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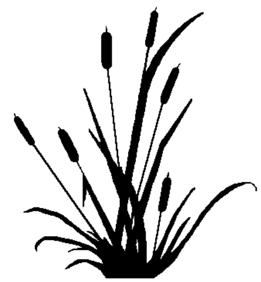
The Buzzards Bay National Estuary Program Pocket Guide to Delineating Wetlands



The Buzzards Bay National Estuary Program
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NOTES:

This document is largely taken from Delineating Bordering Vegetated Wetlands under the Wetlands Protection Act, published by the Massachusetts Department of Environmental Protection, Division of Wetlands and Waterways.

Sections on the community analysis methods, Relative Dominance by Layers and the Wetland Site Index, with the accompanying forms, were written and developed by John Rockwell, Wetlands Specialist for the Buzzards Bay National Estuary Program Mr. Rockwell's master's project was "A Comparison of Wetlands Delineation Techniques Used Pursuant to the Wetlands Protection Act."

The Buzzards Bay National Estuary Program is jointly administered by the Environmental Protection Agency and Massachusetts Coastal Zone Management. The Buzzards Bay NEP provides technical assistance to the communities in the Buzzards Bay watershed on items relating to the water quality of the bay.

Value (soil color): the relative lightness or intensity of color; one of the three variables of color.

Vegetative community: the plant populations existing in a shared habitat or environment.

Water mark: a line on vegetation or other upright structures that represent the maximum height reached in an inundation event.

Water table: the upper limit or depth below the surface of the ground that is completely saturated with water.

Wetlands: areas that under normal circumstances have hydrophytic vegetation, hydric soils, and wetland hydrology.

Wetland boundary: a line between an upland and a BVW (as defined at 310 CMR 10.55).

Wetland hydrology: in general terms, permanent or periodic inundation or prolonged saturation sufficient to create anaerobic conditions in the soil.

Wetland indicator category: the frequency with which a plant species occurs in wetlands; categories include obligate wetland, facultative wetland, facultative, facultative upland, and upland (U.S. Fish and Wildlife Service).

Wetland indicator plants: as defined in the Massachusetts Wetlands Protection Regulations: plant species listed in the Wetlands Protection Act; plants in the genus *Sphagnum;* plants in the National List classified as OBL, FACW+, FACW, FACW-, FAC+ and FAC; or any plants demonstrating morphological or physiological adaptations to life in saturated or inundated conditions

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Soil: unconsolidated material on the earth's surface that supports or is capable of supporting plants.

Soil profile: vertical section of the soil through all its horizons.

Soil series: a group of soils similar in characteristics and arrangements in the soil profile.

Soil taxonomy: a classification system for soils developed by the U.S. Natural Resources Conservation Service (NRCS).

Soil texture: the relative proportions of the various sizes of particles (silt, sand, and clay) in a soil.

Species name: a Latin form of the name of a plant made up of genus and species; also known as scientific name.

Spodic horizon: in a spodosol, a subsurface layer of soil characterized by the accumulation of aluminum oxides (with or without iron oxides) and organic matter.

Spodosols: soils that possess an E-horizon and spodic horizon due to the leaching of iron and aluminum oxides and organic matter by organic acids.

Stratum: a layer of vegetation used to determine dominant species in a plant community.

Surface water: water present above the substrate or soil surface.

Topography: the position in a landscape, including elevation and change in slope.

Transect: an imaginary line on the ground that bisects a parcel of land along which observations are made or plots established for collecting data (e.g. runs perpendicular to slope or topographic changes in wetland or upland communities).

Transpiration: loss of water from plant surfaces.

Tree: a vegetative layer that includes woody plants greater than or equal to 20 feet in height and with a diameter at breast height (dbh) of 5 inches or greater.

Uplands: non-wetlands.

Upland species (UPL): classification of plants that occur in wetlands less than one percent of the time (U.S. Fish and Wildlife Service).

Percent dominance: a measurement calculated by dividing the percent cover for a species by the total percent cover for all species in that layer; a value used in the dominance test.

Percolation: the infiltration of surface water into the ground.

Physiological adaptation: an adaptation of the basic physical and chemical activities that occur in cells and tissues of an organism; generally not observable without the use of specific equipment or tests.

Plant community: the plant populations existing in a shared habitat or environment.

Polymorphic leaves: two or more different types of leaves that form on plants.

Precipitation: water droplets or ice particles condensed from atmospheric water that fall to the earth's surface, such as rain, sleet, or snow.

R-horizon: a layer of hard, unbroken bedrock such as granite, basalt, and quartzite; occurs below all other horizons where present or may have outcroppings of ledge above the surface of the ground. (Actually the R-layer.)

Reduction: chemical changes resulting from the absence of oxygen.

Sandy: a soil texture of loamy fine sand or coarser that is dominant within 20 inches of the soil surface.

Sapling: a vegetative layer that includes woody vegetation over 20 feet in height with a diameter at breast height (dbh) greater than or equal to 0.4 inches to less than 5 inches.

Saprists: organic soils (mucks) in which most of the plant material is decomposed and the original constituents cannot be recognized; less than one-third of the fibers remain visible upon rubbing the materials between fingers.

Saturated: a condition in which the soil has all or most of its pores within the root zone filled with water.

Scientific name: the name of a plant or animal that is comprised of a genus name and a species name.

Seedling: woody vegetation that is less than 3 feet in height.

Shrub: a vegetative layer that includes woody vegetation greater than or equal to 3 feet but less than 20 feet in height.

Delineation Criteria

The Wetlands Protection Act defines a wetland as an area with a significant portion of wetland indicator plants and subject to certain hydrologic conditions (surface water or groundwater). Wetland indicator plants are often accurate indicators of wetland hydrology. Under certain site conditions, such as where there is an abrupt change in topography, the use of plants alone generally will yield an accurate BVW boundary. In other cases, such as when the transition zone is gradual, other indicators of wetland hydrology, together with vegetation, may be used to determine the BVW boundary. The wetlands protection regulations describe those situations where vegetation alone is presumed to be sufficient for delineating BVW boundaries, and when vegetation and hydrology should both be used.

When vegetation alone may be used for delineating BVWs (and hydrology is presumed to be present)

The wetlands protection regulations presume that the delineation of BVWs based on vegetation alone is accurate under any one of the following circumstances:

1. All dominant species in the vegetative community have an indicator category of OBL, FACW+, FACW or FACW- and the slope is distinct or abrupt between the upland plant community and the wetland plant community.

2. The area where the work will occur is clearly limited to the buffer zone.

3. The issuing authority (conservation commission or DEP) determines that sole reliance on wetland indicator plants will yield an accurate delineation. (Note: if information on indicators of hydrology is submitted, it must be evaluated by the issuing authority.)

Vegetation may be used as the sole criteria for delineating BVWs in the vast majority of cases. Where activities are proposed in areas that are clearly outside wetland resource areas (in buffer zones), BVW delineations based on vegetation alone are generally sufficient. In other cases, such as where BVWs have abrupt or distinct boundaries or where the conservation commission or DEP determines that reliance on vegetation alone is sufficient for determining the BVW boundary, information about soils or other indicators of hydrology do not have to be submitted. However, when information on indicators of wetland hydrology is submitted (such as long-term hydrologic data or the presence or absence of hydric soils), it must be evaluated for accuracy and used by the issuing authority to establish the BVW boundary.

In determining whether reliance on vegetation alone will yield an accurate delineation, the following factors should be considered:

* Facultative plant species commonly occur in uplands as well as in wetlands (e.g.

sweet pepperbush *(Clethra alnifolia)*, cottonwood *(Populus deltoides)*, sheep laurel (Kalmia angustifolia), New York fern *(Thelypteris noveboracensis).*

* Several plants with an indicator category of FAC- or drier are not uncommon in wetlands, such as white pine *(Pinus strobus),* pitch pine *(Pinus rigida),* and American beech *(Fagus grandifolia).*

* Extended droughts can produce changes in vegetation in herbaceous plant communities.

* Many species in the ground cover layer may not be detectable or identifiable in winter or early spring.

* In areas where the vegetation has been altered (wetlands violations, lawns, golf courses, cultivated areas), hydric soils and other indicators of hydrology are particularly useful for identifying and delineating BVWs.

In these situations, the issuing authority has the discretion to request additional information to document the presence of wetland hydrology, such as whether hydric soils are present.

When vegetation and hydrology should be used for delineating BVWs

When the BVW boundary based on vegetation alone is not presumed accurate, or to overcome the presumption, vegetation and hydrology should both be used to establish the BVW boundary. This generally will occur when:

1. the wetland area is not dominated by plants with an indicator category of FACW- or wetter,

2. the BVW boundary is not abrupt or discrete, or

3. the plant community has been altered.

In these cases, the applicant should submit information on vegetation and other indicators of hydrology (such as hydric soils) to document the presence of wetland hydrology. The issuing authority should review all the information, evaluate its accuracy, and use it to establish or verify the BVW boundary.

Tools to Bring to the Site

100-foot measuring tape	compass
flagging tape	site plans
field data form	permanent marking pen

Mineral soil: any soil consisting primarily of mineral material (sand, silt, clay, and gravel) rather than organic matter.

Morphological adaptation: an adaptation that is evident in the form or shape of a plant, such as adventitious roots and aerenchymous tissues.

Mottles: spots or blotches of different color or shades of color interspersed within the dominant matrix color in a soil horizon.

Mucks: organic soils (saprists) in which most of the plant material is decomposed and the original constituents cannot be recognized; less than one-third of the fibers remain visible upon rubbing the materials between fingers.

National List: the U.S. Fish and Wildlife Service's National List of Plant Species That Occur in Wetlands (Reed, 1988).

Nodule: same as concretion but without internal symmetry.

Non-hydric soil: a soil that has developed under predominantly aerobic soil conditions.
O-horizon: a layer of organic soil usually at the surface.

Obligate wetland species (OBL): classification of plants that occur in wetlands greater than 99 percent of the time; also known as "obligate" species (U.S. Fish and Wildlife Service).

Observation plot: a sampling point at which a wetland determination is made.

Organic soil: soil that contains a minimum of 20 percent organic matter when no clay is present or a minimum of 30 percent organic matter when 60 percent or more clay is present.

Oxidation: chemical changes resulting from the presence of oxygen.

Oxidized rhizospheres: oxidized channels and soil surrounding living roots and other underground plant structures.

Parent material: the unconsolidated and more or less weathered mineral or organic matter from which the soil profile is developed.

Peats: organic soils (fibrists) in which plant remains show very little decomposition and retain their original shape; more than two-thirds of the fibers remain after rubbing the materials between fingers.

Percent cover: the percent of the ground surface that would be covered if foliage from a particular species or vegetative layer were projected on the ground, ignoring small gaps between the leaves and branches.

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Growing season: the portion of the year when soil temperatures are above biologic zero (41 degrees Fahrenheit, 4 degrees centigrade); generally March to November in Massachusetts.

Hemist: organic soils (peaty-mucks and mucky-peats) in which the plant remains show a fair amount of decomposition; between one-third and two-thirds of the fibers are still visible upon rubbing.

Herb: non-woody (herbaceous) plants.

Histic epipedon: contained in a hydric soil with 8-16 inches of organic soil measured from the ground surface.

Histosols: a type of hydric soil with at least 16 inches or more of organic material measured from the ground surface; histosols include fibrists (peats), saprists (mucks) and hemists (peaty-mucks and mucky-peats).

Horizon: a distinct layer of soil generally parallel with the soil surface having similar properties such as color and texture.

Hue: a characteristic of color related to one of the main spectral colors (red, yellow, green, blue, or purple), or various combinations of these principle colors; one of the three variables of color.

Hydric soil: a soil that is saturated, ponded, or flooded long enough during the growing season to cause anaerobic conditions at or near the surface.

Hydrology: the properties, distribution, and circulation of water.

Hydrophyte: any plant that generally grows in water or is adapted to wet conditions; generally the same as wetland indicator plant.

Hypertrophied lenticels: pores on the stem of woody plants which can become swollen or enlarged in response to saturated or inundated conditions.

Inundation: a condition in which water temporarily or permanently covers an area, such as flooding.

Litter: a layer of recently deposited leaves and/or pines needles; may be found above the 0-horizon on the forest floor.

Matrix: the undisturbed soil material composed of both mineral and organic matter; matrix color refers to the predominant color of the soil in a particular horizon.

USFWS plant list
Munsell Soil Color Chart
soil auger
knife
calculator
plant identification guides
shovel (spade)
spray bottle
hand lens

Measuring Plant Abundance

Vegetative Layers

Plants within vegetative communities are divided into strata, or layers, for analysis. Five layers are used in this assessment: ground cover, shrub, sapling, climbing woody vine, and tree.

The **ground cover** layer includes woody vegetation less than 3 feet in height (seedlings), non-climbing woody vines less than 3 feet in height, and all nonwoody vegetation (herbs and mosses) of any height.

Shrubs are woody vegetation greater than or equal to 3 feet, but less than 20 feet in height.

The **sapling** layer includes woody vegetation over 20 feet in height with a diameter at breast height (dbh) greater than or equal to 0.4 inches to less than 5 inches. Diameter at breast height is measured 4.5 feet from the ground.

Trees are woody plants with a dbh of 5 inches or greater and a height of 20 feet or more.

Climbing woody vines are a separate vegetative layer.

Observation Plots

Observation plots are used for measuring or estimating plant abundance. The number of plots should be based on the complexity of the site. Plots generally should be located in vegetative communities that are not clearly wetland or upland. Plot locations should be chosen so that the vegetation within the plot is representative of the vegetation within the community as a whole. Circular plots with the following dimensions are recommended:

Circular plot dimensions.

Ground cover:	5 foot radius
Shrubs:	15 foot radius

Plot dimensions continued:

Saplings:	15 foot radius
Climbing woody vines:	30 foot radius
Trees:	30 foot radius

Note: Plot size and shape may be varied when site conditions warrant. Plot locations may need to be adjusted to ensure that the vegetative layer being sampled is representative of the plant community.

At the site, do a quick check of the vegetation and identify the layers involved. When choosing your plots, be sure that the vegetation in your sample is representative of the vegetation in that layer as a whole. From a central location (using a tape measure), measure circular plots to the size noted for each layer. Tie flags in the vegetation to mark the boundaries of your circular plots.

As you become more comfortable and experienced doing this analysis, you will be able to estimate plot sizes. You should begin your assessment with the ground cover layer (if present) before you trample the vegetation. With the observation plots marked, you can now evaluate plant abundance for each layer and species in the plot using percent cover.

Percent Cover

Percent cover is a simple method for evaluating plant abundance and can be used for all layers (ground cover, shrub, sapling, climbing woody vine, and tree). Basal area also may be used to evaluate tree abundance (see pages 7 & 8). Percent cover is the percent of the ground surface that would be covered if the foliage from a particular species or layer were projected onto the ground, ignoring small gaps between the leaves and branches. Foliage from different species in the same layer can overlap, and as a result, total percent cover may exceed 100 percent.

Cover Range	Ranges Midpoint
1-5%	3.0
6-15%	10.5
16-25%	20.5
26-50%	38.0
51-75%	63.0
76-95%	85.5
96-100%	98.0

Using cover ranges and midpoint values will reduce the variability of results from different people. (See examples of percent cover, cover ranges, and midpoint values in Delineating Bordering Vegetated Wetlands Under the Wetlands Protection Act)

Diameter at breast height (dbh): the width of a tree trunk as measured at breast height (4.5 feet above the ground).

Dominant plant: based on calculations in the dominance test, a plant determined to be dominant in a particular vegetative layer.

Dominance test: a method of vegetative community assessment based on the number of dominant plants that are wetland indicator plants.

Drift line: an accumulation of water-borne debris often deposited in lines that are roughly parallel to the direction of water flow.

E-horizon: a layer below the 0 or A-horizon where iron and aluminum oxides and organic matter have been leached out of the soil by organic acids.

Evaporation: loss of water from surface water bodies.

Facultative species (FAC): classification of plants that occur in wetlands 34-66 percent of the time; also known as "fac" species (U.S. Fish and Wildlife Service).

Facultative upland species (FACU): classification of plants that occur in wetlands 1-33 percent of the time; also known as "fac-up" species (U.S. Fish and Wildlife Service).

Facultative wetland species (FACW): classification of plants that occur in wetlands 67-99 percent of the time; also known as "fac-wet" species (U.S. Fish and Wildlife Service).

Fibrist: an organic soil (peat) in which plant remains show very little decomposition and retain their original shape; more than two-thirds of the fibers remain after rubbing the materials between fingers.

Flooded: a condition in which an area is temporarily covered with flowing or standing water.

Gleization: a process in saturated and/or nearly saturated soils which involves the reduction of iron, its segregation into mottles and concretions, or its removal by leaching from the gleyed horizon.

Gleyed: a soil condition resulting from gleization which is characterized by the presence of neutral gray, bluish, or greenish colors in the soil matrix or in mottles among other colors.

Ground cover: a vegetative layer that includes woody vegetation less than 3 feet in height, non-climbing woody vines less than 3 feet in height, and all non-woody vegetation (including mosses) of any height.

Glossary

A-horizon: a surface layer of mineral soil darkened by the presence of organic matter; also known as topsoil.

Adventitious roots: roots found on plant stems in positions where roots do not normally occur. These roots may or may not form in response to inundation or saturation.

Aerenchyma: plant tissue that contains large air cells, resulting in a spongy texture.

Aerobic: a condition where free oxygen is present.

Anaerobic: a condition where free oxygen is unavailable.

B-horizon: a zone of weathered mineral soil below the 0, A, or E-horizon.

Basal area: the cross-sectional area of a tree trunk measured at breast height (4.5 feet above the ground).

Bordering Vegetated Wetland (BVW): a freshwater wetland that borders a creek, river, stream, pond, or lake; a wetland resource area defined in the Massachusetts Wetlands Protection Regulations (310 CMR 10.55).

Buttressed trunks: the swollen or enlarged bases of trees that develop in response to prolonged inundation.

Capillary fringe: a zone just above the water table that is nearly saturated with water due to capillary action.

C-horizon: A zone of unweathered soil below the A-horizon and, if present, the B - horizon. (Actually the C-layer.)

Chroma: the relative purity of a color; one of three variables of color.

Climbing woody vine: a vegetative layer that includes woody vines that are attached, rooted, or climbing on trees, saplings, or shrubs.

Concretion: a cemented body of material with internal symmetry such as iron or manganese formed by precipitation of dissolved material; can be removed from the soil intact.

Cover range: a category into which plant species would fit based upon their percent cover.

When estimating or measuring percent cover, include any foliage in the layer that occurs in the observation plot only if the stem or trunk of the plant originates within the plot. When using basal area to estimate abundance for the tree layer, include only those trees whose trunks originate within the plot.

Please Note:

Plant abundance should be estimated or measured for each layer where the total percent cover is 5 percent or greater. All vegetative layers present in an observation plot must be reported in the evaluation unless the total percent cover of a layer is less than 5 percent. Within each of those layers, estimate or measure plant abundance for each species. Any plant species with 1 percent cover or less should not be included.

Percent Cover Tricks and Rules of Thumb

The area of a five foot radius circle is 78.5 square feet. 1% is 0.79 square feet or the size of a standard size clipboard. If a plant in the ground cover has less than a clipboard of cover, then it's a trace sample and should not be included in your calculations. (Although you may wish to note its presence with a "T" for "trace.")

The area of a fifteen foot radius circle is 707 square feet. 1% is 7 square feet or the size of nine standard size clipboards. If a plant in the shrub layer has less than 9 clipboards of cover, or only one plant with a diameter of one meter (3.2 feet), then it's a trace sample.

The area of a thirty foot radius circle is 2827 square feet. 1% is 283 square feet or the size of a small one car garage, or a large shipment of clipboards. If a plant in the tree layer has less than a small garage of cover, or there is only one tree with an aerial cover diameter of 19 feet, or two trees with a diameter of 13 feet, then it's a trace sample.

Wetland Indicator Plants Identified in the Massachusetts Wetlands Protection Act

The Wetlands Protection Act lists plants by a common name and one of the following: family name, genus name, or species name. Some plants are listed only by family or genus. DEP has determined that the plants listed in the Act only by scientific name (plants with a genus and species name) are considered wetland indicator plants. Plants listed in the Act by family or genus only must also be listed in the National List as OBL, FACW+, FACW, FACW-, FAC+ or FAC species to be considered wetland indicator plants. In addition, all plants in the genus *Sphagnum* are considered wetland indicator plants (species in this genus have not yet been categorized by indicator category).

The following plants are listed by scientific name in the Act. (Note: the National List indicator category is included here for reference.)

American or white elm	*(Ulmus americans)*	FACW-
aster	*(Aster nemoralis)*	FACW+
azalea	*(Rhododendron canadense)*	FACW
azalea	*(Rhododendron viscosum)*	OBL
black alder	*(Ilex verticillata)*	FACW+
black gum tupelo	*(Nyssa sylvatica)*	FAC
black spruce	*(Picea mariana)*	FACW-
buttonbush	*(Cephalanthus occidentalis)*	OBL
cowslip	*(Caltha palustris)*	OBL
cranberry	*(Vaccinium macrocarpon)*	OBL
hemlock	*(Tsuga canadensis)*	FACU
highbush blueberry	*(Vaccinium corymbosum)*	FACW-
larch	*(Larix lamina)*	FACW
laurel	*(Kalmia angustifolia)*	FAC
laurel	*(Kalmia polifolia)*	OBL
leatherleaf	*(Chamaedaphne calyculata)*	OBL
marsh fern	*(Dryopteris thelypteris)*	FACW+
pitcher plants	*(Sarracenia purpurea)*	OBL
poison sumac	*(Toxicodendron vernix)*	OBL
red maple	*(Acer rubrum)*	FAC
sensitive fern	*(Onoclea sensibilis)*	FACW
skunk cabbage	*(Symplocarpus foetidus)*	OBL
spicebush	*(Lindera benzoin)*	FACW-
sweet gale	*(Myrica gale)*	OBL
sweet pepper bush	*(Clethra alnifolia)*	FAC+
water willow	*(Decodon verticillatus)*	OBL
white cedar	*(Chamaecyparis thyoides)*	OBL
white Hellebore	*(Veratrum viride)*	FACW+

Winter Delineations

Delineating or verifying BVW boundaries during the winter months, especially with deep snow cover or frozen soil conditions, is difficult and under some extreme circumstances virtually impossible. Vegetation and other indicators of hydrology that are used to determine BVW boundaries are not readily observable or may be misleading during these times.

Herbaceous vegetation or remnant vegetation (nuts, fruits, leaves) may be present but not visible if covered with snow. An example is the fertile frond of the sensitive fern *(Onoclea sensibilis),* which is persistent throughout the year, but may be hidden by deep snow.

Indicators of hydrology may be misleading or covered with snow. An example would be pockets or channels of ice on the ground surface. This condition may appear to indicate the presence of wetland hydrology, but also may be due to a number of different factors, such as snow melt that quickly freezes or a quick temperature drop after a brief rain that occurred with frozen soil conditions. As a practical matter, frozen soil conditions make digging holes and accurately observing the soil profile difficult or nearly impossible. Morphological adaptations (such as swollen trunks) and subtle changes in topography the sensitive also are difficult to observe when deep snow conditions are present.

For these reasons, DEP recommends that BVW delineations be avoided if possible when deep snow cover or "deep freeze" conditions exist. It is best for applicants and conservation commissions to agree upon a reasonable time period for continuing the RDA, ANORAD, or NOI processes in order to conduct or review the boundary delineation when frozen or snow covered conditions are likely to change. Because winter delineations are more difficult to do, disagreements - and subsequent appeals - may arise. Avoiding lengthy appeals and disagreements will benefit all parties involved.

When deep snow conditions do not exist, it may be possible to delineate BVW boundaries during the winter by using twigs, buds, leaf scars, and other vegetative indicators.

Delineating BVWs where Hydrology or Vegetation has been Altered

In areas where either hydrology or vegetation has been altered, additional investigation of site conditions will be needed to locate the BVW boundary. The procedure is basically the same as that previously outlined for using vegetation and soils to determine the BVW boundary. However, site conditions may require modifications that emphasize some indicators over others.

* In areas where hydrology has been recently altered, creating flooded conditions, hydric soils may not have formed. As a result, indicators of hydric soils may not be present even if wetland hydrology exists. In these areas, use vegetation and indicators of hydrology other than soils (e.g. hydrological records, water marks, water-stained leaves) to delineate the BVW boundary.

* Areas that have been recently drained will usually possess hydric soil indicators but lack other indicators of hydrology. Wetland plants may be present or absent depending on how recently and how extensively the hydrology has been altered. Hydric soils are often the best indicators for delineating recently drained wetlands.

* Areas where vegetation has been altered or removed - such as golf courses, lawns, and agricultural fields - require the use of soils and other indicators of hydrology to delineate BVW boundaries. In some cases, such as where vegetation has been cut or removed (e.g. ongoing forestry activity), remnant vegetation should be considered, but other indicators of hydrology also should be used to establish the BVW boundary.

* Areas where fill has been placed in wetlands require the analysis of soils directly beneath the fill. A hole must be dug through the fill until the original soil is exposed. Look for evidence of a buried surface horizon and evidence of normal horizonation (topsoil and subsoil layers). Soil surveys may be useful as a reference for distinguishing between the original soil and fill material. Once you have dug through the fill, analyze the original soils and determine whether they are hydric soils or not. Look for evidence of soil saturation (see page 26). If the fill is recent, there also may be identifiable plant parts beneath the fill that can be used to help delineate the BVW boundary.

* Areas where soil and vegetation have been removed often are the most difficult sites to evaluate. In these cases, historical records, such as NWI maps and aerial photographs, and visual assessments of adjacent sites may be useful in establishing the BVW boundary.

Measuring Basal Area

Basal area may be used to estimate percent dominance of trees for vegetative analysis. Trees are woody plants with a diameter at breast height (dbh) of 5 inches or greater and a height of 20 feet or more. Basal area is the cross-sectional area of a tree trunk at breast height (measured 4.5 feet from the ground). To visualize basal area, imagine a tree trunk cut off 4.5 feet above the ground; basal area is the surface area of the top of the stump. Basal area can be added for a number of trees and used like any other unit of measure in analyses of vegetative communities. Trees with multiple trunks that originate below 4.5 feet should be counted as two or more trees (depending on the number of trunks). Each trunk of a multiple trunk tree should be counted separately when determining total basal area for a plant species. For instance, each trunk of a three-trunk red maple would be measured individually to determine basal area for that species.

One method for calculating basal area involves measuring diameter at breast height (dbh) for each tree in a sampling plot and then using a formula for the area of a circle to calculate basal area (basal area = $\pi d^2 \div 4$). (Note: $\pi = 3.1416$.) Diameter at breast height is measured using a diameter tape or calipers or is calculated from measurements of circumference at breast height ($d = \text{circumference} \div \pi$). Each conversion of circumference to dbh, or dbh to basal area, must be done separately for each tree trunk before basal areas are added for analysis.

Basal Area Conversion Table

(converts circumference or dbh in inches to basal area in square inches for use in vegetative analyses; note: π = 3.1416 for these calculations)

Circumference in Inches	Diameter in Inches	Basal Area Sq. Inches	Circumference in Inches	Diameter in Inches	Basal Area Sq.Inches
15.7	5.0	19.6	33.0	10.5	86.7
16.0	5.1	20.4	34.0	10.8	92.0
17.0	5.4	23.0	35.0	11.1	97.5
18.0	5.7	25.8	36.0	11.5	103.1
19.0	6.0	28.7	37.0	11.8	108.9
20.0	6.4	31.8	38.0	12.1	114.9
21.0	6.7	35.1	39.0	12.4	121.0
22.0	7.0	38.5	40.0	12.7	127.3
23.0	7.3	42.1	41.0	13.1	133.8
24.0	7.6	45.8	42.0	13.7	140.4
25.0	8.0	49.7	43.0	14.0	147.1
26.0	8.3	53.8	44.0	14.3	154.1
27.0	8.6	58.0	45.0	14.6	161.1
28.0	8.9	62.4	46.0	15.0	168.4
29.0	9.2	66.9	47.0	15.3	175.8
30.0	9.5	71.6	48.0	15.6	183.3
31.0	9.9	76.5	49.0	15.9	191.1
32.0	10.2	81.5	50.0	16.2	198.9

Circumference in Inches	Diameter in Inches	Basal Area Sq. Inches	Circumference in Inches	Diameter in Inches	Basal Area Sq.Inches
51.0	16.2	207.0	89.0	28.3	630.3
52.0	16.6	215.2	90.0	28.6	644.6
53.0	16.9	223.5	91.0	29.0	659.0
54.0	17.2	232.0	92.0	29.3	673.5
55.0	17.5	240.7	93.0	29.6	688.3
56.0	17.8	249.6	94.0	29.9	703.1
57.0	18.1	258.5	95.0	30.2	718.2
58.0	18.5	267.7	96.0	30.6	733.4
59.0	18.8	277.0	97.0	30.9	748.7
60.0	19.1	286.5	98.0	31.2	764.3
61.0	19.4	296.1	99.0	31.5	779.9
62.0	19.7	305.9	100.0	31.8	795.8
63.0	20.1	315.8	101.0	32.1	811.8
64.0	20.4	325.9	102.0	32.5	827.9
65.0	20.7	336.2	103.0	32.8	844.2
66.0	21.0	346.6	104.0	33.1	860.7
67.0	21.3	357.2	105.0	33.4	877.3
68.0	21.6	368.0	106.0	33.7	894.1
69.0	22.0	378.9	107.0	34.1	911.1
70.0	22.3	389.9	108.0	34.4	928.2
71.0	22.6	401.1	109.0	34.7	945.5
72.0	22.9	412.5	110.0	35.0	962.9
73.0	23.2	424.1	111.0	35.3	980.5
74.0	23.6	435.8	112.0	35.7	998.2
75.0	23.9	447.6	113.0	36.0	1016.1
76.0	24.2	459.6	114.0	36.3	1034.2
77.0	24.5	471.8	115.0	36.6	1052.4
78.0	24.8	484.1	116.0	36.9	1070.8
79.0	25.1	496.6	117.0	37.2	1089.3
80.0	25.5	509.3	118.0	37.6	1108.0
81.0	25.8	522.1	119.0	37.9	1126.9
82.0	26.1	535.1	120.0	38.2	1145.9
83.0	26.4	548.2	121.0	38.5	1165.1
84.0	26.7	561.5	122.0	38.8	1184.4
85.0	27.1	574.9	123.0	39.2	1203.9
86.0	27.4	588.6	124.0	39.5	1223.6
87.0	27.7	602.3	125.0	39.8	1243.4
88.0	28.0	616.2	126.0	40.1	1263.4

Vegetative Community Analysis

The Dominance Test

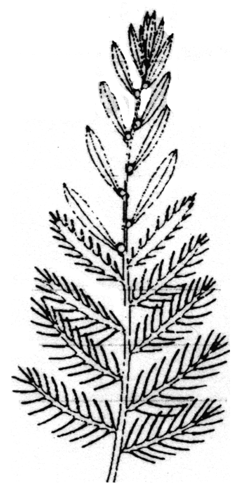
DEP recommends the use of the dominance test to verify or delineate BVW boundaries. The dominance test should be used to determine whether wetland indicator plants make up 50 percent or more of the vegetative community. The dominance test is a sampling technique that uses dominant plants within an observation plot to determine if the plot is a wetland or an upland. The test uses only the dominant plants in an observation plot since the dominant plants directly influence the composition of the remainder of the vegetation. However, the dominance test can be used to characterize the entire plant community in an observation plot. By identifying the dominant plants and whether they are wetland indicator plants, the vegetative community within an observation plot can be

Species	Common Name	Adaptation
Alisma spp.	Water plantain	Polymorphic leaves
Alternanthera phizoxeroides	Alligatorweed	Adventitious roots; inflated, floating stems
Avicennia nitida	Black mangrove	Pneumatophores; hypertrophied lenticels
Brasenia schreberi	Watershield	Inflated, floating leaves
Cladium mariscoides	Twig rush	Inflated stems
Cyperus spp. (most species)	Flat sedge	Inflated stems and leaves
Eleocharis spp. (most species)	Spikerush	Inflated stems and leaves
Fraxinus pennsylvanica	Green ash	Buttressed trunks; adventitious roots
Juncus SPP-	Rush	Inflated stems and leaves
Limnobium spongia	Frogbit	Inflated, floating leaves
Ludwigia spp.	Water primrose	Adventitious roots; inflated floating stems
Menyanthes trifoliata	Buckbean	Inflated stems (rhizome)
Myrica gale	Sweetgale	Hypertrophied lenticels
Nymphaea spp.	Water lily	Floating leaves
Nyssa aquatics	Water tupelo	Buttressed trunks; pneumatophores; adventitious roots
Nyssa ogechee	Ogechee tupelo	Buttressed trunks; multi-trunk; stooling
Nyssa sylvatica var. *biflora*	Swamp black gum	Buttressed trunks
Platanus occidentalis	Sycamore	Adventitious roots
Populus deltoides	Cottonwood	Adventitious roots
Quercus laurifolia	Laurel oak	Shallow root system
Quercus palustris	Pin oak	Adventitious roots
Sagittaria spp.	Arrowhead	Polymorphic leaves
Salix spp.	Willow	Hypertrophied lenticels; adventitious roots; oxygen pathway to roots
Salix nigra	Black Willow	Adventitious Roots
Scirpus spp.	Bulrush	Inflated stems and leaves
Spartina alterniflora	Smooth cordgrass	Oxygen pathway to roots

Many other species exhibit one or more morphological adaptations for occurrence in wetlands. However, not all individuals of a species will exhibit these adaptations under field conditions, and individuals occurring in uplands characteristically may not exhibit them.

***Enlarged (hypertrophied) lenticels** on woody plants are indicators of inundated or saturated growing conditions. Lenticels are small pores, usually resembling dots or thin horizontal lines on the stems and twigs of woody plants. In response to saturated or inundated growing conditions, these pores can become swollen or enlarged. Enlarged lenticels can occasionally be found on red maple *(Acer rubrum),* silver maple *(Acer saccharinum),* and willows *(Salix spp.).*

***Polymorphic leaves** form on certain plant species when portions of the plant are submerged while other portions extend above water. Plants like mermaidweed *(Proserpinaca palustris),* water parsnip *(Sium suave),* and arrowheads *(Sagittaria latifolia)* have different leaf forms depending on whether they grow above or below the water surface. Underwater leaves tend to be narrow or finely divided; leaves above the water surface tend to be broader and less divided. Where both forms occur on the same plant (polymorphic leaves), these are good evidence of surface water for an extended period during the growing season.



Plant with polymorphic leaves: mermaidweed *(Proserpinaca palustris)*

***Air-filled tissue (aerenchyma)** forms in the roots and stems of many plants in response to prolonged periods of saturation or inundation. These specialized tissues help move oxygen from plant structures above water to those that are underwater or in saturated soil. Plants that possess these air-filled tissues are spongy when squeezed and the air cells are obvious when the plants are cut.

Partial List of Species With Known Morphological Adaptations for Occurrence in Wetlands

Species	Common Name	Adaptation
Acer negundo	Box elder	Adventitious roots
Acer rubrum	Red maple	Hypertrophied lenticels, multiple trunks, shallow roots,

determined to be wetland or upland. If the number of wetland indicator plants is equal to or greater than the number of non-wetland indicator plants, the observation plot is in a wetland plant community.

The dominance test determines a plant species' dominance by evaluating percent cover. Information on percent cover is recorded for all plant species in each vegetative layer (ground cover, shrub, sapling, climbing woody vine, tree) present in the observation plot, but only for those layers with total percent cover greater than 5 percent. Basal area may be used instead of percent cover for identifying dominant plants in the tree layer (see page 7). Once dominant plants have been identified in each layer, they can be combined for purposes of the dominance test even if basal area is used for trees and percent cover is used for the other layers (see Example #1 in Appendix C of the DEP handbook). Dominant plants within each layer are recorded and classified as being either wetland indicator plants or non-wetland indicator plants.

The dominance test is less rigorous than some other sampling techniques and can be performed fairly rapidly with practice. It is a method that generally yields good results. Conservation commissioners can apply the dominance test as a quick check in the field by visually identifying dominant plants in an area (without detailed estimates or measurements) and then determining whether 50 percent or more of the dominant plants are wetland indicator plants.

Other methods of vegetative community analysis are available and may be appropriate for use where site conditions are atypical or when rigorous documentation is required. In situations where reliance on dominant species would not adequately characterize the vegetation of an area, or where the dominance test yields inconclusive results, use of a more rigorous analysis may be advisable. At the discretion of the conservation commission or DEP, other methods may be used instead of the dominance test. Applicants who use methods other than the one recommended by DEP should provide a written explanation for using an alternative method and a description of how the methodology is used. See pages 15-17 for more on alternative vegetative analysis techniques.

The Dominance Test Procedure Summary

1. Evaluate percent cover: For each observation plot do the following (basal area may be used for the tree layer):

a. Determine how many of the vegetative layers (ground cover, shrub, sapling, climbing woody vine, tree) have a total percent cover of 5 percent or more within the observation plot. Only those layers with a total percent cover of 5 percent or greater are to be used.

b. For each vegetative layer, estimate or measure percent cover for each plant species in the layer. Any plant species with 1 percent cover or less should not be included. If you know a plant species' name, list the name and its percent cover. If you do not recognize a plant or do not know a plant's name, call it a generic name (e.g. species x) and list its percent cover.

2. Determine percent dominance for plants in each layer: For those layers within the observation plot with 5 percent cover or more, determine percent dominance for each plant species as follows:

a. Add up percent cover for all plant species in the layer to determine the total percent cover for the layer.

b. Divide the percent cover for each plant species by the total percent cover for the layer, and multiply this by 100. This will yield percent dominance for each plant species in each layer.

3. Identify dominant plants: Within the observation plot, identify the dominant plants in each layer:

a. Beginning with the most abundant species, list the plants in the layer until the cumulative total for percent dominance meets or exceeds 50 percent. In some cases, this will only be one species; in other cases, several species may be needed to meet the 50 percent threshold. These species are dominant plants for the layer.

b. Other species, not already listed in 3a., with a percent dominance of 20 percent or greater also are dominant plants and should be listed.

c. If additional species in the layer have the same percent dominance as any species already listed in 3a. and b., those species also are dominant plants and should be listed.

d. Those plants that meet a., b., and c. above are dominant plants for the layer. Identify the scientific name and indicator category for all dominant plants. The indicator category is taken from the National List of Plant Species That Occur in Wetlands: 1988 - Massachusetts.

4. Determine whether the plant community is wetland or upland:

a. List the dominant plants (from 3a., b., and c. above) for all layers being evaluated. A given species may appear more than once on this list, if it is a dominant plant in more than one layer.

b. Determine how many of the dominant plants are wetland indicator plants according to the wetlands protection regulations. (Wetland indicator plants = plant species listed in the Wetlands Protection Act (see page 6); plants in the genus *Sphagnum;* plants in the National List classified as OBL, FACW+, FACW, FACW-, FAC+, and FAC; or any plants demonstrating morphological or physiological adaptations to life in saturated or inundated conditions.)

Morphological Plant Adaptations

Morphological adaptations are evident in the form or shape of a plant. Adaptations that result from inundation or saturation during the growing season are good indicators of wetland hydrology. In addition, plants demonstrating morphological adaptations are considered wetland indicator plants.

***Shallow root systems** are probably the most useful adaptations that indicate wetland hydrology in areas near the wetland/upland boundary. This indicator can be just as useful with shrubs, saplings, and herbs as it is with trees. For instance, look for swollen trunks or roots along the surface of the ground as evidence of shallow root systems, or observe them directly on overturned trees. The key is to compare the root structures of like or similar species growing further upslope in an upland setting. Be aware that shallow root systems also form in upland areas where bedrock is close to the surface or in very stony soils. Use soil maps and topography to confirm that shallow root systems are the result of wetland hydrology and not stony soils or bedrock.

Shallow root systems

Buttressed or fluted trunks are good indicators of hydrology that are often cited in publications about wetland delineation. In Massachusetts, however, trees and saplings rarely demonstrate the exaggerated, swollen bases typical of this adaptation. The moderately swollen bases typically found in Massachusetts usually indicate the presence of shallow root systems.

Adventitious roots are roots that form on plant stems in positions where roots normally do not occur. This adaptation is most common on active floodplains and may be found on box elder *(Acer* negundo), sycamore *(Platanus occidentalis)*, pin oak *(Quercus palustris),* green ash *(Fraxinus pennsylvanica),* cottonwood *(Populus deltoides),* and willows *(Salix spp.).*

Adventitious roots

Be aware, however, that there are terrestrial snails in Massachusetts; their presence is not an indicator of wetland hydrology. Freshwater mussels, unlike fingernail clams, only occur in areas that are permanently flooded. The presence of mussel shells in areas other than aquatic habitats are not good indicators of wetland hydrology because they often are transported by predators.

Caddisfly cases can occasionally be found in dry pools or intermittent streams. Caddisflies are insects that are aquatic as larvae and winged as adults. The larvae of many species construct tubelike cases around themselves, made of leaf fragments, twigs, pine needles, or sand. These cases often persist long after the water has dried up and serve as good indicators of extended periods of inundation during the growing season.

Evidence of Soil Saturation

The following indicators of hydrology may be used as evidence of soil saturation.

Free water in a soil test hole indicates depth to the water table at that particular time. The depth at which water is observed weeping out of the soil into the hole also is an indicator of water table depth. Free water or weeping within 12 inches of the surface is a good indicator of wetland hydrology. However, recent weather conditions should be considered when using this indicator.

Saturated soil usually occurs in areas above the water table due to capillary action within the soil. Saturated soils will yield water when squeezed. Saturated soil within 12 inches of the surface generally is a good indicator of wetland hydrology. However, recent weather conditions should be considered when using this indicator.

Oxidized rhizospheres within the A-horizon together with low-chroma colors right below the A-horizon are good indicators of soil saturation during the growing season. Look for orange-stained channels along living plant roots in the soil (see page 19 for more information).

NOTES:

c. Determine total number of wetland indicator plants and total number of non-wetland indicator plants.

d. If the number of wetland indicator plants is equal to or greater than the number of nonwetland indicator plants, the wetland vegetation criterion has been met. If vegetation alone is presumed adequate for the delineation, the plot is in a BVW. If vegetation alone is not presumed adequate or to overcome the presumption, other indicators of hydrology also should be used to delineate the BVW boundary (see page 1 & 2).

DEP Field Data Form

The Department of Environmental Protection's field data form should be used when delineating the boundary of a Bordering Vegetated Wetland (BVW) under the Massachusetts Wetlands Protection Act (M.G.L. Chapter 131, Section 40) and regulations (310 CMR 10.55). It should be used whether the boundary is delineated by vegetation alone or by vegetation and other indicators of wetland hydrology. Note: if detailed vegetative assessment is not necessary for the site, make a note on the data form and submit it. The field data form should be submitted with a Request for Determination of Applicability or a Notice of Intent. Details on the criteria for delineating a BVW boundary and the terminology used in this field data form are described in the handbook, *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act* (MA Department of Environmental Protection, Division of Wetlands and Waterways, 1995). An improved copy of the DEP FieldData Form is available at the wetland section of the Buzzards Bay NEP website, www.buzzardsbay.org.

INSTRUCTIONS

The data form includes a section on project identification, including the applicant's name, the name of the person performing the delineation, project location, and the DEP file number, if available.

If vegetation alone is presumed adequate to delineate the BVW boundary, mark the first box, complete Section I of the data form, and submit the document. If vegetation and other indicators of hydrology are used to delineate the BVW boundary, mark the second box, complete Sections I and II of the form, and submit the document.

DEP has selected the dominance test as the preferred method of vegetation analysis at sample plot locations. The information gathered for that method should be recorded on the form. If a method other than the dominance test is used, mark the third box and explain the method and why it was used.

Section I: Vegetation

Section I should be used to record information about the vegetation within an observation plot and on a transect used to delineate the BVW boundary. Note the date of the delineation. Submit a separate data form for each observation plot. Attach supplemental sheets if more space is needed.

A. Sample Layer and Plant Species

Record each plant species using common and scientific names for the following layers (povided there is at least 5% total vagetative cover in that layer):

Ground Cover: woody vegetation less than 3 feet in height (seedlings), non-climbing woody vines less than 3 feet in height, and non-woody vegetation (including spagnum moss) of any height within a 5-foot radius plot;

Shrubs: woody vegetation between 3 feet and 20 feet in height within a 15-foot radius plot;

Saplings: woody vegetation over 20 feet in height with a diameter at breast height (dbh) greater than or equal to 0.4 inches to less than 5 inches within a 15-foot radius plot; (note: dbh is measured 4.5 feet from the ground);

Climbing woody vines: woody vines that are attached, rooted, or climbing on trees, saplings, or shrubs within a 30-foot radius plot; and

Trees: woody vegetation with a dbh of 5 inches or greater and over 20 feet in height within a 30-foot radius plot.

If you do not recognize a plant species or do not know a plant's name, call it a generic name. Unknown plants need to be identified only if they are determined to be dominant plants. In that case, a plant identification book or key may be used to determine the species.

B. Percent Cover

Determine percent cover (or basal area for trees) for each plant species in each layer by visual analysis or measurement. (See this guide for information about determining percent cover, pages 4 & 5.)

C. Percent Dominance

Determine percent dominance for each plant species by dividing the percent cover or basal area for each plant species by the total percent cover or basal area for the layer. (See the pages 9 - 11 for the Dominance Test Procedure Summary.)

D. Dominant Plants

1. Identify the dominant plants. Dominant plants are:

Hydrological records, such as those from U.S. Geological Survey (USGS) stream gauging stations, U.S. Army Corps of Engineers data for major water bodies, state and local flood data, or NRCS state offices, can provide information on flood elevations, as well as the frequency and duration of flooding. Hydrological records that provide evidence of periods of continuous flooding from 7 to 21 days during the growing season are indicators of wetland hydrology.

Direct observation of inundation during the growing season is an obvious indication of the presence of water. Observations over a period of days or weeks will provide a more reliable indication that the area has wetland hydrology. Recent weather conditions should be taken into consideration when using this indicator to establish the presence of wetland hydrology.

Water marks on trees, boulders, bridge abutments, or other objects are good indicators of extended periods of inundation. Water marks can be stained or silt covered areas, or an abrupt change in plant or lichen growth that is present on several objects at a consistent elevation.

Water-stained leaves on the ground are an indicator of inundation. Water-stained leaves are usually dull gray or black in color, and are flattened compared with those in surrounding (upland) areas.

Sediment deposits on plants, leaves, or the ground are indicators of surface water, but generally do not provide much information about the timing or duration of inundation.

Drift lines are accumulations of plant material or debris that are deposited, usually in lines parallel to the stream flow, during flood events. Drift deposits may be evident on the ground or occasionally in the branches of trees and shrubs. They are good indicators of surface water, but do not provide much information about the timing or duration of flooding.

Scoured areas are good indicators of flowing water. These generally can be recognized by the relative absence of leaf litter and other debris on the ground, or where fine soils have been washed away, leaving gravel and cobble. Scoured areas are good indicators of flowing conditions, but do not provide much information about the timing or duration of flowing water.

Drainage patterns left by flowing water indicate the presence of surface water. These can be water-induced patterns on the ground (washboard or braided patterns in the sediments), channels in the leaf litter, or where vegetation has been bent in one direction by the force of running water. Although these patterns do serve as indicators of surface water, they also may occur in upland areas.

Fingernail clam and aquatic snail shells can occasionally be found in dry depressions and are good indicators of extended periods of inundation during the growing season.

10. If the organic layer is less than 8 inches deep, use the Munsell Soil Color Charts to determine the color of the soil matrix and mottles (if present) within 20 inches of the mineral surface or just below the A-horizon. To evaluate color, break off a representative chunk of moist soil material and compare it to the color chips on the Munsell charts. Use a spray bottle to moisten the chunk of soil, if the soil is not moist. Color comparisons should be made in good light, preferably direct sunlight (no sunglasses). Refer to the hydric soil indicators listed on pages 19 & 20 to determine whether hydric indicators are present.

11. Look for oxidized rhizospheres (root channels) and note their depth and abundance. Oxidized rhizospheres within the A-horizon together with low-chroma colors right below the A-horizon are indicators of hydric soil.

12. Observe to see if standing water gathers in the hole and note the depth. Free water may take a while to gather in the soil test hole. You may want to leave the hole to continue your delineation steps and then go back later to see if water is present. Also note the depth at which water weeps from the sides of the test hole. Free water or weeping within 12 inches of the surface measured from the bottom of the 0-horizon is a good indicator of wetland hydrology.

13. Flag the location of the test hole(s) and note their location on the plans.

Other Indicators of Hydrology

Vegetation and soils are considered the most reliable indicators of long-term wetland hydrology because they generally are observable throughout the year. However, other indicators also may be used to confirm the presence of wetland hydrology. These other indicators are presented in three categories: evidence of surface water, evidence of soil saturation, and morphological plant adaptations.

When delineating or reviewing a BVW boundary, note the presence of any of these other indicators and consider them in the evaluation. At many sites, these indicators can be used to refine the boundary delineation. When encountering difficult sites, it may be necessary to actively seek these other indicators to make the determination. Keep in mind, however, that some of these hydrologic indicators can be affected by recent heavy rain or seasons with above average amounts of precipitation. Conversely, these indicators may not be present during the entire year or may be absent during prolonged periods of drought.

Evidence of Surface Water

The following indicators may be used as evidence of surface water. Professional judgment should be used in deciding whether the presence of one or more of these indicators in an area is sufficient for establishing that wetland hydrology is present.

* plants with a percent dominance of 50 percent or greater, or plants whose percent dominance add up to immediately exceed 50 percent;

* plants with a percent dominance of 20 percent or greater;

* plants with a percent dominance equal to a plant already listed as a dominant species.

2. Determine common and scientific names for any unknown plants identified as dominant plants.

E. Wetland Indicator Category
1. Identify the Wetland Indicator Category for all dominant plant species using the *National List of Plant Species That Occur in Wetlands: Massachusetts.*

2. Use an asterisk to mark the wetland indicator plants. Wetland indicator plants are any of the following:

* plants in the genus *Sphagnum;*

* plants listed as Facultative (FAC), Facultative+ (FAC+), Facultative Wetland (FACW-), Facultative Wetland (FACW), Facultative Wetland+ (FACW+) or Obligate (OBL);

* plants with morphological or physiological adaptations (such as buttressed or fluted trunks, shallow roots, or adventitious roots). [See pages 27 - 29.]

If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk (e.g. White pine, *Pinus strobus,* FACU*/shallow roots, buttressed trunks).

Vegetation Conclusion
List the number of dominant wetland indicator plants and the number of dominant non-wetland indicator plants. If the number of dominant wetland indicator plants is equal to or greater than the number of non-wetland indicator plants, and vegetation alone is presumed adequate for the delineation, the plot is located in a BVW.

If vegetation alone has been chosen for the delineation at this site, complete only Section I and submit the form with a Request for Determination of Applicability or a Notice of Intent. Otherwise, continue the delineation process and record information for Section II on the second page of the form.

Section II: Indicators of Hydrology

Section II should be used to record information on indicators of hydrology in those areas where vegetation alone is not presumed adequate to delineate the BVW boundary, or to overcome the presumption that vegetation alone is adequate.

Hydric Soil Interpretation

1. Soil Survey: Record information about the site from the Soil Survey Report prepared by the U.S. Natural Resources Conservation Service (NRCS) - formerly called the Soil Conservation Service.

2. Soil Description: Record information based on observations at a soil test hole located within the vegetation observation plot. Describe the soil profile of each soil horizon, noting the depth. Identify the matrix and mottles colors by hue, value, and chroma (information from Munsell Soil Color Charts). For example, 10YR 5/2. Notes on soil texture and other soil characteristics may be recorded in the Remarks section.

3. Other: note any additional information used to determine if hydric soil is present, such as regional field indicator guides.

Conclusion: Indicate whether the soil is hydric based on information observed in the field.

(See list of Hydric Soil Indicators in this pocket guide, page 19 & 20, and Field Indicators for Identifying Hydric Soils in New England, Version 3.)

Other Indicators of Hydrology

Record observations of other indicators of hydrology. Check and describe all that apply. Due to their seasonal or temporal nature, these other indicators generally are used in conjunction with vegetation and soils to determine the location of the BVW boundary.

Vegetation and Hydrology Conclusion

Determine if the observation plot is in a BVW. The observation plot is in a BVW if the number of dominant wetland indicator plants is equal to or greater than the number of dominant non-wetland indicator plants, and if hydric soil or other indicators of hydrology are present.

For an observation plot located in a disturbed area, any one of the three indicators is sufficient to determine that the sample location is in a BVW. In that case, make a note on the form about that conclusion.

Procedure for Evaluating Soils

The following is the recommended procedure for evaluating soils. While conducting these steps, record information on the DEP field data form.

1. **Consult topographic maps, soil survey maps, and other available information before heading out to the site.** Check to see whether soils in the area are on the list of hydric soils for the region. Familiarize yourself with the general soil characteristics (color, texture, drainage class) that you expect to encounter at the site.

2. **In the field, check the site for signs that the hydrology may have been altered (drainage ditches, drainage tiles, dams, etc.).**

3. **Evaluate the plant communities using the dominance test to identify wetland and upland communities.**

4. **Choose locations for soil test holes**. Soil test holes should be located in areas that are representative of each vegetative community (wetland and upland) within the observation plots. In areas where the topography is characterized by a combination of small mounds and depressions, several test holes may be needed to accurately characterize an area. Locate the test holes within whichever feature (mound or depression) is most abundant.

5. **Use a pointed shovel or spade to dig a hole approximately 1 foot by 1 foot to a depth of 20 inches.** Note: A shovel or spade should be used for digging soil test holes and sampling soils. Shovels or spades are recommended because augers often mix soil from different horizons and may disturb or obliterate soil characteristics. However, a soil auger may be used to quickly check soil conditions or to refine your boundary determination by checking between soil test holes.

6. **Note whether a strong odor of hydrogen sulfide ("rotten egg") is present.** A strong hydrogen sulfide odor identifies a hydric soil.

7. **After digging the test hole, use a knife to probe the upper part of the soil profile to determine the bottom of the litter layer** (where the knife does not go into the soil easily). This will indicate the soil surface, which generally is the level from which depths are measured.

8. **Use the shovel to remove a clean slice (cross section) of the soil profile approximately 6 inches wide and 20 inches deep.** It is easiest to evaluate the horizons by removing a clean slice from the hole and laying it on the ground.

9. **Feel or probe the soil to determine if there is an 0-horizon (see organic soils).** If the 0-horizon is at least 8 inches deep, then the soil is hydric and has a histic epipedon. When the 0-horizon has a thickness greater than 16 inches, the soil is hydric and classified as a histosol.

colors are not necessarily the result of saturation or inundation, but form as a result of the leaching of organic material and aluminum and iron oxides by organic acids. These soils are called **spodosols** and the gray layer that forms below the surface is known as the E-horizon. Organic material and aluminum and iron oxides are deposited in a layer below the E-horizon called the spodic horizon.

Hydric indicators in spodosols include a combination of two or more of the following features, with one occurring within the upper 12 inches of the soil surface and others documented below the soil surface:

a) a thick, black, sandy surface layer;

b) organic streaking in the E-horizon;

c) mottles within the E-horizon;

d) oxidized rhizospheres within the A or E-horizon;

e) iron concretions/nodules within the E-horizon or spodic horizon;

f) a partially or wholly cemented spodic horizon usually within 18 inches of the surface measured from the bottom of the 0-horizon; and mottling within the spodic horizon.

Non-hydric spodosols can be recognized by brightly colored soil material below the E-horizon and without mottles or other indicators of saturation.

Spodosols are a problem soil. Check Field Indicators for Indentifying Hydric Soils in New England, Version 3. and Supplement to Field Indicators for Indentifying Hydric Soils in New England, Version 3. The "Field Indicators" and "Supplement" have information on the identification of hydic spodosols and spodosol identification field criteria

Areas where the hydrology has been recently altered. In areas where the hydrology has been recently altered, hydric soil indicators may not accurately reflect the current hydrology of the site. Areas that have been recently flooded - or where the water table has risen due to flooding or some other change in hydrologic conditions - may not exhibit hydric soil characteristics. These areas may not have been saturated long enough to develop hydric characteristics. Conversely, areas that have been effectively drained and wetland hydrology is no longer present may still possess hydric soil indicators. Where there is evidence that the hydrology has been substantially altered at a site, careful evaluation of vegetation, soils, and other indicators of hydrology should be made before making a final delineation. Altered areas are particularly difficult to evaluate and require special attention.

Using Relative Dominance of Wetland Species by Layers to Delineate Wetlands in Massachusetts

One of the problems with strictly adhering to one vegetative technique is that, depending on site peculiarities, any one method can give a "false negative" for the vegetative criteria.

It is acceptable to use alternative delineation techniques when the Dominance Test gives skewed results. One alternative method determines the percent wetland plant community composition by the relative dominance of wetland species by layers (**RDL**). The **RDL** method built upon vegetation mapping practices that had been in use since the turn of the century. The technique corresponds to the regulatory requirements and has been accepted at adjudicatory hearings. When using the RDL test, provide a written explanation to the Conservation Commission of how and why it was used.

[To guard against a "false negative" always use the vegetative analysis method that provides the highest vegetative line. Don't worry about a "false positive" using vegetation as you should be using soil information to adjust the vegetative line downward.]

INSTRUCTIONS:

Note: If any one vegetative layer has less than 5% absolute cover of the study plot, do not use that layer to calculate the mean wetland plant contribution.

1. Determine plot area. This should be performed in the same manner as the dominance test (see page 3).

2. List all upland species, then all wetland species in the ground cover in a 5' radius along the plot boundary centered on flag location. Determine, then record % aerial coverage for each group. Note if a sampling grid is used.

Example: With a ground cover layer of:

15% Cinnamon fern	*Osmunda cinnamomea*	FACW
15% Canada May	*Maianthmum canadense*	FAC-
15% Starflower	*Trientalis borealis*	FAC

The observation would be that there is twice as much wetland species as upland species. (30% total wetland plant cover compared compared to 15% upland plant cover.) 66% wetland species is recorded for the ground cover.

3. List all upland species present in the tree layer, then all wetland species, in a 30' radius along the plot boundary. Determine, then record, the % basal area (based on dbh) or % aerial coverage of upland and wetland species relative to each other.

4. Repeat Step 3 for climbing woody vines.

5. In the sapling layer, list all upland species, then all wetland species, in the shrub layer in a 15' radius along the plot boundary. Determine by visual estimate and record % aerial coverage for each group.

6. Repeat Step 5 for the shrub layer.

7. Calculate the mean of the % coverage of wetland species from the results of each vegetative layer.

8. If using other than the default height values for the different vegetative layers in the DEP manual, note that difference on the RDL form.

The RDL form is self-explanatory. The form is available at the wetland section of the Buzzards Bay NEP website, www.buzzardsbay.org. The method is quick and as simple as the Dominance Test.

Using the Wetland Site Index to Delineate Wetlands in Massachusetts

To determine the edge of the wetland, one technique to evaluate the vegetational community that has been accepted at adjudicatory hearings is the weighing method known as the Wetland Site Index, (WSI). While the WSI technique does not strictly meet the requirements of the regulations for evaluating the vegetational community, there are times when its use will give an appropriately positive result for the vegetational criteria when other quantitative techniques will not.

The use of hydrological indicators should always be used when relying on the WSI for establishing a BVW boundary when the WSI is below .67.

Dr. Michener, the creator of the WSI, cautioned against the strict use of the .50 value for the wetland determination cutoff point. Since the regulations include all FAC species as wetland plants, perform soil investigations when the WSI is as low as .45.

If you are using WSI data sheets, check to make sure that you are using the method that will provide the "highest line" and you have checked the soil characteristics when the WSI index is between .45 and .67. A copy of the WSI form is availabale at the wetland section of the Buzzards Bay National Estuary Program website, www.buzzardsbay.org.

WSI INSTRUCTIONS:
1. Determine plot area. The wetland flag is the center of the plot. The boundaries of the plot are the radius of the plot and the wetland edge.

2. List all species in the ground cover in the study plot. Determine then record the % aerial coverage for each species.

and make a determination. At some sites, more weight should be given to other indicators of hydrology and vegetation if the soils information is inconclusive. In particularly difficult cases, consultation with the Natural Resources Conservation Service is recommended. The following is a list and discussion of soils that are difficult to analyze:

Sandy soils. Soil colors often are not distinctive in most sandy soils. Instead, look for these indicators of hydric sandy soils:

a) high organic content in the surface layer (typically darker colors with values less than 3 and chroma of 2 or less) with mottles or other indicators of saturation directly below;

b) organic streaking directly below the A-horizon; or

c) matrix chroma of 3 (from the Munsell Soil Color Charts) in the top 12 inches of soil measured from the bottom of the 0-horizon, with distinct or prominent mottling.

Indicators of hydric soils may be lacking altogether in the soil of newly formed sand bars and interdunal depressions. Check Field Indicators for Indentifying Hydric Soils in New England, Version 3, for more information concerning sandy soils.

Floodplain soils. These soils usually are characterized by distinctly layered soil material. The layers form when new sediment is deposited during flood events. As a result of this pattern of deposition, hydric soil indicators may never form, or may be buried even though saturated or inundated conditions are present long enough to create wetland hydrology.

Soil from highly colored parent material. Some soils derived from highly colored parent material have strong red, brown, or black colors. As a result, the gray colors indicative of hydric soils may not be obvious. Red soils generally are confined to certain areas within the Connecticut River Valley. Brown soils derived from Brimfield schists generally are found in and around the town of Brimfield. Black soils generally are confined to southeastern Massachusetts (principally Bristol County).

A-horizons that are thick and very dark. A-horizons greater than or equal to 12 inches thick with values less than 3 and chroma of 2 or less are difficult to analyze because indicators of saturation are difficult to see. Therefore, look directly below the A-horizon for a matrix chroma of 1 or less and values of 4 or higher. If the matrix color directly below the thick and dark A-horizon is chroma 2 and value 4 or higher, other indicators of saturation need to be present in the soil directly below the A-horizon. In uncommon situations, it may be necessary to dig deeper to evaluate colors below the A-horizon.

Evergreen forest soils. Sandy soils on Cape Cod and other areas dominated by evergreen trees may possess gray colored E-horizons just beneath the surface. These chroma colors or other evidence of saturation, look for indicators directly below the A - horizon and within the top 12 inches of the soil surface. In areas where the 0-horizon is less than 8 inches thick, soil depths are measured from the bottom of the 0-horizon.

When the 0-horizon is 8 inches or greater (for histosols and soils with histic epipedons), such depths are measured from the soil surface. The soil surface is the top of the mineral soil; or, for soils with an 0-horizon, the soil surface is measured from the top of the 0-horizon. Fresh leaf or needle fall that has not undergone observable decomposition (the litter layer) is excluded from soil and may be separately described.

The following is a list of some hydric soil indicators - any of which can be used to identify the presence of wetland hydrology:

1. Histosols (organic soils). Histosols are soils with at least 16 inches of organic material measured from the soil surface.

2. Histic epipedons. These are soils with 8 to 16 inches of organic material measured from the soil surface.

3. Sulfidic material. A strong "rotten egg" smell generally is noticed immediately after the soil test hole is dug.

4. Gleyed soils. Soils that are predominantly neutral gray, or occasionally greenish or bluish gray in color within 12 inches from the bottom of the 0-horizon. (The Munsell Soil Color Charts have special pages for gleyed soils.)

5. Soils with a matrix chroma of 0 or 1 and values of 4 or higher within 12 inches from the bottom of the 0-horizon.

6. Within 12 inches from the bottom of the 0-horizon, soils with a chroma of 2 or less and values of 4 or higher in the matrix, and mottles with a chroma of 3 or higher.

7. Within 12 inches from the bottom of the 0-horizon, soils with a matrix chroma of 3 and values of 4 or higher, with 10 percent or more low-chroma mottles, as well as indicators of saturation (i.e., mottles, oxidized rhizospheres, concretions, nodules) within 6 inches of the soil surface.

Soils that are Difficult to Analyze

In most cases, the hydric soil indicators previously listed are sufficient to identify wetland soils. However, certain soils are more difficult to assess, making it harder to determine whether hydric conditions exist. When these situations are encountered, a delineator or reviewer must evaluate all of the information that is available at the site

3. List all species in the tree layer in the study plot (30 ft. radius). Determine then record the % aerial coverage for each species.

4. Repeat Step 3 for climbing woody vines.

5. In the sapling layer, list all species in the study plot (15 ft. radius). Determine then record the % aerial coverage for each species.

6. Repeat Step 5 for the shrub layer.

7. Record the USFWS indicator status for each entry.

8. Based on cover class, establish the abundance factor for each entry.

9. Establish the sum of abundance factors for each USFWS category.

10. Multiply the sum of the abundance factor for each USFWS category by the computed value for that USFWS category to establish a product for each USFWS category.

11. Add all the products to establish a total product.

12. Add all the abundance factors to establish a total abundance.

13. Establish the WSI by dividing the total product by the total abundance.

14. If WSI < .45 then site is upland. If WSI is > .45, and < .67, check soils. If WSI is > .67, site is wetland.

NOTES:

Soils as an Indicator of Wetland Hydrology

Hydric Soil

Soils found in wetlands are called hydric soils. Hydric soil is a relatively new term developed in the mid-1970s by wetland scientists working for the U.S. Fish and Wildlife Service with help from the Natural Resources Conservation Service (NRCS). Hydric soil is defined as "a soil that is saturated, ponded, or flooded long enough during the growing season to cause anaerobic conditions in the upper part." Anaerobic conditions produce physical and chemical changes in the soil that are readily observable and serve as hydric soil indicators. Hydric soil indicators generally require many years to develop. As a result, soils are good indicators of the long-term hydrology of an area. Once developed, the physical indicators of saturated conditions persist even after the hydrology of an area has been altered. Hydric soil indicators are especially useful for delineating wetlands where the vegetation has been altered.

The NRCS has developed local lists (by county) of soil series that are considered hydric. It is important to note, however, that boundaries shown on soil survey maps are approximate. A site visit is essential to verify the information contained in the soil survey and to accurately delineate the BVW boundary.

Hydric soils can be divided into two groups based on characteristics that can be observed in the field using soil test holes. These are organic soils and hydric mineral soils.

Organic Soils

Organic soils are made up of partially to well decomposed plant material mixed with mineral elements. Generally, organic matter makes up 20-30 percent or more of the soil (depending on the amount of clay present). Organic soils form in certain wetlands (especially bogs, fens, and marshes) where anaerobic conditions slow the rate of decomposition and organic matter accumulates over time. They generally can be recognized in the field by their dark color, slippery or fibrous texture, and tendency to stain fingers when handled. Organic soils also are less resistant than mineral soils to probing with a knife or shovel. When walking across these soil areas, they often feel spongy underfoot.

Soils with at least 16 inches of organic material measured from the ground surface are hydric soils and are referred to as **histosols.** Histosols are classified as fibrists (peats), saprists (mucks), and hemists (mucky-peats and peaty-mucks). Soils with 8 to 16 inches of organic material measured from the ground surface also are hydric soils and are referred to as having a **histic epipedon** (thick organic surface layer). Histosols and soils with a histic epipedon are always hydric soils.

Hydric Mineral Soils

Mineral soils contain less than 20-30 percent organic matter and are made up primarily

of sand, silt, and clay, with varying amounts of gravel, cobbles, and stones. Hydric mineral soils are typically characterized by low-chroma colors (0-2 on the Munsell Soil Color Charts) that result from gleization.

Gleization occurs when iron is reduced and becomes mobile due to anaerobic soil conditions. Chemical change resulting from the presence of oxygen is called oxidation. Many of the bright colors (brown, orange, and red) found in upland soils are the result of oxidized iron on the surface of soil grains. Chemical change that results from the absence of oxygen (anaerobic conditions) is called reduction. When soils are saturated or inundated long enough to produce anaerobic conditions, iron is reduced. Unlike oxidized iron, reduced iron is soluble in water and may move a short distance, or is sometimes entirely leached out of saturated sandy soils. This leaching process often creates soils that are dull-colored (low-chroma) or gray. These are hydric soils and are known as **gleyed soils.** They are typically neutral gray or occasionally bluish, or greenish-gray in color. The Munsell Soil Color Charts have special pages for gleyed soils.

Some mineral soils may not readily show hydric soil characteristics due to texture (sandy soils), high iron contents (red soils), or floodplain dynamics. (See the section on Soils that are Difficult to Analyze, pages 20 - 22.)

Under conditions of prolonged saturation, sulfur may become reduced and is converted by bacteria into sulfur gas (hydrogen sulfide), giving some wetland soils a smell like "rotten eggs."

In areas where the water table fluctuates, leading to alternating periods of oxidation and reduction, iron often accumulates in brightly colored mottles or concretions (hard nodules). In areas of fluctuating water tables, oxidized iron also may accumulate along the living roots of plants, forming oxidized rhizospheres.

Oxidized Rhizospheres

Roots and other underground plant structures growing in saturated soil conditions may produce brightly colored areas in the soil called oxidized rhizospheres. Roots need oxygen in order to survive and function. Under anaerobic soil conditions, oxygen moves to the roots from other parts of the plant. Leakage of this oxygen results in the oxidation of iron in the soil surrounding the roots. In areas of fluctuating water tables, this process creates brightly colored root channels (oxidized rhizospheres) in the soil. Oxidized rhizospheres are often evident within the topsoil and can be especially useful for confirming the presence of saturated soil conditions just below the ground's surface.

Hydric Soil Indicators

Most hydric soils have a soil horizon with a chroma of 0, 1, or 2 below the A-horizon. These are referred to as low-chroma colors. (Reminder: the Munsell Soil Color Charts are used to determine soil colors.) Generally, when evaluating mineral soils for low