U.S. Department of Agriculture
Natural Resources Conservation Service

CONNECTICUT

A 2003 oblique photo of Little Narragansett Bay facing northeast with Sandy Point in the foreground.

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April 2007

Contents

Foreword

Although proposals to include permanently submersed sediments as soil had been put forth since the mid 1800's, it was not until the early 1990's that the concept of subaqueous soils was developed in the U.S. The pioneer in U.S. subaqueous soils was the late Dr. George Demas, a soil scientist working for the National Cooperative Soil Survey in the Chesapeake Bay region of Maryland. Dr. Demas observed that subaqueous areas met the definition of soil by being able to support rooted plant growth (such as eelgrass) and had formed soil horizons. Further study revealed that these submersed sediments underwent other soil forming (pedogenic) processes including additions, losses, and transformations of energy and matter.

Soil Taxonomy defines the upper limit of soil as the boundary between soil and air, shallow water, live plants, or plant materials that have not begun to decompose. The lower limit of soil has been arbitrarily set at 200 cm. The horizontal boundaries of soil are areas where the soil grades into deep water (typically 2.5 meters deep), barren areas, rock, or ice (Soil Survey Staff 2006).

The United States Department of Agriculture - Natural Resource Conservation Service (USDA-NRCS), a member of the National Cooperative Soil Survey, is the lead federal agency for the mapping and interpretations of the nation's soil resources. The well established standards, techniques, and protocols used to map and interpret the nation's soil resources have been applied to this project.

Soil scientists prepared this report to disseminate information about the soil resources in the Little Narragansett Bay area, where the resources are, and how they can be used. Soil horizons were studied and characterized by examining a combination of properties and characteristics, instead of, a single component or parameter. In this manner, subaqueous soils can be characterized as ecological map units and provide a site-based system to identify the geomorphic settings that represent this landscape. The implications are that subaqueous soils may then represent signatures of the various hydromorphic settings reflective of submerged aquatic vegetation (SAV) or shellfish habitat.

Objectives of the coastal zone soil survey of Little Narragansett Bay:

1. To inventory, map, and develop interpretations for subaqueous soils with particular emphasis upon existing and potential eelgrass and shellfish habitat;

2. To refine and standardize protocols required for future surveys of subaqueous soils throughout the Long Island Sound Estuary (an Estuary of National Importance), and the northeast coastal habitats;

3. To apply established pedological soil-landscape conventions to explain relationships of subaqueous soil to submersed geomorphic settings that pertain to the conservation of eelgrass and shellfish habitat; use and management of estuarine resources; and

4. To develop partnerships with agencies, organizations, and institutions involved with Long Island Sound restoration efforts.

This pilot project is a subset of the updated *Soil Survey of the State of Connecticut*. Map units and series are provisional until correlated. The information presented in this report is not a substitute for an on-site investigation.

The need for coastal–zone mapping to inform policy makers and management is widely recognized as critical for mitigating hazards, creating resource inventories, and tracking environmental changes (National Research Council, 2004; U.S. Commission on Ocean Policy, 2004).This study will help increase understanding of the rare subaqueous soils in the ecosystem of Long Island Sound. It will hopefully lead to the development of a program to inventory additional coastal resources and develop interpretations that will assist in making better informed natural resources decisions.

Field work was conducted by Barbara Alexander, Nels Barrett, Kipen Kolesinskas, Lisa Krall, Shawn McVey, Charlie Morgan, Donald Parizek, Maggie Payne, Deborah Surabian, and James Turenne of Natural Resources Conservation Service, USDA, and graduate students from the University of Rhode Island (URI) Department of Natural Resources Science and the Graduate School of Oceanography, University of Rhode Island.

Additional support for the project came from a variety of federal agencies and institutions. Partners included:

- USDA-NRCS MLRA-12 Office, Amherst, Massachusetts
- USDA-NRCS Subaqueous Soils Project Office, Warwick, Rhode Island
- USDA-NRCS, Maryland and Delaware
- University of Rhode Island (URI) Department of Natural Resources Science
- URI GSO Environmental Studies and Paleomagnetics Laboratory
- MapCoast

Figure 1

Soil sampling on the submerged headlands major soil landform unit in Little Narragansett Bay with the CT NRCS boat.

General Nature of Little Narragansett Bay

The focus of this project is the ecologically significant estuary of Little Narragansett Bay, located along the coast of southeastern Connecticut and southwestern Rhode Island. This area is also part of the larger estuarine system that makes up Long Island Sound. The project encompasses an area approximately 1100 hectares (2700 acres) in size. The area contains subaqueous and submerged soils (typically 2.5 m deep) formed from marine deposits, till, organic deposits, glaciofluvial and alluvium parent materials.

As the names imply, subaqueous and submerged soils are soils that occur under water (both fresh and salt water). The difference between subaqueous and submerged soils is that submerged soils became submerged as a result of rising water tables, flooding events (such as a beaver dam), or sea level rise. Submerged soils formed in an upland environment but are now underwater. Subaqueous soils formed under a continuous water column (such as in an estuary), although their sediments may have originated from an upland area such as a dune.

Formation of Little Narragansett Bay

Glaciation was an important factor in the creation of Connecticut's coastline. The last ice advance (Wisconsin) reached Connecticut about 26,000 years ago. At that time, sea level was about 91 meters (300 feet) lower than it is today and the shoreline was 80 to 110 kilometers (50 - 70 miles) south of Long Island (Lewis, 1997).

By about 15,000 years ago, the glacier had retreated out of Connecticut and glacial Lake Connecticut had just about completely drained to the sea through an outlet in the moraine dam at the Race (between Fishers and Long Islands). The land had been pushed down by the weight of the glacier, and it was "rebounding" upward in response to the absence of the ice. The upward "rebound" of the land was accompanied by a rise in sea level as water from the melting glacier returned to the sea. For an unknown period, there was a complex interplay between the rising sea and the rising land. During this time, the sea probably entered the Long Island Sound basin through the Race (Lewis, 1997).This event marked the birth of the Long Island Sound and the creation of Connecticut's coastline.

Sedimentation started to keep pace with sea-level rise, and marshes began to develop along the margins of the estuary. With the shelter of Long Island and Connecticut's drowned coastline, Connecticut's rivers were forced to dump their loads, nourishing fertile salt marshes and mud flats. One of the state's largest salt marshes is Barn Island located in Stonington. As shown in Table 6, the organic carbon dates of organic material taken from the cores predate the historical record of hurricanes in the area.

Since wave energy is fairly low in the sound, wave action has not greatly modified the shore, and the Connecticut coast is very much a reflection of the shape of the land before it was drowned by the sea (Lewis, 1997). However, even with a sheltered coastline of calm winds and waters, Connecticut's coast keeps realigning and reshaping. Change on the coast comes about through erosion and deposition of sediments by winds, waves, and tides.

Five intense hurricanes have occurred in this region in 1635, 1638, 1815, 1869, and 1938. Historical records indicate that these storms produced storm surges greater than 3 meters in southern Connecticut (Donnelly et. al, 2001). Storm surges of this magnitude can overtop barrier islands, remove sediments from beaches and nearshore environments, and deposit materials on back-barrier marshes, lakes and lagoons. Smaller hurricanes are more frequent and have since struck in 1944, 1954, 1955, 1960, 1976 and 1985.

On September 21, 1938 a great hurricane careened into Connecticut changing the look of the coastline forever. In Little Narragansett Bay, Sandy Point was disconnected from Watch Hill and made into a barrier island. During the winter of 2001-02, Sandy Point was again eroded and split into two barrier islands (see Figures 2 and 3).

The continued rise in sea level is also important. As deglaciation proceeded, sea level rose in response to the return of water to the oceans; from about 8000 to about 100 years ago, the ocean swelled an average of four inches every century. But over the last century, sea level has risen twelve to sixteen inches (Bell, 1985).

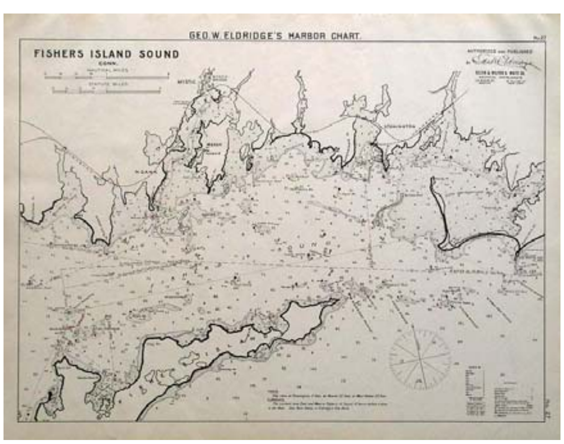


Figure 2
A chart from George Eldridge's Book of Harbor Charts, Connecticut dated 1901-09. This black and white chart shows Little Narragansett Bay on the far right hand side, with Watch Hill and Sandy Point joined together (Grace Galleries, 2007).

Figure 3
2005 NAIP imagery shows Watch Hill Point disconnected from Sandy Point. Sandy Point is split into two barrier islands and is shifting northeast into Little Narragansett Bay.

History of Growth

The first known users of Little Narragansett Bay and the Pawcatuck River were the Native American Indian tribes of Niantic, Pequot, and Narragansett, who hunted and fished throughout the extensive estuary. Although resident Indian tribes relied heavily on the natural resources of the watershed, their uses did not significantly alter the landscape characteristics of the watershed. European colonists exploited the protected waters of the estuary; and by 1680 shipbuilding was the most active occupation along the banks of the river, converting forest and marsh to commercial and residential uses. Shipbuilding proliferated into the 1800s when the Industrial Revolution shifted the attention of regional investors to industrial manufacturing. The river's naturally flowing waters provided a source of power for factories, and industrial development of the watershed began (Desbonnet and Schneider, 1992).

With the growth of industry, river damming continued into the mid-1900s. Unfortunately, this practice ultimately led to the extinction of the Atlantic salmon population in the river by denying access to adult salmon returning upriver to spawn. As more factories appeared along the river and estuary, the growing demand for a work force drew more people into the region. As both the number of mills and people within the watershed increased, so did the extent and volume of industrial and municipal wastes discharged into the river, resulting in poor water quality. Increased pollution of the river continued into the 1950s, when the textile industry in New England abruptly collapsed and many of the region's factories closed. Many of the abandoned factories fell to ruin, but others were converted to new industrial uses (Desbonnet and Schneider, 1992).

Studies conducted in the early 1990's by several teams of University of Rhode Island researchers, in cooperation with the R.I. Department of Environmental Management, have shown that the water in both the river and the estuary is generally of high quality, and provides healthy habitat for a wide variety of plants and animals. Bacterial concentrations have also improved to the point where shellfishing has been allowed in Rhode Island and/or Connecticut waters on a conditional basis since 1990 (Desbonnet and Schneider, 1992).

Recreation

Little Narragansett Bay has beaches, boat ramps, the Barn Island Wildlife Management Area, and Sandy Point (owned by Avalonia Land Trust) all located within the mapping area. It is a site of intensive recreational use, being both an area where boaters congregate and a transit area for those destined for the marinas upriver. It is also an active fishing, sailing, and waterskiing site. The area around Sandy Point where the federal channel enters Fishers Island Sound is an especially active and congested area, as boats leaving and entering the Bay must utilize this channel.

Little Narragansett Bay is used by both recreational and commercial shell fishermen for the harvest of hard clams, small populations of bay scallops, soft shell clams, and blue mussels. In addition, fishing is commonplace and the species found in the area are smelt, small cod, winter flounder, eel, summer fluke, tautog, bluefish, scup, menhaden, striped bass, and white perch.

The mapping area is also adjacent to Watch Hill Harbor and includes Wequetequock Cove, which support water-dependent commercial and high-intensity recreational activities. It contains several commercial marinas and associated mooring areas. A small portion of the Pawcatuck River Estuary is included in the mapping area, which is narrow for some distance, however, widens significantly as it enters the bay.

Habitat

Little Narragansett Bay supports extensive submerged aquatic vegetation (SAV), shellfish beds, and other fisheries habitats. The area has a variety of rich natural habitats and supports a wide diversity of species, thus making knowledge of these areas an important component of a comprehensive Long Island Sound (LIS) mapping program.

Estuarine salt marshes in the Barn Island Marshes were the subject of some of the earliest and most important salt marsh studies in the U.S. These marshes are dominated by saltmarsh cordgrass (*Spartina alterniflora*) in low marsh areas and saltmeadow cordgrass (*S. patens*) in high marshes, often with a mosaic of species and communities characterized by spike grass (*Distichlis spicata*), black grass (*Juncus* *gerardii*) and glasswort (*Salicornia bigelovii*), ponds of widgeon grass (*Ruppia maritima*), and upland borders of marsh elder (*Iva frutescens*) and groundsel-bush (*Baccharis halimifolia*). Common reed (*Phragmites australis*) is becoming invasive in many saltmarshes in this area, often displacing cordgrass vegetation.

Marshes at Barn Island provide nesting habitat for American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), black rail (*Laterallus jamaicensis*), and seaside sparrow (*Ammodramus maritimus*) – all regional species of special emphasis. Harbor seal (*Phoca vitulina*) haulouts are located on several rock islands. Little Narragansett Bay and coves in this area provide significant spawning and nursery habitat for winter flounder (*Pseudopleuronectes americanus*). Horseshoe crabs (*Limulus polyphemus*) and blue crabs (*Callinectes sapidus*) are benthic or bottom-dwelling organisms also found in Little Narragansett Bay.

Aquaculture in Connecticut has for the last 150 years traditionally harvested native set shellfish from the bottom. The State of Connecticut Department of Agriculture states that more than 70,000 acres of shellfish farms are now under cultivation in Connecticut's coastal waters. Connecticut's oysters are among the most valued oysters reared in the United States. There are also commercially important beds of hard-shelled clams (*Mercenaria mercenaria*), soft-shelled clams (*Mya arenaria*) and bay scallop (*Aequipecten irradians*) scattered over this area (Dowhan, 1991).

Figure 4
Napatree sand, 0 to 2 percent slopes on a bouldery submerged headland, covered by shell fragments.

How Are Subaqueous Soils Mapped?

Traditional soil mapping is conducted by a field soil scientist trained to understand the interaction of soil forming processes and soil-landscape relations. Mapping soil involves mostly field work with the soil scientist traversing the landscape and digging many holes to observe the soil condition and classify the soil. Subaqueous soil mapping is performed in much the same way, except the soil is under water. Instead of topographic maps to provide landscape position, subaqueous soil mapping uses bathymetric maps to identify landscapes and landforms. Shovels are replaced with augers and special tools such as peat corers and vibracores to obtain the soil samples.

In Little Narragansett Bay, National Oceanic and Atmospheric Administration (NOAA) bathymetry was supplemented with bathymetry created by NRCS technology to develop a 1:12,000 scale contour map of the submerged topography. The bathymetry, used in combination with aerial photography, was used to delineate different landscapes. Slope, landscape-surface shape, and geographic location were used to differentiate and describe landform by both descriptive nomenclature and commonly used estuarine terminology. At multiple locations in each landform unit, soils were examined and a soil-landscape model was derived with a minimum size delineation of approximately 3 acres. Within each landform unit, locations were then chosen to capture both the variability and extent of soil types. Soils were accessed either by wading or by boat and each sample location was recorded using a Garmin GPSMAP 178C fathometer.

Figure 5
Soil sample collected with a McCauley/Eijkelkamp peat sampler.

Soil samples were collected with a standard bucket auger, McCauley/Eijkelkamp peat sampler, push tube, and vibracore. Using these tools, soil profiles were described to depths up to 200 cm. If the soils were very soft and fluid (high *n* value soils) or high in organic material the peat sampler or push tubes were used. Based on these descriptions, representative soils were sampled for laboratory analysis from each landform unit using a vibracore.

The Rhode Island NRCS pontoon boat and University of Rhode Island (URI) Graduate School of Oceanography (GSO) vibracoring vessel were used to extract soil samples. Core barrels were vibrated into the soil to refusal – or to a depth of 2 meters – and extracted from the soil using an electric or manual winch secured to the platform of the boat. Once extracted, core barrels were removed from the vibracore set up, sealed and refrigerated.

The core barrels were cut open lengthwise and the soils were described following standard procedures (Soil Survey Division Staff 1993) and classified using the *Keys to Soil Taxonomy* taking into account the flow regime, water column attributes, and major soil forming factors. Soil samples were then shipped cold to the National Soil Survey Center - Soil Survey Laboratory in Lincoln, Nebraska, for full soil characterization. URI collected a few additional soil samples for analysis at URI and chose a few core barrels of interest to preserve in cold storage for future reference. Field observations and laboratory analyses indicated significant differences in such characteristics as particle size class, organic carbon content, pH, and fluidity (*n-value*), as shown in Table 7. Six series have been proposed with diagnostic criteria including permanent submergence by shallow water.

Figure 6
University of Rhode Island Graduate School of Oceanography vibracoring vessel in Little Narragansett Bay.

Major Soil Landform Units

In this section, each proposed major soil landform unit recognized in the mapping area is described. The descriptions are arranged in alphabetical order. Characteristics of the landform, soil and the material in which it formed are identified for each unit. The detailed map included with this soil survey represents the major soil landforms in the Little Narragansett Bay area.

Barrier Island: A long, narrow, sandy island representing a broad barrier beach that is above high tide and parallel to the shore, and that commonly has dunes, vegetated zones, and swampy terrains extending lagoonward from the beach; also a long series of barrier beaches (modified from Jackson, 1997). This mapping unit includes small areas of sandy dredge spoils. The sandy soils found in this mapping unit most likely include excessively-drained Udipsamments on the higher, more stable, and vegetated coastal dunes of the Barrier Island. The lower, less stable areas that are subject to frequent storm wash over and have little or no vegetation are dominated by Beaches.

Bay Bottom: The nearly level or slightly undulating central portion of a submerged, low-energy, depositional estuarine embayment characterized by relatively deep water and sandy textures (1.0 to >2.5 m). The soils in this mapping unit are Haplic Sulfaquents (Haplic Sulfiwassents). Some areas may have gravelly surface layers and few boulders. Wave action and subsurface currents are sufficient to keep silts and clays from settling out of the water column. The soil surface is firm in most places

Navigation Channel: A roughly linear, deep water area for navigation purposes (after Wells et al., 1994; dredged hole). This deep channel has steep sides and a parabolic shape and strong currents in places.

Mainland Cove Loamy: A loamy, subaqueous area adjacent to the mainland or a submerged mainland beach that forms a cove or embayment within the larger basin. Sulfic Fluvaquents and Haplic Sulfaquents (Sulfic Fluviwassents and Haplic Sulfiwassents) are the dominant soil types in this mapping unit. Some areas may have a few boulders. Buried terrestrial soil profiles are common in this mapping unit. The soil surface is soft and fluid.

Mainland Cove Sandy: A sandy, subaqueous area adjacent to the mainland or a submerged mainland beach that forms a cove or embayment within the larger basin. Haplic Sulfaquents (Haplic Sulfiwassents) are the most common soil types. Some areas may have a few boulders. Buried terrestrial soil profiles are common in this mapping unit. The soil surface is soft and fluid in most places.

River Bottom: A nearly level to slightly undulating riverbed or channel in which a river flows. The area consists of, or is covered by, sandy unconsolidated material. The soils in this mapping unit are Haplic Sulfaquents (Haplic Sulfiwassents). Some areas may have gravelly surface layers and few boulders. Wave action and subsurface currents are sufficient to keep silts and clays from settling out of the water column. The soil surface is firm in most places.

Shoal Sandy: A natural subaqueous ridge, bank, or bar consisting of, or covered by, sandy unconsolidated material rising above the general subaqueous estuarine floor to near the surface. Typic Endoaquents (Typic Haplowassents) dominate this mapping unit. The soil surface is firm in most places.

Shore Face: A nearly level to gently sloping dynamic and unstable landform seaward of the barrier island that may have small areas exposed at low tide. The soils in these areas are sandy in texture. Dramatic changes can occur in this mapping unit over time resulting from severe storm events. Wave action and strong currents promote the formation of Typic Psammaquents (Fluventic Psammowassents) in this environment. The soil surface is firm and sandy.

Shore Complex: Generally a narrow transverse area that parallels a coastline, commonly cutting across diverse inland landforms, and dominated by landforms derived from active coastal processes which give rise to beach ridges, overwash fans, beaches, dunes, wave-cut platforms, barrier islands, cliffs, stacks, etc. (Schoeneberger and Wysocki, 2002). Wave action and strong currents promote the formation of Typic Psammaquents (Typic Psammowassents and Fluventic Psammowassents) in this environment. The soil surface is firm and sandy.

Submerged Headlands: Bouldery, submerged glacial deposits adjacent to glaciated uplands with numerous boulders and stones, some of them above the high tide mark. Submerged terrestrial soils with a capping of sandy marine deposits are common in this mapping unit. Aeric Endoaquents (Aeric Haplowassents) are the dominant soil types in this mapping unit. The potential for submarine (fresh) groundwater discharge zones are high in this map unit given the geomorphic links with the surrounding upland land forms. The soil surface is firm in most places.

Submerged Stream Valley: Linear feature occupying a former stream valley submerged by sea level rise. Submerged alluvial, glacial fluvial, and organic marsh deposits are common in this mapping unit along with a capping of loamy sulfidic marine deposits. Haplic Sulfaquents and Typic Sulfaquents (Haplic Sulfiwassents and Typic Sulfiwassents) are the dominant soil types in this mapping unit. The soil surface is soft and fluid in most places.

Submerged Tidal Marsh: Nearly level organic deposits submerged by sea level rise that are adjacent to upland tidal marshes bordering the coast. Formerly a tidal marsh alternately covered and uncovered by the tide is now permanently submerged by sea level rise. Submerged marsh soils with a capping of loamy marine deposits are common in this mapping unit. Typic Sulfihemists and Terric Sulfisaprists (Terric Haplowassists) are the common soil types in this mapping unit. The soil surface is soft and fluid in most places.

Tidal Inlet: Any inlet through which water alternately floods landward with the rising tide and ebbs seaward with the falling tide (Jackson, 1997). Typic Sulfaquents and Sulfic Fluvaquents (Typic Sulfiwassents and Sulfic Fluviwassents) are the dominant soil types in this mapping unit. The bathometry of this unit is in constant change as storms and tides sculpt the floor.

Washover-Fan Flat: A gently sloping, fan-like subaqueous landform created by overwash from storm surges that transports sediment from the seaward side to the landward side of a barrier island (Jackson, 1997). Sediment is carried through overwash channels that cut through the dune complex on the barrier spit (Fisher and Simpson, 1979; Boothroyd et al., 1985; Davis, 1994) and spill out onto the lagoon-side platform where they coalesce to form a broad belt. The soils in this mapping unit are Typic Psammaquents (Fluventic Psammowassents) with numerous buried horizons. They provide links to stable periods between catastrophic storm events that breeched the barrier island in numerous places. The history of major storm events along the southern New England coast is entombed in the profiles of the washover fan.

Figure 7

A 2003 oblique photograph of Little Narragansett Bay facing west over Sandy Point. Four major soil landform units are labeled on the photograph.

The map units on the detailed soil map at the back of this soil survey represent the soils in the Little Narragansett Bay area. The soil map unit descriptions in this section, along with the soil map, can be used to determine the suitability and potential of a soil for a specific use.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and gives the principle hazards in planning for specific uses.

Some map units are made up of two or more major soils. These map units are called undifferentiated groups or soil complexes.

An undifferentiated group is two or more soils that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils in the mapped area are not uniform and may only be made up of one of the major soils. *Wequetequock and Wamphassuc soils, 0 to 2 percent slopes* is an undifferentiated group in this area.

A soil complex consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. *Beaches-Udipsamments complex, coastal* is an example.

This survey includes miscellaneous areas. Such areas have little or no soil material and support little or no vegetation. Beaches and Navigational Channels are two examples.

Figure 8
Typic Psammaquents (shore complex) in the foreground and Beaches-Udipsamments complex (barrier island) in the background.

Most map units include small, scattered areas of soils other than those for which the map unit is named. These may include soils having properties that differ substantially from those of the major soil or soils. The included soils are identified in each map unit.

This report includes soil map units that are classified to the soil order through the soil series.

Table 1 gives the hectares and proportionate extent of each map unit within the Little Narragansett Bay area. The glossary defines many of the terms used in describing soils.

301 –Beaches–Udipsamments complex, coastal

This complex is on barrier islands and beaches. Mapped areas range from 1 to 40 hectares (3 to 100 acres). Slope ranges from nearly level to gently sloping.

The mapped acreage of this complex is about 50 percent beaches, 35 percent Udipsamments, and 15 percent minor components. Included with this complex in mapping are small areas of very poorly drained Westbrook, Pawcatuck, and

Ipswich soils in tidal marshes and subaqueous Rhodesfolly soils on washover fans, bay bottoms, and shore faces. Also included are areas of Udorthents, urbanized areas, and a few areas of rock outcrop. Udorthents are in areas that have been altered by cutting and filling.

Typically, Beaches has a very light brownish gray gravelly sand layer 0 to 165 cm thick.

Typically, Udipsamments has a very light brownish gray sand 0 to 96 cm surface layer. The substratum is light olive brown sand.

This soil is an area of intensive recreational use, being both an area where boaters congregate and an active fishing site. It also serves as an area of natural resources for the benefit of wildlife, such as shore birds.

800 – Wamphassuc and Wequetequock soils, 0 to 2 percent slopes

These nearly level subaqueous soils are in permanently submerged stream valleys and terraces. Mapped areas are elongated in shape and range from 5 to 23 hectares (12 to 57 acres). Slope ranges from 0 to 2 percent.

The mapped acreage of this undifferentiated group is about 55 percent Wamphassuc, 30 percent Wequetequock, and 15 percent other soils. Mapped areas consist of either Wamphassuc or Wequetequock, or both. These soils were mapped together because there are no major differences in most uses and management. Included with this complex in mapping are small areas of subaqueous Quanaduck, Napatree, and Anguilla soils.

Typically, this Wamphassuc soil has a soft, black or greenish black, mucky silt loam or silt loam surface layer, 10 to 40 cm thick. The substratum is black, very dark grayish brown, or very dark grayish green mucky silt loam through loamy sand glacial deposits.

Typically, this Wequetequock soil has a soft black, mucky silt loam or silt loam surface layer, 15 to 50 cm thick. The substratum is very dark brown, mucky silt loam through sandy loam, 25 to 65 cm thick.

The Wamphassuc soils are permanently submerged with salt or brackish water. All horizons have a pH of strongly acid through moderately alkaline and ultra acid through very strongly acid after 8 weeks incubation. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and moderately high to high saturated hydraulic conductivity.

Figure 9

A 2003 oblique photograph of Wequetequock Cove in Stonington, Connecticut.

The Wequetequock soils are permanently submerged with salt or brackish water. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Some pedons are underlain by organic deposits greater than 100 cm from the soil surface and/or have thin layers less than 20 cm thick of organic deposits in the soil profile. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and moderately high to high saturated hydraulic conductivity.

These soils contain sulfidic materials within 50 cm of the mineral soil surface. If drained or dredged and exposed to air, sulfides will oxidize and create acid sulfate drainage causing serious environmental damage.

These soils support submerged aquatic vegetation and wildlife habitats. The area is used by recreational fishermen for the harvest of crabs and fishing. Native vegetation includes rooted and floating algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 15 percent.

810 - Napatree sand, 0 to 2 percent slopes

This subaqueous soil is on bouldery mainland coves adjacent to glaciated uplands with numerous boulders and stones. Mapped areas are irregular in shape and range from 1 to 19 hectares (3 to 46 acres). Slope ranges from 0 to 2 percent.

Included with this soil in mapping are small areas of subaqueous Quanaduck and Anguilla soils. Included areas make up about 15 percent of this map unit.

Typically, this Napatree soil has a firm, black or very dark grayish brown sand surface layer, 15 to 30 cm thick. The subsoil is olive brown sandy loam, 20 to 35 cm thick. The substratum is dark grayish brown or gray silt loam, sandy loam, or loamy sand glacial deposits.

The Napatree soils are permanently submerged with salt or brackish water except for some of the surface boulders that are exposed to the air during low tides. All horizons have a pH of neutral through slightly alkaline and a pH of very strongly acid through neutral after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >20 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

This soil is used for recreation and wildlife habitat. Shellfish cultivation is important in these soils. Few areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 15 percent.

820 – Quanaduck silt loam, 0 to 2 percent slopes

This subaqueous soil is on mainland coves. Mapped areas are irregular in shape and range from 1 to 6 hectares (3 to 16 acres). Slope ranges from 0 to 2 percent.

Included with this soil in mapping are small areas of subaqueous Wequetequock, Wamphassuc, Napatree, and Anguilla soils. Included areas make up about 15 percent of this map unit.

Typically, this Quanaduck soil has a soft, black or greenish black silt loam surface layer, 15 to 30 cm thick. The substratum is firm, very dark greenish gray or dark greenish gray coarse sand.

The Quanaduck soils are permanently submerged with salt or brackish water. All horizons have a pH of slightly alkaline through moderately alkaline and a pH of ultra acid through slightly acid after 8 weeks incubation. One or more horizons below 50 cm and within 100 cm of the soil surface have a pH of 4.0 or less after 8 weeks incubation. Depth to first lithologic discontinuity ranges from 30 to 50 cm. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

These soils contain sulfidic materials in the soil profile. If drained or dredged and exposed to air, sulfides will oxidize and create acid sulfate drainage causing serious environmental damage.

This soil is used for recreation and wildlife habitat. The area is used by recreational fishermen for the harvest of crabs and fishing. Some areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 35 percent.

Figure 10
Quanaduck silt loam, 0 to 2 percent slopes in the foreground.

830 – Anguilla mucky sand, 0 to 5 percent slopes

This subaqueous soil is on mainland coves or embayments within the larger basin. Mapped areas are irregular in shape and range from 4 to 15 hectares (11 to 36 acres). Slope ranges from 0 to 5 percent.

Included with this soil in mapping are small areas of subaqueous Rhodesfolly, Napatree, and Quanaduck soils. Included areas make up about 15 percent of this map unit.

Typically, this Anguilla soil has a soft, black mucky sand surface layer, 30 to 50 cm thick. The subsoil is olive brown loamy sand, 20 to 35 cm thick. The substratum is very dark grayish brown, very gravelly coarse sand.

The Anguilla soils are permanently submerged with salt or brackish water. All horizons have a pH of neutral and a pH of ultra acid through strongly acid after 8 weeks incubation. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high saturated hydraulic conductivity.

These soils contain sulfidic materials in the soil profile. If drained or dredged and exposed to air, sulfides will oxidize and create acid sulfate drainage causing serious environmental damage.

This soil supports submerged aquatic vegetation and wildlife habitats. The area is used by recreational fishermen for the harvest of crabs. In addition, fishing is commonplace. Some areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 35 percent.

840 – Rhodesfolly fine sand, 0 to 5 percent slopes

This subaqueous soil is on bay bottoms, washover fan-flats, and shore faces. Mapped areas are expansive and range from 6 to 119 hectares (16 to 293 acres). Slope ranges from 0 to 5 percent.

Included with this soil in mapping are small areas of subaqueous Napatree and Anguilla soils. Included areas make up about 15 percent of this map unit.

Typically, this Rhodesfolly soil has a firm, very dark gray fine sand surface layer, 0 to 23 cm thick. The substratum is dark gray or very dark gray sandy deposits with numerous buried horizons.

The Rhodesfolly soils are permanently submerged with salt or brackish water. All horizons have a pH of neutral through strongly alkaline and a pH of very strongly acid through slightly alkaline after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

This soil is used for recreation and benthic wildlife habitat. Shellfish cultivation is important in these soils. Fishing is commonplace. Some areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 35 percent.

850 – Sandy, mixed mesic Haplic Sulfaquents (bay bottom)

This subaqueous soil is on bay bottoms. Mapped areas are expansive and range from 137 to 227 hectares (335 to 560 acres). Slope ranges from 0 to 5 percent.

Included with this soil in mapping are small areas of subaqueous Rhodesfolly, Napatree, and Anguilla soils. Included areas make up about 15 percent of this map unit.

Typically, this soil has a firm, black sand surface layer, 0 to 10 cm thick. The substratum is dark grayish brown sandy deposits.

This soil is permanently submerged with salt or brackish water. All horizons have a pH of slightly acid through slightly alkaline and a pH of extremely acid through strongly acid after 8 weeks. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

These soils contain sulfidic materials in the soil profile. If drained or dredged and exposed to air, sulfides will oxidize and create acid sulfate drainage causing serious environmental damage.

This soil is used for recreation and benthic wildlife habitat. Fishing is commonplace. Some areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 35 percent.

Figure 11
Histosols on a submerged tidal marsh in the foreground. A shorebird nesting perch is on the tidal marsh soil in the background.

860 – Histosols (submerged tidal marsh)

This subaqueous soil is on submerged tidal marshes. Mapped areas range from 1 to 7 hectares (3 to 18 acres). Slope ranges from 0 to 2 percent.

Included with this soil in mapping are small areas of subaqueous Napatree, Quanaduck, and Anguilla soils. Included areas make up about 15 percent of this map unit.

Typically, this soil has a soft, black muck surface layer, 25 to 70 cm thick. The substratum is dark grayish brown fine sandy loam.

This soil is permanently submerged with salt or brackish water. All horizons have a pH of neutral and a pH of ultra acid through slightly acid after 8 weeks. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

These soils contain sulfidic materials in the soil profile. If drained or dredged and exposed to air, sulfides will oxidize and create acid sulfate drainage causing serious environmental damage.

This soil is used for benthic wildlife habitat. Shellfish cultivation is important in these soils. This area contains noted shellfish beds during the season. Most areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 85 percent.

880 – Typic Psammaquents (shore complex)

This subaqueous soil is on shore complexes. Mapped areas are expansive and range from 81 to 147 hectares (200 to 364 acres). Slope ranges from 0 to 5 percent.

Included with this soil in mapping are small areas of subaqueous Rhodesfolly soils. Included areas make up about 10 percent of this map unit.

Typically, this soil has a firm, dark gray sand surface layer, 0 to 20 cm thick. The substratum is dark gray or very dark gray sandy deposits.

The soils are permanently submerged with salt or brackish water. All horizons have a pH of neutral through strongly alkaline and a pH of extremely acid through slightly alkaline after 8 weeks. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

This soil is used for recreation and benthic wildlife habitat. Shellfish cultivation is important in these soils. Fishing is commonplace. Most areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover ranges from 0 to 85 percent.

900 – Navigational Channel

This miscellaneous area is on navigational channels. Mapped areas are expansive and range from 40 to 50 hectares (100 to 135 acres).

This miscellaneous area has intensive recreational use as a transit area for those destined for the marinas upriver. The area around Sandy Point where the federal channel enters Fishers Island Sound is an especially active and congested area, as boats leaving and entering the Bay must utilize this point.

910 – Sandy, mixed mesic Haplic Sulfaquents (river bottom)

This subaqueous soil is on river bottoms. Mapped areas are expansive and range from 40 to 60 hectares (100 to 150 acres). Slope ranges from 0 to 5 percent.

Included with this soil in mapping are small areas of subaqueous Napatree and Anguilla soils. Included areas make up about 15 percent of this map unit.

Typically, this soil has a firm, black sand surface layer, 0 to 10 cm thick. The substratum is very dark grayish brown sandy deposits.

This soil is permanently submerged with salt or brackish water. All horizons have a pH of slightly acid through slightly alkaline and a pH of extremely acid through strongly acid after 8 weeks. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >20 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

These soils contain sulfidic materials in the soil profile. If drained or dredged and exposed to air, sulfides will oxidize and create acid sulfate drainage causing serious environmental damage.

This soil is used for recreation and benthic wildlife habitat. Fishing is commonplace. Some areas are vegetated with native algae and eelgrass (*Zostera marina*). Vegetative cover is less than 35 percent.

Figure 12

Looking east on the Pawcatuck River at the sandy, mixed mesic Haplic Sulfaquents (river bottom) soil map unit. The area closer to the red buoy marks the start of the Navigational Channel.

Classification of the Soils

The *Keys to Soil Taxonomy* (the 10th edition) is the system of soil classification used by the National Cooperative Soil Survey. It has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family and series. In Table 4, the soils in the project area are classified according to this system.

Over the years, *Soil Taxonomy* has been modified and expanded to reflect the increased knowledge of the world's soils. This edition does not, however, reflect the proposed suborder classification for subaqueous soils called Wassents. In Table 5, the soils in the project area are classified according to the proposed system.

In this section, each proposed soil recognized in the mapping area is described. The descriptions are arranged in alphabetical order. Characteristics of the soil and the material in which it formed are identified. The soil is compared to similar soils and with nearby soils of other series. A pedon, a three-dimensional area of soil, which is typical of the soil found in the project area, is described following standards in the *Soil Survey Manual*. Unless otherwise stated, colors in the descriptions are for satiated soil. Following the pedon description is the range of important characteristics of the soils.

Anguilla series

The Anguilla series consists of subaqueous soils that formed in sandy marine deposits over outwash. Anguilla soils are adjacent to the mainland in areas that form a cove or embayment within the larger basin. Slope ranges from 0 to 5 percent.

Anguilla soils are near subaqueous Rhodesfolly, Napatree, and Quanaduck soils. The Rhodesfolly soils are sandy soils formed in sandy marine deposits with multiple buried horizons on bay bottoms, washover fans, and shore faces. Napatree soils are coarse-loamy soils with a capping of sandy marine deposits formed on submerged headlands. The Quanaduck soils are coarse-silty over sandy or sandy-skeletal soils formed on submerged inland bay coves.

TYPICAL PEDON: Anguilla mucky sand on a south facing, concave slope in a mainland cove under 1.1 m of estuarine water (Colors are for moist soil).

Ag—0 to 10 cm; black (N 2.5/) mucky sand; single grain; very fluid; 1 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline (30 ppt); neutral (pH 7.0); ultra acid (pH 3.4) after 8 weeks; clear boundary.

ACg—10 to 40 cm; very dark greenish gray (10Y 3/1) mucky sand; single grain; very fluid; 1 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline; neutral (pH 7.1); ultra acid (pH 3.2) after 8 weeks; abrupt boundary. (Combined thickness of A and AC horizons is 30 to 50 cm)

2Bwb—40 to 100 cm; olive brown (2.5Y 4/4) loamy sand; few fine prominent strong brown (7.5YR 4/6) masses of iron accumulation; single grain; nonfluid; 20 percent herbaceous fibers, 5 percent rubbed; 5 percent gravels; strongly saline; neutral (pH 7.0); very strongly acid (pH 4.9) after

8 weeks; abrupt boundary. (0 to 100 cm thick)

3Cgb—100 to 150 cm; very dark grayish brown (2.5Y 3/2) very gravelly coarse sand; single grain; nonfluid; 50 percent gravels; strongly saline; neutral (pH 7.0); strongly acid (pH 5.5) after 8 weeks.

The soils are permanently submerged. All horizons have a pH of neutral and a pH of ultra acid to strongly acid after 8 weeks incubation. Sulfidic materials occur within 50 cm of the soil surface. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt throughout the profile.

The Ag and ACg horizons, when present, have hues of 5Y, 10Y, or N, value of 2.5 or 3, and chroma of 0 through 3. Texture is silt loam, sandy loam, mucky sand, sand, or coarse sand. Consistence is very fluid. It has 5 to 15 percent organic matter. Herbaceous fibers are 0 to 5 percent unrubbed and 0 percent rubbed. Sulphurous odor is present.

The C and 2C horizons, when present, have hues of 5Y or 2.5Y, value of 3, and chroma of 3. Texture is sandy loam, loamy sand, sand, or coarse sand in the fine earth fraction. Consistence is nonfluid. Gravel content is 0 to 20 percent.

The 2Bwb horizon, when present, has hue of 5Y or 2.5Y, value of 4, and chroma of 4. Texture is sandy loam, loamy sand, sand, or coarse sand. Consistence is nonfluid. Gravel content is 0 to 10 percent.

The 2Cgb and 3Cgb horizon, when present, have hues of 5Y or 2.5Y, value of 3, and chroma of 2 or 3. Texture is sandy loam, loamy sand, sand, or coarse sand in the fine earth fraction. Consistence is nonfluid. Gravel content is 0 to 55 percent.

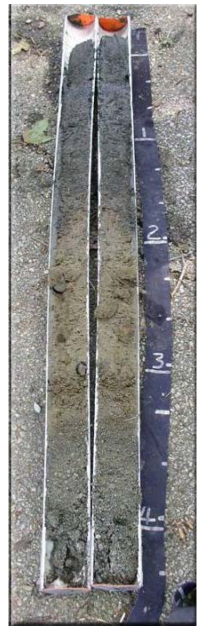


Figure 13
Vibracore sample of the proposed Anguilla series.

Histosols

The Histosols consists of subaqueous soils that are formed in submerged organic materials underlain by loamy deposits. These soils are formed in submerged tidal marshes. Slope ranges from 0 to 2 percent.

These soils are near Napatree, Quanaduck, and Anguilla soils. All of these soils lack thick buried organic deposits. Quanaduck soils are on mainland cove landforms and have a contrasting particle-size class family of coarse-silty over sandy or sandy-skeletal. Napatree soils are on submerged headland landforms, have an Aeric subgroup, and do not have sulfidic materials. Anguilla soils are on mainland cove landforms and have a particle-size class family of sandy.

TYPICAL PEDON: Histosols on a south facing, concave slope in a submerged stream valley under 1.3 m of estuarine water (Colors are for moist soil).

Oa1—0 to 7 cm; black (7.5YR 2.5/1) muck; massive; very fluid; 15 percent herbaceous fibers, 2 percent rubbed; strongly saline (19 ppt); neutral (pH 6.9); moderately acid (pH 5.6) after 8 weeks; clear boundary.

Oa2—7 to 33 cm; black (5YR 2.5/1) muck; massive; very fluid; 20 percent herbaceous fibers, 5 percent rubbed; strongly saline; neutral (pH 7.0); moderately acid (pH 5.8) after 8 weeks; clear boundary.

Oe—33 to 56 cm; very dark brown (7.5YR 2.5/2) mucky peat; massive; very fluid; 35 percent herbaceous fibers, 20 percent rubbed; sulphurous odor; neutral (pH 7.0); moderately acid (pH 6.0) after 8 weeks; strongly saline; clear boundary.

Oa—56 to 68cm; black (5YR 2.5/1) mucky muck; massive; very fluid; 10 percent herbaceous fibers, 2 percent rubbed; sulphurous odor; neutral (pH 6.9); slightly acid (pH 6.1) after 8 weeks; strongly saline; abrupt boundary.

2Cg1—68 to 71 cm; dark grayish brown (10YR 4/2) fine sandy loam; massive; nonfluid; 2 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline; neutral (pH 7.0); slightly acid (pH 6.5) after 8 weeks; abrupt boundary.

2Cg2—71 to 78 cm; dark brown (7.5Y 3/2) silt loam; massive; nonfluid; 2 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline; neutral (pH 7.0); moderately acid (pH 5.6) after 8 weeks; abrupt boundary.

2Cg3—78 to 85 cm; very dark grayish brown (2.5Y 3/2) coarse sandy loam; massive; nonfluid; 1 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline; neutral (pH 7.0); extremely acid (pH 4.2) after 8 weeks; abrupt boundary.

2Cg4—85 to 88 cm; dark grayish brown (2.5Y 4/1) sandy loam; massive; nonfluid; 1 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline; neutral (pH 7.0); extremely acid (pH 3.8) after 8 weeks; abrupt boundary.

2Cg5—88 to 100 cm; dark grayish brown (2.5Y 4/1) silt loam; massive; nonfluid; sulphurous odor; strongly saline; neutral (pH 7.0); extremely acid (pH 3.8) after 8 weeks; abrupt boundary.

This soil is permanently submerged with salt or brackish water. All horizons have a pH of neutral and a pH of ultra acid through slightly acid after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

The Oa and Oe horizons (2Oab or 2Oeb when present) have hues of 5YR through 10YR, value of 2 or 3, and chroma of 1 through 3. It is muck or mucky peat. Organic matter is 40 to 70 percent. Consistence is very fluid. Sulphurous odor is present.

The Ag horizon, when present, has hue of N or 2.5Y, value of 2.5, and of chroma 0 or 1. Textures are mucky silt loam through silt loam. Organic matter is 5 to 15 percent. Consistence is very fluid. Sulphurous odor is present.

The Cg and 2Cg horizons, when present, have hues of N, 2.5Y or 5Y, value of 2 through 3, and chroma of 0 through 2.5. Textures are mucky silt loam through sandy loam. Consistence is nonfluid. Sulphurous odor is present.

Figure 14
Vibracore sample of a submerged tidal marsh soil.

Napatree series

The Napatree series consists of subaqueous soils that formed in sandy marine deposits overlying glacial till materials. Napatree soils are found in bouldery, glacial deposits adjacent to uplands. Slope ranges from 0 to 2 percent.

Napatree soils are near subaqueous Quanaduck and Anguilla soils. Quanaduck soils are coarse-silty over sandy or sandy-skeletal soils formed on submerged inland bay coves. The Anguilla soils are sandy soils formed in sandy marine deposits over outwash on submerged inland bay coves.

TYPICAL PEDON: Napatree sand on a south facing, bouldery 2 percent slope in a submerged headland under 1.6 m of estuarine water (Colors are for moist soil).

Ag—0 to 20 cm; black (N 2.5/) sand; single grain; nonfluid; many fine distinct olive brown (2.5Y 4/4) iron accumulations; 10 percent gravels; 5 percent shell fragments; sulphurous odor; strongly saline (28ppt); neutral (pH 6.9); very strongly acid (pH 5.0) after 8 weeks; clear boundary. (15 to 30 cm thick)

C1—20 to 32 cm; olive brown (2.5Y 4/3) loamy sand; single grain; nonfluid; 10 percent gravels; strongly saline; neutral (pH 6.9); moderately acid (pH 6.0) after 8 weeks; clear boundary.

C2—32 to 45 cm; olive brown (2.5Y 4/3) gravelly sandy loam; massive; nonfluid; common fine faint olive brown (2.5Y 4/4) masses of iron accumulation; 18 percent gravels; strongly saline; neutral (pH 7.2); very strongly acid (pH 6.2) after 8 weeks; abrupt boundary. (Combined thickness of the C horizons is 20 to 35 cm thick).

2Cgb1—45 to 58 cm; dark grayish brown (2.5Y 4/2) silt loam; massive; nonfluid; many fine distinct gray (5Y 5/1) iron depletions; strongly saline; slightly alkaline (pH 7.4); neutral (pH 6.8) after 8 weeks; clear boundary.

2Cgb2—58 to 65 cm; gray (5Y 5/1) silt loam; massive; nonfluid; common fine distinct light olive brown (5Y 5/4) iron accumulations; strongly saline; slightly alkaline (pH 7.4); neutral (pH 6.8) after 8 weeks; abrupt boundary. (Combined thickness of the 2Cg horizons is 10 to 50 cm thick).

3Cgb1—65 to 120 cm; dark grayish brown (2.5Y 4/2) very gravelly loamy sand; single grain; nonfluid; 40 percent gravels; strongly saline; neutral (pH 7.2); neutral (pH 6.9) after 8 weeks.

The soils are permanently submerged except for some of the surface boulders that are exposed to the air during low tides. All horizons have a pH of neutral through slightly alkaline and a pH of very strongly acid through neutral after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >20 ppt (strongly saline) throughout the profile.

The Ag and ACg horizons, when present, have hues of N, 5GY, or 10YR, value of 2.5 or 3, and chroma of 0 through 2. It is sandy loam, loamy coarse sand, sand, or coarse sand. Organic matter is 0 to 2 percent. Consistence is nonfluid. Gravel content is 0 to 10 percent. Shell fragment content is 0 to 10 percent. Sulphurous odor may or may not be present. Redoximorphic features may or may not be present.

The C horizon has hue of 2.5Y or 5Y, value of 4, and chroma of 3 or 4. It is sandy loam or loamy sand along with gravelly analogs. Consistence is nonfluid. Gravel content is 0 to 20 percent.

The 2Cgb horizon has hue of 10YR, 10Y, 2.5Y or 5Y, value of 4 or 5, and chroma of 1 through 2. It is silt loam, fine sandy loam, loamy fine sand, and loamy sand. Consistence is nonfluid. Gravel content is 0 to 10 percent.

The 3Cgb horizon, when present, has hue of 10YR, 10Y, 2.5Y or 5Y, value of 4 or 5, and chroma of 1 through 2. It is very fine sandy loam and loamy sand along with gravelly or very gravelly analogs. Consistence is nonfluid. Gravel content is 0 to 40 percent.

The 2Cb horizon, when present, has hue of 10YR, 2.5Y or 5Y, value of 3 or 4, and chroma of 3 or 4. It is loamy sand, loamy coarse sand, loamy very coarse sand, sand, or coarse sand. Consistence is nonfluid. Gravel content is 0 to 5 percent.

Figure 15
Vibracore sample of the proposed Napatree series.

Quanaduck series

The Quanaduck series consists of subaqueous soils that formed in loamy marine deposits underlain by sandy or sandy-skeletal materials. Quanaduck soils are found in mainland coves. Slope ranges from 0 to 2 percent.

Quanaduck soils are near subaqueous Wequetequock, Wamphassuc, Napatree, and Anguilla soils. Wequetequock and Wamphassuc soils are on submerged stream valleys and do not have a contrasting family particle-size control section. Napatree soils are on submerged headland landforms, have an Aeric subgroup, and do not have sulfidic materials. Anguilla soils are on mainland cove landforms and are dominated by textures coarser than loamy fine sand.

TYPICAL PEDON: Quanaduck silt loam on a south facing, 2 percent slope in a mainland cove under 1.2 m of estuarine water (Colors are for moist soil).

Ag—0 to 30 cm; black (N 2.5/) silt loam; dark gray (5Y 4/1) dry; massive; very fluid; 20 percent herbaceous fibers, 1 percent rubbed; sulphurous odor; strongly saline (30 ppt); moderately alkaline (pH 8.2); strongly acid (pH 5.5) after 8 weeks; clear boundary.

ACg—30 to 39 cm; black (N 2.5/) silt loam; very dark grayish brown (10YR 3/2) dry; massive; moderately fluid; 20 percent herbaceous fibers, 0 percent rubbed; 1 percent gravels; sulphurous odor; strongly saline; slightly alkaline (pH 7.6); slightly acid (pH 6.4) after 8 weeks; clear boundary.

Cg1—39 to 46 cm; 50 percent dark grayish brown (10YR 4/2) and 50 percent very dark greenish gray (10Y 3/1) sandy loam; dark gray (10YR 4/1) dry; massive; moderately fluid; 20 herbaceous fiber, 0 percent rubbed; 7 percent gravels; sulphurous odor; strongly saline; slightly alkaline (pH 7.6); slightly acid (pH 6.4) after 8 weeks; clear boundary.

Cg2—46 to 54 cm; very dark greenish gray (10Y 3/1) coarse sand; dark grayish brown (10YR 4/2) dry; massive; nonfluid; 5 percent herbaceous fibers, 0 percent rubbed; 6 percent gravels; sulphurous odor; strongly saline; slightly alkaline (pH 7.8); moderately acid (pH 5.9) after 8 weeks; abrupt boundary.

Cg3—54 to 58 cm; dark greenish gray (5G 4/1) gravelly coarse sand; grayish brown (10YR 5/2) dry; single grain; nonfluid; 2 percent herbaceous fibers, 0 percent rubbed; 15 percent gravels; sulphurous odor; strongly saline; moderately alkaline (pH 8.0); moderately acid (pH 5.9) after 8 weeks; abrupt boundary. (Combined thickness of the Cg horizons is about 10 to 20 cm)

Agb—58 to 66 cm; very dark greenish gray (10Y 3/1) coarse sand; light olive brown (2.5Y 5/3) dry; massive; nonfluid; 5 percent herbaceous fibers, 0 percent rubbed; 14 percent gravels; sulphurous odor; strongly saline; slightly alkaline (pH 7.6); moderately acid (pH 5.6) after 8 weeks; gradual boundary.

Cg’1—66 to 72 cm; very dark greenish gray (10Y 3/1) gravelly coarse sand; light brownish gray (2.5Y 6/2) dry; single grain; nonfluid; 2 percent herbaceous fibers, 0 percent rubbed; 26 percent gravels; sulphurous odor; strongly saline; slightly alkaline (pH 7.4); moderately acid (pH 6.0) after 8 weeks; abrupt boundary.

Cg’2—72 to 82 cm; dark greenish gray (10GY 4/1) loamy coarse sand; light bluish gray (5PB 7/1) dry; single grain; nonfluid; 8 percent gravels; sulphurous odor; strongly saline; slightly alkaline (pH 7.8); strongly acid (pH 5.5) after 8 weeks; abrupt boundary.

Cg’3—82 to 86 cm; 50 percent dark greenish gray (10Y 4/1) and 50 percent dark greenish gray (10GY 4/1) coarse sandy loam; light greenish gray (10Y 7/1) dry; single grain; nonfluid; 7 percent gravels; sulphurous odor;

slightly alkaline (pH 7.6); extremely acid (pH 4.0) after 8 weeks; strongly saline; abrupt boundary. (Combined thickness of Cg' horizons is about 5 to 20 cm)

2Cgb1—86 to 107 cm; gray (N 5/) silt loam; light gray (5Y 7/1) dry; massive; nonfluid; 5 percent gravels; strongly saline; slightly alkaline (pH 7.6); slightly acid (pH 6.4) after 8 weeks; clear boundary.

2Cgb2—107 to 120 cm; dark gray (2.5Y 4/1) sandy loam; light gray (2.5Y 7/1) dry; massive; nonfluid; 14 percent gravels; strongly saline; slightly alkaline (pH 7.8); moderately acid (pH 5.8) after 8 weeks; gradual boundary.

2Cgb3—120 to 155 cm; dark gray (2.5Y 4/1) silt loam; light gray (5Y 7/1) dry; massive; nonfluid; 13 percent gravels; strongly saline; slightly alkaline (pH 7.8); moderately acid (pH 6.0) after 8 weeks. (Combined thickness of the 2Cgb horizons is about 20 to 70 cm)

The soils are permanently submerged. All horizons have a pH of slightly alkaline through moderately alkaline and a pH of ultra acid through slightly acid after 8 weeks incubation. One or more horizons below 50 cm and within 100 cm of the soil surface have a pH of 4.0 or less after 8 weeks incubation. Depth to first lithologic discontinuity ranges from 80 to 100 cm. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile.

The Ag and ACg horizons, when present, have hues of N, 2.5Y, 10Y or 10YR, value of 2.5 through 4, and chroma of 0 through 2. Textures are muck silt loam, silt loam, fine sandy loam and sandy loam. Gravel content is 0 to 10 percent. Organic matter is 5 to 15 percent. Herbaceous fibers are 0 to 20 percent unrubbed and 0 to 5 percent rubbed. Consistence is moderately fluid or very fluid. Sulphurous odor is present.

The Cg horizon has hue of N, 5G, 2.5Y, 10Y or 10GY, value of 3 through 6, and chroma of 0 or 1. Textures are sandy loam through coarse sand along with gravelly analogs. Gravel content is 0 to 30 percent. Consistence is nonfluid.

The Agb horizon has hue of 10Y or 2.5Y, value of 3, and chroma of 1. Textures are mucky fine sandy loam through coarse sand along with gravelly analogs. Gravel content is 0 to 20 percent. Herbaceous fibers are 0 to 10 percent unrubbed and 0 to 5 percent rubbed. Organic matter is 5 to 15 percent. Consistence is slightly fluid through nonfluid. Sulphurous odor is present.

The 2Cgb horizon has hue of N or 2.5Y, value of 4 or 5, and chroma of 0 or 1. Textures are silt loam and sandy loam along with gravelly analogs. Gravel content is 0 to 20 percent. Consistence is nonfluid.

Figure 16
Vibracore sample of the proposed Rhodesfolly series.

Rhodesfolly series

The Rhodesfolly series consists of subaqueous soils that are formed in sandy marine deposits. Rhodesfolly soils are found in bay bottoms, washover fan-flats, and shore faces. Slope ranges from 0 to 5 percent.

Rhodesfolly soils are near subaqueous Napatree and Anguilla soils. Napatree soils are in submerged headland landforms and have an Aeric subgroup. Anguilla soils are in mainland cove landforms and have sulfidic materials within 50 cm of the soil surface.

TYPICAL PEDON: Rhodesfolly fine sand on a north facing, nearly level slope in a shoreface under 1.3 m of estuarine water (Colors are for moist soil).

Ag—0 to 13 cm; very dark gray (N 3/) fine sand; white (5Y 8/1) dry; single grain; nonfluid; 4 percent gravels; 2 percent shell fragments; sulphurous odor; strongly saline (32 ppt); slightly alkaline (pH 7.6), slightly alkaline (pH 7.6) after 8 weeks; abrupt boundary. (0 to 23 cm thick)

Cg —13 to 20 cm; dark gray (5Y 4/1) coarse sand; light greenish gray (10Y 7/1) dry; single grain; nonfluid; 12 percent gravels; 20 percent mixed white and blue mussel shell fragments sulphurous odor; strongly saline; moderately alkaline (pH 8.0); slightly alkaline (pH 7.8) after 8 weeks; abrupt boundary. (Thickness of the Cg horizons is 6 to 68 cm thick)

Agb —20 to 29 cm; black (N 2.5/) coarse sand; greenish gray (10Y 6/1) dry; single grain; nonfluid; 5 percent herbaceous fibers, 0 percent rubbed; 6 percent gravels; 50 percent shell fragments; sulphurous odor; strongly saline; moderately alkaline (pH 8.2); slightly alkaline (pH 7.6) after 8 weeks; abrupt boundary. (Thickness of the Ab horizons is 4 to 22 cm thick)

C'g1—29 to 39 cm; very dark gray (2.5Y 3/1) coarse sand; greenish gray (10Y 6/1) dry; single grain; nonfluid; 7 percent gravels; 10 percent white mussel shell fragments; strongly saline; moderately alkaline (pH 8.4); slightly alkaline (pH 7.6) after 8 weeks; clear boundary.

C'g2 --39 to 61 cm; gray (N 5/) coarse sand; light gray (N 7/) dry; single grain; nonfluid; 1 percent gravels; 2 percent shell fragments; sulphurous odor; strongly saline; strongly alkaline (pH 8.6); slightly alkaline (pH 7.5) after 8 weeks; clear boundary.

A'gb—61 to 72 cm; very dark gray (2.5Y 3/1) coarse sand; gray (N 6/) dry; single grain; nonfluid; 3 percent herbaceous fibers, 0 percent rubbed; 3 percent gravels; 20 percent mussel shell fragments; sulphurous odor; strongly saline; strongly alkaline (pH 8.7); slightly alkaline (pH 7.6) after 8 weeks; clear boundary.

C''g —72 to 78 cm; dark gray (2.5Y 4/1) coarse sand; gray (N 6/) dry; single grain; nonfluid; 11 percent gravel; sulphurous odor; strongly saline; moderately alkaline (pH 8.6); slightly alkaline (pH 7.7) after 8 weeks; abrupt boundary.

A'''gb1—78 to 82 cm; very dark gray (2.5Y 3/1) gravelly coarse sand; gray (N 6/) dry; single grain; nonfluid; 1 percent herbaceous fibers, 0 percent rubbed; 22 percent gravels; 25 percent soft shell clam fragments; sulphurous odor; strongly saline; moderately alkaline (pH 8.4); slightly alkaline (pH 7.6) after 8 weeks; abrupt boundary.

A’’’gb2 --82 to 92 cm; greenish black (10Y 2.5/1) fine sand; gray (5Y 5/1) dry; single grain; nonfluid; 2 percent herbaceous fibers, 0 percent rubbed; 22 percent gravels; sulphurous odor; strongly saline; moderately alkaline (pH 8.3); slightly acid (pH 6.3) after 8 weeks; abrupt boundary.

C’’’g—92 to 150 cm; dark gray (5Y 4/1) fine sand; gray (5Y 6/1) dry; single grain; nonfluid; sulphurous odor; strongly saline; moderately alkaline (pH 8.4); slightly acid (pH 6.2) after 8 weeks.

The soils are permanently submerged. All horizons have a pH of neutral through strongly alkaline and a pH of very strongly acid through slightly alkaline after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile.

The Ag and ACg horizons, when present, have hues of N or 10Y, value of 2.5 or 3, and chroma of 0 or 1. Textures include loamy fine sand through coarse sand. Organic matter is 0 to 2 percent. Gravel content is 0 to 10 percent. Shell fragment content is 0 to 10 percent. Consistence is nonfluid.

The CAg horizon, when present, has hue of 5Y, value of 3 through 6, and chroma of 0 through 2. Textures include sandy loam through sand. Gravel content is 0 to 5 percent. Consistence is nonfluid.

The Agb horizon has hue of N, 7.5YR, 5Y, 10Y or 2.5Y, value of 2.5 or 3, and chroma of 0 through 2. Textures include very fine sandy loam, fine sand, mucky sand, sand, or coarse sand in the fine earth fraction. Organic matter is 0 to 2 percent. Gravel content is 0 to 25 percent. Shell fragment content is 0 to 50 percent. Herbaceous fibers are 0 to 10 percent unrubbed and 0 to 5 percent rubbed. Consistence is nonfluid.

The Cg horizon has hue of 5Y, 10Y, 2.5Y or N, value of 2.5 through 5, and chroma of 0 through 2. Textures include loamy sand through coarse sand in the fine earth fraction. Gravel content is 0 to 20 percent. Shell fragment content is 0 to 40 percent. Consistence is nonfluid.

The 2Cg horizon, when present, has hue of 5Y, value of 2 through 5, and chroma of 0 through 2. Textures include sandy loamy through sand. Gravel content is 0 to 5 percent. Consistence is nonfluid.

Figure 17
Vibracore sample of the proposed Rhodesfolly series.

Sandy, mixed, mesic Haplic Sulfaquents

The sandy, mixed, mesic Haplic Sulfaquents consist of subaqueous soils that are formed in sandy marine sediments. These soils are found in bay and river bottoms. Slope ranges from 0 to 5 percent.

These soils are near subaqueous Rhodesfolly, Napatree, and Anguilla soils. Rhodesfolly soils are in bay bottoms, washover fans, and shore faces and do not have sulfidic materials. Anguilla soils are in mainland cove landforms. Napatree soils are in submerged headland landforms, have an Aeric subgroup, and do not have sulfidic materials.

TYPICAL PEDON: Haplic Sulfaquents on a north facing, 2 percent slope in a bay bottom under 1.2 m of estuarine water (Colors are for moist soil.)

Ag—0 to 10 cm; black (2.5Y 2.5/1) gravelly coarse sand; single grain; nonfluid; 22 percent gravels; sulphurous odor; strongly saline; neutral (pH 7.3); very strongly acid (pH 5.0) after 8 weeks; abrupt boundary.

Cg1—10 to 24 cm; 80 percent very dark grayish brown (2.5Y 3/2) and 10 percent black (2.5Y 2.5/1) gravelly coarse sand; single grain; nonfluid; 25 percent gravels; sulphurous odor; strongly saline; neutral (pH 7.3); very strongly acid (pH 5.0) after 8 weeks; abrupt boundary.

Cg2—24 to 32 cm; 60 percent olive gray (5Y 4/2), 30 percent dark olive gray (5Y 3/2) and 10 percent black (2.5Y 2.5/1) gravelly loamy coarse sand; single grain; nonfluid; 19 percent gravels; no sulphurous odor; strongly saline; neutral (pH 7.1); extremely acid (pH 4.3) after 8 weeks; clear boundary.

Cg3—32 to 39 cm; 85 percent very dark grayish brown (2.5Y 3/2) and 15 percent dark grayish brown (2.5Y 4/2) gravelly sand; single grain; nonfluid; 23 percent gravels; no sulphurous odor; strongly saline; neutral (pH 6.9); extremely acid (pH 3.5) after 8 weeks; abrupt boundary.

Cg4—39 to 54 cm; 85 percent very dark grayish brown (2.5Y 3/2) and 15 percent dark grayish brown (2.5Y 4/2) very gravelly coarse sand; single grain; nonfluid; 41 percent gravels; no sulphurous odor; strongly saline; slightly acid (pH 6.4); ultra acid (pH 3.3) after 8 weeks; abrupt boundary.

Cg5—54 to 60 cm; dark gray (2.5Y 4/1) gravelly coarse sand; single grain; nonfluid; 25 percent gravels; no sulphurous odor; strongly saline; neutral (pH 6.6); extremely acid (pH 4.2) after 8 weeks.

This soil is permanently submerged with salt or brackish water. All horizons have a pH of slightly acid through slightly alkaline and a pH of ultra acid through strongly acid after 8 weeks. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >20 ppt (strongly saline) for river bottoms and >25 ppt (strongly saline) for bay bottoms throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity.

The Ag horizon has hue of N, 5Y, and 2.5Y, value of 2 or 2.5, chroma of 0 or 1. Texture is loamy sand through sand. Consistence is nonfluid. Organic matter is 0 to 2 percent. Sulphurous odor is present.

The CAg horizon, when present, has hue of N, 5Y, and 2.5Y, value of 2 through 3, chroma of 1 or 2. Texture is loamy sand through sand. Consistence is nonfluid. Sulphurous odor is present.

The Cg horizon has hue of 5Y and 2.5Y, value of 3 or 4, and chroma of 1 or 2. Textures are loamy sand through coarse sand along with gravelly analogs. Consistence is nonfluid. Gravel content is 0 to 30 percent.

Typic Psammaquents

The Typic Psammaquents consist of subaqueous soils that are formed in sandy marine sediments. These soils are found on shore complexes. Slope ranges from 0 to 5 percent.

These soils are near subaqueous Rhodesfolly soils. Rhodesfolly soils are in bay bottoms, washover fans, and shore faces and have an irregular decrease in organic carbon from a depth of 25 to 125 cm.

TYPICAL PEDON: Typic Psammaquents on a south facing, convex slope on a shore complex under 2.0 m of estuarine water (Colors are for moist soil.)

Cg1—0 to 20 cm; dark gray (5Y 4/1) sand; single grain; nonfluid; strongly saline; slightly alkaline (pH 7.4); neutral (pH 7.1) after 8 weeks; gradual boundary.

Cg2—20 to 40 cm; dark gray (N 4/) coarse sand; single grain; nonfluid; strongly saline; slightly alkaline (pH 7.6); neutral (pH 7.3) after 8 weeks.

The soils are permanently submerged with salt or brackish water. All horizons have a pH of neutral to strongly alkaline and a pH of very strongly acid through slightly alkaline after 8 weeks. Electrical conductivity is >16 mmhos/cm and salinity is >25 ppt (strongly saline) throughout the profile. This soil has a peraquic moisture regime and high to very high saturated hydraulic conductivity

The Ag and ACg, when present, have hues of N, 5Y, and 2.5Y, value of 2 through 4, chroma of 0 or 1. Texture is loamy sand through sand. Consistence is nonfluid. Organic matter is 0 to 2 percent. Gravel content is 0 to 10 percent

The Cg horizon has hue of N, 5Y, or 2.5Y, value of 3 or 4, and chroma of 0 through 2. Textures are loamy sand through coarse sand along with gravelly analogs. Consistence is nonfluid. Gravel content is 0 to 30 percent.

Udipsamments

The Udipsamments consist of excessively drained soils that are formed in sandy beach deposits. These soils are found on barrier islands and coastal dunes. Slope ranges from 0 to 8 percent.

These soils are near, Merrimac (somewhat excessively drained, more soil profile development), Hinckley (sandy-skeletal, more soil profile development), Windsor (more soil profile development), Ipswich (very poorly drained organic soil), Pawcatuck (very poorly drained organic materials over sandy or sandy skeletal), Westbrook (very poorly drained organic materials over loamy), and Rhodesfolly (subaqueous soil).

TYPICAL PEDON: Udipsamments.

C1—0 to 96 cm; 85 percent very light brownish gray (2.5Y 6/2), 10 percent yellow (2.5Y 7/6) and 5 percent black (10 YR 2/1) sand; single grain; loose; few fine and medium roots; moderately acid; clear smooth boundary.

C2—96 to 127 cm; 85 percent light brownish gray (2.5Y 6/2), 10 percent yellow (2.5Y 7/6) and 5 percent black (10 YR 2/1) coarse sand; single grain; loose; slightly acid; abrupt smooth boundary.

C2—127 to 165 cm; 50 percent light olive brown (2.5Y 5/4) and 50 percent olive yellow (2.5Y 6/6) sand; single grain; loose; neutral.

The soils are excessively drained. All horizons have a pH of slightly acid through moderately alkaline.

The C horizon has hue of 5Y or 10YR, value of 2 through 7, chroma of 1 through 6. Texture is fine sand, sand or coarse sand. Reaction is moderately acid to neutral. Rock fragment content is 0 to 34 percent. Depth to bedrock is more than 200 cm.

Wamphassuc series

The Wamphassuc series consists of subaqueous soils that are formed in loamy marine deposits. Wamphassuc soils are found in permanently submerged stream valleys and terraces. Slope ranges from 0 to 2 percent.

Wamphassuc soils are near subaqueous Wequetequock, Quanaduck, Napatree, and Anguilla soils. Wequetequock soils have an n-value greater than 0.7 in all horizons. Quanaduck and Anguilla soils are in mainland cove landforms and are dominated by textures coarser than loamy fine sand in the series control section. Napatree soils are in submerged headland landforms, have an Aeric subgroup, and do not have sulfidic materials.

TYPICAL PEDON: Wamphassuc mucky silt loam on a north facing, nearly level slope in a submerged stream valley under 0.6 m of estuarine water (Colors are for moist soil).

Ag1—0 to 15 cm; black (10YR 2/1) mucky silt loam; massive; very friable, nonsticky, nonplastic, very fluid; about 90 percent mineral content; sulphurous odor; strongly saline (24 ppt); neutral (pH 7.1); extremely acid (pH 4.4) after 8 weeks; gradual boundary.

ACg1—15 to 27 cm; black (10YR 2/1) mucky silt loam; massive; very friable, nonsticky, nonplastic, very fluid; 2 percent herbaceous fibers, 0 percent rubbed; sulphurous odor; strongly saline (23 ppt); slightly alkaline (pH 7.4); extremely acid (pH 4.3) after 8 weeks; gradual boundary.

ACg2—27 to 39 cm; greenish black (5GY 2.1/1) mucky silt loam; massive; very friable, nonsticky, nonplastic, very fluid; sulphurous odor; strongly saline (29 ppt); slightly alkaline (pH 7.6); extremely acid (pH 4.1) after 8 weeks; clear boundary.

Cg1—39 to 78 cm; very dark greenish gray (10Y 3/1) silt loam; massive; friable, nonsticky, nonplastic, nonfluid; 5 percent herbaceous fibers, 0 percent rubbed; 1 percent gravels; sulphurous odor; strongly saline (20 ppt); neutral (pH 7.3); extremely acid (pH 3.8) after 8 weeks; abrupt boundary.

Cg2—78 to 91 cm; very dark brown (10YR 2/1) sandy loam; massive; friable, nonsticky, nonplastic, nonfluid; 15 percent herbaceous fibers, 0 percent rubbed; 1 percent gravels; sulphurous odor; strongly saline (26 ppt); neutral (pH 7.2); extremely acid (pH 3.7) after 8 weeks; clear boundary.

Cg3—91 to 112 cm; very dark brown (10YR 2/1) fine sandy loam; massive; friable, nonsticky, nonplastic, nonfluid; 10 percent herbaceous fibers, 0 percent rubbed; strongly saline (20 ppt); neutral (pH 7.1); extremely acid (pH 4.3) after 8 weeks; clear boundary.

Cg4—112 to 122 cm; black (2.5Y 2.5/1) sandy loam; massive; friable, nonsticky, nonplastic, nonfluid; 5 percent herbaceous fibers, 0 percent rubbed; strongly saline (27 ppt); neutral (pH 7.1); extremely acid (pH 4.3) after 8 weeks; clear boundary.

2Cg—122 to 140 cm; black (7.5YR 2.5/1) gravelly loamy coarse sand; single grain; loose; nonsticky, nonplastic, nonfluid; 16 percent gravels; strongly saline (18 ppt); neutral (pH 7.1); extremely acid (pH 3.6) after 8 weeks.

The soils are permanently submerged. All horizons have a pH of strongly acid through moderately alkaline and ultra acid through very strongly acid after 8 weeks incubation. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile.

The Ag and ACg horizon has hue of N, 10Y, 5Y, 2.5Y, and 10YR, value of 2 or 3, chroma of 0 or 1. Texture is mucky silt loam or silt loam. Consistence is very fluid. Organic matter is 5 to 15 percent. Sulphurous odor is present.

The Cg horizon has hues of N, 10YR, 2.5Y, 5Y, or 5GY, value of 2 through 5, and chroma of 0 through 2. Textures are mucky silt loam through sandy loam along with gravelly analogs. Consistence is slightly fluid through nonfluid. Gravel content is 0 to 25 percent.

The 2Cg and 3Cg horizons, when present, have hues of N, 10YR, 2.5Y, 5Y, or 5GY, value of 2 through 5, and chroma of 0 through 2. Textures are loamy sand through coarse sand along with gravelly analogs. Consistence is nonfluid. Gravel content is 0 to 25 percent.

The C or 2C horizons, when present, have hues of 5Y, value of 4, and chroma of 3. Textures are fine sandy loam through loamy sand. Consistence is nonfluid. Gravel content is 0 to 10 percent.

Figure 18
Vibracore sample of the proposed Wamphassuc series.

Wequetequock series

The Wequetequock series consists of subaqueous soils that are formed in loamy marine deposits. Wequetequock soils are formed in permanently submerged stream valleys and terraces. Slope ranges from 0 to 2 percent.

Wequetequock soils are near Anguilla, Napatree, Quanaduck, and Wamphassuc soils. Anguilla soils are on mainland cove landforms and have a contrasting particle-size class family of sandy. Napatree soils are on submerged headland landforms, have an Aeric subgroup, and do not have sulfidic materials. Quanaduck soils are on mainland cove landforms and have a contrasting particle-size class family of coarse-loamy over sandy or sandy-skeletal. The Wamphassuc soils have an n-value of 0.7 or less and/or less than 8 percent clay in some horizons at a depth between 20 and 50 cm below the mineral soil surface.

TYPICAL PEDON: Wequetequock silt loam on a south facing, concave slope in a submerged stream valley under 1.3 m of estuarine water (Colors are for moist soil).

Ag—0 to 15 cm; black (N 2.5/) silt loam; massive; very fluid; 5 percent unrubbed and 5 percent rubbed herbaceous fibers; sulphurous odor; strongly saline (30 ppt); slightly acid (pH 6.3); very strongly acid (pH 4.7) after 8 weeks; clear boundary.

Cg1—15 to 40 cm; black (N 2.5/) silt loam; massive; very fluid; 1 percent unrubbed and 0 percent rubbed herbaceous fibers; sulphurous odor; strongly saline; moderately acid (pH 5.8); very strongly acid (pH 4.9) after 8 weeks; clear boundary.

Cg2—40 to 60 cm; very dark gray (2.5Y 3/1) silt loam; single grain; moderately fluid; sulphurous odor; strongly saline; very strongly acid (pH 4.9); extremely acid (pH 4.0) after 8 weeks; clear boundary.

Cg3—60 to 105 cm; very dark gray (2.5Y 3/1) sandy loam; massive; moderately fluid; 6 percent gravels; sulphurous odor; strongly saline; ultra acid (pH 3.1); ultra acid (pH 2.6) after 8 weeks; abrupt boundary. (20 to 90 cm thick)

2Oeb—105 to 150 cm; dark brown (7.5YR 3/3) muck, broken face sapric material, very dark grey (10YR 3/1) rubbed; massive; very fluid; about 48 percent mineral content; 16 percent unrubbed and 2 percent rubbed herbaceous fibers; 2650 +/- 40 BP measured and 2600 +/- 40 BP conventional radiocarbon age; sulphurous odor; neutral (pH 6.6);

neutral (pH 6.6) after 8 weeks; strongly saline. (20 to 45 cm thick)

The soils are permanently submerged. One or more horizons within 50 cm have a pH of 4.0 or less after 8 weeks incubation. Some pedons are underlain by organic deposits greater than 100 cm from the soil surface and/or have thin layers less than 20 cm thick of organic deposits in the soil profile. Electrical conductivity is >16 mmhos/cm and salinity is >18 ppt (strongly saline) throughout the profile.

The Ag or ACg horizon, when present, has hue of N or 2.5Y, value of 2.5, and of chroma 0 or 1. Textures are mucky silt loam or silt loam. Organic matter is 5 to 15 percent. Consistence is very fluid. Reaction is very strongly acid through slightly alkaline and ultra acid through moderately acid after 8 weeks incubation.

The Cg, 2Cg, and 3Cg horizons, when present, have hues of 2.5Y or 5Y, value of 2 through 3, and chroma of 1 or 2. Textures are mucky silt loam through sandy loam. Gravel content is 0 to 20 percent. The consistence of the Cg is slightly fluid through very fluid. The consistence of the 2Cg and 3Cg is nonfluid through slightly fluid. Reaction is ultra acid through moderately alkaline and ultra acid through slightly acid after 8 weeks incubation.

The 2Oab and 2Oeb horizons, when present, have hues of 10YR through 5YR, value of 2 or 3, and chroma of 1 through 3. It is muck or mucky peat. Organic matter is 40 to 70 percent. Consistence is moderately fluid or very fluid. Reaction is neutral through moderately alkaline and extremely acid through moderately alkaline after 8 weeks incubation.

The C horizon, when present, has hue of 2.5Y, value of 4, and chroma of 3. Texture is sandy loam through loamy coarse sand. Gravel content is 0 to 25 percent. Reaction is ultra acid through moderately alkaline and ultra acid through slightly acid after 8 weeks incubation.

Figure 19
Vibracore sample of the proposed Wequetequock series.

This soil report is an inventory and evaluation of the soils in the Little Narragansett Bay area. It can be used to identify soil limitations and potentials of natural resources and the environment. It can also help avoid soil-related problems. The information presented here is not, however, a substitute for an on-site investigation.

In preparing this soil report, soil scientists collected extensive field data about the nature and behavior characteristics of the soils. Field experience and data collected on soil properties are used as a basis in predicting soil behavior.

The following is a list of specific soil based interpretations that could be developed for subaqueous soils or of potential uses of the project information:

- Potential for SAV restoration**
- Bottom type**
- Crab habitat
- Management for sustainable shellfish production
- Nutrient reduction
- Benthic preservation site identification
- Wildlife management
- Wading shore birds, migratory waterfowl, nurseries and spawning areas
- Habitat protection for horseshoe crab
- Dredging island creation
- Tidal marsh protection and creation
- Bathymetric map
- Navigational channel creation/maintenance
- Effects of dredging on benthic ecology
- Off -site disposal of dredge spoil
- Presence of sulfidic materials**
- Dune and beach maintenance/replenishment
- Carbon sequestration
- Moorings**
- Dock development and maintenance
- Shoreline erodibilty

**currently developed

Presence of Sulfidic Materials

Table 2 indicates those map units dominated by soils containing sulfidic materials within 1 meter from the soil surface. If soils containing sulfidic materials are disturbed without appropriate management and remediation, they pose a significant threat to development and the natural environment.

Sulfidic materials most commonly accumulate in coastal marshes near the mouth of rivers that carry noncalcareous sediments, but they may occur in freshwater marshes if there is sulfur in the water. Upland sulfidic materials may have accumulated in a similar manner in the geologic past.

Figure 20
The effects of actual acid sulfate soils (AASS) are evident in the foreground. This dredged spoil material will remain either unvegetated or suitable only to acid tolerant species.

Acid sulfate soils (ASS) are soils and other soft sediments that contain iron sulfides mostly pyrite (FeS_2) with typically smaller quantities of iron monosulfides (FeS) (Sullivan and Bush, 2002). ASS include 'actual' and 'potential' acid sulfate soils. Actual acid sulfate soils (AASS) contain highly acidic soil horizons generally with pH 4 or less (sulfuric horizons). Potential acid sulfate soils (PASS) contain iron sulfides, known as sulfidic material, which have not been oxidized or exposed to air. Their field pH is generally pH 4 or greater (SACPB, 2003).

Under oxygen-depleted conditions, iron present within soils or sediments combines with sulfur from sulfate to form iron sulfides, in particular pyrite (FeS_2). When these sulfides are disturbed and exposed to air, oxidation occurs and sulfuric acid is produced. For every ton of sulfidic matter that is oxidized, 1.6 tons of sulfuric acid is produced (NWPASS, 2000). The pH value, which normally is near neutral before drainage or exposure, will drop below pH 3 (USDA-NRCS, 2006).

Figure 21
The corrosivity of acid sulfate drainage is demonstrated by the etched concrete (exposed aggregate) down slope of the road cut on which an AASS is present (Fanning, 2006). This photo also demonstrates how remediation of the AASS soil surface for plant growth does not stop the underlying acid sulfate weathering and subsequent acid sulfate drainage.

Figure 22
Monosulfidic black ooze (MBO) in the soil surface layer of the Wamphassuc and Wequetequock soils that are formed in submerged stream valleys.

Pale yellow redoximorphic concentrations of jarosite that characterize a sulfuric horizon often confirm the presence of these soils. The transition from sulfidic materials to a sulfuric horizon normally occurs within a few weeks and may last for decades. A sample of sulfidic materials, if air-dried slowly in shade for about 2 months with occasional remoistening, becomes extremely acid or ultra acid (USDA NRCS, 2006).

Iron monosulfides (FeS) are often associated with organic-rich new sediments, drains and lake bottoms, and oxidize rapidly when exposed to oxygen. Organic oozes enriched in iron monosulfides are called monosulfidic black ooze (MBO).

MBOs are black, often oily in appearance, greatly enriched in monosulfide, high in organic matter and can form thick accumulations in waterways within ASS landscapes. The formation of MBO needs a combination of acid sulfate runoff, carbon and a low flow environment. This combination explains why they tend to be commonly found in submerged stream valleys or drains in coastal ASS areas (RTA, 2005).

Figure 23

Sulfidic materials encountered in a newly constructed housing development on upland soils. Neighborhood lawns in this subdivision have no grass, in spite of being sodded with new turf two times. The sidewalks are reddish-orange in color due to being coated with iron (hydr)oxides (Fanning, 2006).

MBOs are easily mobilized during runoff events and can be distributed into rivers or if flooding occurs, distributed over surrounding landscapes. When MBOs are disturbed (during major flood events or by boat propellers) the sulfide oxidizes very rapidly and consumes the dissolved oxygen in the water causing fish and biota kills. This demonstrates that the common perception that lots of dilution will solve water quality problems' is a flawed approach when ASS are involved (RTA, 2005).

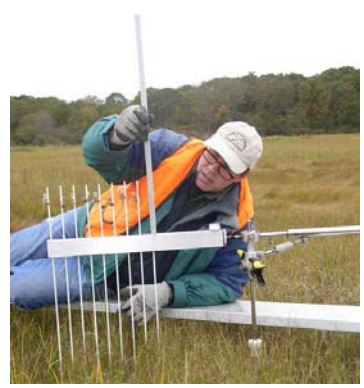
Habitat degradation and loss of biodiversity is caused by the release of acid and metal ions into the environment. Much of the acid produced either drains into waterways or reacts with carbonates and clay minerals in soils or sediments to liberate dissolved aluminum, iron, manganese, heavy metals such as copper and arsenic, and other metal ions. If buildups of acid or dissolved ions then occur, this can be extremely toxic to plants and animals.

Where the effects of AASS are evident, acidic scalds or drain spoils are often seen. These remain either unvegetated or are suitable only to acid tolerant species. Pulses of acidic water entering estuarine and coastal environments can cause massive kills of fish, crustaceans, shellfish and other organisms. Research suggests a strong association between acidity, aluminum and gill damage in fish (NWPASS, 2000). Moreover, exposure to acidic water can damage fish skin and lead to infection by the fungus.

Acidic waters affect aquatic plants through direct exposure to acid, aluminum or manganese toxicity. In such cases, plant communities decrease in diversity and become dominated by acid-tolerant plants. Harmful algal blooms can also be triggered by acidic water containing dissolved iron and silica (SACPB, 2003).

Prolonged exposure of coastal AAS to air also causes 'soil ripening' – an irreversible loss of water resulting in physical, chemical and biological changes to the soil. Soils can shrink 50 percent or more by volume, particularly if peat topsoil is oxidized or areas are drained (SACPB, 2003). This in effect causes lower elevations in drained areas compared to those that remain undrained.

Figure 24



USDA Natural Resources Conservation Service is also involved in rod surface elevation table monitoring on the Barn Island salt marshes, a cooperative effort to monitor the effects of sea level rises on salt marshes around the globe.

The impacts of AAS can be numerous (Sammut and Lines-Kelly, 1996) and include:

- Sulfuric acid mobilizes Fe, Al, Mn, and Cd, and lowers soil pH making some soils toxic to plant growth causing scalding (similar to salinity)
- Sulfuric acid corrodes concrete, iron and steel foundations and piping
- Acid waters can cause rust colored stains and slimes
- Plastic corrugated drainage becomes blocked by iron oxides
- Drainage waters can release sufficient sulfuric acid and Al to cause fish disease and mortality
- Acid waters can mobilize aluminum and heavy metals such as cadmium which can be adsorbed by fish and aquatic life
- Effects on aquaculture industries
- Poor quality stock water
- Bitumen road failure
- Irreversible soil shrinkage
- Low bearing capacity of soils
- Human health problems: algae, heavy metals in drinking water, dermatitis, eye inflammations
- Arsenic toxicity
- Sulfidic odor caused by boat traffic or wave action

Figure 25
A 2003 oblique photograph of the Barn Island salt marshes facing west. On the lower right hand side is the Barn Island boat launch located in Stonington, Connecticut.

Figure 26
Microbes visible as tiny white threads on the soil surface of a mainland cove major soil landform unit in Little Narragansett Bay. The color is due to grains of sulfur that result from the microbe's oxidation of sulfide. These areas are known sources for AASS when they are dredged and exposed to air.

Ideally, areas of high coastal ASS risk should not be disturbed by development activities. The cost to the surrounding environment and inevitably to the development itself of releasing acid and metal ions into the soil and groundwater outweighs any short-term gain. Where ASS have been disturbed in the past, structures have subsided, building materials have been corroded and agricultural or aquaculture productivity has been markedly reduced (NWPASS 2000).

To avoid disturbing coastal ASS and the need for subsequent remedial works or rehabilitation, alternative approaches need to be considered before any earthworks are undertaken. These include:

- Relocating the development to a low-risk area
- Reserving areas of high risk for environmental protection
- Redesigning site layouts to avoid ASS
- Using only clean fill not from ASS areas to avoid remediation (SACPB, 2003)

Where developments have already occurred in coastal ASS or where they may proceed within the coastal zone at risk of environmental or structural damage, remedial actions will be necessary to reduce any adverse impacts and rehabilitate the site and surrounding affected areas (SACPB, 2003). The main strategies for the treatment and management of coastal ASS include:

- Avoidance – by leaving coastal ASS in an undisturbed state

- Minimization of disturbance – by not undertaking any activity that results in the release, or accumulation and potential future release, of acid from the oxidation of undisturbed PASS, and by preventing any lowering of the permanent water table

- Neutralization – by applying neutralizing agents such as agricultural lime or bioremediating the soils so that all actual and potential acidity is neutralized, such as in AASS fill or dredged materials

- Strategic reburial or reinterment below the water table – by preventing oxidation of soils through long term/permanent storage in an anoxic environment

- Hydraulic separation techniques – by removing fine particles of pyrite and monosulfides (PASS fines). The process generally involves suspending PASS fines in a slurry and separating them from larger particles by either sluicing or cycloning (Queensland Government 2002)

In recognition of the disturbance caused by ASS to the coastal environment, an Upland and Coastal ASS Risk Map is advised. ASS risk maps can be used for planning purposes, a checklist for developments or habitats, risk assessments, and to guide development.

Figure 27
Wamphassuc and Wequetequock soils, 0 to 2 percent slopes are in the foreground, in submerged stream valleys. Both of these soils have sulfidic materials present in the soil profile.

Bottom Type

Table 2 indicates if the soil map unit is dominated by soils that have a soft or hard bottom type of material. The bottom type of material is measured by the soil structural stability n-value of the soil surface horizon. An *n-value* of slightly fluid through very fluid is classed as a soft bottom. An *n-value* of nonfluid is hard bottom. The approximate equivalent n-values, Pons and Zonneveld (1965), are as follows: nonfluid or deformable < 0.7; slightly fluid 0.7-1; moderately fluid 1-2; very fluid > 2.

Composed of different proportions of sand, silt, and clay sized particles the soils on the Little Narragansett Bay floor play a complicated role in the ecosystem. Knowledge of bottom types provides a framework for mapping benthic habitats and managing marine resources (DOI USGS, 2006).

Both the sediment type and its morphology are important features for mollusk growth. Generally flat bottoms with a narrow range of density (differing for clams and oysters) are required for their growth. Clams grow a short distance (1-2 inches) below the water sediment interface with little mobility in this environment (TCASE, 2004). The highest grade oysters come from areas where the

Figure 28
Monosulfidic black oozes (MBOs) in the soil surface layer of the Wamphassuc and Wequetequock soils have high n-values.

bottom is firm and not shifting. Except in the earliest stage of their development, oysters lack power of locomotion. They are found lying motionless on the floor of brackish bays, coves and estuaries, usually attached to rocks or other hard, submerged objects, sometimes in great clusters.

The distribution of bottom types (soft or hard) is just one of the fundamental parameters that largely determine the species of flora and fauna that inhabit a particular area. When suspended, soil particles cloud the water column, block sunlight, and undermine the health of certain aquatic species. They attract, trap, and transport waterborne pollutants and may even fill navigational channels. Also, nutrients stored within the soils can be released during resuspension events which may induce algal blooms. Within Little Narragansett Bay, efforts to restore the ecosystem are occurring due to increased turbidity, eelgrass mortality, and algal blooms.

Moorings

In the last decade, the boating population has exploded and moorings are increasing in number. Table 3 indicates map unit suitability for either mushroom or deadweight style anchors for mooring. Years ago, only *inner* harbors were used for mooring areas. Now, *outer* harbors and even bays and ocean-front properties have moorings that are very exposed. In New England, prevailing winds set the anchors in the westerly direction. Along comes a roaring northeaster or hurricane opposite the westerly set and the anchor gets spun around 180° and rolls out of the bottom. Away goes the vessel – mooring and all (INAMAR, 2000). The soil surface layers or bottom type of material influences the types of anchors the boat mooring facility may use. Navigational channels are not rated because boats cannot anchor in a channel unless circumstances require the boat to anchor, such as being broken down.

Mushroom anchors work best in silt or mud – soft bottom types of material – when they are left in and allowed to set. These anchors work on the principle of surface area and suction effect. Cohesion of the bottom material is very important. Rocks, gravel, or coarse sand lack good cohesive properties allowing the anchor to pull free. Mushroom anchors in sand will not bury completely. They will only sink to displace an equal weight of sand. Their large round dish design is not well-suited to penetrating the bottom. A rocky or coarse sand bottom is not a good place for mushroom anchors (INAMAR, 2000). Soils rated for mooring type using the mushroom anchors are either not limited or very limited. Not limited means the soil has high n-value soil surface layers or a soft bottom type of material in which the mushroom anchor works the best. Very limited means the soil has low n-value soil surface layers or a hard bottom type of material in which the use of a mushroom anchor is not suitable.

Deadweights are the best choice for rock, gravel, or coarse sand – low n-value soil surface layers or hard bottom types of material. These anchors work on the principle of being heavy. Whether the anchor is a block of stone, concrete, or iron its holding power is weight. Deadweight anchors provide the greatest reliability. If they are dragged, they will resist with constant force. By contrast, once a mushroom breaks free, it will not reset and will simply skip along the bottom. Granite is a common choice of material in the Northeast as it is readily available and inexpensive. It is a bit awkward to handle, but once in position, it will not move. The further one travels south from northern New England, concrete and iron become more common (INAMAR, 2000). Soils rated for mooring type using deadweights are either not limited or very limited. Not limited means the soil has low n-value soil surface layers or a hard bottom type of material in which deadweights work the best. Very limited means the soil has high n-value soil surface layers or a soft bottom type of material in which the use of deadweights is not suitable.

Figure 29

Boat mooring area in Little Narragansett Bay. In the last decade, the boating population has exploded and moorings are increasing in number.

Submerged Aquatic Vegetation (SAV)

SAV beds, rooted vegetation that grows under water, are among the most productive ecosystems in the world. SAV is a highly important food source and shelter for many species of birds, finfish, and shellfish. A partial listing of species associated with SAV beds is as follows:

- mudsnail (*Ilyanassa obsolete)*
- northern lacuna (*Lacuna vincta)*
- common periwinkle (*Littorina littorea)*
- lunar dovesnail (*Mitrella lunata)*
- bay scallop (*Argopecten irradians)*
- northern quahog (*Mercenaria mercenaria)*
- softshell clam (*Mya arenaria)*
- common clamworm (*Nereis virens)*
- isopod (*Idotea triloba)*
- sand shrimp (*Crangon septemspinosa)*
- blue mussel (*Mytilus edulis)*
- blue crab (*Callinectes sapidus)*
- hermit crab (*Pagurus longicarpus)*
- horseshoe crab (*Limulus polyphemus)*
- bluefish (*Pomatomus saltatrix)*
- striped bass (*Morone Americana)*
- winter flounder (*Pleuronectes americanus)*
- lobster (*Homarus americanus)* (TSCHR, 2003)

Factors influencing SAV distribution and growth include light penetration, nutrients, substrate, temperature, current velocity, wave energy, and salinity. SAV commonly grows in beds. These beds can be dense or sparse and contain one species or many. Generally, species diversity increases as the salinity decreases. Substrate requirements range from sand and gravel to mud (TSCHR, 2003).

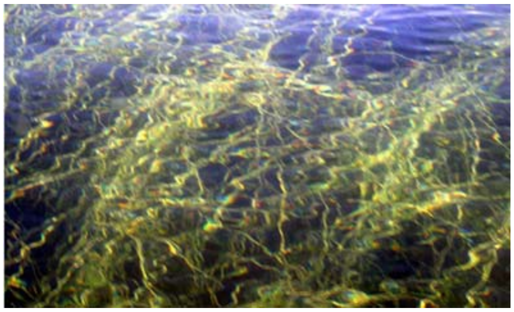


Figure 30
Eelgrass beds on the shore face major soil landform unit in Little Narragansett Bay. They serve as a haven for crabs, scallops, numerous species of fish, and other wildlife, providing these creatures with habitat, nursery grounds, and food.

Table 8 indicates the potential for SAV restoration by soil map unit. To increase restoration success, the potential ratings focus on soil map units where existing SAV was observed and rate the same map unit without SAV to determine the best sites for full scale eelgrass restoration. High potential ratings are assigned to soils that have less than 85 percent SAV, medium potential ratings are soils that have less than 35 percent SAV, and low potential ratings are soils that have less than 15 percent SAV. This nearshore data can help guide habitat criteria development and assessment of restoration efforts.

This information may also be linked to a suitability index such as the one developed in the model by Short and Kopp. This model takes into account numerous ecological variables that can effect whether a site is conducive to eelgrass restoration. The following is a list of the variables:

- Historical eelgrass distribution
- Current eelgrass distribution
- Proximity to natural eelgrass beds
- Sediment (soil characteristics)
- Water quality
- Wave exposure
- Water depth
- Bioturbation (Short et al, 2002)

Historically the most abundant SAV species in LIS, eelgrass was widely dispersed in the eastern, central, and western sections. Its current distribution in LIS is limited to the eastern shoreline of Connecticut. The ecological importance of eelgrass is derived from its productivity and substantial habitat it creates. Eelgrass may form extensive meadows or patchy beds interspersed with bare areas, and the location of these beds can shift over time. Eelgrass, a kind of seagrass, is the only true marine SAV found in LIS. Seagrasses are characterized as having linear, grass-like leaves and an extensive root and rhizome system (TSCHR, 2003).

In LIS, eelgrass is found at depths between 1.8 and 12 feet below mean low water (Koch and Beer, 1996). The upper limit of growth is determined by physical factors such as wave action, ice scour, and desiccation (TSCHR, 2003).

Figure 31
Structures that affect wave energy or currents such as bulkheads, seawalls, and riprap can degrade or destroy eelgrass beds. Beds can grow at sustained current velocities up to 59 inches sec-1 and may tolerate brief exposure to higher velocities (Fonseca et al., 1982). If the structure increases current velocity above this point for extended periods or if the point of wave breaking is shifted, the eelgrass bed may become weakened and degraded. In addition to these problems, the increased energy will contribute to greater turbidity.

In many cases of eelgrass bed degradation, there is a combination of stresses. For example, a widespread problem such as impaired water quality may be coupled with localized physical disturbances. It is important to note that bed density, size, and distribution all naturally fluctuate. In areas where stressed beds exist, growth may appear sparse, leaf blades may be short and narrow, and seed production may be sporadic (Koch *et al.*, 1994).

Disturbances that can severely impact or damage eelgrass beds are trawls, nets, lobster traps, scallop dredges, mooring chains, motorboat propellers, feeding herbivores (such as Canada geese (*Branta canadensis*) and the introduced mute swan (*Cygnus olor*)), shoreline erosion control structures, newly created shaded areas by docks or piers, dredging activities, and the placement of fill or dredged materials (TSCHR, 2003).

Vascular plants and algae common to the tidal habitats of Little Narragansett Bay are listed in Table 9, and include SAV, tidal marsh, and coastal plain species important to the area. Table 9 is sorted by soil salinity tolerance from high to none and common name. Also presented is the currently accepted scientific binomial, NRCS Plants database reference symbol, growth habit, U.S. nativity, New England regional wetland indicator status, pH range, and salinity tolerance, if known.

Salinity tolerance as presented in Table 9 refers to a plants tolerance not to diminish more than 10% in growth under the soil conditions: high = tolerant to a soil with an electrical conductivity of the soil solution extract of greater than 8.0 deciSeimans/meter; medium = tolerant to 4.1-8.0 dS/m; low = tolerant to 2.1-4.0 dS/m; none = tolerant to 0-2 dS/m.

One should be careful only to equate soil salinity in a most general, qualitative way, to estuarine salinity ranges used by the National Wetland Inventory given in Practical Salinity Units (PSU) or parts per thousand, ppt, as follows: Polyhaline – waters with salinity between 18 and 30 ppt; Mesohaline –waters between 5 and 18 ppt; Oligohaline – waters between 0.5 and 5 ppt; and fresh – waters less than 0.5 ppt.

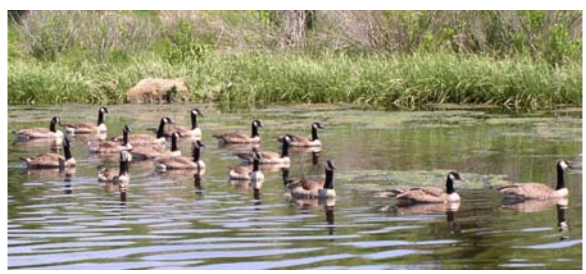


Figure 32

Feeding herbivores such as Canada geese (Branta canadensis) shown here in Wequetequock Cove can severely impact or damage eelgrass beds.

Table 1. Hectares and Proportionate Extent of the Soils

Map Symbol	Soil Name	Hectares	Percent
301	Beaches-Udipsamments complex, coastal	14	1
800	Wamphassuc and Wequetequock soils, 0 to 2 percent slopes	55	5
810	Napatree sand, 0 to 2 percent slopes	88	8
820	Quanaduck silt loam, 0 to 2 percent slopes	30	3
830	Anguilla mucky sand, 0 to 5 percent slopes	55	5
840	Rhodesfolly fine sand, 0 to 5 percent slopes	185	17
850	Sandy, mixed, mesic Haplic Sulfaquents (bay bottom)	362	33
860	Histosols (submerged tidal marsh)	14	1
880	Typic Psammaquents (shore complex)	147	13
900	Navigational Channel	55	5
910	Sandy, mixed, mesic Haplic Sulfaquents (river bottom)	95	9
	Total	1100	100

Table 2. Soil Features

Map Symbol	Soil Name	Sulfidic Materials	Bottom Type
301	Beaches-Udipsamments complex, coastal	No	-----
800	Wamphassuc and Wequetequock soils, 0 to 2 percent slopes	Yes	Soft
810	Napatree sand, 0 to 2 percent slopes	No	Hard
820	Quanaduck silt loam, 0 to 2 percent slopes	Yes	Soft
830	Anguilla mucky sand, 0 to 5 percent slopes	Yes	Soft
840	Rhodesfolly fine sand, 0 to 5 percent slopes	No	Hard
850	Sandy, mixed, mesic Haplic Sulfaquents (bay bottom)	Yes	Hard
860	Histosols (submerged tidal marsh)	Yes	Soft
880	Typic Psammaquents (shore complex)	No	Hard
900	Navigational Channel	Not Rated	Not Rated
910	Sandy, mixed, mesic Haplic Sulfaquents (river bottom)	Yes	Hard

Table 3. Moorings

	Mooring Type	
Map Symbol and Soil Name	**Mushroom Anchor**	**Deadweight**
301 Beaches ------------------------------------ Udipsamments ------------------------------	-------- --------	-------- --------
800 Wamphassuc ------------------------------- Wequetequock -----------------------------	Not Limited Not Limited	Very Limited soft bottom Very Limited soft bottom
810 Napatree	Very Limited hard bottom	Not Limited
820 Quanaduck	Not Limited	Very Limited soft bottom
830 Anguilla	Not Limited	Very Limited soft bottom
840 Rhodesfolly	Very Limited hard bottom	Not Limited
850 Sandy, mixed, mesic Haplic Sulfaquents (bay bottom)	Very Limited hard bottom	Not Limited
860 Histosols (submerged tidal marsh)	Not Limited	Very Limited soft bottom
880 Typic Psammaquents (shore complex)	Very Limited hard bottom	Not Limited
900 Navigational Channel	Not Rated	Not Rated
910 Sandy, mixed, mesic Haplic Sulfaquents (river bottom)	Very Limited hard bottom	Not Limited

Table 4. Classification of the Soils

Soil Name	Taxonomic Class
Anguilla	Sandy, mixed, mesic Haplic Sulfaquents
Haplic Sulfaquents	Haplic Sulfaquents
Histosols	Histosols
Napatree	Coarse-loamy, mixed, active, nonacid, mesic Aeric Endoaquents
Quanaduck	Coarse-loamy over sandy or sandy-skeletal, aniso, mixed, superactive, nonacid, mesic Sulfic Fluvaquents
Rhodesfolly	Mixed, mesic Typic Psammaquents
Typic Psammaquents	Typic Psammaquents
Udipsamments	Udipsamments
Wamphassuc	Coarse-loamy, mixed, active, nonacid, mesic Haplic Sulfaquents
Wequetequock	Coarse-loamy, mixed, active, nonacid, mesic Typic Sulfaquents

Table 5. Proposed Wassents Classification of the Soils

Soil Name	Wassents Classification
Anguilla	Sandy, mixed, mesic, Haplic Sulfiwassents.
Haplic Sulfaquents	Haplic Sulfiwassents
Napatree	Coarse-loamy, mixed, active, nonacid, mesic Aeric Haplowassents
Quanaduck	Coarse-loamy over sandy or sandy-skeletal, aniso, mixed, superactive, nonacid, mesic Sulfic Fluviwassents
Rhodesfolly	Mixed, mesic Fluventic Psammowassents
Typic Psammaquents	Typic Psammowassents
Wamphassuc	Coarse-loamy, mixed, active, nonacid, mesic Haplic Sulfiwassents
Wequetequock	Coarse-loamy, mixed, active, nonacid, mesic Fluvic Sulfiwassents

Table 6. Radiocarbon Dating of Organic Horizons

Series	Sample #	Horizon	Depth (cm)	Measured Radiocarbon Age	Conventional Radiocarbon Age
Rhodesfolly	S05RI009008	Ab2	44–55	620 +/- 40 BP	650 +/- 40 BP
Rhodesfolly	S05RI009008	Ab4	140-150	610 +/- 40 BP	710 +/- 40 BP
Quanaduck	S05CT011005	2Ab	58-66	3470 +/- 40 BP	3450 +/- 40 BP
Wequetequock	S05CT011006	Oab	105-150	2650 +/- 40 BP	2600 +/- 40 BP

Table 7. Chemical and Physical Properties

Map Symbol and Soil Name	Depth (cm)	Organic Matter (percent)	Soil Reaction (pH)	Soil Reaction (8 wk incub. pH)	Salinity (ppt)	n-value
301						
Beaches -------------------	-------	------	-------	-------	-----	-----
Udipsamments -----------	0 – 96	------	5.6 – 7.3	-------	-----	-----
	96 – 127		5.6 – 7.3			
	127 - 165		5.6 – 7.3			
800						
Wamphassuc ------------	0 – 39	5 – 15	5.1 – 8.4	<3.5 – 5.0	>18	> 2
	39 – 122		5.1 – 8.4	<3.5 – 5.0	>18	< 1
	122 – 140		5.1 – 8.4	<3.5 – 5.0	>18	< 0.7
Wequetequock -----------	0 – 40	5 – 15	4.5 – 7.8	<3.5 – 6.5	>18	> 2
	40 – 105		<3.5 – 8.4	<3.5 – 6.5	>18	> 0.7
	105 – 150	40 – 70	6.6 – 8.4	<3.5 – 6.5	>18	> 2
810 Napatree	0 – 20	0 – 2	6.6 – 7.8	4.5 – 7.3	>20	< 0.7
	20 – 45		6.6 – 7.8	4.5 – 7.3	>20	< 0.7
	45 – 65		6.6 – 7.8	4.5 – 7.3	>20	< 0.7
	65 – 160		6.6 – 7.8	4.5 – 7.3	>20	< 0.7
820 Quanaduck	0 – 30	5 – 15	7.4 - 8.4	<3.5 - 5.5	>18	> 2
	30 – 46	5 – 15	7.4 - 8.4	<3.5 - 5.5	>18	> 1
	46 – 58		7.4 - 8.4	<3.5 - 5.5	>18	< 0.7
	58 – 66	5 – 15	7.4 - 8.4	<3.5 - 5.5	>18	< 0.7
	66 – 86		7.4 - 8.4	<3.5 - 5.5	>18	< 0.7
	86 – 155		7.4 - 8.4	<3.5 - 5.5	>18	< 0.7
830 Anguilla	0 – 40	5 – 15	6.6 - 7.3	<3.5 – 4.4	>18	> 2
	10 – 40		6.6 - 7.3	<3.5 – 4.4	>18	> 2
	40 – 100		6.6 - 7.3	<3.5 – 4.4	>18	< 0.7
	100 – 150		6.6 - 7.3	<3.5 – 4.4	>18	< 0.7
840 Rhodesfolly	0 – 13	0 – 2	6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	13 – 20		6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	20 – 29	0 – 2	6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	29 – 61		6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	61 – 72	0 – 2	6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	72 – 78		6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	78 – 92	0 – 2	6.6 – 9.0	4.5 – 7.8	>25	< 0.7
	92 – 150		6.6 – 9.0	4.5 – 7.8	>25	< 0.7
850 Sandy, mixed, mesic Haplic Sulfaquents (bay bottom)	0 – 10	0 - 2	6.1 – 7.8	<3.5 – 5.5	>25	< 0.7
	10 – 24		6.1 – 7.8	<3.5 – 5.5	>25	< 0.7
	24 – 60		6.1 – 7.8	<3.5 – 5.5	>25	< 0.7

Map Symbol and Soil Name	Depth (cm)	Organic Matter (pct)	Soil Reaction (pH)	Soil Reaction (8 wk incub. pH)	Salinity (ppt)	n-value
860 Histosols (submerged tidal marsh)	0 – 68 68 – 100	40 – 70	6.6 – 7.3 6.6 – 7.3	<3.5 – 6.5 <3.5 – 6.5	>25 >25	> 1 < 0.7
880 Typic Psammaquents (shore complex)	0 – 20 20 – 40	0 - 2	7.4 – 9.0 7.4 – 9.0	4.3 – 7.8 4.3 – 7.8	>25 >25	< 0.7 < 0.7
900 Navigational Channel	--------	-------	--------	--------	-----	-----
910 Sandy, mixed, mesic Haplic Sulfaquents (river bottom)	0 – 10 10 – 24 24 – 60	0 – 2	6.1 – 7.8 6.1 – 7.8 6.1 – 7.8	<3.5 – 5.5 <3.5 – 5.5 <3.5 – 5.5	>20 >20 >20	< 0.7 < 0.7 < 0.7

The approximate equivalent n-values, Pons and Zonneveld (1965), are as follows: nonfluid or deformable < 0.7; slightly fluid 0.7-1; moderately fluid 1-2; very fluid > 2.

Table 8. Potential for Submerged Aquatic Vegetation (SAV) Restoration

Map Symbol	Soil Name	Potential for SAV Restoration
301	Beaches-Udipsamments complex, coastal	--------
800	Wamphassuc and Wequetequock soils, 0 to 2 percent slopes	Low Potential
810	Napatree sand, 0 to 2 percent slopes	Low Potential
820	Quanaduck silt loam, 0 to 2 percent slopes	Medium Potential
830	Anguilla mucky sand, 0 to 5 percent slopes	Medium Potential
840	Rhodesfolly fine sand, 0 to 5 percent slopes	Medium Potential
850	Sandy, mixed, mesic Haplic Sulfaquents (bay bottom)	Medium Potential
860	Histosols (submerged tidal marsh)	High Potential
880	Typic Psammaquents (shore complex)	High Potential
900	Navigational Channel	Not Rated
910	Sandy, mixed, mesic Haplic Sulfaquents (river bottom)	Medium Potential

Table 9. Plants and Algae Common to the Tidal Habitats of Little Narragansett Bay

Common Name	Scientific Name	PLANTS database Symbol	Growth Habit	US Nativity	Regional Wetland Indicator Status	pH (Min)	pH (Max)	Salinity Tolerance
bearded saltmeadow grass	Leptochloa fusca ssp. Fascicularis (=Diplachne maritima)	LEFUF	Graminoid	Native	FACW	4	7.5	high
big cordgrass	Spartina cynosuroides	SPCY	Graminoid	Native	OBL	5.8	7.5	high
blackgrass rush	Juncus gerardii	JUGE	Graminoid	Native	FACW+			high
Carolina sealavender	Limonium carolinianum / Limonium nashii	LICA17	Forb/herb	Native	OBL	6	8.5	high
dwarf saltwort	Salicornia bigelovii	SABI	Forb/herb	Native	OBL			high
eastern annual saltmarsh aster	Symphyotrichum subulatum (=Aster subulatus)	SYSU5	Forb/herb	Native	OBL	5.6	7	high
goose tongue	Plantago maritima	PLMA3	Forb/herb	Native	FACW			high
hairy smotherweed	Bassia hirsuta	BAHI3	Forb/herb	Introduced	OBL			?
herbaceous seepweed	Suaeda maritima	SUMA	Forb/herb	Introduced	OBL			high
hightide bush	Iva frutescens	IVFR	Subshrub	Native	FACW+	5	5.7	high
perennial saltmarsh aster	Symphyotrichum tenuifolium (=Aster tenuifolius)	SYTE6	Forb/herb	Native	OBL			high
red goosefoot	Chenopodium rubrum	CHRU	Forb/herb	Native	FACW	6	8.5	high
saltmarsh bulrush	Bolboschoenus maritimus (=Scirpus maritimus var. paludosus)	SCMA8	Graminoid	Native	OBL	4	7	high
saltmeadow cordgrass	Spartina patens	SPPA	Graminoid	Native	FACW+	5.3	7.5	high
seaside arrowgrass	Triglochin maritima	TRMA20	Graminoid	Native				high
seaside brookweed	Samolus valerandi ssp. parviflorus	SAVAP	Forb/herb	Native	OBL			high
seaside goldenrod	Solidago sempervirens	SOSE	Forb/herb	Native	FACW	5.5	7.5	high
seawrack	Zostera marina	ZOMA	Forb/herb	Native	OBL			high
smooth cordgrass	Spartina alterniflora	SPAL	Graminoid	Native	OBL	5.4	7	high
spear saltbush	Atriplex patula	ATPA4	Forb/herb	Native	FACW			high
spikegrass	Distichlis spicata	DISP	Graminoid	Native	FACW+	6.4	10.5	high
sturdy bulrush	Schoenoplectus robustus (=Scirpus robustus)	SCRO5	Graminoid	Native	OBL	6.4	8.4	high
sweetscent	Pluchea odorata var. succulenta	PLODS	Forb/herb	Native	OBL			high
Virginia glasswort	Salicornia depressa (=Salicornia europaea)	SADE10	Forb/herb	Native	OBL			high
widgeongrass	Ruppia maritima	RUMA5	Forb/herb	Native	OBL	5.4	8.5	high
knotted wrack	Ascophyllum nodosum		brown algae					high
rockweed	Fucus vesiculosus		brown algae					high
Sea lettuce	Ulva lactuca		green algae					high
sputnik weed	Codium fragile		green algae					high
string sea lettuce	Ulva intestinalis		green algae					high
beaked spikerush	Eleocharis rostellata	ELRO2	Graminoid	Native	OBL	6	8	medium
British alkaligrass	Puccinellia rupestris	PURU	Graminoid	Native	OBL			medium

Common Name	Scientific Name	PLANTS database Symbol	Growth Habit	US Nativity	Regional Wetland Indicator Status	pH (Min)	pH (Max)	Salinity Tolerance
brittle waternymph	Najas minor	NAMI	Forb/herb	Introduced	OBL	6.3	7.2	medium
Bushy knotweed	Polygonum ramosissimum	PORAR	Forb/herb	Native	FACW			medium
Canadian rush	Juncus canadensis	JUCA3	Graminoid	Native	OBL	4.5	5.9	medium
chairmaker's bulrush	Schoenoplectus americanus (=Scirpus americanus)	SCAM6	Graminoid	Native	OBL			medium
claspingleaf pondweed	Potamogeton perfoliatus	POPE7	Forb/aquatic	Native	OBL			medium
climbing hempvine	Mikania scandens	MISC	Vine, herb	Native	FACW+	5.7	7.5	medium
common marshmallow	Althaea officinalis	ALOF2	Forb/herb	Introduced	FACW+			Medium
common threesquare	Schoenoplectus pungens var. pungens	SCPUP5	Graminoid	Native	FACW+	3.7	7.5	medium
creeping bentgrass	Agrostis stolonifera	AGST2	Graminoid	Native	FACW	5	7.5	medium
dotted smartweed	Polygonum punctatum	POPU5	Forb/herb	Native	OBL	6	8.7	medium
dwarf spikerush	Eleocharis parvula	ELPA5	Graminoid	Native	OBL	6	8	medium
eastern mudwort	Lilaeopsis chinensis	LICH	Forb/herb	Native	OBL			medium
Eaton's beggartick	Bidens eatonii	BIEA	Forb/herb	Native	OBL			medium
fall panicgrass	Panicum dichotomiflorum	PADI	Graminoid	Native	FACW-	4.8	7	medium
fern flatsedge	Cyperus filicinus	CYFI	Graminoid	Native	OBL			medium
fragrant flatsedge	Cyperus odoratus	CYOD	Graminoid	Native	FACW	5	7.2	medium
golden dock	Rumex maritimus	RUMA4	Forb/herb	Native	FACW	5	8.2	medium
groundsel bush	Baccharis halimifolia	BAHA	Shrub	Native	FACW	5.5	7.8	medium
horned pondweed	Zannichellia palustris	ZAPA	Forb/herb	Native	OBL			medium
hybrid cattail	Typha ×glauca	TYGL	Forb/herb	Native	OBL			medium
inkberry	Ilex glabra	ILGL	Shrub	Native	FACW-	4.5	7	medium
marsh straw sedge	Carex hormathodes	CAHO8	Graminoid	Native	OBL			medium
narrowleaf cattail	Typha angustifolia	TYAN	Forb/herb	Introduced	OBL	3.7	8.5	medium
needle spikerush	Eleocharis acicularis	ELAC	Graminoid	Native	OBL	4.5	7	medium
New England bulrush	Bolboschoenus novae-angliae (=Scirpus cylindricus)	SCNO5	Graminoid	Native	OBL			medium
reed canarygrass	Phalaris arundinacea	PHAR3	Graminoid	Native	FACW+	5.5	8	medium
sago pondweed	Stuckenia pectinata (=Potamogeton pectinatus)	STPE15	Forb/aquatic	Native	OBL			medium
salt sandspurry	Spergularia salina (=Spergularia marina)	SPSA5	Forb/herb	Native	OBL			medium
saltmarsh alkaligrass	Puccinellia fasciculata	PUFA	Graminoid	Native	OBL			medium
saltmarsh false foxglove	Agalinis maritima	AGMA3	Forb/herb	Native	FACW+			medium
seaside crowfoot	Ranunculus cymbalaria	RACY	Forb/herb	Native	OBL	6.5	8	medium
Small bushy knotweed	Polygonum ramosissimum var. prolificum	PORAP	Forb/herb	Native	FACW			medium
smooth sawgrass	Cladium mariscoides	CLMA	Graminoid	Native	OBL			medium
spotted ladysthumb	Polygonum persicaria	POPE3	Forb/herb	Introduced	FACW			medium
sweetgrass	Hierochloe odorata	HIOD	Graminoid	Native	FACW	5.7	7.4	medium
switchgrass	Panicum virgatum	PAVI2	Graminoid	Native	FACW-	4.5	7.5	medium
tidal arrowhead	Sagittaria calycina var. spongiosa	SACAS	Forb/herb	Native	OBL			medium
tidalmarsh amaranth	Amaranthus cannabinus	AMCA2	Forb/herb	Native	OBL			medium

Common Name	Scientific Name	PLANTS database Symbol	Growth Habit	US Nativity	Regional Wetland Indicator Status	pH (Min)	pH (Max)	Salinity Tolerance
Walter's millet	Echinochloa walteri	ECWA	Graminoid	Native	FACW+	3.8	9.4	medium
water pygmyweed	Crassula aquatica	CRAQ	Forb/herb	Native	OBL			medium
Welsh mudwort	Limosella australis	LIAU6	Forb/herb	Native	OBL			medium
western waterweed	Elodea nuttallii	ELNU2	Forb/herb	Native	OBL			medium
American eelgrass	Vallisneria americana	VAAM3	Forb/herb	Native	OBL	6	7.3	low
American water horehound	Lycopus americanus	LYAM	Forb/herb	Native	OBL	5.2	7.8	low
annual wildrice	Zizania aquatica	ZIAQ	Graminoid	Native	OBL	6.4	7.4	low
arrowleaf tearthumb	Polygonum sagittatum	POSA5	Vine, herb	Native	OBL	4	8.5	low
awl-leaf arrowhead	Sagittaria subulata	SASU	Forb/herb	Native	OBL			low
broadleaf cattail	Typha latifolia	TYLA	Forb/herb	Native	OBL	5.5	7.5	low
broom sedge	Carex scoparia	CASC11	Graminoid	Native	FACW	4.6	6.9	low
common buttonbush	Cephalanthus occidentalis	CEOC2	Tree, Shrub	Native	OBL	5.3	8.5	low
common reed	Phragmites australis	PHAU7	Graminoid	Native	FACW	4.5	8	Low
common rush	Juncus effusus	JUEF	Graminoid	Native	FACW+	5.5	7	low
rosemallow	Hibiscus moscheutos	HIMO	Subshrub	Native	OBL	4	7.5	low
curlytop knotweed	Polygonum lapathifolium	POLA4	Forb/herb	Native	FACW+			low
European sweetflag	Acorus calamus	ACCA4	Forb/herb	Native	OBL	5.2	7.2	low
false indigo	Amorpha fruticosa	AMFR	Shrub	Native	FACW	5.5	7.5	low
forked rush	Juncus dichotomus	JUDI	Graminoid	Native	FACW	4.5	6.5	low
fowl bluegrass	Poa palustris	POPA2	Graminoid	Native	FACW	4.9	7.5	low
halberdleaf tearthumb	Polygonum arifolium	POAR6	Vine, herb	Native	OBL			low
hemlock waterparsnip	Sium suave	SISU2	Forb/herb	Native	OBL			low
herbwilliam	Ptilimnium capillaceum	PTCA	Forb/herb	Native	OBL			low
highbush blueberry	Vaccinium corymbosum	VACO	Shrub	Native	FACW-	4.7	7.5	low
leatherleaf	Chamaedaphne calyculata	CHCA2	Shrub	Native	OBL	5	6	low
marsh skullcap	Scutellaria galericulata	SCGA	Forb/herb	Native	OBL			low
pickerelweed	Pontederia cordata	POCO14	Forb/herb	Native	OBL	6	8	low
prairie cordgrass	Spartina pectinata	SPPE	Graminoid	Native	OBL	6	8.5	low
purple chokeberry	Photinia floribunda (=Aronia prunifolia)	PHFL9	Shrub	Native	FACW			low
red chokeberry	Photinia pyrifolia (=Aronia arbutifolia)	PHPY4	Shrub	Native	FACW	5.5	7.5	low
redtop	Agrostis gigantea	AGGI2	Graminoid	Introduced	NI	4.5	8	low
seaside gerardia	Agalinis purpurea	AGPU5	Forb/herb	Native	FACW-			low
silverweed cinquefoil	Argentina anserina (=Potentilla anserina)	ARAN7	Forb/herb	Native	OBL	7	8	low
softstem bulrush	Schoenoplectus tabernaemontani (=Scirpus validus)	SCTA2	Graminoid	Native	OBL	5.4	7.5	low
swamp spikerush	Eleocharis palustris	ELPA3	Graminoid	Native	OBL	4	8	low
tapertip rush	Juncus acuminatus	JUAC	Graminoid	Native	OBL	4.4	7.2	low
American water plantain	Alisma subcordatum	ALSU	Forb/herb	Native	OBL	5	7	none
bluejoint	Calamagrostis canadensis	CACA4	Graminoid	Native	FACW+	4.5	8	none
broadleaf arrowhead	Sagittaria latifolia	SALA2	Forb/herb	Native	OBL	4.7	8.6	none
brown beaksedge	Rhynchospora capitellata	RHCA12	Graminoid	Native	OBL			none
Canada germander	Teucrium canadense	TECA3	Forb/herb	Native	FACW-	4.5	8	none

Common Name	Scientific Name	PLANTS database Symbol	Growth Habit	US Nativity	Regional Wetland Indicator Status	pH (Min)	pH (Max)	Salinity Tolerance
clammy hedgehyssop	Gratiola neglecta	GRNE	Forb/herb	Native	OBL			none
clearweed	Pilea pumila	PIPU2	Forb/herb	Native	FACW			none
common sneezeweed	Helenium autumnale	HEAU	Forb/herb	Native	FACW+	4	7.5	none
common winterberry	Ilex verticillata	ILVE	Tree, Shrub	Native	FACW+	4.5	7.5	none
coon's tail	Ceratophyllum demersum	CEDE4	Forb/herb	Native	OBL	6.2	8.3	none
curly pondweed	Potamogeton crispus	POCR3	Forb/aquatic	Introduced	OBL	6.4	8.5	none
devil's beggartick	Bidens frondosa	BIFR	Forb/herb	Native	FACW	5.2	7.2	none
ditch stonecrop	Penthorum sedoides	PESE6	Forb/herb	Native	OBL	5	7	none
dwarf St. Johnswort	Hypericum mutilum	HYMU	Forb/herb	Native	FACW	4.8	7.2	none
eastern gamagrass	Tripsacum dactyloides	TRDA3	Graminoid	Native	FACW	5.1	7.5	none
Engelmann's arrowhead	Sagittaria engelmanniana	SAEn	Forb/herb	native	OBL			none
fowl mannagrass	Glyceria striata	GLST	Graminoid	native	OBL	4	8	none
fringed sedge	Carex crinita	CACR6	Graminoid	native	OBL	4	7.5	none
golden hedgehyssop	Gratiola aurea	GRAU	Forb/herb	native	OBL			none
green arrow arum	Peltandra virginica	PEVI	Forb/herb	native	OBL	5.2	9.5	none
groundnut	Apios americana	APAM	Vine, herb	native	FACW	6	7.5	none
lake sedge	Carex lacustris	CALA16	Graminoid	native	OBL	5.6	6.8	none
marsh bedstraw	Galium palustre	GAPA3	Forb/herb	native	OBL			none
marshpepper knotweed	Polygonum hydropiper	POHY	Forb/herb	Introduced	OBL	5	7.5	none
meadowbeauty	Rhexia virginica	RHVI	Forb/herb	native	OBL			none
monkeyflower	Mimulus ringens	MIRI	Forb/herb	native	OBL			none
new York aster	Symphyotrichum novi-belgii (=Aster novi-belgii)	SYnOn	Forb/herb	native	FACW+	5.5	7	none
new York ironweed	Vernonia noveboracensis	VEnO	Forb/herb	native	FACW+	4.5	8	none
nodding beggartick	Bidens cernua	BICE	Forb/herb	native	OBL	5.1	7	none
northern bugleweed	Lycopus uniflorus	LYUn	Forb/herb	native	OBL			none
ovate spikerush	Eleocharis ovata	ELOV	Graminoid	native	OBL	4.6	6.8	none
purplestem angelica	Angelica atropurpurea	AnAT	Forb/herb	native	OBL			none
rice cutgrass	Leersia oryzoides	LEOR	Graminoid	native	OBL	5.1	8.8	none
river bulrush	Bolboschoenus fluviatilis (=Scirpus fluviatilis)	SCFL11	Graminoid	native	OBL	4	7.5	none
riverbank grape	Vitis riparia	VIRI	Vine	native	FACW	6.1	8.5	none
royal fern	Osmunda regalis	OSRE	Forb/herb	native	OBL	4	6	none
seedbox	Ludwigia alternifolia	LUAL2	Forb/herb	native	FACW+			none
sensitive fern	Onoclea sensibilis	OnSE	Forb/herb	native	FACW			none
slender fimbry	Fimbristylis autumnalis	FIAU2	Graminoid	native	FACW+			none
slender flatsedge	Cyperus bipartitus (=Cyperus rivularis)	CYBI6	Graminoid	native	FACW+	4.5	6.5	none
smallspike false nettle	Boehmeria cylindrica	BOCY	Forb/herb	native	FACW+	5.1	7	none
smooth beggartick	Bidens laevis	BILA	Forb/herb	native	OBL	5	7	none
steeplebush	Spiraea tomentosa	SPTO2	Shrub	native	FACW	4.5	7	none
Strawcolor flatsedge	Cyperus strigosus	CYST	Graminoid	native	FACW	6.4	7	none
swamp azalea	Rhododendron viscosum	RHVI2	Shrub	native	OBL	4	7	none
Swamp beggartick	Bidens connata	BICO5	Forb/herb	native	FACW+	5.2	7.1	none
swamp dock	Rumex verticillatus	RUVE3	Forb/herb	native	OBL			none
swamp loosestrife	Decodon verticillatus	DEVE	Subshrub	native	OBL	5.2	7.2	none

Common Name	Scientific Name	PLANTS database Symbol	Growth Habit	US Nativity	Regional Wetland Indicator Status	pH (Min)	pH (Max)	Salinity Tolerance
swamp milkweed	Asclepias incarnata	ASIn	Forb/herb	native	OBL	5	8	none
sweetgale	Myrica gale	MYGA	Shrub	native	OBL	5	7.8	none
teal lovegrass	Eragrostis hypnoides	ERHY	Graminoid	native	OBL	4.5	8.5	none
threelobe beggartick	Bidens tripartita	BITR	Forb/herb	native	OBL	5	7.2	none
threepetal bedstraw	Galium trifidum	GATR2	Vine, herb	native	FACW+	4.6	8	none
threeway sedge	Dulichium arundinaceum	DUAR3	Graminoid	native	OBL	4.7	7.5	none
true forget-me-not	Myosotis scorpioides	MYSC	Forb/herb	Introduced	OBL	5.5	7.5	none
tussock sedge	Carex stricta	CAST8	Graminoid	native	OBL	3.5	7	none
twoheaded water-starwort	Callitriche heterophylla	CAHE3	Forb/aquatic	native	OBL	5.2	6.8	none
Virginia St. Johnswort	Triadenum virginicum	TRVI2	Forb/herb	native	OBL			none
Virginia water horehound	Lycopus virginicus	LYVI4	Forb/herb	native	OBL	5	6.3	none
water horsetail	Equisetum fluviatile	EQFL	Forb/herb	native	OBL	4.5	6	none
water knotweed	Polygonum amphibium	POAM8	Forb/herb	native	OBL	4	7	none
whitegrass	Leersia virginica	LEVI2	Graminoid	native	FACW	4.5	8.5	none
wild mint	Mentha arvensis	MEAR4	Forb/herb	native	FACW	5	7	none
woolgrass	Scirpus cyperinus	SCCY	Graminoid	native	FACW+	4.8	7.2	none
yellow jewelweed	Impatiens capensis	IMCA	Forb/herb	native	FACW	6.4	7.4	none
yellowseed false pimpernel	Lindernia dubia	LIDU	Forb/herb	native	OBL			none
American waterwort	Elatine americana	ELAM3	Forb/herb	native	OBL			
blue skullcap	Scutellaria lateriflora	SCLA2	Forb/herb	native	FACW+			
brownfruit rush	Juncus pelocarpus	JUPE	Graminoid	native	OBL			
Canada St. Johnswort	Hypericum canadense	HYCA7	Forb/herb	native	FACW			
coastal joepyeweed	Eupatoriadelphus dubius	EUDU2	Forb/herb	native	FACW			
creeping jenny	Lysimachia nummularia	LYnU	Forb/herb	Introduced	OBL			
earth loosestrife	Lysimachia terrestris	LYTE2	Forb/herb	native	OBL			
eastern blue-eyed grass	Sisyrinchium atlanticum	SIAT	Forb/herb	native	FACW			
Elliott's goldenrod	Solidago latissimifolia (=Solidago elliottii)	SOLA4	Forb/herb	native	OBL			
hairy willowherb	Epilobium hirsutum	EPHI	Forb/herb	Introduced	FACW			
maleberry	Lyonia ligustrina	LYLI	Shrub	native	FACW			
olive spikerush	Eleocharis olivacea	ELOL	Graminoid	native	OBL			
paleyellow iris	Iris pseudacorus	IRPS	Forb/herb	Introduced	OBL			
purple loosestrife	Lythrum salicaria	LYSA2	Forb/herb	Introduced	FACW+			
slender yelloweyed grass	Xyris torta	XYTO	Forb/herb	native	OBL			
smooth winterberry	Ilex laevigata	ILLA	Tree, Shrub	native	OBL			
swamp doghobble	Eubotrys racemosa (=Leucothoe racemosa)	EURA5	Shrub	native	FACW			
swamp verbena	Verbena hastata	VEHA2	Forb/herb	native	FACW+			
Virginia chainfern	Woodwardia virginica	WOVI	Forb/herb	native	OBL			
watercress	nasturtium officinale	nAOF	Forb/herb	Introduced	OBL			
wild yam	Dioscorea villosa	DIVI4	Vine, herb	native	FAC+			
woollyfruit sedge	Carex lasiocarpa	CALA11	Graminoid	native	OBL			
yellow pond-lily	nuphar lutea	nULU	Forb/herb	native	OBL			

Glossary

Acid Sulfate Soil (ASS)

A soil or soil horizon which contains sulfides or an acid soil horizon affected by oxidation of sulfides. Acid sulfate soils are the common name given to naturally occurring sediments and soils containing iron sulfides (principally iron sulfide or iron disulfide or their precursors). The exposure of the sulfide in these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid.

Note: The term acid sulfate soil generally includes both actual and potential acid sulfate soils. Actual and potential acid sulfate soils are often found in the same soil profile, with actual acid sulfate soils generally overlying potential acid sulfate soil horizons.

Actual Acid Sulfate Soils (AASS)

Soils containing highly acidic soil horizons or layers resulting from the aeration of soil materials that are rich in iron sulfides, primarily sulfide. This oxidation produces hydrogen ions in excess of sediment's capacity to neutralize the acidity resulting in soils of pH of 4 or less when measured in dry season conditions. These soils can usually be identified by the presence of yellow mottles and coatings of jarosite.

Algae

Non-vascular photosynthetic plant-like organisms, some of which live in or on the soil.

Aquaculture

The farming of plants and animals that live in water (i.e. shellfish, fish, algae).

Bathymetry

The physical characteristics – including depth, contour, and shape – of the bottom of a body of water.

Beach

A gently sloping area adjacent to a lake or ocean that lies between the low and high water marks, which is devoid of vegetation, and is composed of unconsolidated material, typically sand or gravel, deposited by waves or tides.

Brackish

Somewhat salty water, as in an *estuary*.

Boulders — Rock fragments larger than 600 millimeters in diameter.

Chroma — The relative purity, strength, or saturation of a color; directly related to the dominance of the determining wavelength of the light and inversely related to grayness; one of the three variables of color. See also Munsell color system, hue, and value.

Classification, Soil — The systematic arrangement of soils into groups or categories on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties. The USDA soil classification system of soil taxonomy was adapted for use in publications by the National Cooperative Soil Survey on 1 Jan. 1965.

Coarse Fragments — If round, mineral or rock particles 2 millimeters to 25 cm (10 inches) in diameter; if flat, mineral or rock particles 15.2 to 38.1 cm (6 to 15 inches) long.

Control Section — The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is the part of the soil profile between depths of 10 inches and 40 or 80 inches (25 to 100 cm).

Delineation — An individual polygon shown by a closed boundary on a soil map that defines the area, shape, and location of a map unit within a landscape.

Deposit — Material left in a new position by a natural transporting agent such as water, wind, ice, or gravity, or by the activity of man.

Electrical Conductivity (EC) — How well the soil conducts an electrical charge. EC is a measure of salinity, generally expressed as decisiemens per meter at 25 degrees Celsius (dS/m).

Estuary — A seaward end or the widened funnel-shaped tidal mouth of a river valley where fresh water comes into contact with seawater and where tidal effects are evident; e.g., a tidal river, or a partially enclosed coastal body of water where the tide meets the current of a stream.

Glaciofluvial Deposits

Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces.

Gleyed

A soil condition resulting from prolonged soil saturation, which is manifested by the presence of bluish or greenish colors through the soil mass or in mottles (spots or streaks) among the colors. Gleying occurs under reducing conditions, by which iron is reduced predominantly to the ferrous state.

Gravel

Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 cm) in diameter.

Groundwater

That portion of the water below the surface of the ground at a pressure equal to or greater than atmospheric.

Habitat

The place were a given organism lives.

Horizon, Soil

The layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes.

Histosols

Organic soils that have organic soil materials in more than half of the upper 80 cm, or that are of any thickness if overlying rock or fragmental materials that have interstices filled with organic soil materials. (An order in the U.S. system of soil taxonomy.)

Hydromorphic

A general term for soils that develop under conditions of poor drainage in marshes, swamps, seepage areas, or flats.

Imagery

General term for base map or reference map materials.

Intertidal

The area of shore located between high and low tides.

Jarosite

$KFe_3(OH)_6(SO_4)_2$. A pale yellow potassium iron sulfate mineral. The presence of jarosite concentrations is evidence of a sulfuric horizon.

Landform

Any physical, recognizable form or feature on the earth's surface, having a characteristic shape, and produced by natural causes. Landforms provide an empirical description of similar portions of the earth's surface.

Landscape — A collection of related landforms; usually the land surface which the eye can comprehend in a single view.

Map Unit, Soil — (i) A conceptual group of one to many delineations identified by the same name in a soil survey that represent similar landscape areas comprised of either: (1) the same kind of component soil, plus inclusions, or (2) two or more kinds of component soils, plus inclusions, or (3) component soils and miscellaneous area, plus inclusions, or (4) two or more kinds of component soils that may or may not occur together in various delineations but all have similar, special use and management, plus inclusions, or (5) a miscellaneous area and included soils. (ii) A loose synonym for a delineation.

Marine — Refers to the ocean.

Marsh — An emergent *wetland* that is usually seasonally flooded or wet, and often dominated by one or a few plant species.

Mineral Soil — A soil consisting predominantly of, and having its properties determined predominantly by, mineral matter.

Mooring — a structure which is employed to moor, dock or otherwise secure a vessel used for waterborne travel; this may consist of a mooring buoy secured by bottom anchor.

Muck — Organic soil material in which the original plant parts are not recognizable. Contains more mineral matter and is usually darker in color than peat.

Mucky Peat — Organic soil material in which a significant part of the original plant parts are recognizable and a significant part is not.

Munsell Color System — A color designation system that specifies the relative degrees of the three simple variables of color: hue, value, and chroma. For example: 10YR 6/4 is a color (of soil) with a hue = 10YR, value = 6, and chroma = 4.

Nearshore

The region of land extending between the backshore, or shoreline, and the beginning of the offshore zone. Water depth in this area is usually less than 10 m (33 ft).

n-value

The relationship between the percentage of water under field conditions and the percentages of inorganic clay and of humus.

Organic Soil

A soil in which the sum of the thicknesses of layers containing organic soil materials is generally greater than the sum of the thicknesses of mineral layers.

Organic Soil Materials

Soil materials that are saturated with water and have 174 g kg^{-1} or more organic carbon if the mineral fraction has 500 g kg^{-1} or more clay, or 116 g kg^{-1} organic carbon if the mineral fraction has no clay, or has proportional intermediate contents, or if never saturated with water, have 203 g kg^{-1} or more organic carbon.

Outwash

Stratified detritus (chiefly sand and gravel) removed or "washed out" from a glacier by melt-water streams and deposited in front of or beyond the end moraine or the margin of an active glacier. The coarser material is deposited nearer to the ice.

Parent Material

The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of soils is developed by pedogenic processes.

Ped

A unit of soil structure such as a block, column, granule, plate, or prism, formed by natural processes (in contrast with a clod, which is formed artificially).

Pedon

A three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations.

pH, Soil

The pH of a solution in equilibrium with soil. It is determined by means of a glass, quinhydrone, or other suitable electrode or indicator at a specified soil-solution ratio in a specified solution, usually distilled water, 0.01 M $CaCl_2$, or 1 M KCl.

Potential Acid Sulfate Soils (PASS)

Soils which contain iron sulfides or sulfidic material which have not been exposed to air or oxidized. The field pH of these soils in their undisturbed state can be pH4 or more and may be neutral or slightly alkaline. However, they pose a considerable environmental risk when disturbed, as they will become very acidic when exposed to air and oxidized.

Profile, Soil

A vertical section of the soil extending through all its horizons and into the parent material.

Pyrite

Pale-bronze or brass-yellow, isometric mineral: FeS_2; the most widespread and abundant of the sulfide minerals.

Reaction, Soil

The degree of acidity or alkalinity of a soil, usually expressed as a pH value. Descriptive terms commonly associated with certain ranges in pH are: extremely acid, <4.5; very strongly acid, 4.5-5.0; strongly acid, 5.1-5.5; moderately acid, 5.6-6.0; slightly acid, 6.1-6.5; neutral, 6.6-7.3; slightly alkaline, 7.4-7.8; moderately alkaline, 7.9-8.4; strongly alkaline, 8.5-9.0; and very strongly alkaline, >9.1.

Rock Fragments

Unattached pieces of rock 2 mm in diameter or larger that are strongly cemented or more resistant to rupture.

Salinity

A measure of the salt concentration of water. Higher salinity means more dissolved salts. Usually measured in parts per thousand (ppt).

Salinity, Soil

The amount of soluble salts in a soil. The conventional measure of soil salinity is the electrical conductivity of a saturation extract.

Salinity Regime

A portion of an estuary distinguished by the amount of tidal influence and salinity of the water. The major salinity regimes are, from least saline to most saline:

- **Tidal Fresh –** Describes waters with salinity between 0 and 0.5 parts per thousand (ppt). These areas are at the extreme reach of tidal influence.

- **Oligohaline –** Describes waters with salinity between 0.5 and 5 ppt. These areas are typically in the upper portion of an estuary.
- **Mesohaline –** Describes waters with salinity between 5 and 18 ppt. These areas are typically in the middle portion of an estuary.
- **Polyhaline –** Describes waters with salinity between 18 and 30 ppt. These areas are typically in the lower portion of an estuary, where the ocean and estuary meet.

Salt Marsh

A coastal habitat consisting of salt-resistant plants residing in an organic-rich sediment accreting toward sea level.

SAV

See submerged aquatic vegetation.

Sediment

Material that settles to the bottom of a body of water. Solid fragments of inorganic or organic material that come from the weathering of rock and are carried and deposited by wind, water, or ice.

Series, Soil

A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the underlying materials. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Shellfish

An aquatic animal, such as a mollusk (e.g. clams, oysters, and snails) or crustacean (e.g. crabs and shrimp), having a shell or shell-like external skeleton (exoskeleton).

Slope

The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by the horizontal distance, and then multiplied by 100. Thus a slope of 5 percent is a drop of 5 feet in 100 feet of horizontal distance.

Soil

(i) The unconsolidated mineral or organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. (ii) The unconsolidated mineral or organic matter on the surface of the earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics.

Soil Auger

A tool for boring into the soil and withdrawing a small sample for field or laboratory observation.

Soil Horizon

A layer of soil or soil material approximately parallel to the land surface and differing from adjacent genetically related layers in physical, chemical, and biological properties or characteristics such as color, structure, texture, consistency, kinds and number of organisms present, degree of acidity or alkalinity, etc.

Soil Series

The lowest category of U.S. system of soil taxonomy; a conceptualized class of soil bodies (polypedons) that have limits and ranges more restrictive than all higher taxa. Soil series are commonly used to name dominant or codominant polypedons represented on detailed soil maps. The soil series serve as a major vehicle to transfer soil information and research knowledge from one soil area to another.

Soil Structure

The combination or arrangement of primary soil particles into secondary units or peds. The secondary units are characterized on the basis of size, shape, and grade (degree of distinctness).

Soil Texture

The relative proportions of the various soil separates in a soil as described by the classes of soil texture

Solum

A set of horizons that are related through the same cycle of pedogenic processes; the A, E, and B horizons.

Subaqueous Soil

Soils that occur under water (both fresh and salt water). The depth range of the water column where these soils may be found is not known, an arbitrary depth of 2.5 meters below the surface has been set for soil survey inventory. Subaqueous soils formed under a continuous water column (such as in an estuary), although their sediments may have originated from an upland area such as a dune.

Submerged Aquatic Vegetation (SAV)

Rooted vegetation that grows under water in shallow zones where light penetrates.

Submerged Soil

Soil that is under water as a result of rising water tables, flooding events (such as a Beaver Dam), or sea level rise.

Submerged soils formed in an upland environment but are now underwater.

Subsoil — The B horizon.

Substratum — Any layer lying beneath the soil solum, either conforming or unconforming.

Sulfidic Materials — Sulfidic materials contain oxidizable sulfur compounds. They are mineral or organic soil materials that have a pH value of more than 3.5 and that, if incubated as a layer 1 cm thick under moist aerobic conditions (field capacity) at room temperature, show a drop in pH of 0.5 or more units to a pH value of 4.0 or less (1:1 by weight in water or in a minimum of water to permit measurement) within 8 weeks.

Sulfuric Horizon — A horizon composed either of mineral or organic soil material that has both pH <3.5 and jarosite mottles.

Suspended Sediments — Particles of soil, sediment, living material, or detritus suspended in the water column.

Taxadjuncts — A soil that is correlated as a recognized, existing soil series for the purpose of expediency. They are so like the soils of the defined series in morphology, composition, and behavior that little or nothing is gained by adding a new series.

Terrestrial — Living on land, as opposed to marine or aquatic.

Tidal Marsh — Low coastal grassland whose surface is covered and uncovered by tidal flow.

Tides — Periodic movement of water resulting from gravitational attraction between the earth, sun, and moon.

Till

1. Unsorted and unstratified earth material, deposited by glacial ice, which consists of a mixture of clay, silt, sand, gravel, stones, and boulders in any proportion..
2. To prepare the soil for seeding; to seed or cultivate the soil.

Turbidity — The decreased clarity in a body of water due to the suspension of silt or sedimentary material.

Undifferentiated Group A kind of map unit used in soil surveys comprised of two or more taxa components that are not consistently associated geographically. Delineations show the size, shape, and location of a landscape unit composed of one or the others, or all of two or more component soils that have the same or very similar use and management for specified common uses. Inclusions may occur up to some allowable limit.

Upland Land at a higher elevation, in general, land above lowlands in streams and submerged areas.

Wassents Proposed taxonomy for subaqueous soils.

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