New York City Department of Environmental Protection

Bureau of Water Supply

Reference Wetland Conditions in the Catskill and Delaware Watersheds of the New York City Water Supply System

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1. Introduction

DEP has collected vegetation, soils, and hydrologic data from reference wetlands throughout the Catskill and Delaware Watersheds for over a decade. Reference wetlands are defined in the Wetland Hydrogeomorphic Functional Assessment Method (HGM) as sites within a geographic region that encompass the known variation within a wetland type. The HGM Method intended that data collected from reference wetlands would be used to develop models for conducting site-specific functional assessment of proposed wetland impacts and compensatory mitigation to benefit implementation of Section 404 of the Clean Water Act (Brinson et al 1995, 1997).

The use of reference wetlands, however, is not limited to the development of site-specific, HGM-based functional impact assessment models. Reference wetlands provide an essential source of data to guide the design and assessment of wetland restoration, creation, and enhancement projects. The National Research Council (NRC) indicates that many mitigation projects fail to meet permit standards and are 'weakened by insufficient knowledge'. Projects have been unsuccessful in replicating conditions exhibited by 'natural' wetlands, partly due to a lack of data to provide a template for project design. Hence, reference wetland data can provide regulators and project managers with information to design, track project standards, and guide corrective measures as needed (National Research Council 2001, Brinson et al 1997).

Reference sites also provide region-specific information on the characteristics of relatively undisturbed, self-sustaining wetlands, which greatly benefits public education and outreach efforts. Information about the diverse array of wetland types and conditions can expand the public perception of wetlands beyond the most common 'wettest' types (e.g. marshes - which has obvious benefit to wetland protection efforts (Brinson et al 1997).

The goal of this report is to summarize vegetation, soils, and hydrologic data collected from DEP reference wetlands into metrics primarily to guide the design and assessment of wetland restoration, construction, and enhancement efforts. This will fill in information gaps not only for mitigation projects that DEP undertakes on city lands, but also those projects that DEP reviews throughout the watershed in its regulatory programs. The information will also provide a characterization of wetland resources in the Catskill and Delaware Watersheds, which will undoubtedly guide outreach efforts.

A complete list of native plant species occurring in the reference wetlands is provided, along with measures of their abundance among wetland cover types (Cowardin et al 1979). Stratification by cover type is necessary to provide meaningful metrics for plant density and abundance, which are key elements of project design. For example, averaging tree density for forested and emergent wetlands would provide a meaningless index with little heuristic value.

The range and median values of soil organic matter, pH, and nutrient levels are summarized. These properties exhibit large influence on wetland function and vegetation establishment, and are often included in wetland design specifications with little regional context. Finally, this report also describes the depth and duration of wetland saturation and

inundation during the growing, as hydrologic regime is a major driver of wetland vegetation communities, soil conditions, and overall functions.

Figure 1.1. Monitoring a forested wetland in the Cannonsville basin.

2. Methods

2.1 Study Area

Potential reference wetland study sites in the Catskill and Delaware watersheds were identified in 2003 and 2004 using digital orthophotos, National Wetlands Inventory (NWI), parcel boundaries, hydrography, soils and other Geographic Information System (GIS) data. Several wetlands were field evaluated in 2004 to select sites with minimal current and potential future disturbance, and accessibility for routine sampling. Nineteen sites, totaling approximately 117 acres were identified for inclusion as reference wetlands (Figure 2.1, Table 2.1).

Each site was named using a three letter code, the first letter of which designates the reservoir basin in which the site is located, and the remaining letters reference a local landmark (e.g. road or stream name). The boundaries of the reference wetland sites were delineated using a Trimble Pro XR Global Positioning System (GPS) unit in 2004 and 2005. GIS shapefiles were generated from the GPS data (Appendix A, Figures A.1 through A.18).

Cowardin cover types were delineated within each reference wetland through aerial photography interpretation (Cowardin et al. 1979). Classes include forested, scrub-shrub, and emergent wetlands. The emergent wetlands consist of shallow emergent and sedge meadow types as described in Ecological Communities of New York State (Edinger et al. 2002). Forested wetlands were further divided into deciduous (hardwood) and evergreen cover types. Evergreen cover types were denoted as hemlock-hardwood, as the stands were mostly mixed, with hemlocks dominant. Within the 19 sites, 4 emergent, 6 scrub-shrub, 8 hardwood forest, and 10 hemlock-hardwood forest wetland areas were delineated (Table 2.1).

2.2 Vegetation Sampling

Vegetation sampling grids (50 m x 50 m) were constructed for all of the study sites using GIS. The grid origins were selected randomly to construct a systematic random sampling design. Each intersection point on the sampling grid that was at least 10 m from the wetland boundary was included as a vegetation sampling plot. Vegetation sampling plots were located and flagged at all of the wetlands using real-time GPS when site conditions permitted, or using a tape and compass when cloud or canopy cover precluded the use of GPS. Each water table monitoring well location (see below) also served as the central point of a vegetation sampling plot when no other plots were located within 10 m of a well.

Vegetation sampling was completed during the 2004 and 2005 growing seasons. At each plot, the percent cover by each species in the herbaceous stratum was measured in a 1 m^2 circular plot. The herbaceous stratum included all herbaceous plants, woody plants less than 1 m tall, and vines (USACE 2012). The species and number of all shrubs and saplings present in a 12.6 m^2 area (0.0031 acre, 2 m radius) were recorded. The diameter at breast height (dbh) and species of all trees present within a 314 m^2 area (0.0776 acre, 10 m radius) were recorded. The shrub and sapling layer included woody plants with a dbh less than 10.2 cm (4 inches), and trees were defined as woody plants with a dbh > 10.2 cm. Any species present in the 12.6 m^2 plot that were not recorded in the 1 m^2 plot were recorded to collect data for species richness.

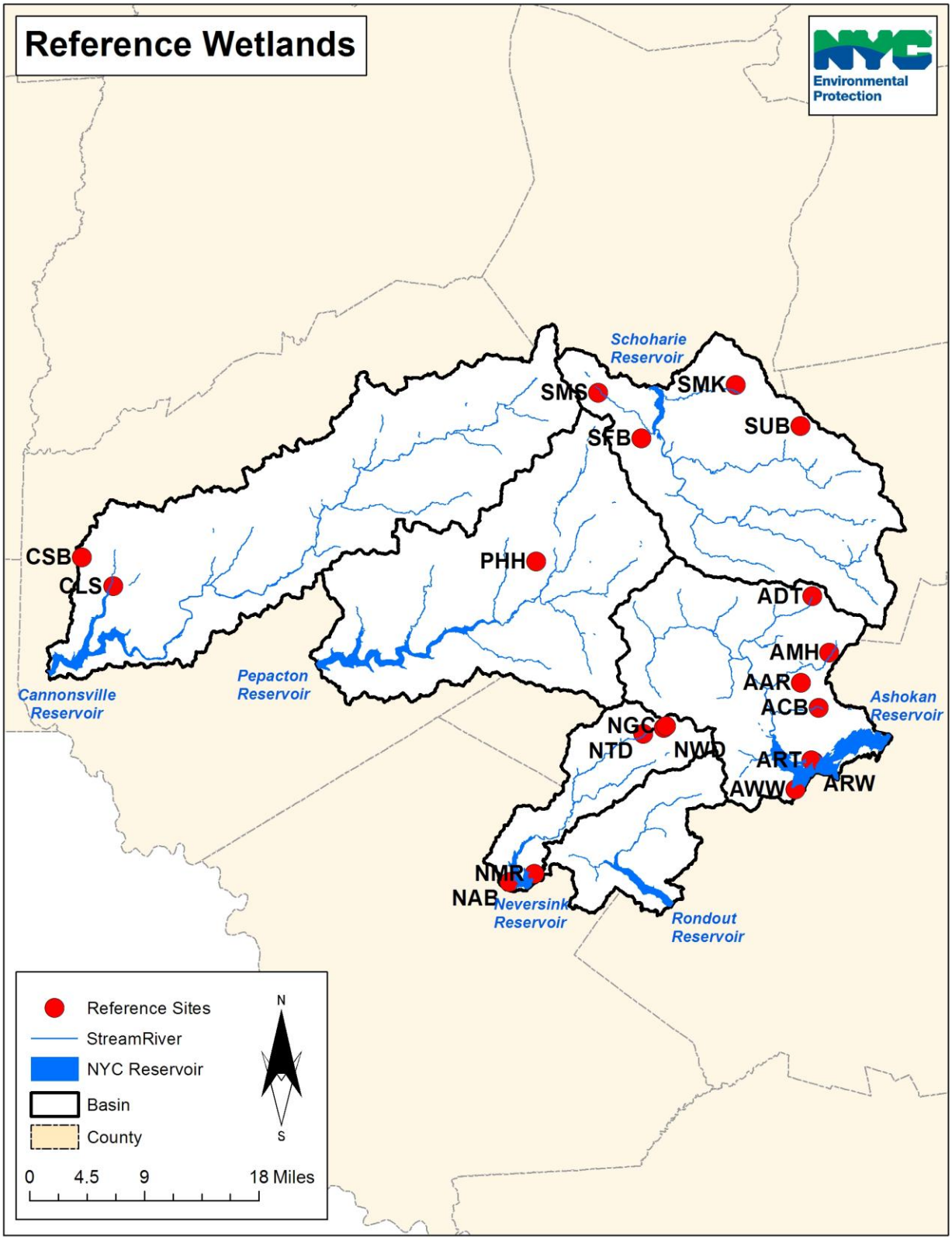

Figure 2.1. Reference wetland locations in the Catskill and Delaware Watersheds.

Species were identified using the Manual of Vascular Plants of Northeastern United States and Adjacent Canada. 2nd Ed. (Gleason and Cronquist 1991) and taxonomy was updated according to the International Code of Botanical Nomenclature (International Association for Plant Taxonomy 2007). The wetland indicator status was provided for each species, when available, from the 2014 National Wetlands Plant List (NWPL) (Lichvar et al. 2014).

Table 2.1. Cover types of reference wetland sites.

	Emergent		**Scrub-shrub**		**Hardwood Forested**		**Hemlock-hardwood Forested**		**Total**	
Site	Acres	no. of plots	Acres	no. of plots	Acres	no. of plots	Acres	no. of plots	Acres	no. of plots
AAR							0.3	1	0.3	1
ACB							7.6	6	7.6	6
ADT	3.1	4							3.1	4
AMH	3.8	8					4.4	3	8.2	11
ART							7.4	6	7.4	6
ARW					12.9	13			12.9	13
AWW					3.0	5			3.0	5
CLS							1.2	1	1.2	1
CSB			3.8	6			1.7	0	5.6	6
NAB	5.3	6	1.2	3	2.5	5	4.4	3	13.3	17
NGC	0.4	0			0.4	0	1.4	2	2.1	2
NMR	1.4	3			4.4	3	13.5	18	19.2	24
NTD					0.4	1			0.4	1
NWD							1.6	4	1.6	4
PHH			0.9	1			3.9	5	4.8	6
SFB					3.4	5			3.4	5
SMK			0.2	1	3.6	1			3.8	2
SMS			3.2	4	1.9	0			5.1	4
SUB			3.2	4	10.3	7			13.6	11
Total	**13.9**	**21**	**12.5**	**19**	**42.8**	**40**	**47.4**	**49**	**116.7**	**129**

2.3 Water Table Monitoring

Thirty Ecotone™ monitoring wells were installed throughout the study sites during the early 2004 growing season. In general, two wells were placed in lotic wetlands (those with stream throughflow), with one near the inflow and one near the outflow, and a single well was placed centrally within the terrene (no stream inflow) wetlands. In 2008, DEP began replacing the original Ecotone™ monitoring wells with an updated, more reliable model that employs industrial lithium rather than alkaline batteries to minimize data loss due to battery depletion. All wells were replaced by 2013.

The Ecotone™ data loggers record groundwater levels relative to a calibration point at 6 hour intervals and are downloaded periodically. The calibration point is the distance from the sensor to a reference point within the well above the soil surface. The distance from the calibration point to the soil surface was manually measured and recorded at each well. The Ecotone™ logs the distance from the calibration point to the water level as a negative value. The water level is therefore calculated as the difference between the logged water level (relative to the calibration point) minus the distance between the soil surface and the calibration point. Values of 0 indicate the water table is at the soil surface, negative values are below the soil surface, and positive values indicate inundation.

2.4 Soil Sampling and Analysis

Soil samples were collected from the well bore holes during the Ecotone™ installations. A sample from each horizon was oven-dried and submitted to Cornell Nutrient Analysis Laboratory for analysis of pH (in water), percent organic matter (OM) by loss on ignition, percent total Nitrogen (N) (dry combustion), total Phosphorus (P) by nitric acid digestion, available forms of P, Potassium (K) , Magnesium (Mg), and Calcium (Ca) (Morgan extraction).

Figure 2.2. Data collection from an Ecotone™ monitoring well in the Schoharie basin (SMS).

2.5 Data Analysis

2.5.1 Vegetation

Simple frequency and frequency were calculated for all species by cover type (hardwood, hemlock-hardwood, scrub-shrub, emergent) as follows:

Simple frequency = the number of sites of cover type x in which a species occurs

Frequency = simple frequency ÷ total number of sites within cover type x

The following metrics were also calculated by cover type:

2.5.1.1 Tree stratum

The dbh for each tree was converted to basal area according to the following formula:

$$BA\ (ft^2) = (dbh(in))^2 \times 0.005454$$

Within each site, the basal areas of individual trees were summed for each species. Basal area (ft^2/acre) was calculated for each species by dividing its total basal area (ft^2) by the area sampled within each site.

For each species within a site:

$$\text{Total BA}_{\text{species a}}\ (ft^2/\text{acre}) = \sum BA\ (ft^2)_{\text{species a}} \div ((\text{total number of plots sampled}) \times (0.0776\ \text{acre/plot}))$$

For each site, the total basal area of all trees was calculated as:

$$\text{Total BA}_{\text{all species}}\ (ft^2/\text{acre}) = \sum \text{Total BA}_{\text{species a…n}}$$

2.5.1.2 Tree and Shrub Strata

The density of tree species was calculated as:

$$\text{Density}_{\text{species A}} = \text{total number of stems of species A rooted within all sampling plots} \div ((\text{total number of plots sampled}) \times (0.0776\ \text{acre/plot}))$$

And for shrubs as:

$$\text{Density}_{\text{species A}}\ (\text{stems/acre}) = \text{total number of stems of species A rooted within all sampling plots} \div ((\text{total number of plots sampled}) \times (0.0031\ \text{acre/plot}))$$

Total density (stems/acre) was calculated separately for trees and shrubs for each site as:

$$\text{Total Density (stems/acre)} = \sum \text{Density}_{\text{species a}\ldots\ldots n}$$

2.5.1.3 Herbaceous stratum

For each species, the percent cover within a site was estimated by taking the average of the percent covers for that species among all plots sampled as:

$$\%\ \text{cover}_{\text{species A}} = \sum \%\text{cover}_{\text{species a}}\ \text{plot}\ 1\ldots..n/\ n\ \text{plots}$$

For each site the total % cover of herbaceous species was calculated as:

$$\text{Total}\ \%\ \text{cover} = \sum \%\text{cover}_{\text{species a}.....n}$$

The herbaceous data was also summarized by calculating % total cover for forbs (broad-leaved flowering plants), graminoids (grasses, sedges, and rushes), ferns, seedlings, and vines.

2.5.2 Wells

Well data from 2004 through December 2013 was analyzed for completeness. Because the original alkaline battery technology resulted in frequent data gaps, a subset of wells from each cover with the most complete hydrologic record during the growing seasons (defined as April 15 through October 1) between 2008 and 2013 were selected for this report (Table 2.2).

Using Statistica 64© Version 10 (Statsoft Inc.), the mean, median, and range of water levels were calculated for each well for the growing season. For this report, analysis was limited to the growing season since hydrodynamics during this period most strongly influence vegetation and soil characteristics. To provide an index of hydroperiod, the percentage of water level measurements during the growing season that were between 0 and -30 cm (12 in) was also calculated for each well. Measurements within this range demonstrate saturation in the root zone, which was defined as 30 cm (12) in below the soil surface, consistent with the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (USACE 2013). The percentage of water level measurements during the growing season that were above the soil surface (> 0 in) was also calculated for each well, indicating the duration of inundation.

2.5.3 Soils

Data from surface horizons were analyzed for this report, as these layers most strongly influence and are influenced by the biotic community. Soil horizons were defined as surface horizons if all or the majority of their thickness was entirely within the root zone. For analysis, soils were grouped as mineral soils or Histosols. Mineral soils contain less than 12% organic matter (OM). Soils were considered Histosols if greater than 2/3 of the solum was organic soil material (i.e. containing more than 12% OM). Mineral soils were further categorized between those having organic accumulation (in the form of a histic epipedon or O horizon) and those without organic layers. Sites were described as having a histic epipedon if they were composed of organic soil material that were 7.9 to 15.7 in. thick, but comprised less than 2/3 of the solum.

Surface horizons that were comprised of organic soil material and were less than 7.9 inches thick were noted as O horizons (Soil Survey Staff 2014).

The mean, median, and range of soil pH, percent OM, percent total N, total P, and available P, K, Mg, and Ca were summarized by soil type (Mineral, Mineral with O horizon/histic epipedon, Histosol). Comparisons of soil properties among wetland community types, reservoir basins, and soil types were made using Krusal-Wallis. The distribution of soil groups among community types was tested using a Chi-square goodness of fit test (Statistica 64© Version 10 (Statsoft Inc.)).

Table 2.2. Well data included in analysis. X indicates years in which growing season data is available. The first three letters of well ID indicate the site name. In and Out are specified for lotic wetlands with wells at both inflows and outflows.

Cover Type	Well ID	Growing Season					
		2008	2009	2010	2011	2012	2013
Emergent	ADTIN	X	X	X	X	X	X
	AMHOUT	X	X	X	X	X	X
	NABOUT			X	X		X
Hemlock-hardwood	ACBIN		X	X	X	X	X
	ART			X	X	X	X
	NGC		X	X	X	X	X
	PHHIN		X	X	X	X	X
Hardwood	ARWOUT		X	X	X	X	X
	NABIN		X		X	X	X
	NTD		X	X	X	X	X
	SFB		X	X	X		X
Scrub-shrub	CSBIN	X	X	X	X	X	X
	CSBOUT	X	X	X	X	X	X
	SMK	X	X	X	X	X	X
	SMS	X		X	X	X	X

3. Results

3.1 Vegetation

Two hundred and four species were recorded in the reference wetland sampling plots, including 22 trees, 24 shrubs, 98 forbs, 44 graminoids, 11 ferns, and 5 vines. The distribution of the species among the four wetland community types is summarized in Tables 3.5 through 3.10. Metrics of species abundance and/or frequency within each community type are provided in Appendix B and discussed in the following sections.

Figure 3.1. Emergent vegetation and red maple at a reference wetland in the Ashokan basin (ADT).

3.1.1 Hardwood Wetlands

Figure 3.2. Red maple hardwood reference wetland with a sensitive fern understory in the Neversink basin (NAB).

One hundred forty eight native species were recorded in the 8 hardwood wetland areas, including 24 trees, 16 shrubs, 68 forbs, 29 graminoids, 7 ferns, and 4 vines (Appendix B, Tables B.1 through B.8).

Tree density in hardwood wetlands ranged from 90 to 309 trees per acre, with a median of 165. Basal area ranged from 52 to 157 feet^2/acre, with a median of 91. Shrub density was highly variable ranging from 0 stems per acre at two sites to a maximum of 4,968 stems per acre, for a median of 729. This high variability in shrub density is likely due to the high density of small species such as *Spiraea latifolia* (meadowsweet) at SUB and due to the presence of multi-stemmed species such as *Alnus incana* (speckled alder) and *Vaccinium corymbosum* (highbush blueberry) at SUB and AWW, respectively (Table 3.1).

Table 3.1. Tree basal area, shrub and tree density, and herbaceous cover for hardwood wetland study areas.

Site	no. of plots	Tree Stratum		Shrub Stratum	Herbaceous Stratum (% cover)					
		Total Density (stems/acre)	Total Basal Area (ft^2/acre)	Total Density (stems/acre)	Graminoids	Forbs	Ferns	Seedlings	Vines	Total
ARW	13	162.6	157.3	620	17.7	13.1	0.2	1.1	0.9	32.9
AWW	5	309.3	103.6	1097	9.0	14.2	0.8	0.5	0.1	24.6
NAB	5	141.8	78.4	839	6.4	51.9	12.5	1.2	0.0	72.0
NMR	3	305	102.8	108	4.3	3.5	0.0	0.7	0.0	8.5
SFB	5	167.5	122.9	4968	1.1	24.3	27.0	18.2	0.0	70.6
SUB	7	123.7	64.7	1335	23.6	17.6	0.9	13.0	0.0	55.1
SMK	1	90.2	51.8	0	4.5	29.5	0.0	4.0	3.0	41.0
NTD	1	268.8	73.7	0	22.5	50.0	0.0	0.0	0.0	72.5

Acer rubrum (red maple) had the highest frequency and basal area in the hardwood wetlands. All but one of the 8 hardwood wetland areas were dominated by red maple and can be classified as red maple-hardwood (Edinger et al. 2002). The remaining hardwood site, SUB, was dominated by *Fraxinus pennsylvanica* (green ash). Ash had the second highest frequency, occurring at 7 of the 8 hardwood wetland areas. *Pinus strobus* (white pine) had the third highest frequency occurring in 5 of the 8 sites. *Tsuga canadensis* (eastern hemlock), *Betula alleghaniensis* (yellow birch) and *Acer saccharum* (sugar maple) were recorded in half of the sites (Appendix B, Table B.1).

Several facultative upland tree species were recorded in the study plots. This is indicative of the fairly high degree of microtopography within forested wetlands in the Catskills. Species such as sugar maple and white pine frequently occur on microtopographic highs within wetland areas. Many of the remaining species were typically found near the wetland-upland boundaries.

A total of 19 native woody species were recorded in the shrub stratum of the 8 hardwood wetland areas, 12 of these were saplings of tree species that had also been recorded in the tree plots. Shrub frequencies were low overall and no species occurred in more than 2 of the 10 study sites. Twenty five woody species were present as seedlings in the herbaceous statum. Seventeen of these species were also present in the shrub and/or tree strata. Most of the remaining seedlings (n=8) were shrub species that had not been previously recorded (Appendix B, Tables B.2 and B.3).

Herbaceous vegetation cover ranged from 8.5% to 72.5% of the hardwood wetlands, with a median of 48.1%. Forb and graminoid species had the highest cover with medians of 21 and

8%, respectively. Coverage by seedlings was lower (median = 1.1%), followed by ferns (median =0.5%) and vines (median = 0%) (Table 3.1).

The most commonly occurring herbaceous hydrophytes in hardwood wetlands included *Persicaria sagittata* (arrow-leaved tearthumb), *Impatiens capensis* (orange jewelweed), *Onoclea sensibilis* (sensitive fern), and *Glyceria striata* (fowl mannagrass). The remaining herbaceous species exhibited low frequencies, each occurring in less than half of the sites (Appendix B, Table B.4 through B.8).

3.1.2 Hemlock-hardwood Wetlands

Figure 3.3. Hemlock-hardwood wetland in the Ashokan basin (ACB)

A total of 123 native species were recorded in the 10 hemlock-hardwood wetland areas, including 23 trees, 20 shrubs, 48 forbs, 20 graminoids, 9 ferns, and 3 vines (Appendix B, Tables B.9 thorough B.16).

Tree density ranged from 39 to 219 stems per acre in the hemlock-hardwood wetland areas, and total basal area ranged from 103 to 453 feet^2/acre, with a median of 207 feet^2/acre.

Shrub density ranged from 0 stems/acre in two sites to 538 stems/acre, with a median of 188 stems/acre. Herbaceous cover ranged from 0 to 108%, with a median of 32%. Ferns and forbs had the highest cover with medians of 11% and 5%, respectively. Graminoids, seedlings, and vines all had median covers of less than 1%. The highest cover occurred at NGC, where the vegetation plot is comprised of two cover types, emergent and hemlock-hardwood (Table 3.2).

Table 3.2. Tree basal area, shrub and tree density, and herbaceous cover for hemlock-hardwood wetland study areas.

Site	no. of plots	Tree Stratum		Shrub Stratum	Herbaceous stratum (% cover)					
		Total Density (stems/acre)	Total Basal Area (ft^2/acre)	Total Density (stems/acre)	Graminoids	Forbs	Ferns	Seedlings	Vines	Total
AAR	1	207.4	335.1	0	0.0	0.0	0.0	0.0	0.0	0.0
ACB	6	127.7	453.2	161	0.5	10.6	14.7	0.2	0.0	25.9
AMH	3	53.1	137.5	538	27.3	7.5	15.7	0.7	0.0	51.2
ART	6	195.4	208.3	54	0.4	7.0	0.0	0.8	0.1	8.3
CLS	1	39.3	103.1	0	0.0	7.0	60.0	0.0	0.0	67.0
NAB	3	218.6	240.5	430	0.0	0.0	0.0	0.5	0.0	0.5
NGC	2	77.6	283.5	161	79.5	15.0	13.8	0.0	0.0	108.3
NMR	18	125.9	195.4	215	2.2	9.2	15.4	10.9	0.0	37.6
NWD	4	98.2	206.2	323	0.0	4.0	9.1	6.1	0.0	19.3
PHH	5	61.2	170.1	258	2.2	47.5	0.3	0.1	0.2	50.3

Eastern hemlock was dominant in all 10 hemlock-hardwood wetland areas and had the highest relative basal area overall, comprising over 50% of the basal area in 6 of the 10 hemlock-hardwood wetland areas. Hemlock was a co-dominant with other hardwood species such as yellow birch and red maple in the remaining 4 sites. Yellow birch also occurred in all 10 sites, and red maple occurred in 9 of the 10 sites. The remaining tree species had frequencies less than 50%. As in the hardwood wetlands, a number of facultative-upland tree species were recorded in the study plots. Most of these species occur on microtopographic highs and near upland wetland boundaries (Appendix B, Table B.9).

Thirteen shrub species were recorded in the shrub stratum, 7 of which were saplings of species occurring in the tree stratum. Eastern hemlock had the highest frequency of species observed in the shrub layer, occurring in 30% of the hemlockhardwood sites. The majority (n=8) of species observed in the shrub layer had a frequency of 10%. Thirty six woody species were present in the herbaceous plots, 14 of which were also present in the tree and/or shrub strata. The remaining 22 were previously unrecorded shrub (n=15) and tree (n=7) species (Appendix B, Tables B.10 and B.11).

The herbaceous layer was comprised of many shade tolerant plants. *Scutellaria lateriflora* (mad dog skullcap) had the highest frequency of occurrence (70%), followed by other shade tolerant or acid loving plants such as *Trientalis borealis* (star flower), *Osmunda cinnamomea* (cinnamon fern), sensitive fern, fowl mannagrass, arrow-leaved tearthumb, *Mitchella repens* (partridge berry), *Maianthemum canadensis* (Canada mayflower), jewelweed, *Coptis trifolia* (goldthread), and *Chrysosplenium americanum* (golden saxifrage) (Appendix B, Tables B.12 through B.16).

3.1.3 Scrub-shrub Wetlands

Figure 3.4. Scrub-shrub wetland in the Schoharie basin (SMS).

A total of 85 species were recorded in the scrub-shrub wetland sites, including 8 trees, 8 shrubs 47 forbs, 15 graminoids, 6 ferns, and 1 vine (Appendix B, Tables B.17 through B.24).

Shrub density ranged from 968 to 19,113 stems per acre with a median of 6,895. The highest stem densities were recorded for small species such as *Spiraea latifolia* (broad-leaf meadowsweet). Not surprisingly, tree density and total basal area were relatively low, ranging from 0 to 42 stems per acre (median 24) and from 0 to 26 feet^2/acre (median 6), respectively. Herbaceous cover was fairly high at the scrub-shrub wetlands, with a median of 87%. One site,

PHH, had very low herbaceous cover, possibly due to shading by the *Salix sericea* (silky willow) canopy. Forbs and seedlings had the highest median coverage (25% and 18%, respectively) (Table 3.3).

Table 3.3. Tree basal area, shrub and tree density, and herbaceous cover of scrub-shrub wetland areas.

Site	no. of plots	Tree Stratum		Shrub Stratum	Herbaceous Stratum (% cover)					
		Total Density (stems/acre)	Total Basal Area (ft^2/acre)	Total Density (stems/acre)	Graminoids	Forbs	Ferns	Seedlings	Vines	Total
CSB	6	26	6.6	3602	23.0	52.6	9.1	10.9	0.0	95.6
NAB	3	21	4.8	8629	3.0	35.3	8.7	25.5	0.0	72.5
PHH	1	0	0.0	5161	0.0	1.0	0.0	0.0	0.0	1.0
SMS	4	42	7.4	19113	0.8	29.0	11.0	51.6	0.0	92.4
SUB	4	23	4.8	15887	18.6	7.4	0.5	25.5	1.8	53.8
SMK	1	26	26.1	968	33.0	20.0	70.0	3.0	0.5	126.5

All but one of the scrub-shrub wetland areas had trees within the 10 m radius sampling plots. Red maple was present in 5 of the 6 scrub-shrub wetland areas (frequency = 83%). The remaining trees all had a frequency of 17%, indicating their presence in just one of the six sites. Of the shrubs, broad-leaf meadowsweet, and speckled alder had the highest frequencies. The remaining shrub species had frequencies less than 50% (present in 1 or 2 of the study sites). A total of 11 woody species were recorded in the seedling layer, 6 of which also occurred in the shrub and/or tree stratum (Appendix B, Tables B.17 through B.19).

The most commonly observed species in the herbaceous layer include sensitive fern and orange jewelweed which occurred in all sites, and *Chelone glabra* (white turtle head), arrow-leaved tearthumb, *Symphiotrichum novi-belgii* (New York Aster), *Solidago rugosa* (wrinkle leaved goldenrod), *Leersia oryzoides* (rice cutgrass), and broad-leaf meadowsweet. The remaining species had frequencies of less than 50% (Appendix B, Tables B.20 through B.24).

3.1.4 Emergent Wetlands

Figure 3.5. Emergent reference wetland in the Ashokan basin (AMH), dominated by sensitive fern and sedges.

A total of 107 species were recorded in the emergent wetland areas including 7 trees, 12 shrubs, 51 forbs, 27 graminoids, 7 ferns, and 3 vines (Appendix B, Tables B.25 through B.32).

As expected, trees were sparse in the emergent wetlands, with a median density of 11.5 stems/acre and a median basal area of 3.7 feet^2/acre. Two of the four emergent wetland areas lacked trees in the sampling plots. Red maple and white pine were present in both of the emergent areas with trees (Table 3.4, Appendix B, Table B.25).

Shrub stem density was fairly low (median 161 stems/acre) in all but one site (NAB). NAB is a spatially and temporally variable wetland due to beaver influence. This plot was likely misinterpreted from the aerial photography as an emergent, rather than scrub-shrub area.

Herbaceous cover ranged from 85% to 115% in emergent wetlands, with a median of 95%. Graminoids had the highest median cover (34%) followed by forbs (22%), ferns (15%), seedlings (9%) and vines (0%) (Table 3.4).

Table 3.4. Tree basal area, tree and shrub density, and herbaceous cover of emergent wetland areas.

Site	no. of plots	Tree stratum		Shrub Stratum	Herbaceous Stratum (% cover)					
		Total Density (stems per acre)	Basal Area (ft2/acre)	Total Density (stems per acre)	Graminoids	Forbs	Ferns	Seedlings	Vines	Total
ADT	4	0	0	0	20.3	40.6	25.0	3.5	25.0	114.4
AMH	8	23	7.4	323	23.4	14.4	53.7	6.9	0.0	98.4
NAB	6	0	0	5753	44.9	25.7	4.5	10.3	0.0	85.3
NMR	3	39	13.1	0	48.7	18.2	0.3	23.5	0.0	90.7

Many herbaceous species had frequencies greater than 75% such as sensitive fern, *Euthamia graminifolia* (flat-topped goldenrod), arrow-leaved tearthumb, mad dog skullcap, wrinkle-leaved goldenrod, *Hydrocotyl americana* (marsh pennywort), orange jewelweed, *Glyceria canadensis* (rattlesnake mannagrass), *Juncus effusus* (soft rush), *Rubus hispidus* (swamp dewberry), *Scirpus cyperinus* (wool grass), and several sedges such as *Carex scoparia* (pointed broom sedge), *Carex crinita* (fringed sedge), and *Carex lurida* (shallow sedge) (Appendix B, tables B.28 through B.32).

Figure 3.6. Wool grass and goldenrod at a wetland in the Ashokan basin.

Table 3.5. Canopy and understory trees present in reference wetland sampling plots. 'X' indicates presence in one or more of the reference sites for each community. Includes those measured in tree plots, shrub plots (saplings) and herbaceous plots (seedlings). An indicator status of NL indicates 'not listed' in the NWPL, a blank indicates that the specimen was not identified to species level.

Species	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Abies balsamea	balsam fir	FAC	X	X			50
Acer pensylvanicum	striped maple	FACU	X				25
Acer rubrum	red maple	FAC	X	X	X	X	100
Acer saccharinum	silver maple	FACW		X			25
Acer saccharum	sugar maple	FACU	X	X			50
Acer spicatum	mountain maple	FACU		X			25
Betula alleghaniensis	yellow birch	FAC	X	X		X	75
Betula lenta	black birch	FACU		X			25
Betula papyrifera	paper birch	FACU	X				25
Carpinus caroliniana	American hornbeam	FAC	X	X			50
Carya ovata	shagbark hickory	FACU	X	X			50
Fagus grandifolia	American beech	FACU	X	X			50
Fraxinus pennsylvanica	green ash	FACW	X	X	X		75
Hamamelis virginiana	witch hazel	FACU	X	X		X	75
Juniperus virginiana	eastern red cedar	FACU	X				25
Malus coronaria	sweet crab-apple	NL	X	X			50
Nyssa sylvatica	black gum (tupelo)	FAC	X	X			50
Ostrya virginiana	eastern hop-hornbeam	FACU	X	X			50
Picea glauca	white spruce	FACU		X		X	50
Picea mariana	black spruce	FACW		X			25
Pinus strobus	white pine	FACU	X	X		X	75
Populus tremuloides	quaking aspen	FACU	X			X	50
Prunus serotina	black cherry	FACU	X	X			50
Prunus virginiana	choke cherry	FACU			X		25
Quercus alba	northern white oak	FACU	X	X			50
Quercus bicolor	swamp white oak	FACW	X				25
Quercus rubra	red oak	FACU	X	X		X	75
Robinia spp.	locus				X		25
Tilia americana	American basswood	FACU	X				25
Tsuga canadensis	eastern hemlock	FACU	X	X		X	75
Ulmus americana	American elm	FACW	X	X	X		75

Table 3.6. Shrub species present in the reference wetland sampling plots. 'X' indicates presence in one or more of the reference sites for each community type. Includes those measured in both shrub and herbaceous plots (seedlings). An indicator status of NL indicates 'not listed' in the NWPL, a blank indicates that the specimen was not identified to species level.

Latin Name	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Alnus incana	speckled alder	FACW	X		X	X	75
Cornus drummondii	rough-leaved dogwood	FAC		X			25
Cornus racemosa	gray dogwood	FAC	X				25
Gaultheria procumbens	wintergreen	FACU		X			25
Gaylussacia dumosa	dwarf huckleberry	FAC	X	X			50
Ilex verticillata	winterberry holly	FACW	X	X			50
Kalmia latifolia	mountain laurel	FACU		X		X	50
Lonicera spp.	honeysuckle			X			25
Lyonia ligustrina	maleberry	FACW				X	25
Rhododendron maximum	white(great) laurel	FAC	X	X			50
Rosa spp.	rose			X			25
Rubus allegheniensis	common blackberry	FACU	X				25
Rubus flagellaris	northern dewberry	FACU				X	25
Rubus hispidus	swamp dewberry	FACW	X	X	X	X	100
Rubus idaeus	red raspberry	FACU	X		X	X	75
Rubus pubescens	dwarf raspberry	FACW	X	X	X		75
Rubus setosus	bristly blackberry	FACW		X			25
Salix sericea	silky willow	OBL			X	X	50
Spiraea latifolia	broad-leaf meadowsweet	FACW	X	X	X	X	100
Spiraea tomentosa	hardhack	FACW	X	X	X	X	100
Vaccinium angustifolium	lowbush blueberry	FACU		X			25
Vaccinium corymbosum	highbush blueberry	FACW	X	X	X	X	100
Vaccinium myrtilloides	velvetleaf blueberry	FACW		X		X	50
Viburnum dentatum	arrowwood	FAC	X	X	X		75
Viburnum lantanoides	hobblebush	FACU		X			25
Viburnum lentago	nannyberry	FAC	X				25

Figure 3.7. Highbush blueberry.

Table 3.7. Forb species present in the reference wetland sampling plots. 'X' indicates presence in one or more of the reference sites for each community. An indicator status of NL indicates 'not listed' in the NWPL, a blank indicates that the specimen was not identified to species level.

Latin Name	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Alisma triviale	water plantain	OBL	X				25
Anemone acutiloba	sharp-lobed hepatica	NL	X				25
Anemone quinquefolia	wood anemone	FACU	X	X		X	75
Arisaema triphyllum	Jack in the pulpit	FAC	X	X	X	X	100
Asclepias spp.	milkweed					X	25
Bidens cernua	nodding bur-marigold	OBL			X	X	50
Bidens connata	swamp beggar-ticks	OBL	X	X		X	75
Bidens frondosa	devil's bit	FACW	X		X		50
Boehmeria cylindrica	small-spike false nettle	OBL	X				25
Caltha palustris	marsh marigold	OBL	X	X			50
Chelone glabra	white turtlehead	OBL	X	X	X	X	100
Chrysosplenium americanum	golden saxifrage	OBL	X	X	X	X	100
Cicuta bulbifera	water hemlock	OBL		X			25
Circaea lutetiana ssp. canadensis	enchanter's nightshade	FACU	X				25
Cirsium spp.	thistle					X	25
Coptis trifolia	goldthread	FACW	X	X			50
Doellingeria umbellata	flat-topped white aster	FACW	X	X	X	X	100
Elodea canadensis	Canadian waterweed	OBL				X	25
Epilobium ciliatum	fringed willowherb	FACW	X	X	X	X	100
Epilobium coloratum	purple-leaf willowherb	OBL	X	X	X		75
Eupatorium perfoliatum	boneset	FACW	X	X	X	X	100
Eurybia divaricata	white wood-aster	NL		X			25
Eurybia radula	low rough aster	OBL			X		25
Euthamia graminifolia	flat-topped goldenrod	FAC	X	X	X	X	100
Eutrochium maculatum	spotted Joe-pye weed	OBL	X		X	X	75
Fragaria vesca	wood strawberry	UPL	X	X	X	X	100
Galium aparine	cleavers	FACU	X		X		50
Galium palustre	marsh bedstraw	OBL			X	X	50
Galium tinctorium	stiff marsh bedstraw	OBL		X			25
Galium trifidum	sweet-scented bedstraw	FACU		X	X	X	75
Geranium maculatum	wild geranium	FACU				X	25
Geranium robertianum	Robert's geranium	FACU				X	25
Geum aleppicum	yellow avens	FAC	X				25
Geum canadense	white avens	FAC	X				25
Geum laciniatum	rough avens	FACW	X				25
Geum macrophyllum	big-leaved avens	FACW			X		25
Heuchera americana	American alum-root	FACU	X				25
Hieracium spp.	hawkweed			X			25
Hydrocotyle americana	marsh pennywort	OBL	X	X	X	X	100
Hypericum canadense	lesser St. Johnswort	FACW				X	25
Hypericum ellipticum	pale St. Johnswort	OBL	X			X	50
Hypericum mutilum	dwarf St. Johnswort	FACW		X	X	X	75
Hypericum punctatum	spotted St. Johnswort	FAC			X	X	50
Impatiens capensis	orange jewelweed	FACW	X		X	X	75
Impatiens pallida	yellow jewelweed	FACW			X	X	50
Iris versicolor	blue flag	OBL			X		25
Lemna spp.	duckweed				X		25

Table 3.7. Forbs continued.

Latin Name	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Lycopus americanus	water-horehound	OBL	X		X		50
Lycopus uniflorus	northern bugleweed	OBL	X	X	X	X	100
Lysimachia ciliata	fringed loosestrife	FACW	X	X	X	X	100
Lysimachia terrestris	swamp candles	OBL	X		X	X	75
Maianthemum canadense	Canada mayflower	FACU	X	X			50
Micranthes pensylvanica	swamp saxifrage	OBL	X		X		50
Mitchella repens	partridgeberry	FACU	X	X			50
Mitella spp.	unknown miterwort			X			25
Myosotis laxa	bay forget-me-not	OBL		X		X	50
Myosotis scorpioides	true forget-me-not	OBL	X				25
Oxalis montana	white wood-sorrel	FACU		X			25
Oxalis stricta	common wood-sorrel	FACU	X	X		X	75
Packera aurea	heart-leaved groundsel	FACW	X	X		X	75
Persicaria arifolia	halberd-leaf tearthumb	OBL	X	X			50
Persicaria punctata	dotted smartweed	OBL	X				25
Persicaria sagittata	arrow-leaf tearthumb	OBL	X	X	X	X	100
Pilea pumila	clearweed	FACW	X	X		X	75
Polygala paucifolia	gay-wing milkwort	FACU	X				25
Potentilla simplex	common cinquefoil	FACU	X	X	X	X	100
Prenanthes altissima	tall white lettuce	FACU	X				25
Prunella vulgaris	self heal	FAC	X			X	50
Ranunculus hispidus	bristly buttercup	FAC		X			25
Ranunculus sceleratus	cursed crow's foot	OBL	X	X	X	X	100
Rorippa aquatica	true water-cress	OBL	X	X	X		75
Rumex spp.	dock		X		X	X	75
Sagittaria latifolia	common arrow head	OBL			X	X	50
Scutellaria galericulata	marsh skullcap	OBL				X	25
Scutellaria lateriflora	mad dog skullcap	OBL	X	X	X	X	100
Sium suave	water parsnip	OBL	X				25
Solidago canadensis	Canada goldenrod	FACU	X		X	X	75
Solidago gigantea	smooth goldenrold	FACW	X	X	X		75
Solidago patula	round-leaved goldenrod	OBL	X	X	X		75
Solidago rugosa	wrinkle leaved goldenrod	FAC	X	X	X	X	100
Solidago uliginosa	bog goldenrod	OBL	X		X		50
Sparganium americanum	American bur-reed	OBL	X		X		50
Stellaria alsine	bog stitchwort	OBL				X	25
Streptopus lanceolatus	rosy twisted stalk	FACU	X				25
Symphyotrichum lateriflorum	calico (starred) aster	FAC	X				25
Symphyotrichum novae-angliae	New England aster	FACW		X			25
Symphyotrichum novi-belgii	New York aster	FACW	X	X	X	X	100
Symphyotrichum prenanthoides	crooked-stemmed aster	FAC			X		25
Symphyotrichum puniceum	purple-stemmed aster	OBL	X		X	X	75
Symphyotrichum racemosum	small headed aster	FACW	X			X	50
Thalictrum pubescens	tall meadow rue	FACW	X				25
Tiarella cordifolia	heart-leaf foamflower	FACU	X	X			50
Trientalis borealis	star flower	FAC	X	X			50
Typha latifolia	common cattail	OBL	X		X	X	75
Veratrum viride	false hellebore	FACW	X				25
Veronica spp.	speedwell			X			25
Viola spp.	violet		X	X		X	75
Waldsteinia fragarioides	barren strawberry	NL				X	25

Table 3.8. Graminoid species present in the reference wetland sampling plots. 'X' indicates presence in one or more of the reference sites for each community. An indicator status of NL indicates 'not listed' in the NWPL, a blank indicates that the specimen was not identified to species level.

Latin Name	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Agrostis canina	velvet bentgrass	UPL				X	25
Agrostis hyemalis	ticklegrass	FAC	X	X		X	75
Brachyelytrum erectum	southern long-awned wood grass	FACU	X				25
Carex arctata	drooping woodland sedge	FACW	X				25
Carex atlantica	prickly bog sedge	FACW				X	25
Carex bromoides	brome-like sedge	FACW	X	X			50
Carex brunnescens	brownish sedge	FACW		X	X		50
Carex crinita	fringed sedge	OBL	X	X	X	X	100
Carex echinata	star sedge	OBL				X	25
Carex intumescens	bladder sedge	FACW	X	X			50
Carex lurida	sallow sedge	OBL	X	X	X	X	100
Carex retrorsa	retrorse sedge	OBL				X	25
Carex scoparia	pointed broom sedge	FACW	X	X	X	X	100
Carex seorsa	weak stellate sedge	FACW	X				25
Carex stipata	stalk-grain sedge	OBL	X	X	X	X	100
Carex stricta	tussock sedge	OBL	X				25
Carex swanii	swan's sedge	FACU	X	X		X	75
Carex sylvatica	European woodland sedge	FACU				X	25
Carex tenera	quill sedge	FAC	X				25
Carex trisperma	three-seed sedge	OBL	X	X	X	X	100
Carex utriculata	nw territory sedge	OBL			X		25
Carex vulpinoidea	common fox sedge	OBL	X				25
Cinna latifolia	slender wood-reed	FACW		X			25
Danthonia compressa	flattened wild oat grass	FACU	X				25
Dulichium arundinaceum	three-way sedge	OBL	X			X	50
Eleocharis spp.	spike rush					X	25
Glyceria canadensis	rattlesnake mannagrass	OBL	X	X	X	X	100
Glyceria grandis	American mannagrass	OBL			X	X	50
Glyceria melicaria	northeastern mannagrass	OBL	X			X	50
Glyceria striata	fowl mannagrass	OBL	2		X	X	100
Glyceria x laxa	northern mannagrass	OBL	X				25
Graphephorum melicoides	purple false oat	FACW	X		X		50
Juncus effusus	soft rush	OBL	X	X	X	X	100
Juncus pylaei	common rush	OBL	X			X	50
Juncus tenuis	lesser poverty (path) rush	FAC	X				25
Leersia oryzoides	rice cutgrass	OBL	X	X	X	X	100
Panicum spp.	panic grass			X		X	50
Poa alsodes	bluegrass	FAC				X	25
Poa compressa	flat-stem blue grass	FACU				X	25
Scirpus atrovirens	green bulrush	OBL	X				25
Scirpus cyperinus	wool grass	OBL	X	X	X	X	100
Sporobolus cryptandrus	sand dropseed	FACU	X				25
Thalictrum pubescens	tall meadow rue	FACW		X			25
Torreyochloa pallida	pale false mannagrass	OBL		X		X	50
Xyris smalliana	small's yellow-eyed grass	OBL				X	25

Table 3.9. Fern species present in the reference wetland sampling plots. 'X' indicates presence in one or more of the reference sites for each community. An indicator status of NL indicates 'not listed' in the NWPL, a blank indicates that the specimen was not identified to species level.

Latin Name	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Dennstaedtia punctilobula	hay-scented fern	UPL		X			25
Dryopteris campyloptera	mountain wood fern	FACU		X			25
Dryopteris carthusiana	spinulose woodfern	FACW	X	X	X	X	100
Dryopteris cristata	crested woodfern	OBL	X	X	X		75
Dryopteris X bootii	boot's fern	FACW	X		X		50
Onoclea sensibilis	sensitive fern	FACW	X	X	X	X	100
Osmunda cinnamomea	cinnamon fern	FACW	X	X	X	X	100
Parathelypteris noveboracensis	New York fern	FAC		X		X	50
Parathelypteris simulata	bog fern	FACW	X	X		X	75
Polystichum acrostichoides	Christmas fern	FACU				X	25
Thelypteris palustris	marsh fern	FACW	X	X	X	X	100

Figure 3.8. Cinnamon and sensitive ferns in the AMH reference site.

Table 3.10. Vine species present in the reference wetland sampling plots. 'X' indicates presence in one or more of the reference sites for each community. An indicator status of NL indicates 'not listed' in the NWPL, a blank indicates that the specimen was not identified to species level.

Latin Name	Common Name	Wetland Indicator Status	Hardwood	Hemlock-hardwood	Scrub-shrub	Emergent	% of Wetland Types
Amphicarpaea bracteata	hog peanut	FAC	X	X		X	75
Clematis virginiana	Virginia's virgin-bower	FAC	X		X	X	75
Cuscuta sp.	dodder		X				25
Parthenocissus quinquefolia	Virginia creeper	FACU		X			25
Toxicodendron radicans	poison ivy	FAC	X	X		X	75

Figure 3.9. Jewelweed occurred in nearly all wetland cover types with the exception of the shaded hemlock-hardwood sites.

3.2 Soils

Fifty soil samples were collected from surface horizons at the 30 well plots, as 17 of the sites had more than one horizon in the upper 12 inches of the solum (i.e. a thin O horizon overlying a mineral soil). The number of soil sampling plots in each community type is proportional to the acreage of the reference wetland population, with the most samples collected in hemlock-hardwood sites, and the fewest in scrub-shrub areas (Figure 3.10, Table 2.1).

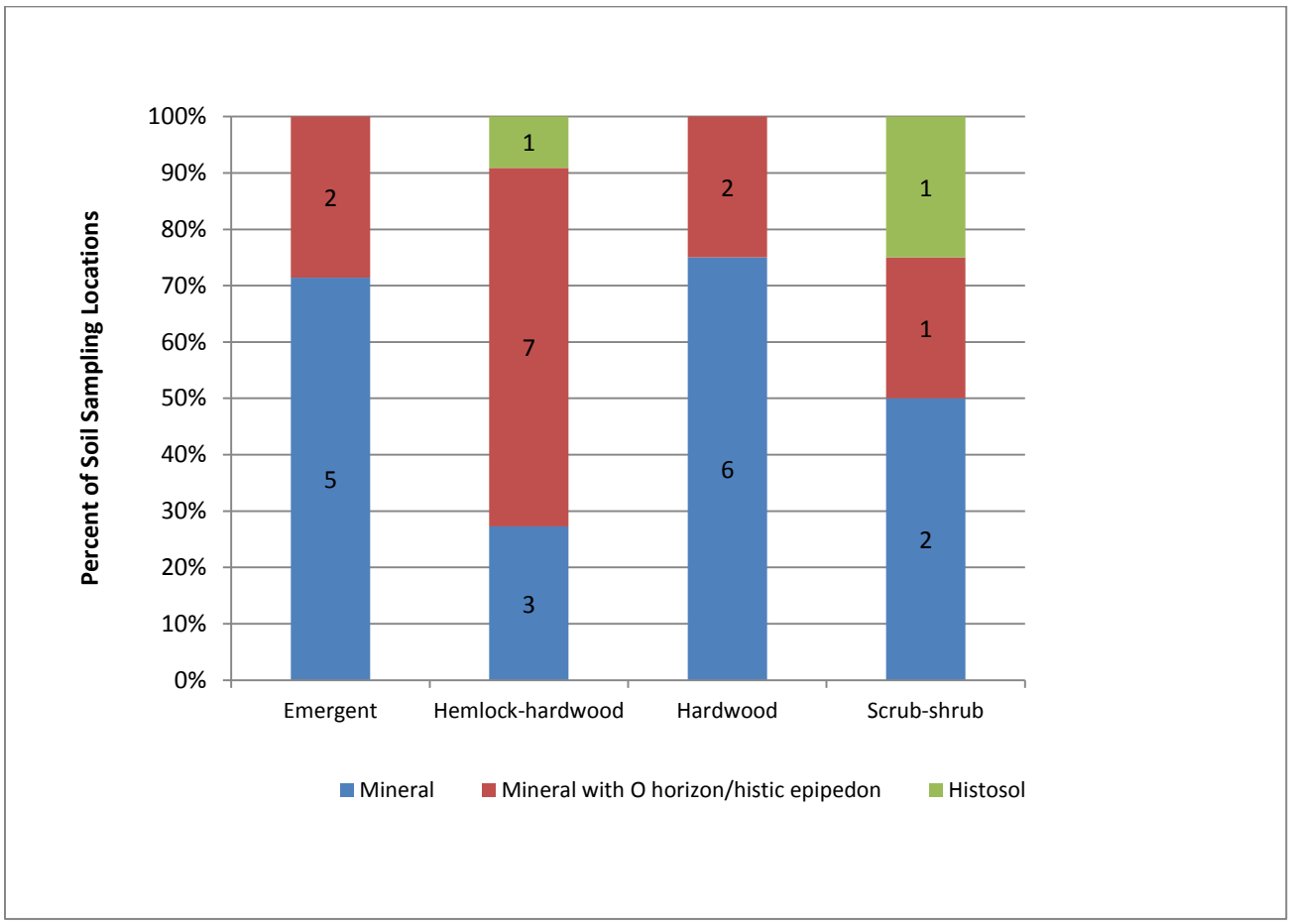

Figure 3.10. The number of soil types identified at the 30 well plots within the four reference wetland community types. The Y axis represents the proportion of soil types within the four community types.

Emergent and hardwood forested wetlands had the highest proportion of mineral soils, and no Histosols were present among the seven emergent and eight hardwood wetland soil sampling sites. The high proportion of mineral soil types was significant within hardwood wetlands (χ^2=6.99, p = 0.03), but not within emergent wetlands (χ^2=5.4, p = 0.07), likely due to the low sample size. Hemlock-hardwood sites had the highest proportion soils with organic matter accumulation in the form of an O horizon, histic epipedon, or Histosol. However, this trend was not significant (χ^2=5.08, p = 0.08). Soil types in scrub-shrub wetlands were equally

distributed with half being mineral soils with no organic horizons, and the remaining showing accumulation as O horizons, histic epipedons, or Histosols (χ^2=05, p = 0.78) (Figure 3.10).

Soil properties are summarized overall and for each soil type in Table 3.11. Soil type accounted for much of the observed variance in soil properties, with all parameters except pH varying significantly among the soil types at α=0.05. Site level soils data is provided in Appendix C.

Within each soil type (mineral, mineral with organic horizon/histic epipedon, Histosol) percent OM, percent total N, and available P did not vary significantly among community types at α=0.05. Among wetlands with mineral soils, available K, Mg, Ca, and pH were higher in hardwood wetlands than in hemlock-hardwood, scrub-shrub, and emergent wetlands (Kruskal-Wallis, H=8.6, p=0.04; H=9.5, p = 0.02; H=11.7, p = 0.01; H=14.3, p =0.003). This may be due to geologic parent material effects, as approximately 80% of the hardwood reference wetland acreage is located in in the Schoharie and Ashokan basins (Table 2.1).

When comparisons were limited to individual reservoir basins (as a coarse control for parent material influence), K, Mg, and Ca did not differ among wetland community type. However, pH was still significantly higher in hardwood wetlands within the Ashokan (H=9.7, p = 0.008), but not in the Neversink (H=4.1, p = 0.13) basins (Figure 3.11). There were inadequate hardwood sample sizes to compare pH among wetland community types within the Schoharie and Pepacton basins. Soil pH also varied by basin overall, with the lowest values occurring in the poorly buffered Neversink basin (Figure 3.12).

Table 3.11 Soil properties summarized for surface horizons of wetlands with mineral soils, mineral soils with organic horizons, and Histosols.

Analyte	Mineral Soils (n=26)			O horizons, histic epipedons (n=21)			Histosols (n=3)		All Soils (n=50)		
	Range	Quartile Range	Median	Range	Quartile Range	Median	Range	Median	Range	Quartile Range	Median
% Organic Matter	1.1-11.8	3.5-9.0	6.5	1.7-88.1	12.7-21.7	15.5	34.5-63.9	45.8	1.1-88.1	4.7-16.6	9.5
pH	4.1-6.4	4.9-5.3	5.2	3.7-6.0	5.0-5.5	5.3	5.0-5.5	5.1	3.7-6.4	4.9-5.4	5.2
Available P (mg/kg)	0.5-9.9	1.2-2.9	1.9	0.8-38.4	2.4-5.7	4.4	4.1-11.3	5.4	0.50-38.4	1.3-4.5	2.9
Available K (mg/kg)	16.6-88.2	26.0-49.0	37.1	23.7-547.0	47.0-105.0	80.1	84.0-520.0	144.0	16.6-547.0	31-88.2	48.5
Available Mg (mg/kg)	11.3-314.1	49.0-124.8	73.6	27.2-930.0	120.0-263.2	202.4	232.2-1224.6	291.6	11.3-1224.6	55.1-232.2	122.4
Available Ca (mg/kg)	51.4-2039.0	336.5-777.9	442.3	105.1-319.0	973.0-2560.2	1887.6	3295.0-9488.0	4494.0	51.4-9488.0	397.0-2039.0	816.3
% Total N	0.05-0.4	0.12-0.30	0.2	0.04-1.7	0.39-0.67	0.5	0.8-2.2	1.5	0.04-2.2	0.18-0.48	0.3
Total P (ug/g)	114.3-1234.0	246.9-540.9	455.0	435.1-2220.6	556.3-1230.1	997.0	1225.9-1533.4	1256.5	114.3-2220.6	435.1-1048.7	551.8

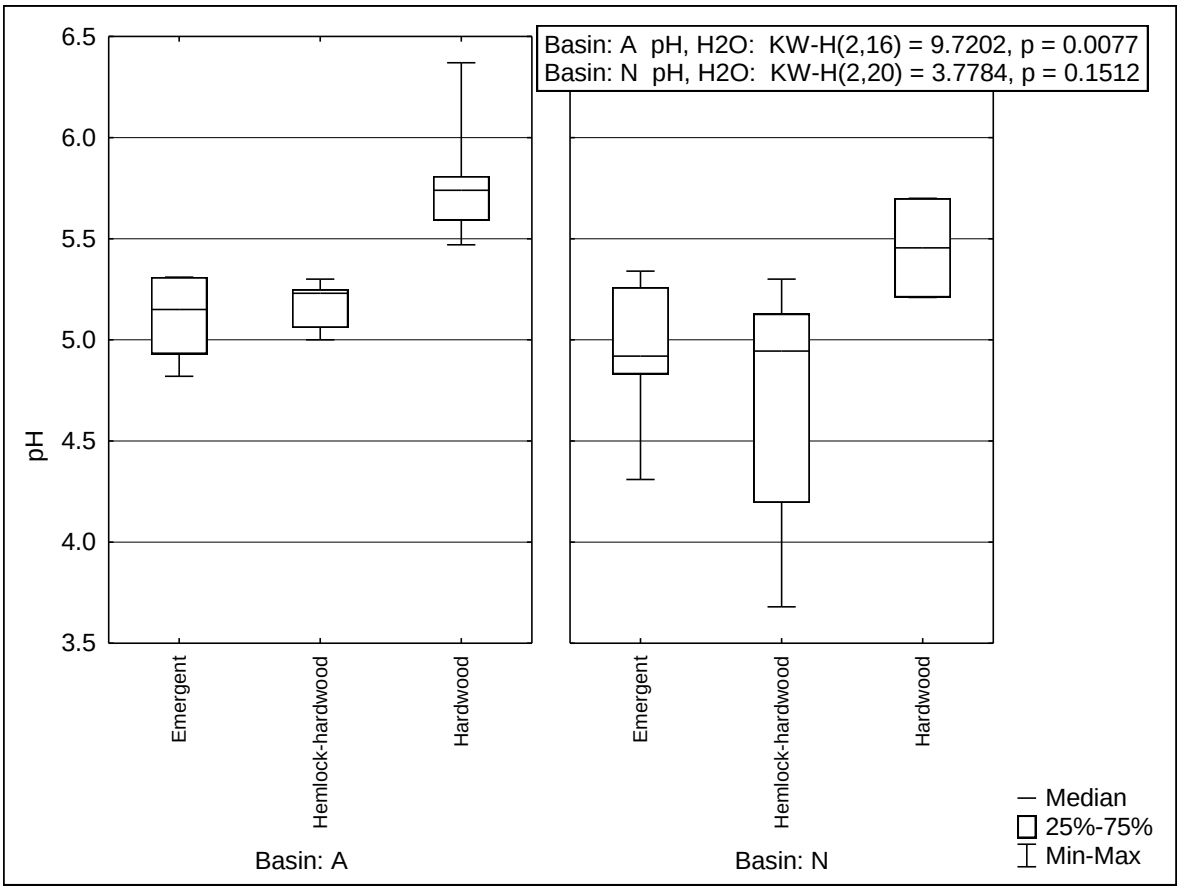

Figure 3.11. Soil pH values by community type within the Ashokan (A) and Neversink (N) basins.

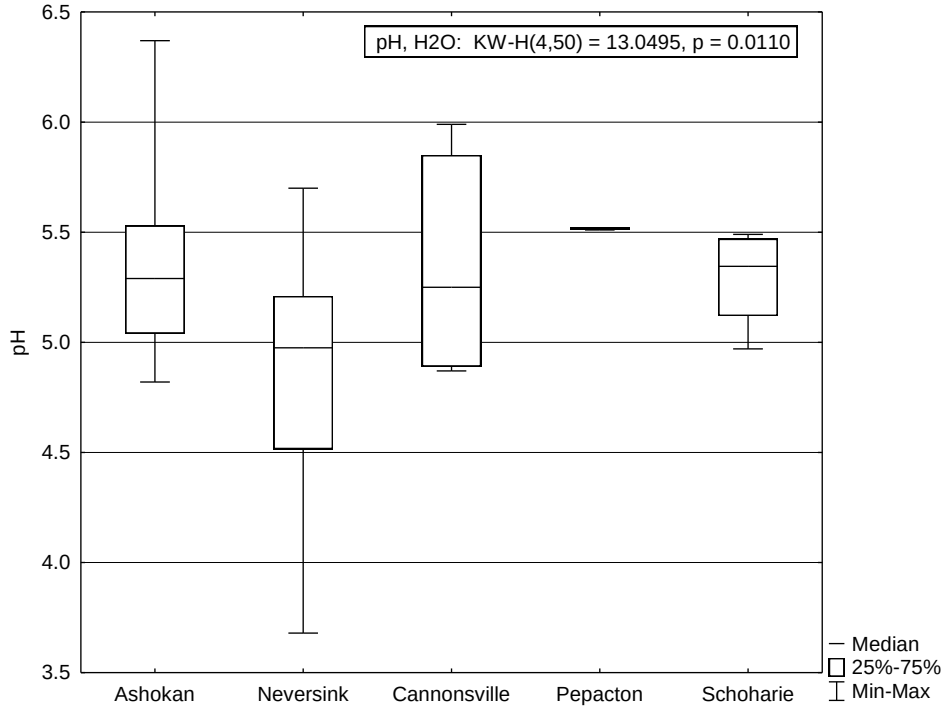

Figure 3.12. Soil pH by basin.

3.3 Hydrology

Metrics summarizing growing season water table levels and fluctuations for the selected subset of reference site wells are provided in Table 3.12. Hydrographs for these wells are provided for each year in Appendix D.

Median water levels were significantly lower in emergent than in scrub-shrub, hardwood, and hemlock-hardwood wetland types (Figure 3.13). Of all of the reference sites, only three wells had ranges over 40 inches, two of which are in emergent wetlands indicating a substantially fluctuating hydrologic regime. The third highly fluctuating well (NGC) is within a plot that is divided evenly between both hemlock-hardwood and emergent cover types (Figures 3.14 through 3.17).

Table 3.12. Summary statistics for individual wells for the growing seasons (GS) included in the study period (Table 2.2). Saturated refers to water table measurements within the upper 12 inches of the soil profile.

Wetland Type	Site	Median Water Level (in)	Minimum Water Level (in)	Maximum Water Level (in)	% GS saturated or inundated	% GS Saturated	% GS Inundated	Median Inundation Depth (in)	Maximum Inundation Depth(in)
Hardwood	ARWOUT	-2	-12.2	16.2	98.7	76.7	22.0	1.5	16.2
	NABIN	-4.6	-12.1	2.7	100.0	98.3	1.8	0.9	2.7
	NTD	0.7	-2.6	3.5	99.9	28.5	71.4	1.1	3.5
	SFB	-1.6	-9.7	10.8	100.0	62.3	37.7	3	10.8
Hemlock-hardwood	ACBIN	-0.7	-11.8	15.25	100.0	67.0	33.0	1.2	15.25
	ART	-6.1	-13.2	0.3	100.0	99.7	0.3	0.2	0.3
	NGC	-2.3	-27.6	18.4	77.5	72.2	5.3	0.7	18.4
	PHHIN	0.75	-7.15	7.95	100.0	35.4	64.6	1.45	7.95
Scrub-shrub	CSBIN	-0.9	-6.9	9.4	99.7	65.1	34.6	1.1	9.4
	CSBOUT	-4	-23.75	4.4	68.0	62.0	6.0	0.8	4.4
	SMK	-1.4	-10	8.1	100.0	77.5	22.5	0.85	8.1
	SMS	2.55	-2.8	11.85	100.0	6.9	93.1	3.15	11.85
Emergent	ADTIN	-11	-21.1	25	48.9	46.6	2.3	2	25
	AMHOUT	-6.2	-17.5	5.6	86.4	85.8	0.6	0.7	5.6
	NABOUT	-4.6	-19.7	23	76.6	68.7	7.9	3.7	23

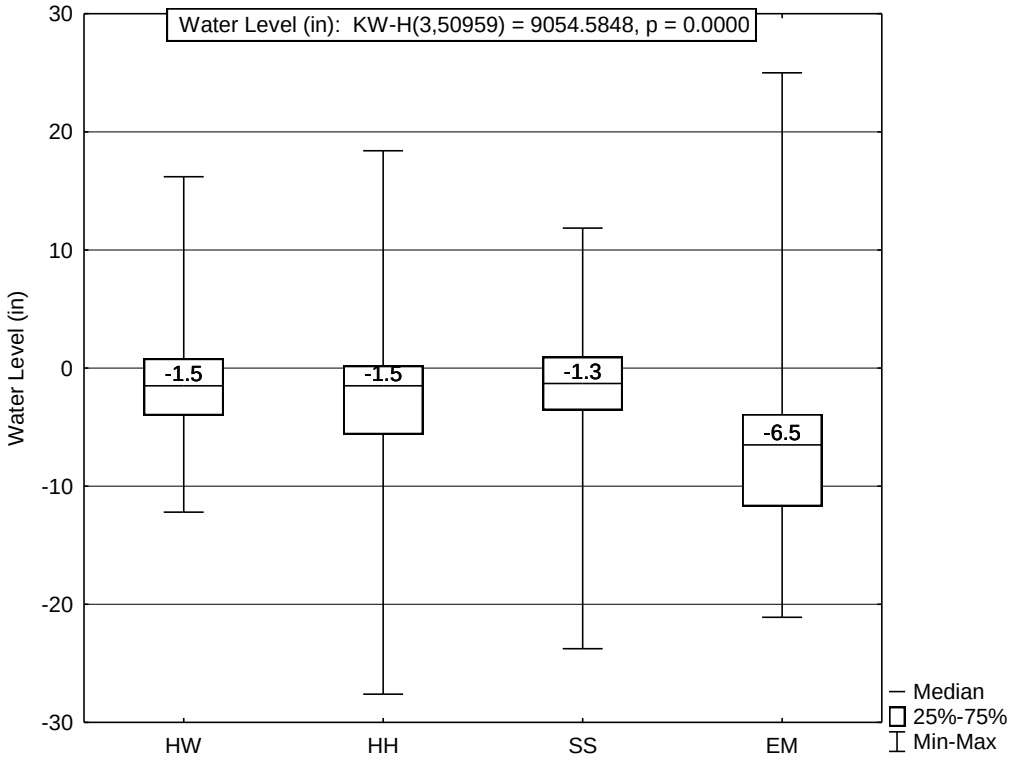

Figure 3.13. Median well water levels summarized by community type.

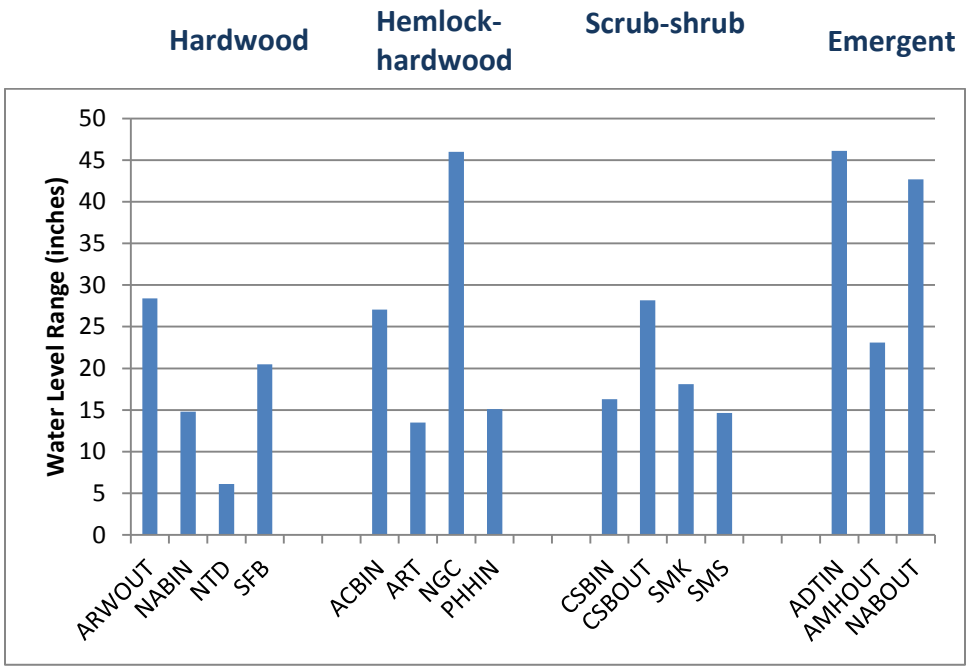

Figure 3.14. Observed ranges in reference wetland wells.

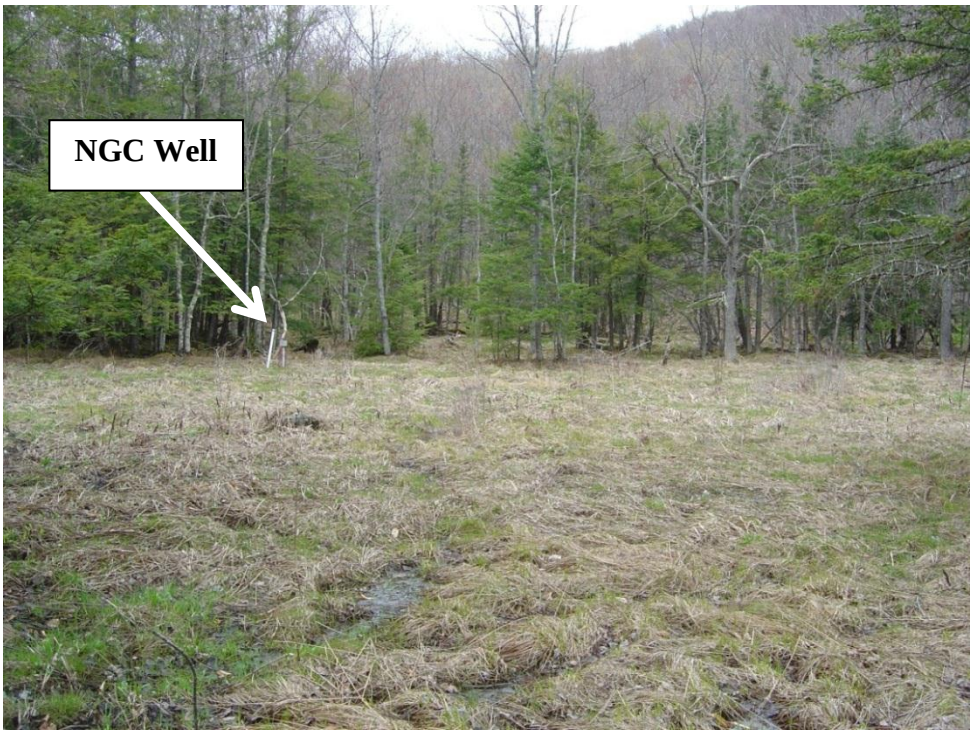

Figure 3.15. NGC well at emergent and hemlock-hardwood community boundary. This well was saturated for an average of 76% of the growing season.

Figure 3.16. Well in emergent wetland plot AMH. This well was saturated for an average of 86% of the growing season with a median water level of 6.2 inches below the soil surface.

Ten of the 15 well plots were saturated or inundated for over 98% of the growing seasons analyzed. The remaining five wells, three of which are in emergent wetlands, were saturated or inundated from 49% to 86% of the growing season. Nearly all of the wetland areas were saturated more often than inundated. Inundation depths were fairly low, with a maximum of 25 inches, an upper quartile of 2.6 inches, and a median of 1.5 inches overall (Table 3.12, Figure 3.18).

Variation among individual wells demonstrated the influence of site specific factors such as landscape position on wetland hydrology. For example, among hardwood wetlands, NTD had the highest median water level and lowest range, and was inundated with shallow water for a majority of growing seasons. This is a slope wetland with consistent groundwater input and no stormflow detention capacity, thereby resulting in a shallow inundated regime with minimal variation. SMS had the highest median water level overall, with a relatively low range and was nearly constantly inundated (Figures 3.18 through 3.23). This site is in a peat-forming open depression that receives and detains surface water flows and likely receives substantial groundwater input.

Well placement and site microtopography also strongly influenced water level measurements. The CSBOUT and ADTIN wells, for example are placed near the sites upland boundary and show deeper water table levels than other scrub-shrub and emergent wells, respectively (Figure 3.24).

Figure 3.17. Inundation just upstream of a beaver dam at NABOUT. This plot was saturated and inundated for an average of 69% and 9% of the growing season, respectively.

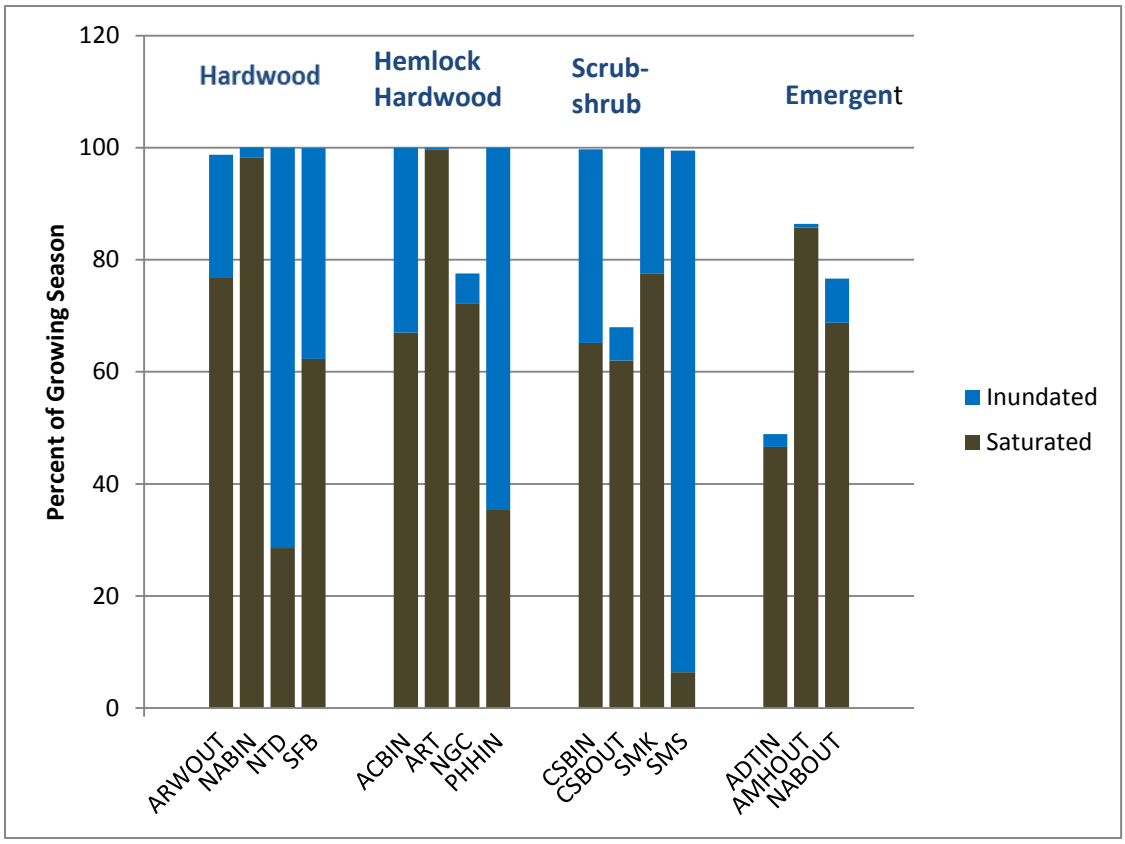

Figure 3.18. The percentage of the growing season that the well plots were saturated or inundated. Values are the average of all growing seasons analyzed.

Figure 3.19. Groundwater emergence at slope wetland NTD. This well was inundated for an average of 71% of the growing season, with a median inundation depth of 1.1 inches.

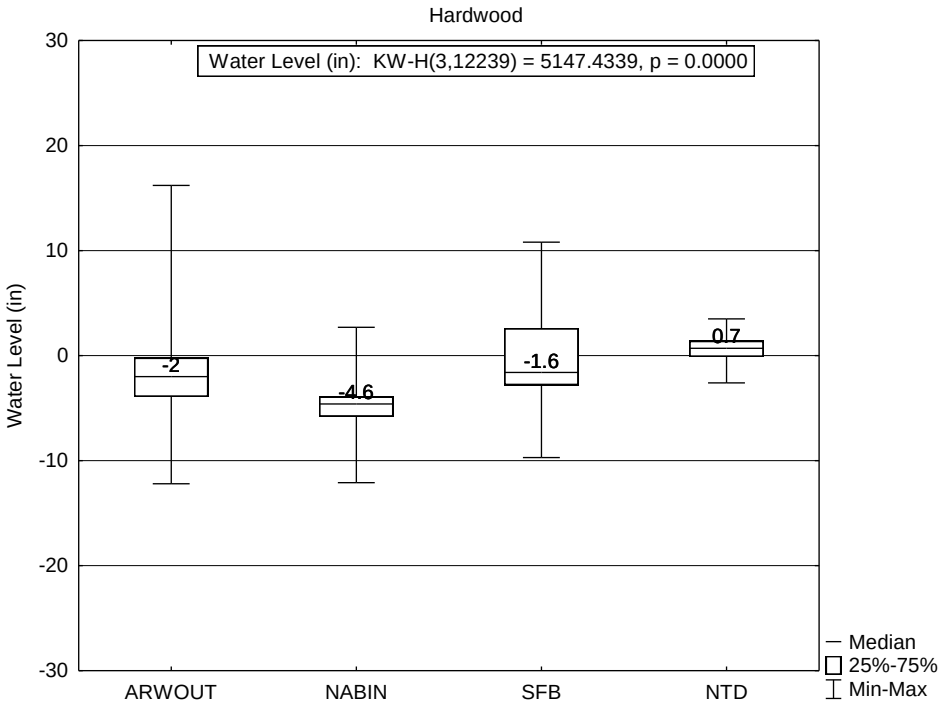

Figure 3.20. Growing season water levels measured at select wells within hardwood reference wetlands over the period of record.

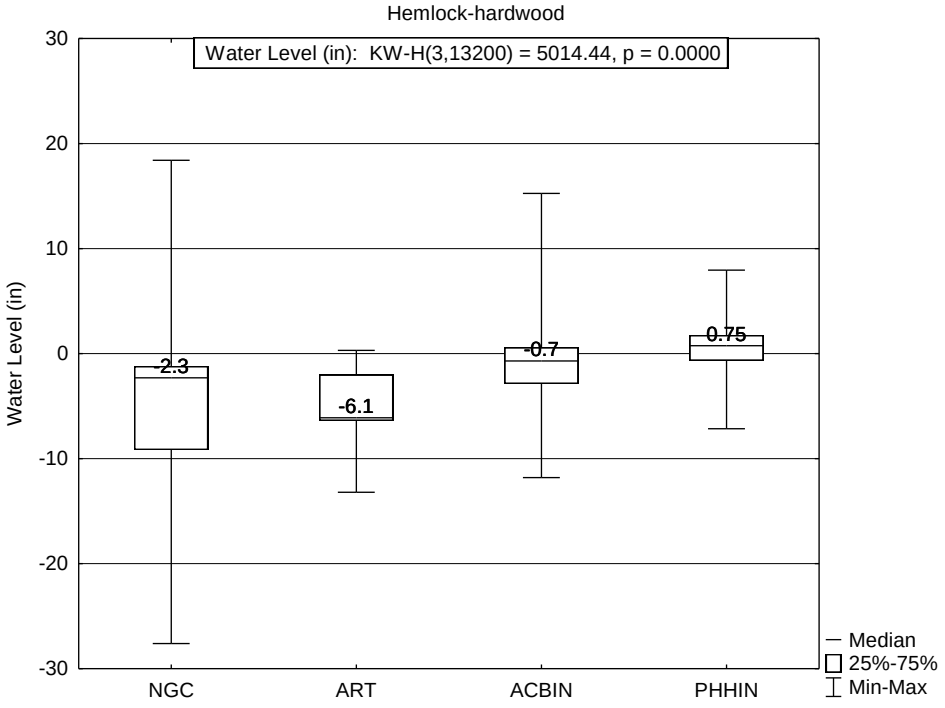

Figure 3.21. Growing season water levels measured at select wells within hemlock-hardwood reference wetlands over the period of record.

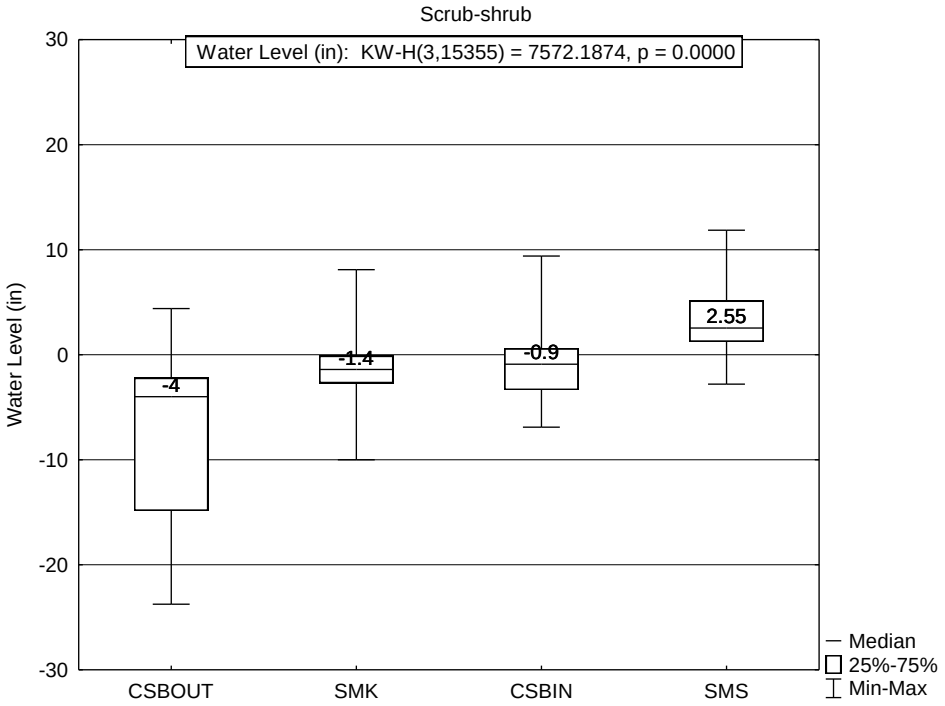

Figure 3.22. Growing season water levels measured at select wells within scrub-shrub reference wetlands over the period of record.

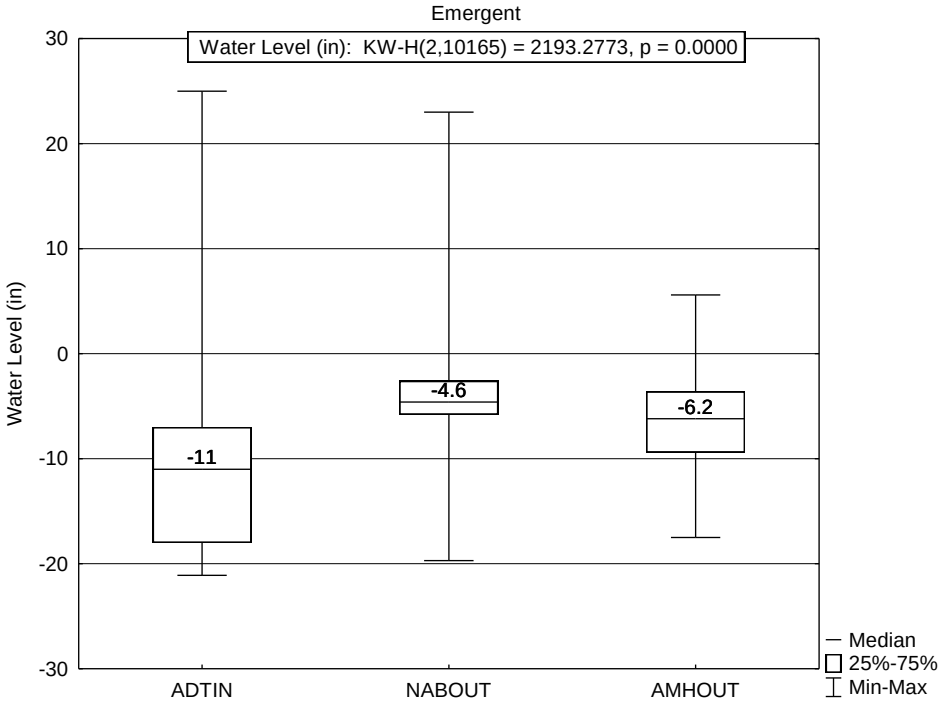

Figure 3.23. Growing season water levels measured at select wells within emergent reference wetlands over the period of record.

Figure 3.24. CSBOUT well located near wetland boundary. This site was saturated or inundated for an average of 68% of the growing season, with a median level of 4 inches below the soil surface.

4. Summary and Conclusions

This report condenses long-term data collected from nineteen reference wetlands in the Catskill and Delaware Watersheds into metrics that can be used to guide the design and assessment of wetland creation and restoration projects for both regulatory and non-regulatory purposes. This characterization of wetland resources in the Catskill and Delaware Watersheds will inform DEP's regulatory review, land management, and outreach efforts, and provide a baseline for assessing long-term trends.

Measures of frequency and abundance of 204 native plant species among hardwood, hemlock-hardwood, scrub-shrub, and emergent wetland types were provided. This provides a suite of native species that can be referenced during mitigation site design. Measures of abundance such as total tree basal area per acre, shrub and tree stem density, and herbaceous cover can guide the determination of planting quantities during project design as well as performance standards during mitigation site assessment.

The range and median of soil organic matter, nutrient, and pH levels were also summarized and can be used to determine soil specifications for mitigation areas. Some parameters such as soil organic matter can also be used as benchmarks for the establishment of performance standards (Bishel-Machung 1996). Organic and mineral soil types were treated separately because their properties vary significantly from one another and they were distributed fairly evenly across communities. Further, it would be unreasonable to assess early mitigation sites against properties of Histosols that have accumulated organic matter over a geologic time scale. In fact, quartile ranges may provide the most meaningful benchmarks for mitigation design and assessment as they avoid the impacts of outliers on the data distribution.

Water level data from automated monitoring wells were analyzed to describe the depth and duration of saturation and inundation during the growing season at reference wetlands. While community level hydrologic generalizations are difficult to make due to site level factors, the data for most sites show a saturated hydrologic regime for long duration in the growing season, with periodic shallow inundation. This supports the design and construction of mitigation wetlands with a saturated rather than permanently inundated hydrologic regime. Quantitative evidence of this nature can help guide designs of saturated systems, rather than inundated ponds which have been proliferating, perhaps partially at the expense of vegetated wetlands, through mitigation projects (Dahl 2011, DEP 2009).

While the goal of this report was to summarize, rather than compare, data for four major wetland cover types, some generalizations can nevertheless be drawn. For example, the hemlock-hardwood wetlands had higher tree basal area per acre than hardwood wetlands. As a result, shrub density and herbaceous coverage were lower in hemlock-hardwood than in hardwood wetlands. The herbaceous species composition differed among these two forested wetland types, with shade-tolerant forbs and other herbs having higher coverage in hemlock-hardwood wetlands. Also, the emergent wetland types included in the study generally had the

highest depth to, and variation in, the water table, as well as the lowest duration of saturation and inundation. Such community comparisons were beyond the scope of this report, but further work in this area would yield information about the relationships between species composition and environmental parameters, and would provide a basis for assessing long-term trends in wetland community composition.

This study is by no means a full characterization of wetland types in the Catskill and Delaware Watershed. For example, the emergent types included in this study showed 'drier' hydrologic regimes than forested and scrub-shrub types. However, the study was limited to wet meadows and sedge meadows, and did not include deep emergent types such as marshes. The percentages of both emergent and scrub-shrub wetlands within the reference sites are significantly lower than that of forested wetland types. Additionally, a wider geographic distribution of wetlands would enable a more thorough characterization of the Catskill and Delaware Watersheds since factors such as geology, soil parent material, and land use vary among reservoir basins. Compared to NWI wetlands, the extent of reference wetlands is disproportionately high in the Ashokan and Neversink basins and low in the Cannonsville, Pepacton, and Rondout basins (Figure 4.1).

Nonetheless, this summarization of data from DEP's reference wetlands provides significant progress in characterizing reference wetland conditions in the Catskill and Delaware Watersheds. With this report, DEP has consolidated a broad array of data to provide region-specific knowledge that will benefit wetland creation, restoration, regulatory review, preservation, and education efforts throughout the watershed.

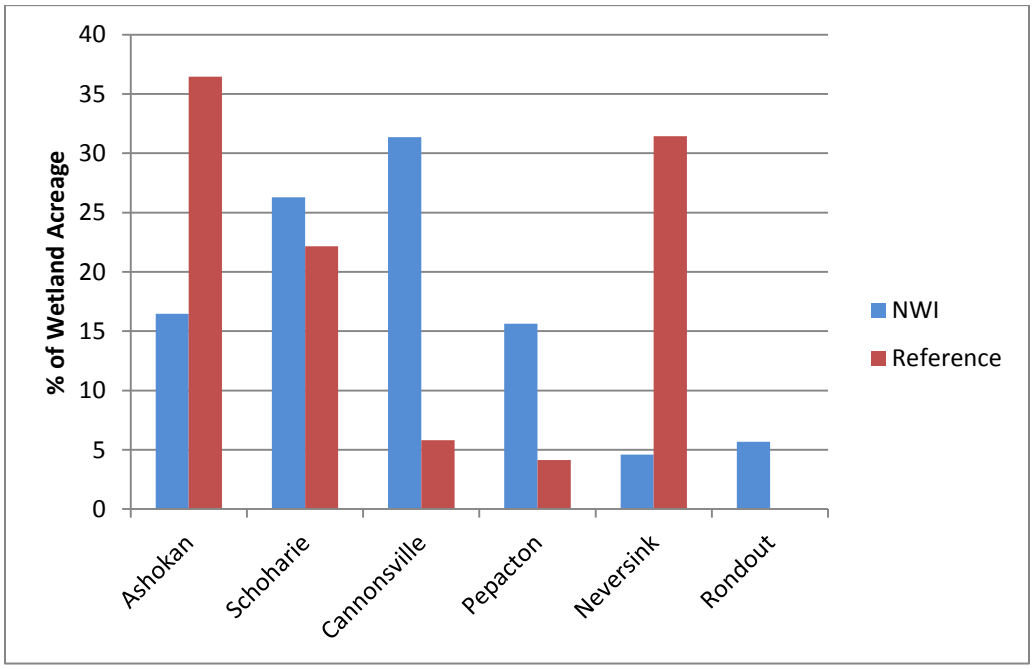

Figure 4.1. The distribution of reference and NWI wetlands among reservoir basins.

Figure 4.2. Wetland mitigation monitoring in the Ashokan basin.

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Appendix A

Reference Site Maps

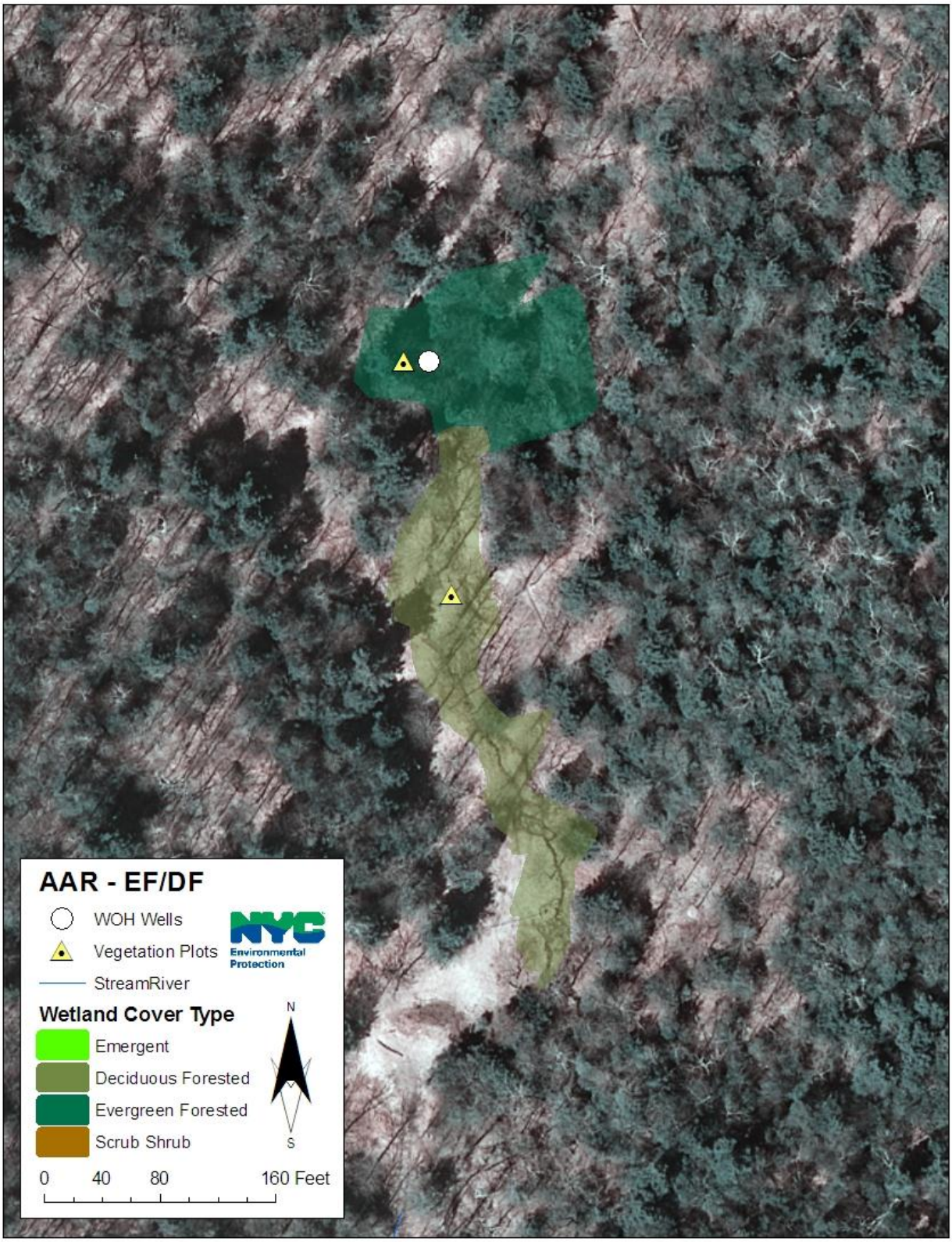

Figure A.1. Ashokan Basin – Abbey Road (AAR).

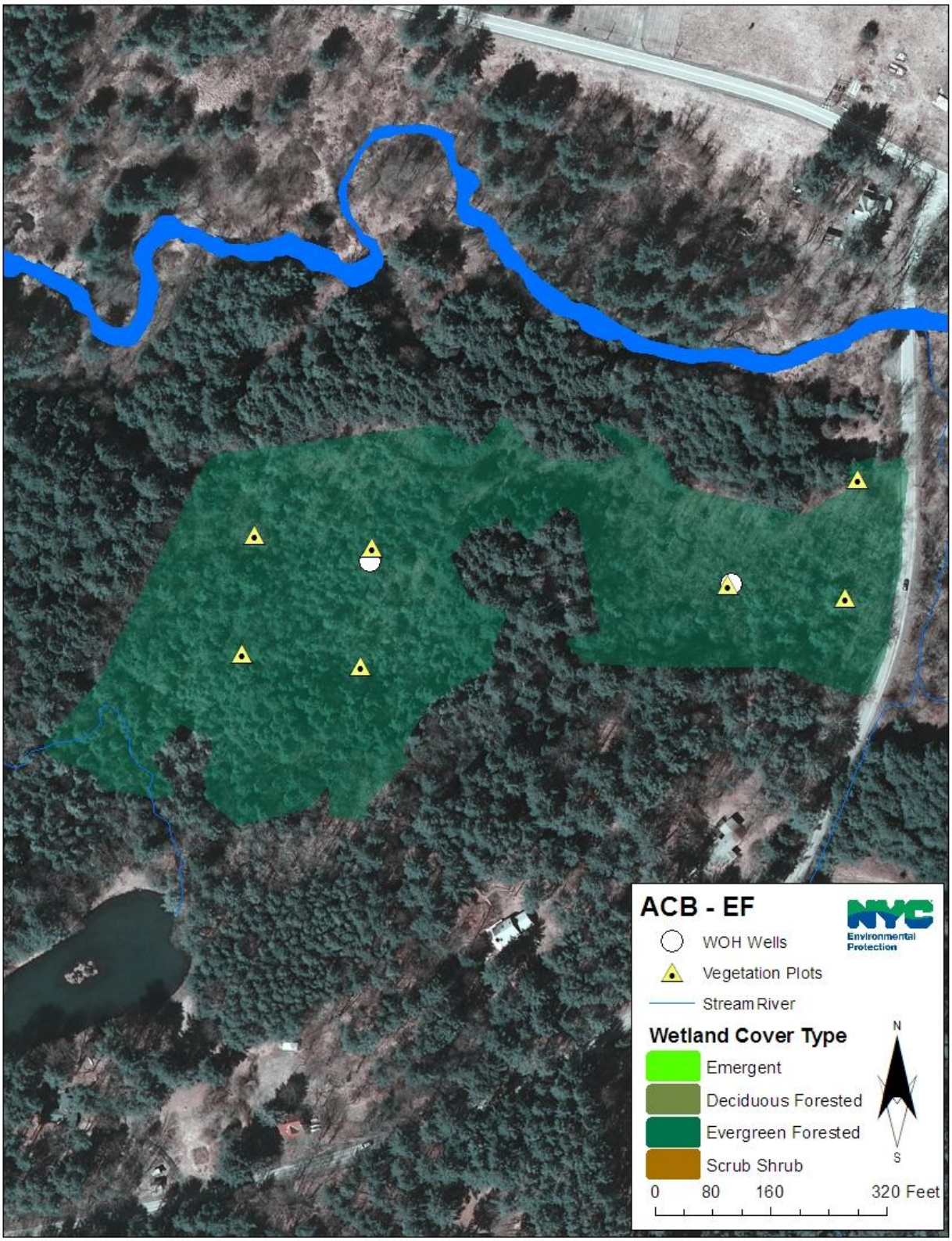

Figure A.2. Ashokan Basin – Cold Brook (ACB).

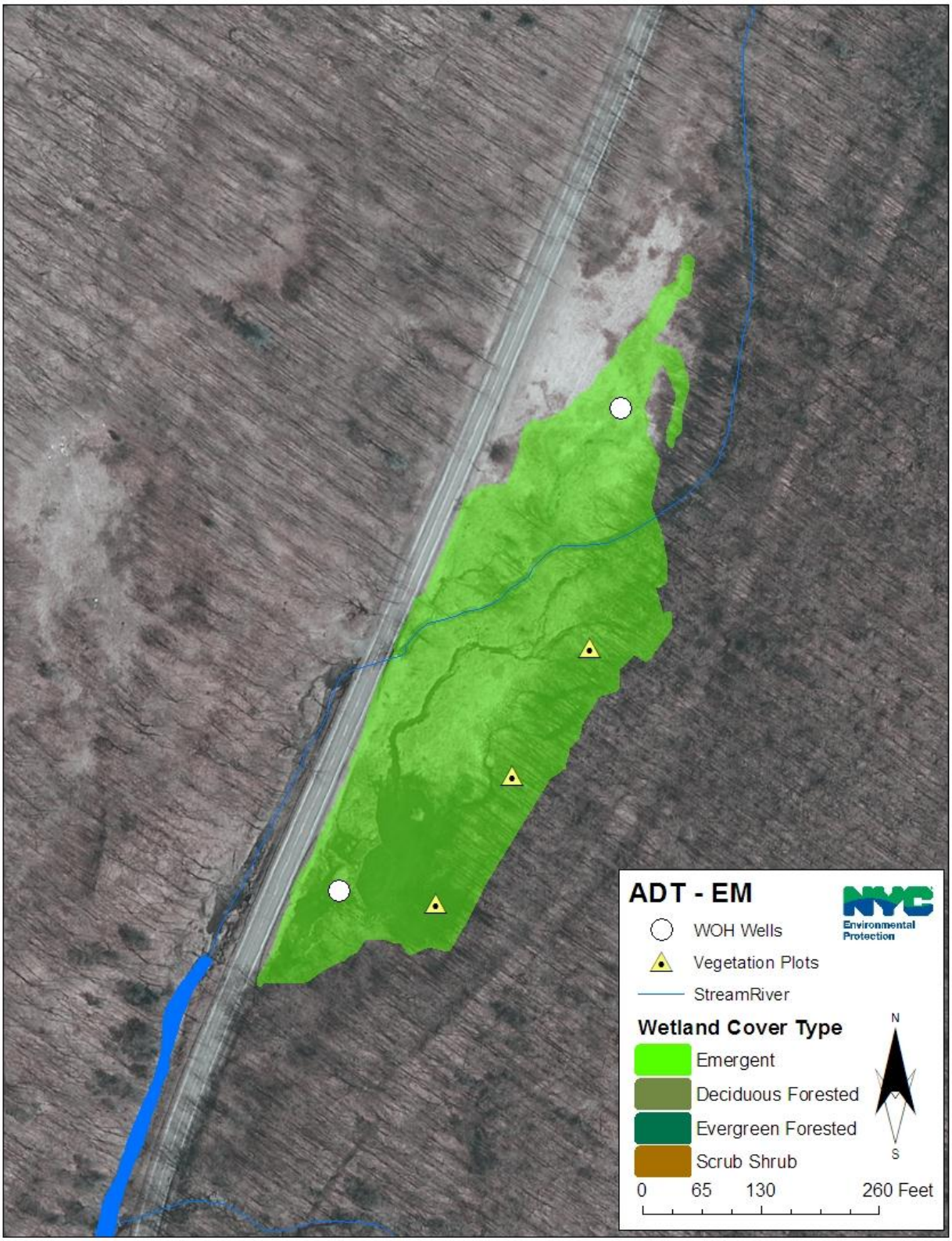

Figure A.3. Ashokan Basin – Devil's Tombstone (ADT).

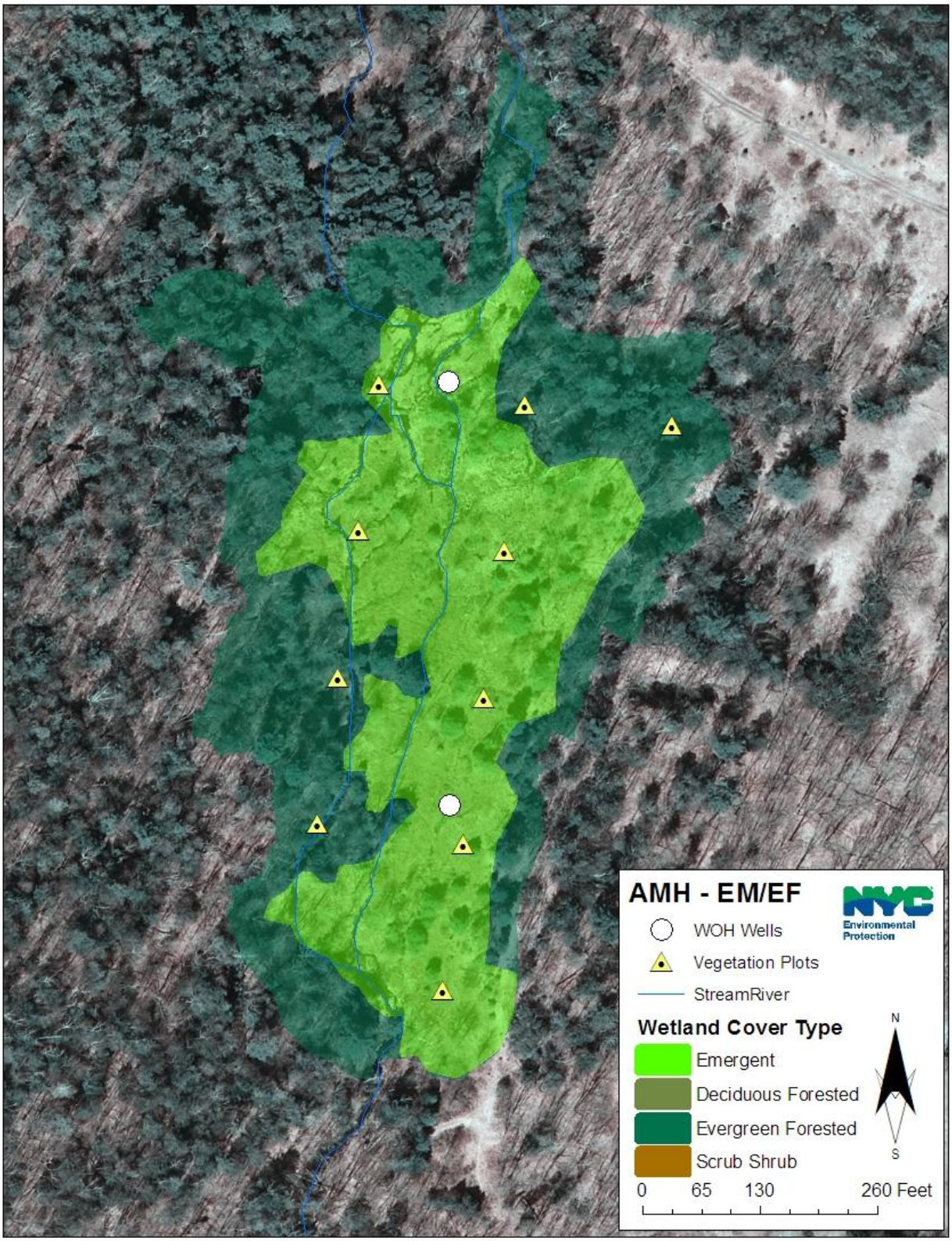

Figure A.4. Ashokan Basin – Mink Hollow (AMH).

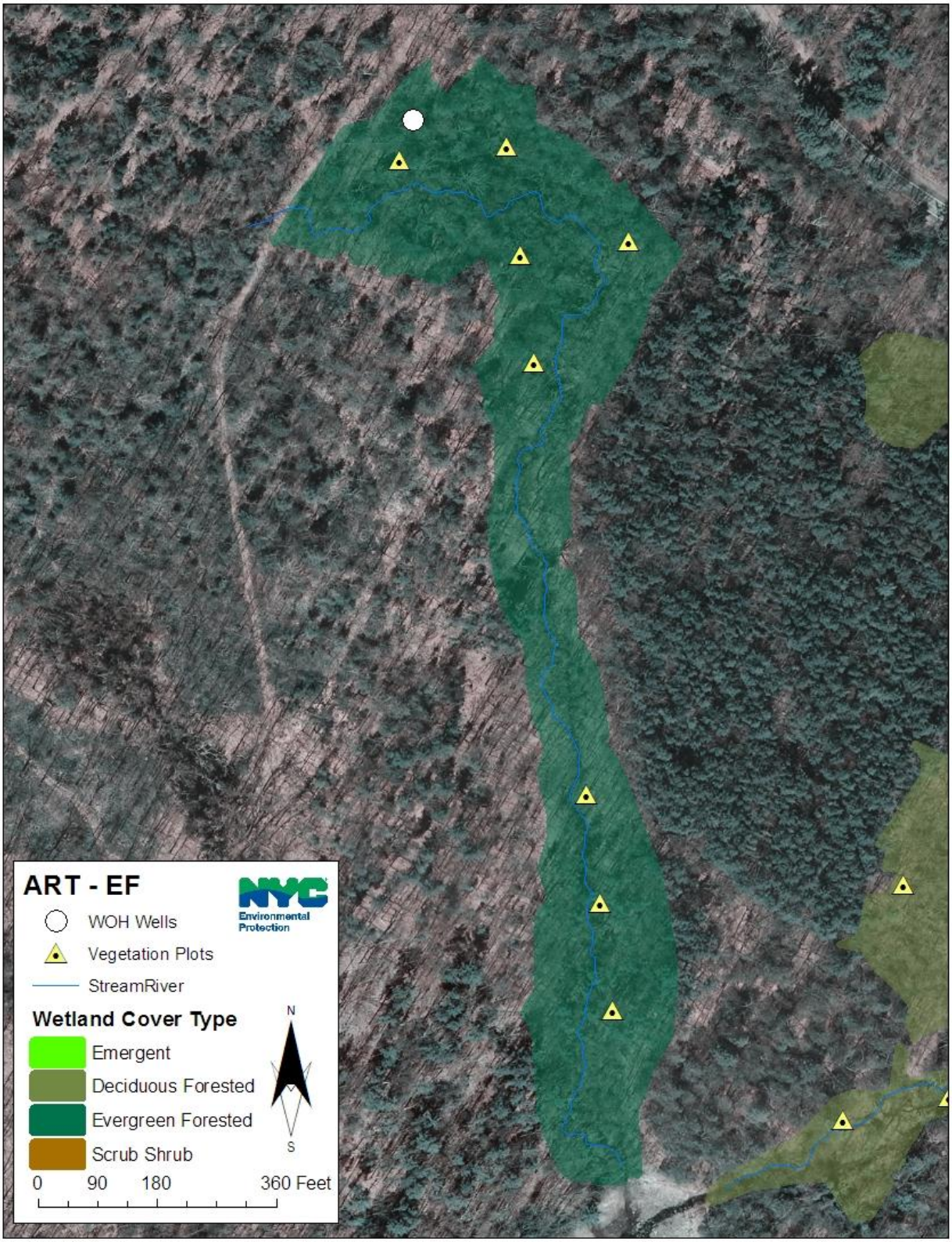

Figure A.5. Ashokan Basin – Reservoir Terrene (ART).

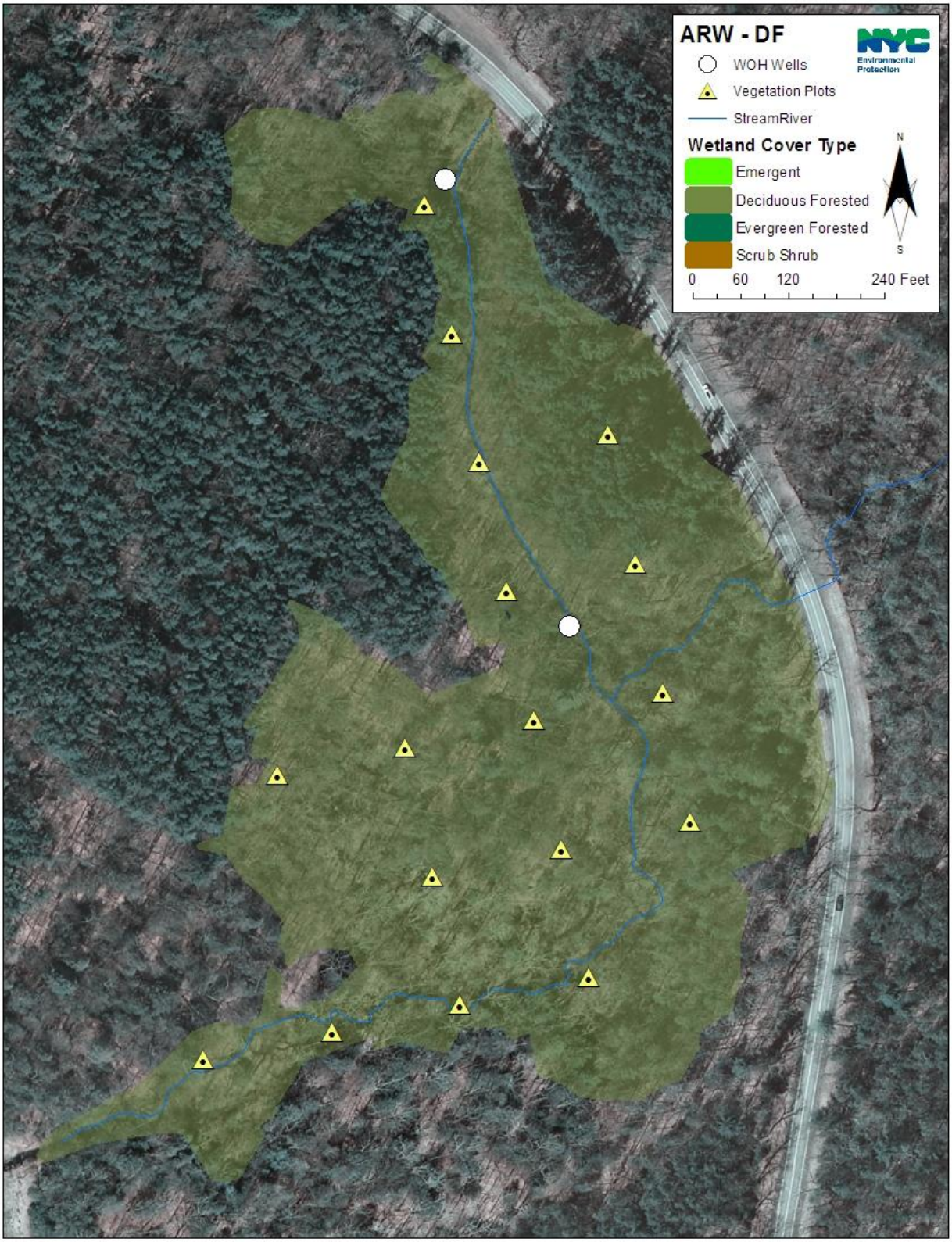

Figure A.6. Ashokan Basin – Reservoir West (ARW).

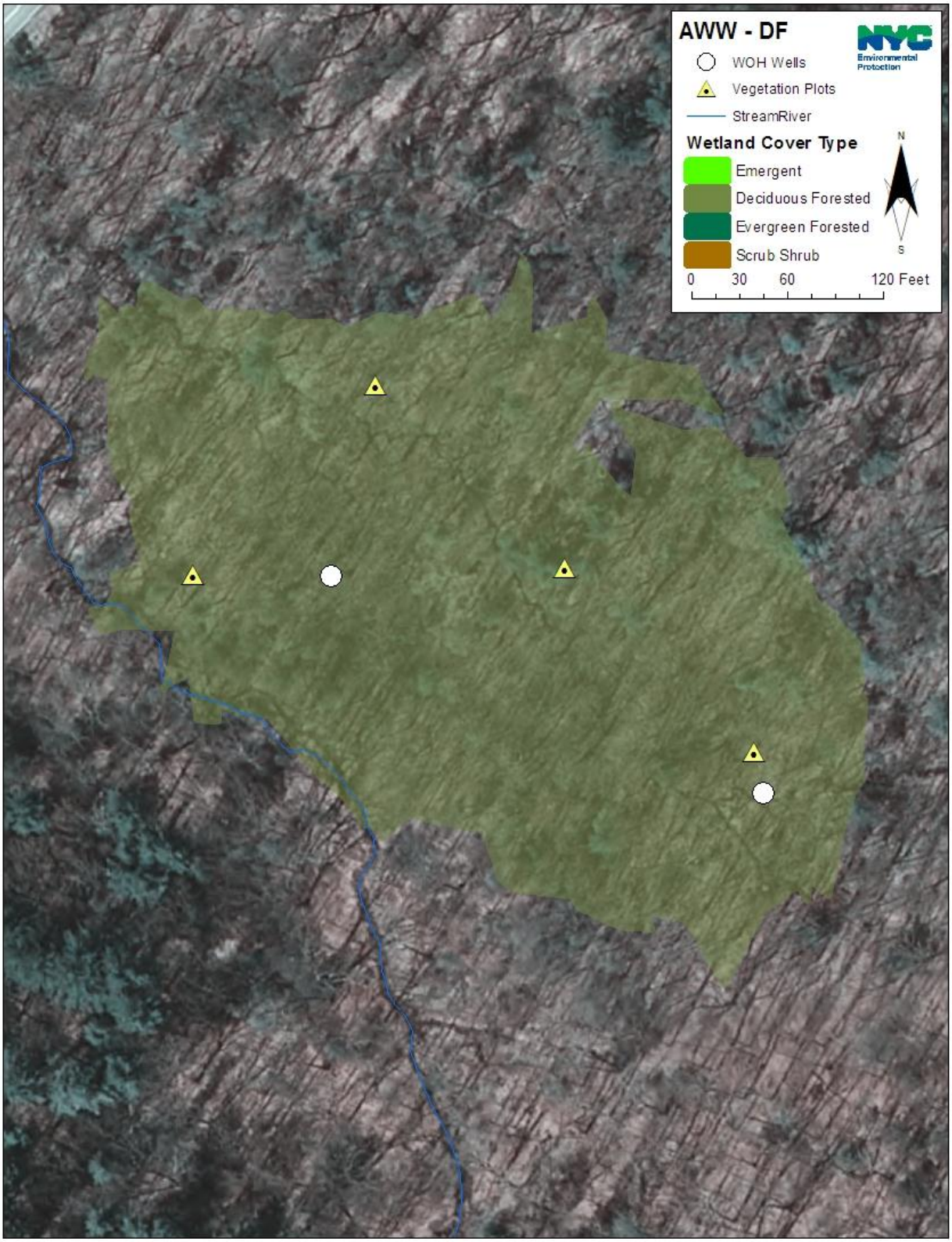

Figure A.7. Ashokan Basin – Weeping Wall (AWW).

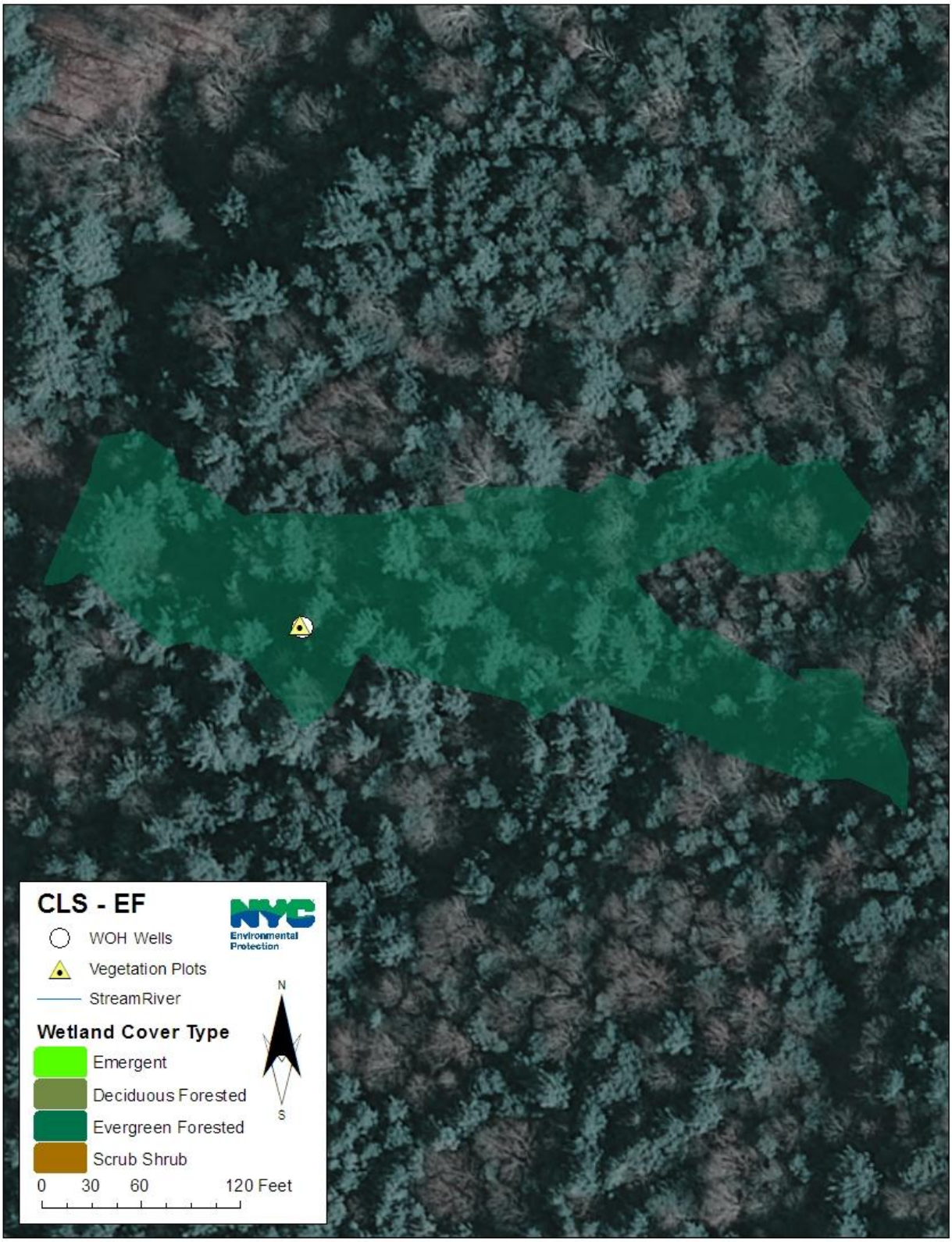

Figure A.8. Cannonsville Basin – Locust Spring (CLS).

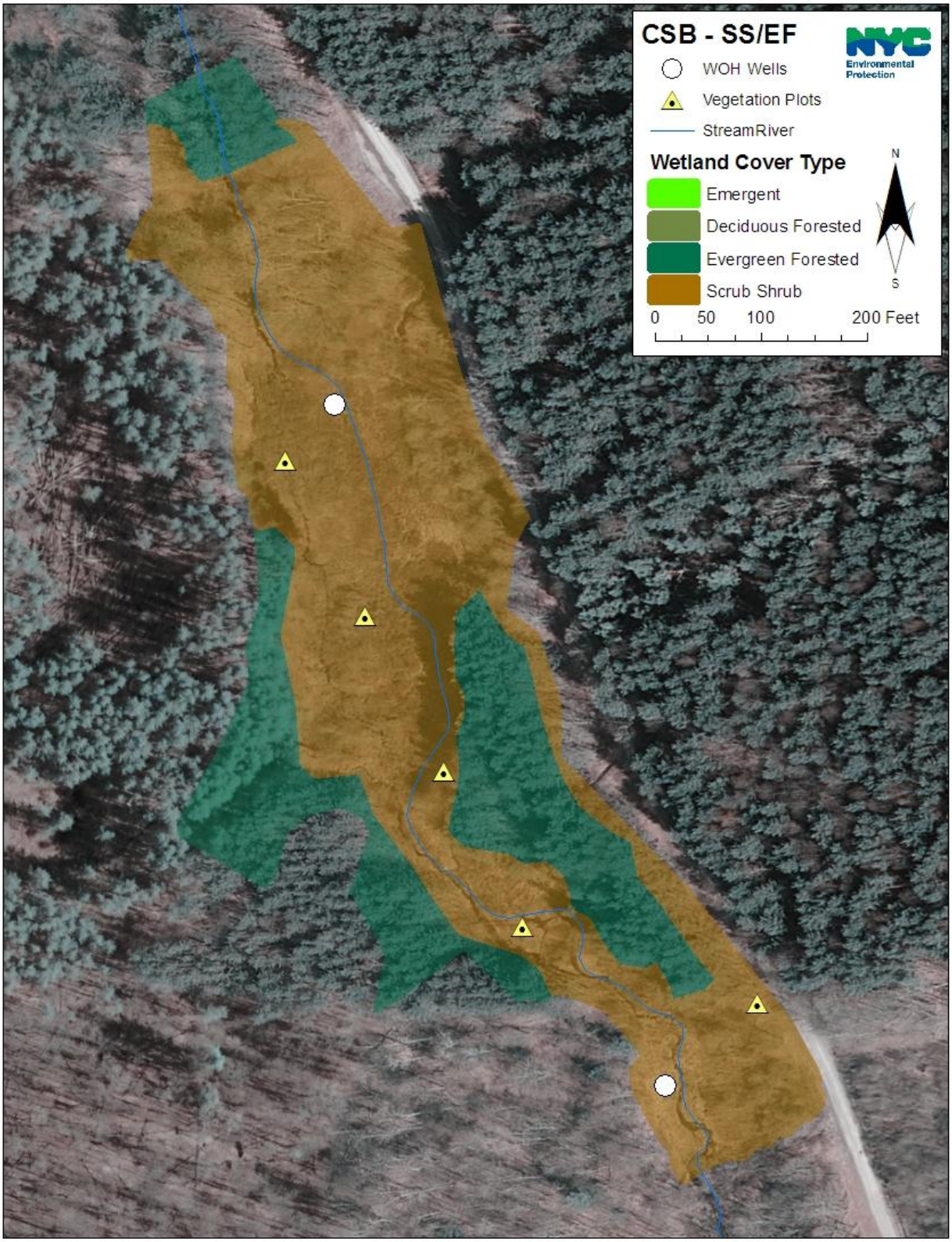

Figure A.9. Cannonsville Basin – Sherruck Brook (CSB).

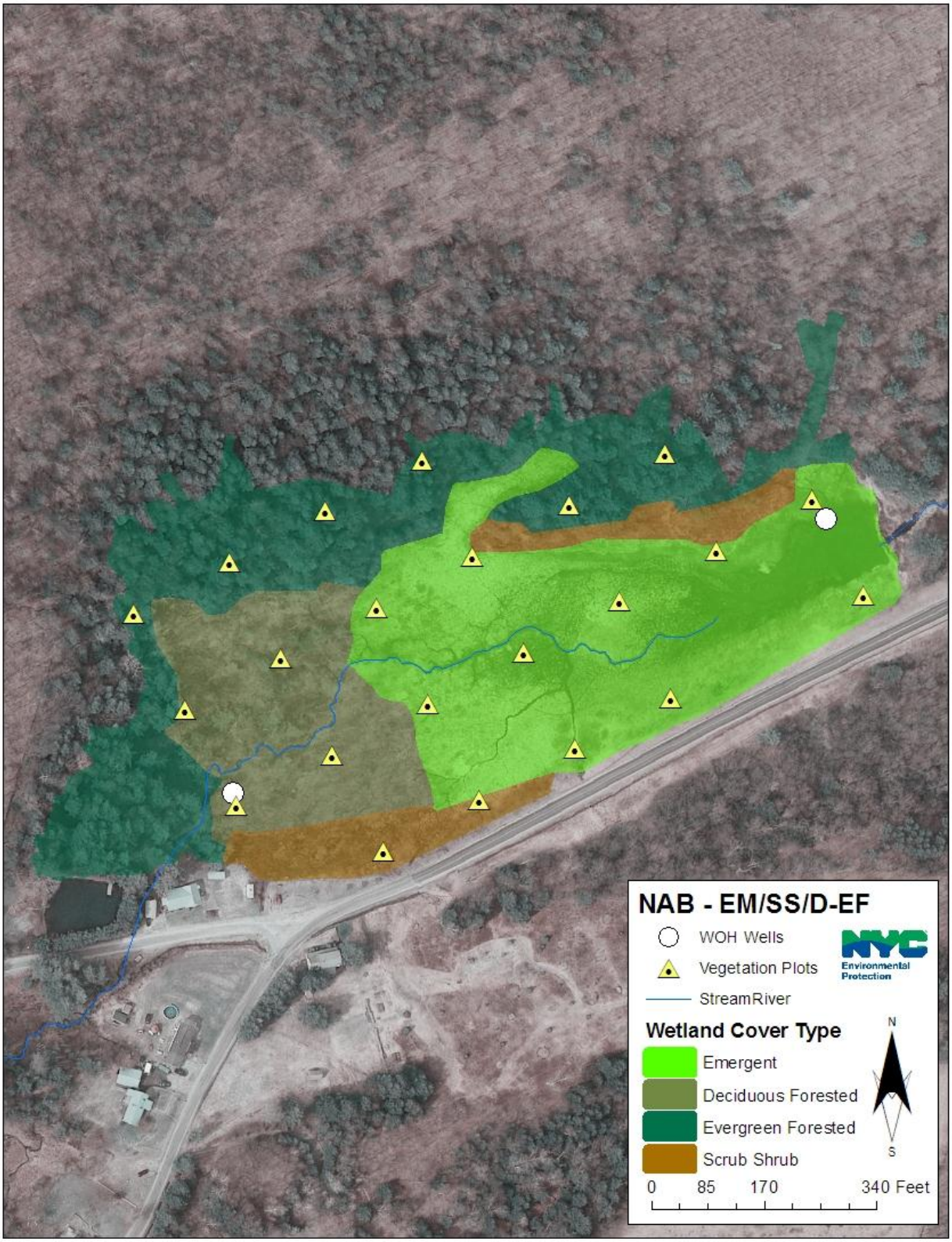

Figure A.10. Neversink Basin – Aden Bradley (NAB).

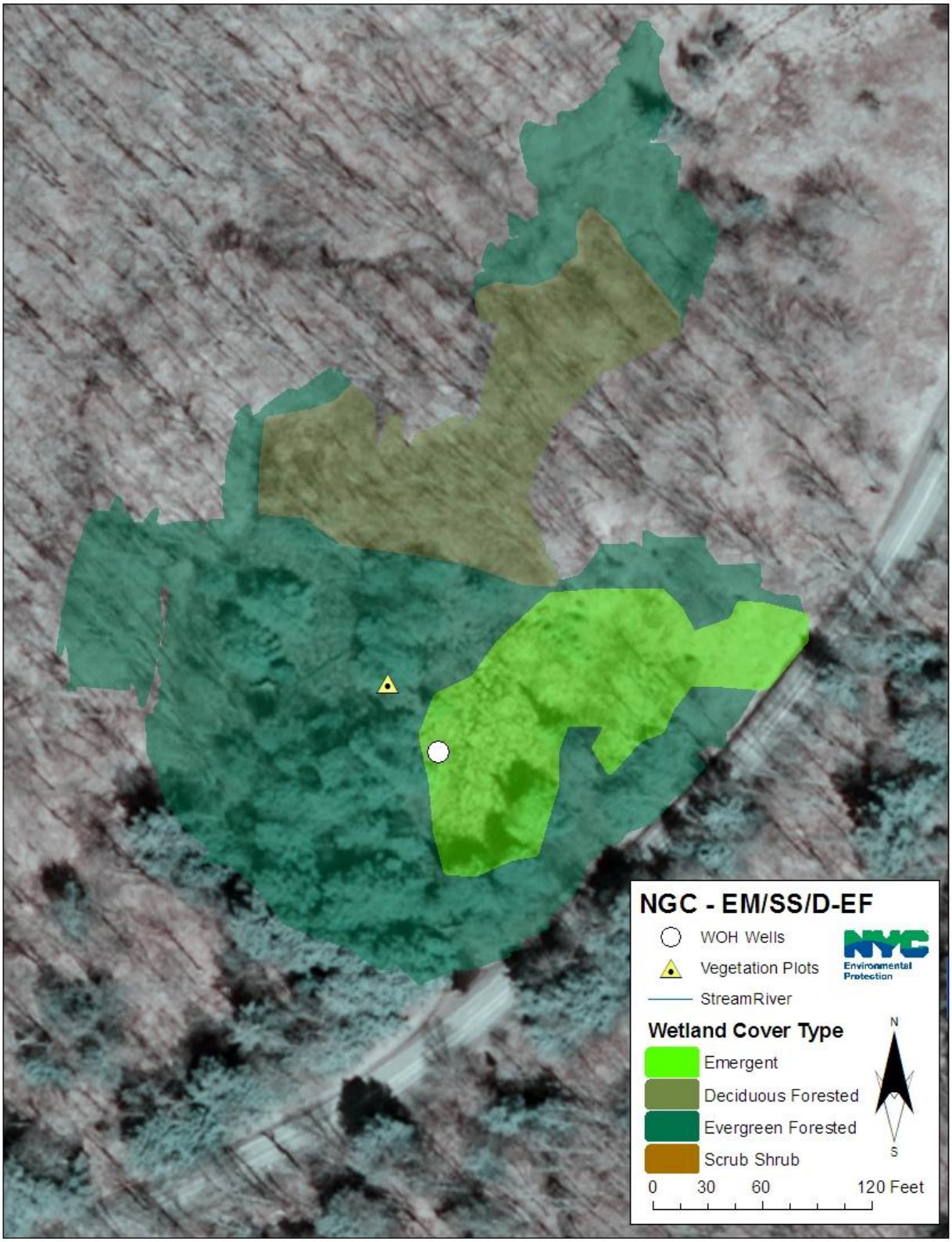

Figure A.11. Neversink Basin – Gun Club (NGC).

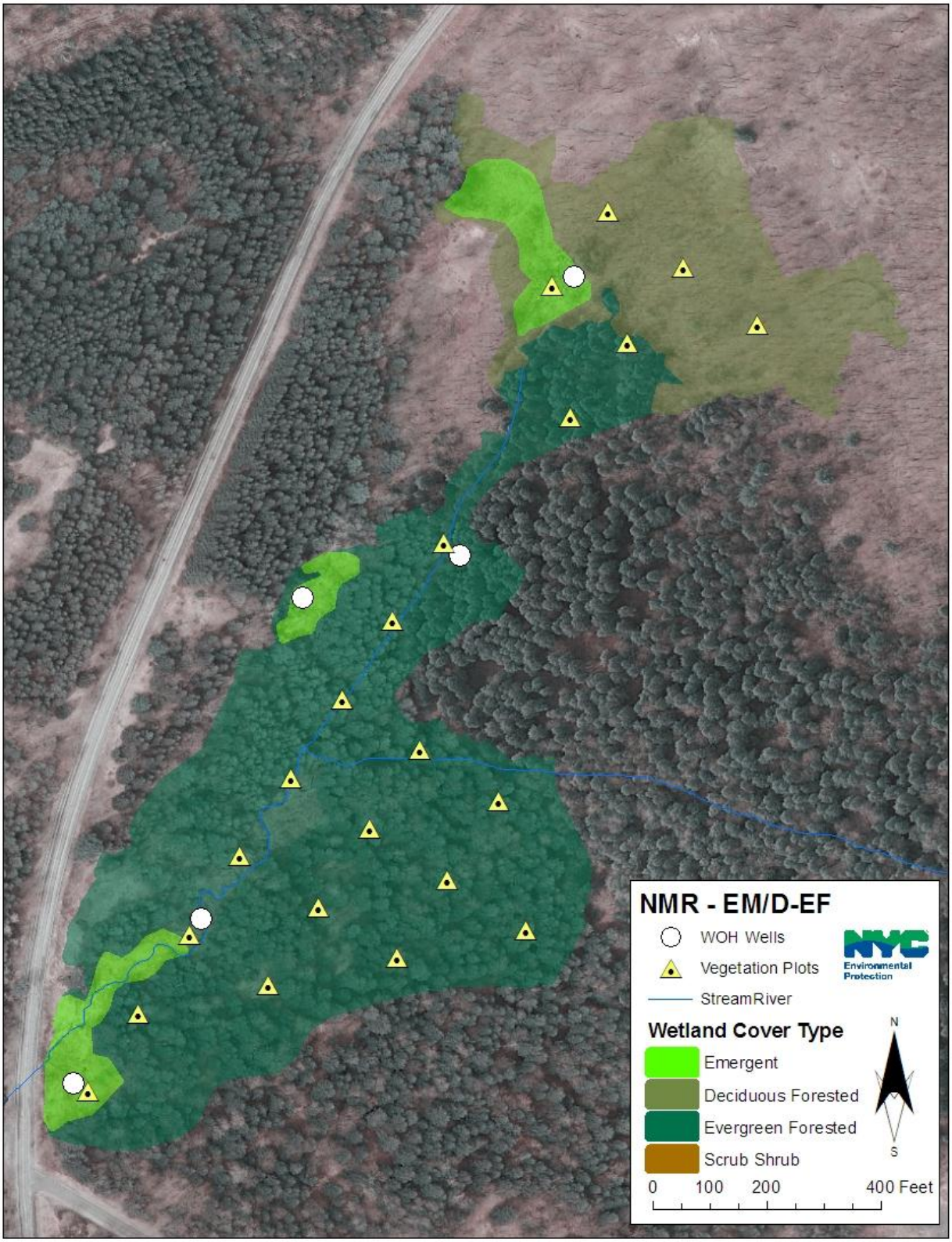

Figure A.12. Neversink Basin – Myers Road (NMR).

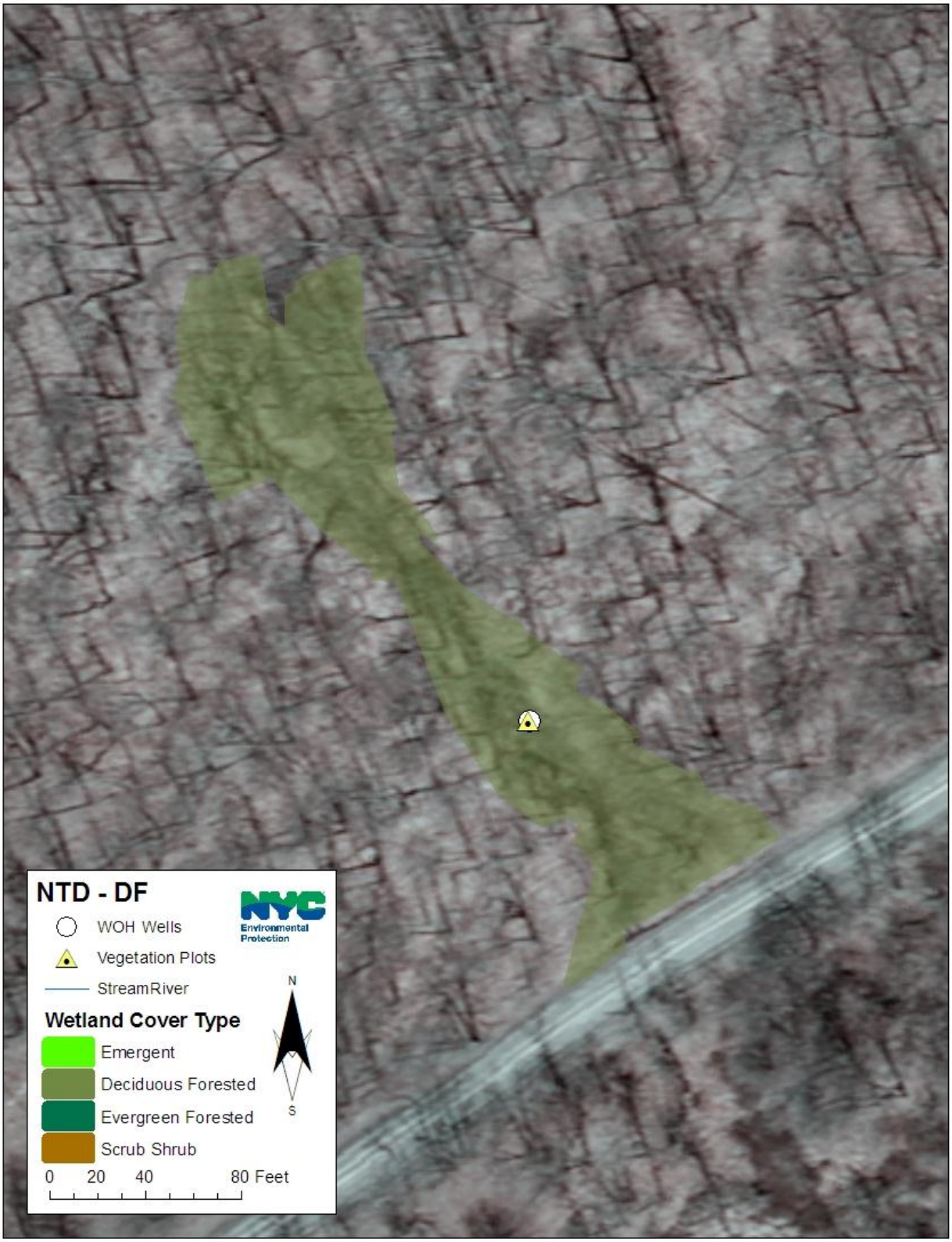

Figure A.13. Neversink Basin – Tear Drop (NTD).

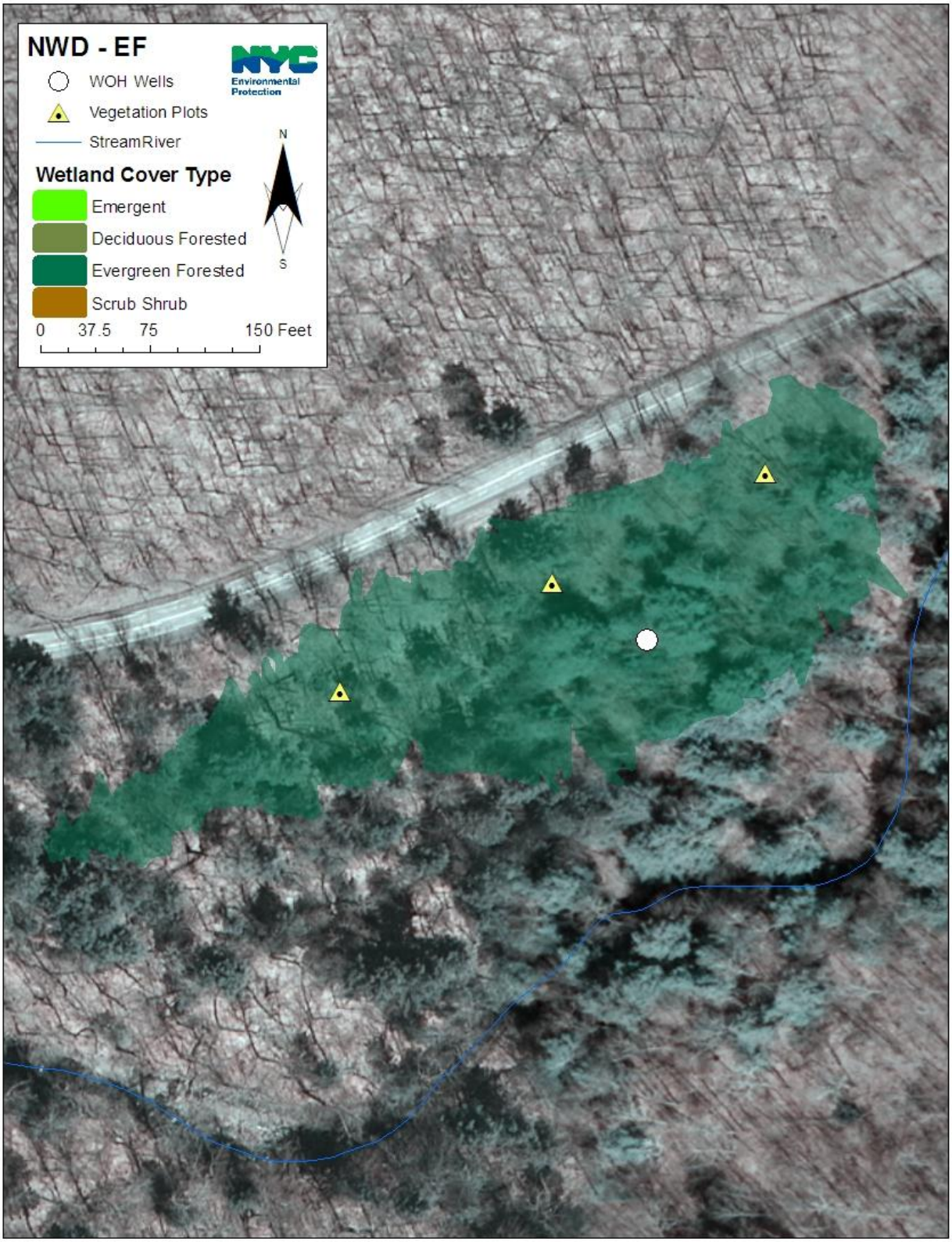

Figure A.14. Neversink Basin – White Deer (NWD).

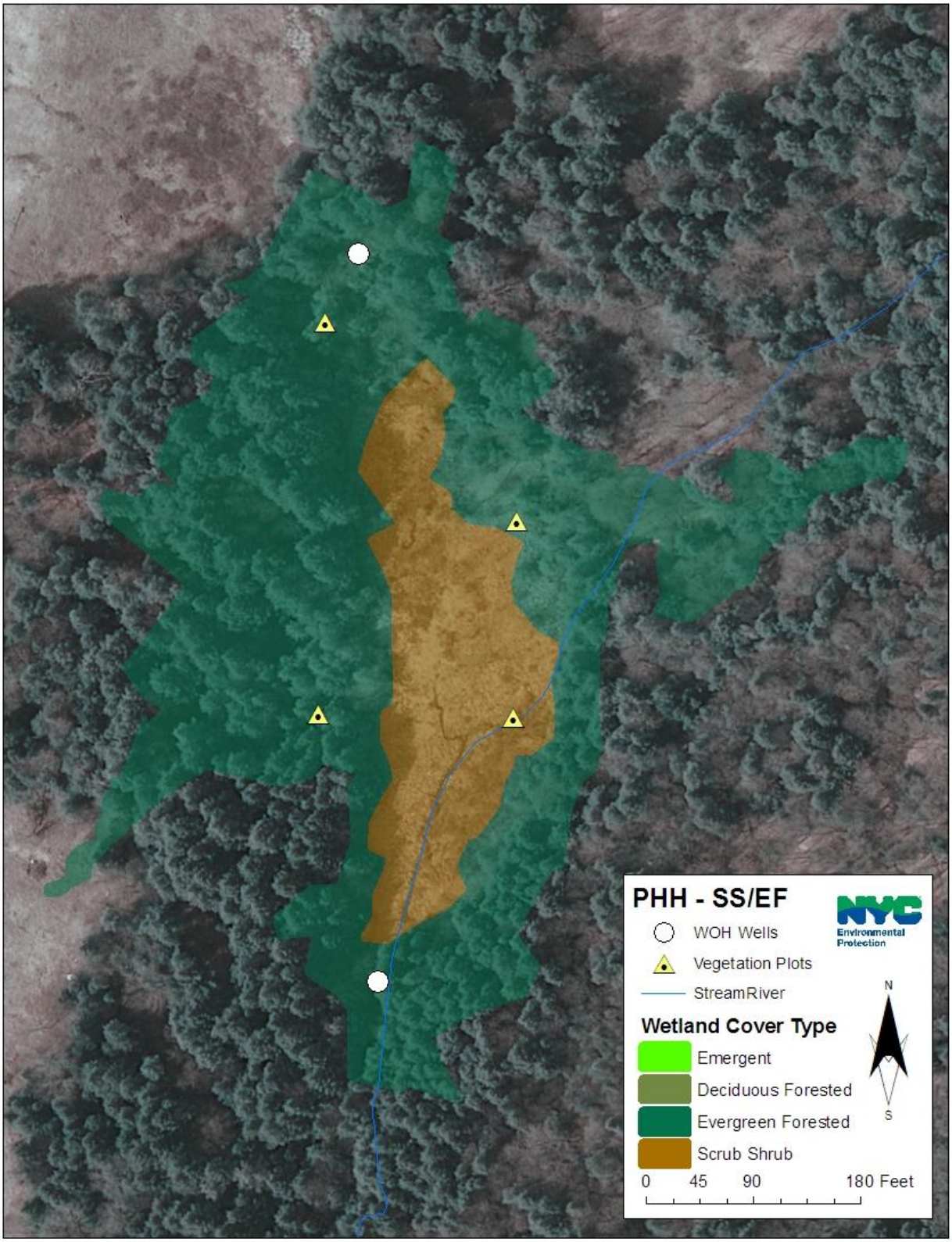

Figure A.15. Pepacton Basin – Hubble Hollow (PHH).

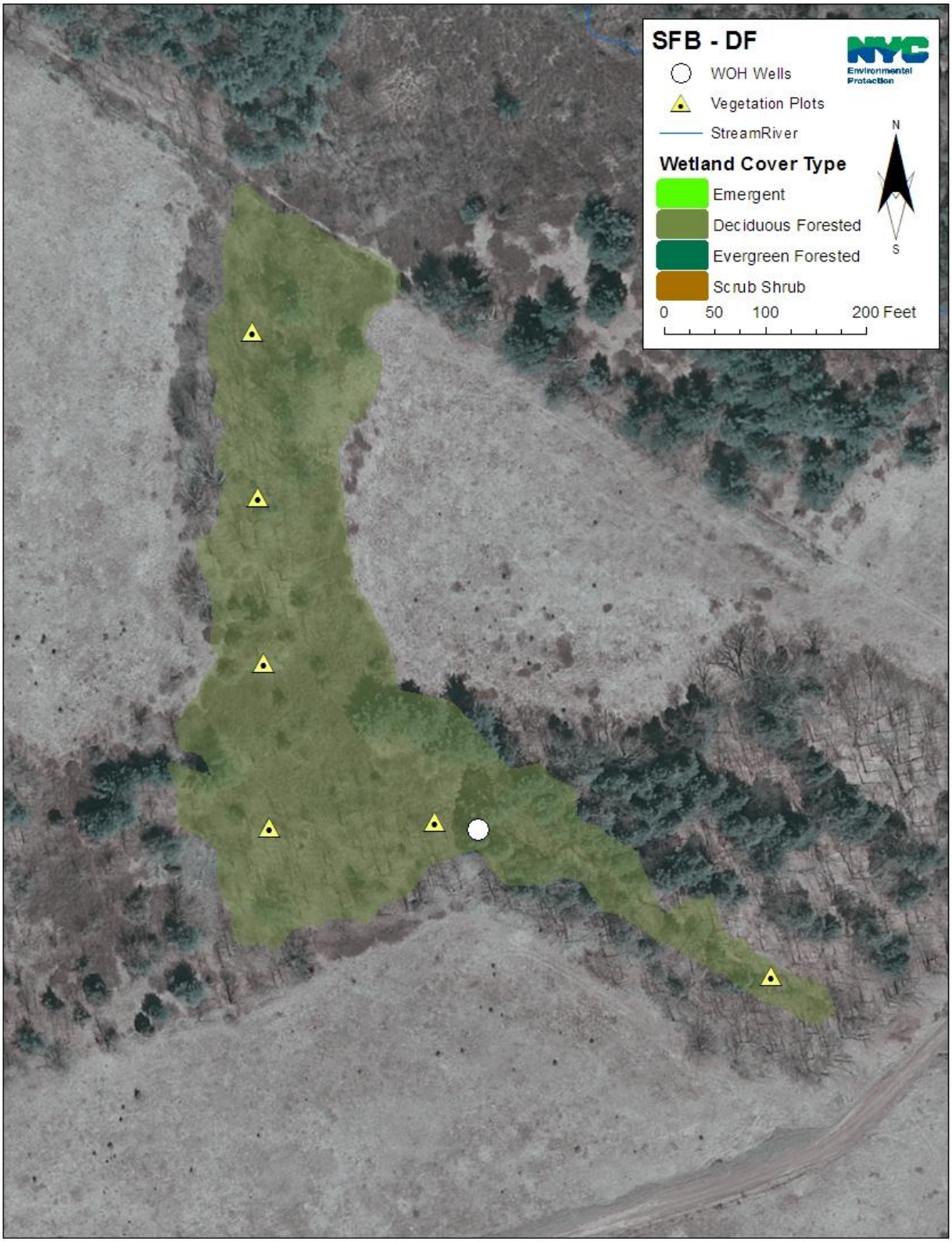

Figure A.16. Schoharie Basin – Fanny Brook (SFB).

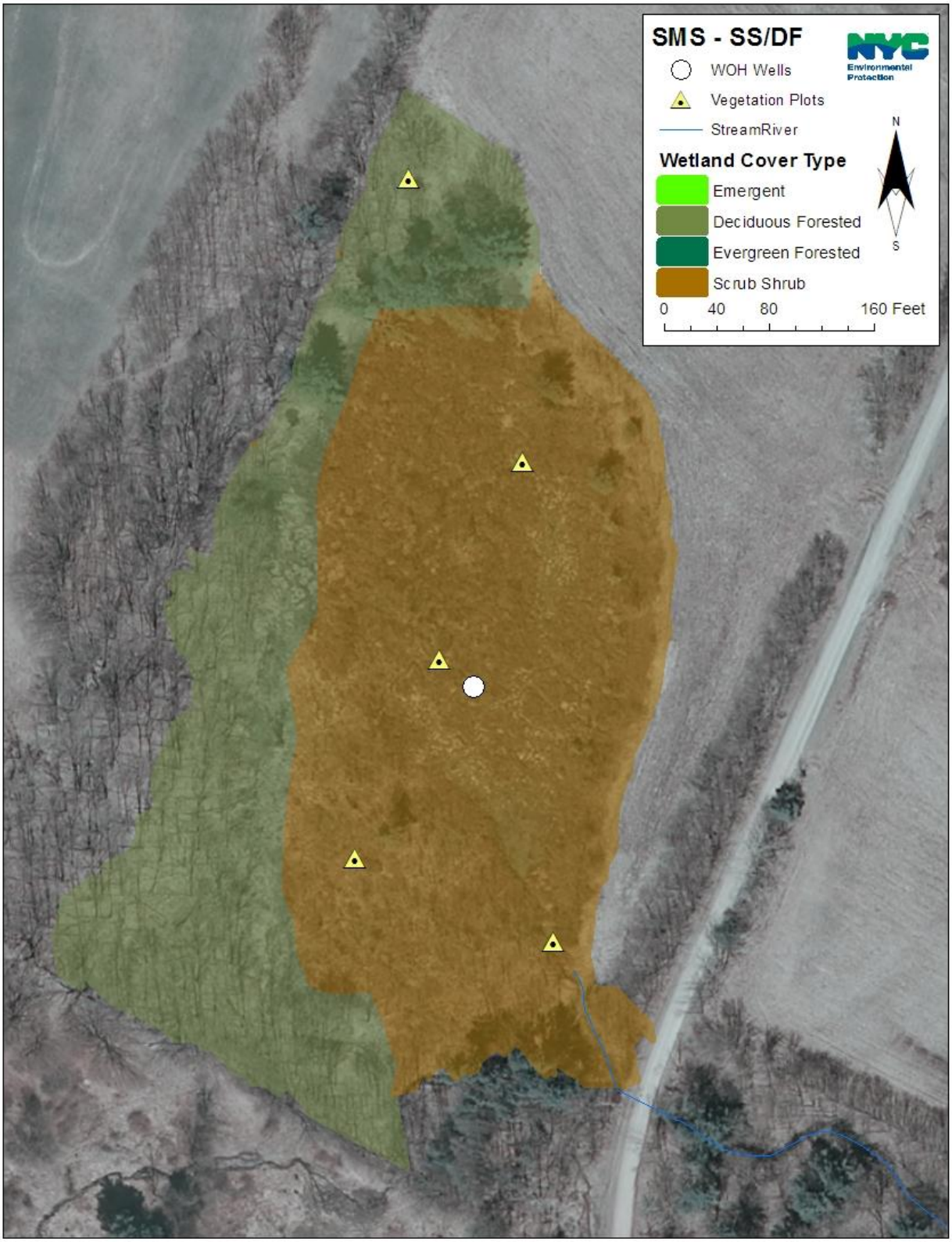

Figure A.17. Schoharie Basin – Matt Schwille (SMS).

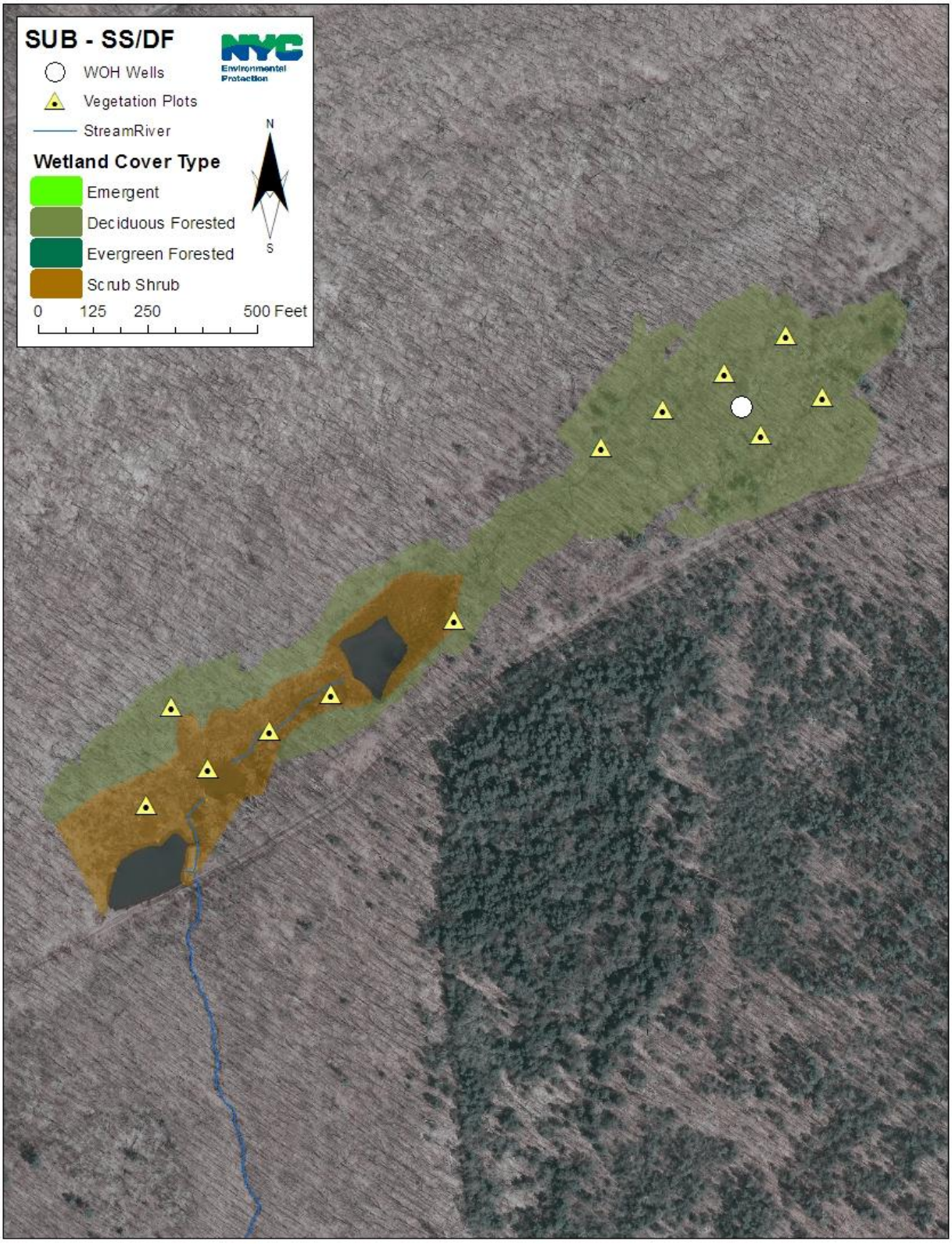

Figure A.18. Schoharie Basin – Upper Begeley (SUB).

Appendix B

Species Metrics for Hardwood, Hemlock-hardwood, Scrub-shrub, and Emergent Reference Wetlands

Hardwood Reference Wetland Vegetation Data

Table B.1. Frequency, density, and basal area of tree species recorded in hardwood reference wetlands. The range and median values of density and basal area are provided for species that occurred in more than one hardwood wetland (frequency > 12.5%). An indicator status of NL indicates the species was not listed on the 2014 NWPL. A blank indicator status is for plants not identified to the species level.

				Stems per acre		Basal area (ft^2/acre)	
Latin Name	**Common name**	**Indicator Status**	**Frequency (%)**	**Range**	**Median**	**Range**	**Median**
Abies balsamea	balsam fir	FAC	12.5		2		1.0
Acer rubrum	red maple	FAC	100	28-241	79	8.2-81.8	55.2
Acer saccharum	sugar maple	FACU	50	3-39	15	0.7-10.6	5.1
Betula alleghaniensis	yellow birch	FAC	50	4-44	5	0.5-23.2	5.0
Betula papyrifera	paper birch	FACU	25	3-13	8	0.7-2.9	1.8
Carpinus caroliniana	American hornbeam	FAC	25	8-10	9	0.8-1.1	1.0
Carya ovata	shagbark hickory	FACU	25	3-6	4	0.9-4.3	2.6
Fagus grandifolia	American beech	FACU	25	2-13	7	0.4-1.1	0.8
Fraxinus spp	ash		87.5	3-125	13	0.9-47.1	6.9
Juniperus virginiana	eastern red cedar	FACU	12.5		15		2.8
Malus coronaria	sweet crab-apple	NL	12.5		6		1.2
Nyssa sylvatica	black gum	FAC	25	3-4	3	0.9-1.8	1.3
Ostrya virginiana	hop-hornbeam	FACU	12.5		1		0.1
Pinus strobus	white pine	FACU	62.5	2-21	12	0.7-14.3	10.1
Populus tremuloides	quaking aspen	FACU	25	8-46	27	7.0-19.2	13.1
Prunus serotina	black cherry	FACU	25	4-13	9	0.7-1.8	1.2
Prunus spp	cherry species		25	11-13	12	1.9-2.0	2.0
Quercus alba	white oak	FACU	12.5		7		17.1
Quercus bicolor	swamp white oak	FACW	12.5		2		7.0
Quercus rubra	red oak	FACU	25	6-18	12	3.7-28.1	15.9
Tilia americana	American linden	FACU	37.5	2-3	3	1.9-2.4	2.0
Tsuga canadensis	eastern hemlock	FACU	50	9-34	10	2.2-16	6.2
Ulmus americana	American Elm	FACW	12.5		13		6.6
Viburnum lentago	nannyberry	FAC	12.5		3		0.3

Table B.2. Frequency and density of species recorded in the shrub layer of hardwood reference wetlands. The range in density is provided for species that occurred in more than one hardwood wetland (frequency > 12.5%). An indicator status of NL indicates the species was not listed on the 2014 NWPL.

Latin Name	Common name	Indicator Status	Frequency (%)	Density (stems/acre)
Acer rubrum	red maple	FAC	25	46.1 -193.5
Acer saccharum	sugar maple	FACU	12.5	107.0
Alnus incana	speckled alder	FACW	12.5	645.2
Betula alleghaniensis	yellow birch	FAC	12.5	64.5
Betula papyrifera	paper birch	FACU	12.5	92.2
Carpinus caroliniana	American hornbeam	FAC	25	64.5-74.4
Carya ovata	shagbark hickory	FACU	12.5	92.2
Cornus racemosa	northern swamp dogwood	FAC	12.5	92.2
Fraxinus pennsylvanica	green ash	FACW	25	129.0-230.4
Hamamelis virginiana	witchhazel	FACU	12.5	24.8
Ilex verticillata	winterberry holly	FACW	12.5	49.6
Malus coronaria	sweet crab-apple	NL	12.5	46.1
Ostrya virginiana	Hop-hornbeam	FACU	12.5	46.1
Pinus strobus	white pine	FACU	25	193.5-446.7
Quercus rubra	red oak	FACU	12.5	46.1
Rhododendron maximum	white laurel	FAC	12.5	580.6
Spirea latifolia	northern meadowsweet	FACW	12.5	4967.7
Tsuga canadensis	eastern hemlock	FACU	12.5	24.8
Vaccinium corymbosum	highbush blueberry	FACW	12.5	709.7

Table B.3. Seedlings present in the herbaceous layer of the hardwood reference wetlands. Frequency is the percentage of the hardwood reference wetlands in which a species occurred. An indicator status of NL indicates the species was not listed on the 2014 NWPL. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Acer pensylvanicum	striped maple	FACU	12.5
Acer rubrum	red maple	FAC	37.5
Alnus incana	speckled alder	FACW	12.5
Betula alleghaniensis	yellow birch	FAC	12.5
Carpinus caroliniana	American hornbeam	FAC	12.5
Fagus grandifolia	American beech	FACU	12.5
Fraxinus pennsylvanica	green ash	FACW	12.5
Gaylussacia dumosa	dwarf huckleberry	FAC	12.5
Ilex verticillata	winterberry holly	FACW	12.5
Malus coronaria	sweet crab-apple	NL	12.5
Nyssa sylvatica	black gum	FAC	12.5
Ostrya virginiana	hop-hornbeam	FACU	12.5
Pinus strobus	white pine	FACU	12.5
Populus spp.	poplar		12.5
Quercus spp.	oak		12.5
Rhododendron maximum	white laurel	FAC	12.5
Rubus allegheniensis	common blackberry	FACU	12.5
Rubus hispidus	swamp dewberry	FACW	25
Rubus idaeus	red raspberry	FACU	12.5
Rubus pubescens	dwarf raspberry	FACW	12.5
Spiraea alba	meadowsweet	FACW	37.5
Spiraea tomentosa	hardhack	FACW	25
Tsuga canadensis	eastern hemlock	FACU	12.5
Vaccinium corymbosum	highbush blueberry	FACW	12.5
Viburnum dentatum	arrowwood	FAC	12.5
Viburnum lentago	nannyberry	FAC	12.5

Table B.4. Forbs present in the herbaceous layer of the hardwood reference wetlands. Frequency is the percentage of the hardwood reference wetlands in which a species occurred. An indicator status of NL indicates the species was not listed on the 2014 NWPL. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Alisma triviale	water plantain	OBL	12.5
Anemone acutiloba	sharp-lobed hepatica	NL	12.5
Anemone quinquefolia	wood anemone	FACU	25
Arisaema triphyllum	Jack in the pulpit	FAC	37.5
Bidens connata	swamp beggar-ticks	OBL	12.5
Bidens frondosa	devil's bit	FACW	12.5
Boehmeria cylindrica	small-spike false nettle	OBL	12.5
Caltha palustris	marsh marigold	OBL	12.5
Chelone glabra	white turtlehead	OBL	12.5
Chrysosplenium americanum	golden saxifrage	OBL	25
Circaea lutetiana ssp. canadensis	enchanter's nightshade	FACU	12.5
Coptis trifolia	goldthread	FACW	12.5
Doellingeria umbellata	flat-topped white aster	FACW	12.5
Epilobium ciliatum	fringed willowherb	FACW	25
Epilobium coloratum	purple-leaf willowherb	OBL	25
Eupatorium perfoliatum	boneset	FACW	12.5
Euthamia graminifolia	flat-topped goldenrod	FAC	12.5
Eutrochium maculatum	spotted Joe-Pye weed	OBL	12.5
Fragaria vesca	wood strawberry	UPL	37.5
Galium aparine	cleavers	FACU	12.5
Geum aleppicum	yellow avens	FAC	25
Geum canadense	white avens	FAC	12.5
Geum laciniatum	rough avens	FACW	12.5
Heuchera americana	American alum-root	FACU	12.5
Hydrocotyle americana	marsh pennywort	OBL	37.5
Hypericum ellipticum	pale St. Johnswort	OBL	12.5
Impatiens capensis	orange jewelweed	FACW	75
Impatiens spp.	jewelweed		37.5
Lycopus americanus	cut-leaf water-horehound	OBL	12.5
Lycopus uniflorus	northern bugleweed	OBL	25
Lysimachia ciliata	fringed loosestrife	FACW	37.5
Lysimachia terrestris	swamp candles	OBL	12.5

Table B.5. Forbs in hardwood reference wetlands, continued.

Latin Name	Common Name	Indicator Status	Frequency (%)
Maianthemum canadense	Canada mayflower	FACU	37.5
Micranthes pensylvanica	swamp saxifrage	OBL	12.5
Mitchella repens	partridgeberry	FACU	25
Myosotis scorpioides	true forget-me-not	OBL	12.5
Oxalis stricta	common wood-sorrel	FACU	50
Packera aurea	heart-leaved groundsel	FACW	12.5
Persicaria arifolia	halberd-leaf tearthumb	OBL	12.5
Persicaria punctata	dotted smartweed	OBL	12.5
Persicaria sagittata	arrow-leaf tearthumb	OBL	87.5
Pilea pumila	clearweed	FACW	12.5
Polygala paucifolia	gay-wing milkwort	FACU	12.5
Potentilla simplex	common cinquefoil	FACU	62.5
Prenanthes altissima	tall white lettuce	FACU	12.5
Prunella vulgaris	selfheal	FAC	50
Ranunculus sceleratus	cursed buttercup	OBL	12.5
Rorippa aquatica	true water-cress	OBL	12.5
Rumex spp.	dock		12.5
Scutellaria lateriflora	mad dog skullcap	OBL	25
Sium suave	water parsnip	OBL	12.5
Solidago canadensis	Canada goldenrod	FACU	25
Solidago gigantea	smooth goldenrod	FACW	25
Solidago patula	round-leaved goldenrod	OBL	25
Solidago rugosa	wrinkle leaved goldenrod	FAC	37.5
Solidago uliginosa	bog goldenrod	OBL	12.5
Sparganium americanum	American bur-reed	OBL	25
Streptopus lanceolatus	rosy twisted stalk	FACU	12.5
Symphyotrichum lateriflorum	calico (starred) aster	FAC	12.5
Symphyotrichum novi-belgii	New York aster	FACW	12.5
Symphyotrichum puniceum	purple-stemmed aster	OBL	12.5
Symphyotrichum racemosum	small headed aster	FACW	12.5
Thalictrum pubescens	tall meadow rue	FACW	12.5
Tiarella cordifolia	heart-leaf foamflower	FACU	12.5
Trientalis borealis	star flower	FAC	25
Typha latifolia	common cattail	OBL	12.5
Veratrum viride	false hellebore	FACW	12.5
Viola spp.	violet		37.5

Table B.6. Graminoids present in the herbaceous layer of the hardwood reference wetlands. Frequency is the percentage of the hardwood reference wetlands in which a species occurred. An indicator status of NL indicates the species was not listed on the 2014 NWPL.

Latin Name	Common Name	Indicator Status	Frequency (%)
Agrostis hyemalis	ticklegrass	FAC	12.5
Brachyelytrum erectum	southern long-awned wood grass	FACU	12.5
Carex arctata	drooping woodland sedge	NL	12.5
Carex bromoides	brome-like sedge	FACW	12.5
Carex crinita	fringed sedge	OBL	12.5
Carex intumescens	bladder sedge	FACW	37.5
Carex lurida	sallow sedge	OBL	37.5
Carex scoparia	pointed broom sedge	FACW	12.5
Carex seorsa	weak stellate sedge	FACW	12.5
Carex stipata	stalk-grain sedge	OBL	12.5
Carex stricta	tussock sedge	OBL	12.5
Carex swanii	swan's sedge	FACU	12.5
Carex tenera	quill sedge	FAC	25
Carex trisperma	three-seed sedge	OBL	12.5
Carex vulpinoidea	common fox sedge	OBL	12.5
Danthonia compressa	flattened wild oat grass	FACU	12.5
Dulichium arundinaceum	three-way sedge	OBL	12.5
Glyceria canadensis	rattlesnake mannagrass	OBL	12.5
Glyceria melicaria	northeastern mannagrass	OBL	12.5
Glyceria striata	fowl mannagrass	OBL	50
Glyceria x laxa	northern mannagrass	OBL	12.5
Graphephorum melicoides	purple false oat	FACW	12.5
Juncus effusus	soft rush	OBL	37.5
Juncus tenuis	lesser poverty (path) rush	FAC	12.5
Leersia oryzoides	rice cutgrass	OBL	12.5
Scirpus atrovirens	green bulrush	OBL	12.5
Scirpus cyperinus	wool grass	OBL	12.5
Sporobolus cryptandrus	sand dropseed	FACU	12.5

Table B.7. Ferns present in the herbaceous layer of the hardwood reference wetlands. Frequency is the percentage of the hardwood reference wetlands in which a species occurred.

Latin Name	Common Name	Indicator Status	Frequency (%)
Dryopteris carthusiana	spinulose wood fern	FACW	37.5
Dryopteris cristata	crested wood fern	OBL	12.5
Dryopteris X bootii	Boot's fern	FACW	12.5
Onoclea sensibilis	sensitive fern	FACW	50
Osmunda cinnamomea	cinnamon fern	FACW	12.5
Parathelypteris simulata	bog fern	FACW	12.5
Thelypteris palustris	marsh fern	FACW	25

Table B.8. Vines present in the herbaceous layer of the hardwood reference wetlands. Frequency is the percentage of the hardwood reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Amphicarpaea bracteata	hog peanut	FAC	12.5
Clematis virginiana	Virginia's virgin-bower	FAC	12.5
Cuscuta sp.	dodder		12.5
Toxicodendron radicans	poison ivy	FAC	25

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Table B.9. Frequency, density, and basal area of tree species recorded in hemlock-hardwood reference wetlands. The range and median values of density and basal area are provided for species that occurred in more than one hardwood wetland (frequency > 10%). A blank indicator status is for plants not identified to the species level.

Species	Common name	Indicator Status	Frequency (%)	Stems per acre		Basal area (ft^2/acre)	
				Range	Median	Range	Median
Abies balsamea	balsam fir	FAC	10		3		1.2
Acer rubrum	red maple	FAC	90	3-137	39	4.8-54.4	37.2
Acer saccharum	sugar maple	FACU	10		16		8.3
Betula alleghaniensis	yellow birch	FAC	100	11-106	27	1.4-54.9	11.3
Betula lenta	black birch	FACU	20	4-13	9	1.0-7.5	4.3
Carya ovata	shagbark hickory	FACU	10		13		7.2
Fagus grandifolia	American beech	FACU	40	1-26	6	0.8-8.2	1.4
Fraxinus spp	ash		30	24-28	26	5.5-12.5	10.0
Nyssa sylvatica	black gum	FAC	10		21		28.4
Ostrya virginiana	Hop-hornbeam	FACU	10		1		0.1
Picea glauca	white spruce	FACU	10		1		0.3
Pinus strobus	white pine	FACU	40	1-39	14	1.2-32	6.4
Prunus serotina	black cherry	FACU	20	2-4	3	1.6-1.8	1.7
Quercus alba	white oak	FACU	10		9		27.6
Quercus rubra	red oak	FACU	10		13		15.9
Tsuga canadensis	eastern hemlock	FACU	100	48-180	122	17.8-135.0	47.7
Ulmus americana	American elm	FACW	10		1		0.2

Table B.10. Frequency and density of species recorded in the shrub layer of hemlock-hardwood reference wetlands. The range in density is provided for species that occurred in more than one hardwood wetland (frequency > 10%).

Latin Name	Common name	Indicator Status	Frequency (%)	Density (stems/acre)
Acer rubrum	red maple	FAC	20	18-161
Acer saccharum	sugar maple	FACU	20	18-81
Betula alleghaniensis	yellow birch	FAC	20	54-65
Fagus grandifolia	American beech	FACU	10	242
Fraxinus pennsylvanica	green ash	FACW	10	54
Ilex verticillata	winterberry holly	FACW	10	54
Kalmia latifolia	mountain laurel	FACU	20	215-538
Picea glauca	white spruce	FACU	10	18
Pinus strobus	white pine	FACU	10	129
Rhododendron maximum	white laurel	FAC	10	215
Spiraea tomentosa	hardhack	FACW	10	18
Tsuga canadensis	eastern hemlock	FACU	30	54-72
Vaccinium corymbosum	highbush blueberry	FACW	10	72

Table B.11. Seedlings present in the herbaceous layer of the hemlock-hardwood reference wetlands. Frequency is the percentage of the hemlock hardwood reference wetlands in which a species occurred. An indicator status of NL indicates the species was not listed on the 2014 NWPL. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Abies balsamea	balsam fir	FAC	10
Acer rubrum	red maple	FAC	40
Acer saccharinum	silver maple	FACW	10
Acer saccharum	sugar maple	FACU	20
Acer spicatum	mountain maple	FACU	10
Betula alleghaniensis	yellow birch	FAC	10
Betula lenta	black birch	FACU	10
Carpinus caroliniana	American hornbeam	FAC	20
Fagus grandifolia	American beech	FACU	20
Fraxinus pennsylvanica	green ash	FACW	10
Gaultheria procumbens	wintergreen	FACU	10
Gaylussacia dumosa	dwarf huckleberry	FAC	10
Hamamelis virginiana	witch hazel	FACU	10
Ilex verticillata	winterberry holly	FACW	10
Lonicera spp.	honeysuckle		20
Malus coronaria	sweet crab-apple	NL	10
Nyssa sylvatica	black gum	FAC	10
Picea glauca	white spruce	FACU	10
Picea mariana	black spruce	FACW	10
Pinus strobus	white pine	FACU	10
Prunus serotina	black cherry	FACU	10
Quercus spp.	unknown oak		10
Rhododendron maximum	white laurel	FAC	10
Rosa spp.	rose		10
Rubus hispidus	swamp dewberry	FACW	10
Rubus pubescens	dwarf raspberry	FACW	20
Spiraea alba	broad-leaf meadowsweet	FACW	10
Spiraea tomentosa	hardhack	FACW	20
Tsuga canadensis	eastern hemlock	FACU	20
Vaccinium angustifolium	lowbush blueberry	FACU	20
Vaccinium corymbosum	highbush blueberry	FACW	10
Vaccinium myrtilloides	velvetleaf blueberry	FACW	20
Viburnum dentatum	arrowwood	FAC	10
Viburnum lantanoides	hobblebush	FACU	10

Table B.12. Forbs present in the herbaceous layer of the hemlock-hardwood reference wetlands. Frequency is the percentage of the hemlock-hardwood reference wetlands in which a species occurred. An indicator status of NL indicates the species was not listed on the 2014 NWPL. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Anemone quinquefolia	wood anemone	FACU	20
Arisaema triphyllum	Jack in the pulpit	FAC	30
Bidens connata	swamp beggar-ticks	OBL	10
Caltha palustris	marsh marigold	OBL	10
Chelone glabra	white turtlehead	OBL	10
Chrysosplenium americanum	golden saxifrage	OBL	40
Cicuta bulbifera	water hemlock	OBL	10
Coptis trifolia	goldthread	FACW	40
Doellingeria umbellata	flat-topped white aster	FACW	20
Epilobium ciliatum	fringed willowherb	FACW	10
Epilobium coloratum	purple-leaf willowherb	OBL	20
Eupatorium perfoliatum	boneset	FACW	10
Eurybia divaricata	white wood-aster	NL	10
Euthamia graminifolia	flat-topped goldenrod	FAC	30
Fragaria vesca	wood strawberry	UPL	40
Galium tinctorium	stiff marsh bedstraw	OBL	10
Galium trifidum	three-lobed bedstraw	FACW	20
Geum spp.	geum		10
Hieracium spp.	hawkweed		10
Hydrocotyle americana	marsh pennywort	OBL	30
Hypericum mutilum	dwarf St. Johnswort	FACW	10
Impatiens spp.	jewelweed		40
Lycopus uniflorus	northern bugleweed	OBL	30
Lysimachia ciliata	fringed loosestrife	FACW	10
Maianthemum canadense	Canada mayflower	FACU	40
Mitchella repens	partridgeberry	FACU	40
Mitella spp.	miterwort		10
Myosotis laxa	bay forget-me-not	OBL	10
Oxalis montana	white wood-sorrel	FACU	30
Oxalis stricta	common wood-sorrel	FACU	10

Table B.13. Forbs present in the herbaceous layer of the hemlock-hardwood reference wetlands, continued. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Packera aurea	heart-leaved groundsel	FACW	10
Persicaria arifolia	halberd-leaf tearthumb	OBL	20
Persicaria sagittata	arrow-leaf tearthumb	OBL	40
Pilea pumila	clearweed	FACW	10
Potentilla simplex	common cinquefoil	FACU	10
Ranunculus hispidus	bristly buttercup	FAC	10
Ranunculus sceleratus	cursed buttercup	OBL	20
Rorippa aquatica	true water-cress	OBL	20
Scutellaria lateriflora	mad dog skullcap	OBL	70
Solidago gigantea	smooth goldenrod	FACW	10
Solidago patula	round-leaved goldenrod	OBL	10
Solidago rugosa	wrinkle leaved goldenrod	FAC	30
Symphyotrichum novae-angliae	New England aster	FACW	10
Symphyotrichum novi-belgii	New York aster	FACW	20
Tiarella cordifolia	heart-leaf foamflower	FACU	30
Trientalis borealis	star flower	FAC	60
Veronica spp.	speedwell Veronica		10
Viola spp.	violet		10

Table B.14. Graminoids present in the herbaceous layer of the hemlock-hardwood reference wetlands. Frequency is the percentage of the hemlock-hardwood reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Agrostis hyemalis	ticklegrass	FAC	10
Carex bromoides	brome-like sedge	FACW	10
Carex brunnescens	brownish sedge	FACW	10
Carex crinita	fringed sedge	OBL	30
Carex intumescens	bladder sedge	FACW	10
Carex lurida	sallow sedge	OBL	20
Carex scoparia	pointed broom sedge	FACW	30
Carex stipata	stalk-grain sedge	OBL	10
Carex swanii	swan's sedge	FACU	10
Carex trisperma	three-seed sedge	OBL	30
Cinna latifolia	slender wood-reed	FACW	20
Glyceria canadensis	rattlesnake mannagrass	OBL	10
Glyceria striata	fowl mannagrass	OBL	50
Juncus effusus	soft rush	OBL	10
Leersia oryzoides	rice cutgrass	OBL	10
Panicum spp.	unknown panic-grass		10
Scirpus cyperinus	wool grass	OBL	10
Sporobolus spp.	dropseed		10
Thalictrum pubescens	tall meadow rue	FACW	20
Torreyochloa pallida	pale false manna grass	OBL	20

Table B.15. Ferns present in the herbaceous layer of the hemlock-hardwood reference wetlands. Frequency is the percentage of the hemlock-hardwood reference wetlands in which a species occurred.

Latin Name	Common Name	Indicator Status	Frequency (%)
Dennstaedtia punctilobula	hay-scented fern	UPL	20
Dryopteris campyloptera	mountain wood fern	FACU	10
Dryopteris carthusiana	spinulose wood fern	FACW	20
Dryopteris cristata	crested wood fern	OBL	20
Onoclea sensibilis	sensitive fern	FACW	50
Osmunda cinnamomea	cinnamon fern	FACW	50
Parathelypteris noveboracensis	New York fern	FAC	10
Parathelypteris simulata	bog fern	FACW	30
Thelypteris palustris	marsh fern	FACW	10

Table B.16. Vines present in the herbaceous layer of the hemlock-hardwood reference wetlands. Frequency is the percentage of the hemlock-hardwood reference wetlands in which a species occurred.

Latin Name	Common Name	Indicator Status	Frequency (%)
Amphicarpaea bracteata	hog peanut	FAC	10
Parthenocissus quinquefolia	Virginia creeper	FACU	20
Toxicodendron radicans	poison ivy	FAC	20

Scrub-shrub Reference Wetland Vegetation Data

Table B.17. Frequency, density, and basal area of tree species recorded in scrub-shrub reference wetlands. The range and median values of density and basal area are provided for species that occurred in more than one hardwood wetland (Frequency >16.7). A blank indicator status is for plants not identified to the species level.

Species	Common Name	Indicator Status	Frequency (%)	Denisty (Stems per acre)		Basal Area (ft2/acre)	
				Range	Value	Range	Value
Acer rubrum	red maple	FAC	83.3	9-26	19	2-26	4.0
Fraxinus pennsylvanica	green ash	FACW	16.7		3		0.9
Prunus spp.	cherry		16.7		4		0.5
Robinia spp.	locust		16.7		2		0.3
Salix sericea	silky willow	OBL	16.7		11		1.7
Ulmus americana	American elm	FACW	16.7		29		5.7

Table B.18. Frequency and density of species recorded in the shrub layer of scrub-shrub reference wetlands. The range of density is provided for species that occurred in more than one hardwood wetland (frequency > 16.7).

Latin names	Common name	Indicator Status	Frequency (%)	Density (stems/acre)
Acer rubrum	red maple	FAC	33.3	161-484
Alnus incana	speckled alder	FACW	50	968-1935
Prunus virginiana	choke cherry	FACU	16.7	81
Salix sericea	silky willow	OBL	66.7	403-5161
Spiraea alba	broad-leaf meadowsweet	FACW	66.7	376-13952
Vaccinium corymbosum	highbush blueberry	FACW	16.7	161
Viburnum dentatum	arrowwood	FAC	16.7	4516

Table B.19. Seedlings present in the herbaceous layer of the scrub-shrub reference wetlands. Frequency is the percentage of the scrub-shrub reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Acer rubrum	red maple	FAC	16.7
Alnus incana	speckled alder	FACW	33.3
Betula spp.	birch		16.7
Rubus hispidus	swamp dewberry	FACW	16.7
Rubus idaeus	red raspberry	FACU	16.7
Rubus pubescens	dwarf raspberry	FACW	33.3
Salix sericea	silky willow	OBL	33.3
Spiraea alba	broad-leaf meadowsweet	FACW	83.3
Spiraea tomentosa	hardhack	FACW	16.7
Vaccinium corymbosum	highbush blueberry	FACW	16.7
Viburnum dentatum	arrowwood	FAC	50.0

Table B.20. Forbs present in the herbaceous layer of the scrub-shrub reference wetlands. Frequency is the percentage of the scrub-shrub reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Arisaema triphyllum	Jack in the pulpit	FAC	50.0
Bidens cernua	nodding bur-marigold	OBL	16.7
Bidens frondosa	devil's bit	FACW	33.3
Chelone glabra	white turtlehead	OBL	83.3
Chrysosplenium americanum	golden saxifrage	OBL	33.3
Doellingeria umbellata	flat-topped white aster	FACW	50.0
Epilobium ciliatum	fringed willowherb	FACW	50.0
Epilobium coloratum	purple-leaf willowherb	OBL	33.3
Eupatorium perfoliatum	boneset	FACW	16.7
Eurybia radula	low rough aster	OBL	16.7
Euthamia graminifolia	flat-topped goldenrod	FAC	16.7
Eutrochium maculatum	spotted Joe-Pye weed	OBL	50.0
Fragaria vesca	wood strawberry	UPL	16.7
Galium aparine	cleavers	FACU	16.7
Galium palustre	marsh bedstraw	OBL	16.7
Galium trifidum	three-lobed bedstraw	FACW	16.7
Geum macrophyllum	big-leaved avens	FACW	16.7

Table B.21. Forbs present in the herbaceous layer of the scrub-shrub reference wetlands, continued

Species	Common Name	Indicator Status	Frequency (%)
Heuchera spp.	alum-root		16.7
Hydrocotyle americana	marsh pennywort	OBL	33.3
Hypericum mutilum	dwarf St. Johnswort	FACW	33.3
Hypericum punctatum	spotted St. Johnswort	FAC	16.7
Impatiens capensis	orange jewelweed	FACW	100.0
Impatiens pallida	yellow jewelweed	FACW	16.7
Iris versicolor	blue flag	OBL	16.7
Lemna spp.	duckweed	OBL	16.7
Lycopus americanus	cut-leaf water-horehound	OBL	16.7
Lycopus uniflorus	northern bugleweed	OBL	50.0
Lysimachia ciliata	fringed loosestrife	FACW	33.3
Lysimachia terrestris	swamp candles	OBL	16.7
Micranthes pensylvanica	swamp saxifrage	OBL	50.0
Persicaria sagittata	arrow-leaf tearthumb	OBL	83.3
Potentilla simplex	common (oldfield) cinquefoil	FACU	33.3
Ranunculus sceleratus	cursed (buttercup) crow's foot	OBL	50.0
Rorippa aquatica	true water-cress	OBL	33.3
Rumex spp.	dock		16.7
Sagittaria latifolia	common arrow head	OBL	16.7
Scutellaria lateriflora	mad dog skullcap	OBL	50.0
Solidago canadensis	Canada goldenrod	FACU	16.7
Solidago gigantea	smooth (late) goldenrod	FACW	50.0
Solidago patula	round-leaved goldenrod	OBL	33.3
Solidago rugosa	wrinkle leaved goldenrod	FAC	66.7
Solidago uliginosa	bog goldenrod	OBL	16.7
Sparganium americanum	American bur-reed	OBL	16.7
Symphyotrichum novi-belgii	New York aster	FACW	83.3
Symphyotrichum prenanthoides	crooked-stemmed aster	FAC	16.7
Symphyotrichum puniceum	purple-stemmed aster	OBL	50.0
Typha latifolia	common cattail	OBL	16.7

Table B.22. Graminoids present in the herbaceous layer of the scrub-shrub reference wetlands. Frequency is the percentage of the scrub-shrub reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common Name	Indicator Status	Frequency (%)
Carex brunnescens	brownish sedge	FACW	16.7
Carex crinita	fringed sedge	OBL	33.3
Carex lurida	sallow sedge	OBL	33.3
Carex scoparia	pointed broom sedge	FACW	33.3
Carex stipata	stalk-grain sedge	OBL	16.7
Carex trisperma	three-seed sedge	OBL	16.7
Carex utriculata	NW Territory sedge	OBL	16.7
Glyceria canadensis	rattlesnake mannagrass	OBL	16.7
Glyceria grandis	American mannagrass	OBL	16.7
Glyceria striata	fowl mannagrass	OBL	66.7
Graphephorum melicoides	purple false oat	FACW	16.7
Juncus effusus	soft rush	OBL	33.3
Leersia oryzoides	rice cutgrass	OBL	66.7
Poa spp.	poa		33.3
Scirpus cyperinus	wool grass	OBL	33.3

Table B.23. Ferns present in the herbaceous layer of the scrub-shrub reference wetlands. Frequency is the percentage of the scrub-shrub reference wetlands in which a species occurred.

Latin Name	Common Name	Indicator Status	Frequency (%)
Dryopteris carthusiana	spinulose wood fern	FACW	33.3
Dryopteris cristata	crested wood fern	OBL	16.7
Dryopteris X bootii	Boot's fern	FACW	16.7
Onoclea sensibilis	sensitive fern	FACW	100.0
Osmunda cinnamomea	cinnamon fern	FACW	50.0
Thelypteris palustris	marsh fern	FACW	33.3

Table B.24. Vines present in the herbaceous layer of the scrub-shrub reference wetlands. Frequency is the percentage of the scrub-shrub reference wetlands in which a species occurred.

Latin Name	Common Name	Indicator Status	Frequency (%)
Clematis virginiana	Virginia's virgin-bower	FAC	33.3

Emergent Reference Wetland Vegetation Data

Table B.25. Frequency, density, and basal area of tree species recorded in emergent reference wetlands. The range and median values of density and basal area are provided for the two species that occurred in more than one emergent wetland (frequency = 50%).

Latin Name	Common name	Indicator Status	Frequency (%)	Density (stems/acre)		Basal Area (ft2/acre)	
				Range	Value	Range	Value
Acer rubrum	red maple	FAC	50	4-6	5	0.5-3.1	1.8
Picea glauca	white spruce	FACU	25		26		7.1
Pinus strobus	white pine	FACU	50	4-5	5	1.0-4.2	2.6
Populus tremuloides	quaking aspen	FACU	25		4		1.2
Quercus rubra	red oak	FACU	25		2		0.5
Tsuga canadensis	eastern hemlock	FACU	25		8		2.3

Table B.26. Frequency and density of species recorded in the shrub layer of emergent reference wetlands.

Latin Name	Common name	Indicator Status	Frequency (%)	Density (stems/acre)
Acer rubrum	red maple	FAC	25	322.6
Alnus incana	speckled alder	FACW	25	1075.3
Betula alleghaniensis	yellow birch	FAC	25	40.3
Hamamelis virginiana	witch hazel	FACU	25	40.3
Kalmia latifolia	mountain laurel	FACU	25	80.6
Pinus strobus	white pine	FACU	25	40.3
Salix sericea	silky willow	OBL	25	2311.8
Spiraea alba	broad-leaf meadowsweet	FACW	25	1935.5
Tsuga canadensis	eastern hemlock	FACU	25	121.0
Vaccinium corymbosum	highbush blueberry	FACW	25	107.5

Table B.27. Seedlings present in the herbaceous layer of the emergent reference wetlands. Frequency is the percentage of the emergent reference wetlands in which a species occurred.

Latin Name	Common name	Indicator Status	Frequency (%)
Acer rubrum	red maple	FAC	50
Kalmia latifolia	mountain laurel	FACU	25
Lyonia ligustrina	maleberry	FACW	25
Rubus flagellaris	northern dewberry	FACU	25
Rubus hispidus	swamp dewberry	FACW	75
Rubus idaeus	red raspberry	FACU	50
Salix sericea	silky willow	OBL	25
Spiraea alba	broad-leaf meadowsweet	FACW	100
Spiraea tomentosa	hardhack	FACW	50
Vaccinium corymbosum	highbush blueberry	FACW	25
Vaccinium myrtilloides	velvetleaf blueberry	FACW	25

Table B.28. Forbs present in the herbaceous layer of the emergent reference wetlands. Frequency is the percentage of the emergent reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common name	Indicator Status	Frequency (%)
Anemone quinquefolia	wood anemone	FACU	25
Arisaema triphyllum	Jack in the pulpit	FAC	25
Asclepias spp.	milkweed		25
Bidens cernua	nodding bur-marigold	OBL	25
Bidens connata	purple-stemmed swamp beggar ticks	OBL	25
Chelone glabra	white turtlehead	OBL	25
Chrysosplenium americanum	golden saxifrage	OBL	50
Cirsium spp.	thistle		25
Doellingeria umbellata	flat-topped white aster	FACW	25
Elodea canadensis	Canadian waterweed	OBL	25
Epilobium ciliatum	fringed willowherb	FACW	25
Eupatorium perfoliatum	boneset	FACW	50
Euthamia graminifolia	flat-topped goldenrod	FAC	100
Eutrochium maculatum	spotted Joe-Pye weed	OBL	25
Fragaria vesca	wood strawberry	UPL	50
Galium palustre	marsh bedstraw	OBL	50
Galium trifidum	three-lobed bedstraw	FACW	25
Geranium maculatum	wild geranium	FACU	25
Geranium robertianum	Robert's geranium, herb Robert	FACU	25
Geum spp.	geum		25

Table B.28 Forbs present in the herbaceous layer of the emergent reference wetlands, continued

Latin Name	Common name	Indicator Status	Frequency (%)
Hydrocotyle americana	marsh pennywort	OBL	75
Hypericum canadense	lesser St. Johnswort	FACW	25
Hypericum ellipticum	pale St. Johnswort	OBL	25
Hypericum mutilum	dwarf St. Johnswort	FACW	50
Hypericum punctatum	spotted St. Johnswort	FAC	25
Impatiens capensis	orange jewelweed	FACW	75
Impatiens pallida	yellow jewelweed	FACW	25
Lycopus uniflorus	northern bugleweed	OBL	75
Lysimachia ciliata	fringed loosestrife	FACW	25
Lysimachia terrestris	swamp candles	OBL	50
Myosotis laxa	bay forget-me-not	OBL	25
Oxalis stricta	common wood-sorrel	FACU	50
Packera aurea	heart-leaved (golden) groundsel	FACW	25
Persicaria sagittata	arrow-leaf tearthumb	OBL	100
Pilea pumila	clearweed	FACW	25
Potentilla simplex	common (oldfield) cinquefoil	FACU	75
Prunella vulgaris	self heal	FAC	25
Ranunculus sceleratus	cursed (buttercup) crow's foot	OBL	25
Rumex spp.	unkown dock		25
Sagittaria latifolia	common arrow head	OBL	25
Scutellaria galericulata	marsh skullcap	OBL	25
Scutellaria lateriflora	mad dog skullcap	OBL	100
Solidago canadensis	Canada goldenrod	FACU	25
Solidago rugosa	wrinkle leaved goldenrod	FAC	100
Stellaria alsine	bog stitchwort	OBL	25
Symphyotrichum novi-belgii	New York aster	FACW	25
Symphyotrichum puniceum	purple-stemmed aster	OBL	75
Symphyotrichum racemosum	small headed aster	FACW	25
Typha latifolia	common cattail	OBL	25
Viola spp.	unknown violet		75
Waldsteinia fragarioides	barren strawberry		25

Table B.30. Graminoids present in the herbaceous layer of the emergent reference wetlands. Frequency is the percentage of the emergent reference wetlands in which a species occurred. A blank indicator status is for plants not identified to the species level.

Latin Name	Common name	Indicator Status	Frequency (%)
Agrostis canina	velvet bentgrass	UPL	25
Agrostis hyemalis	ticklegrass	FAC	50
Carex atlantica	prickly bog sedge	FACW	25
Carex crinita	fringed sedge	OBL	75
Carex echinata	star sedge	OBL	25
Carex lurida	sallow sedge	OBL	75
Carex retrorsa	retrorse sedge	OBL	25
Carex scoparia	pointed broom sedge	FACW	100
Carex stipata	stalk-grain sedge	OBL	25
Carex swanii	swan's sedge	FACU	25
Carex sylvatica	European woodland sedge	FACU	25
Carex trisperma	three-seed sedge	OBL	25
Dulichium arundinaceum	three-way sedge	OBL	25
Eleocharis spp.	spike rush		25
Glyceria canadensis	rattlesnake mannagrass	OBL	75
Glyceria grandis	American mannagrass	OBL	25
Glyceria melicaria	northeastern mannagrass	OBL	25
Glyceria striata	fowl mannagrass	OBL	25
Juncus effusus	soft rush	OBL	75
Leersia oryzoides	rice cutgrass	OBL	50
Panicum spp.	unknown panic-grass		25
Poa alsodes	grove blue grass	FAC	25
Poa compressa	flat-stem blue grass	FACU	25
Scirpus cyperinus	wool grass	OBL	75
Torreyochloa pallida	pale false manna grass	OBL	25
Xyris sp.	yellow-eyed grass		50

Table B.31. Ferns present in the herbaceous layer of the emergent reference wetlands. Frequency is the percentage of the emergent reference wetlands in which a species occurred.

Latin Name	Common name	Indicator Status	Frequency (%)
Dryopteris carthusiana	spinulose wood fern	FACW	25
Onoclea sensibilis	sensitive fern	FACW	100
Osmunda cinnamomea	cinnamon fern	FACW	50
Parathelypteris noveboracensis	New York fern	FAC	25
Parathelypteris simulata	bog fern	FACW	25
Polystichum acrostichoides	Christmas fern	FACU	25
Thelypteris palustris	marsh fern	FACW	50

Table B.32. Vines present in the herbaceous layer of the emergent reference wetlands. Frequency is the percentage of the emergent wetlands in which a species occurred.

Latin Name	Common name	Indicator Status	Frequency (%)
Amphicarpaea bracteata	hog peanut	FAC	25
Clematis virginiana	Virginia's virgin-bower	FAC	25
Toxicodendron radicans	poison ivy	FAC	25

Appendix C

Reference Wetland Soil Properties

Summarized by Site and Cover Type

Table C.1. Soil surface horizon properties in hemlock-hardwood reference wetlands .

Well	Soil type	Avail. P mg/kg	Avail. K mg/kg	Avail. Mg mg/kg	Avail. Ca mg/kg	% Total N	Total P ug/g	pH	% Organic Matter
ACBIN	Histosol	4.1	84.0	232.2	3295.0	0.9	1256.5	5.1	34.5
ACBIN	Histosol	5.4	144.0	291.6	4494.0	1.5	1533.4	5.0	45.8
NGC	Mineral	0.6	22.5	34.0	188.9	0.1	162.0	5.0	2.0
NGC	Mineral	1.6	40.6	73.3	465.4	0.3	523.9	4.7	7.2
NMRMID	Mineral	1.3	24.3	55.1	266.1	0.2	350.9	4.3	8.4
NMRMID	Mineral	1.3	23.8	64.1	336.5	0.3	445.9	4.1	9.9
NWD	Mineral	4.0	21.2	26.7	138.1	0.0	114.3	5.1	1.2
NWD	Mineral	3.0	29.2	73.9	689.9	0.3	368.7	4.9	10.4
ACBOUT	Ohor/histic	4.3	26.9	94.6	569.9	0.1	471.4	5.3	2.8
ACBOUT	Ohor/histic	5.7	102.2	270.9	2560.2	0.6	1048.7	5.2	22.8
ART	Ohor/histic	4.4	118.0	202.4	1333.0	0.4	1391.0	5.3	14.1
CLS	Ohor/histic	1.0	47.0	169.2	973.0	0.1	540.3	5.9	3.0
CLS	Ohor/histic	4.5	95.0	450.4	2801.0	0.4	645.0	6.0	15.5
NMM	Ohor/histic	1.5	69.8	263.2	2017.8	0.4	1010.1	5.0	19.2
NMM	Ohor/histic	1.2	57.6	208.2	1422.8	0.3	547.4	5.2	11.8
NMM	Ohor/histic	38.4	547.0	930.0	7319.0	1.7	997.0	5.2	88.1
NMRIN	Ohor/histic	5.4	23.7	27.2	105.1	0.0	556.3	5.3	1.7
NMRIN	Ohor/histic	3.2	193.0	120.0	470.0	1.0	1183.4	3.7	56.6
NMRIN	Ohor/histic	0.8	34.0	44.5	172.0	0.5	615.4	4.0	17.9
PHHIN	Ohor/histic	9.2	80.1	167.2	2157.5	0.6	1310.0	5.5	16.7
PHHOUT	Ohor/histic	4.8	69.7	162.6	1887.6	0.5	1230.1	5.5	14.1
Median		**4.0**	**57.6**	**162.6**	**973.0**	**0.4**	**615.4**	**5.1**	**14.1**

Table C.2. Soil surface horizon properties of hardwood reference wetlands.

Well	Soil type	Avail. P mg/kg	Avail. K mg/kg	Avail. Mg mg/kg	Avail. Ca mg/kg	% Total N	Total P ug/g	pH	% Organic Matter
ARWIN	Mineral	9.9	56.2	136.3	2039.0	0.4	1240.0	5.8	8.6
AWWIN	Mineral	1.0	78.8	229.9	1468.6	0.3	627.5	5.6	10.0
AWWIN	Mineral		31.8	124.8	593.4	0.1	211.4	6.4	2.2
AWWOUT	Mineral	1.7	88.2	314.1	1554.4	0.3	814.3	5.5	9.8
NABIN	Mineral	2.5	48.0	75.7	777.9	0.3	580.8	5.2	7.5
NTD	Mineral	2.2	29.2	85.6	550.0	0.1	206.3	5.7	3.5
SUB	Mineral	1.2	47.4	156.1	979.7	0.2	540.9	5.4	5.2
ARWOUT	Ohor/histic	9.8	98.8	232.9	2279.3	0.5	2220.7	5.7	14.3
SFB	Ohor/histic	4.7	92.0	247.8	2657.0	0.7	1290.0	5.3	21.5
SFB	Ohor/histic	5.9	148.0	318.6	3855.0	1.0	1467.6	5.1	35.8
Median		**2.5**	**67.5**	**193.0**	**1511.5**	**0.3**	**720.9**	**5.5**	**9.2**

Table C.3. Soil surface horizon properties of scrub-shrub reference wetlands.

Well	Soil type	Avail. P mg/kg	Avail. K mg/kg	Avail. Mg mg/kg	Avail. Ca mg/kg	% Total N	Total P ug/g	pH	% Organic Matter
SMS	Histosol	11.3	520.0	1224.6	9488.0	2.2	1226.0	5.5	63.9
CSBIN	Mineral	2.4	37.0	49.1	419.2	0.3	519.0	5.2	5.7
CSBIN	Mineral	2.9	26.0	39.8	402.0	0.2	428.4	4.9	4.7
CSBIN	Mineral	3.0	74.7	136.7	854.6	0.4	714.0	5.3	9.0
CSBOUT	Mineral	3.8	59.0	49.5	399.0	0.3	832.4	4.9	8.2
SMK	Ohor/histic	3.8	65.8	246.3	2361.6	0.7	970.4	5.0	21.8
SMK	Ohor/histic	6.3	105.0	366.9	3539.0	0.8	1172.2	5.5	21.7
Median		**3.8**	**65.8**	**136.7**	**854.6**	**0.4**	**832.4**	**5.2**	**9.0**

Table C.4. Soil surface horizon properties in emergent reference wetlands.

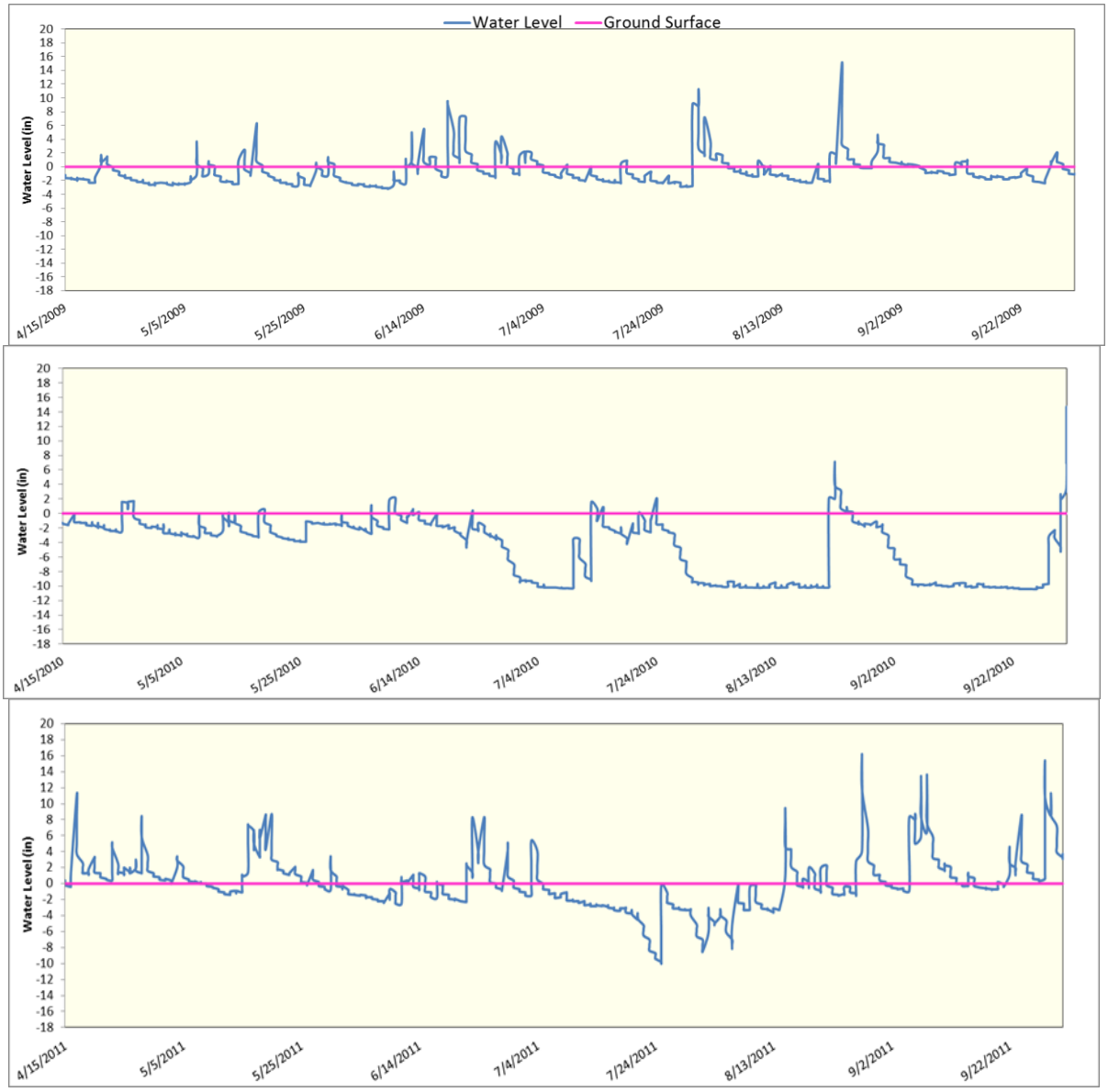
Well	Soil type	Avail. P mg/kg	Avail. K mg/kg	Avail. Mg mg/kg	Avail. Ca mg/kg	% Total N	Total P ug/g	pH	% Organic Matter
ADTIN	Mineral	0.6	37.2	49.4	516.3	0.2	521.7	5.3	5.2
AMHIN	Mineral	2.3	74.0	140.2	1368.0	0.3	464.1	4.9	9.2
AMHIN	Mineral	0.8	24.0	42.8	331.0	0.1	191.3	5.3	2.5
NABOUT	Mineral	0.5	29.0	55.0	390.0	0.2	220.5	5.0	4.7
NABOUT	Mineral	0.6	31.0	100.6	746.0	0.3	259.2	4.8	11.8
NMROUT	Mineral	3.0	45.1	27.5	115.8	0.2	378.4	4.3	8.2
NMROUT	Mineral	1.9	16.6	11.3	51.4	0.1	246.9	4.9	2.0
NMRPER	Mineral	1.2	41.0	99.0	368.0	0.1	499.8	5.3	3.3
NMRPER	Mineral	3.4	49.0	95.2	397.0	0.2	507.6	5.3	5.1
ADTOUT	Ohor/histic	2.5	40.5	55.1	1410.2	0.4	498.6	4.8	13.9
AMHOUT	Ohor/histic	2.5	126.4	131.2	996.5	0.5	772.8	5.0	12.7
AMHOUT	Ohor/histic	1.0	41.8	56.3	395.9	0.2	435.1	5.3	4.7
Median		**1.5**	**40.7**	**55.7**	**396.4**	**0.2**	**449.6**	**5.0**	**5.2**

Appendix D

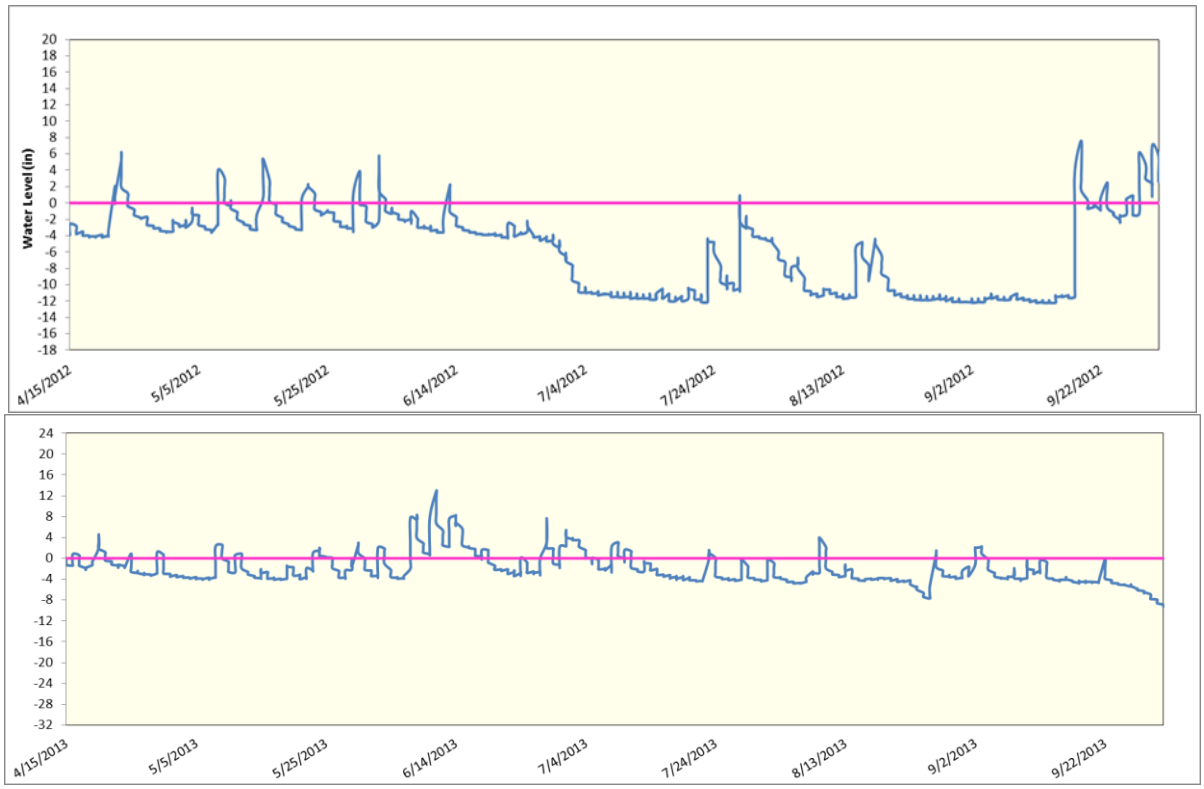
Hydrographs

Hardwood Reference Wetland Wells

ARWOUT


Water Level
Ground Surface
Water Level (in)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
Water Level (in)
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011

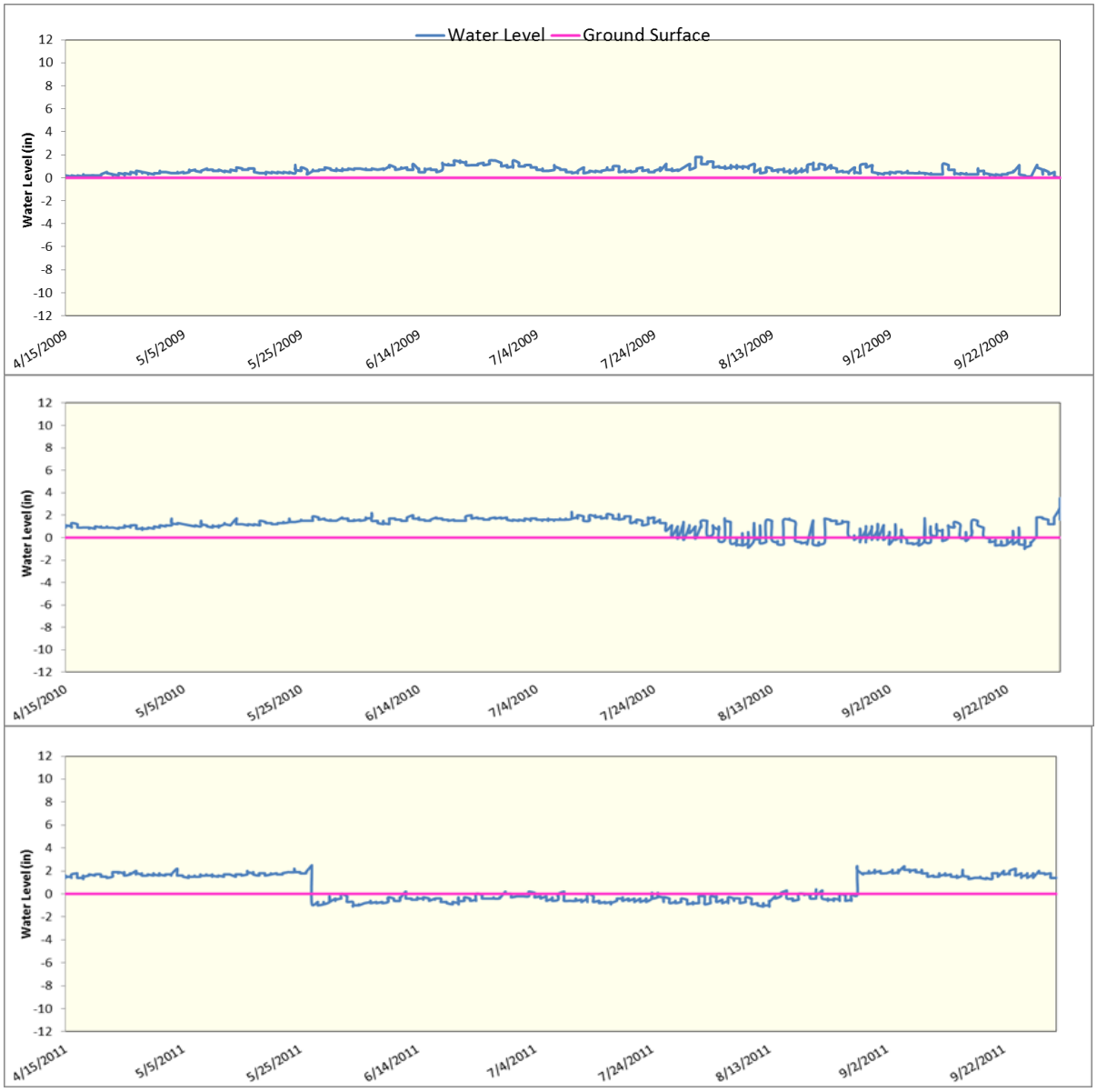
ARWOUT, continued



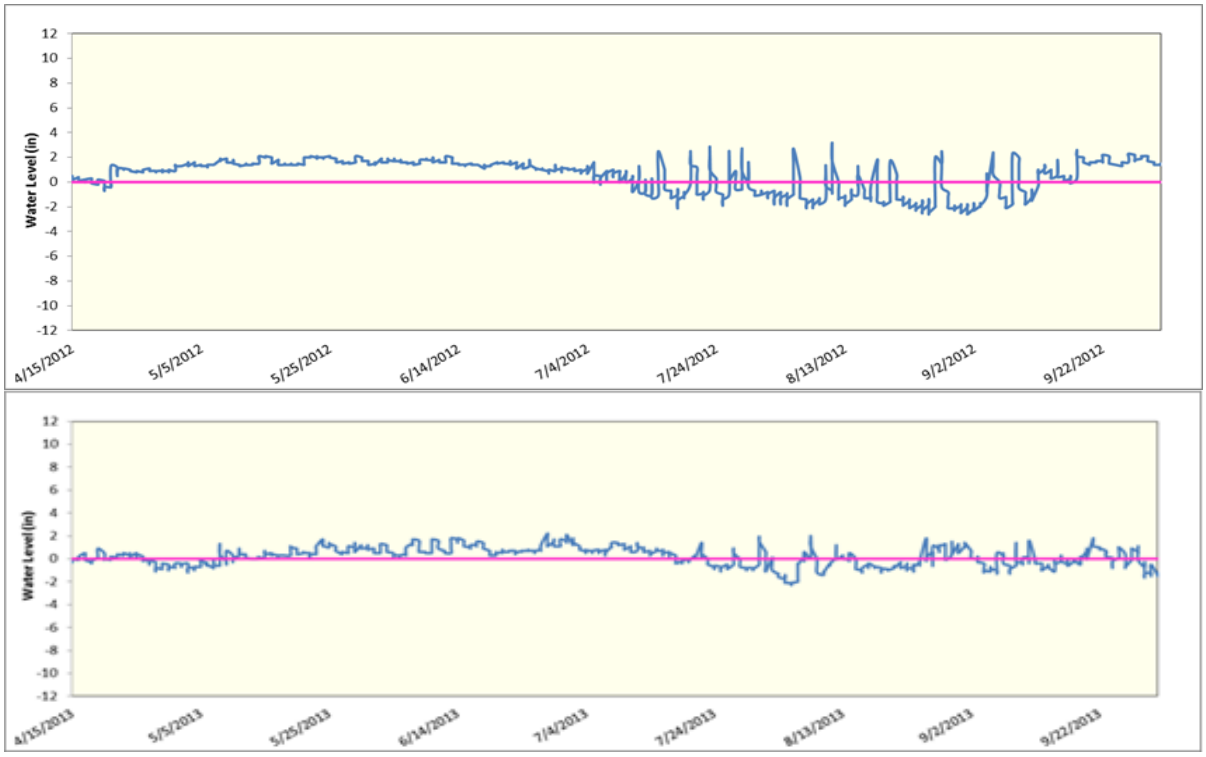
NABIN


Water Level
Ground Surface
Water Level (in)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011
4/15/2012
5/5/2012
5/25/2012
6/14/2012
7/4/2012
7/24/2012
8/13/2012
9/2/2012
9/22/2012
4/15/2013
5/5/2013
5/25/2013
6/14/2013
7/4/2013
7/24/2013
8/13/2013
9/2/2013
9/22/2013

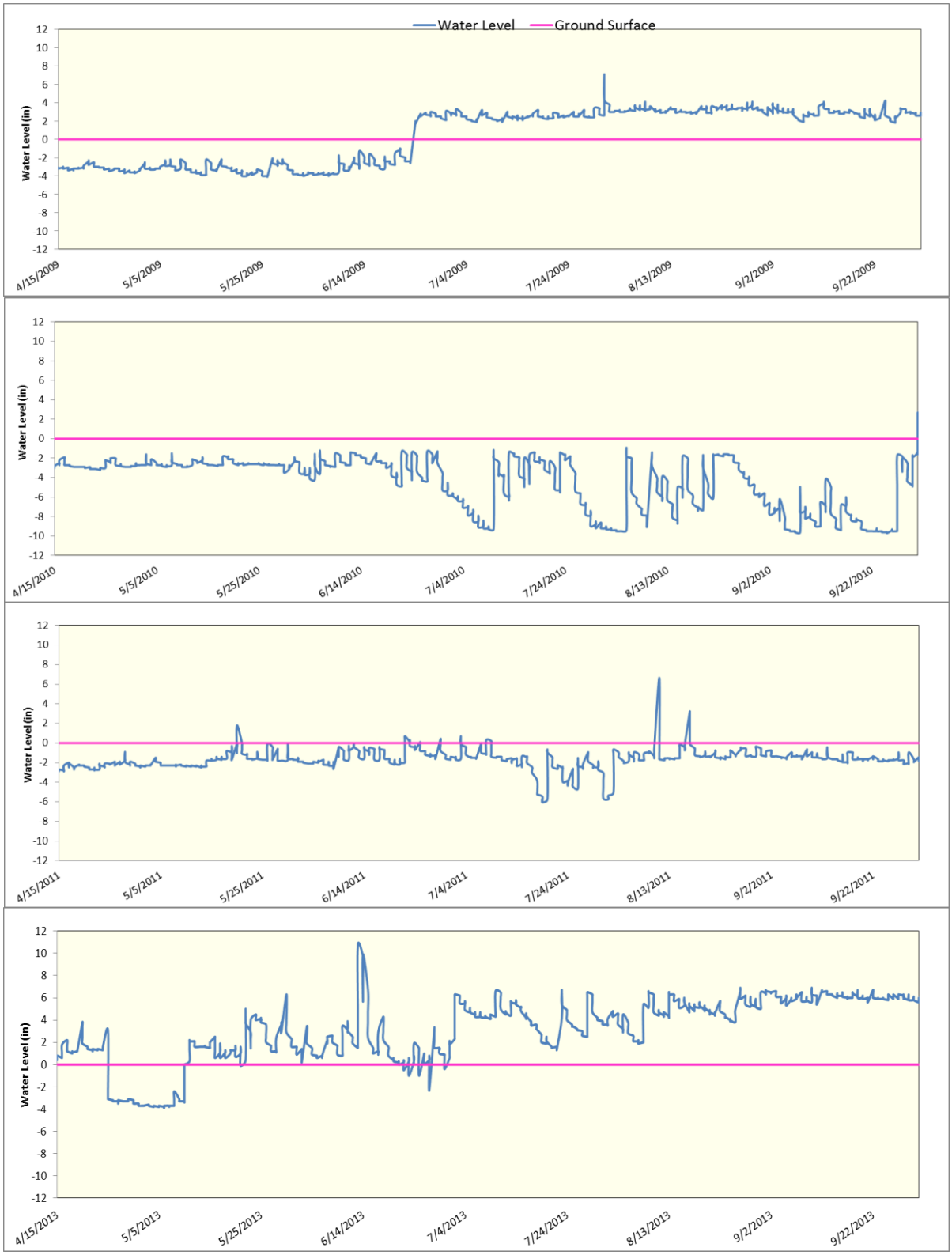
NTD


Water Level
Ground Surface
Water Level (in)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
Water Level (in)
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011

NTD, continued

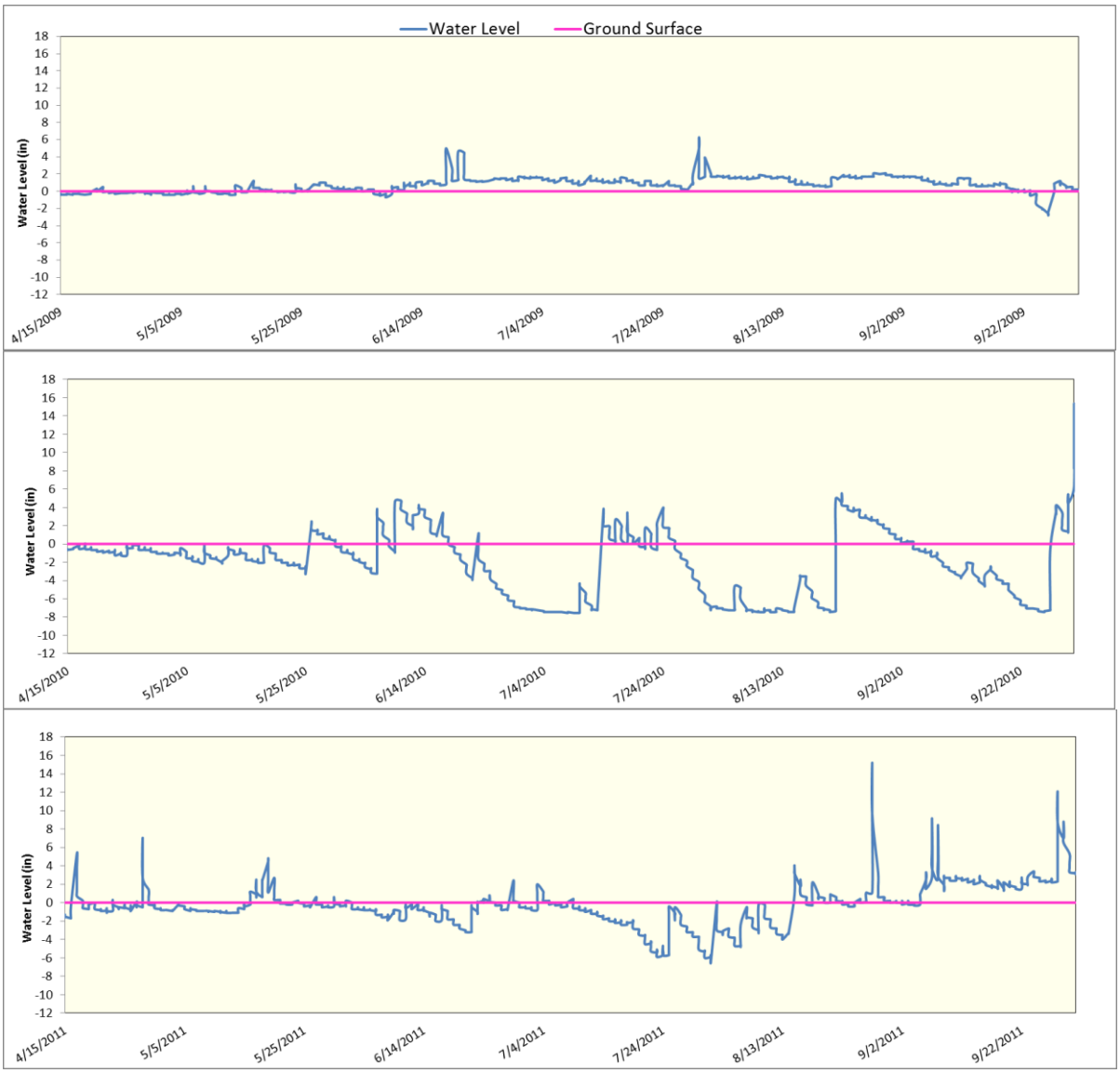


SFB

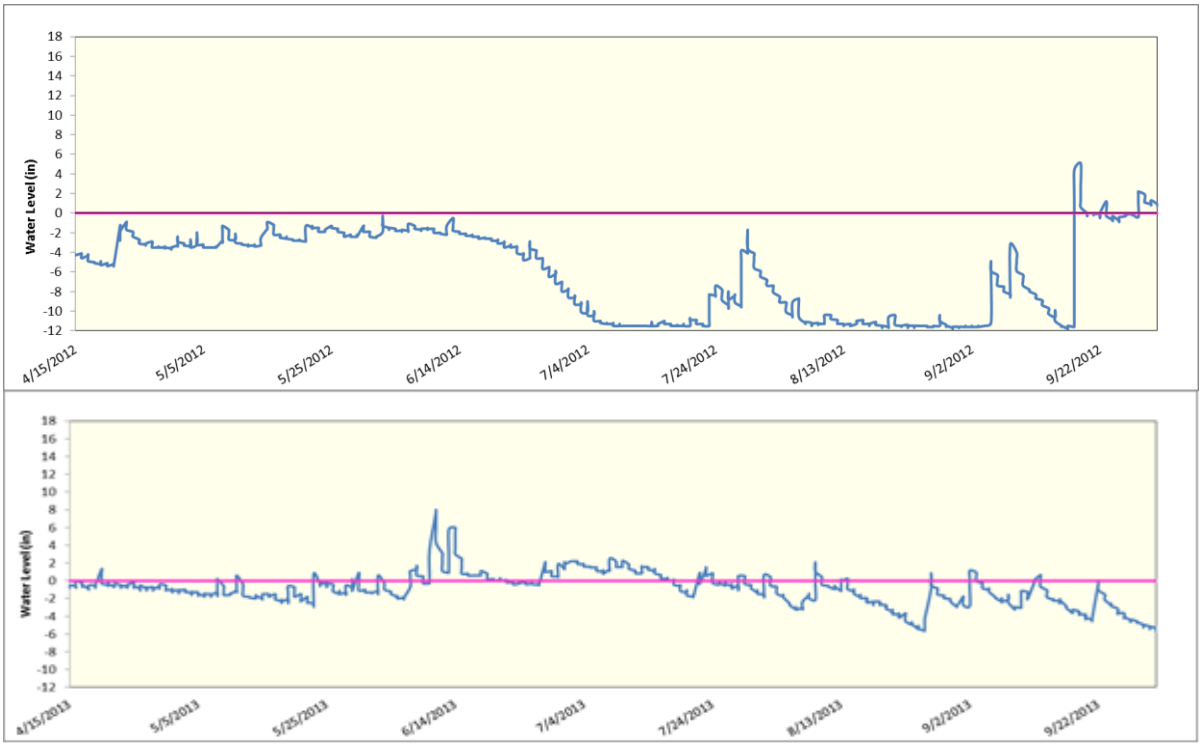

Water Level
Ground Surface
Water Level (in)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011
4/15/2013
5/5/2013
5/25/2013
6/14/2013
7/4/2013
7/24/2013
8/13/2013
9/2/2013
9/22/2013

Hemlock-hardwood Reference Wetland Wells

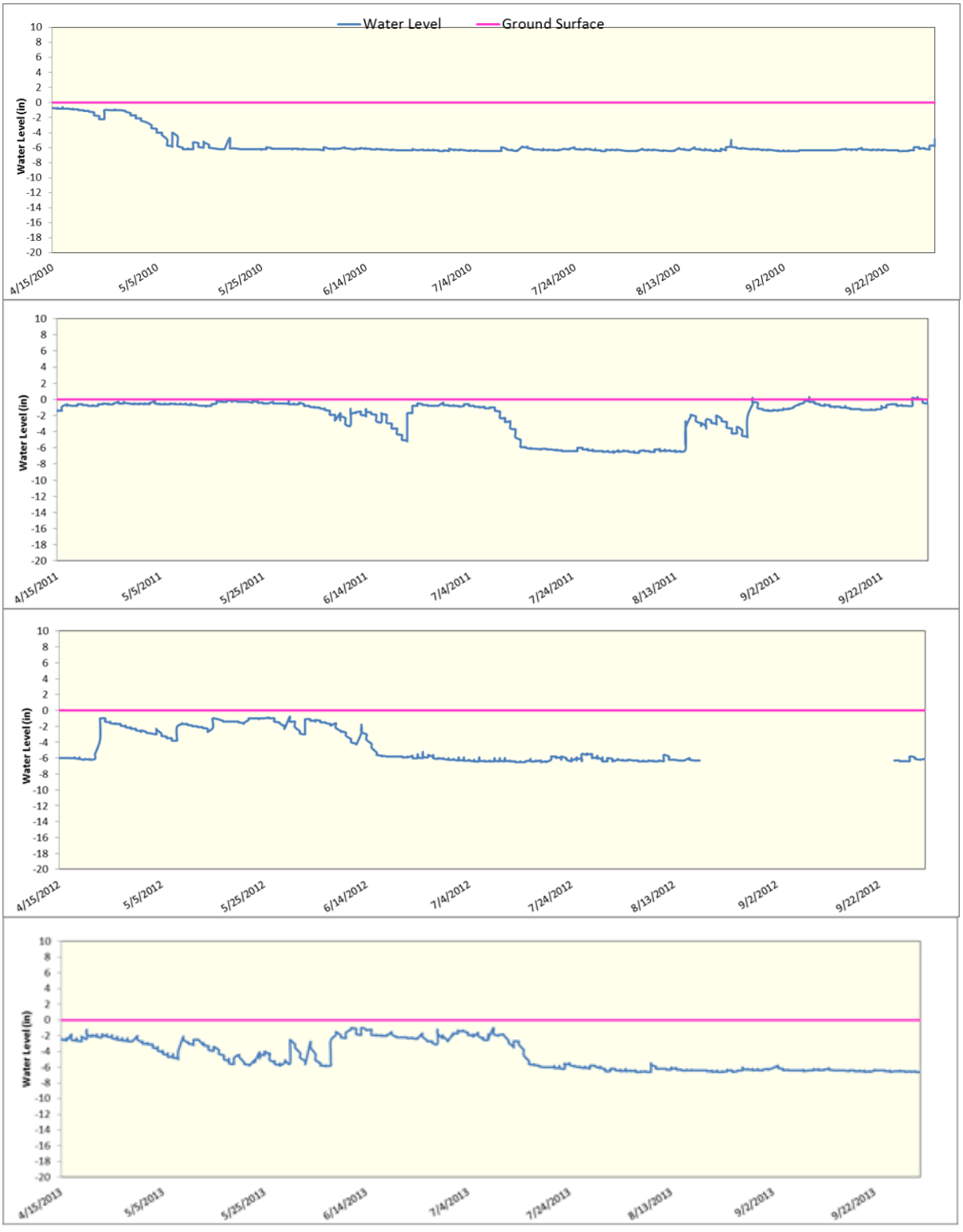
ACBIN


Water Level
Ground Surface
Water Level (in)
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
Water Level (in)
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011

ACBIN, continued



ART


Water Level
Ground Surface
Water Level (in)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011
4/15/2012
5/5/2012
5/25/2012
6/14/2012
7/4/2012
7/24/2012
8/13/2012
9/2/2012
9/22/2012
4/15/2013
5/5/2013
5/25/2013
6/14/2013
7/4/2013
7/24/2013
8/13/2013
9/2/2013
9/22/2013

NGC


Water Level
Ground Surface
Water Level (in)
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
4/25/2010
5/5/2010
5/15/2010
5/25/2010
6/4/2010
6/14/2010
6/24/2010
7/4/2010
7/14/2010
7/24/2010
8/3/2010
8/13/2010
8/23/2010
9/2/2010
9/12/2010
9/22/2010
Water Level (in)
4/15/2011
4/25/2011
5/5/2011
5/15/2011
5/25/2011
6/4/2011
6/14/2011
6/24/2011
7/4/2011
7/14/2011
7/24/2011
8/3/2011
8/13/2011
8/23/2011
9/2/2011
9/12/2011
9/22/2011

NGC, continued

PHHIN


Water Level
Ground Surface
Water Level (in)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
Water Level (in)
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011

PHHIN, continued

Scrub-shrub Reference Wetland Wells

CSBIN


Water Level
Ground Surface
Water Level (in)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2008
5/5/2008
5/25/2008
6/14/2008
7/4/2008
7/24/2008
8/13/2008
9/2/2008
9/22/2008
Water Level (in)
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010

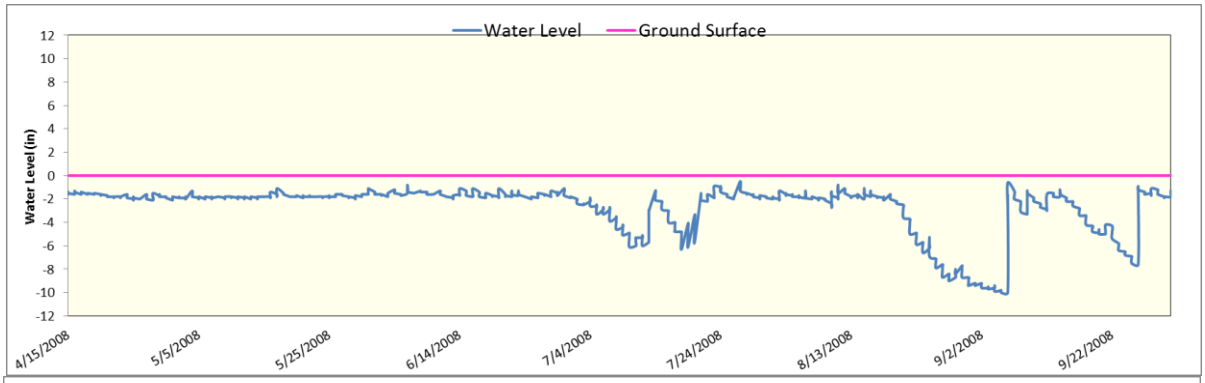
CSBIN, continued

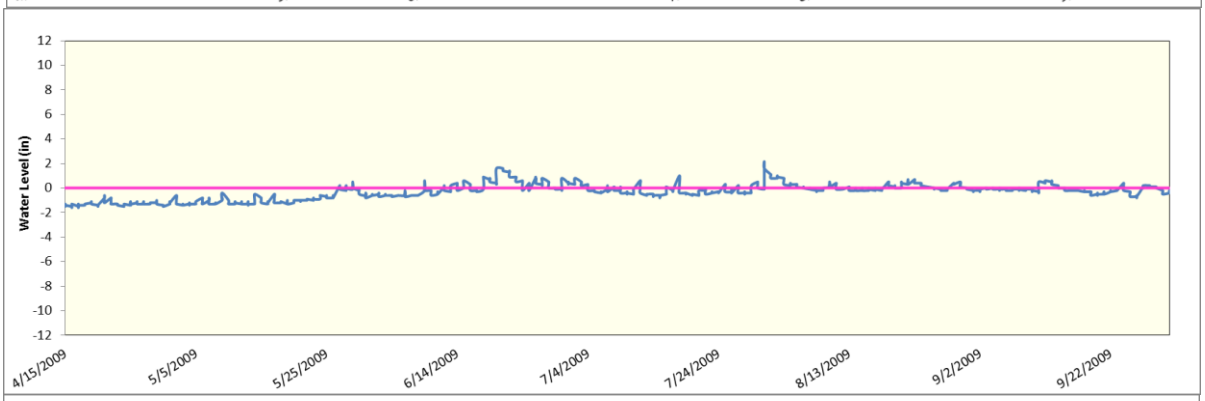
CSBOUT

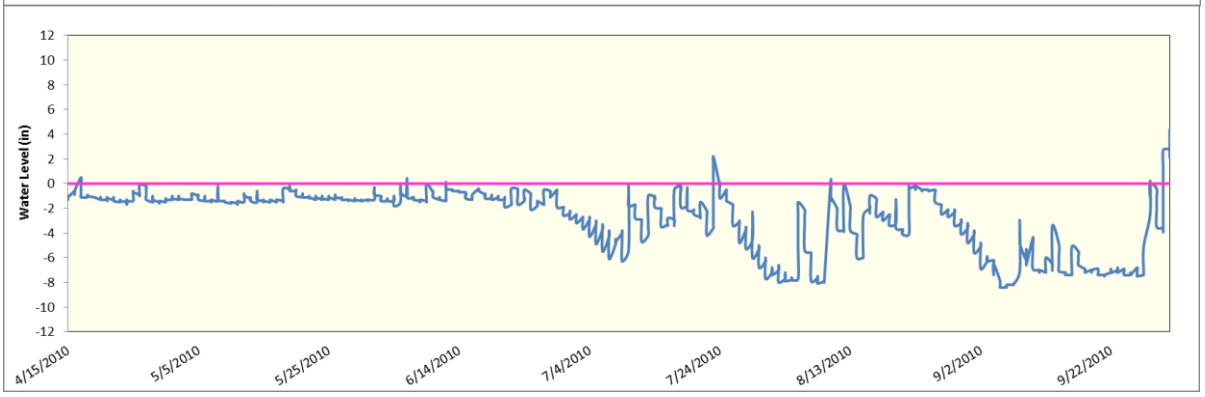

Water Level
Ground Surface
Water Level (in)
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
4/15/2008
5/5/2008
5/25/2008
6/14/2008
7/4/2008
7/24/2008
8/13/2008
9/2/2008
9/22/2008
Water Level (in)
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010

CSBOUT, continued

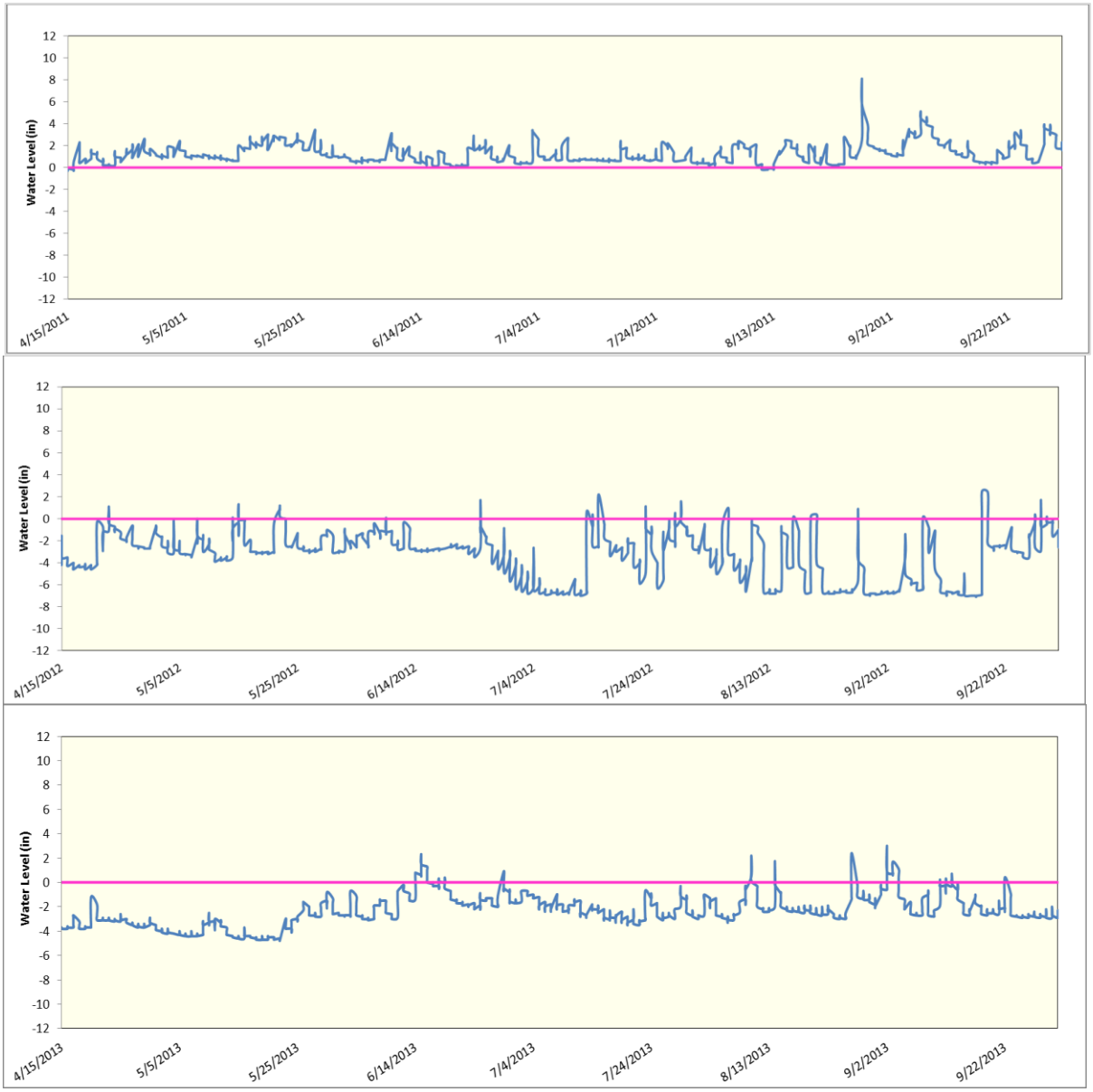
SMK


Water Level
Ground Surface
Water Level (in)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2008
5/5/2008
5/25/2008
6/14/2008
7/4/2008
7/24/2008
8/13/2008
9/2/2008
9/22/2008

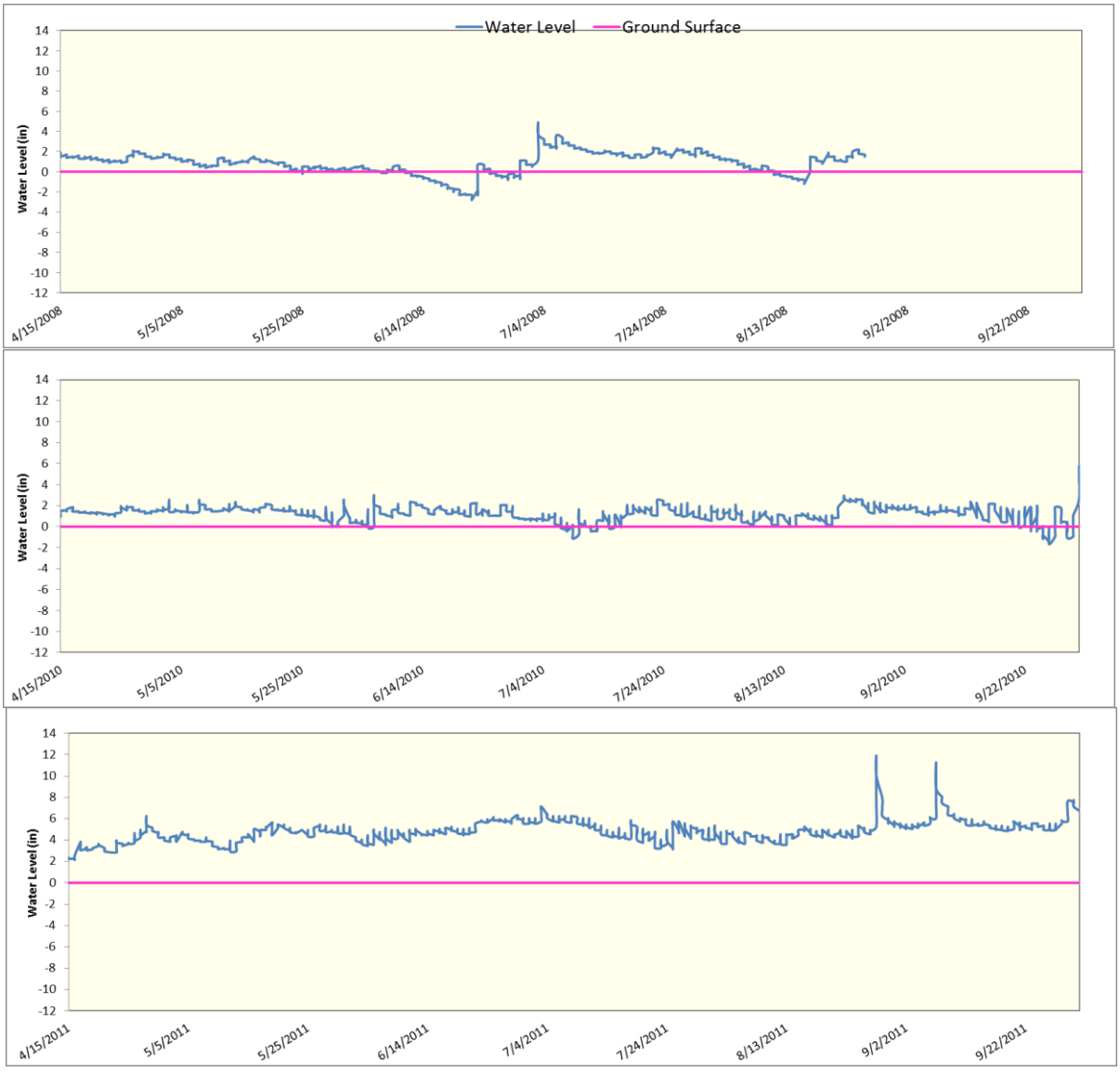

Water Level (in)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009


Water Level (in)
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010

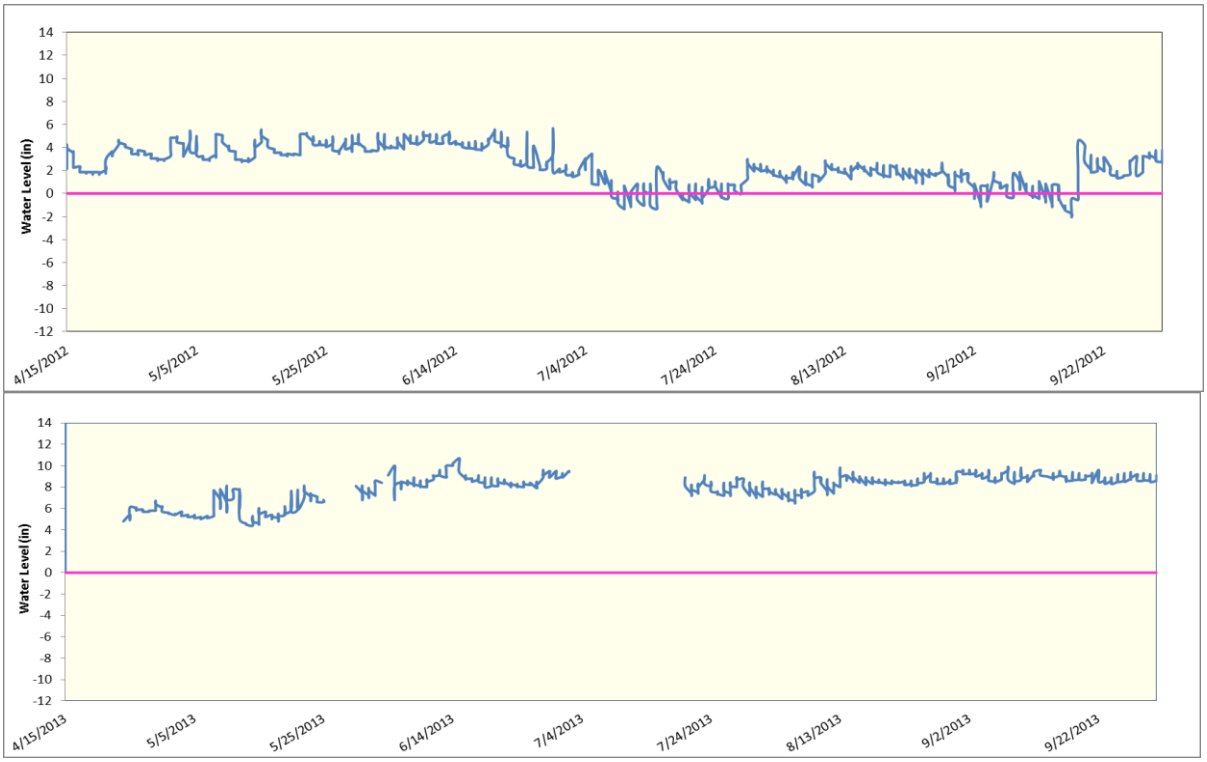
SMK, continued



SMS

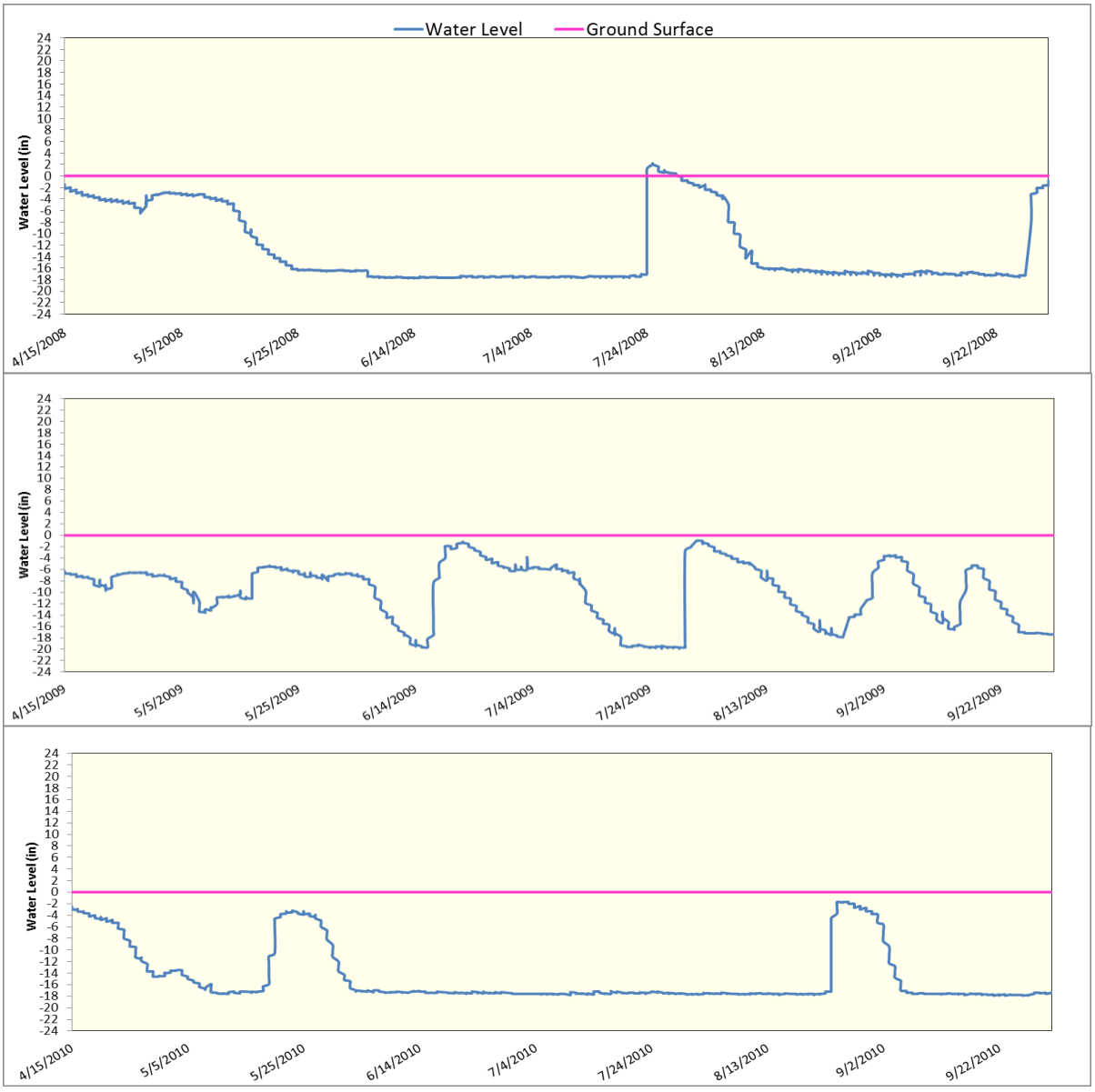

Water Level
Ground Surface
Water Level (in)
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
4/15/2008
5/5/2008
5/25/2008
6/14/2008
7/4/2008
7/24/2008
8/13/2008
9/2/2008
9/22/2008
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010
Water Level (in)
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011

SMS, continued

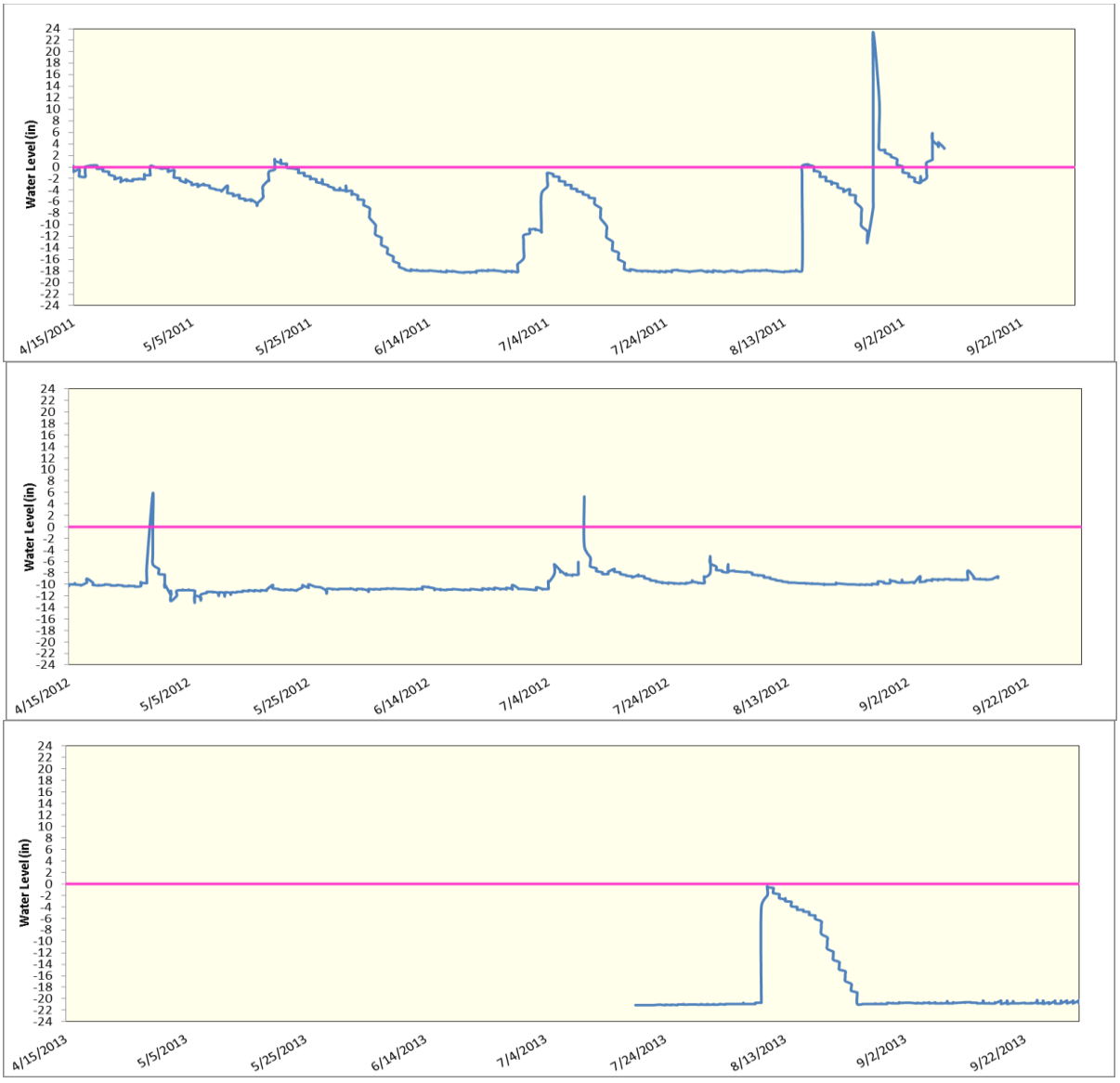


Emergent Reference Wetland Wells

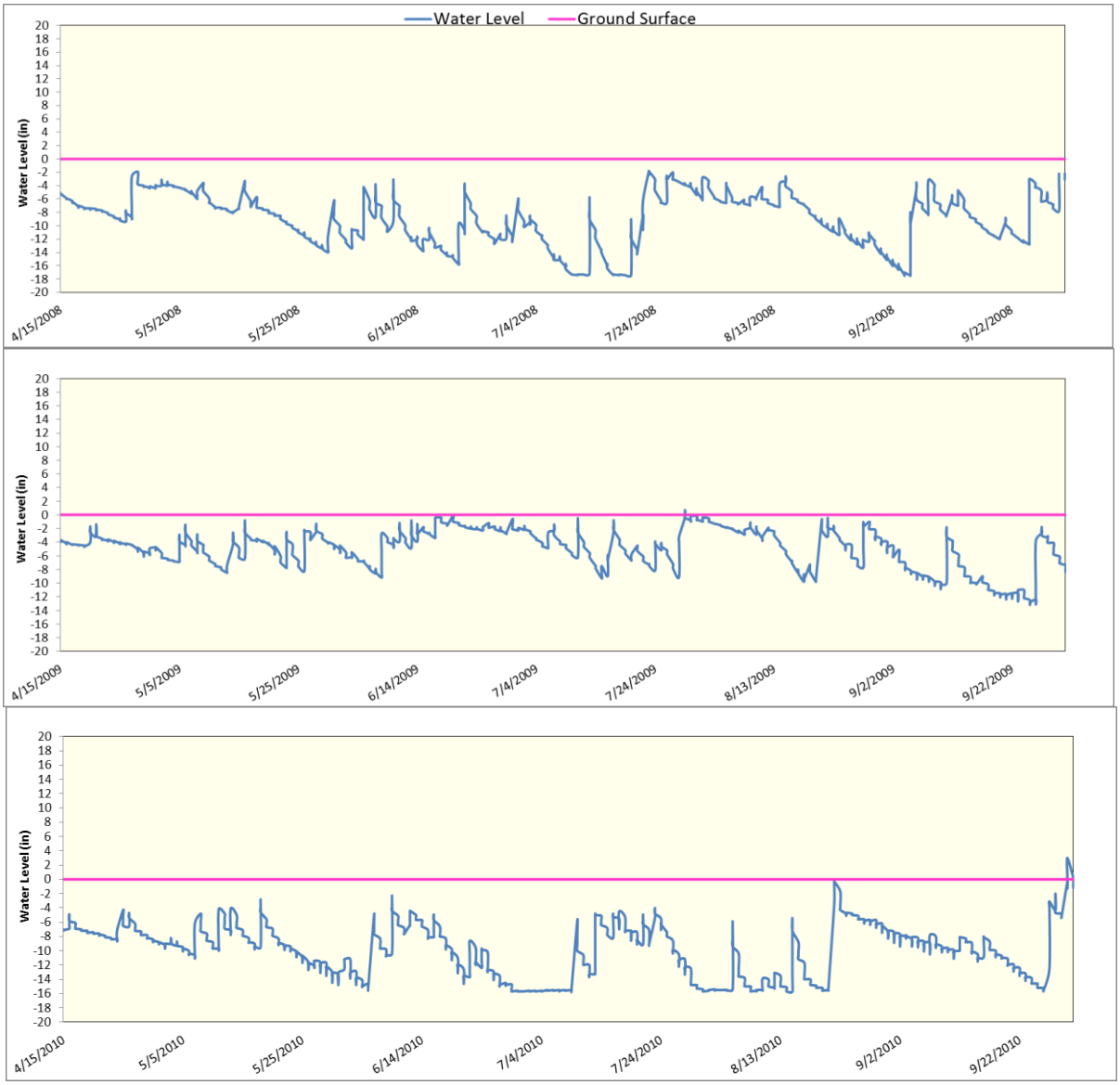
ADTIN


Water Level
Ground Surface
Water Level (in)
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
4/15/2008
5/5/2008
5/25/2008
6/14/2008
7/4/2008
7/24/2008
8/13/2008
9/2/2008
9/22/2008
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010

ADTIN, continued

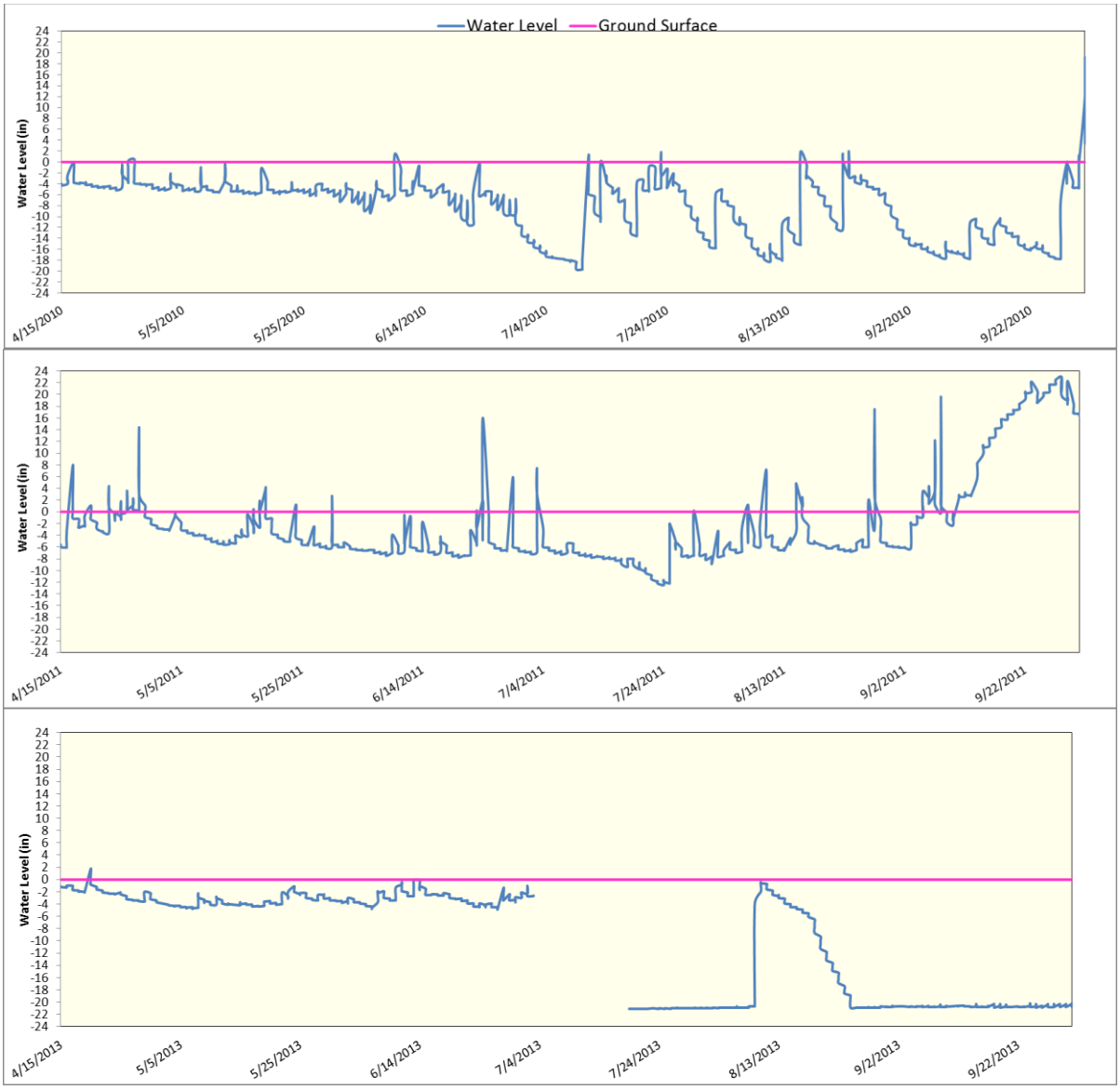


AMHOUT


Water Level
Ground Surface
Water Level (in)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
4/15/2008
5/5/2008
5/25/2008
6/14/2008
7/4/2008
7/24/2008
8/13/2008
9/2/2008
9/22/2008
Water Level (in)
4/15/2009
5/5/2009
5/25/2009
6/14/2009
7/4/2009
7/24/2009
8/13/2009
9/2/2009
9/22/2009
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
8/13/2010
9/2/2010
9/22/2010

AMHOUT, continued

NABOUT


Water Level
Ground Surface
Water Level (in)
4/15/2010
5/5/2010
5/25/2010
6/14/2010
7/4/2010
7/24/2010
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9/2/2010
9/22/2010
Water Level (in)
4/15/2011
5/5/2011
5/25/2011
6/14/2011
7/4/2011
7/24/2011
8/13/2011
9/2/2011
9/22/2011
Water Level (in)
4/15/2013
5/5/2013
5/25/2013
6/14/2013
7/4/2013
7/24/2013
8/13/2013
9/2/2013
9/22/2013