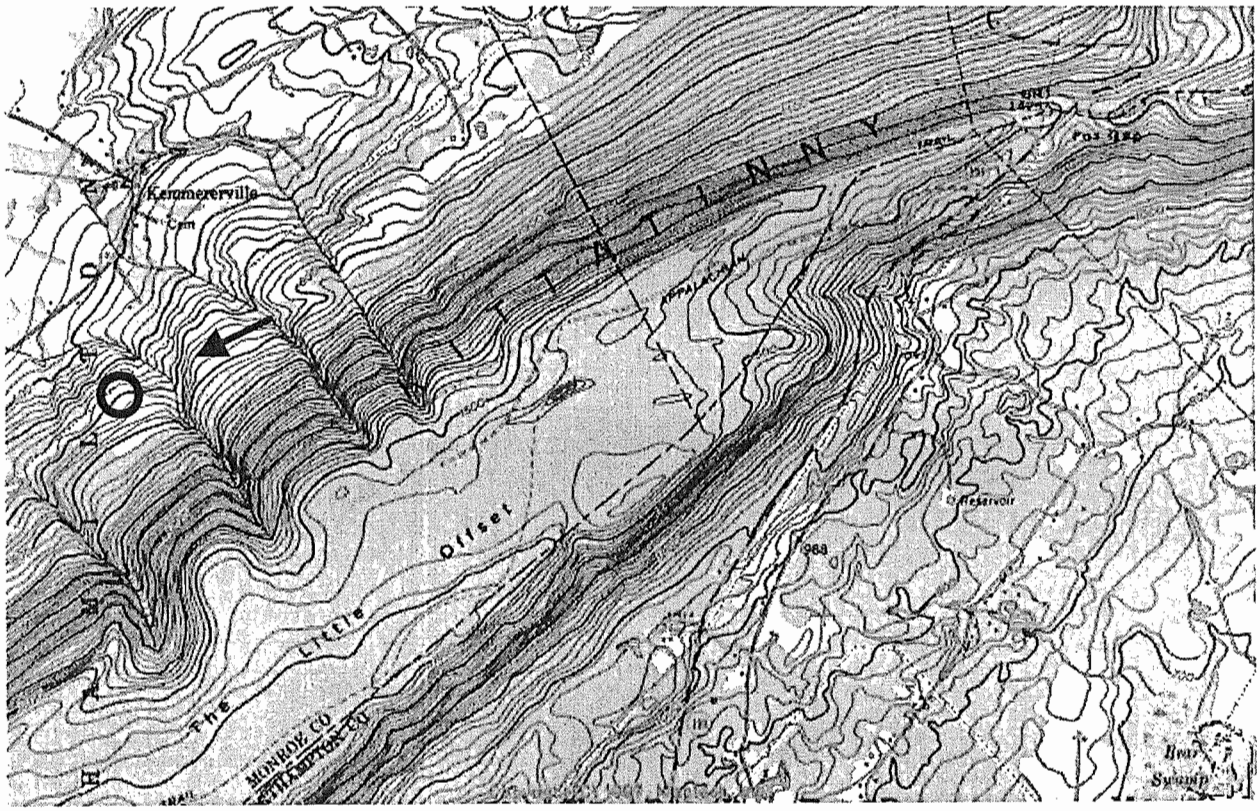
Kemmererville Seeps 1 and 2 are located at the base of a steep ridge. The exposed sandstone and sandstone conglomerate on the upper portion of the ridge gives way first to shale and siltstone, then glacial deposits, then terminal (end) moraine deposits. Both seeps are located in the terminal moraine deposits. The recharge zone includes both bedrock and glacial deposits and extends to the crest of Kittatinny Mountain. This large recharge zone is covered by mature forest. Groundwater discharge showed only minor fluctuations throughout the year. Seep 1 is dominated by graminoids (*Carex interior* and *C. leptalea*) and forbs (*Thelypteris palustris* and *Parnassia glauca*) with sparse tree cover present around the edges and a sparse scattering of shrubs (*Toxicodendron vernix*, *Lindera benzoin*) throughout the seep. Seep 2 has partial forest canopy dominated by *Liriodendron tulipifera* and *Tsuga canadensis* with a shrub layer that covers about a third of the seep. Seeps 1 and 2 contain many of the same species, but Seep 2 appears to be in an advancing stage of succession.

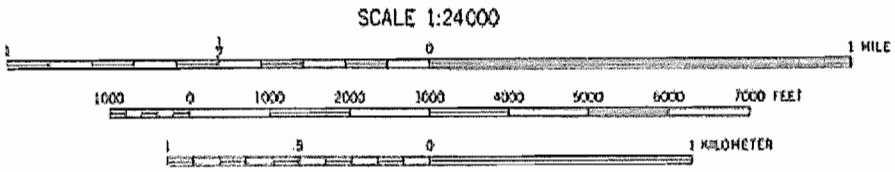


Site: Kemmererville Seeps 2

USGS 7.5' Quadrangle: Stroudsburg, PA - NJ		Latitude:	405530
Monroe County, Hamilton Twp.		Longitude:	751447
Location: Kemmererville (Kemmertown), 0.82 km SSW		Elevation:	171 m

Kemmererville Seeps 1 and 2 are located at the base of a steep ridge. The exposed sandstone and sandstone conglomerate on the upper portion of the ridge gives way first to shale and siltstone, then glacial deposits, then terminal (end) moraine deposits. Both seeps are located in the terminal moraine deposits. The recharge zone includes both bedrock and glacial deposits and extends to the crest of Kittatinny Mountain. This large recharge zone is covered by mature forest. Groundwater discharge showed only minor fluctuations throughout the year. Seep 1 is dominated by graminoids (*Carex interior* and *C. leptalea*) and forbs (*Thelypteris palustris* and *Parnassia glauca*) with sparse tree cover present around the edges and a sparse scattering of shrubs (*Toxicodendron vernix*, *Lindera benzoin*) throughout the seep. Seep 2 has partial forest canopy dominated by *Liriodendron tulipifera* and *Tsuga canadensis* with a shrub layer that covers about a third of the seep. Seeps 1 and 2 contain many of the same species, but Seep 2 appears to be in an advancing stage of succession.

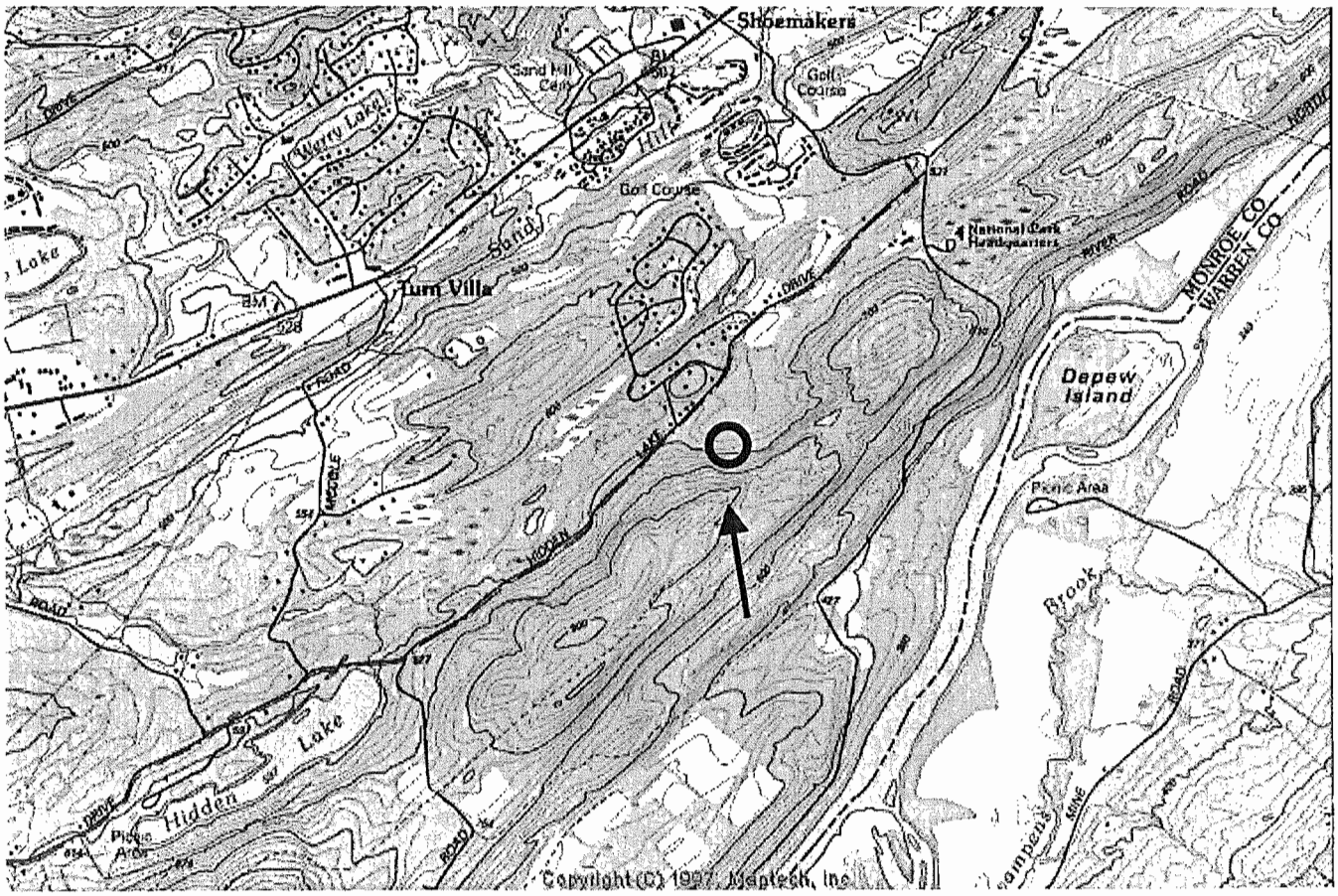




Site: Shoemaker Swamp Seep

USGS 7.5' Quadrangle: Bushkill, PA - NJ		Latitude:	410347
Monroe County, Middle Smithfield Twp.		Longitude:	750144
Location: Shoemakers, 1.63 km S		Elevation:	171 m

Shoemakers Swamp Seep occurs at the base of a steep ridge. The ridge slope consists of cherty limestone and shale while the wide, gently sloping ridge crest consists of sandstone and limestone. This relatively small recharge zone is forested. Groundwater flow to the seep is strongly seasonal with flow present only in spring. Shoemakers Seep is partially forested with *Fraxinus nigra* the dominant species and *Betula alleghaniensis* common but providing less cover.



SCALE 1:24000

1 ½ 0 1 MILE

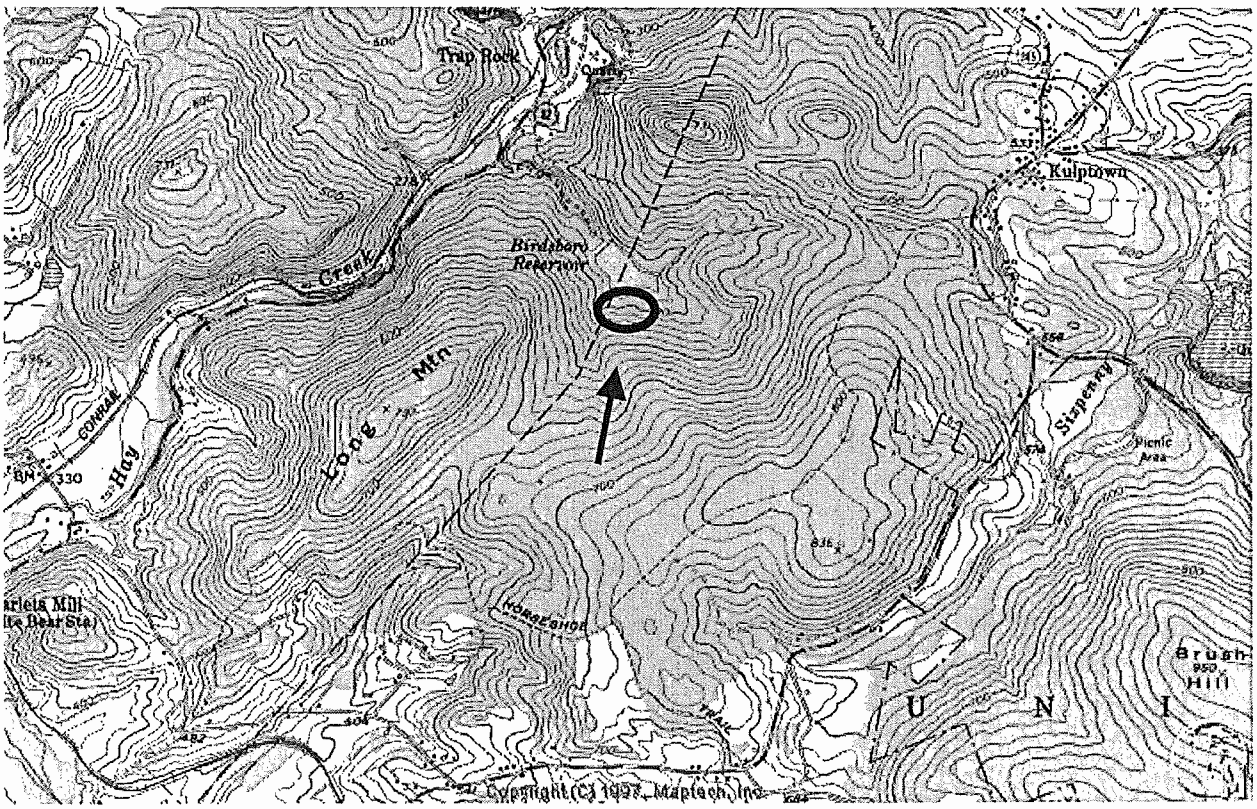
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

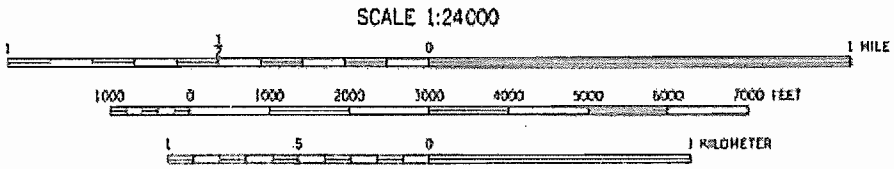
1 .5 0 1 KILOMETER

Site: Birdsboro Reservoir Seeps

USGS 7.5' Quadrangle: Elverson, PA		Latitude:	401417
Berks County, Union Twp.		Longitude:	754903
Location: Kulptown, 1.88 km WSW		Elevation:	122 m

Birdsboro Reservoir Seep occurs on the lower slope of a small sandstone and coarse quartz conglomerate mountain. The groundwater recharge zone extends to the summit of the mountain and is characterized by mature forest. The strong groundwater flow shows only minor seasonal fluctuations in volume. *Acer rubrum* and *Liriodendron tulipifera*, rooted outside the seep in the upland, provide partial canopy cover while saplings of *Acer rubrum* rooted within the seep provide sparse subcanopy cover. Cover by non-vascular (dominated *by Rhizomnium pseudopunctatum* and *Rhynchostegium serrulatum*) and vascular (dominated by *Symplocarpus foetidus*, *Impatiens capensis* and *Chrysosplenium americanum*) species occurs across about half of the exceedingly stony/gravelly surface of the seep.

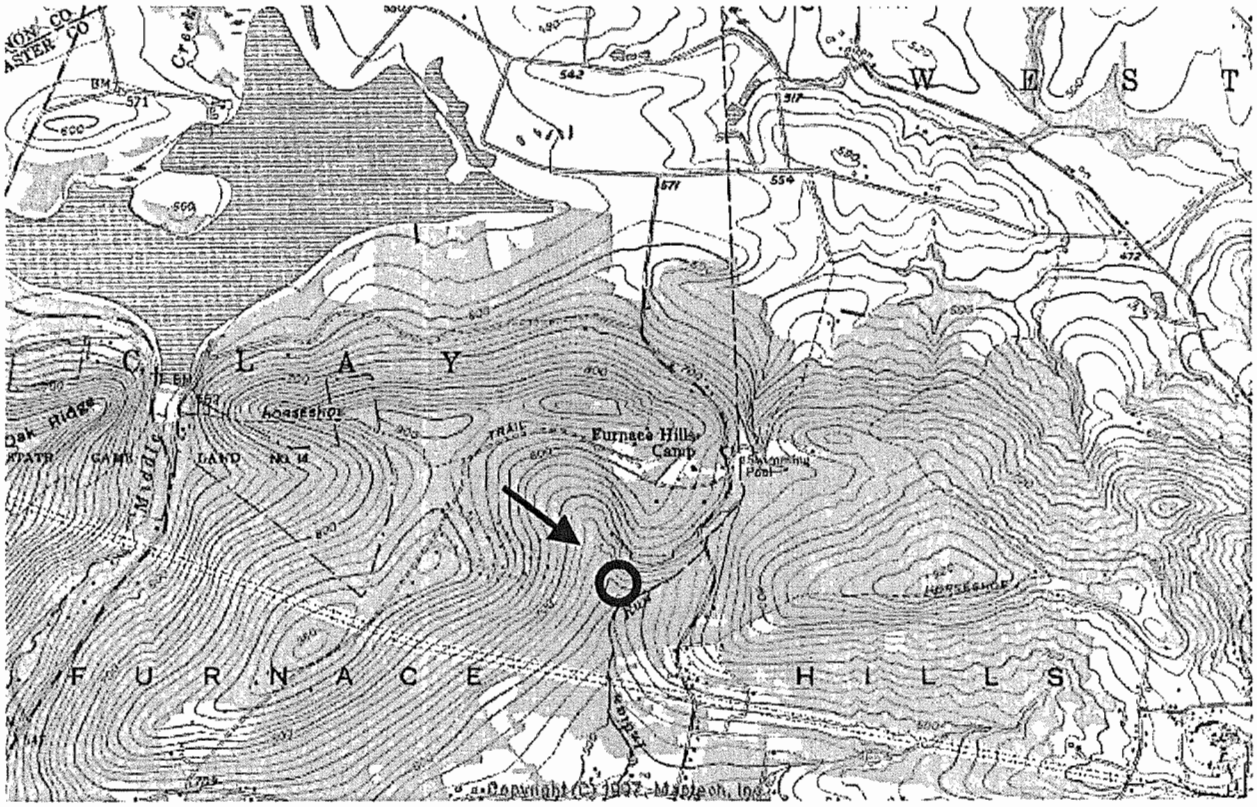


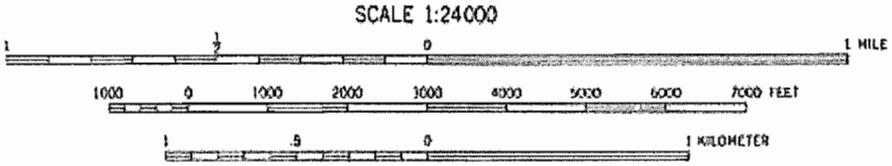


Site: Indian Run Seeps

USGS 7.5' Quadrangle: Womelsdorf, PA		Latitude:	401531
Lancaster County, Clay Twp.		Longitude:	761255
Location: Cocalico, 3.42 km SSW		Elevation:	189 m

Indian Run Seep occurs at the base of a sandstone ridge. Land use in the recharge zone consists of maturing forest, but density of residential development is increasing at the top of the ridge. Groundwater flow volume is nearly constant throughout the year. Full forest canopy cover is provided by *Betula alleghaniensis*, *Liriodendron tulipifera* and *Acer rubrum* which are rooted on drier hummocks within the seep.

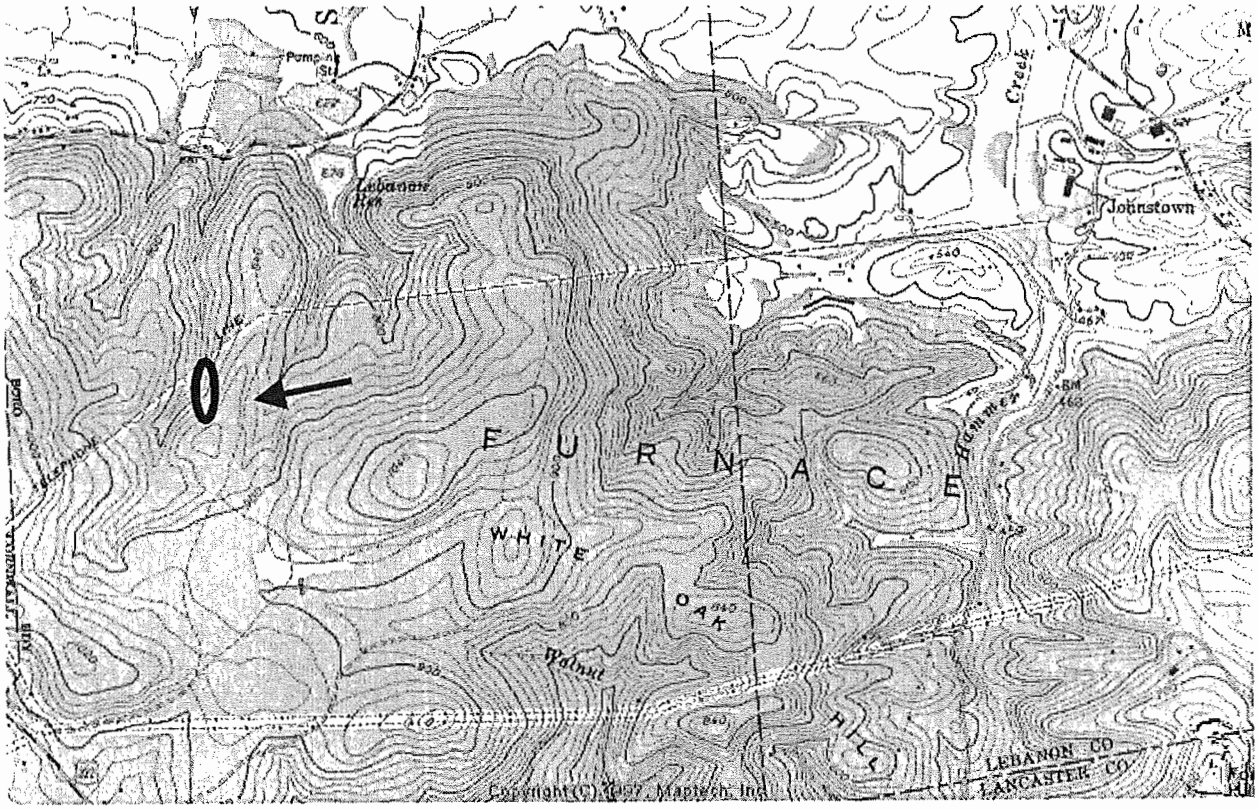


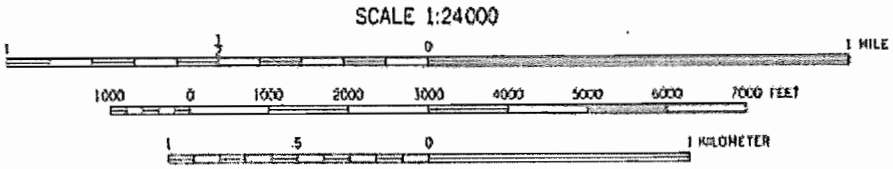


Site: State Game Lands No. 156

USGS 7.5' Quadrangle: Richland, PA		Latitude:	401603
Lebanon County, South Lebanon Twp.		Longitude:	762154
Location: Buffalo Springs, 3.68 km SW		Elevation:	232 m

The seep at State Game Lands No. 156 is located along a small stream at the base of a large hill that consists of bands of quartzose conglomerate and sandstone. Land in the recharge zone is undeveloped with mature forest cover. Groundwater flow exhibits only slight seasonal fluctuation. *Acer rubrum* and *Fraxinus pennsylvanica* contribute 45 % tree canopy cover to the seep while *Liriodendron tulipifera* and *Betula lenta* (both rooted outside the seep) contribute 15% cover. The dominant herbaceous layer species are *Symplocarpus foetidus* and *Impatiens capensis*. Sand and weathered quartz gravel cover most of the seep surface.

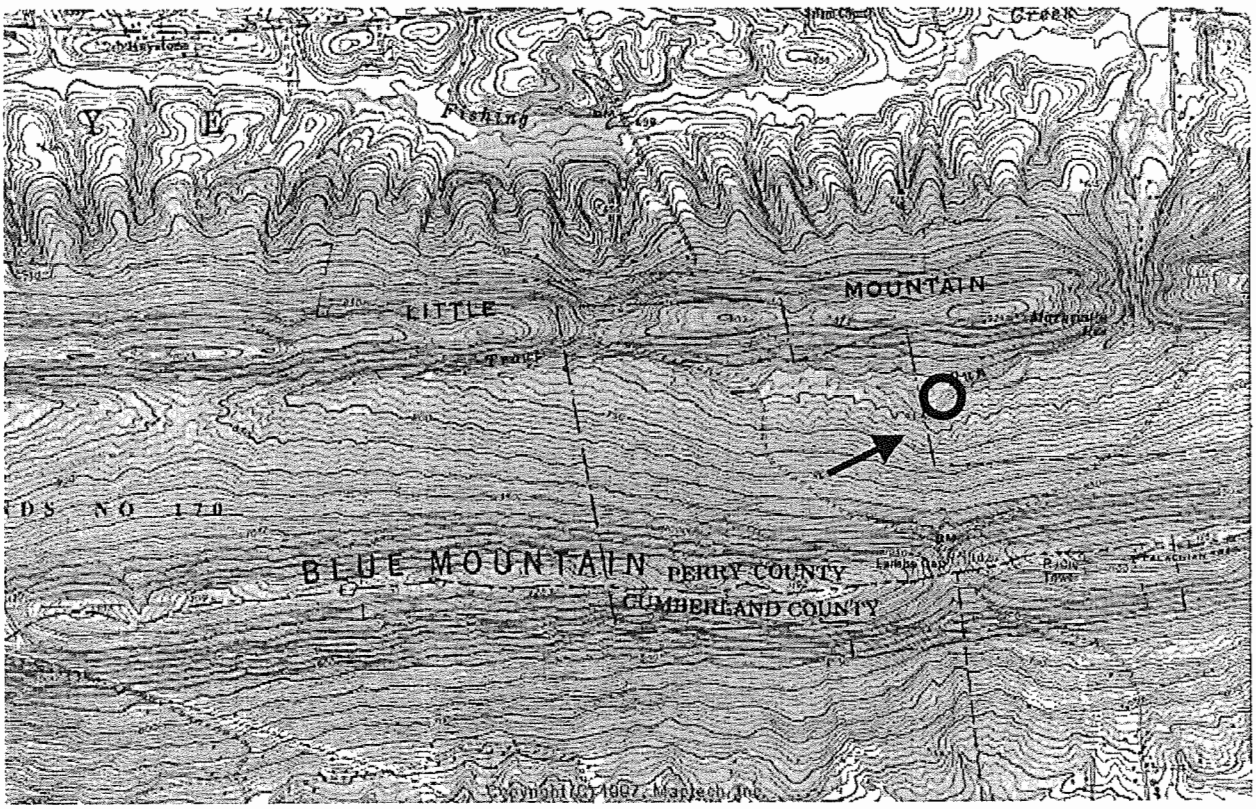


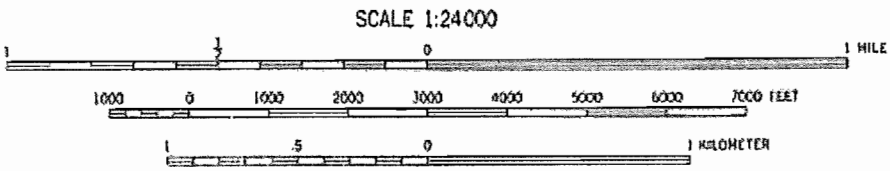


Site: Lambs Gap Seeps

USGS 7.5' Quadrangle: Wertzville, PA		Latitude:	401840
Perry County, Rye Twp.		Longitude:	770057
Location: Wertzville, 3.85 km NE		Elevation:	189 m

Lambs Gap Seep occurs at the base of a small, steep sandstone mountain. The lower slopes and valley floor are mainly shales with some sandstone and siltstone. Land use in the recharge zone is a blend of successional and mature forest. The diffuse groundwater flow shows seasonal fluctuation but remains near the surface, though at diminished volume, throughout the growing season. The tree canopy (about 60% cover) is dominated by *Fraxinus nigra* and *Liriodendron tulipifera*. *Lindera benzoin* dominates the shrub layer which covers about a third of the seep.

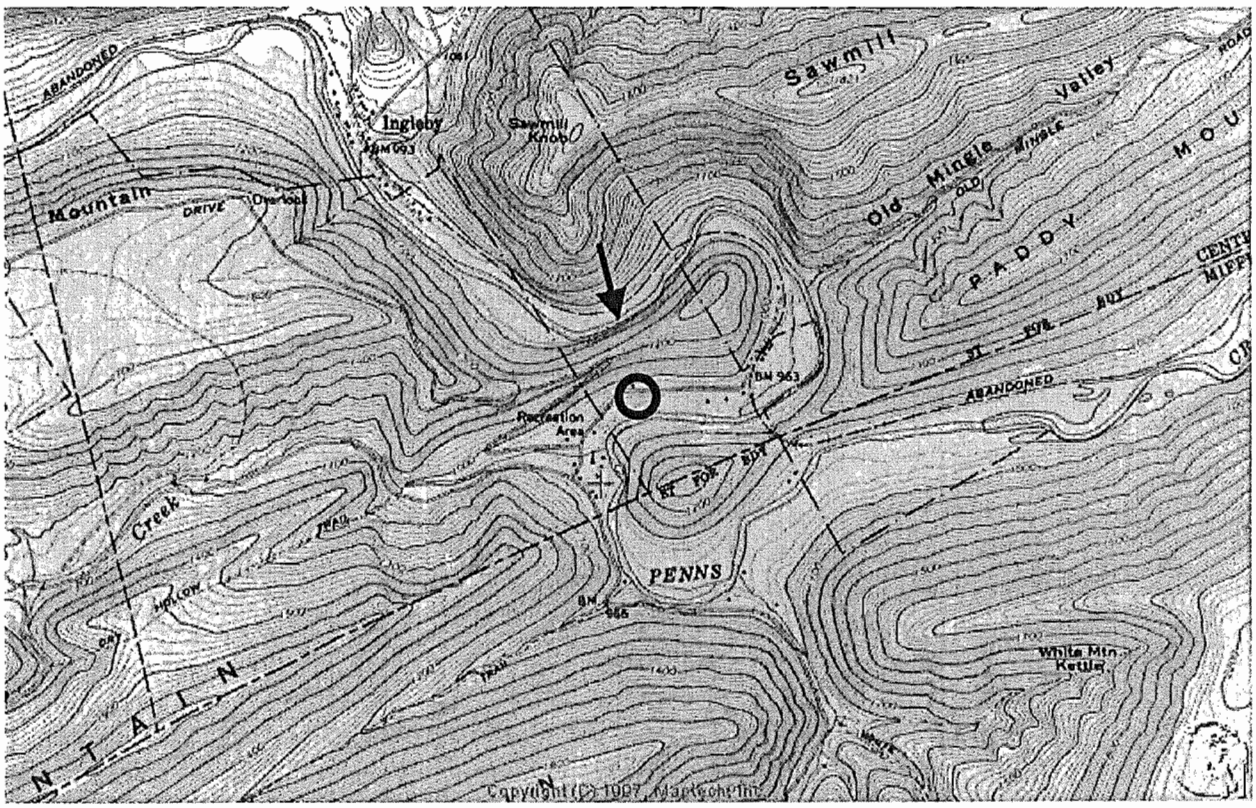


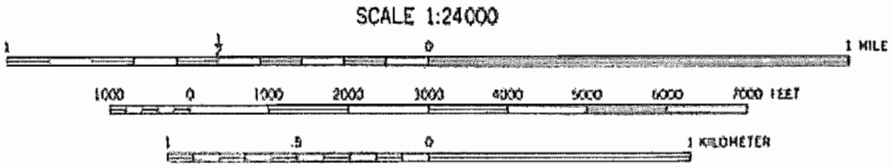


Site: Poe Paddy Seep

USGS 7.5' Quadrangle: Coburn, PA		Latitude:	405011
Centre County, Haines Twp.		Longitude:	772455
Location: Ingleby, 1.6 km SE		Elevation:	293 m

Poe Paddy Seep occurs at the base of a sandstone ridge along Penns Creek. Land use in the rather small recharge zone is forest, with the upper slopes and crest limited to xeric forest type. Groundwater flow at the seep remains relatively constant and strong throughout the year. Poe Paddy can best be characterized as a shrub-dominated seep with *Alnus rugosa* and *Lindera benzoin* as the dominant species. *Tsuga canadensis*, *Fraxinus nigra*, *Betula alleghaniensis* and *Salix (alba or fragilis)* are present in the sparse tree canopy.

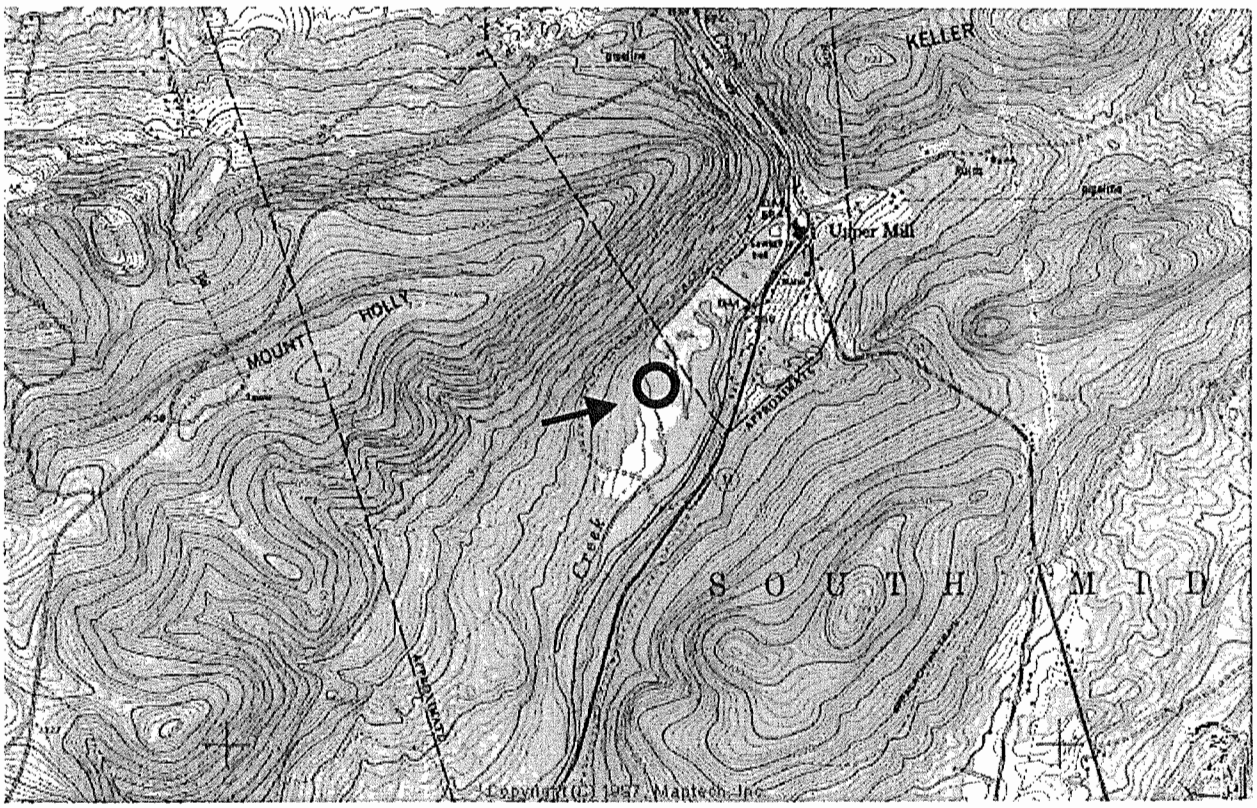


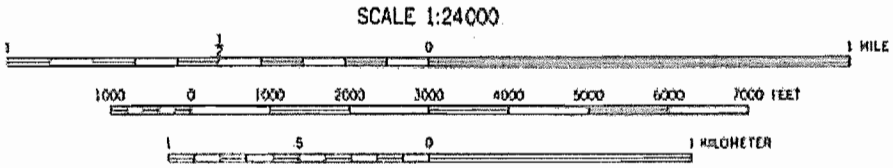


Site: Mount Holly Preserve Seep

USGS 7.5' Quadrangle: Mount Holly Springs, PA		Latitude:	400547
Cumberland County, South Middleton Twp.		Longitude:	771118
Location: Mount Holly Springs, 2.35 km S		Elevation:	186 m

Mount Holly Seep is located at the base of a steep quartzite ridge. Although the seep is on the edge of a creek floodplain, nearly all of the recharge zone is associated with the quartzite ridge. Land use on the slopes above the seep is maturing forest. Residential development is generally precluded by the very steep slope. Seasonal groundwater flow volume fluctuations are minor. The partial tree cover (about 30%) is dominated by *Acer rubrum*. Shrubs cover about a third of the seep and are dominated by *Ilex verticillata*, *Lindera benzoin* and *Vaccinium corymbosum*

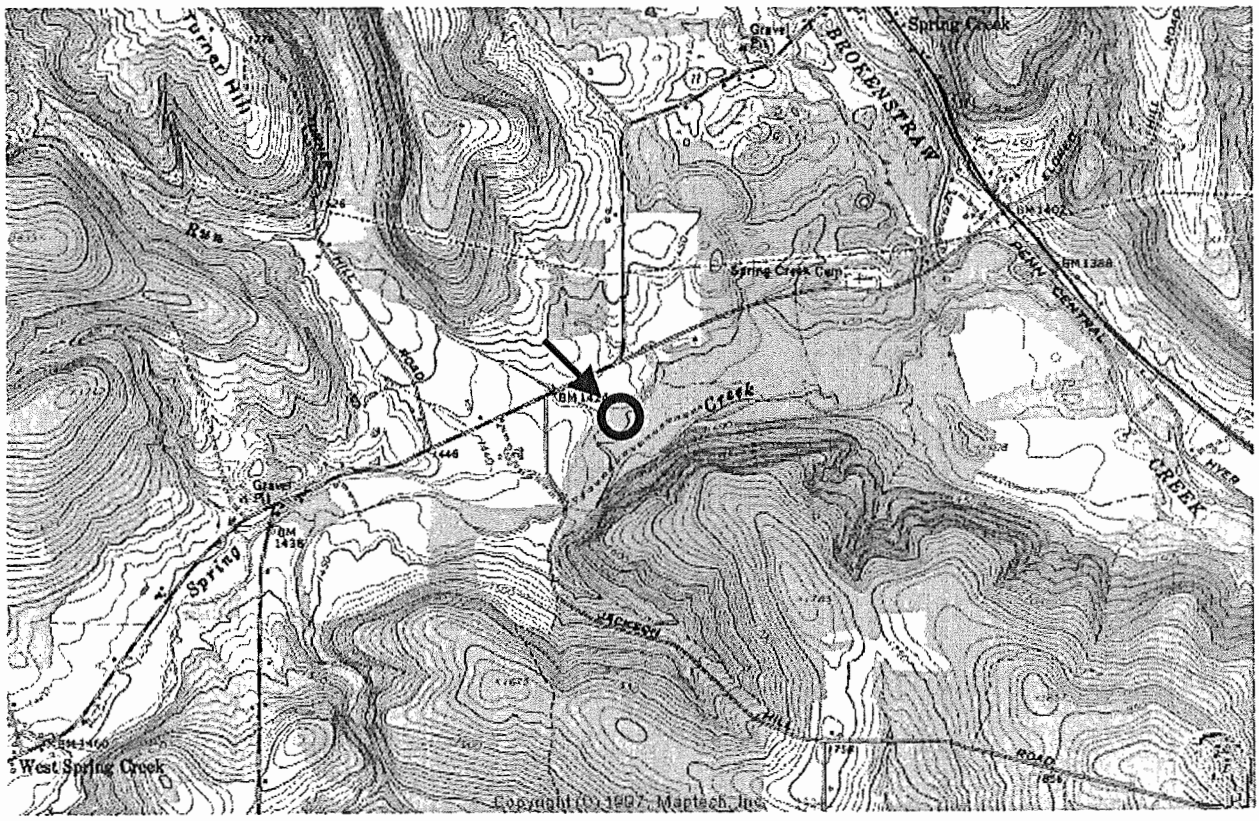


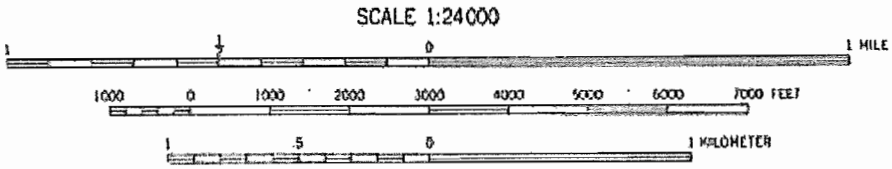


Site: Carlisle Farm 1

USGS 7.5' Quadrangle: Spring Creek, PA	Latitude:	415132
Warren County, Spring Creek Township	Longitude:	793217
Location: West Spring Creek, 3.0 km ENE	Elevation:	421 m

Carlisle Farm Seeps #1 sits at the base of a kame deposit where the kame meets the floodplain of Spring Creek. One of a number of strong seeps originating from this hill, this seep is perennial and the substrate saturated. Uplands representing the recharge area are a mix of active and reverting agricultural fields. Forb-dominated with *Myosotis scorpiodes, Onoclea sensibilis*, and *Symplocarpus foetidus* prominent, small trees like *Amelanchier* provide a partial canopy. A large *Pinus strobus* fell on this plot after the first year of sampling.

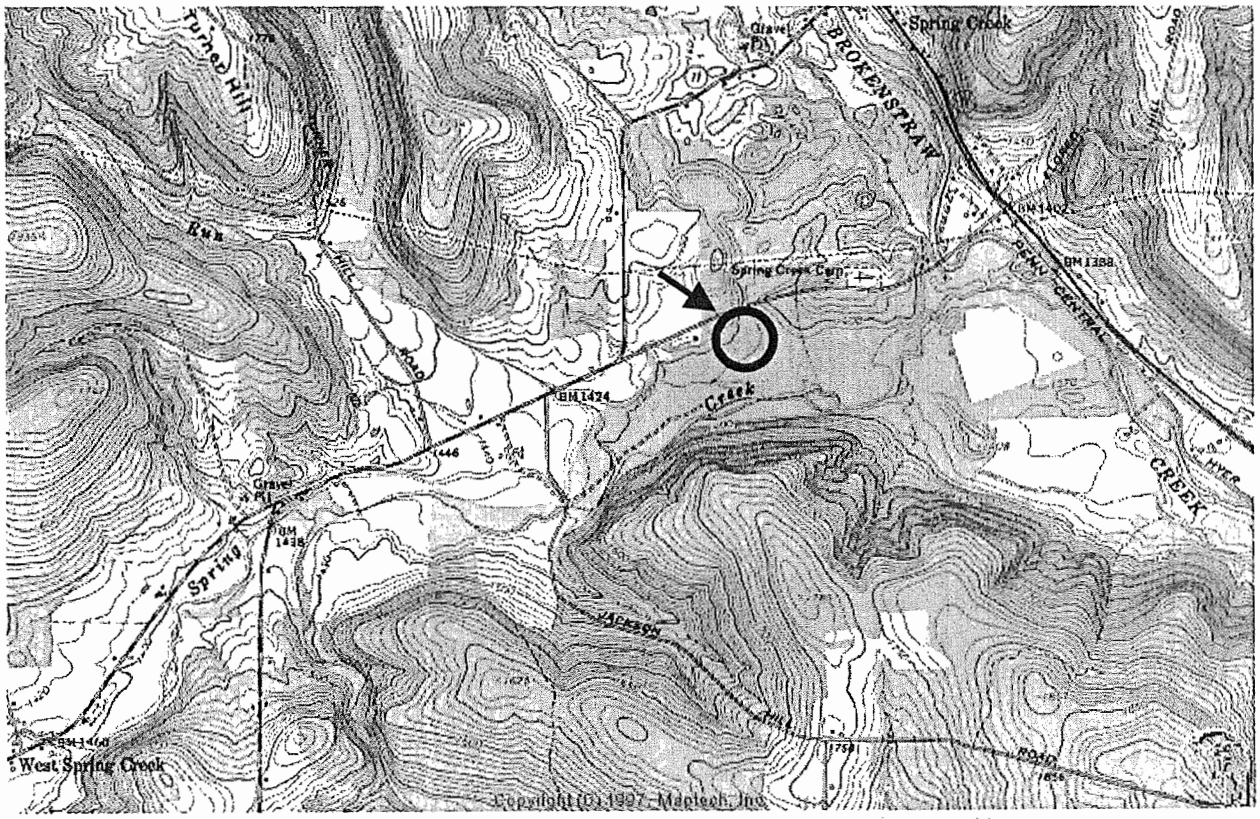


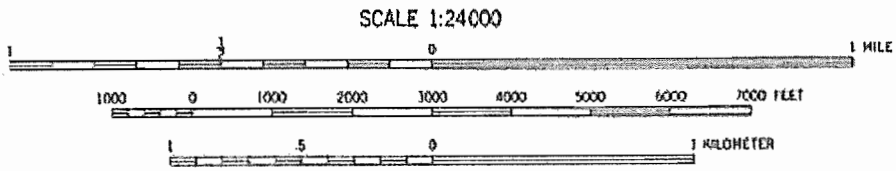


Site: Carlisle Farm 2

USGS 7.5' Quadrangle: Spring Creek, PA	Latitude:	415132
Warren County, Spring Creek Township	Longitude:	793150
Location: West Spring Creek, 3.6 km ENE	Elevation:	424 m

Carlisle Farm Seeps #2 lies along the edge of the same kame as does Carlisle #1. However, this is a large and diffuse area of seepage within a *Tsuga canadensis – Betula alleghaniensis – Acer rubrum* full canopy forest. Still within an agricultural setting, this seep has substantial forest buffer upslope. Hummocks and extensive peat-muck characterize the surface. *Osmunda cinnamomea, Impatiens capensis*, and *Symplocarpus foetidus* are dominant forbs.

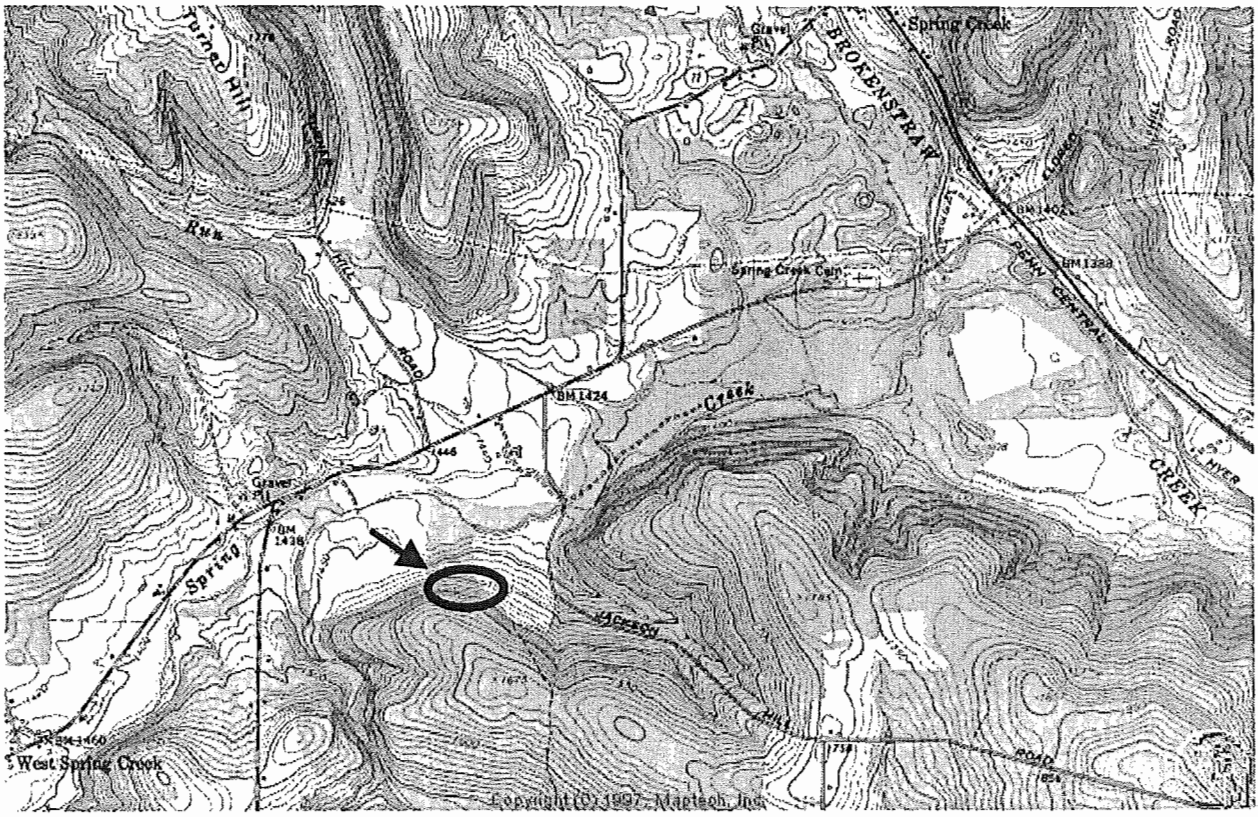


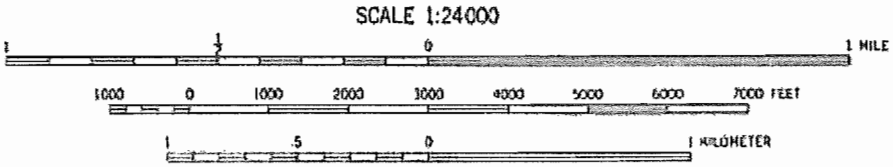


Site: Carlisle Farm 3

USGS 7.5' Quadrangle: Spring Creek, PA		Latitude:	415157
Warren County, Spring Creek Township		Longitude:	793240
Location: West Spring Creek, 2.5 km ENE		Elevation:	485 m

Carlisle Farm Seeps #3 sits at a break in the slope along an end moraine. Having moderate flow in the Spring and diffuse, minimal flow in the Autumn, the substrate is a mix of wet clay, stones, and gravel. Situated at the edge of an older, reverting pasture and a maturing forested slope, current agriculture does not appear to directly effect the seep. Several shrub-trees – *Carpinus caroliniana, Hamamelis virginiana* – supply significant cover to this forb-graminoid dominated seep with several *Carex spp., Viola cuculata* and *Impatiens capensis* as prominent species.

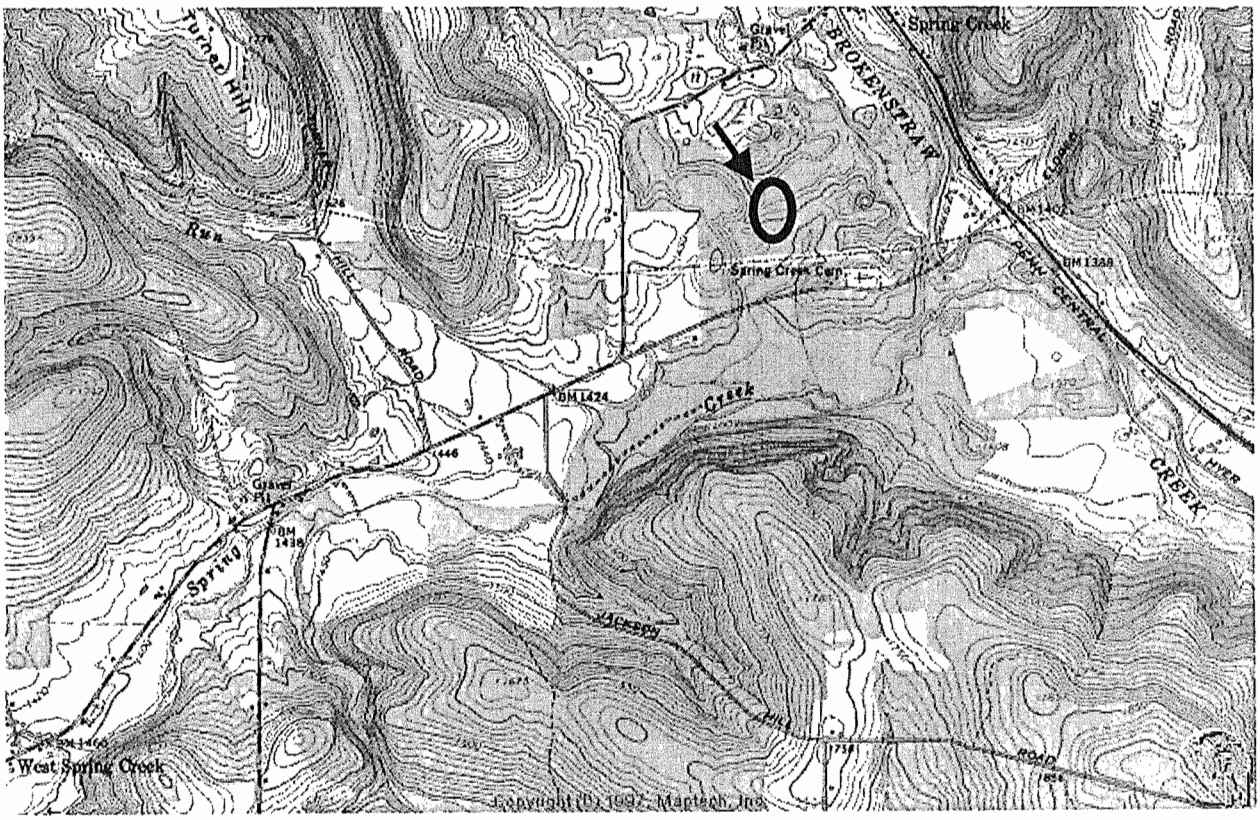


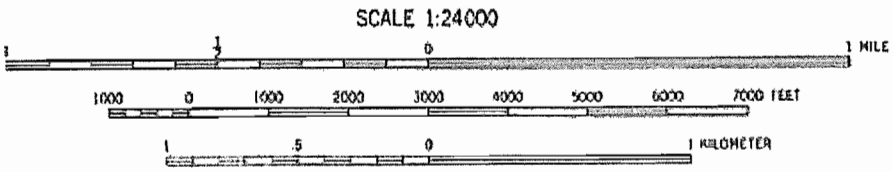


Site: Carlisle Farm 4

USGS 7.5' Quadrangle: Spring Creek, PA		Latitude:	415157
Warren County, Spring Creek Township		Longitude:	793158
Location: West Spring Creek, 3.9 km NE		Elevation:	427 m

Carlisle Farm Seeps #4 lies within the same kame deposit as Carlisle #1 and #2. Water flow here is moderately strong and perennial and the substrate is a mixture of gravel and loamy clay with thin pockets of peat. *Betula alleghaniensis* and *Tsuga canadensis* supply a nearly full canopy but surrounding (upslope)areas have been recently logged and several tree-falls have increased light penetration to the seep. *Impatiens capensis, Onoclea sensibilis*, and *Osmunda cinnamomea* supply a large proportion of forb cover.

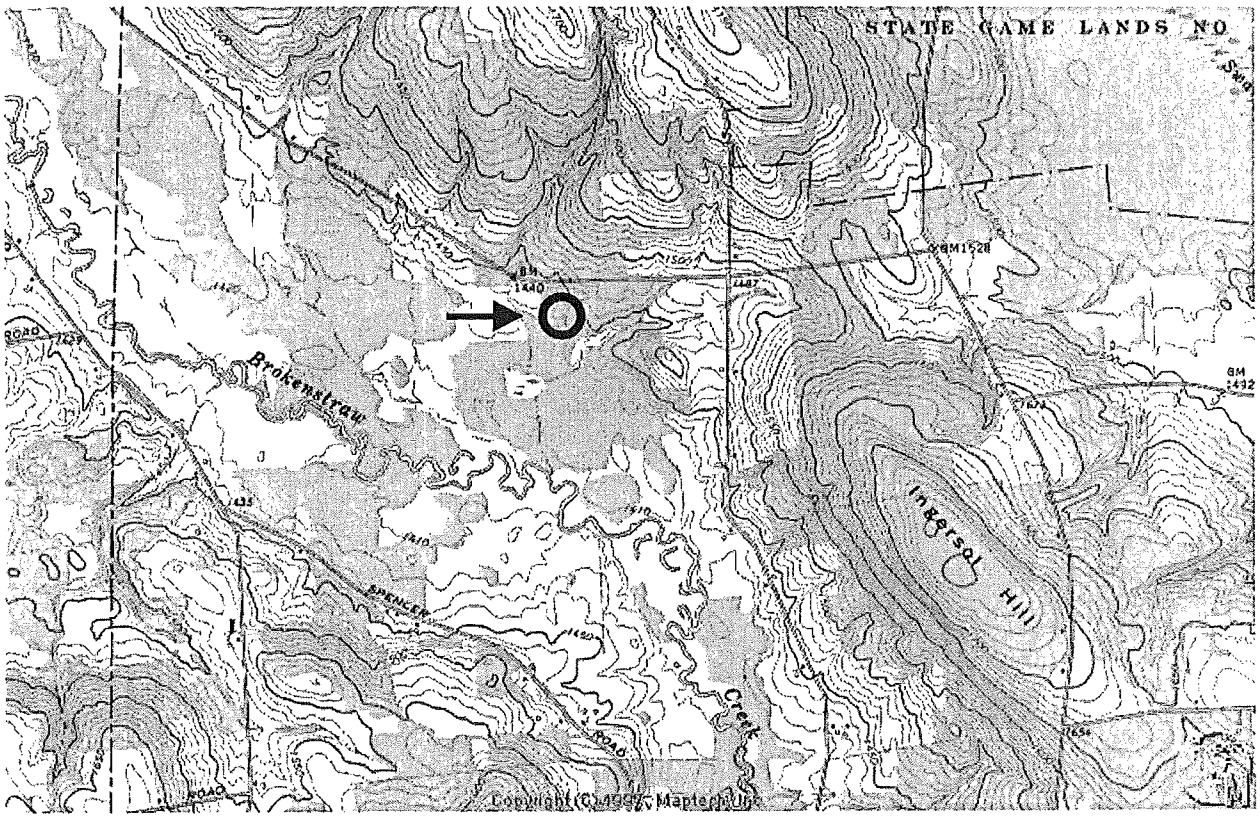


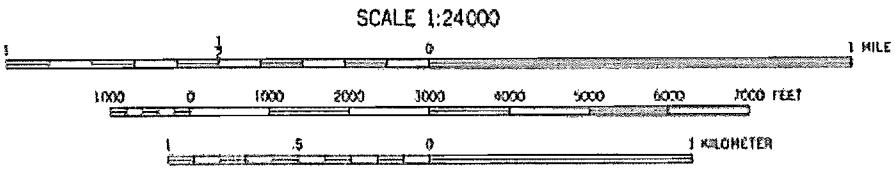


Site: State Game Lands #197

USGS 7.5' Quadrangle: Columbus, PA		Latitude:	415825
Warren County, Columbus Township		Longitude:	793502
Location: Columbus, 4.0 km N		Elevation:	433 m

The State Game Lands #197 seepage occurs at the base of a kame deposit where it meets the Brokenstraw Creek floodplain. A moderate, somewhat diffuse, perennial water flow keeps the peat over gravelly clay substrate saturated. Light residential development and minimal agriculture occur in the otherwise surrounding forested landscape. *Pinus strobus* and some scattered *Hamamelis virginiana* supply a partial canopy to this forb-graminoid dominated seep. *Symplocarpus foetidus, Osmunda cinnamomea, Veronica americana*, and *Equisteum arvense* are prominent forbs.

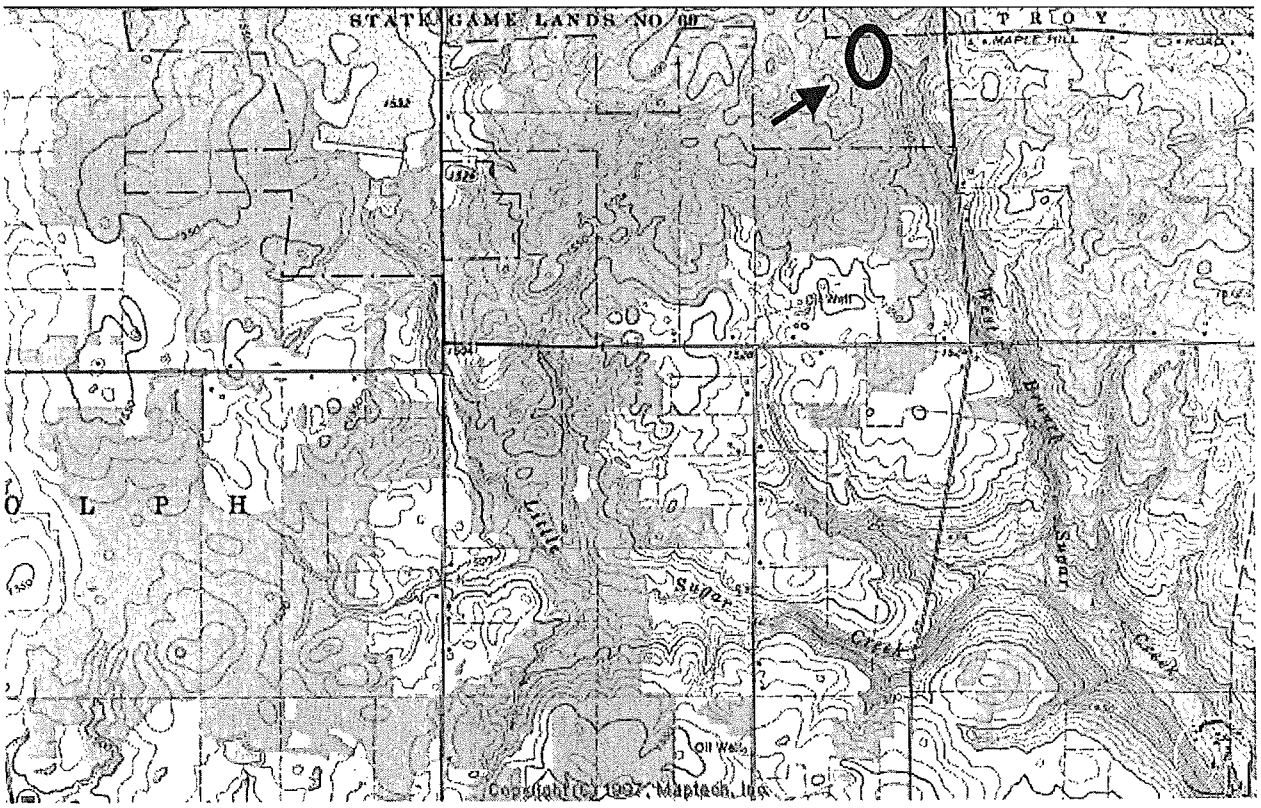


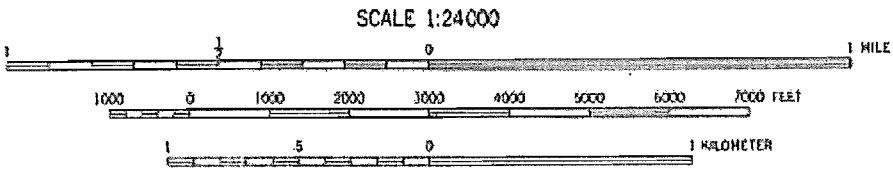


Site: State Game Lands #69

USGS 7.5' Quadrangle: Sugar Lake, PA		Latitude:	413723
Crawford County, Randolph Township		Longitude:	795329
Location: Mt Hope, 6.5 km ENE		Elevation:	478 m

The State Game Lands #69 seepage extends along a floodplain terrace that is part of the Kent End Moraine. This ephemeral seep shows diffuse moderate, diffuse in the Spring and little or no flow later in the season. The surface substrate is a clay loam and a mix of successional and maturing forest surround the site. *Acer saccharum, Tilia americana* and *Betula alleghaniensis* create a closed canopy over this forb-graminoid dominated seep. *Impatiens capensis* and *Veratrum viride* are the dominant ground covers with *Chrysosplenium americanum, Carex prasina*, and *Dropteris intermedia* also prominent.

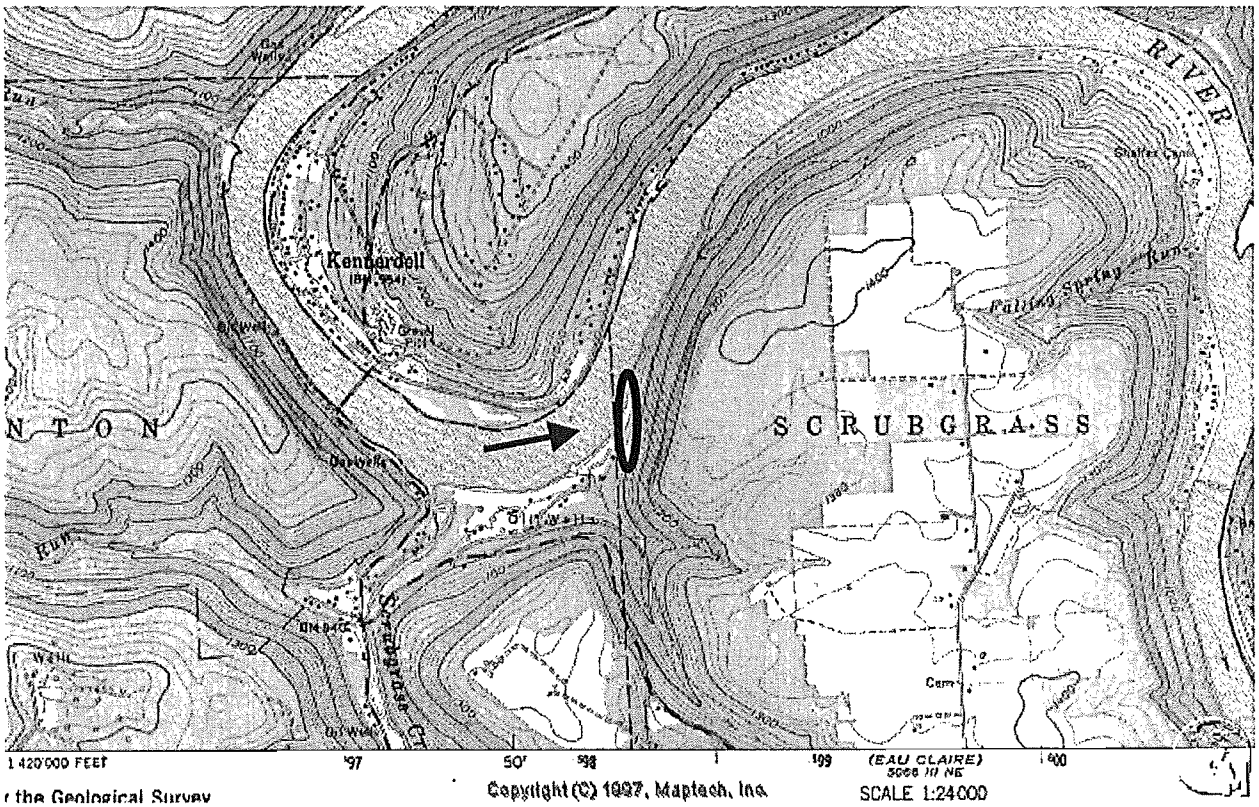


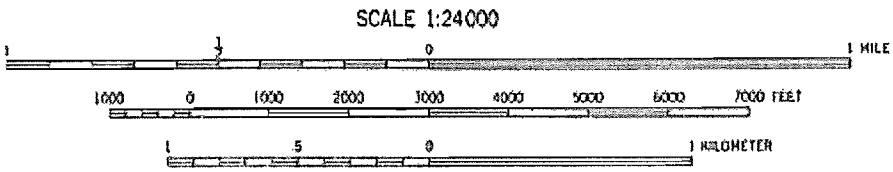


Site: Kennerdell

USGS 7.5' Quadrangle: Kennerdell		Latitude:	411548
Venago County, Clinton Township		Longitude:	794939
Location: Kennerdell, 1.1 km SE		Elevation:	341 m

Kennerdell Seeps sits at the base of a steep sandstone valley wall along the Allegheny River. Several areas of strong perennial flow keep parts of this area saturated throughout the year. Occasional scouring from river floodwaters maintain a surface of cobbles and rocks over a fine sandy clay. The slopes above this site are Tsuga dominated forest. Completely open, this seep has graminoid patches dominated by *Juncus tenuis* and *Eleocharis tenuis* as well as forb-graminoid dominated areas with prominent species like *Eupatorium perfoliatum, Mimulus moschatus*, and *Agrostis stolonifera.*

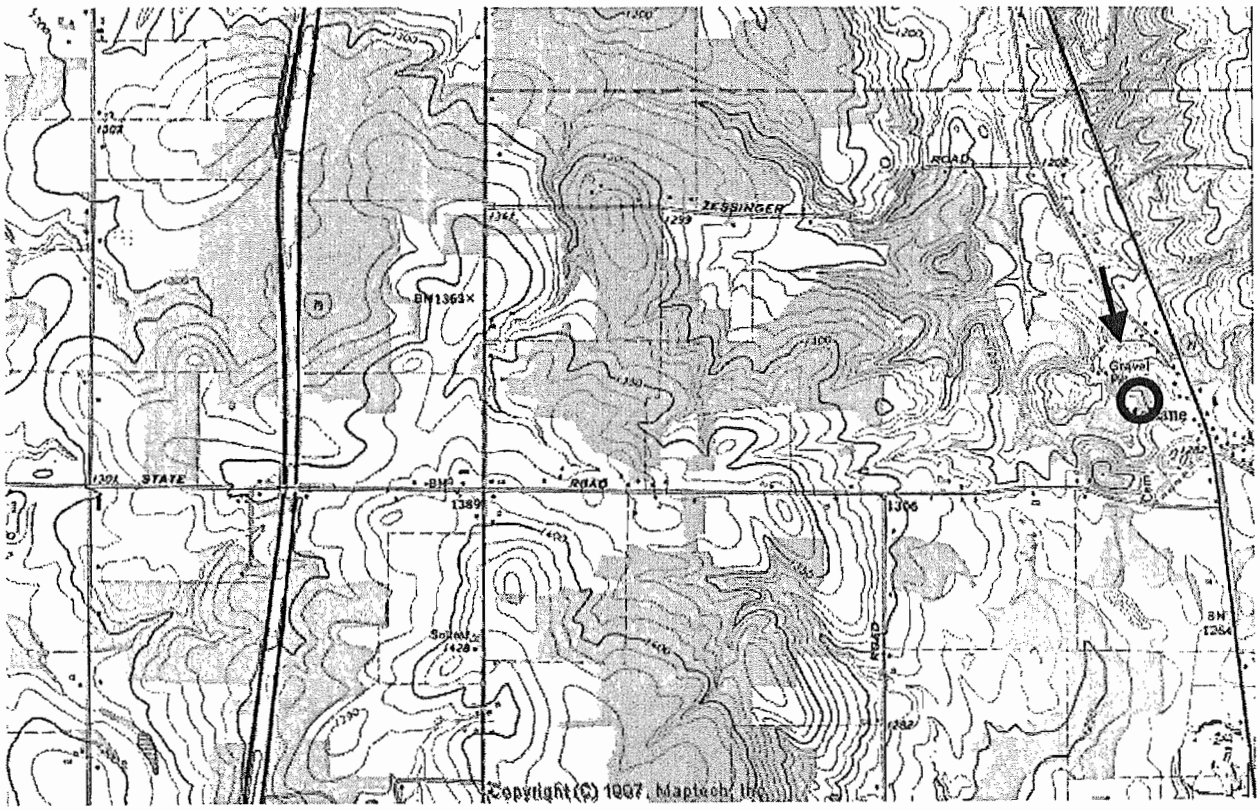


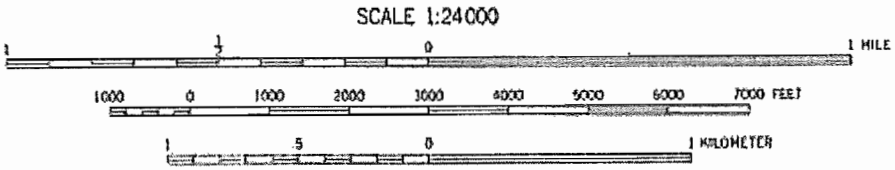


Site: McLane Seepage Swamp

USGS 7.5' Quadrangle: Edinboro		Latitude:	415616
Erie County, Washington Township		Longitude:	800754
Location: McLane, 0.8 km NW		Elevation:	372 m

McLane Seepage Swamp sits within a kame complex near an end moraine. Seepages occur throughout the site on moderately steep hillsides that drain into a basin swamp. Water flow is perennial and diffuse to moderately defined with soils remaining saturated and mucky or peaty over layers of sandy clay. Surrounding are areas of successional forest, light residential development and some agriculture. An abandoned gravel mine sits within the kame deposit and some channels appear to have been established for drainage. Under a partial canopy of *Acer saccharum, Tsuga canadensis*, and *Acer rubrum,* the seep itself remains open with *Impatiens capensis, Carex scabrata*, and *Chrysosplenium americanum* dominating.

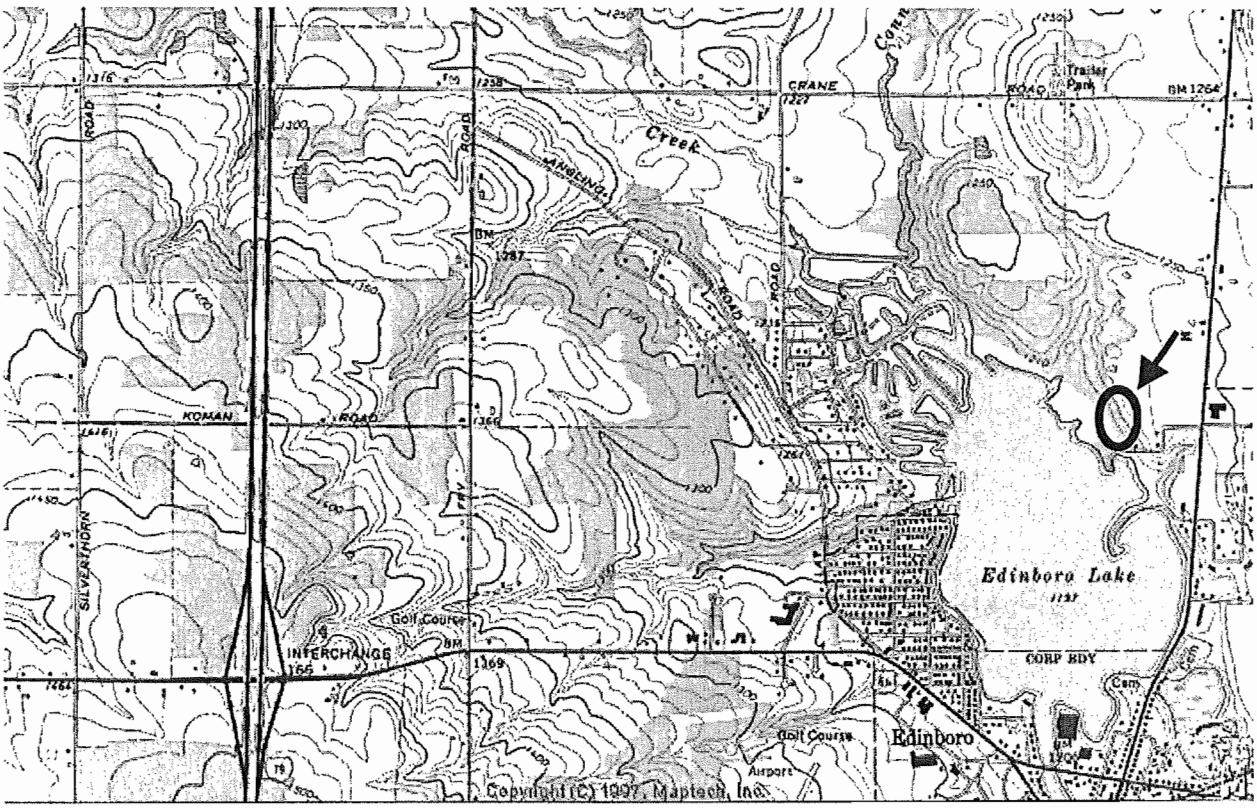


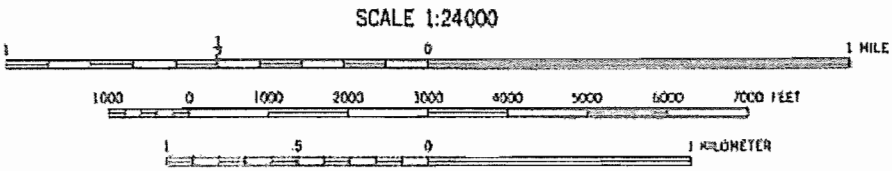


Site: Edinboro Lake Seeps

USGS 7.5' Quadrangle: Edinboro		Latitude:	415325
Erie County, Washington Township		Longitude:	800757
Location: Edinboro, 1.5 km N		Elevation:	369 m

Edinboro Lake Seeps sit on the gradual slopes above the lake on glacial outwash deposits. Ephemeral water flow allows the silty clay substrate to drain later in the season. Agricultural fields and light commercial /residential development surround the site. Shrub and forb dominated, this seep receives shading from adjacent *Acer rubrum* and *Fraxinus americana* trees. *Ilex verticillata, Cornus sericea, Symplocarpus foetidus*, and *Osmunda regalis* dominate this seep.

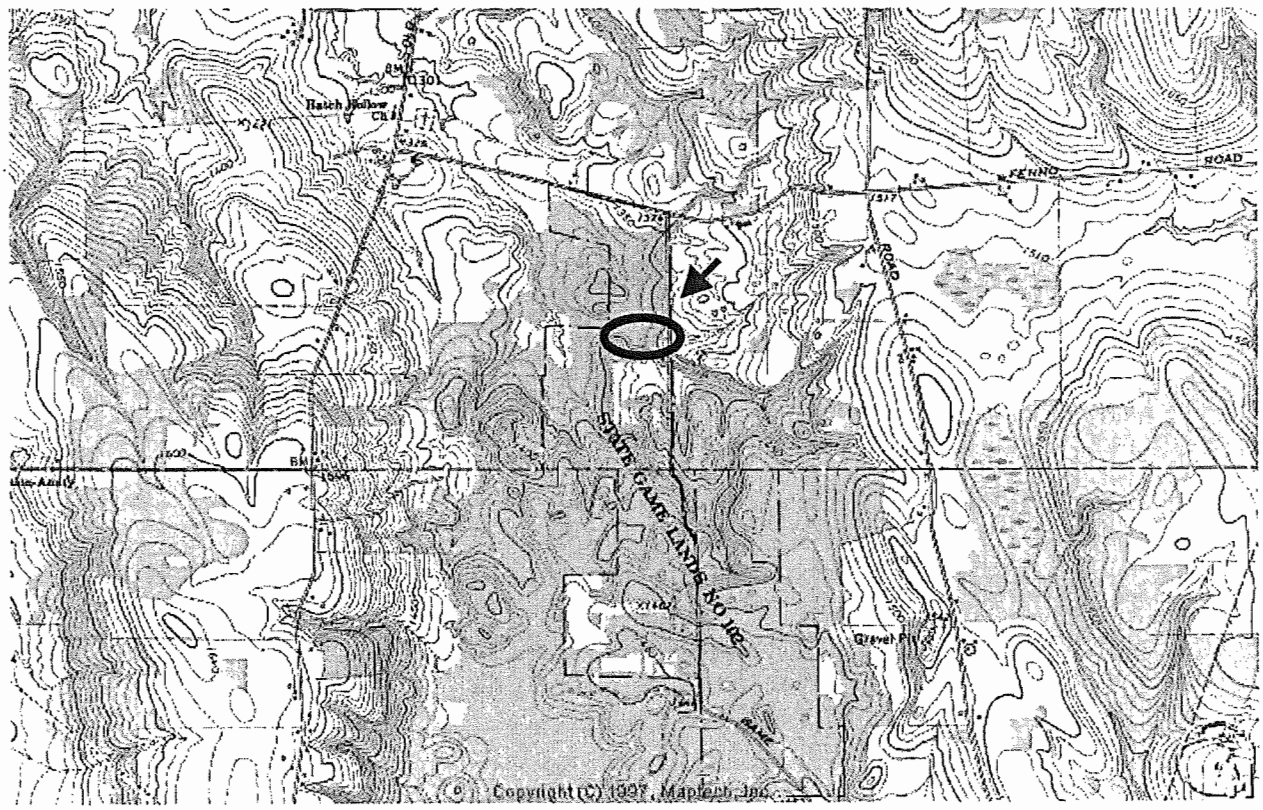


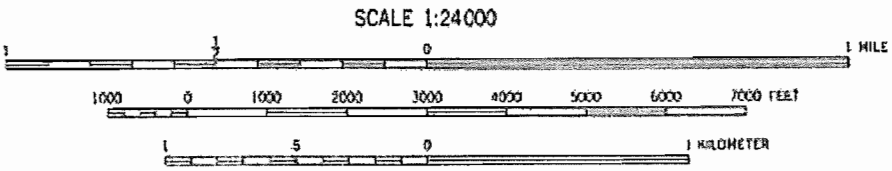


Site: State Game Lands #102

USGS 7.5' Quadrangle: Union City, PA		Latitude:	415624
Erie County, Amity Township		Longitude:	794838
Location: Union City, 5.5 km NE		Elevation:	408 m

The State Game Lands #102 Seeps sit at the base of a steep kame-hill above a basin swamp. The flow for all the seepages along the hill is perennial and moderately strong. Much of the surrounding land-use is active agriculture and successional areas used for wildlife propagation areas. The seeps themselves are open, sparsely vegetated with *Symplocarpus foetidus, Chelone glabra*, and *Carex scabrata* often dominant. Surrounding *Tsuga, Fagus grandifolia*, and other trees furnish a fairly full canopy and dense shading.

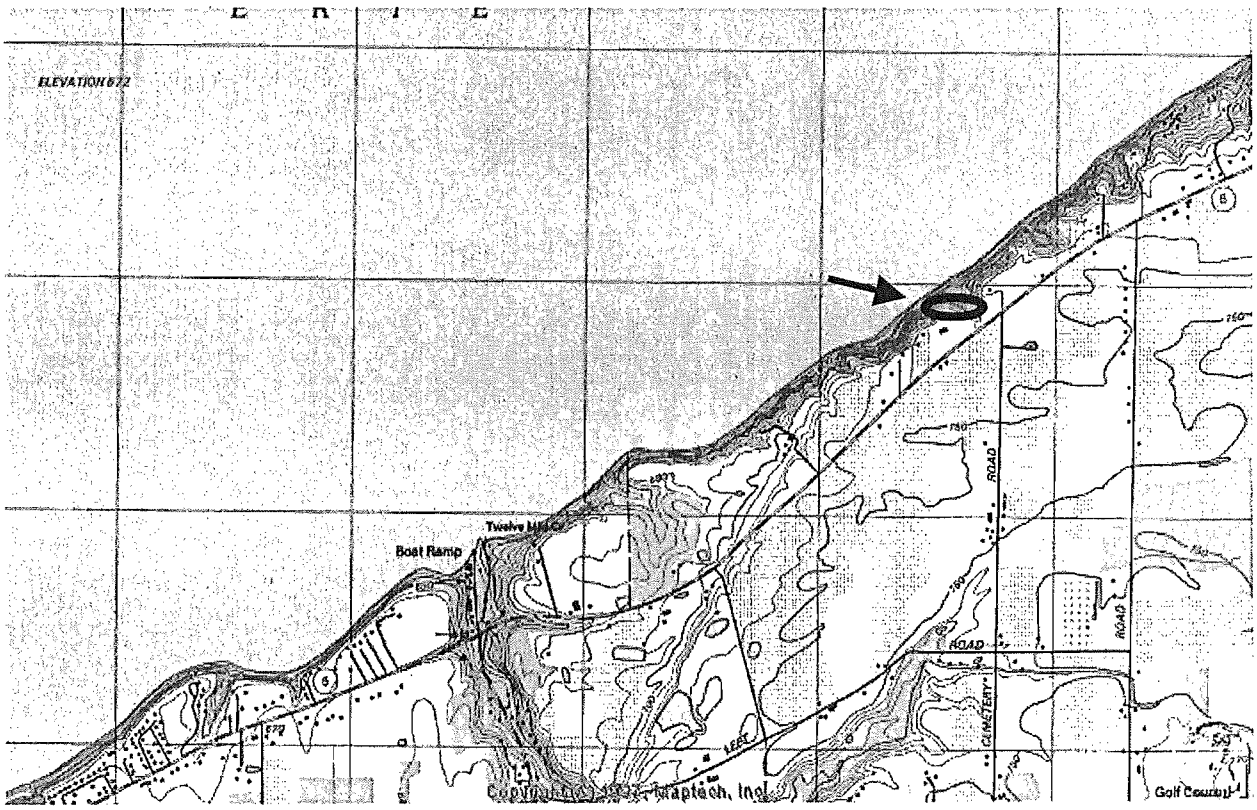


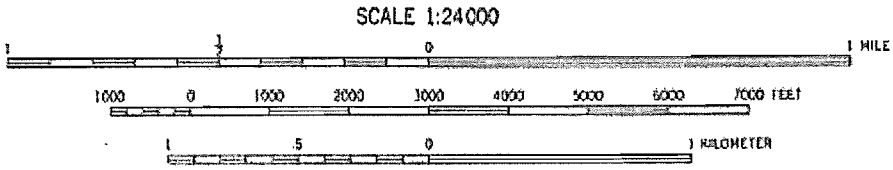


Site: North East Slumps – West 1

USGS 7.5' Quadrangle: Harbor Creek, PA		Latitude:	421318
Erie County, Harbor Creek Township		Longitude:	795324
Location: Moorheadville, 3.8 km NE		Elevation:	190 m

North East Slumps – West #1 sits in a forested cove on sand and beach gravel deposits underlain by dense clay tills along the Lake Erie shoreline. Water flow in this broad seepage area is perennial, moderately strong, and diffuse over a mucky silt substrate. Uplands bordering this seep are almost completely agricultural (grape vineyards). *Impatiens pallida, Solanum dulcamara*, and *Solidago flexicaulis* make up the majority of ground layer cover in this forb-dominated seep. Surrounding *Acer saccharum* and *Fagus grandifolia* supply a partial –full canopy and fairly heavy shading within this cove.

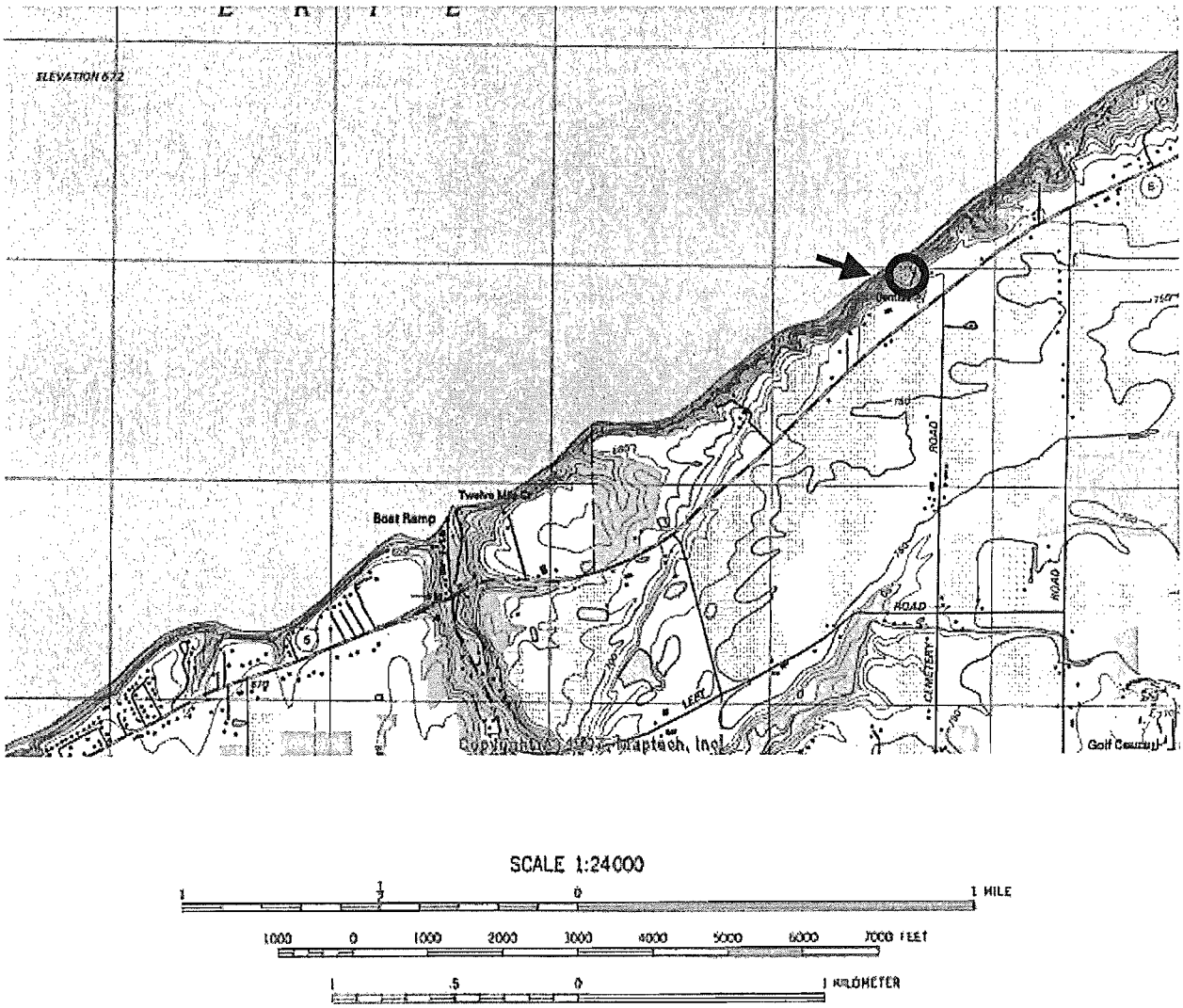




Site: North East Slumps – West 2

USGS 7.5' Quadrangle: Harbor Creek, PA		Latitude:	421318
Erie County, Harbor Creek Township		Longitude:	795324
Location: Moorheadville, 3.8 km NE		Elevation:	190 m

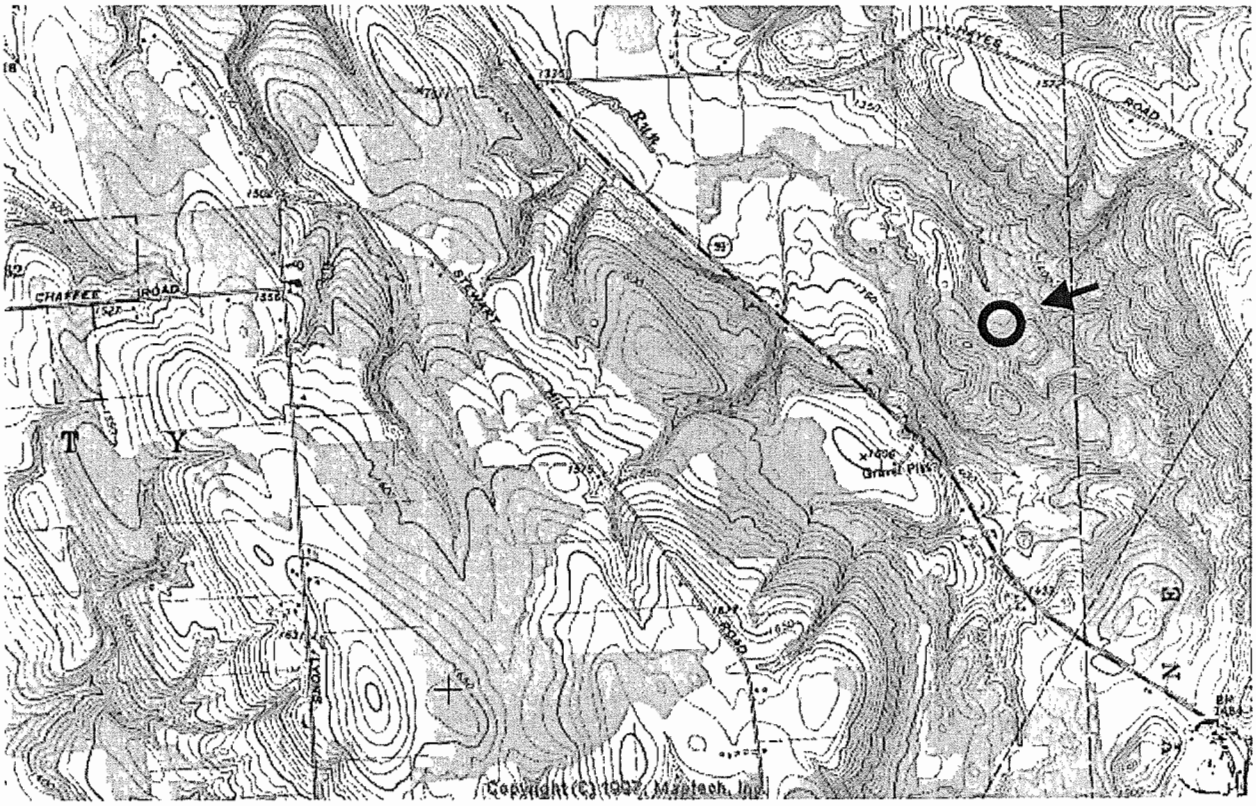
North East Slumps – West #2 sits directly on the lake shore and on the same sand and beach gravel deposits underlain by dense clay tills as for NE Slumps – West #1. The substrates remain saturated throughout the year and small rivulets divide sections of slumping material. The uplands are almost completely in agriculture (Grape vineyards). This band of seeps is completely open with *Equisteum arvense, Parnassia glauca*, and several species of *Carex* prominent and dominant.

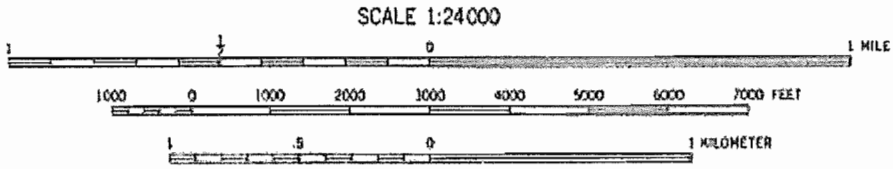


Site: Hubbel Run Seeps 1

USGS 7.5' Quadrangle: Union City, PA		Latitude:	415751
Erie County, Amity Township		Longitude:	794553
Location: Wattsburg, 4.8 km SE		Elevation:	402 m

Hubbel Run Seeps #1 sits on the edge of a small shrub-dominated basin within a large kame complex. Several areas of seepage occur along the hill and perennial and moderately strong. Surrounding land is predominately forest and reverting forest. Forb-graminoid dominated with *Symplocarpus foetidus, Osmunda cinnamomea*, and *Carex scabrata* as dominate ground cover, the seep sits within the cover provided by the *Tsuga canadensis - Acer rubrum* forest growing along the lower slopes.

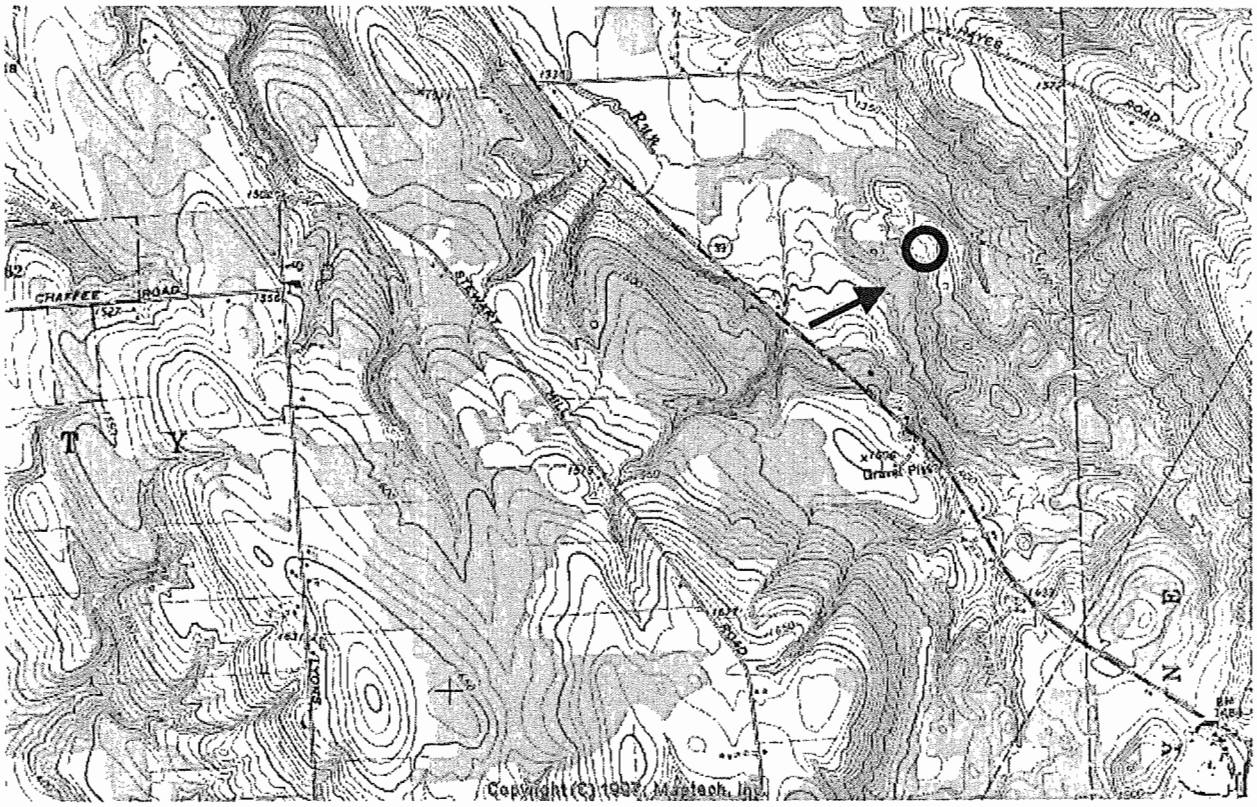


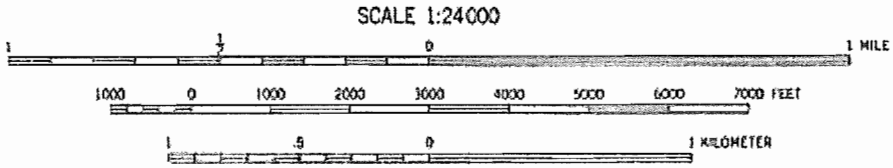


Site: Hubbel Run Seeps 2

USGS 7.5' Quadrangle: Union City, PA	Latitude:	415837
Erie County, Amity Township	Longitude:	794610
Location: Wattsburg, 4. 5 km SE	Elevation:	408 m

Hubbel Run Seeps #2 lies within the same kame complex as Hubbel Run #1 but at the base of a slope where the kame deposits meet the floodplain and outwash of Hubbel Run. Water flow is ephemeral and diffuse but the mucky – peat soils remain saturated throughout the year. *Tsuga canadensis, Acer rubrum*, and *Betula alleghaniensis* provide a nearly closed canopy over a ground cover *with Impatiens capensis, Chrysosplenium americanum*, and *Symplocarpus foetidus* dominating.

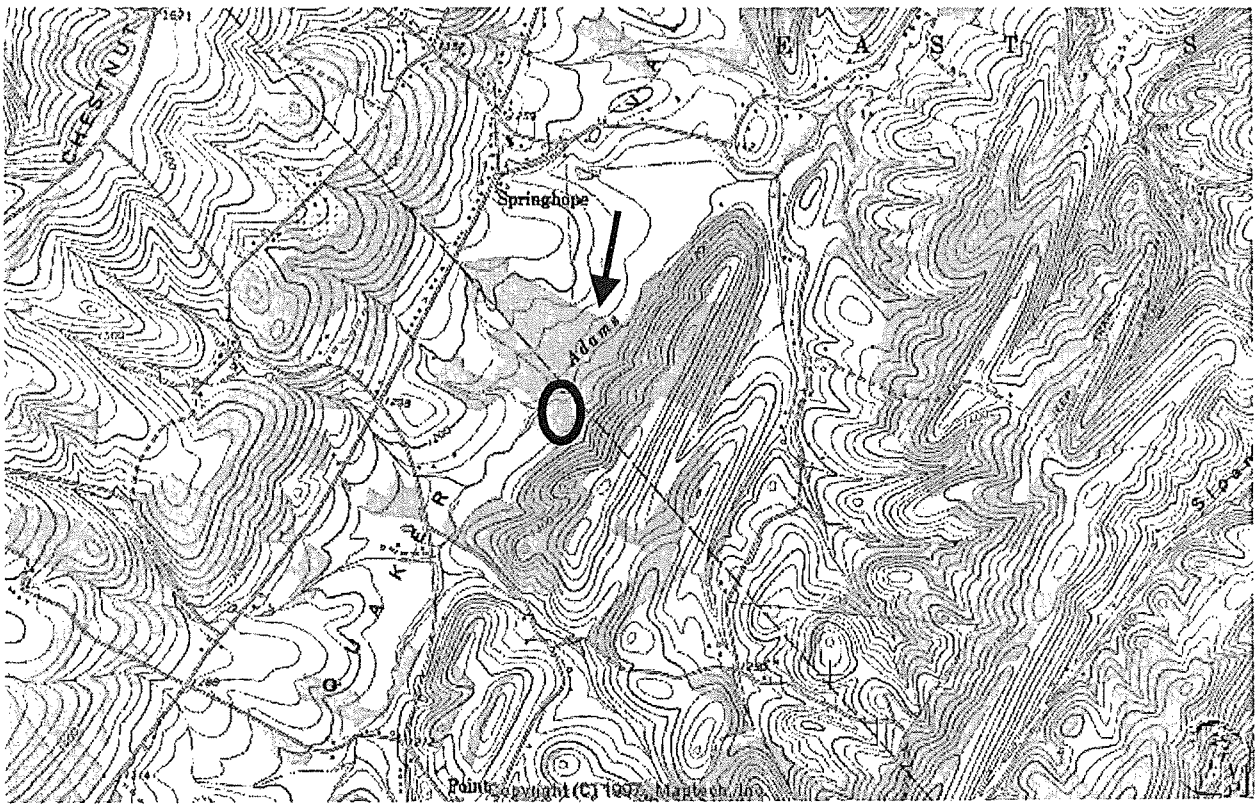


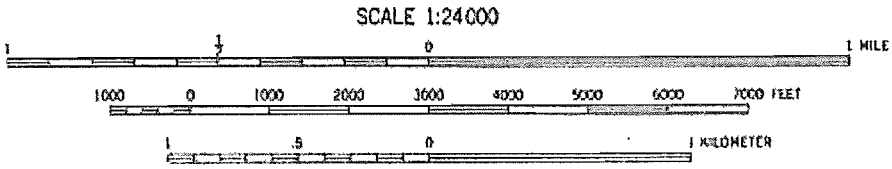


Site: Springhope Seeps

USGS 7.5' Quadrangle: Bedford, PA		Latitude:	400538
Bedford County, East St. Clair Township		Longitude:	783550
Location: Springhope, 1.2 km SSE		Elevation:	384 m

Springhope Seeps sits at the base of a forested, shale slope where it meets the floodplain of Adams Run. Water flow is ephemeral and diffuse and the clay-loam soils change from saturated to moist as the season progresses. Surrounding land-use includes reverting pasture patches within the floodplain and maturing forest on the slopes above the seeps. Open to partially shaded by *Carya ovata*, the seep is forb-graminoid dominated with *Impatiens capensis, Carex gynandra, Poa palustris*, and *Solidago gigantea* as dominants.

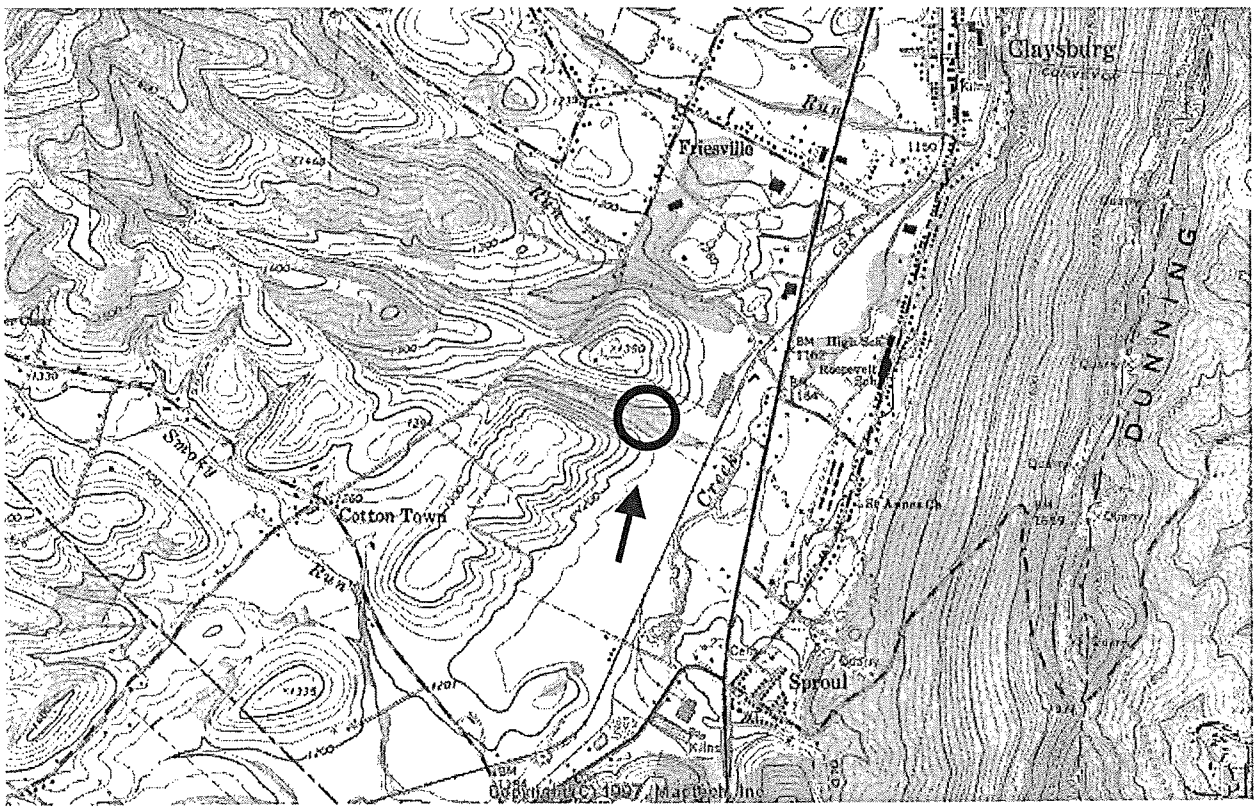


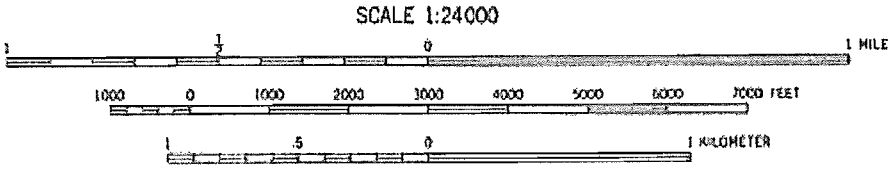


Site: Sproul Seeps

USGS 7.5' Quadrangle: Roaring Springs, PA		Latitude:	401659
Blair County, Greenfield Township		Longitude:	782756
Location: Sproul, 1.3 km NNW		Elevation:	366 m

Sproul Seeps lies along a small drainage at the base of a low shale hill overlooking the Boiling Spring Run Valley. Groundwater flow is ephemeral and diffuse but the dense clay soils soils remain saturated for most of the growing season. Surrounding land-use is successional forest, reverting agriculture and light residential development. *Tsuga canadensis* and *Ulmus americana* supply some shading to this forb-graminoid dominated seep. *Symplocarpus foetidus, Impatiens capensis*, and *Chrysosplenium americanum* dominate the seep.

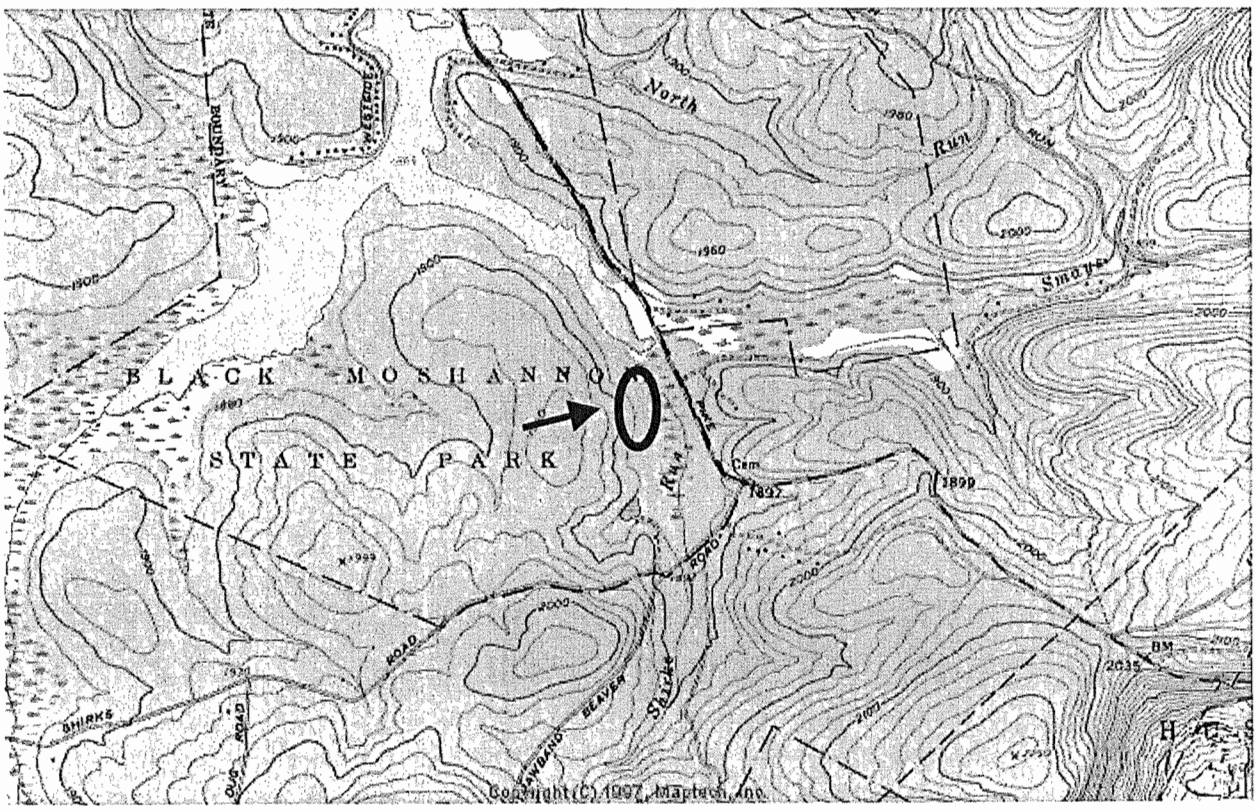


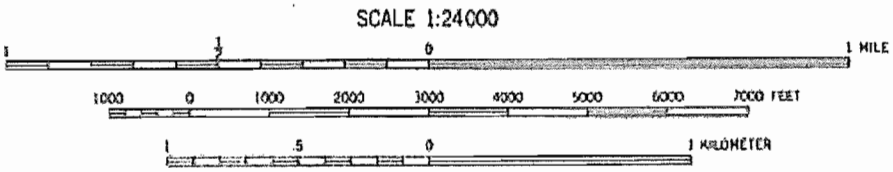


Site: Black Moshannon Seeps

USGS 7.5' Quadrangle: Black Moshannon, PA		Latitude:	405329
Centre County, Forest Township		Longitude:	790243
Location: Phillipsburg, 12.5 km E		Elevation:	573 m

Black Moshannon Seeps sits at the base of a mild sandstone/mixed shale- siltstone- mudstone slope on the edge a basin swamp. Water flow is ephemeral and diffuse but maintains saturation in the mucky over sandy clay soils. Surrounding land is forested and within Pennsylvania State Park property. The seep stands as open forb-graminoid dominated with a definite shrub (*Vaccinium corymbosum – Alnus incana*) component. *Osmunda cinnamomea, Symplocarpus foetidus, Veratrum viride,* and *Carex gynandra* are especially prominent species in the seep.

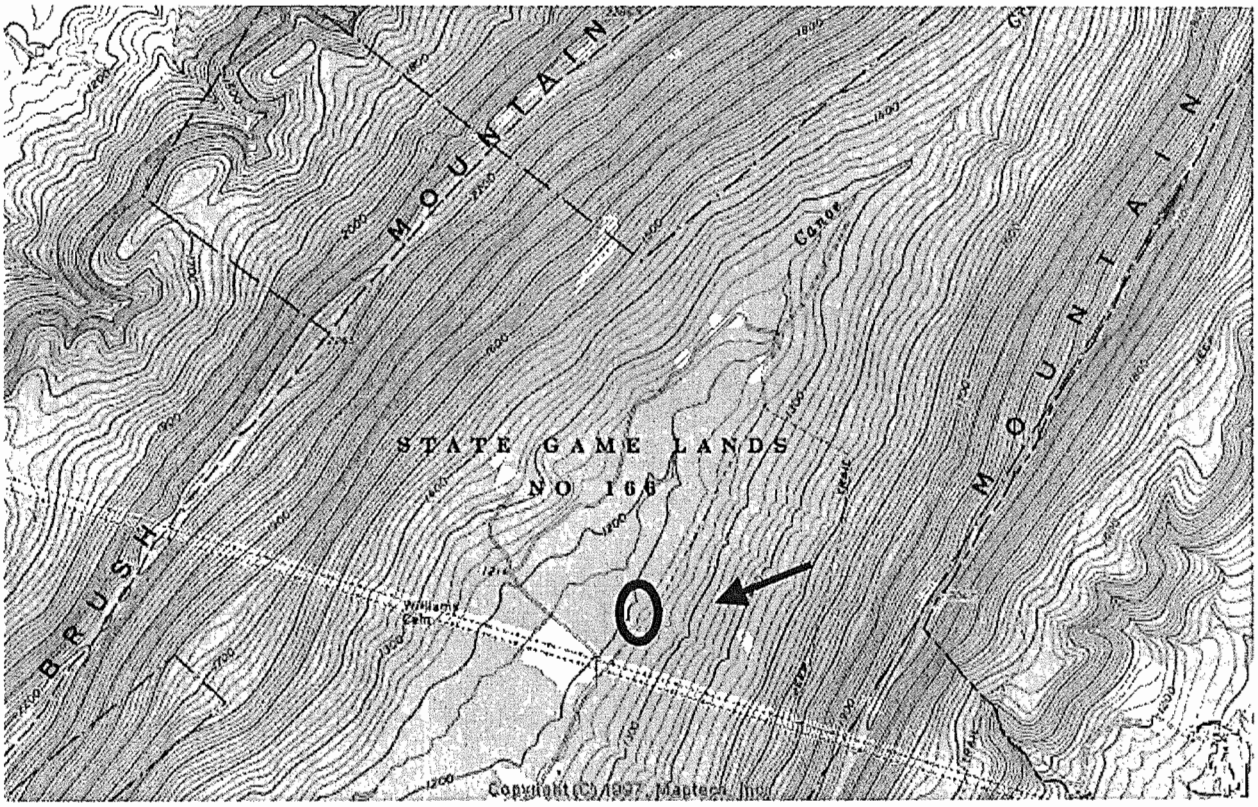


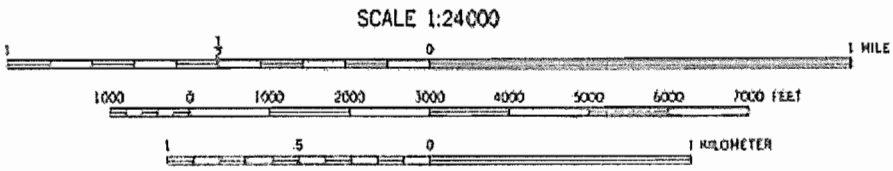


Site: State Game Lands #166

USGS 7.5' Quadrangle: Spruce Creek, PA		Latitude:	403402
Blair County, Catherine Township		Longitude:	781244
Location: Water Street, 6.5 km WSW		Elevation:	366 m

The State Game Lands #166 seeps lie along the lower slope of a valley within the fold of a sandstone ridge. This diffuse, somewhat ephemeral series of seeps shows limited flow in the late part of the growing season although the clay soils remain saturated throughout the year. Surrounding land is forest, some of which is older reverting agriculture. A powerline right-of-way cuts along the ridge just upslope from the seepages. *Lindera benzoin* forms a lower canopy and adjacent *Tsuga canadensis and Betula alleghaniensis* supply some cover to the seep. *Glyceria melicaria, G. striata, Carex prasina*, and *Osmunda cinnamomea* account for much of the cover below the shrub layer.

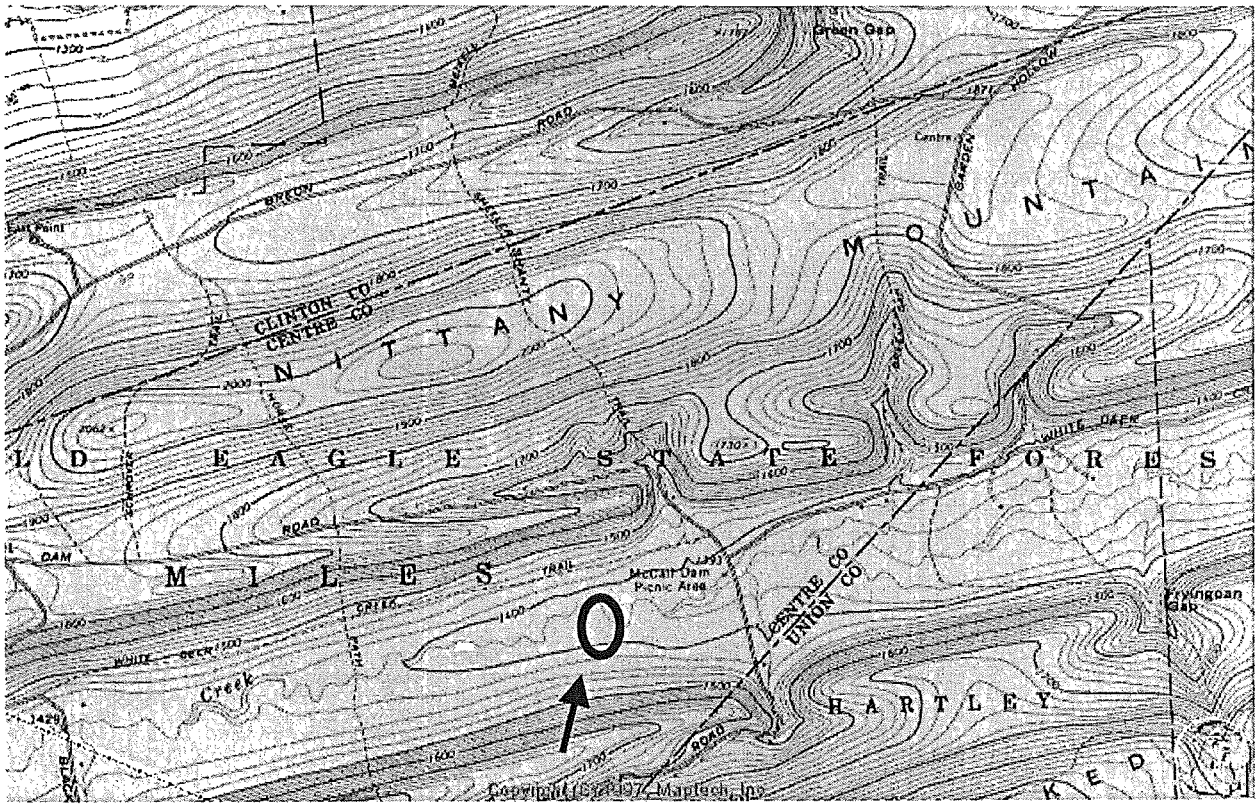


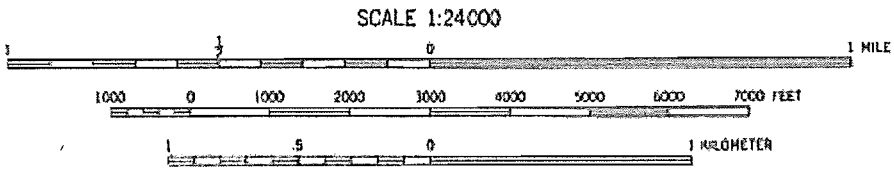


Site: McCall Dam Seeps 1

USGS 7.5' Quadrangle: Carroll, PA		Latitude:	410055
Centre County, Miles Township		Longitude:	771109
Location: Eastville, 3.8 km SE		Elevation:	427 m

McCall Dam Seeps #1 sits at the base of sandstone ridge, at the head of a seepage channel that flow into White Deer Creek. Water flow is strong and perennial and the sandy clay soils remain completely saturated throughout the growing season. Situated within the Bald Eagle State Forest, surrounding land-use is limited to forestry. *Thelypteris novae-borecensis*, *Impatiens capensis, Glyceria melicaria*, and *Carex frankii* are among the dominant species in this open, forb-graminoid dominated seep. Surrounding Tsuga canadensis and Betula alleghaniensis furnish a partial canopy over this seep.

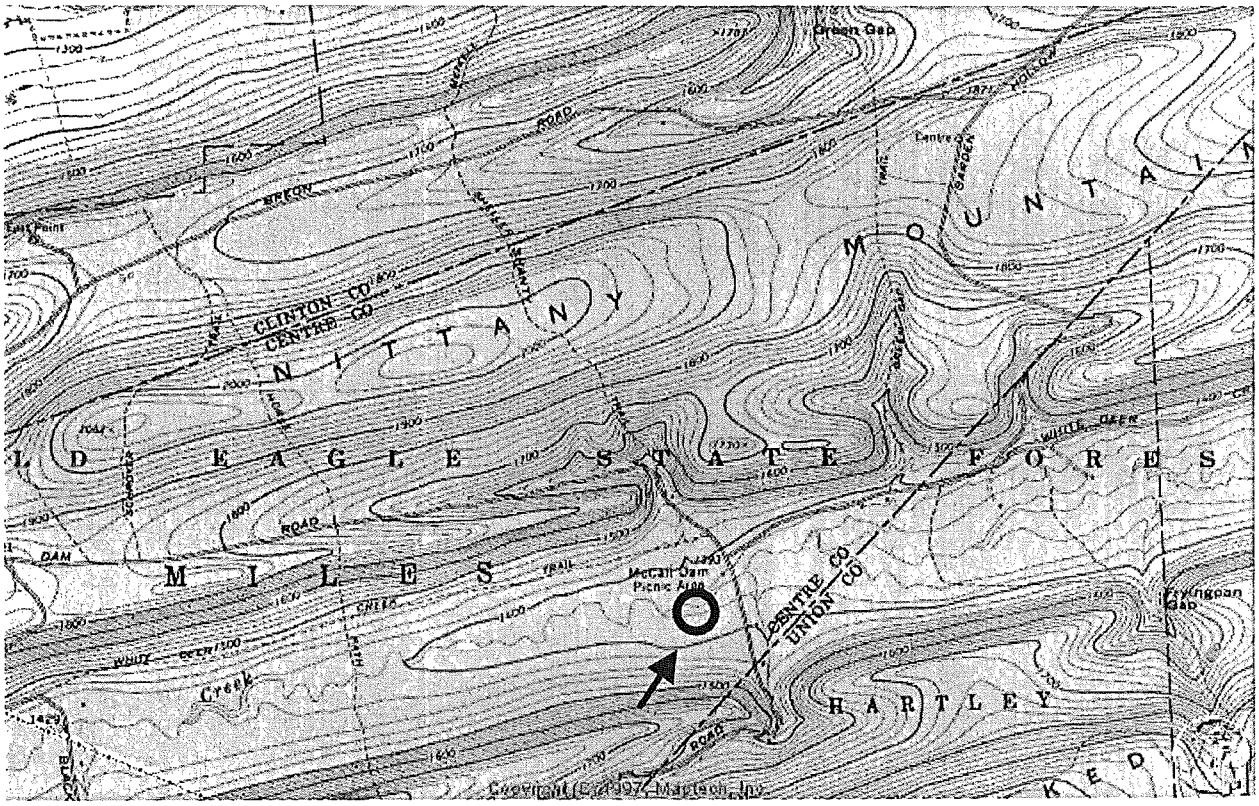


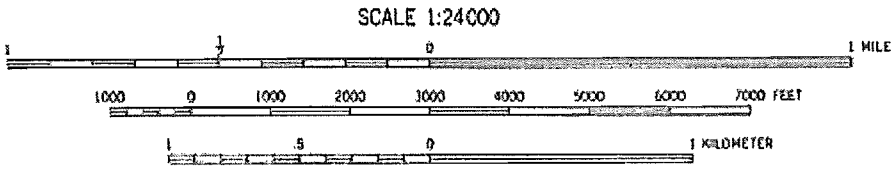


Site: McCall Dam Seeps 2

USGS 7.5' Quadrangle: Carroll, PA		Latitude:	410057
Centre County, Miles Township		Longitude:	771050
Location: Eastville, 4.25 km SE		Elevation:	427 m

McCall Dam Seeps #2 sits at the base of the same sandstone ridge as McCall Dam #1. Water flow is diffuse and somewhat fluctuating with lower flows later in the growing season. . Situated within the Bald Eagle State Forest, surrounding land-use is limited to forestry. A shrub layer of Alnus rugosa provides some shading to this seep which is otherwise forb-graminoid dominated. *Carex atlantica, Sphagnum umbricatum, Juncus effusus*, and *Thelypteris palustris* account for much of the cover in this seep.

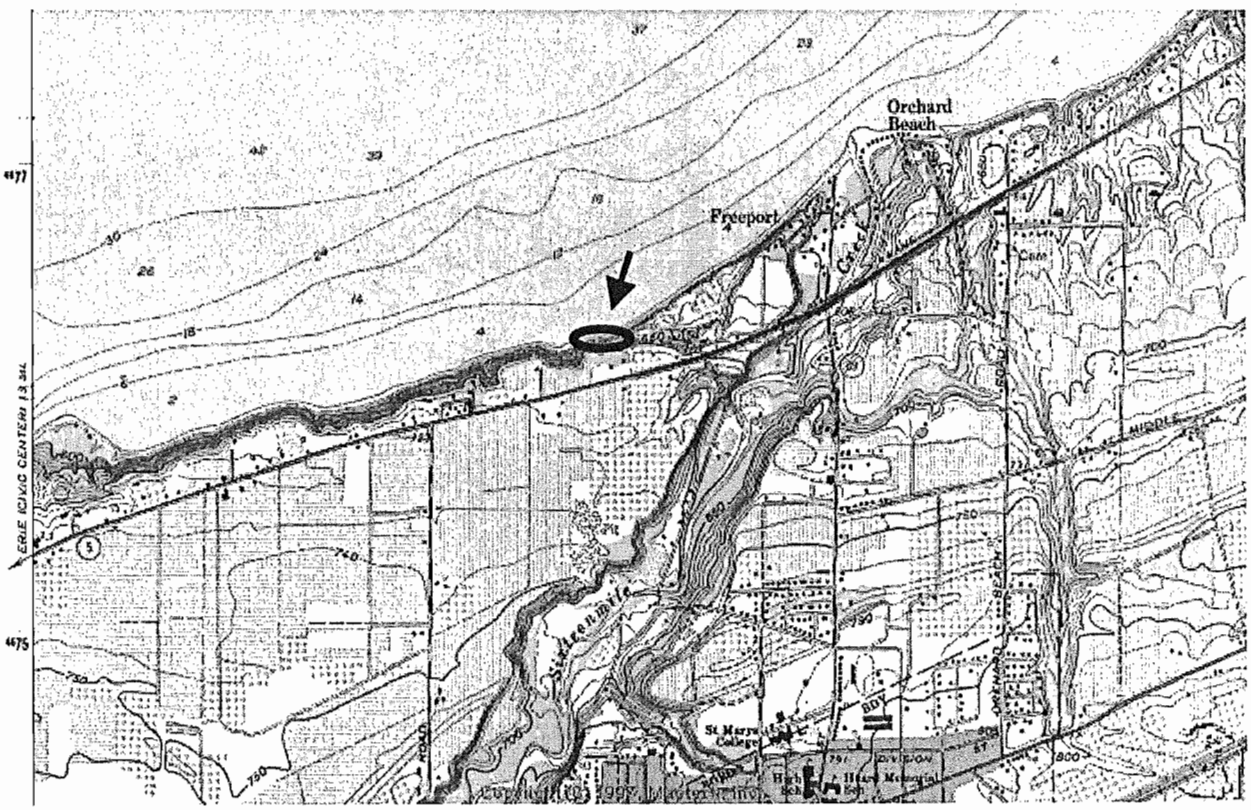


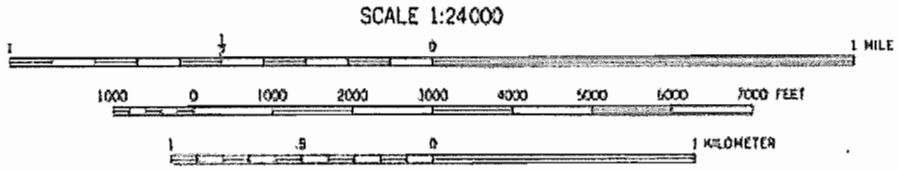


Site: North East Slumps – East

USGS 7.5' Quadrangle: North East, PA		Latitude:	421406
Erie County, North East Township		Longitude:	795040
Location: North East, 1.5 km SE		Elevation:	190 m

North East Slumps – East sits directly along the shore of Lake Erie on sand and beach gravel deposits underlain by dense clay tills. Small rivulets divide sections of slumping material where flow is diffuse and the substrate remains saturated throughout the year and. The uplands are almost completely in agriculture (Grape vineyards) with scattered houses bordering State Route 5. *Equisetum arvense and Tussilago farfara* dominate these open forb-graminoid seep. Small *Salix* shrubs provide minimal cover.

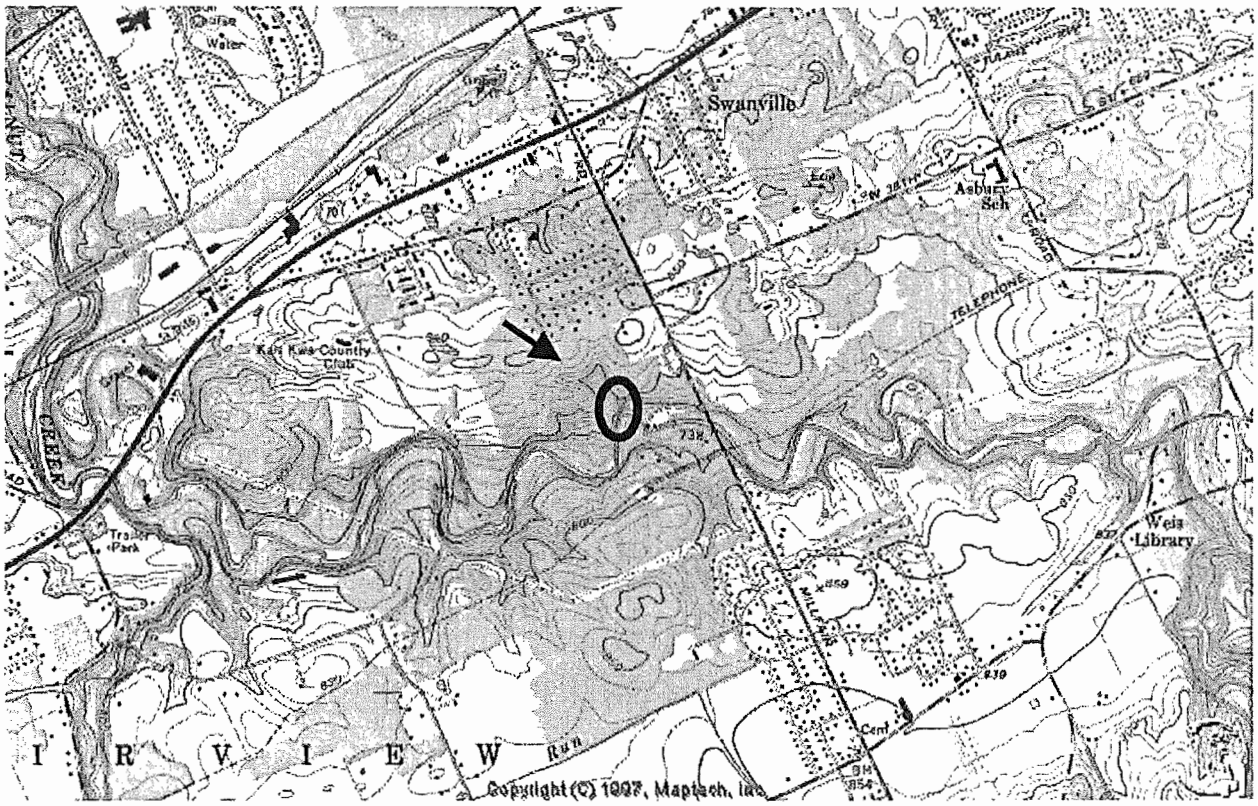


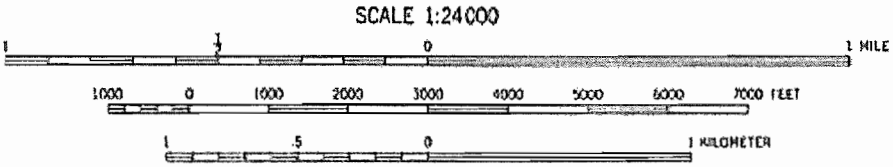


Site: Walnut Creek 2

USGS 7.5' Quadrangle: Swanville, PA		Latitude:	420310
Erie County, Fairview Township		Longitude:	801145
Location: Swanville, 1.5 km SW		Elevation:	238 m

Walnut Creek Seeps #2 lies on the wall of a steep gorge where water exits near the interface of glacial deposits overlying shale bedrock. Flow is strong and perennial and little soil accumulates on these very active seepages. Upland land-use is light residential. *Senecio aureus, Parnasia glauca* and *Carex granularis* account for much of the cover on the unshaded seep.

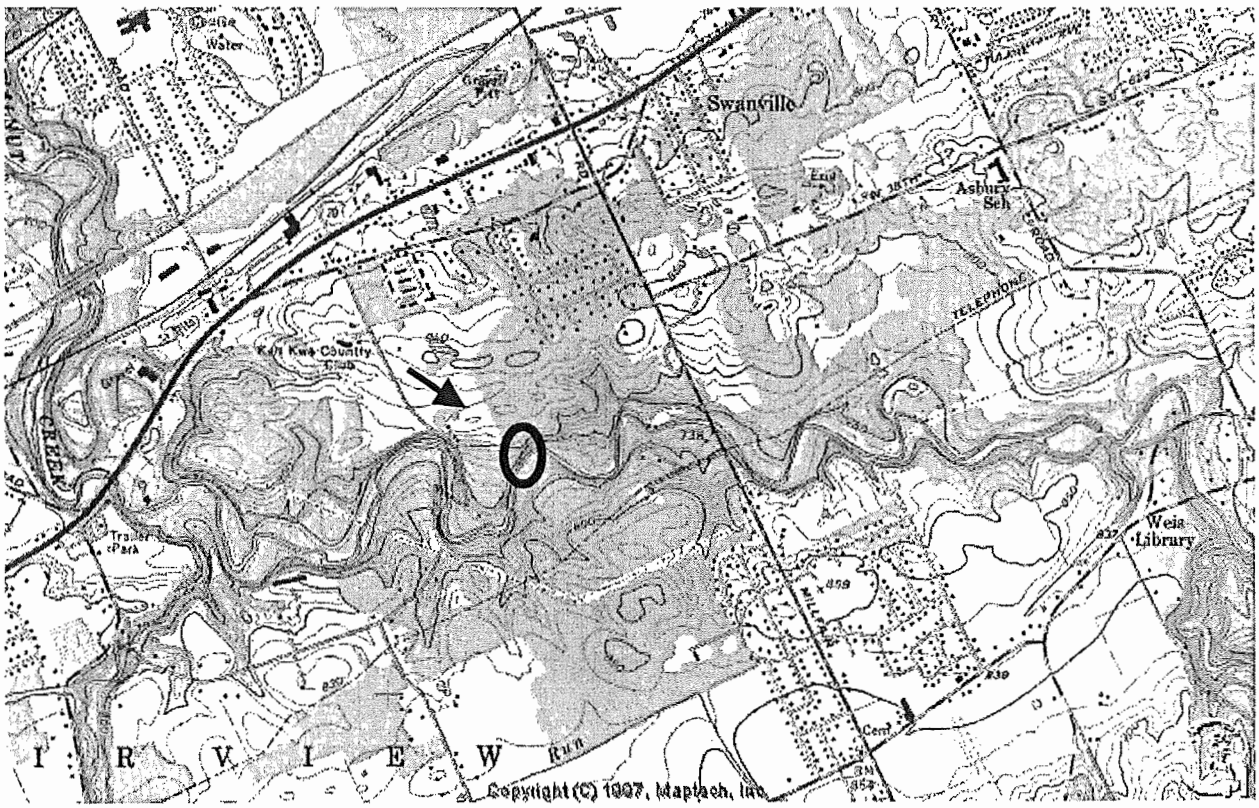


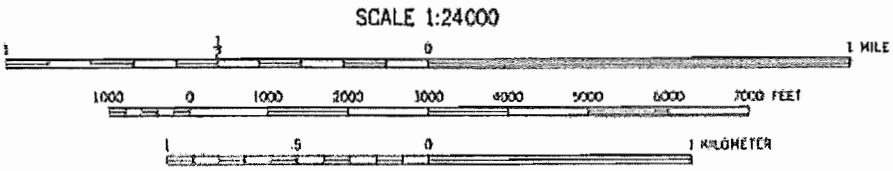


Site: Walnut Creek 1

USGS 7.5' Quadrangle: Swanville, PA		Latitude:	420303
Erie County, Fairview Township		Longitude:	801201
Location: Swanville, 1.3 km SSW		Elevation:	238 m

Walnut Creek Seeps #1 lies on a steep, slumping section of gorge adjacent to a small cave. Water exits near the interface of glacial deposits overlying shale bedrock and flow remains constant throughout the growing season. Land immediately surrounding the seep is forested with residential beyond that forest buffer. Some silty muck accumulates at the edges of the seepage but little soil does so on the active seep. Open and dominated by *Senecio aureus, Impatiens capensis, Eupatorium rugosum*, and *Glyceria striata*, this seep receives shading from the surrounding slope forest.

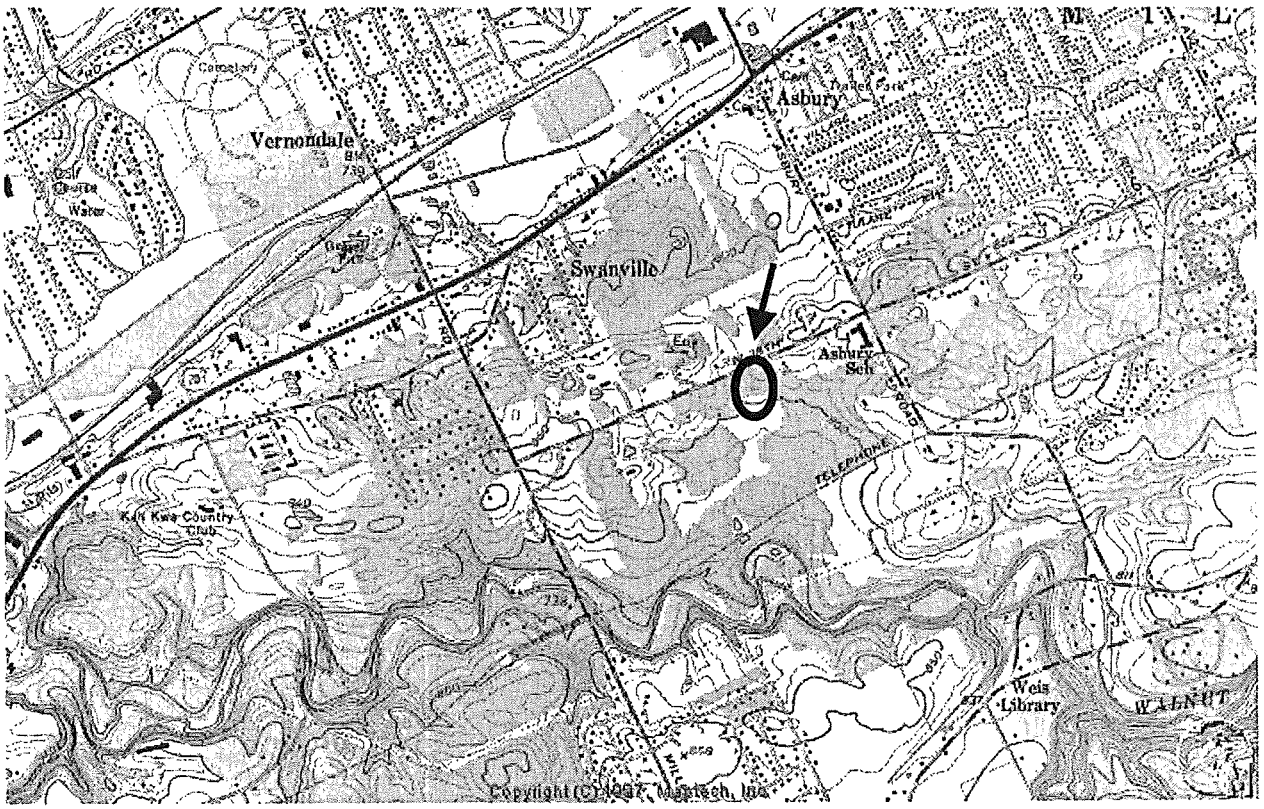


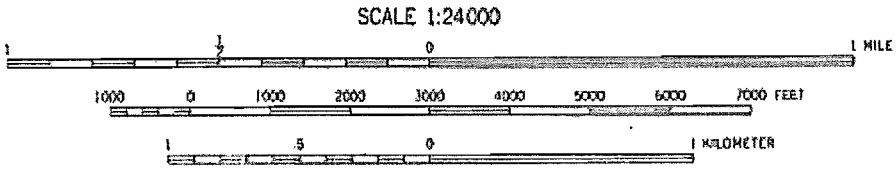


Site: James Preserve Seeps 1 & 2

USGS 7.5' Quadrangle: Swanville, PA		Latitude:	420333
Erie County, Fairview Township		Longitude:	801058
Location: Swanville, 1.0 km SE		Elevation:	232 m

James Preserve Seeps #1 and #2 sit nearly adjacent to one another on a mild slope situated on a ridge of glacial end moraine till along the edge of the lake plain. Water flow is perennial and diffuse with peat over sandy clay substrates remaining saturated throughout the year. Much of the site is part of reverting pasture land and residential development and a golf course sit up-slope from the preserve. Seep #1 and #2 together characterize the patch types found on the site: seep #1 being a shrub and forb dominated with *Rhamnus frangula, Cornus sericea, Senecio aureus*, and *Thelypteris palustris* accounting for much of the cover; seep #2 being forb-graminoid dominated with large amounts of graminoid cover attributed to *Juncus brevicaudatus* and *Eleocharis spp.*.

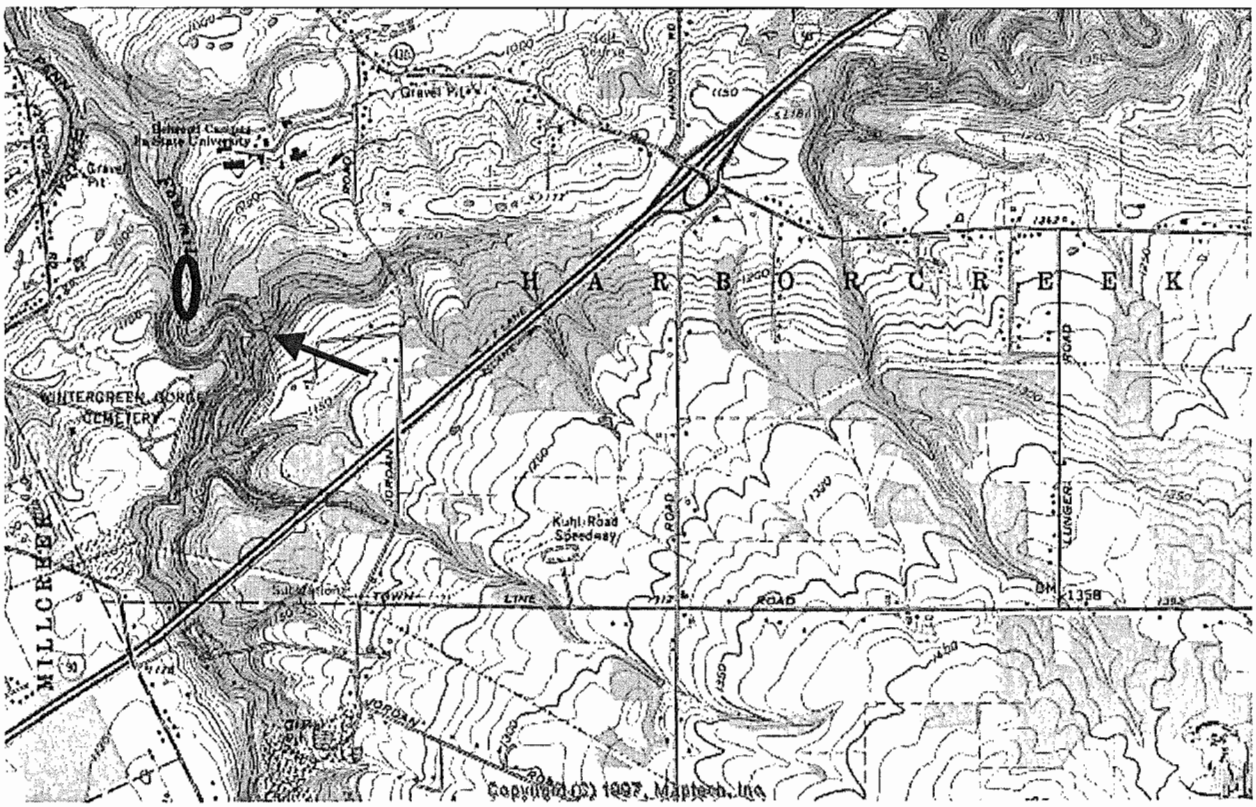


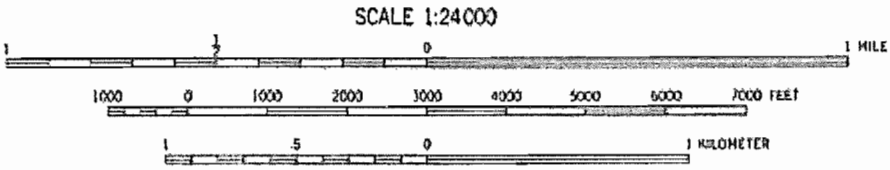


Site: Behrend Slumps 1

USGS 7.5' Quadrangle: Hammett, PA		Latitude:	420652
Erie County, Harborcreek Township		Longitude:	795921
Location: Hammett, 5.6 km NNW		Elevation:	316 m

Behrend Slumps #1 occurs on a gentle sloping bench along the rim of Fourmile Creek on glacial deposits and weathered shale bedrock. Water flow is perennial and diffuse and the peat over clay substrate remains saturated throughout the growing season. The immediate area above the seeps is forested and a nature preserve of Penn State University. Adjacent land is part of the campus facility. The seep supports sparse vegetation under a dense *Lindera benzoin* shrub layer within an *Acer saccharum – Tsuga canadensis* section of forest. *Solidago flexicaulis, Carex scabrata*, and *Arisaema triphyllum* furnish most of the ground cover in this seep.

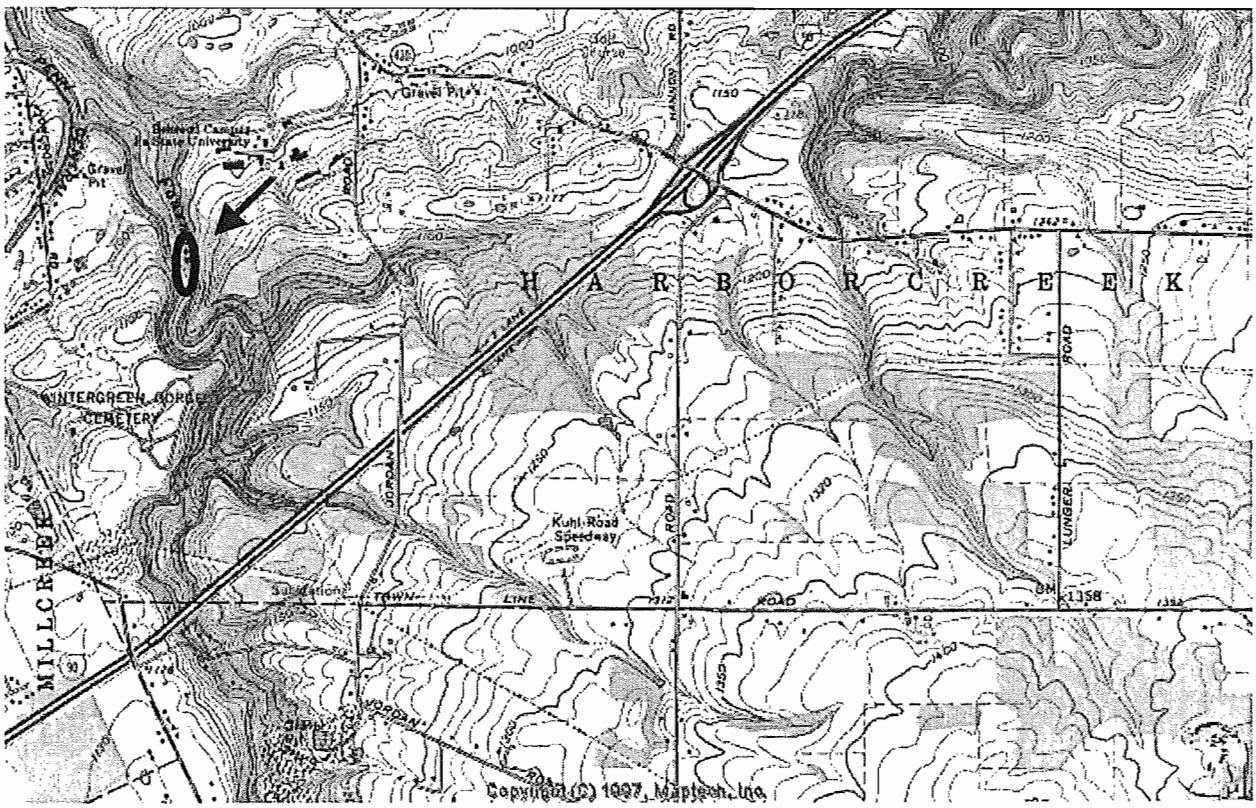


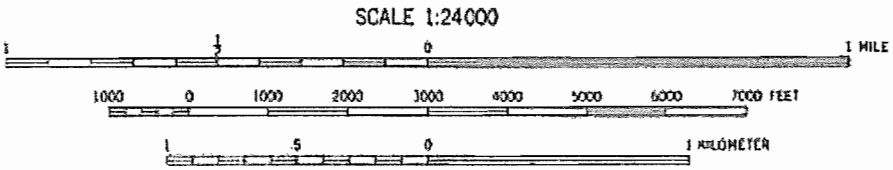


Site: Behrend Slumps 2

USGS 7.5' Quadrangle: Hammett, PA		Latitude:	420652
Erie County, Harborcreek Township		Longitude:	795921
Location: Hammett, 5.6 km NNW		Elevation:	314 m

Behrend Slumps #2 sits on a very steep, slumping slope along the rim of Fourmile Creek on glacial deposits and weathered shale bedrock. Water flow is perennial and diffuse originating along the bedrock interface with up-slope soils. The immediate area above the seeps is forested and a nature preserve of Penn State University. Adjacent land is part of the campus facility. *Tsuga canadensis and Amelanchier arborea* adjacent to the seep provide a partial canopy over the moderately sparse vegetation growing on the seep. *Solanum dulcamara* and *Solidago flexicaulis* provide the bulk of the ground cover on the seep.

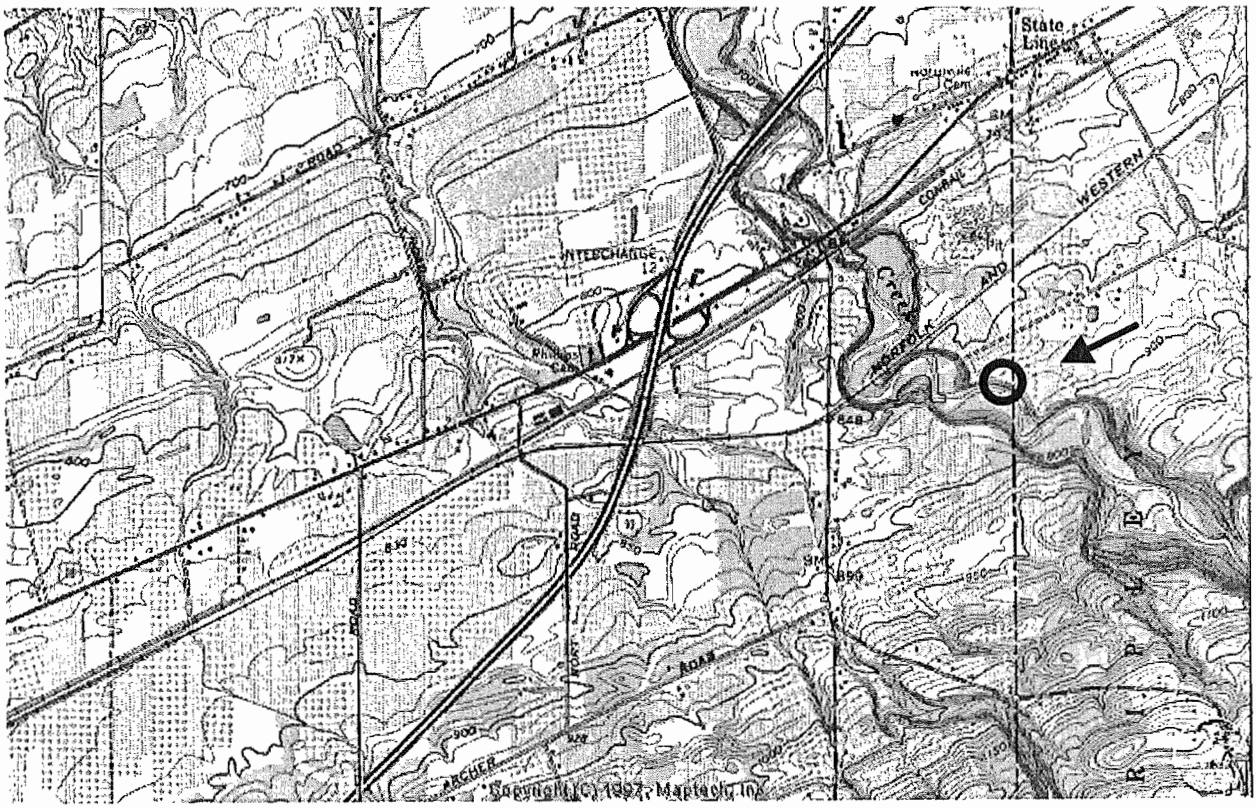


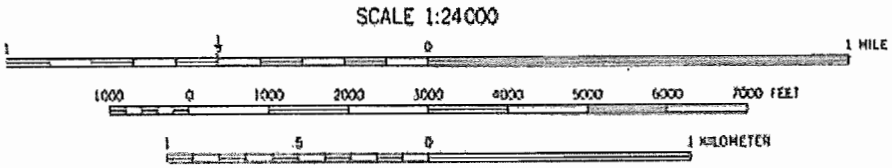


Site: Twentymile Creek Seeps 1

USGS 7.5' Quadrangle: North East, PA		Latitude:	421353
Erie County, North East Township		Longitude:	794548
Location: North East, 5.1 km ENE		Elevation:	213 m

Twentymile Creek Seeps #1 sits on the steep south-facing wall of the Twentymile Creek gorge where groundwater exits near the interface of glacial deposits over weathered shale bedrock. Water flow is strong and perennial and little soil accumulates on the exposed shale surface of the seep. Surrounding land-use is agricultural (vineyards) and light residential. Forbs and graminoids dominate the seep with *Senecio aureus, Juncus tenuis*, and *Panicum lanuginosum* accounting for much of the cover.

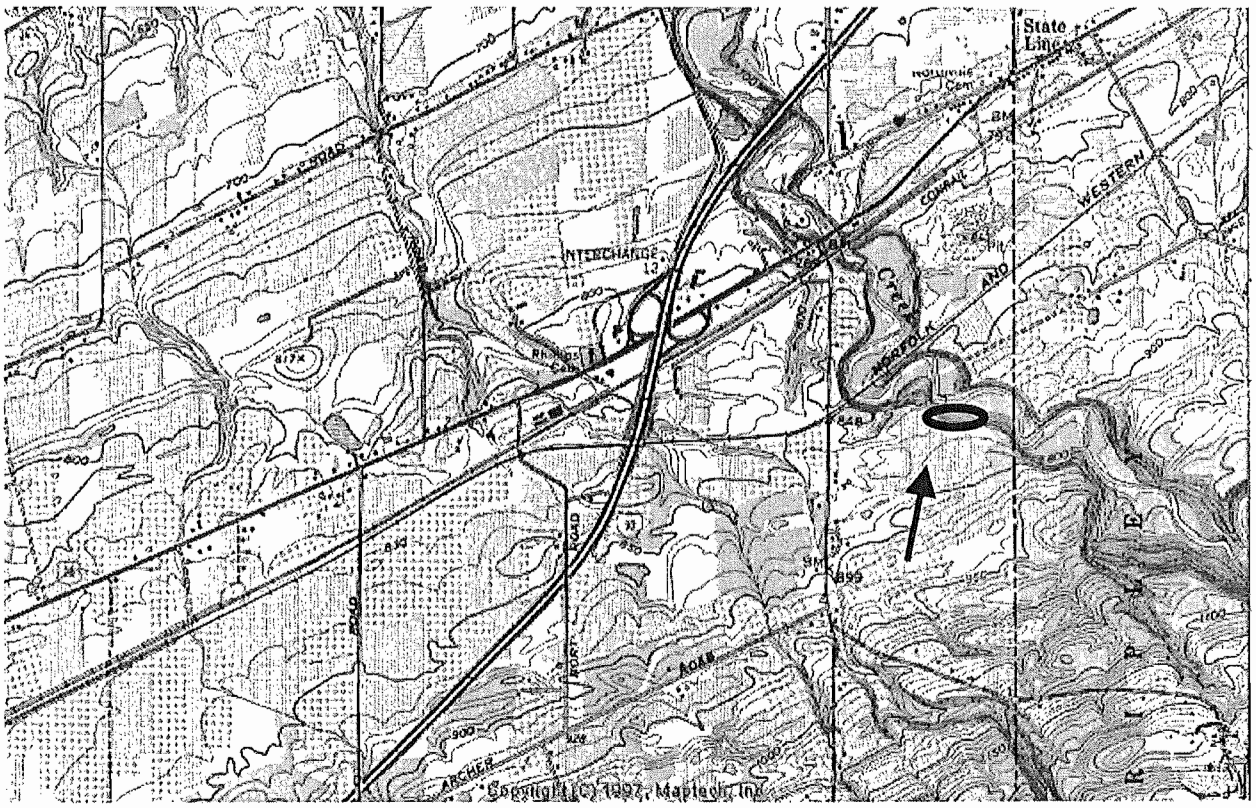


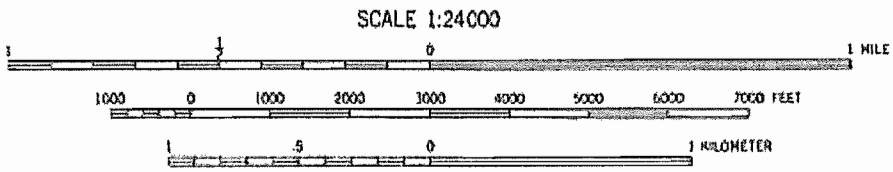


Site: Twentymile Creek Seeps 2

USGS 7.5' Quadrangle: North East, PA	Latitude:	421352
Erie County, North East Township	Longitude:	794548
Location: North East, 5.1 km ENE	Elevation:	225 m

Twentymile Creek Slumps #2 sits on the steep north-facing wall of the Twentymile Creek gorge where groundwater exits near the interface of glacial deposits over weathered shale bedrock. Water flow is strong and perennial and little soil accumulates on the exposed shale surface of the seep. Surrounding land-use is agricultural (vineyards) and light residential. This forb -dominated seep is open but receives shade from the slope above. *Impatiens pallida*, *Chelone glabra, Eupatorium maculatum*, and *Lycopus uniflorus* account for the majority of the cover.

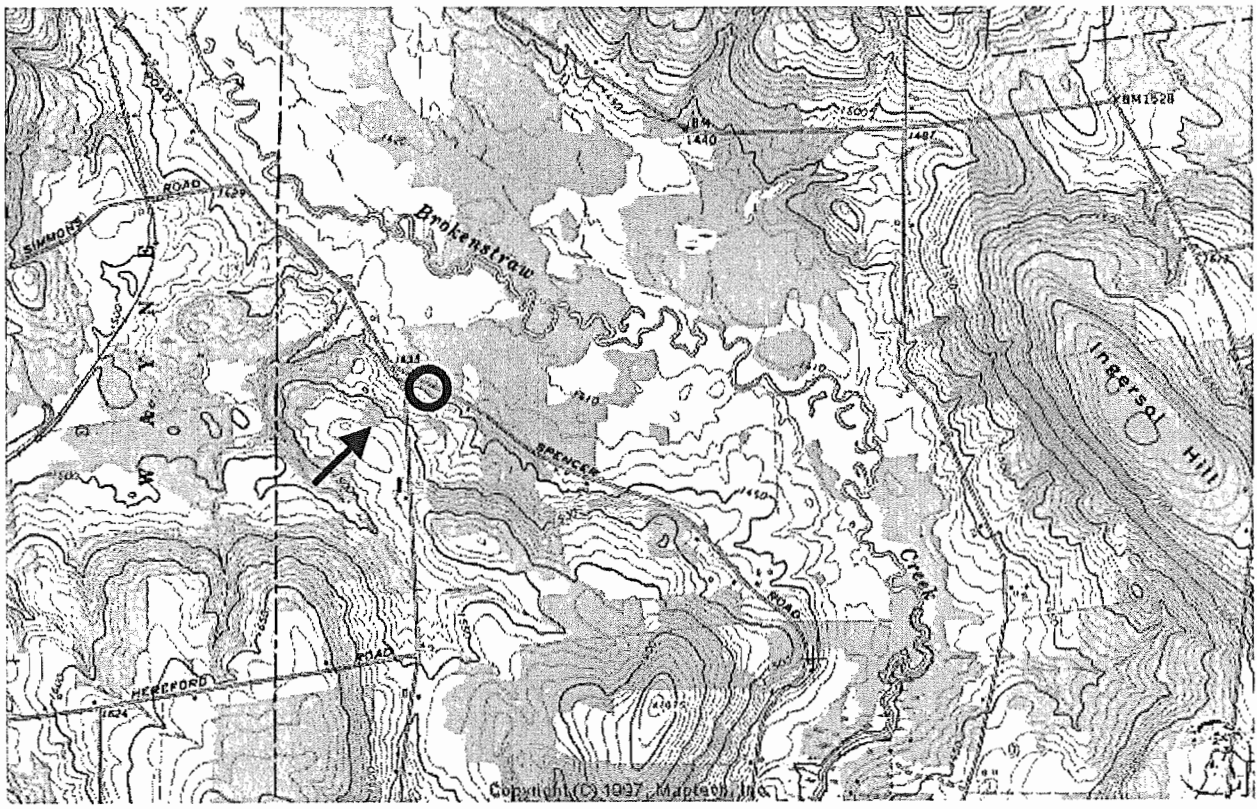


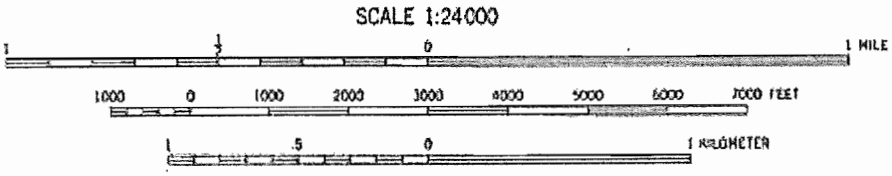


Site: Spencer-Plank Road Seeps

USGS 7.5' Quadrangle: Columbus, PA		Latitude:	415807
Warren County, Columbus Township		Longitude:	793607
Location: Columbus, 3.5 km NNW		Elevation:	439 m

Spencer-Plank Road Seeps sits on the lower slope of a kame-hill within the Brokenstraw Creek Valley. Water flow is strong and perennial with the mucky-peat over clay loam substrate remaining saturated throughout the growing season. Surrounding land-use is agricultural with corn fields and dairy pasture up-slope of the seep. The seep itself is open, sparsely vegetated with *Symplocarpus foetidus*, *Equisetum arvense*, and Chelone glabra producing the majority of the cover. *Prunus serotina* and *Carpinus caroliniana* growing on the slope shade the seep considerably.

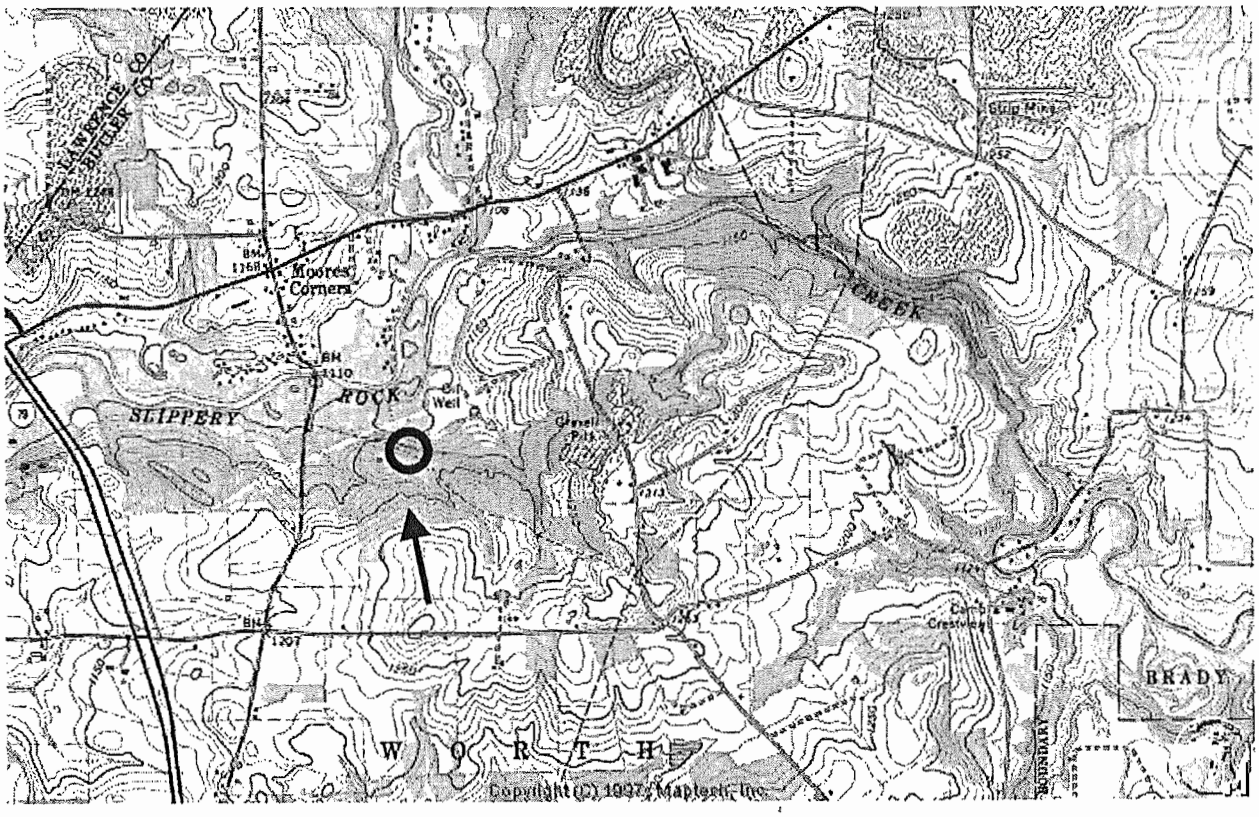


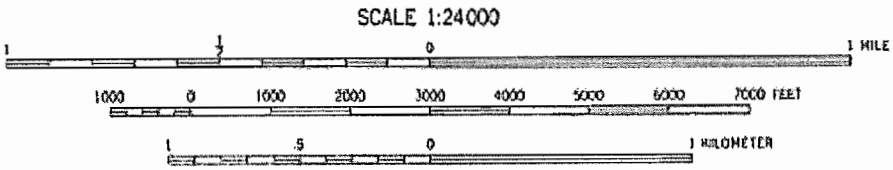


Site: Moores Corners Seeps 1&2

USGS 7.5' Quadrangle: Slippery Rock, PA		Latitude:	410208
Butler County, Worth Township		Longitude:	800630
Location: Moores Corners, 1.0 km SE		Elevation:	351 m

Moores Corners Seeps #1 and #2 lie on the mid-slope of a kame deposit along the Slippery Rock Creek Valley. Water flow is perennial and strong and the sandy gravel substrate remains saturated throughout the growing season. The seeps sit within a forested landscape with reverting pasture and successional forest on the uplands above. The active sections of the both seeps remain free of shrubs and trees and are forb-graminoid dominated. *Symplocarpus foetidus, Chelone glabra, Chrysosplenium americana*, and *Carex scabrata* are prominent species within both seeps. Surrounding forest provides an almost closed canopy above these seeps.

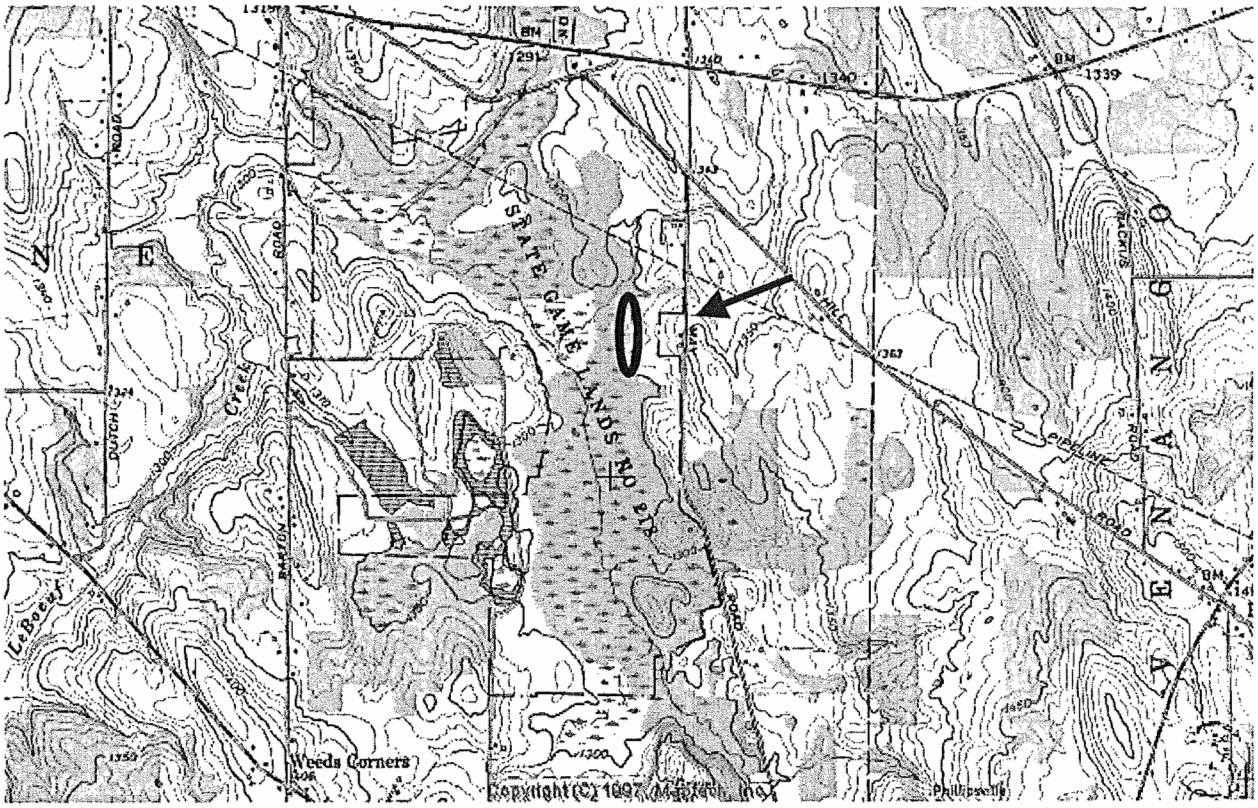


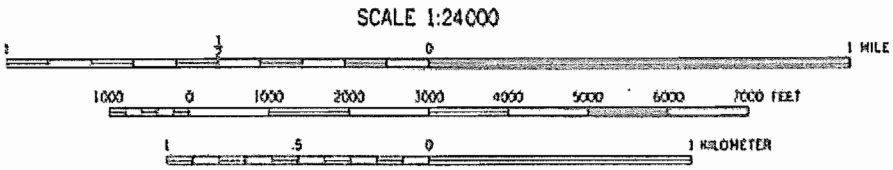


Site: State Game Lands #218

USGS 7.5' Quadrangle: Hammett, PA		Latitude:	420240
Erie County, Greene Township		Longitude:	795457
Location: Phillipsville, 2.5 km WNW		Elevation:	396 m

The State Game Lands #218 Seeps sit on a mild slope at the edge of a large kame deposit near the headwaters of Le Boeuf Creek. Water flow is diffuse and although it decreases slightly as the growing season proceeds, the peat and muck over clay substrate remains moist and in some places saturated throughout the year. Surrounding land-use is a mix of agriculture and low density residential. This seeps sits within a Tsuga canadensis – *Betula alleghaniensis* forest and receives a moderate amount of shading. *Symplocarpus foetidus*, *Carex stipata*, *Tiarella cordifolia*, and *Glyceria striata* are the dominant species in these generally sparsely vegetated seeps.

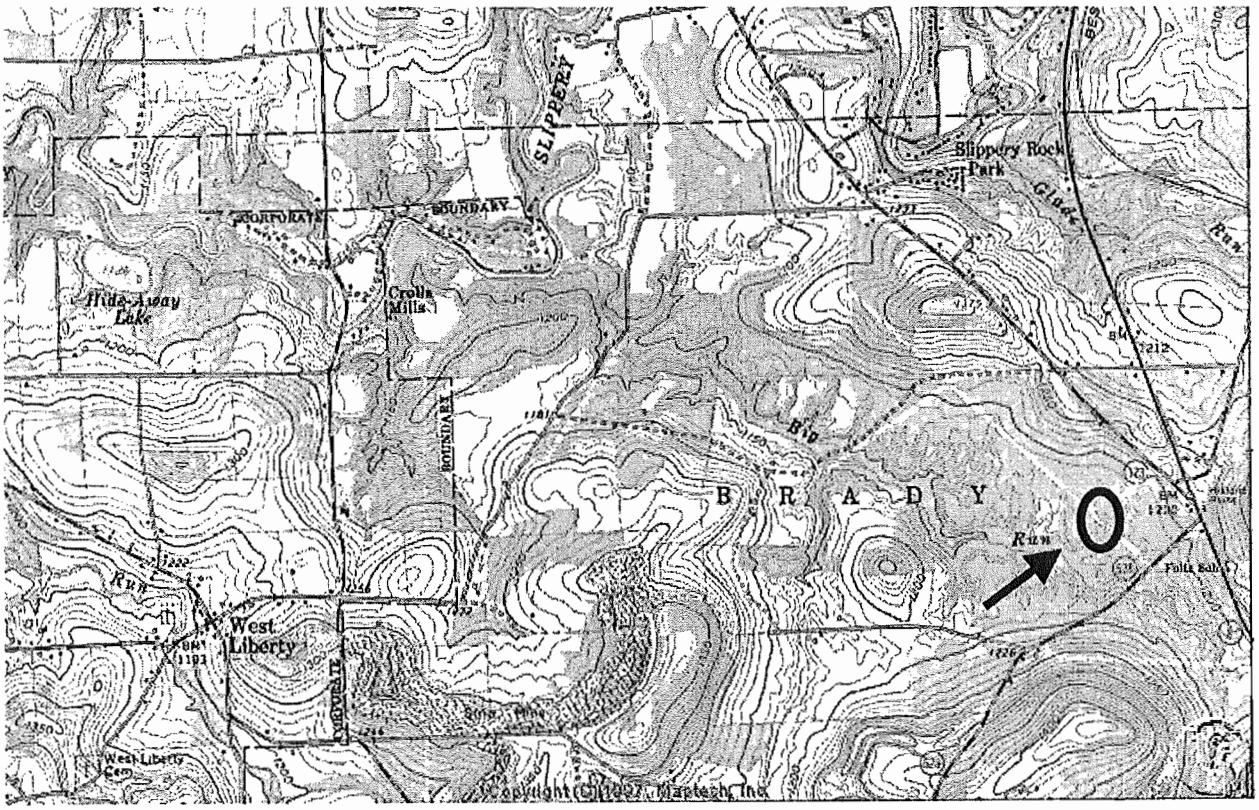


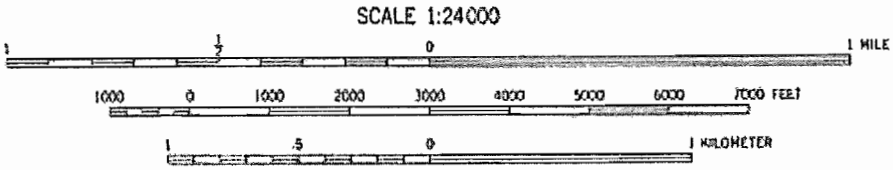


Site: Jennings Prairie Seeps

USGS 7.5' Quadrangle: Slippery Rock, PA		Latitude:	410044
Butler County, Brady Township		Longitude:	800023
Location: West Liberty, 4.0 km East		Elevation:	354 m

Jennings Prairie Seeps lie on a mild slope in an area of pro-glacial lake deposits along a tributary to Slippery Rock Creek. Water flow is diffuse and ephemeral and the humic-clay over dense clay substrate which is saturated in the Spring becomes drier later in the growing season. Located with a Pennsylvania Bureau of State Parks environmental education facility, land surrounding the seeps is managed prairie and young woodland. Several major roads border the facility to the east and south. This forb-graminoid dominated seep is open but does contain a significant shrub component (*Physocarpus opulifolius, Cornus spp.*). *Carex stricta* and *C. bromoides* account for a large percentage of the cover and forbs like *Symplocarpus foetidus* and *Solidago patula* stand out prominently.

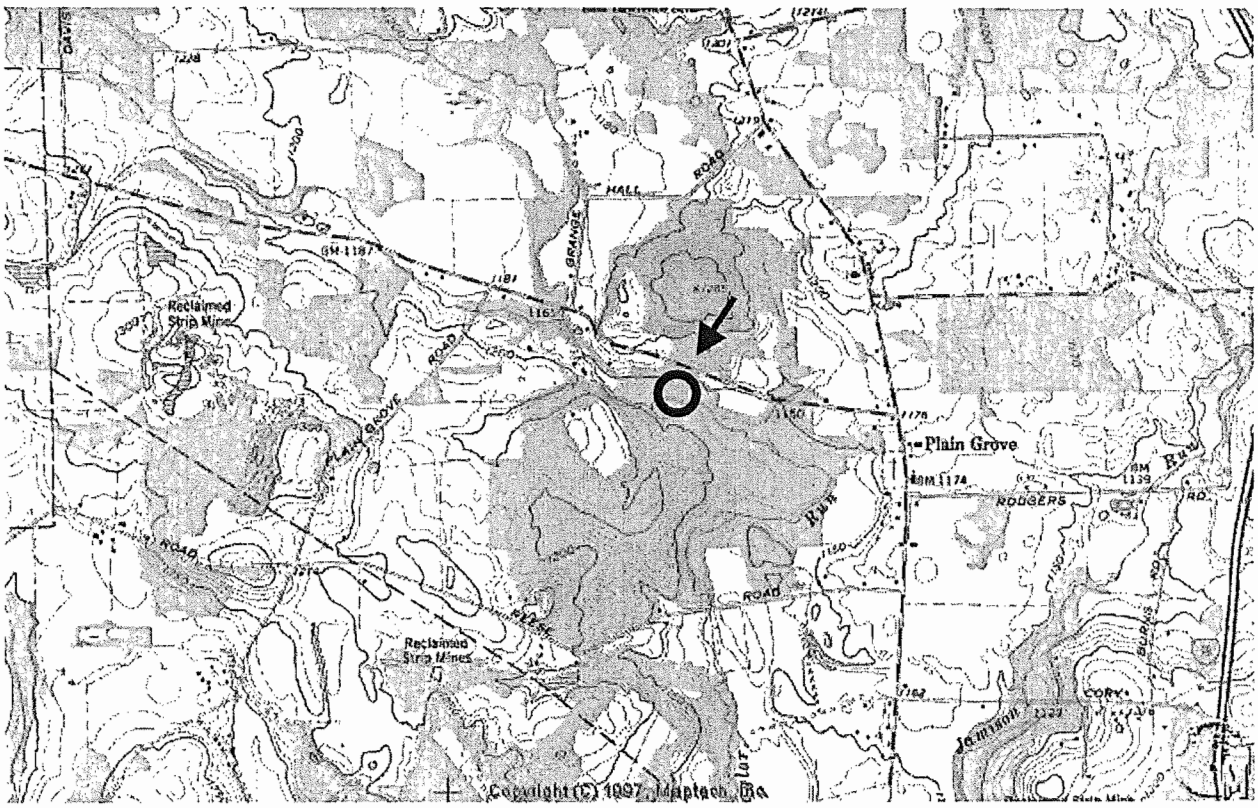


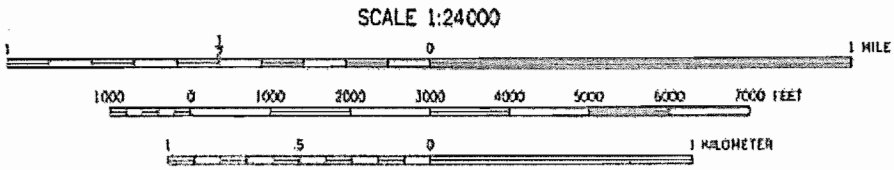


Site: Plain Grove Fens Seep

USGS 7.5' Quadrangle: Harlansburg, PA		Latitude:	410327
Lawrence County, Plain Grove Township		Longitude:	800915
Location: Plain Grove, 1.0 km East		Elevation:	351 m

Plain Grove Fens Seep sits on a mild slope near the base of an isolated kame deposit just above the narrow floodplain of Taylor Run. Water flow in this seep is strong and fluctuates little throughout the growing season. Peat accumulates at the edges of the shrubby edges of the seep but the strongly flowing section remains open with exposed gravel and sand on the surface. Agriculture is the dominant surrounding land-use and several gravel mines occur just beyond the site. The moss, *Tomenthypnum nitens*, along with *Carex tetanica, Selaginella apoda*, and *Pycnanthemum virginiana* account for the majority of cover.

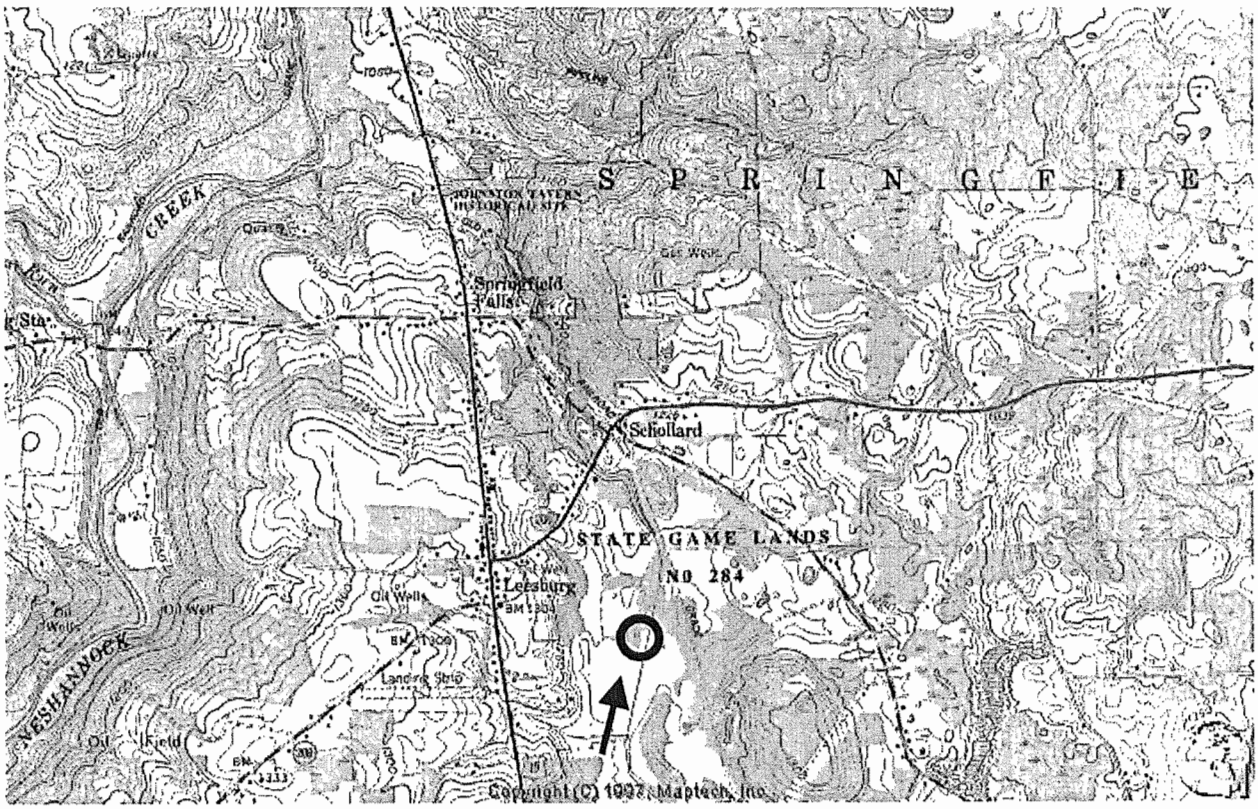


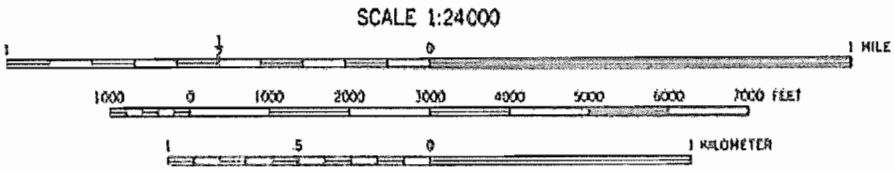


Site: State Game Lands #284

USGS 7.5' Quadrangle: Mercer, PA		Latitude:	410752
Mercer County, Springfield Township		Longitude:	801248
Location: Leesburg, 0.6 km SE		Elevation:	369 m

The State Game Lands #284 seep occurs on the toeslope of a kame deposit at the edge of a large wetlands complex. Water flow is ephemeral and diffuse, the organic upper layer of soil drying down considerably later in the growing season. Surrounding land is active and abandoned agriculture and reverting forest. The seep is forb-graminoid dominated by *Carex stricta* and forbs like *Angelica atropupurea*, *Solidago canadensis*, and *Solidago patula*.





Appendix I: Vascular and Non-vascular Plants within Pennsylvania Seepage Wetland Study Plots

(species and %cover)

Chrome Serpentine Barrens Seeps 1

Acer rubrum	1
Agalinis purpurea	1
Carex echinata	8
Carex gynandra	1
Carex hystericina	2
Carex stipata	1
Cerastium arvense	3
Cirsium ~~vulgare~~ muticum	1
Cyperus strigosus	1
Deschampsia cespitosa	45
Eleocharis elliptica	2
Eupatorium perfoliatum	1
Glyceria striata	1
Juncus subcaudatus	1
Juncus tenuis	1
Leersia oryzoides	45
Lycopus uniflorus	2
Microstegium vimineum	1
Muhlenbergia mexicana	1
Polygonum punctatum	2
Polygonum sagittatum	3
Pycnanthemum virginianum	1
Scirpus validus	1
Sorghastrum nutans	1
Aulacomium palustre	1
Campylium polygamum	2
Philonotis capillaris	2

Chrome Serpentine Barrens Seeps 2

Alnus serrulata	1
Anthoxanthum odoratum	1
Carex hystericina	1
Carex interior	2
Carex stipata	2
Cerastium arvense	3
Cyperus strigosus	1
Deschampsia cespitosa	28
Eleocharis tenuis	8
Glyceria striata	1
Impatiens capensis	1
Juncus tenuis	1
Leersia oryzoides	25
Lycopus uniflorus	1
Microstegium vimineum	1
Muhlenbergia mexicana	1
Oxalis stricta	1
Panicum clandestinum	1
Panicum philadelphicum	1
Polygonum punctatum	1
Polygonum sagittatum	1
Pycnanthemum virginianum	1
Sorghastrum nutans	1
Vernonia noveboracensis	1
Philonotis capillaris	1

Nottingham Serpentine Barrens Seeps 1

Acer rubrum	1
Achillea millefolium	1
Amphicarpaea bracteata	1
Aster lateriflorus	1
Boehmeria cylindrica	1
Carex hystericina	1
Carex interior	2
Carex stipata	1
Cerastium arvense	1
Cirsium ~~vulgare~~ muticum	1
Cyperus strigosus	1
Deschampsia cespitosa	50
Eleocharis elliptica	1
Eupatorium maculatum	1
Eupatorium perfoliatum	1
Glyceria striata	1
Helianthus decapetalus	1
Juncus tenuis	1
Leersia oryzoides	1
Lindera benzoin	1
Lycopus uniflorus	1
Microstegium vimineum	1
Muhlenbergia mexicana	1
Oxalis stricta	1
Panicum clandestinum	20
Polygonum punctatum	1
Polygonum sagittatum	1
Smilax rotundifolia	1
Vaccinium corymbosum	1
Vernonia noveboracensis	5
Campylium polygamum	1
Philonotis capillaris	1

Appendix I (cont.)

Nottingham Serpentine Barrens Seeps 2

Acer rubrum	1
Agalinis purpurea	1
Alnus serrulata	1
Carex interior	1
Cirsium ~~vulgare~~ muticum	1
Cyperus strigosus	1
Deschampsia cespitosa	25
Eleocharis elliptica	50
Eupatorium maculatum	1
Eupatorium perfoliatum	7
Glyceria striata	1
Helianthus giganteus	1
Leersia oryzoides	10
Lycopus uniflorus	5
Microstegium vimineum	4
Panicum clandestinum	1
Polygonum punctatum	2
Polygonum sagittatum	3
Rhynchospora alba	1
Sanguisorba canadensis	5
Scirpus validus	5
Symplocarpus foetidus	2
Vernonia noveboracensis	2
Viola pallens	10
Campylium polygamum	1
Philonotis capillaris	1

Warwick Seeps

Acer rubrum	45
Agrimonia gryposepala	1
Amphicarpaea bracteata	1
Arisaema triphyllum	5
Asarum canadense	1
Aster divaricatus	3
Aster lateriflorus	1
Aster prenanthoides	1
Berberis thunbergii	1
Boehmeria cylindrica	1
Carex gracillima	1
Carex laxiculmis	1
Carex prasina	1
Carex radiata	1
Cinna arundinacea	1
Circaea lutetiana	1
Clematis virginiana	1
Collinsonia canadensis	2
Cryptotaenia canadensis	1
Dioscorea villosa	1
Dryopteris carthusiana	1
Equisetum hyemale	1
Eupatorium rugosum	5
Fraxinus pennsylvanica	15
Galium lanceolatum	1
Galium obtusum	1
Galium triflorum	1
Geranium maculatum	1
Geum sp. 1	1
Glyceria striata	5
Ilex verticillata	1
Impatiens capensis	1
Leersia virginica	1
Lindera benzoin	6
Liriodendron tulipifera	1
Lonicera japonica	1
Onoclea sensibilis	1
Osmunda cinnamomea	1
Parthenocissus quinquefolia	20
Poa trivialis	1
Podophyllum peltatum	1
Polygonatum pubescens	1
Polygonum virginianum	1
Quercus bicolor	5
Ranunculus abortivus	1
Ranunculus recurvatus	1
Rosa multiflora	1
Scutellaria lateriflora	1
Solidago rugosa	1
Stellaria graminea	1
Symplocarpus foetidus	1
Toxicodendron radicans	3
Ulmus americana	35
Vaccinium corymbosum	1
Viburnum dentatum	5
Viburnum prunifolium	2
Viola cucullata	1
Brachythecium rivulare	5
Climaceum americanum	7
Eurhychium pulchellum	2
Eurhynchium riparioides	8
Plagiomnium cuspidatum	18
Plagiothecium laetum	3
Thuidium delicatulum	8
Thuidium recognitum	1

Trythall Woods Seeps

Acer rubrum	5
Acer saccharum	5
Arisaema triphyllum	1
Aster divaricatus	1
Athyrium thelypterioides	5
Cardamine pensylvanica	1
Carex bromoides	5
Cryptotaenia canadensis	1
Dryopteris carthusiana	2
Dryopteris intermedia	1
Fraxinus nigra	30
Fraxinus pennsylvanica	10
Galium aparine	1
Glyceria striata	2
Hydrocotyle americana	1
Impatiens capensis	1
Leersia virginica	1
Lindera benzoin	12
Lonicera japonica	1
Osmunda cinnamomea	1
Oxalis stricta	1
Parthenocissus quinquefolia	1
Pilea pumila	1
Poa trivialis	10
Polystichum acrostichoides	1
Polygonatum pubescens	1
Polygonum virginianum	1
Prunus virginiana	1
Ranunculus recurvatus	1
Rosa multiflora	1
Sambucus canadensis	6
Symplocarpus foetidus	35
Thelypteris noveboracensis	1
Tilia americana	5
Veratrum viride	2
Viburnum prunifolium	5
Vitis labrusca	3
Amblystegium noterophilum	1
Amblystegium tenax	5
Brachythecium rutabulum	5
Brachythecium sp.	3
Bryhnia novae-angliae	3
Cirriphyllum piliferum	1
Cladonia sp. 2	1
Dicranella heteromalla	1
Hygrohypnum luridum	2
Plagiomnium ciliare	1
Plagiothecium laetum	1
Rhizomnium punctatum	1
Thuidium delicatulum	9
Thuidium recognitum	2

Appendix I (cont.)

West Branch Pine Creek Tributary Seeps	
Acer rubrum	35
Arisaema triphyllum	1
Aster divaricatus	1
Aster puniceus	1
Athyrium filix-femina	1
Boehmeria cylindrica	1
Cardamine pensylvanica	1
Carex lurida	1
Carex prasina	1
Chelone glabra	1
Chrysosplenium americanum	2
Cinna arundinacea	1
Dryopteris carthusiana	2
Fraxinus americana	1
Geum sp. 1	1
Glyceria striata	1
Ilex verticillata	12
Impatiens capensis	60
Juncus effusus	1
Lindera benzoin	20
Osmorhiza sp.	1
Osmunda cinnamomea	1
Pilea pumila	2
Poa trivialis	5
Polygonum arifolium	5
Ranunculus recurvatus	1
Rosa multiflora	1
Sambucus canadensis	1
Scutellaria lateriflora	1
Solidago rugosa	1
Symplocarpus foetidus	60
Veratrum viride	1
Viola cucullata	5
Amblystegium tenax	7
Bryhnia sp.	10
Pallavicina lyelli	2
Rhynchostegium serrulatum	1
Thuidium delicatulum	7
Thuidium recognitum	4

Dale Seeps 1	
Acer rubrum	75
Alliaria petiolata	1
Arisaema triphyllum	1
Aster divaricatus	2
Athyrium filix-femina	1
Carex leptalea	1
Chelone glabra	1
Circaea lutetiana	1
Dryopteris carthusiana	1
Dryopteris intermedia	1
Fraxinus nigra	1
Galium triflorum	1
Impatiens capensis	20
Leersia virginica	1
Lindera benzoin	20
Lythrum salicaria	1
Nyssa sylvatica	2
Osmorhiza sp.	1
Osmunda cinnamomea	1
Pilea pumila	1
Poa trivialis	1
Podophyllum peltatum	1
Prenanthes sp. 1	1
Ranunculus recurvatus	1
Rubus alleghaniensis	1
Smilacina racemosa	1
Smilax rotundifolia	2
Solidago flexicaulis	1
Symplocarpus foetidus	65
Viola cucullata	3
Brachythecium rutabulum	1
Dicranella cerviculata	3
Rhynchostegium serrulatu	5
Thuidium delicatulum	6
Thuidium recognitum	1

Dale Seeps 2	
Acer rubrum	1
Alnus serrulata	10
Arisaema triphyllum	1
Aster puniceus	1
Athyrium thelypterioides	1
Betula alleghaniensis	1
Betula lenta	2
Cardamine pensylvanica	1
Carex prasina	2
Chelone glabra	1
Chrysosplenium americanum	2
Cinna arundinacea	1
Fraxinus nigra	2
Hydrophyllum virginianum	1
Ilex verticillata	8
Impatiens capensis	2
Leersia virginica	1
Lindera benzoin	6
Osmunda cinnamomea	1
Parthenocissus quinquefolia	1
Pilea pumila	1
Poa trivialis	2
Ranunculus abortivus	1
Ranunculus recurvatus	1
Rubus alleghaniensis	1
Rumex obtusifolius	1
Sambucus canadensis	1
Scutellaria lateriflora	1
Smilacina racemosa	1
Solidago flexicaulis	1
Symplocarpus foetidus	37
Thalictrum pubescens	1
Viola blanda	1
Viola cucullata	5
Brachythecium rivulare	1
Brachythecium rutabulum	1
Dicranella cerviculata	2
Rhynchostegium serrulatum	5
Thuidium delicatulum	7

Appendix I (cont.)

Perklomen Tributary Seeps

Acer rubrum	3
Amphicarpaea bracteata	1
Arisaema triphyllum	1
Aster divaricatus	1
Athyrium filix-femina	1
Athyrium thelypterioides	1
Boehmeria cylindrica	1
Carex laevivaginata	1
Carex leptalea	1
Carex prasina	5
Carex radiata	1
Carex scabrata	1
Carpinus caroliniana	1
Chelone glabra	1
Chrysosplenium americanum	20
Festuca subverticillata	1
Fraxinus pennsylvanica	10
Galium triflorum	1
Glyceria striata	1
Ilex verticillata	1
Impatiens capensis	45
Laportea canadensis	1
Leersia virginica	1
Lindera benzoin	15
Onoclea sensibilis	1
Osmunda cinnamomea	1
Parthenocissus quinquefolia	1
Pilea pumila	5
Poa trivialis	10
Polystichum acrostichoides	1
Polygonum caespitosum	1
Polygonum virginianum	1
Prunus virginiana	1
Ranunculus abortivus	1
Ranunculus recurvatus	1
Rosa multiflora	1
Rumex obtusifolius	1
Sambucus canadensis	2
Saxifraga pensylvanica	1
Scutellaria lateriflora	1
Smilacina racemosa	1
Symplocarpus foetidus	12
Toxicodendron radicans	1
Viola cucullata	10
Amblystegium tenax	1
Rhynchostegium serrulatum	8
Thuidium recognitum	12

Robert Rodale Reserve Seeps

Acer rubrum	10
Alnus incana	4
Anemone quinquefolia	1
Arisaema triphyllum	5
Athyrium filix-femina	1
Athyrium thelypterioides	5
Berberis thunbergii	1
Cardamine pensylvanica	1
Carex prasina	1
Chrysosplenium americanum	5
Collinsonia canadensis	1
Dioscorea villosa	1
Dryopteris intermedia	2
Fraxinus pennsylvanica	4
Galium triflorum	1
Hamamelis virginiana	1
Ilex verticillata	1
Impatiens capensis	20
Leersia virginica	1
Lindera benzoin	8
Liriodendron tulipifera	55
Osmunda cinnamomea	3
Parthenocissus quinquefolia	1
Pilea pumila	1
Poa trivialis	1
Polystichum acrostichoides	1
Prenanthes sp. 1	1
Ranunculus recurvatus	1
Rhododendron viscosum	1
Sambucus canadensis	1
Smilacina racemosa	1
Symplocarpus foetidus	55
Thalictrum pubescens	1
Toxicodendron radicans	1
Veratrum viride	1
Viola cucullata	2
Amblystegium tenax	1
Brachythecium salebrosum	1
Bryhnia novae-angliae	1
Thuidium delicatulum	6
Thuidium recognitum	12

Getz Swamp Seep

Acer rubrum	65
Acer saccharum	1
Alliaria petiolata	1
Alnus serrulata	1
Amphicarpaea bracteata	1
Arisaema triphyllum	1
Aster divaricatus	1
Aster puniceus	1
Aster sp. 1	1
Aster umbellatus	1
Berberis thunbergii	1
Betula alleghaniensis	1
Boehmeria cylindrica	1
Caltha palustris	1
Cardamine pensylvanica	1
Carex blanda	1
Carex gracillima	1
Carex laevivaginata	1
Carex stipata	1
Carex stricta	1
Carpinus caroliniana	1
Chelone glabra	1
Cicuta maculata	1
Cirsium ~~vulgare~~ muticum	1
Collinsonia canadensis	1
Cornus racemosa	1
Cryptotaenia canadensis	1
Dioscorea villosa	1
Dryopteris cristata	1
Dryopteris intermedia	1
Equisetum arvense	1
Eupatorium rugosum	1
Fraxinus pennsylvanica	8
Galium circaezans	1
Galium triflorum	1
Geranium maculatum	1
Geum canadense	1
Glyceria striata	1
Ilex verticillata	1
Impatiens capensis	30
Iris versicolor	1
Lactuca sp.	1
Leersia virginica	1
Lemna sp.	1
Lindera benzoin	40
Liriodendron tulipifera	20
Lobelia siphilitica	1
Lycopus uniflorus	1
Lysimachia ciliata	1
Lysimachia nummularis	1
Lythrum salicaria	1
Malanthemum canadense	1
Microstegium vimineum	1
Mitchella repens	1
Mitella diphylla	1
Onoclea sensibilis	1
Osmunda cinnamomea	1
Parthenocissus quinquefolia	1
Pilea pumila	2
Poa trivialis	1
Polygonum arifolium	1
Polygonatum pubescens	1
Prenanthes sp. 1	1
Prunella vulgaris	1
Ranunculus abortivus	1
Ranunculus hispidus	1

Appendix I (cont.)

Getz Swamp Seep (cont.)

Ranunculus recurvatus	1
Rosa multiflora	1
Rubus hispidus	1
Rubus pubescens	1
Sambucus canadensis	1
Sanicula sp.	1
Saxifraga pensylvanica	1
Scutellaria lateriflora	1
Smilacina racemosa	1
Smilax rotundifolia	1
Solidago gigantea	1
Solidago patula	1
Solidago rugosa	1
Symplocarpus foetidus	25
Thalictrum pubescens	1
Thelypteris palustris	1
Toxicodendron radicans	1
Toxicodendron vernix	1
Trollius laxus	1
Ulmus americana	12
Viburnum dentatum	10
Viburnum lentago	1
Viburnum prunifolium	1
Viola cucullata	1
Vitis labrusca	1
Wolffia sp.	1
Zizia aurea	1
Amblystegium serpens	4
Amblystegium trichopodium	1
Atrichum crispum	1
Barbula fallax	1
Brachythecium oxycladon	1
Brachythecium rivulare	1
Bryhnia novae-angliae	1
Climaceum americanum	1
Plagiomnium ciliare	1
Plagiomnium cuspidatum	1
Plagiothecium laetum	5
Rhynchostegium serrulatum	3
Sphagnum fimbriatum	1
Thuidium delicatulum	7
Thuidium recognitum	4

Lake Poco Seep

Acer rubrum	60
Allium sp.	1
Arisaema triphyllum	5
Aster divaricatus	1
Aster lateriflorus	1
Aster puniceus	1
Berberis thunbergii	1
Betula alleghaniensis	20
Caltha palustris	1
Cardamine concatenata	1
Cardamine pensylvanica	1
Carex radiata	1
Carex scabrata	2
Chelone glabra	1
Chrysosplenium americanum	2
Conioselinum chinense	2
Coptis trifolia	1
Cryptotaenia canadensis	3
Dryopteris intermedia	1
Fraxinus nigra	3
Fraxinus pennsylvanica	2
Galium triflorum	1
Hamamelis virginiana	40
Impatiens capensis	3
Lindera benzoin	20
Luzula multiflora	1
Maianthemum canadense	1
Mitchella repens	1
Mitella diphylla	1
Osmunda cinnamomea	1
Parthenocissus quinquefolia	1
Pilea pumila	5
Poa trivialis	1
Polygonatum pubescens	1
Prenanthes sp. 1	1
Ranunculus hispidus	1
Ranunculus recurvatus	1
Rhododendron viscosum	2
Rosa multiflora	1
Sambucus canadensis	1
Sassafras albidum	5
Saxifraga pensylvanica	1
Senecio aureus	1
Smilacina racemosa	1
Symplocarpus foetidus	15
Toxicodendron radicans	1
Toxicodendron vernix	1
Vaccinium corymbosum	2
Viburnum prunifolium	1
Viola conspersa	1
Viola cucullata	2
Amblystegium tenax	5
Brachythecium rivulare	8
Cephalozia lunulifolia	1
Leucobryum glaucum	1
Rhizomnium punctatum	1
Tetraphis pellucida	1
Thuidium delicatulum	1
Thuidium recognitum	4
Trichocolea tomentella	3

Taylor East Seep

Acer rubrum	1
Anemone sp.	1
Aster lateriflorus	1
Aster puniceus	1
Aster umbellatus	1
Berberis thunbergii	3
Betula alleghaniensis	1
Bidens frondosa	1
Bromus ciliatus	1
Carex flava	15
Carex granularis	1
Carex hystericina	1
Carex leptalea	3
Carex sterilis	10
Carex tetanica	1
Carya cordiformis	2
Cicuta maculata	1
Cirsium ~~vulgare~~ muticum	1
Conioselinum chinense	1
Drosera rotundifolia	1
Eleocharis elliptica	1
Equisetum arvense	1
Eriophorum viridicarinatum	1
Eupatorium maculatum	1
Eupatorium perfoliatum	1
Fraxinus nigra	1
Glyceria striata	1
Helenium autumnale	1
Juncus nodosus	1
Juncus sp. 3	1
Juncus tenuis	1
Juniperus virginiana	1
Lactuca sp.	1
Leersia oryzoides	1
Leersia virginica	1
Linum striatum	1
Liriodendron tulipifera	5
Lobelia kalmii	1
Lobelia siphilitica	1
Lonicera morrowii	1
Ludwigia alternifolia	1
Lycopus americanus	1
Lycopus uniflorus	1
Lythrum salicaria	1
Microstegium vimineum	1
Mikania scandens	1
Muhlenbergia frondosa	1
Muhlenbergia glomerata	1
Myrica pensylvanica	1
Osmunda regalis	1
Panicum dichotomum	1
Panicum lanuginosum	1
Parnassia glauca	4
Parthenocissus quinquefolia	2
Penthorum sedoides	1
Phragmites australis	1
Prunella vulgaris	1
Pycnanthemum virginianum	1
Rhynchospora alba	1
Rosa multiflora	1
Rubus alleghaniensis	1
Rubus phoenicolasius	1
Rubus pubescens	1
Selaginella apoda	5
Solidago patula	10
Solidago rugosa	1

Appendix I (cont.)

Taylor East Seep (cont.)

Solidago uliginosa	1
Sphenopholis obtusata	1
Spiranthes cernua	1
Symplocarpus foetidus	10
Thalictrum pubescens	2
Thelypteris palustris	20
Toxicodendron radicans	1
Toxicodendron vernix	10
Tussilago farfara	1
Typha latifolia	1
Vernonia noveboracensis	1
Viola cucullata	3
Aneura pinguis	1
Campylium polygamum	7
Campylium stellatum	22
Fissidens adiantoides	1
Leucobryum glaucum	3
Pohlia sp.	3
Thuidium delicatulum	3

Raesly Woods

Acer rubrum	65
Amphicarpaea bracteata	1
Arisaema triphyllum	1
Aster divaricatus	1
Aster puniceus	1
Berberis thunbergii	1
Boehmeria cylindrica	1
Caltha palustris	1
Cardamine pensylvanica	1
Carex amphibola	1
Carex bromoides	10
Carex gracillima	1
Carex prasina	20
Carex radiata	1
Carpinus caroliniana	1
Dryopteris carthusiana	1
Duchesnea indica	1
Elymus virginicus	1
Fraxinus nigra	3
Fraxinus pennsylvanica	35
Galium obtusum	1
Galium triflorum	1
Geranium maculatum	1
Ilex verticillata	1
Impatiens capensis	40
Iris versicolor	1
Leersia virginica	1
Lindera benzoin	12
Microstegium vimineum	5
Onoclea sensibilis	1
Osmunda regalis	1
Parthenocissus quinquefolia	1
Pilea pumila	2
Poa trivialis	1
Polygonum sagittatum	1
Polygonum virginianum	4
Quercus rubra	1
Ranunculus abortivus	1
Ranunculus hispidus	1
Ranunculus recurvatus	1
Rosa multiflora	1
Rubus alleghaniensis	1
Saxifraga pensylvanica	1
Smilax rotundifolia	1
Solidago gigantea	1
Solidago patula	1
Solidago rugosa	1
Symplocarpus foetidus	10
Thalictrum pubescens	1
Toxicodendron radicans	1
Trollius laxus	1
Ulmus americana	1
Veratrum viride	1
Viola conspersa	1
Viola cucullata	1
Viola pubescens	1
Brachythecium rivulare	1
Brotherella tenuirostris	3
Bryhnia sp.	2
Bryum pseudotriquetrum	2
Cephalozia bicuspidata	1
Cirriphyllum piliferum	1
Climaceum americanum	10
Plagiomnium ciliare	1
Plagiomnium cuspidatum	1
Polytrichum juniperinum	1

Raesly Woods (cont.)

Pylaisiella polyantha	1
Rhynchostegium serrulatum	1
Sphagnum capillifolium	3
Tetraphis pellucida	2
Thuidium delicatulum	3
Thuidium recognitum	1
Tortella tortuosa	5

Appendix I (cont.)

Mansfield Seep

Acer rubrum	8
Acer saccharum	1
Agrimonia gryposepala	1
Agrostis perennans	1
Alnus serrulata	3
Amphicarpaea bracteata	1
Apios americana	1
Arisaema triphyllum	2
Aster cordifolius	1
Aster lateriflorus	1
Aster puniceus	1
Athyrium filix-femina	1
Berberis thunbergii	1
Betula alleghaniensis	3
Carex gynandra	1
Carex hystericina	1
Carex laevivaginata	1
Carex prasina	10
Carex stricta	1
Carpinus caroliniana	3
Chelone glabra	1
Chrysosplenium americanum	1
Cinna arundinacea	1
Clematis virginiana	1
Collinsonia canadensis	1
Corylus americana	1
Cryptotaenia canadensis	1
Equisetum sylvaticum	1
Eupatorium maculatum	1
Fraxinus pennsylvanica	15
Galium asprellum	1
Galium triflorum	1
Gaylussacia frondosa	1
Glyceria striata	1
Hamamelis virginiana	5
Impatiens capensis	1
Leersia virginica	1
Lilium sp.	1
Lindera benzoin	15
Liriodendron tulipifera	10
Lobelia siphilitica	1
Lycopodium lucidulum	1
Lycopus uniflorus	1
Medeola virginiana	1
Onoclea sensibilis	1
Osmunda cinnamomea	10
Osmunda regalis	15
Parthenocissus quinquefolia	1
Pilea pumila	1
Polygonatum pubescens	1
Polygonum sagittatum	1
Prunella vulgaris	1
Ranunculus recurvatus	1
Rosa multiflora	1
Rubus occidentalis	1
Salix sp.1	1
Sambucus canadensis	1
Smilacina racemosa	1
Solanum dulcamara	1
Solidago rugosa	1
Symplocarpus foetidus	40
Thelypteris palustris	2
Tiarella cordifolia	1
Toxicodendron radicans	1
Toxicodendron vernix	4
Trollius laxus	1
Tussilago farfara	1

Mansfield Seep (cont.)

Tussilago farfara	1
Ulmus americana	5
Vaccinium corymbosum	3
Viburnum dentatum	8
Vitis labrusca	1
Amblystegium tenax	1
Brachythecium rivulare	1
Bryhnia novae-angliae	1
Conocephalum conicum	1
Fissidens adiantoides	1
Thuidium delicatulum	13

Kemmerervillle Seeps 1

Acer rubrum	2
Agrostis gigantea	1
Anthoxanthum odoratum	1
Asclepias incarnata	1
Aster puniceus	2
Betula alleghaniensis	2
Bidens frondosa	2
Cardamine pensylvanica	1
Carex interior	10
Carex leptalea	20
Carya cordiformis	1
Cerastium vulgatum	1
Cirsium ~~vulgare~~ muticum	1
Cyperus bipartitus	1
Drosera rotundifolia	1
Eleocharis tenuis	1
Epilobium coloratum	1
Equisetum arvense	5
Eupatorium maculatum	1
Eupatorium perfoliatum	1
Fraxinus americana	2
Fraxinus pennsylvanica	2
Galium triflorum	1
Geum canadense	1
Glyceria striata	1
Hamamelis virginiana	2
Hydrocotyle americana	1
Impatiens capensis	1
Juncus tenuis	1
Leersia oryzoides	1
Leersia virginica	1
Lindera benzoin	4
Lobelia siphilitica	1
Lycopus uniflorus	1
Lyonia ligustrina	1
Maianthemum canadense	1
Mimulus ringens	1
Mitella diphylla	1
Muhlenbergia mexicana	1
Myosotis laxa	1
Onoclea sensibilis	1
Osmunda cinnamomea	2
Panicum lanuginosum	1
Parnassia glauca	5
Parthenocissus quinquefolia	1
Poa compressa	1
Polygonum hydropiper	1
Polygonum punctatum	1
Polygonum sagittatum	1
Prunella vulgaris	4
Ranunculus recurvatus	1
Rosa palustris	1
Salix discolor	1
Saxifraga pensylvanica	1
Scirpus atrovirens	1
Selaginella apoda	30
Senecio aureus	1
Solidago patula	4
Solidago rugosa	1
Sphenopholis obtusata	1
Sphenopholis pensylvanica	1
Spiraea tomentosa	1
Symplocarpus foetidus	1
Thelypteris palustris	10
Toxicodendron radicans	1
Toxicodendron vernix	4

Appendix I (cont.)

Kemmererville Seeps 1 (cont.)

Tsuga canadensis	1
Tussilago farfara	1
Ulmus americana	1
Vernonia noveboracensis	1
Veronica americana	1
Viola blanda	1
Viola cucullata	3
Amblystegium tenax	1
Aulacomium palustre	1
Brachythecium rivulare	1
Bryum pseudotriquetrum	7
Calliergonella cuspidata	21
Calliergon stramineum	2
Campylium chrysophyllum	1
Campylium stellatum	1
Conocephalum conicum	2
Dicranum scoparium	5
Fissidens cristatus	1
Plagiomnium affine	1
Polytrichum juniperinum	2
Sphagnum palustre	3
Thuidium delicatulum	1
Thuidium recognitum	1
Tortella tortuosa	1

Kemmererville Seeps 2

Acer rubrum	1
Acer saccharum	1
Achillea millefolium	1
Amphicarpaea bracteata	3
Anthoxanthum odoratum	1
Arisaema triphyllum	1
Asclepias incarnata	1
Aster puniceus	1
Athyrium filix-femina	1
Betula alleghaniensis	5
Bidens frondosa	1
Cardamine pensylvanica	1
Carex gynandra	1
Carex hystericina	1
Carex laevivaginata	1
Carex leptalea	1
Cerastium vulgatum	1
Chelone glabra	1
Chrysosplenium americanum	1
Circaea alpina	1
Coptis trifolia	2
Drosera rotundifolia	1
Eleocharis tenuis	1
Epilobium coloratum	1
Equisetum arvense	5
Eupatorium maculatum	1
Fragaria vesca	1
Fraxinus pennsylvanica	1
Galium triflorum	1
Geum canadense	1
Glyceria striata	1
Hamamelis virginiana	5
Holcus lanatus	1
Hydrocotyle americana	1
Impatiens capensis	3
Juncus subcaudatus	1
Juncus tenuis	1
Juniperus virginiana	7
Krigia biflora	1
Leersia oryzoides	1
Lindera benzoin	10
Liriodendron tulipifera	15
Lobelia siphilitica	1
Lycopus uniflorus	1
Maianthemum canadense	1
Microstegium vimineum	1
Mitchella repens	1
Myosotis laxa	1
Onoclea sensibilis	1
Osmunda cinnamomea	10
Parnassia glauca	1
Parthenocissus quinquefolia	1
Pilea pumila	1
Poa trivialis	1
Polystichum acrostichoides	1
Polygonum sagittatum	1
Prunella vulgaris	1
Quercus rubra	1
Ranunculus acris	1
Ranunculus recurvatus	1
Rhamnus alnifolia	1
Rhododendron viscosum	1
Salix discolor	1
Sambucus canadensis	1
Saxifraga pensylvanica	1
Scutellaria lateriflora	1
Selaginella apoda	2

Kemmererville Seeps 2 (cont.)

Solidago patula	1
Solidago rugosa	1
Sphenopholis pensylvanica	1
Spiraea tomentosa	1
Symplocarpus foetidus	2
Thelypteris palustris	2
Toxicodendron radicans	2
Toxicodendron vernix	5
Tsuga canadensis	20
Tussilago farfara	1
Vernonia noveboracensis	1
Veronica americana	1
Viburnum dentatum	1
Amblystegium tenax	7
Bryhnia sp.	1
Bryum pseudotriquetrum	4
Calliergonella cuspidata	1
Conocephalum conicum	4
Fissidens cristatus	1
Plagiomnium affine	1
Rhizomnium punctatum	1
Sphagnum palustre	1
Tetraphis pellucida	1
Thuidium delicatulum	2
Thuidium recognitum	1

Appendix I (cont.)

Shoemakers Swamp Seep

Acer rubrum	1
Acer saccharum	1
Agrostis perennans	1
Amphicarpaea bracteata	10
Arisaema triphyllum	3
Aster divaricatus	1
Aster sp. 1	1
Athyrium filix-femina	3
Berberis thunbergii	1
Betula alleghaniensis	8
Botrychium virginianum	1
Carex gracillima	1
Carpinus caroliniana	4
Cinna arundinacea	1
Circaea lutetiana	1
Dryopteris carthusiana	1
Dryopteris intermedia	6
Epipactis helleborine	1
Eupatorium rugosum	5
Fraxinus nigra	35
Galium triflorum	1
Geranium maculatum	1
Glyceria melicaria	1
Glyceria striata	1
Hamamelis virginiana	1
Impatiens capensis	2
Leersia virginica	1
Lindera benzoin	20
Microstegium vimineum	50
Mitella diphylla	2
Oxalis stricta	1
Parthenocissus quinquefolia	1
Pilea pumila	1
Podophyllum peltatum	10
Polystichum acrostichoides	2
Polygonum arifolium	1
Polygonum caespitosum	5
Polygonum sagittatum	1
Polygonum virginianum	1
Rosa multiflora	1
Rubus pubescens	1
Scutellaria lateriflora	1
Smilacina racemosa	1
Solidago canadensis	1
Solidago rugosa	1
Symplocarpus foetidus	15
Thelypteris hexagonoptera	1
Toxicodendron radicans	1
Tsuga canadensis	1
Ulmus americana	1
Veratrum viride	1
Viola cucullata	1
Viola striata	1
Amblystegium serpens	1
Brachythecium rivulare	7
Brotherella recurvans	1
Climaceum americanum	10
Eurhychium pulchellum	10
Homomallium adnatum	1
Hypnum praetense	1
Parmelia sulcata	1
Pellia epiphylla	1
Plagiomnium ciliare	2
Plagiomnium cuspidatum	1
Rhizomnium punctatum	1
Thuidium delicatulum	4

Birdsboro Reservoir Seep

Acer rubrum	15
Arisaema triphyllum	1
Aster divaricatus	1
Athyrium filix-femina	1
Chelone glabra	1
Chrysosplenium americanum	15
Cinna arundinacea	1
Circaea lutetiana	1
Dryopteris carthusiana	2
Dryopteris intermedia	1
Fagus grandifolia	10
Fraxinus americana	1
Glyceria melicaria	1
Glyceria striata	1
Ilex verticillata	1
Impatiens capensis	25
Leersia virginica	1
Lindera benzoin	1
Malanthemum canadense	1
Osmunda cinnamomea	2
Pilea pumila	10
Pinus strobus	1
Poa trivialis	1
Ranunculus recurvatus	1
Sambucus canadensis	1
Symplocarpus foetidus	35
Thelypteris noveboracensis	1
Viola sp3	3
Chiloscyphus cuspidatus	1
Fissidens bryoides	1
Plagiomnium ciliare	5
Rhizomnium pseudopunctatu	27
Rhizomnium punctatum	5
Rhynchostegium serrulatum	11

Indian Run Seeps

Acer rubrum	20
Anemone quinquefolia	1
Arisaema triphyllum	10
Aster divaricatus	1
Aster lateriflorus	1
Aster prenanthoides	1
Aster puniceus	1
Athyrium filix-femina	1
Athyrium thelypterioides	1
Berberis thunbergii	1
Betula alleghaniensis	45
Cardamine pensylvanica	1
Carex atlantica	1
Carex leptalea	1
Carex seorsa	1
Chelone glabra	1
Chrysosplenium americanum	4
Dioscorea villosa	1
Dryopteris intermedia	1
Fagus grandifolia	4
Fraxinus pennsylvanica	1
Galium triflorum	1
Glyceria striata	1
Hamamelis virginiana	2
Hydrocotyle americana	1
Ilex verticillata	1
Impatiens capensis	30
Kalmia latifolia	2
Leersia virginica	1
Lindera benzoin	10
Liriodendron tulipifera	35
Luzula multiflora	1
Lycopodium lucidulum	1
Malanthemum canadense	1
Mitchella repens	1
Onoclea sensibilis	1
Osmunda cinnamomea	10
Osmunda regalis	1
Podophyllum peltatum	1
Polygonatum pubescens	1
Ranunculus recurvatus	1
Rhododendron viscosum	2
Rosa multiflora	1
Sambucus canadensis	1
Scutellaria lateriflora	1
Smilacina racemosa	1
Smilax rotundifolia	1
Sphenopholis pensylvanica	1
Stellaria alsine	1
Symplocarpus foetidus	40
Thelypteris hexagonoptera	1
Thelypteris noveboracensis	1
Thelypteris palustris	1
Vaccinium corymbosum	1
Viburnum prunifolium	1
Viola cucullata	4
Viola primulifolia	1
Amblystegium tenax	1
Atrichum oestedianum	1
Brachythecium rivulare	1
Brachythecium rutabulum	4
Chiloscyphus cuspidatus	1
Leucobryum glaucum	2
Rhizomnium punctatum	6
Rhynchostegium serrulatum	1
Riccardia multifida	4
Thuidium delicatulum	2
Thuidium recognitum	4

Appendix I (cont.)

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Acer rubrum	35
Arisaema triphyllum	1
Betula alleghaniensis	1
Betula lenta	5
Cardamine pensylvanica	1
Chelone glabra	1
Chrysosplenium americanum	2
Circaea lutetiana	1
Dryopteris carthusiana	1
Fraxinus pennsylvanica	10
Glyceria melicaria	1
Glyceria striata	1
Hamamelis virginiana	25
Ilex verticillata	10
Impatiens capensis	30
Lindera benzoin	10
Lycopodium lucidulum	1
Maianthemum canadense	1
Nyssa sylvatica	1
Osmunda cinnamomea	1
Poa paludigena	1
Rhododendron viscosum	1
Rosa multiflora	1
Sambucus canadensis	1
Solidago rugosa	1
Symplocarpus foetidus	75
Thalictrum pubescens	1
Thelypteris noveboracensis	1
Viburnum dentatum	1
Viola cucullata	5
Vitis labrusca	1
Amblystegium serpens	1
Atrichum oestedianum	3
Mnium lycopodioides	1
Rhizomnium gracile	1
Rhizomnium punctatum	13
Rhynchostegium serrulatum	4
Sphagnum palustre	1
Thuidium delicatulum	1

Lambs Gap Seeps

Acer rubrum	1
Agrimonia gryposepala	1
Amphicarpaea bracteata	1
Anemonella thalictroides	1
Arisaema triphyllum	10
Athyrium thelypterioides	3
Boehmeria cylindrica	1
Botrychium virginianum	1
Brachyeletrum erectum	1
Carex atlantica	1
Carex bromoides	2
Carex gracilescens	1
Carex gracillima	1
Carex laxiculmis	1
Carex leptalea	1
Carex prasina	1
Carpinus caroliniana	1
Chelone glabra	1
Chrysosplenium americanum	1
Circaea lutetiana	1
Dioscorea villosa	1
Dryopteris carthusiana	1
Euphorbia purpurea	1
Festuca subverticillata	1
Fraxinus nigra	50
Galium aparine	1
Galium obtusum	1
Galium triflorum	1
Geranium maculatum	1
Geranium robertianum	1
Glyceria striata	1
Goodyera pubescens	1
Ilex verticillata	1
Impatiens capensis	1
Lilium sp.	1
Lindera benzoin	35
Liriodendron tulipifera	10
Lobelia siphilitica	1
Luzula multiflora	1
Lyonia ligustrina	1
Muhlenbergia sylvatica	1
Nyssa sylvatica	1
Onoclea sensibilis	1
Osmunda cinnamomea	15
Osmunda regalis	5
Oxalis stricta	1
Panax trifolium	1
Panicum dichotomum	1
Parthenocissus quinquefolia	1
Pilea pumila	1
Poa trivialis	1
Podophyllum peltatum	1
Polemonium reptans	1
Polystichum acrostichoides	1
Polygonum caespitosum	1
Rubus occidentalis	1
Selaginella apoda	1
Smilacina racemosa	1
Symplocarpus foetidus	75
Thalictrum pubescens	1
Thelypteris hexagonoptera	1
Thelypteris noveboracensis	1
Toxicodendron radicans	1
Ulmus americana	5
Vaccinium corymbosum	5
Viola cucullata	4
Viola pallens	1

Lambs Gap Seeps (cont.)

Atrichum oestedianum	3
Brachythecium rutabulum	1
Bryhnia novae-angliae	1
Cirriphyllum piliferum	3
Climaceum americanum	1
Parmelia sulcata	1
Plagiomnium ciliare	1
Sphagnum imbricatum	1
Thuidium delicatulum	2
Thuidium recognitum	1
Trichocolea tomentella	2

Appendix I (cont.)

Poe Paddy Seep

Agrostis perennans	1
Alnus incana	25
Arisaema triphyllum	1
Betula alleghaniensis	5
Bidens cernua	1
Bidens connata	1
Boehmeria cylindrica	1
Caltha palustris	1
Carex atlantica	3
Carex baileyi	10
Carex bromoides	1
Carex echinata	3
Carex leptalea	5
Carex scoparia	1
Carex stipata	2
Chelone glabra	1
Chrysosplenium americanum	5
Dryopteris intermedia	1
Epilobium coloratum	1
Fraxinus nigra	10
Galium asprellum	1
Galium obtusum	1
Glyceria melicaria	5
Glyceria striata	10
Hydrocotyle americana	5
Ilex verticillata	2
Impatiens capensis	35
Juncus effusus	2
Leersia oryzoides	1
Lemna sp.	45
Lindera benzoin	10
Ludwigia palustris	1
Lycopus uniflorus	2
Lysimachia nummularis	1
Mentha arvensis	1
Myosotis scorpiodes	1
Nyssa sylvatica	3
Onoclea sensibilis	1
Osmunda cinnamomea	15
Pilea pumila	1
Poa trivialis	1
Polygonum arifolium	1
Polygonum hydropiper	1
Polygonum sagittatum	1
Ranunculus hispidus	1
Rorippa nasturtium-aquaticum	1
Salix alba	10
Scirpus polyphyllus	1
Senecio aureus	1
Stellaria alsine	1
Stellaria longifolia	1
Symplocarpus foetidus	50
Thelypteris palustris	1
Tsuga canadensis	10
Typha latifolia	1
Viola sp.2	4
Amblystegium riparium	1
Amblystegium serpens	2
Brachythecium rivulare	1
Callicrgon cordifolium	1
Helodium paludosum	1
Hypnum imponens	1
Hypnum lindbergii	1
Plagiomnium cuspidatum	1
Plagiomnium rostratum	1
Rhynchostegium serrulatum	1
Sphagnum palustre	1
Sphagnum teres	4
Thuidium delicatulum	2

Mt. Holly Preserve Seep

Acer rubrum	40
Alnus serrulata	2
Arisaema triphyllum	3
Brachyeletrum erectum	2
Carex atlantica	1
Carex folliculata	6
Carex leptalea	1
Chelone glabra	1
Eupatorium maculatum	1
Euphorbia purpurea	1
Fraxinus nigra	1
Glyceria melicaria	1
Glyceria striata	1
Hamamelis virginiana	3
Ilex verticillata	12
Juncus sp. 2	1
Lilium sp.	1
Lindera benzoin	7
Maianthemum canadense	1
Osmunda cinnamomea	10
Panicum dichotomum	1
Rhododendron viscosum	3
Rubus hispidus	5
Sanguisorba canadensis	1
Solidago patula	1
Symplocarpus foetidus	50
Thalictrum pubescens	4
Thelypteris noveboracensis	1
Toxicodendron vernix	3
Vaccinium corymbosum	5
Viburnum dentatum	3
Viola pallens	7
Vitis labrusca	1
Atrichum crispum	1
Rhizomnium punctatum	2
Sphagnum flexuosum	6
Sphagnum palustre	2
Thuidium delicatulum	6

Appendix I (cont.)

Carlisle Farm Seeps 1

Alnus incana	10
Amelanchier arborea	50
Aster prenanthoides	10
Betula alleghaniensis	15
Carex crinita	1
Carex gracillima	1
Carex prasina	5
Chelone glabra	5
Cinna latifolia	1
Crataegus sp.	5
Dryopteris carthusiana	1
Galium obtusum	1
Galium palustre	10
Geum laciniatum	5
Geum rivale	1
Glyceria striata	1
Hydrocotyle americana	1
Impatiens capensis	40
Juncus effusus	5
Lonicera morrowii	2
Lycopus americanus	1
Lysimachia ciliata	1
Myosotis scorpiodes	75
Onoclea sensibilis	35
Osmunda cinnamomea	10
Pinus strobus	35
Polygonum sagittatum	2
Prunus serotina	3
Ranunculus acris	2
Ranunculus hispidus	5
Ribes cynosbati	1
Rorippa nasturtium-aquatic	1
Rubus alleghaniensis	1
Rubus idaeus	2
Rubus pubescens	2
Sphenopholis nitida	10
Sphenopholis obtusata	3
Symplocarpus foetidus	40
Veronica americana	10
Viburnum dentatum	1
Brachythecium rivulare	14
Campylium polygamum	1
Hypnum praetense	2
Thuidium delicatulum	2

Carlisle Farm Seeps 2

Acer rubrum	10
Arisaema triphyllum	2
Athyrium filix-femina	1
Betula alleghaniensis	15
Caltha palustris	10
Carex laevivaginata	1
Carex leptalea	1
Carex leptonervia	1
Carex pedunculata	1
Carex scabrata	1
Carex trisperma	1
Carpinus caroliniana	1
Chelone glabra	1
Chrysosplenium americanum	1
Circaea alpina	1
Clintonia borealis	1
Coptis trifolia	3
Dalibarda repens	1
Dirca palustris	1
Dryopteris carthusiana	2
Dryopteris clintoniana	1
Eupatorium rugosum	1
Fagus grandifolia	1
Galium palustre	1
Galium triflorum	1
Geum canadense	1
Gymnocarpium dryopteris	1
Hamamelis virginiana	10
Impatiens capensis	10
Lindera benzoin	2
Lonicera dioica	1
Lycopodium lucidulum	1
Lycopus uniflorus	1
Magnolia acuminata	3
Maianthemum canadense	1
Mitella diphylla	3
Onoclea sensibilis	1
Osmunda cinnamomea	40
Oxalis acetosella	3
Parthenocissus quinquefolia	1
Pinus strobus	5
Poa palustris	1
Polygonum arifolium	1
Polygonum sagittatum	1
Prunus serotina	1
Quercus alba	1
Quercus rubra	1
Ranunculus hispidus	1
Rubus pubescens	1
Scutellaria lateriflora	1
Senecio aureus	1
Smilacina racemosa	1
Symplocarpus foetidus	10
Tiarella cordifolia	3
Toxicodendron radicans	1
Trientalis borealis	1
Tsuga canadensis	80
Vaccinium angustifolium	1
Viola cucullata	1
Bazzania trilobata	4
Cladonia coniocrea	1
Dicranella cerviculata	1
Dicranum fuscescens	1
Nowellia curvifolia	1
Plagiomnium cuspidatum	1
Rhizomnium appalachianum	1
Rhynchostegium serrulatum	3
Sphagnum fimbriatum	9
Thuidium delicatulum	25
Trichocolea tomentella	2

Carlisle Farm Seeps 3

Acer rubrum	1
Agrostis perennans	1
Arisaema triphyllum	1
Aster divaricatus	1
Aster prenanthoides	1
Athyrium filix-femina	1
Athyrium thelypterioides	1
Betula alleghaniensis	70
Bidens sp.	1
Cardamine diphylla	2
Cardamine pensylvanica	3
Carex brunnescens	1
Carex gracillima	1
Carex leptalea	1
Carex prasina	3
Carex scabrata	1
Carpinus caroliniana	50
Chrysosplenium americanum	2
Circaea alpina	1
Coptis trifolia	2
Dryopteris intermedia	3
Epilobium ciliatum	1
Fagus grandifolia	1
Floerkia proserpinacoides	1
Galium tinctorium	1
Galium triflorum	1
Glyceria melicaria	1
Glyceria striata	6
Hamamelis virginiana	20
Impatiens capensis	35
Laportea canadensis	1
Myosotis scorpiodes	2
Onoclea sensibilis	6
Osmunda cinnamomea	3
Oxalis acetosella	1
Pilea pumila	1
Poa palustris	1
Polygonum sagittatum	1
Polygonum sp.	1
Prunus serotina	1
Quercus rubra	2
Rumex obtusifolius	1
Scutellaria lateriflora	1
Senecio aureus	1
Solidago patula	1
Solidago rugosa	1
Symplocarpus foetidus	2
Thelypteris noveboracensis	1
Tiarella cordifolia	1
Tsuga canadensis	5
Viola cucullata	4
Viola pallens	1
Brachythecium rivulare	23
Rhizomnium appalachianum	1
Thuidium delicatulum	1
Tomenthypnum nitens	1

Appendix I (cont.)

Carlisle Farm Seeps 4

Acer rubrum	1
Agrostis perennans	1
Arisaema triphyllum	1
Athyrium filix-femina	1
Athyrium thelypterioides	1
Betula alleghaniensis	70
Bidens sp.	1
Cardamine diphylla	1
Cardamine pensylvanica	1
Carex brunnescens	1
Carex gracillima	1
Carex leptalea	1
Carex scabrata	1
Chrysosplenium americanum	1
Circaea alpina	1
Coptis trifolia	1
Dryopteris intermedia	2
Epilobium ciliatum	1
Fagus grandifolia	1
Galium triflorum	1
Glyceria melicaria	1
Glyceria striata	1
Impatiens capensis	10
Laportea canadensis	1
Myosotis scorpiodes	1
Onoclea sensibilis	3
Osmunda cinnamomea	3
Oxalis acetosella	1
Pilea pumila	1
Poa palustris	1
Polygonum sagittatum	1
Polygonum sp.	1
Solidago rugosa	1
Symplocarpus foetidus	1
Thelypteris noveboracensis	1
Tiarella cordifolia	1
Tsuga canadensis	5
Viola cucullata	1
Bazzania trilobata	1
Bryhnia novae-angliae	33
Cladonia coniocrea	1
Dicranum scoparium	1
Hypnum fertile	1
Plagiothecium laetum	1
Polytrichum commune	1
Rhizomnium pseudopunctatu	1
Tetraphis pellucida	1
Thuidium delicatulum	1

State Game Lands #197

Arabis sp.	1
Aster lateriflorus	1
Aster prenanthoides	1
Aster puniceus	1
Bidens connata	1
Carex brunnescens	1
Carex gracillima	2
Carex hystericina	1
Carex leptonervia	1
Carex scabrata	4
Carex stipata	1
Chelone glabra	1
Circaea alpina	1
Clematis virginiana	1
Coptis trifolia	1
Dryopteris cristata	1
Epilobium glandulosum	1
Equisetum arvense	3
Galium aparine	1
Galium triflorum	1
Glyceria striata	1
Hamamelis virginiana	10
Impatiens capensis	2
Juncus effusus	1
Lycopus uniflorus	1
Onoclea sensibilis	5
Osmunda cinnamomea	5
Pinus strobus	35
Poa trivialis	5
Polygonum sagittatum	1
Populus tremuloides	1
Prunus serotina	2
Prunella vulgaris	1
Ranunculus hispidus	1
Rubus hispidus	1
Rubus occidentalis	1
Senecio aureus	1
Solidago patula	1
Spiraea alba	1
Symplocarpus foetidus	30
Taraxacum officinale	1
Thelypteris palustris	1
Tiarella cordifolia	2
Tsuga canadensis	1
Veronica americana	3
Viola cucullata	1
Brachythecium rivulare	5
Campylium polygamum	2
Cephalozia lunulifolia	1
Rhizomnium ciliare	1
Riccardia multifida	1
Sphagnum palustre	1
Tetraphis pellucida	1
Thuidium delicatulum	8

State Game Lands #69

Acer saccharum	15
Arisaema triphyllum	1
Aster divaricatus	1
Betula alleghaniensis	40
Carex prasina	5
Carex scabrata	2
Chrysosplenium americanum	5
Dryopteris intermedia	4
Euonymus obovatus	5
Fagus grandifolia	1
Galium triflorum	1
Geum canadense	1
Glyceria melicaria	1
Impatiens capensis	35
Lonicera canadensis	1
Onoclea sensibilis	1
Populus grandidentata	10
Tiarella cordifolia	1
Tilia americana	15
Ulmus rubra	3
Veratrum viride	15
Brachythecium rivulare	2
Bryhnia novae-angliae	6
Hypnum imponens	1
Thuidium recognitum	1

Appendix I (cont.)

Kennerdell Seeps	
Agrostis stolonifera	3
Aster lateriflorus	1
Bidens cernua	1
Carex lurida	1
Carex scoparia	15
Carex stipata	1
Eleocharis tenuis	30
Epilobium ciliatum	1
Eupatorium perfoliatum	3
Galium concinnum	1
Galium palustre	1
Glyceria grandis	1
Helenium autumnale	1
Hypericum mutilum	3
Juncus acuminatus	1
Juncus effusus	1
Juncus tenuis	30
Lycopus americanus	1
Lysimachia vulgaris	2
Mentha arvensis	1
Mimulus moschatus	2
Mimulus ringens	1
Myosotis scorpiodes	1
Poa palustris	1
Polygonum amphibium	1
Polygonum sagittatum	1
Ranunculus sp.	1
Salix sp.	1
Scirpus americanus	1
Scirpus validus	1
Stellaria alsine	1
Verbena hastata	1
Veronica americana	1
Anthoceros laevis	1
Philonotis fontana	1

McLane Seepage Swamp	
Acer rubrum	10
Acer saccharum	35
Arisaema triphyllum	2
Boehmeria cylindrica	1
Carex laevivaginata	1
Carex scabrata	15
Carpinus caroliniana	3
Chelone glabra	1
Chrysosplenium americanum	3
Dryopteris intermedia	1
Fagus grandifolia	10
Galium triflorum	1
Hamamelis virginiana	5
Impatiens capensis	50
Laportea canadensis	1
Lindera benzoin	1
Osmunda cinnamomea	1
Prunus serotina	1
Ranunculus recurvatus	1
Sambucus pubens	1
Scutellaria lateriflora	1
Solanum dulcamara	1
Tsuga canadensis	10
Viola cucullata	1
Amblystegium serpens	2
Brachythecium rivulare	1
Bryhnia novae-angliae	1
Rhizomnium punctatum	1
Rhynchostegium serrulatum	1
Thuidium delicatulum	2

Edinboro Lake Seeps	
Acer rubrum	60
Aster puniceus	1
Cardamine diphylla	1
Chelone glabra	1
Clematis virginiana	1
Cornus sericea	20
Fraxinus americana	10
Galium triflorum	1
Hamamelis virginiana	1
Ilex verticillata	20
Impatiens capensis	1
Lindera benzoin	1
Onoclea sensibilis	1
Osmunda cinnamomea	5
Osmunda regalis	10
Prunus serotina	5
Rosa palustris	5
Sambucus canadensis	1
Solanum dulcamara	1
Symplocarpus foetidus	85
Thalictrum pubescens	1
Vaccinium corymbosum	1
Viburnum dentatum	3
Campylium radicale	1
Dicranum fuscescens	1
Hypnum praetense	3
Leucobryum glaucum	3
Plagiothecium laetum	1

Appendix I (cont.)

State Game Lands #102

Acer saccharum	1
Acer spicatum	4
Aster puniceus	1
Athyrium thelypterioides	1
Betula alleghaniensis	15
Cardamine diphylla	1
Cardamine pensylvanica	1
Carex scabrata	1
Chelone glabra	2
Cornus alternifolia	1
Dryopteris intermedia	1
Equisetum arvense	1
Fagus grandifolia	40
Hamamelis virginiana	1
Impatiens capensis	1
Osmunda cinnamomea	1
Poa palustris	1
Prunus serotina	2
Ranunculus pensylvanicus	1
Ranunculus sp.	1
Symplocarpus foetidus	5
Tiarella cordifolia	1
Tsuga canadensis	15
Amblystegium tenax	2
Brachythecium rivulare	2
Calypogeia muelleriana	1
Chiloscyphus cuspidatus	1
Ditrichum pusillum	1
Hypnum imponens	1
Rhizomnium pseudopunctatum	1
Thuidium delicatulum	1

North East Slumps - West 1

Acer pensylvanicum	1
Acer saccharum	65
Arisaema triphyllum	1
Aster divaricatus	1
Cardamine diphylla	1
Dalibarda repens	1
Epilobium sp.	1
Fagus grandifolia	1
Floerkia proserpinacoides	1
Fraxinus americana	1
Geum canadense	1
Impatiens pallida	50
Ranunculus sp.	1
Rubus occidentalis	1
Rubus odoratus	1
Solanum dulcamara	4
Solidago caesia	1
Solidago flexicaulis	4
Solidago gigantea	1
Bryhnia novae-angliae	1
Eurhychium pulchellum	1

North East Slumps - West 2

Acer saccharum	1
Agrostis stolonifera	1
Betula alleghaniensis	1
Carex aurea	1
Carex eburnea	1
Carex hystericina	1
Equisetum arvense	20
Equisetum variegatum	10
Eupatorium maculatum	2
Gentianopsis crinita	1
Juncus alpinoarticulatus	1
Juncus brachycephalus	1
Parnassia glauca	25
Picea glauca	1
Prenanthes sp.	1
Salix myricoides	3
Scirpus sp.	1
Tsuga canadensis	1
Tussilago farfara	1
Bryum uliginosum	1
Campylium hispidulum	1
Campylium stellatum	4
Conocephalum conicum	1
Hypnum praetense	1
Philonotis muhlenbergii	61
Plagiomnium ciliare	1

Appendix I (cont.)

Hubbel Run Seeps 1

Acer rubrum	35
Acer saccharum	1
Arisaema triphyllum	1
Athyrium filix-femina	3
Betula alleghaniensis	2
Cardamine diphylla	1
Carex leptalea	1
Carex scabrata	15
Carex sp. 3	1
Circaea alpina	1
Cornus alternifolia	1
Equisetum arvense	2
Eupatorium perfoliatum	1
Fragaria virginana	1
Galium aparine	2
Glyceria striata	1
Hypericum sp.	1
Impatiens capensis	5
Juncus effusus	1
Onoclea sensibilis	1
Osmunda cinnamomea	35
Oxalis acetosella	1
Oxalis stricta	1
Parthenocissus quinquefolia	3
Potentila simplex	1
Prunus serotina	1
Prunella vulgaris	1
Ribes sp.	1
Rubus hispidus	1
Salix sericea	1
Solanum dulcamara	1
Solidago rugosa	1
Symplocarpus foetidus	40
Tiarella cordifolia	1
Tsuga canadensis	10
Tussilago farfara	1
Veronica officinalis	1
Vitis sp.	2
Amblystegium serpens	1
Atrichum oestedianum	2
Brachythecium rivulare	3
Calypogeia muelleriana	1
Rhizomnium punctatum	1
Sphagnum palustre	1
Thuidium delicatulum	41

Hubbel Run Seeps 2

Acer rubrum	25
Amelanchier sp.	3
Athyrium thelypterioides	1
Betula alleghaniensis	15
Cardamine pensylvanica	1
Carex bromoides	5
Carex sp. 1	1
Carex stipata	1
Chelone glabra	1
Chrysosplenium americanum	20
Coptis trifolia	1
Dryopteris intermedia	1
Fagus grandifolia	1
Fraxinus nigra	3
Glyceria melicaria	1
Impatiens capensis	45
Laportea canadensis	1
Leersia virginica	1
Lindera benzoin	1
Onoclea sensibilis	1
Osmunda cinnamomea	10
Poa palustris	1
Polygonum sagittatum	1
Ranunculus hispidus	2
Sambucus canadensis	1
Saxifraga pensylvanica	1
Scutellaria lateriflora	1
Senecio aureus	1
Symplocarpus foetidus	30
Tiarella cordifolia	1
Tsuga canadensis	30
Viola cucullata	1
Amblystegium riparium	2
Amblystegium tenax	1
Aneura pinguis	1
Bazzania trilobata	1
Brachythecium rivulare	3
Bryhnia novae-angliae	1
Cinclidium stygium	1
Cladonia sp.	1
Dicranella cerviculata	1
Hypnum imponens	1
Isopterygium distichaceum	1
Rhizomnium punctatum	2
Rhynchostegium serrulatum	1
Sphagnum fimbriatum	3
Thuidium delicatulum	3
Thuidium recognitum	2

Springhope Seeps

Acer rubrum	1
Agrimonia parviflora	1
Aster prenanthoides	1
Aster puniceus	1
Carex prasina	75
Carex stipata	4
Carya ovata	15
Cornus racemosa	1
Cryptotaenia canadensis	1
Euthamia graminifolia	2
Galium obtusum	1
Galium pilosum	1
Glyceria striata	2
Impatiens capensis	20
Juncus effusus	1
Lycopus uniflorus	1
Pilea pumila	1
Polygonum sagittatum	1
Quercus rubra	1
Scutellaria lateriflora	1
Solidago gigantea	10
Stellaria longifolia	1
Symplocarpus foetidus	1
Vernonia noveboracensis	1
Viola cucullata	1
Brachythecium campestre	1
Rhynchostegium serrulatum	1
Thuidium delicatulum	1

Appendix I (cont.)

Sproul Seep

Aster prenanthoides	2
Aster puniceus	2
Cardamine pensylvanica	1
Carex prasina	1
Carex stipata	2
Carya ovata	2
Chrysosplenium americanum	15
Dryopteris cristata	1
Fagus grandifolia	1
Fraxinus nigra	1
Glechoma hederacea	1
Glyceria melicaria	5
Glyceria striata	1
Impatiens capensis	50
Leersia virginica	1
Lindera benzoin	5
Poa palustris	1
Polygonum sagittatum	1
Solidago rugosa	1
Symplocarpus foetidus	85
Toxicodendron radicans	1
Tsuga canadensis	10
Ulmus americana	10
Viburnum dentatum	5
Viola cucullata	1
Calypogeia fissa	1
Campylium polygamum	2
Campylium radicale	1
Sematophyllum demissum	1
Thuidium delicatulum	1

Black Moshannon Seeps

Acer rubrum	1
Agrostis perennans	1
Alnus incana	4
Aronia sp.	1
Aster puniceus	1
Aster umbellatus	1
Athyrium filix-femina	1
Caltha palustris	3
Carex atlantica	1
Carex folliculata	1
Carex gynandra	10
Carex interior	5
Carex leptonervia	1
Carex stipata	1
Chrysosplenium americanum	1
Dalibarda repens	1
Drosera rotundifolia	1
Dryopteris carthusiana	2
Dryopteris cristata	1
Epilobium glandulosum	1
Equisetum arvense	10
Euthamia graminifolia	1
Galium tinctorium	1
Glyceria striata	1
Impatiens capensis	1
Juncus effusus	3
Juncus subcaudatus	1
Lycopus sp.	1
Onoclea sensibilis	1
Osmunda cinnamomea	20
Oxalis acetosella	1
Polygonum sagittatum	1
Populus tremuloides	1
Prunus serotina	5
Rubus hispidus	3
Solidago rugosa	2
Spiraea alba	1
Symplocarpus foetidus	10
Thelypteris noveboracensis	1
Triadenum fraseri	1
Typha latifolia	1
Vaccinium angustifolium	1
Vaccinium corymbosum	5
Veratrum viride	15
Viola cucullata	5
Brachythecium rutabulum	2
Pellia epiphylla	1
Polytrichum commune	1
Rhizomnium punctatum	1
Sphagnum palustre	17
Thuidium delicatulum	1

State Game Lands #166

Acer rubrum	15
Arisaema triphyllum	1
Betula alleghaniensis	35
Carex atlantica	1
Carex crinita	5
Carex prasina	10
Carex stipata	3
Dryopteris carthusiana	1
Glyceria melicaria	15
Glyceria striata	10
Hydrocotyle americana	1
Impatiens capensis	5
Juncus effusus	5
Lindera benzoin	55
Lycopus uniflorus	5
Osmunda cinnamomea	5
Platanthera sp.	1
Poa palustris	1
Polygonum arifolium	1
Polygonum sagittatum	1
Quercus alba	15
Rubus hispidus	3
Tsuga canadensis	5
Viola blanda	5
Aulacomium palustre	2
Campylium polygamum	1
Hypnum imponens	1
Plagiomnium ciliare	1
Rhizomnium punctatum	3
Sphagnum palustre	8
Sphagnum teres	3
Thuidium recognitum	3

Appendix I (cont.)

McCall Dam Seeps 1

Acer rubrum	4
Agrostis perennans	1
Arisaema triphyllum	1
Betula alleghaniensis	15
Carex crinita	2
Carex frankii	3
Carex interior	1
Carex stipata	1
Carex trisperma	1
Chelone glabra	1
Chrysosplenium americanum	1
Galium trifidum	1
Glyceria melicaria	15
Glyceria striata	5
Hydrocotyle americana	1
Impatiens sp.	15
Juncus effusus	1
Lycopus uniflorus	2
Onoclea sensibilis	3
Polygonum punctatum	1
Polygonum sagittatum	1
Scutellaria lateriflora	1
Thelypteris noveboracensis	5
Tsuga canadensis	30
Viola cucullata	1
Amblystegium serpens	2
Chiloscyphus polyanthus	1
Mnium lycopoidioides	1
Plagiomnium rugicum	1
Rhizomnium punctatum	10
Riccardia multifida	1
Sphagnum imbricatum	1
Thuidium delicatulum	4

McCall Dam Seeps 2

	McD 2
Acer rubrum	5
Agrostis perennans	1
Alnus incana	60
Arisaema triphyllum	1
Carex atlantica	20
Carex frankii	5
Carex gynandra	1
Carex interior	1
Carex leptonervia	1
Carex trisperma	1
Chrysosplenium americanu	2
Coptis trifolia	1
Dryopteris carthusiana	1
Dryopteris cristata	1
Fraxinus nigra	10
Galium tinctorium	1
Glyceria melicaria	3
Glyceria striata	1
Impatiens capensis	1
Juncus effusus	5
Kalmia latifolia	1
Lycopus sp.	1
Lysimachia terrestris	1
Onoclea sensibilis	5
Pinus strobus	2
Polygonum sagittatum	1
Rubus hispidus	5
Rubus idaeus	1
Thelypteris palustris	5
Triadenum fraseri	3
Vaccinium angustifolium	1
Viola cucullata	1
Brachythecium rivulare	9
Campylium polygamum	1
Chiloscyphus polyanthus	1
Pallavicina lyelli	1
Plagiomnium ciliare	1
Polytrichum lingisetum	1
Sphagnum imbricatum	35
Thuidium delicatulum	1

North East Slumps - East

Acer saccharum	1
Agrostis hyemalis	1
Aster lateriflorus	2
Betula sp.	1
Equisetum arvense	35
Erigeron philadelphicus	1
Eupatorium fistulosum	1
Eupatorium rugosum	1
Fraxinus sp.	1
Gentianopsis crinita	1
Juncus brevicaudatus	2
Lobelia siphilitica	1
Muhlenbergia glomerata	1
Oenothera biennis	1
Poa compressa	1
Rubus occidentalis	1
Salix sp.	10
Solidago canadensis	1
Solidago gigantea	2
Taraxacum officinale	1
Tussilago farfara	10
Typha latifolia	2
Vitis sp.	1
Asterella tenella	1
Blasia pusilla	1
Conocephalum conicum	7
Didymodon tophaceus	7
Fossombronia wondraczekii	1
Philonotis fontana	2
Plagiothecium laetum	1

Appendix I (cont.)

Walnut Creek Seeps 2

Agrostis perennans	1
Aster lateriflorus	2
Carex aurea	1
Carex granularis	2
Eupatorium perfoliatum	1
Juncus brevicaudatus	1
Lycopus uniflorus	1
Parnassia glauca	15
Poa compressa	1
Salix sp.	1
Senecio aureus	30
Solidago patula	1
Tussilago farfara	1
Ceratodon purpureus	1
Cratoneuron commutatum	40

Walnut Creek Seeps 1

Arisaema triphyllum	1
Aster divaricatus	1
Aster lateriflorus	1
Carex granularis	1
Carex laevivaginata	1
Carpinus caroliniana	3
Cornus alternifolia	1
Cornus sericea	2
Equisetum arvense	1
Equisetum variegatum	1
Eupatorium perfoliatum	1
Eupatorium rugosum	5
Fagus grandifolia	1
Fraxinus nigra	1
Glyceria striata	5
Impatiens pallida	10
Lindera benzoin	1
Liriodendron tulipifera	1
Lobelia siphilitica	1
Lycopus uniflorus	1
Muhlenbergia sylvatica	1
Parnassia glauca	2
Parthenocissus quinquefolia	1
Poa compressa	1
Prunella vulgaris	1
Quercus rubra	1
Rubus odoratus	1
Salix sp.	1
Senecio aureus	2
Solidago patula	1
Tilia americana	10
Tussilago farfara	10
Ulmus americana	10
Veronica americana	1
Vitis sp.	1
Cratoneuron commutatum	1
Cratoneuron filicinum	2
Distichum capillaceum	1
Drepanocladus aduncus	1

James Preserve Seeps 1

Agrostis perennans	1
Aster puniceus	1
Carex aurea	1
Carex interior	1
Carex lurida	1
Carex sp. 2	1
Cornus sericea	10
Daucus carota	1
Eleocharis elliptica	10
Equisetum arvense	2
Eupatorium maculatum	30
Eupatorium perfoliatum	1
Euthamia graminifolia	5
Festuca pratensis	1
Fragaria virginana	1
Holcus lanatus	1
Hypericum perforatum	1
Juncus brevicaudatus	1
Juncus sp. 1	1
Prunella vulgaris	1
Ranunculus acris	2
Rhamnus frangula	30
Scirpus validus	1
Senecio aureus	1
Solidago rugosa	1
Spiranthes sp.	1
Thelypteris palustris	15
Tussilago farfara	1
Typha latifolia	5
Viburnum recognitum	2
Aneura pinguis	1
Campylium stellatum	2
Fissidens adiantoides	5

Appendix I (cont.)

James Preserve Seeps 2

Asclepias incarnata	1
Carex hystericina	4
Carex interior	1
Chara sp.	1
Eleocharis elliptica	2
Eleocharis sp. 2	20
Juncus brevicaudatus	20
Mentha X citrata	1
Panicum lanuginosum	1
Rhamnus frangula	2
Senecio aureus	1
Spiranthes sp.	1
Thelypteris palustris	1
Typha latifolia	1
Campylium stellatum	1

Behrend Slumps 2

Acer saccharum	2
Amelanchier arborea	30
Aster divaricatus	1
Betula alleghaniensis	2
Eupatorium rugosum	1
Fagus grandifolia	3
Fraxinus americana	2
Hamamelis virginiana	1
Lindera benzoin	2
Lobelia siphilitica	3
Ostrya virginiana	1
Quercus rubra	5
Rhamnus frangula	1
Solanum dulcamara	5
Solidago flexicaulis	20
Tsuga canadensis	40
Tussilago farfara	3
Bryum pseudotriquetrum	1
Campylium radicale	1
Chiloscyphus profundus	1
Cratoneuron filicinum	1
Fissidens adiantoides	1
Leucobryum glaucum	1
Pohlia sp.	1

Behrend Slumps 1

Acer saccharum	85
Arisaema triphyllum	5
Aster divaricatus	2
Aster lateriflorus	1
Aster puniceus	1
Carex scabrata	5
Epipactis helleborine	1
Eupatorium rugosum	1
Fraxinus americana	3
Glyceria striata	1
Hamamelis virginiana	1
Lindera benzoin	70
Parthenocissus inserta	2
Quercus rubra	5
Solidago flexicaulis	5
Taxus canadensis	1
Tsuga canadensis	45
Brotherella recurvans	1
Distichum capillaceum	1
Fissidens adiantoides	1
Leucobryum glaucum	2
Taxiphyllum deplanatum	1
Thuidium delicatulum	1

Appendix I (cont.)

Twentymile Creek Seeps 1

Ambrosia artemisiifolia	1
Apocynum cannabinum	1
Aster lateriflorus	1
Aster sagittifolius	1
Carex aurea	1
Carex sp.	3
Cyperus bipartitus	1
Eleocharis erythropoda	3
Equisetum arvense	1
Eupatorium perfoliatum	2
Eupatorium rugosum	1
Euthamia graminifolia	1
Glyceria striata	1
Impatiens capensis	1
Juncus tenuis	10
Lobelia kalmii	1
Muhlenbergia mexicana	1
Panicum lanuginosum	15
Rhynchospora capillacea	1
Robinia pseudoacacia	1
Scirpus atrovirens	3
Senecio aureus	10
Solidago canadensis	2
Bryum sp.	1
Campylium sp.	1
Cirriphyllum piliferum	28
Dicranella cerviculata	2
Helodium paludosum	1

Twentymile Creek Seeps 2

Agrostis perennans	1
Aster divaricatus	1
Aster sagittifolius	1
Bidens cernua	1
Boehmeria cylindrica	1
Chelone glabra	10
Eupatorium maculatum	1
Eupatorium rugosum	55
Glyceria striata	1
Impatiens capensis	2
Impatiens pallida	10
Juncus tenuis	1
Lobelia siphilitica	10
Lycopus uniflorus	10
Onoclea sensibilis	1
Rosa multiflora	1
Rubus alleghaniensis	3
Senecio aureus	2
Taraxacum officinale	1
Atrichum undulatum	1
Bryum pseudotriquetrum	1
Cirriphyllum piliferum	8
Hypnum praetense	1
Pellia epiphylla	1

Spencer-Plank Road Seeps

Acer rubrum	25
Amelanchier arborea	2
Aster puniceus	2
Bromus inermis	1
Cardamine diphylla	1
Carpinus caroliniana	45
Chelone glabra	5
Equisetum arvense	15
Glyceria striata	1
Impatiens capensis	1
Mentha X piperita	1
Onoclea sensibilis	1
Osmunda cinnamomea	2
Prunus serotina	70
Rhamnus alnifolia	1
Rumex obtusifolius	1
Scutellaria lateriflora	1
Solanum dulcamara	1
Solidago patula	1
Symplocarpus foetidus	5
Viburnum recognitum	2
Atrichum crispum	1
Brachythecium rivulare	1
Calypogeia fissa	1
Campylium polygamum	2
Campylium radicale	1
Climaceum americanum	2
Helodium blandowii	1
Plagiomnium rostratum	1
Sematophyllum demissum	1
Thuidium delicatulum	3

Appendix I (cont.)

Moores Corners Seeps 2

Athyrium filix-femina	2
Betula alleghaniensis	5
Cardamine pensylvanica	1
Carex prasina	15
Carex scabrata	65
Chelone glabra	20
Chrysosplenium americanu	3
Cryptotaenia canadensis	1
Dryopteris intermedia	5
Fraxinus americana	5
Galium asprellum	1
Galium triflorum	5
Geum canadense	5
Glyceria striata	8
Grass sp. 1	1
Hamamelis virginiana	5
Impatiens capensis	10
Lindera benzoin	5
Mitella diphylla	2
Ostrya virginiana	2
Pilea pumila	10
Poa palustris	5
Poa sp.	1
Podophyllum peltatum	10
Polygonum virginianum	4
Prunus serotina	25
Ranunculus hispidus	5
Ranunculus recurvatus	3
Rumex obtusifolius	15
Symplocarpus foetidus	45
Ulmus rubra	2
Viola sp.1	1
Cladonia sp.	1
Dicranella cerviculata	1
Fissidens bryoides	1
Lophozia attenuata	1
Rhizomnium appalachianum	1
Rhynchostegium serrulatum	6
Riccardia palmata	1
Tetraphis pellucida	1
Thuidium delicatulum	9

Moores Corners Seeps 1

Acer rubrum	15
Cardamine pensylvanica	1
Carex scabrata	35
Carpinus caroliniana	25
Chelone glabra	1
Chrysosplenium americanum	10
Dryopteris intermedia	3
Floerkia proserpinacoides	10
Fraxinus americana	65
Galium aparine	1
Glechoma hederacea	2
Grass sp.	35
Impatiens capensis	25
Ludwigia palustris	1
Lysimachia ciliata	2
Pilea pumila	20
Poa alsodes	1
Polygonum virginianum	1
Prunus serotina	15
Quercus rubra	1
Ranunculus recurvatus	1
Rumex obtusifolius	5
Symplocarpus foetidus	35
Amblystegium tenax	1
Brachythecium rivulare	7
Rhizomnium punctatum	1
Thuidium delicatulum	1

State Game Lands #218

Arisaema triphyllum	1
Aster lateriflorus	1
Betula alleghaniensis	4
Cardamine diphylla	1
Carex stipata	5
Equisetum arvense	2
Eupatorium perfoliatum	1
Eupatorium rugosum	1
Fraxinus americana	5
Fraxinus nigra	5
Galium triflorum	1
Glyceria striata	1
Hamamelis virginiana	10
Hydrocotyle americana	1
Hypericum punctatum	1
Impatiens capensis	20
Lycopus uniflorus	1
Muhlenbergia mexicana	1
Osmunda cinnamomea	15
Polygonum arifolium	1
Polygonum sagittatum	1
Ranunculus acris	1
Ribes americana	5
Rubus pubescens	2
Saxifraga pensylvanica	1
Scirpus polyphyllus	2
Scutellaria lateriflora	2
Senecio aureus	1
Solanum dulcamara	1
Symplocarpus foetidus	20
Tiarella cordifolia	2
Tsuga canadensis	15
Veronica officinalis	1
Viola cucullata	1
Amblystegium tenax	3
Rhizomnium punctatum	1
Thuidium delicatulum	4

Appendix I (cont.)

Jennings Prairie Seeps

Arisaema triphyllum	1
Asclepias incarnata	1
Carex bromoides	30
Carex pellita	1
Carex stricta	90
Carex vulpinoidea	1
Cornus amomom	4
Cornus racemosa	4
Eupatorium fistulosum	1
Eupatorium perfoliatum	5
Galium asprelium	1
Glyceria striata	1
Helenium autumnale	1
Hypericum prolificum	1
Hystrix patula	1
Juncus marginatus	1
Lonicera dioica	1
Lycopus americanus	1
Lycopus uniflorus	1
Muhlenbergia mexicana	1
Physocarpus opulifolius	10
Poa palustris	1
Pycnanthemum virginianum	5
Ribes sp.	3
Selaginella apoda	1
Solidago canadensis	1
Solidago patula	10
Solidago rugosa	1
Spiraea alba	2
Symplocarpus foetidus	10
Thalictrum pubescens	1
Ulmus americana	1
Vernonia noveboracensis	11
Viburnum lentago	2
Amblystegium serpens	17
Brachythecium rivulare	7
Bryum pseudotriquetrum	5
Cratoneuron commutatum	2
Plagiomnium rugicum	1
Thuidium delicatulum	3

Plain Grove Fens - Island Fen

Agrostis stolonifera	1
Alnus incana	1
Aster lateriflorus	3
Bromus ciliatus	1
Calopogon tuberosus	1
Carex gracillima	1
Carex hystericina	1
Carex interior	1
Carex leptonervia	1
Carex sterilis	1
Carex stricta	1
Carex tetanica	10
Chara sp.	1
Cyperus bipartitus	1
Drosera rotundifolia	1
Eleocharis elliptica	1
Epilobium strictum	1
Equisetum arvense	1
Eriophorum viridicarinatum	1
Hypericum prolificum	1
Hypericum sp.	1
Juncus brevicaudatus	1
Muhlenbergia glomerata	2
Parnassia glauca	1
Physocarpus opulifolius	1
Prunella vulgaris	1
Pycnanthemum virginianu	3
Salix discolor	1
Salix sericea	1
Selaginella apoda	4
Senecio aureus	1
Solidago patula	1
Solidago uliginosa	5
Sphenopholis nitida	1
Spiranthes cernua	1
Spiranthes lucida	1
Symplocarpus foetidus	1
Thelypteris palustris	1
Tussilago farfara	1
Viola cucullata	15
Bryum pseudotriquetrum	1
Cladonia sp.	1
Fissidens adiantoides	1
Pellia epiphylla	1
Thuidium delicatulum	1
Tomenthypnum nitens	63

State Game Lands #284

Agrimonia parviflora	1
Angelica atropurpurea	10
Asclepias incarnata	1
Aster puniceus	1
Bromus ciliatus	1
Cardamine rhomboidea	1
Carex pellita	1
Carex prairea	5
Carex stricta	60
Carex vulpinoidea	1
Cirsium muticum	1
Clematis virginiana	1
Cornus racemosa	1
Eupatorium maculatum	2
Eupatorium rugosum	1
Grass sp.	1
Liriodendron tulipifera	1
Lycopus americanus	3
Lysimachia ciliata	3
Mentha arvensis	2
Mitella diphylla	1
Poa sp.	1
Solidago flexicaulis	20
Solidago rugosa	15
Solidago uliginosa	1
Spiranthes cernua	1
Ulmus americana	2
Vernonia noveboracensis	1
Viburnum recognitum	1
Thuidium delicatulum	1