

WEIR RIVER AREA OF CRITICAL ENVIRONMENTAL CONCERN

Natural Resources Inventory

Massachusetts Department of
Environmental Management

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I. INTRODUCTION

The Weir River Area of Critical Environment Concern (ACEC) was designated by the Massachusetts Secretary of Environmental Affairs in 1986 in recognition of one of the largest and most productive salt marsh ecosystems in the Boston Harbor area. As an ACEC, the region is afforded additional attention and protection from state agencies in order to achieve the goals of designation--to restore, enhance, and manage the resources. The region was nominated by residents of the abutting communities of Hull, Hingham, and Cohasset who took the opportunity to call attention to the uniqueness of the environment and to their concerns that development pressures threatened the estuary's integrity. The Department of Environmental Management (DEM) administers the ACEC Program for the Secretary of the Environmental Affairs. DEM, through the Massachusetts Watershed Initiative, funded this natural resources inventory, as well as a hydrologic flow study, for the Weir River ACEC.

This document comprises a Natural Resources Inventory for the Weir River ACEC, summarizing existing research and the knowledge and experience of local experts and residents who are most familiar with the ACEC's natural environment. The inventory could be used as the first step toward producing a comprehensive resource management plan for the ACEC. It captures the abundance and unique combination of resources in the region and identifies existing pollution problems and threats. As such, this resource inventory was prepared to serve as a reference for scientists, local and state officials, and citizens who are committed to protecting the ecosystem and to making the most of what the ACEC designation offers. In addition, it provides the necessary background to prioritize additional research needs and to assess existing local environmental and land use management practices and policies.

The Weir River ACEC stands apart in terms of its ecological as well as economic contributions to Boston Harbor. With approximately 950 acres, the ACEC represents a diverse wetlands habitat that includes salt marsh, shallow marsh meadow, shrub marsh, and wooded swamp. These wetlands are home to over 100 resident and migratory birds, including the endangered pied-billed Grebe (EOEA 1986, NHESP Appendix A). The ACEC also has several potential vernal pools, which provide refuge for rare plants, reptiles, and amphibians. The Weir River is often described as a significant anadromous and catadromous fish run, featuring alewife, rainbow smelt, white perch, blue back her-

ring, and American eel. Soft shell clams are abundant in the ACEC. Harvested by commercially licensed master diggers, they support an important commercial industry in Boston Harbor.

Despite these favorable features, the Weir River ACEC is not immune to the negative environmental consequences that can result from a densely settled population. A legacy of pesticide applications to control midge populations in Straits Pond, for example, is recorded by toxins accumulated in underlying sediments (IEP 1980; McDermott 2001). Until recently, fecal pathogens and organic pollutants frequently found their way into ACEC waters by way of illicit stormwater connections and failing septic systems (IEP 1980). While most homes surrounding the pond are now connected to a municipal sewer, this was not always the case. Hull homes surrounding Straits Pond were sewered and the pipes laid for Cohasset homes were connected in March of 2000 (Brennan 2000). Along the Weir River Estuary in Hingham, over half of the homes are still not sewered (Capman 2002). Many of these contaminants remain in the slow moving groundwater and will likely impact the ACEC in years to come (Freeze & Cherry 1979; Sullivan 1998). Surface runoff from roadways and lawns are also a factor, carrying a variety of pollutants into the water each time it rains, including hydrocarbons from oil and gas residues, nutrients from fertilizers and sediments (IEP 1980).

Residents in Hull, Hingham, and Cohasset have displayed an undisputable commitment to understand and protect the remaining wildlife and open space in their community. A number of local residents and experts routinely organize bird and nature walks to monitor the bird population. Citizens around Straits Pond have rallied for many years for improved conditions in the pond, codifying their efforts by founding the Straits Pond Watershed Association (SPWA). In addition, a stewardship group has recently formed to serve the interests of residents in the remaining reaches of the ACEC and the entire watershed, the Weir River Watershed Association. The mission of this new association is to promote, preserve, and protect the water quality and quantity of the Weir River while providing access and education. A Weir River Study Committee was also recently appointed by the Hull Selectmen to identify public and private open space that borders the ACEC. This resources inventory will hopefully provide valuable information to expand these initiatives and foster new relationships.

The document presents both anecdotal and scientific data relating to history of the region, geology and soils, watershed characteristics, habitats of the Weir River ACEC, biological resources, hydrography, water quality, land use, and open space and recreation. Interviews with local resource professionals and long time residents supplemented the literature

review of existing reports and studies. Because of differing geomorphologies, hydrodynamics, and available data, discussions in this document often subdivide the ACEC into four component parts: the lower reaches of the Weir River north of Foundry Pond, the Weir River Estuary, Straits Pond, and the portion of Hull Bay west of Sunset Point (see Figure 1-1).

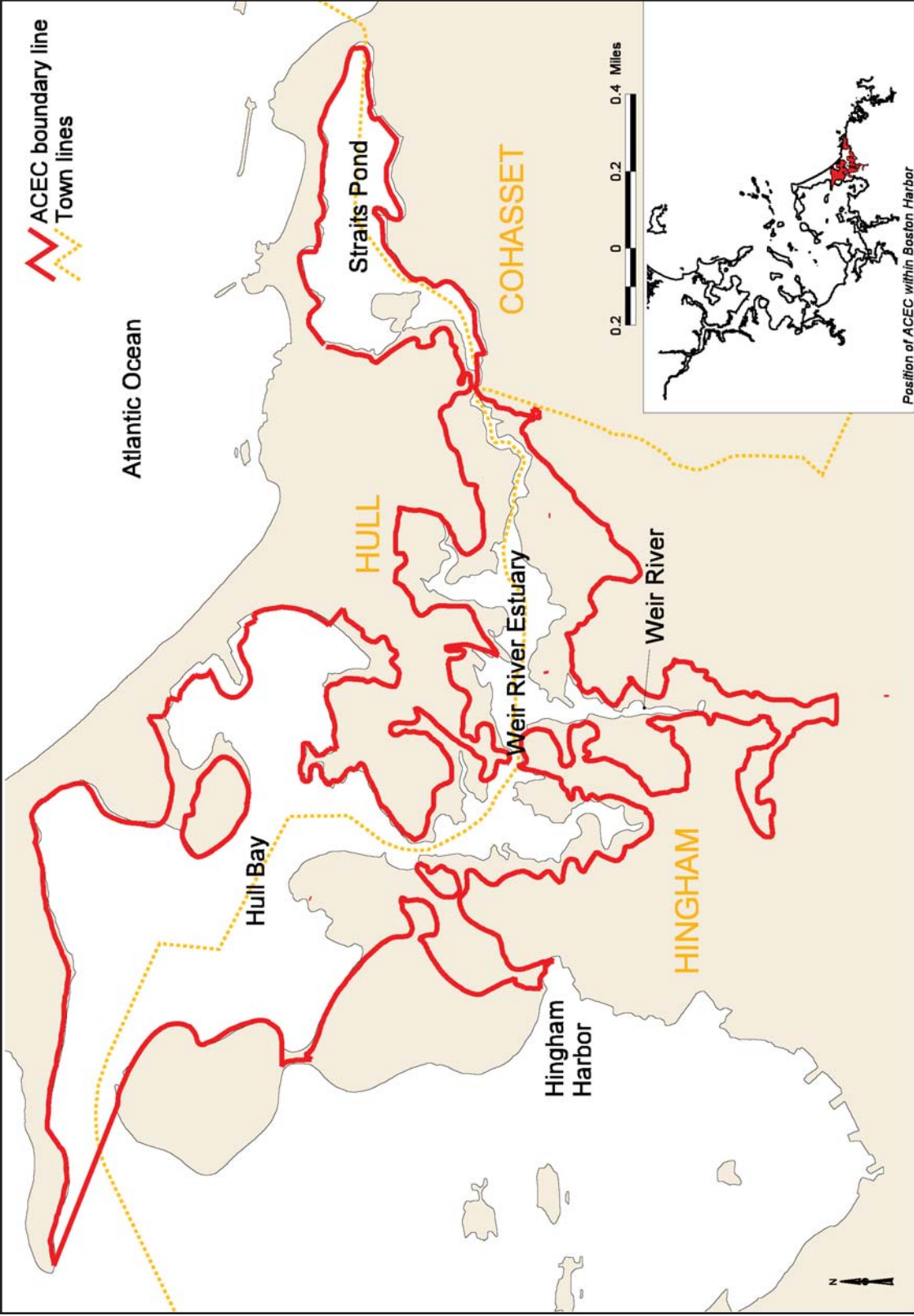
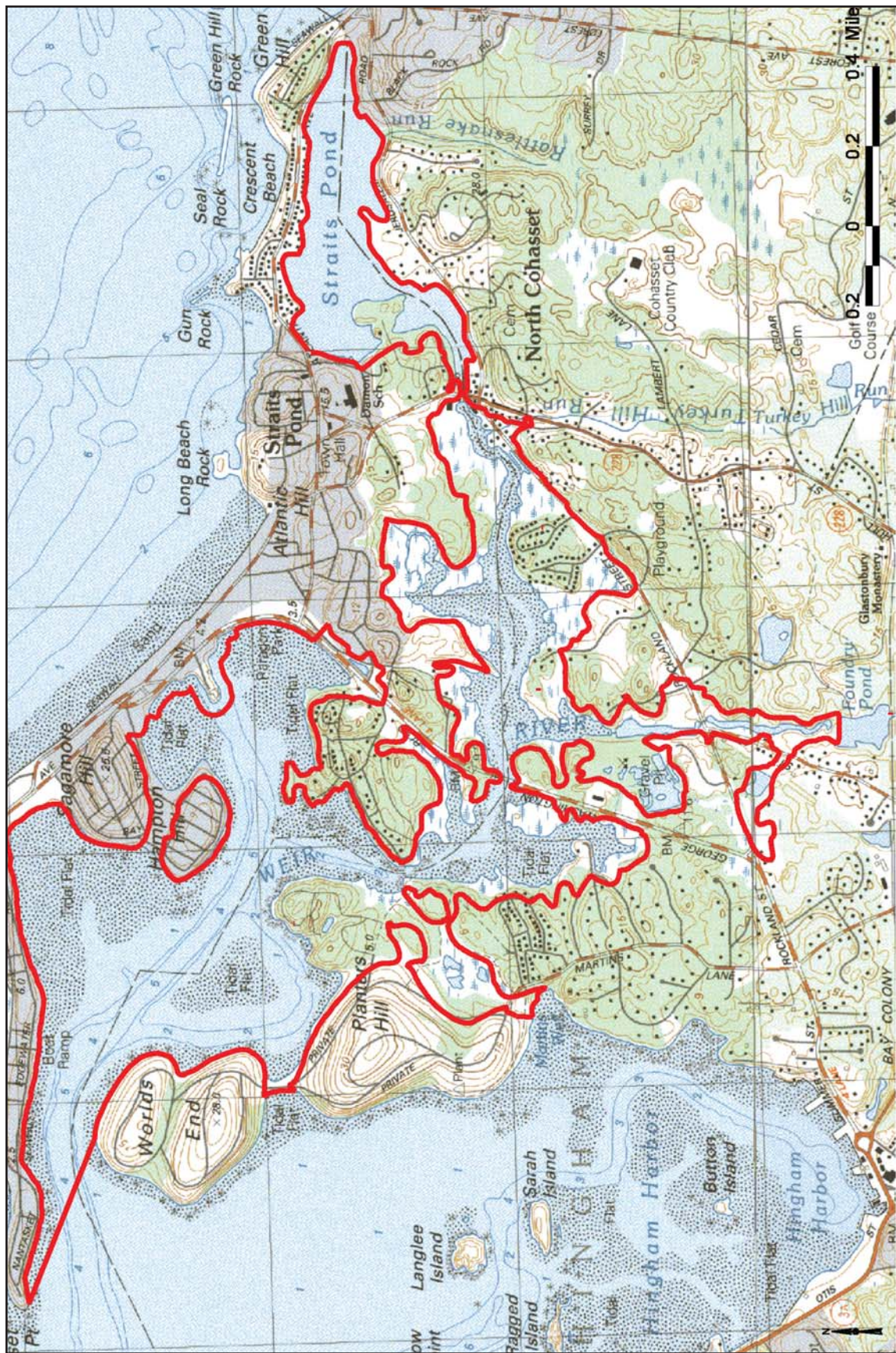


Figure 1-1. Weir River ACEC Boundary Location (Data source: MassGIS, UHI).



2. ACEC CHARACTERISTICS AND DESIGNATION

2.1 ACEC PROGRAM BACKGROUND

The Commonwealth of Massachusetts designated the Weir River Area of Critical Environmental Concern (ACEC) in 1986 (See Appendix B). An ACEC is an area that is formally designated by the state as containing significantly unique and important environmental resources worthy of preservation, restoration and consideration in future management decisions. Goals of the ACEC Program include strengthening protection of ACEC resources and encouraging the development of cooperative actions between communities, agencies, organizations and individuals interested in the management and use of these resources.

The Massachusetts Department of Environmental Management (DEM) administers the ACEC Program on behalf of the Secretary of Environmental Affairs and coordinates closely with the Massachusetts Coastal Zone Management (CZM) Office regarding all coastal ACECs. A decision by the Secretary to designate an area as an ACEC carries with it a requirement that all state environmental agencies acquire information about the resources of the ACEC; preserve, restore, or enhance the resources of the area; and ensure that activities within the ACEC minimize adverse effects on the natural and cultural values of the area. This designation recognizes significant ecosystems and is intended to foster appreciation and stewardship of the associated unique resources (ACEC Program 2001).

Projects within ACEC boundaries require higher environmental standards and review. However, rather than creating new regulations, the goals of an ACEC designation are implemented through the existing state environmental regulatory and review framework. Specific state regulatory requirements concerning ACECs include: Massachusetts Environmental Policy Act (MEPA), Waterways Regulations (Chapter 91), Wetlands Protection Act, Solid Waste Facilities Site Assignment Regulations and CZM policies. The designation also encourages coordination of local, regional, state, and federal programs, plans, and activities to achieve management goals.

2.2 DESIGNATION OF WEIR RIVER ACEC

The Weir River ACEC encompasses approximately 922 acres straddling Hull, Cohasset and Hingham (see Figure 1-1). Figure 2-1 displays town acreage and their

areas as a percentage of total ACEC area. This acreage was calculated in Arc View GIS 3.x.

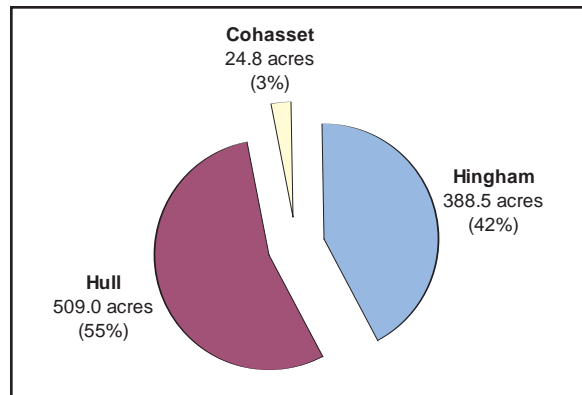


Figure 2-1. Acreage of Towns Within ACEC

The boundary of the Weir River ACEC is depicted in Figures 1-1 and 1-2 and includes a portion of Hull Bay, the Weir River Estuary for its entire length and Straits Pond, generally following the 100-year flood plain line around these water bodies. Important adjacent resources outside the ACEC boundary include the tributaries Turkey Hill Run and Rattlesnake Run, Foundry Pond, and the Weir River downstream of Foundry Pond. The landward boundary usually follows the 100 -year flood elevation as delineated by the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps and Floodway Maps. In some locations the landward boundary changes to the mean high water line or other artificial boundaries and excluded areas. See Appendix B for the ACEC designation document that includes the legal boundary and resource designation. The area begins at the mouth of the Weir River, where it empties into Hingham Harbor between the northernmost point of the World's End Reservation in Hingham and Sunset Point in Hull.

This estuary with a large salt marsh supports over 100 species of migratory and indigenous birds, shellfish beds, an anadromous fish run, and serves as a nursery to a variety of finfish. In the designation of this area, the Secretary of Environmental Affairs found that "the coastal wetland resource areas included in the Weir River ACEC are significant to flood control, the prevention of storm damage, the protection of land containing shellfish, and fisheries: public interests defined in the Wetlands Protection Act."

As well as being an important ecological habitat and breeding ground, the Weir River ACEC provides recre-

ational opportunities within its borders and at the adjoining World's End Reservation and Nantasket Beach. The features of the region that support official designation as an ACEC include (EOEA 1986):

Quality of the Natural Characteristics

The salt marshes within the Weir River Estuary include approximately 100 acres of relatively undisturbed wildlife habitat. The large size of this salt marsh is unusual for its proximity to the city and contains a healthy population of migratory birds, small mammals, an anadromous fish run and soft shell clam and mussel shellfisheries.

Productivity

Estuarine/salt marsh ecosystems are among the most productive areas on earth. Plant growth within the marsh provides a base to a food web including birds, fish, insects and shellfish within the estuary. Plant material is also exported by the tides to provide nutrient input to less productive areas of the open water, rocky tidal areas or sandy beaches. The shallow, protected waters of the estuary also provide a nursery to shellfish and finfish. The Weir River Estuary provides habitat for an alewife run and year-round and seasonal populations of smelt, eel, bluefish, striped bass, flounder and blue-back herring. Migratory waterfowl feed on the diverse benthic community supported by estuarine conditions.

Uniqueness of the Area

This large, relatively undisturbed marsh complex is unique in its proximity to a major metropolitan center. Communities surrounding the Weir River are subject to intense development pressures and this remaining estuarine habitat not only provides wildlife resources, biodiversity, and ecosystem productivity, but public aesthetic, recreational, and educational benefits for residents, businesses, and visitors. Smaller parcels of marshland do exist in the area, but the number of sizable marshlands of this kind is dwindling throughout the state.

Irreversibility of Impact

Estuarine life is extremely sensitive to changes in salinity, pH, and sediment load. Dredging and development

related pollution contribute to nutrient loading, runoff, drainage pattern changes and sediment resuspension that may irreversibly alter ecosystems, surface water and groundwater quality.

Threats to Public Health Through Inappropriate Use

The increased loadings of suspended sediment, heavy metals, hydrocarbons, and bacterial and viral contaminants carried by runoff will add environmental stress to the shellfish beds already suffering the ill-effects of development pressures. Any waters used for recreational swimming, boating and shellfish rearing will reflect the changing runoff content and pathways caused by coastal development.

Imminence of Threat to Resources

Violations of the Wetlands Protection Act prior to ACEC designation proved that irresponsible development and municipal uses were threatening the Weir River Estuary. Plans to rapidly develop in the vicinity of the Weir River, especially in Hull, led to concern for the integrity of the Estuary and the ability of the system to accommodate the effects of increased population and construction. Through designation as an ACEC, development is encouraged to be congruent with the value of the Weir River's natural resources and the sensitivity of the area.

Economic Benefits

Cohasset, Hingham and Hull are all suburban communities that are home to residents who have chosen to live on the South Shore for its high quality of life and natural beauty. The residents support most of the services in the area and any decrease in desirability and attractiveness would lead to adverse effects on the economy of these three towns.

Supporting Factors

Local residents, environmental groups and town Boards and Commissions supported the designation of the Weir River Estuary as an ACEC.

3. REGIONAL HISTORY

3.1 ARCHAEOLOGICAL EVALUATION

The following discussion on archeology was prepared by Tom Mahlstedt, Massachusetts Department of Environmental Management.

The Weir River ACEC contains at least eight recorded prehistoric archaeological sites within its boundaries, with an additional nine within less than 1/4 mile. This site frequency is consistent with the pattern of Native American land use in coastal New England in general, and clearly attests to the ecological significance of estuarine environments for plants, animals and humans since prehistoric times. Perhaps as significantly, it also suggests that the potential for additional undiscovered archaeological sites in and around the Weir River ACEC is extraordinarily high.

The existing archaeological record of the Weir ACEC and its immediate environs documents the presence of Native American hunters and gatherers here since possibly as early as 8,000 years ago (Middle Archaic Period). One of the most significant sites in the region, Atlantic Ledges (19-PL-1), is located at Long Beach Rock where it overlooks the Atlantic Ocean. By the Late Archaic Period (c. 6,000 - 3,000 years ago) it appears that the local population had become well adapted to the local marine resources, as shell middens containing the remains of marine fauna and fish are prominent at the sites of this Period. Shell middens demonstrate that estuarine resources continued to be important throughout the late Woodland Period (ca. 1,200 - 400 years ago), and the presence of domesticated dog is suggested by a worked canine in the midden of 19-PL-570 on World's End. Another regionally significant site in the vicinity of the Weir River ACEC is a proto-historic cemetery (19-PL-268) that contained the graves of four adults and a child that were accompanied by European trade items such as an iron hatchet, a brass kettle, and brass and glass beads, and which further illustrates that this specialized habitat remained economically significant into colonial times.

3.2 LOCAL INDUSTRIES

The Plymouth Colony began trading with the local Native Americans at a post in Hull as early as 1621. The close proximity of coastal fishing, woodland hunting areas and good agricultural lands made this area a probable site for Native Americans and early European trading, fishing, and exploring settlements.

Table 3-1. Weir River Archaeological Site Inventory

Site #	Name
19-PL-1	Atlantic Ledges
19-PL-267	World's End
19-PL-268	HUL-HA-1
19-PL-269	Damde Meadows
19-PL-566	Rocky Neck
19-PL-567	Lincoln Rocks
19-PL-568	Hermits Cove
19-PL-569	Boardwalk
19-PL-570	Boulder Cove
19-PL-571	Bumpkin View
19-PL-572	Site #2
19-PL-573	Martin's Cove
19-PL-824	Kilby Site
19-NF-2	
19-NF-577	Find Spot 1
19-NF-578	Find Spot 2

Hingham and Hull were incorporated in 1635 and 1644, respectively. Cohasset was originally a pastureland for Hingham and did not become an incorporated town until 1771. Early colonists subsided on agriculture, orchards, fishing, and grazing. Hull's early economy was focused on maritime activities, primarily fishing and trade. The group of English that settled in Hingham came from an inland county (Hingham, East Anglia) and retained the inland occupations of farming, grazing, cooperage, and leather tanning until a gradual increase in maritime activities took hold in the early eighteenth century (MCH 1980). As the colony prospered, this corner of the Boston Harbor became an important trading post for fish, lumber, and agriculture and became a defensive position for the colonies before and during the Revolutionary War (MHC (a) 1979, MCH (b) 1979, MCH 1980).

By the late 1700s, fishing, saltworks, cooperage and shipbuilding industries made Hingham, Hull and Cohasset exporters of preserved fish to the West Indies. All three towns had productive saltworks and both Hingham and Cohasset had successful shipbuilding enterprises. Saw and gristmills were early industrial enterprises in Hingham and Hull, producing timber, shingles, and clapboards (MHC (a) 1979, MHC 1980).

Throughout the 19th century, the economies of the three towns diversified to include dairy farms, tanneries, and iron, copper and brass foundries. In Hingham, the iron works contributed to a number of factories in town pro-

ducing nails, ploughs, hammers, guns, and scales and balances (MCH 1980). Hingham also supported textile industries such as woolen and silk production and a factory that produced upholstery trimmings (MHC 1980). Within the immediate area of the Weir River ACEC, a gristmill, iron foundry and some timber harvesting all contributed to the local economy. A sluice gate, spillway and nineteenth century industrial building site are all still visible along the Weir River as well as colonial stone fences in the Weir River Woods (Van Hamm 2001) and an ancient river crossing near Rockland Street (Richardson 1983), historically significant sites worthy of protecting.

Throughout the nineteenth and twentieth centuries, industrial production and commercial fishing declined in Hull, Hingham, and Cohasset, and tourism began dominating the local economy. In Cohasset and Hingham, fishing was a minor part of the economy by the 1880s (MCH (a) 1979, MHC (b) 1979, MHC 1980). Hull maintained its ocean-centered activities, continuing to fish and also employing townspeople in salvaging wrecks in Boston Harbor. Hull, in particular, grew into a popular destination for travelers drawn to the beauty of its coastal environment. But today Hull's reputation as a resort town has faded, and Hingham, Hull and Cohasset are largely bedroom communities with some local employment and many commuters into Boston. Beaches in the area, however, remain preferred day trip destinations.

Long before the first Europeans arrived, shellfish and finfish comprised an important part of the local diet and industry in the region. Shellfish, in particular, comprised a large part of the Native American diet around the Weir River, as evidenced by the piles of shells noticed by colonialist (Iwanowicz 1973). In addition, the fishing techniques used by early colonial subsistence fishermen were probably copied from those of local tribes (Iwanowicz 1973).

In 1637, a herring monopoly was granted to build a weir on the river called "Lyford's Liking," now known as the Weir River (Bigelow 1898). Commercial fishing became increasingly important, and by the mid 1700s town committees designated to manage the alewife fisheries began enforcing protective legislation, including fines for blocking a fish run and tax incentives for mill operators who provided passage for fish (Iwanowicz 1973). In the 1800s, lobster became the major marine resource and Hull became the largest lobster port in Massachusetts, catching over one million lobsters each year (Iwanowicz 1973).

Shellfishing was not popular among early settlers, who did not seem to value clams as a food staple or an economic resource and therefore did not attempt to preserve or exploit the flats. However, by the early 1900s

water pollution had spoiled the clam-flats, and the modern soft shell clam industry was not established until the Shellfish Purification Plant in Newburyport was built in 1930.

3.3 STRAITS POND

A road (now Route 228) was first built across Straits Pond in the late 1800s. Water levels in the pond were controlled by adjusting a series of planks. In the early 1940s, a hand crank replaced the plank system and in 1997 the tide gate was finally motorized. Another manual gate was built in 1999 and the flow is now controlled using a combination of the electrical and manual gates (McNamara 2002). The ongoing operation of this tide gate maintains the water body as a pond.

Although it is not used much for recreation today, summer travelers that once congregated in Hull and the surrounding communities used to swim and boat in Straits Pond. Such long-term recreational and esthetic appreciation of the pond has created a basis for citizen stewardship for its maintenance and restoration and requests for state agency assistance in pond management for over a century.

The State Board of Health conducted the first investigation into foul odors and excess weed growth in Straits Pond in 1900 (Commonwealth of Massachusetts 1954). Again in 1905 and throughout the 1940s, local authorities and experts suggested mechanical removal of the aquatic vegetation and the possibility of opening the pond to either the ocean at Black Rock Beach or to the Weir River. In the 1950s, the Town of Hull expressed interest in constructing a sewage system to alleviate some of the pollution that was entering the pond.

Throughout the years, the pollution sources, midge population and aquatic vegetation growth have prompted several studies and sets of recommendations. The homes surrounding Straits Pond have been sewered to address pollution concerns. The pond has been sprayed with heptacholor, sodium arsenite and kuron, aqualin, arsenic trioxide, princep 80W, hydrothol-47, DDT, lead arsenate, and abate (IEP 1980; McDermott 2001) and the water level has been drained and controlled to obtain an ideal salinity. An extremely active citizens group, the Straits Pond Watershed Association participates in biological, physical and chemical monitoring, public education/outreach and grant writing in a constant effort to improve Straits Pond.

3.4 FLOOD HISTORY

Due to their coastal New England location, Hingham, Hull and Cohasset are all highly susceptible to north-

easterns. Northeasters are storms that travel southwest to northeast along the Atlantic Coast, and although they have less intense winds than hurricanes, northeasterners tend to move much slower and cover a larger area, resulting in a storm that can last several days. Northeasters usually are active long enough to effect at least one high tide, which leads to the most severe flooding conditions for the area surrounded by the Weir River ACEC.

For all three towns, the last 100-year flooding event was the February 1978 storm. For most of the area in the ACEC, a 100-year event is characterized by flood elevations of between 9-13 feet above sea level. Flood insurance records show that sections of the Weir River and the Weir River Estuary have flooded not only in 1978, but also in March of 1962, and during Hurricane Diane in 1955 (FEMA 1983, FEMA 1982, FEMA 1986). Areas that have flooded bordering the ACEC include: neighborhoods north of the Weir River and Rockland Street in Hingham, Crescent Beach at the northwest corner of Straits Pond, Turkey Hill Run outlet into Straits Pond, and Atlantic Avenue in Cohasset and Hull. The most severe flooding on record occurred during the storm in 1978 when the ocean flooded over Crescent Beach and into Straits Pond and the entire seven-mile stretch between Nantasket Beach to Point Allerton was submerged under 6-10 feet of water (FEMA 1982).

The loss of life, damage to property and town facilities and utilities, and potential harm to ecosystem health are all important flood concerns. Seawalls, breakwaters, and bluff stabilization are all engineering techniques that have been used to mitigate flood damage around the ACEC in the past. The state also recommends a combination of the following measures to ensure safe and cost effective hazard mitigation:

- Land use planning & regulation of the development in hazard-prone areas, such as prohibiting new construction in a floodplain, along a coastline or in any other hazard prone area.

- Enforcement of building codes and environmental regulations.

- Public safety measures such as continual maintenance of roadways, culverts and dams.

- Acquisition or relocation of properties, such as purchasing buildings located in a floodplain.

- Retrofitting of structures & design of new construction such as elevating a home or building.

- Coastal zone management, such as dune restoration and harbor safety measures.

- Comprehensive emergency planning, preparedness and recovery. (DEM 1999).

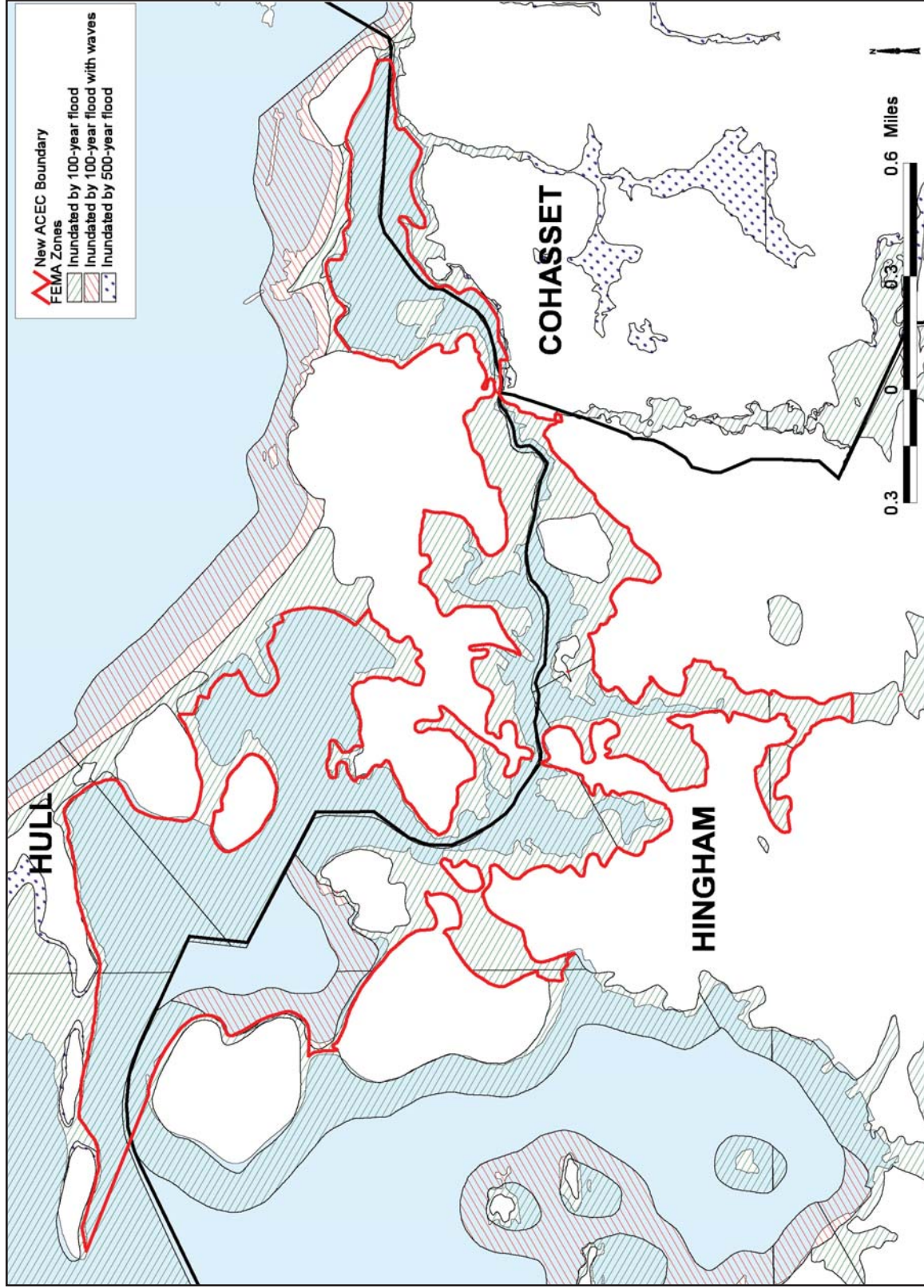


Figure 3-1. Federal Emergency Management Agency Q3 Flood Hazard Map (Data source: MassGIS).

4. GEOLOGY AND SOILS

4.1 GEOLOGY

The Weir River ACEC lies at the southern edge of the geological depression known as the *Boston Basin*. Straits Pond and the upper Weir River east of George Washington Boulevard are the surface expressions of the Ponkagoag Fault, marking the boundary between the Boston Basin and the surrounding Dedham Granite and running northeast to southwest through the ACEC (see Figure 4-1) (Skehan 2001).

Numerous bedrock outcroppings, drumlins, and generally shallow soils (less than 6 feet) are typical of the geology of the Weir River ACEC. The exposed bedrock visible along the shores of the estuary and Straits Pond are Brookline or Squantum members of the Roxbury Conglomerate, Dedham Granite, and volcanics and volcanoclastics (DePaor 2001; IEP 1980). Granite and volcanics are igneous rock formations formed approximately 350 million years ago and conglomerate is a sedimentary stone.

The surface geology of the Weir River watershed is divided into two distinct sections along a line running northeast to southwest along the Boston Basin. The eastern section is till over bedrock, leading to low infiltration and high runoff rates. The till was deposited during the last glacial retreat 12,000 to 15,000 years ago (IEP 1980). Glacial till is a non-sorted, unstratified, homogenized material ranging in particle size from clay to cobbles and occasional boulders. This material is usually dense and relatively impervious. The western section is mostly stratified drift deposits with higher infiltration rates more favorable to supporting productive aquifers (GZA 2000). Retreating glaciers also formed kames, eskers, and outwash deltas and plains from the outwash melt water. Collectively, these deposits are known as stratified drift because they are varying layers of well-sorted material. The stratified drift under the Weir River is made up of coarse sands and gravels that are very pervious.

4.2 SOILS

The soils of the Weir River ACEC fall into one of the following categories (Kreutziger et al. 2000):

Norwell sandy loam - This type of soil can be found under portions of the Hall Estate. Norwell sandy loam is a poorly drained, stony, sandy loam formed from glacial till. This type of soil is acidic and wet and therefore poorly suited for most agricultural uses. Norwell sandy loam is typically wet seven to nine months of the year. The seasonally high watertable also makes this soil less desirable for development.

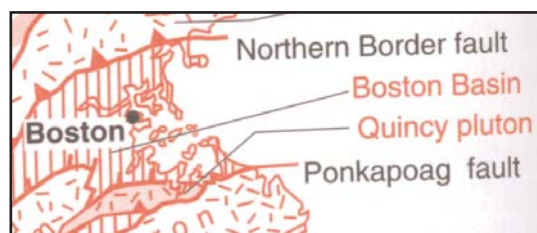


Figure 4-1. Major Geological Features of Boston Harbor and Weir River ACEC (from Roadside Geology of Massachusetts (Skehan 2001))

Scituate sandy loam - A small area of this gently sloping, moderately well drained soil occupies some of Rockaway Annex. Scituate soils were also formed from glacial till and are very stony and usually overlie denser substratum at 18 to 30 inches below the surface (Skehan 2001). Although large surface and subsurface stones and boulders can often be found in Scituate sandy loam, agricultural use is usually possible. The topsoil and subsoil are sandy loam that is mottled in the subsoil. The dense substratum restricts drainage and these soils are saturated until late spring (National Cooperative Soil Survey 2000).

Tidal marsh - Tidal marsh occurs in protected, tidally flooded areas and is made up of very poorly drained mixed organic and mineral material, primarily salt marsh vegetation and silt. Pawcatuck soils are the subset of tidal marsh that is probably found in the Weir River ACEC (Massachusetts Soil Survey Update 2002). Tidal marsh has a high capacity to hold water and is unsuitable for agriculture, woodlands and development.

Newport - Newport soils are deep, well drained soils that are common on the convex sideslopes of uplands and drumlins. Dark colored minerals dominate the glacial till that form Newport soils. These soils are acidic yet well suited to agriculture. A dense substratum does inhibit water drainage below the surface and large surface and subsurface stones are common throughout Newport soils.

Hollis and Charlton fine sandy loams - These two soil types both formed from glacial till in areas of shallow bedrock. Charlton soils are deep, well drained, gently to moderately sloping soils that contain about five (5) inches of black to brown fine sandy loam topsoil and 24 inches of yellowish brown sandy loam subsoil. Hollis soils are shallow, gently sloping to moderately steep, excessively drained soils occurring where bedrock frequently outcrops. Bedrock is typically encountered within 18 inches of the yellow to brown fine sandy loam.

5. WATERSHED CHARACTERISTICS

The Weir River watershed is part of the "Weymouth and Weir Rivers Sub-basin" of the Boston Harbor Watershed. The Boston Harbor Watershed is the most populated basin in the state and supports over 1,070,578 Massachusetts residents (EOEA 2000). Although the Charles River Watershed also drains into Boston Harbor, five sub-basins are characterized as the Boston Harbor Watershed, including the Mystic, Neponset, Fore, Back and Weir Rivers. Expanding citizen-monitoring programs and assessing the stream flow and water supply of the Weir River are top priorities of the Weir Sub-basin and the entire Boston Harbor Watershed.

The Weir River Watershed is located in Plymouth and Norfolk counties, and has a drainage area of about 19.5 square miles (GZA 2000). Located 15 miles south of Boston in the suburban towns of Hingham, Hull, Rockland, Cohasset, Weymouth, and Norwell, the watershed is home to a population of approximately 30,000 residents. Most of the land in the watershed area is residential and undeveloped forest, with a pocket of more industrial zoning close to the southern boundary of the watershed. Wompatuck State Park, owned by the Department of Environmental Management, and the George Washington Town Forest in Hingham surround the upper southeastern portion of the watershed. Population densities and potential stressors to the water-

shed increase as the Weir River flows toward Hull. Although the areas surrounding the ACEC are more developed than some of the upper regions of the river, important open space and conservation lands like World's End and the Weir River Woods provide protected habitats and passive recreation in the northern portion of the watershed.

According to the GZA Water Budget Report (2000), this watershed is characterized by "low-gradient watercourses with well defined channels, broad floodplains, and seasonally variable flow." The Crooked Meadow River and the Fulling Mill Brook combine to form the Weir River near Route 3 in Hingham (Figure 5-2). The Accord Brook and the Crooked Meadow River are the two largest tributaries to the Weir River with lengths of 5.8 miles and 3.7 miles, respectively. Four smaller streams also contribute to the Weir: Turkey Hill Run, Rattlesnake Run, Eel River and Tower Brook. Eight named ponds are included in the Weir River watershed and an additional seven unnamed kettle ponds that were expanded near Fulling Mill. All of the ponds have been artificially constructed or modified for industrial and recreational uses. The Weir River ACEC encompasses the tidal portion of the Weir River, the estuary (which Turkey Hill Run empties into), inner Hull Bay, and Straits Pond, which Rattlesnake Run drains to.

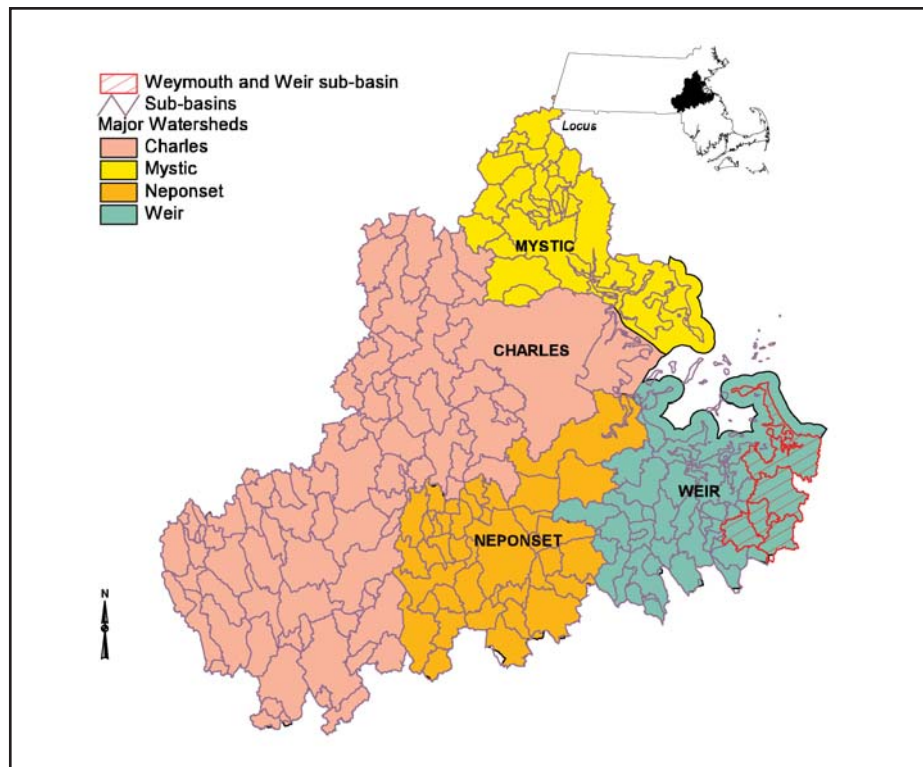


Figure 5-1. Weir River ACEC Watershed Region (Data source: MassGIS)

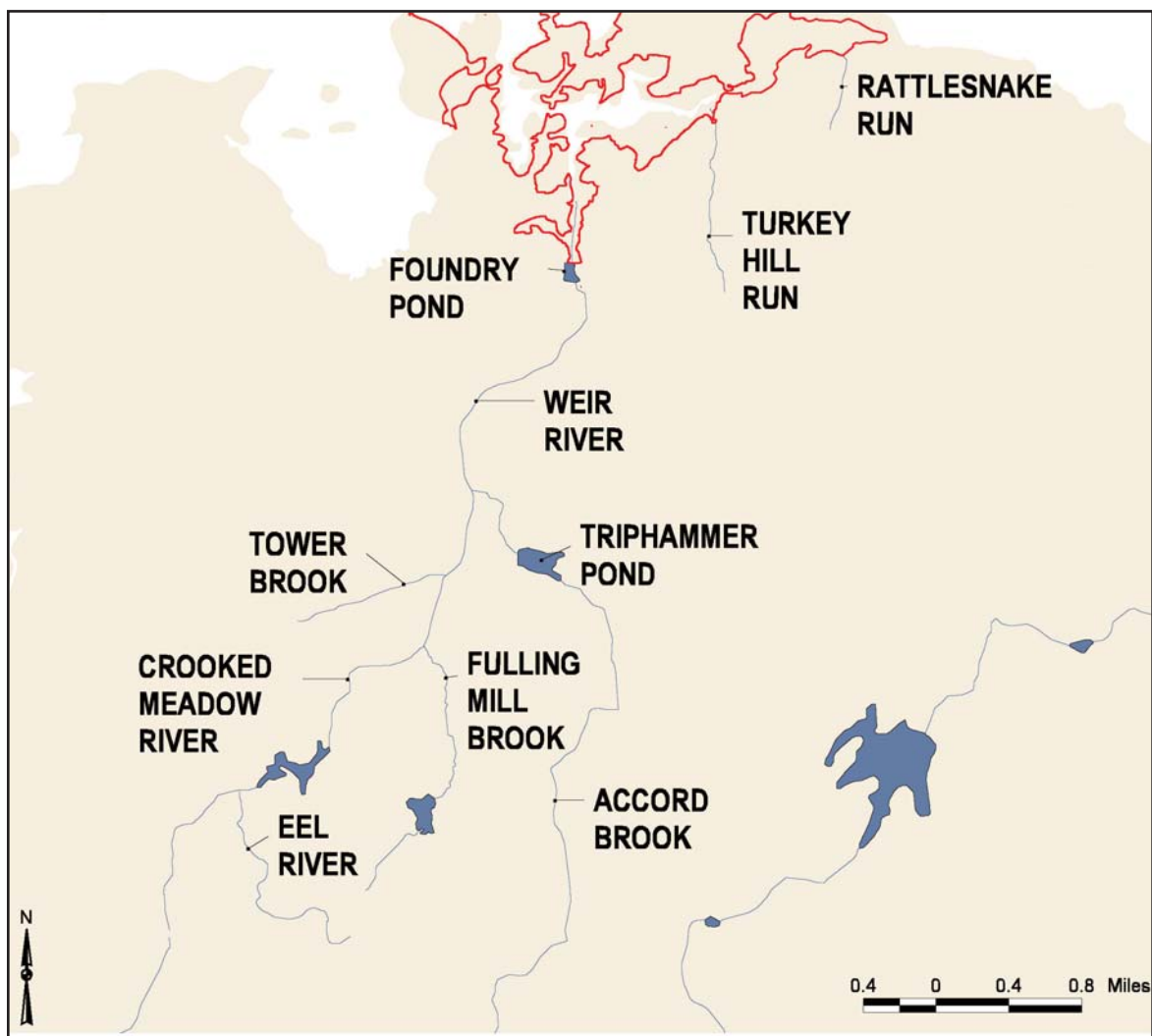


Figure 5-2. Major Hydrographic Features of the Weir River ACEC (Data source: MassGIS)

6. HABITATS OF THE ACEC

The nomination for the Weir River ACEC describes the area as "truly unique as a significant habitat for a wide variety of wildlife in so natural a setting and within 10 miles of a major metropolitan center as Boston." Major habitat features of the estuary are discussed below, including estuaries, tidal flats, salt marsh, eelgrass, and vernal pools. Adjacent barrier beaches are also important habitat features, although not directly within the boundary of the ACEC (see Figure 6-1). These barrier beaches, combined with the outcrops and drumlins that comprise the World's End peninsula and Sunset Point, form a semi-enclosed embayment within Hull Bay and provide for added protection against wind shear and low-grade wave action. However, since these barrier beaches have elevations barely above high tide level, they are also prone to wave washovers during stormy weather. In a washover, water from the Atlantic Ocean is driven across the barrier beach, leading to increased flooding particularly within the more confined area of Straits Pond.

6.1 ESTUARIES

Estuarine waters, where rivers meet the ocean, provide unique physical and biological features and are some of the most productive habitats in the world. Due to the intermediate salinities, both fresh and marine species concentrate in estuarine habitats. The balance between tidal action and the river flow traps organisms, detritus, and nutrients in the estuary. Materials that are carried downstream by rivers, settle out in the estuary, forming the shoals that provide a base for the formation of salt marshes and tidal flat communities.

Nutrients from the river discharge combine with the high amounts of organic detritus to provide a critical environment for fish, vegetation and shellfish. Some organisms remain in estuaries throughout their lives, while others are dependent on this habitat only during a particular life stage. Two thirds of the important commercial finfish of Massachusetts, along with scores of other species, spawn in estuaries. Juveniles of many species utilize estuaries as a nursery while several anadromous species pass through estuaries on the way to spawning sites. See the discussion of Biological Resources that follows for more detailed information.

As estuaries receive all the runoff from the surrounding watershed, they are particularly sensitive to anthropogenic influences. For example, pollution and physical alteration of the river can change nutrient loads, salinity and sedimentation rates and may disturb the balance of conditions on which a productive estuarine community relies.

6.2 TIDAL FLATS

There are approximately three acres of tidal flats, accounting for two percent of total wetlands acreage within the ACEC. The shallow, sloping tidal flats common to estuaries support an enormous density of benthic organisms including the most important commercial shellfish to the Weir River ACEC, the soft shell clam (*Mya arenaria*). More detailed information on the soft shell clam industry is presented in the next section on Biological Resources.

The species composition of such communities is determined by a combination of salinity, substrate quality and the patterns of water movement. As the temperature, salinity, and water depth may vary immensely, organisms must be adapted to the particular conditions of an estuary in order to thrive. As large plants cannot take hold in the sand-mud substrate of tidal flats, algae and fungi, that can tolerate surface exposure, are the primary producers of the flats. However, although their contribution is significant, it is the plankton and detritus carried over the flats by the tidal flow and river currents that represent the main food source for the dense benthic communities. Burrowing animals have adapted to the daily stresses of the tide, extreme salinity and temperature change, by spending much of low tide buried in the exposed substrate. The invertebrates feed on detritus and organic material from the rivers and surrounding estuarine habitats, and provide a link between these communities and the commercial fish that in turn feed upon them at high tide. Tidal flats are also an important feeding ground for migratory shore birds.

6.3 SALT MARSH

The beauty of the Weir River ACEC can largely be attributed to the undisturbed salt marshes that surround the river from Straits Pond to Ringbolt Rock and continue around World's End. There are approximately 129 acres of salt marsh within the ACEC, accounting for 89 percent of the total wetlands acreage. Healthy salt marshes provide the coastal environment with a multitude of biological and physical services. Not only do they buffer the open water from stormwater runoff and pollution, they also protect coastal communities from flood and storm damage. Salt marshes are important nurseries for fish, and habitats for birds, invertebrates, and wetland vegetation and are some of the most productive ecosystems in the world, contributing up to ten tons of organic matter per acre to the surrounding marine and terrestrial communities (Carlozzi *et al.* 1976).

Salt marsh vegetation produces food from solar energy and nutrients, reduces extreme temperatures, transfers moisture to the air via evapotranspiration and adds organic material to the marsh soil. Due to the range of salinity and frequency of flooding, distinct zones of plant and animal life exist within salt marsh communities. The low marsh zone is flooded with every tide and is characterized by the predominance of the broad-leaved salt marsh cordgrass (*Spartina alterniflora*). The smaller salt meadow cordgrass (*Spartina patens*) is more common in the high marsh, where flooding occurs only during extreme high tides or storms (Carlozzi *et al.* 1976). Mats of blue-green algae grow beneath the marsh grass and along the edges of the creeks and rivers all year round. These algae are nitrogen fixers and convert nitrogen from the air into a form that can be used by the marsh vegetation. In the fall and winter, bacteria, algae and organic matter associated with the decomposition of the thick grasses provide food for the bacteria, fungi, plankton and invertebrates living in the marsh. Tidal action flushes the phytoplankton and any excess nutrients through the estuarine and coastal waters, providing food for fish, mollusks, shrimp, crabs and lobsters.

Their ability to filter nutrients, sediment and heavy metals from coastal runoff and the overlying water column makes salt marshes particularly important in the human-coastal dynamic. However, as marshes are filled or altered to make way for expanding development, this ability is reduced, leading to the degradation of the entire coastal environment. Additionally, invasive species such as *Phragmites australis* pose a threat to the complex salt marsh ecosystem by replacing native vegetation and therefore altering the habitat for fish and wildlife. *Phragmites* exists along the shores of the Weir River, however no studies have been implemented to determine if they are spreading. Plans are underway for the restoration of the Damde Meadows salt marsh on the World's End property. This will increase the acreage of salt marsh within the ACEC, and enhance local experts' understanding of the salt marsh system in Hingham and Hull.

6.4 SHALLOW MARSH MEADOW AND WOODED SWAMP

Eleven acres of the Weir River ACEC are classified as shallow marsh meadow or fen and three acres as wooded swamp. These wetlands may comprise all the fresh water wetlands within the ACEC, although some of the shallow marshes might be saline, depending on the tidal reach (Clerkin 2002). A shallow marsh or fen is an emergent wetland characterized by low land, a high water table, and seasonal flooding. Rushes such as *Juncus sp.* and members of the sedge family are plants commonly identified in New England shallow marshes (Tiner 1999).

Swamps, like marshes, are often found near rivers or lakes, are often partially or intermittently covered with water, and have mineral soil that drains very slowly (Tiner 1999). But unlike marshes they have trees and bushes. The wooded swamps within the ACEC are deciduous. One red maple swamp was identified as possibly the only freshwater wetland in the Town of Hull (Coler & Colantino 2001). This swamp was classified as an isolated wetland due to the presence of hydric soils, water-stained leaves, and hydrophytic vegetation.

6.5 EELGRASS BEDS

Although there are no eelgrass beds within the ACEC, there is one located off World's End in Hingham Harbor. Such beds represent sensitive communities that can be affected by changes in temperature, light, ocean currents, substrate, and sedimentation. Future changes within the Weir River ACEC, such as construction, mooring placement, increased recreational boating, and water quality problems could alter these conditions and have a detrimental effect on this eelgrass bed.

Eelgrass beds provide a substrate for plants and shelter organisms from predators and strong currents. Nutrients are cycled through the beds and provide food, both directly and indirectly, through associated bacteria, fungi and algae. Crabs, mollusks, and worms feed on eelgrass detritus while snails, crabs, fish and waterfowl eat the leaves, stems and attached plants and animals. Additionally, the beds are nurseries for species such as the bay scallop and provide a habitat for juvenile fish such as winter flounder and striped bass.

6.6 VERNAL POOLS

Vernal pools are depressions that are seasonally covered in a shallow pool of water. Several rare plants, reptiles and amphibians thrive in the unique environment that these intermittent pools provide. Egg laying amphibians like the spotted salamander (*Ambystoma maculatum*) and wood frog (*Rana sylvatica*) depend on vernal pools as spawning habitats free from predatory fish (EPA 2001). Vernal pools are typically very small or invisible during the drier half of the year, making them particularly vulnerable to development, despite their important ecological functions.

There are no certified vernal pools within the Weir River ACEC. However, the Weir River Woods Trails and Public Access Plan (Coler & Colantino 2001) identified two potential sites within the Weir River Woods and it is planned that these will be revisited in the spring (Hall 2001). An additional study was planned for the spring of 2000, to study a potential vernal pool at Ice Pond in World's End (The Trustees of the Reservation 2001). The National Heritage and Endangered Species Program (NHESP) have also identified several potential

vernal pools along the Weir River, close to Foundry Pond. These vernal pools were identified by NHESP

using aerial photos, but have not been verified by field tests.

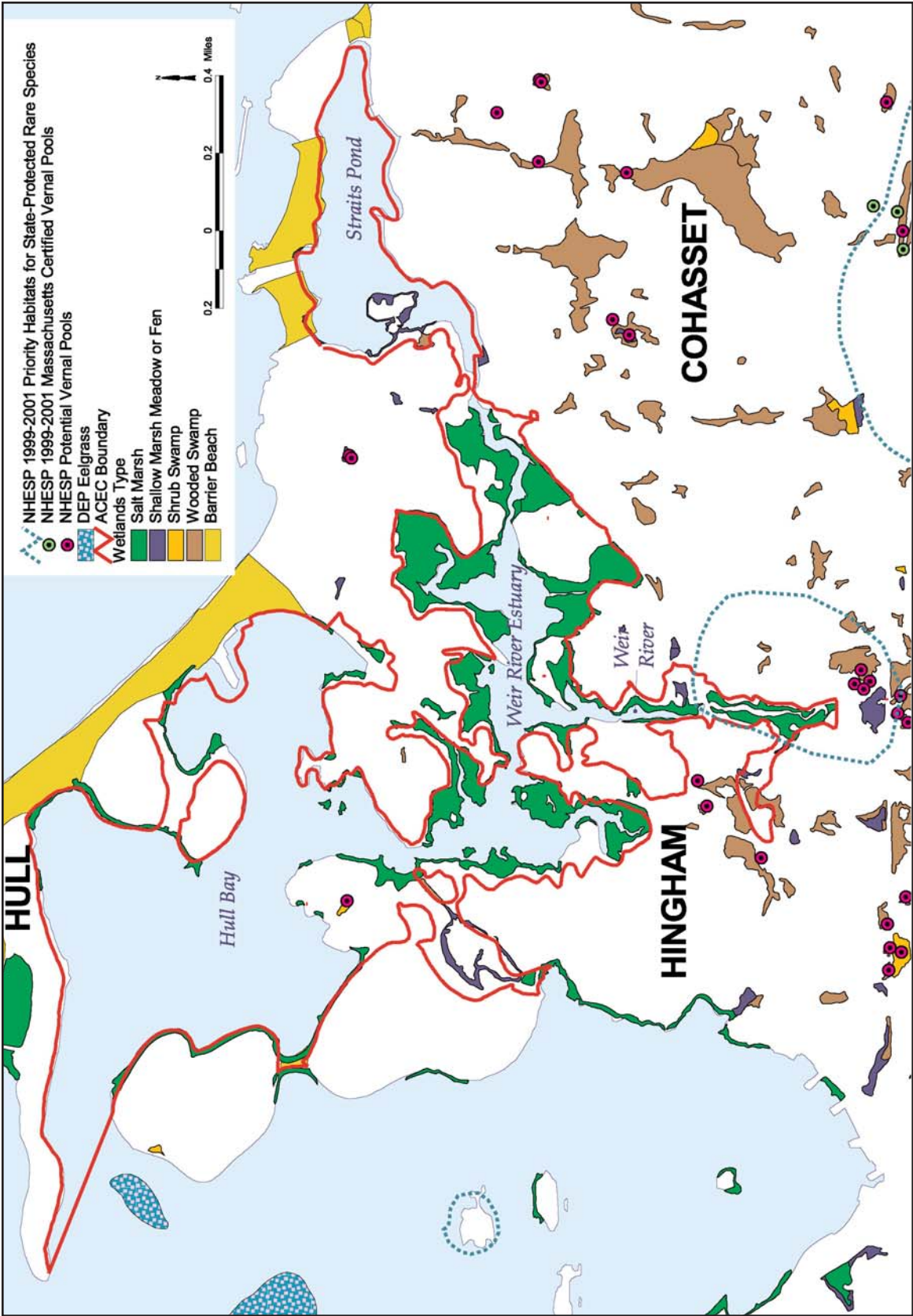


Figure 6-1. Weir River ACEC Natural Habitats (Data source: MassGIS).

7. BIOLOGICAL RESOURCES

7.1 WILDLIFE

ENDANGERED SPECIES. The Natural Heritage and Endangered Species Program (NHESP) of the Division of Fisheries and Wildlife has identified one endangered species reported within the ACEC boundary (see Appendix A). The pied-billed Grebe (*Podilymbus podiceps*) fits the Natural Heritage definition of endangered as: "A native species in danger of extinction throughout all or part of their range, or which are in danger of extirpation from Massachusetts as documented by biological research and inventory." Hull's Biodiversity Days effort also documents two "special concern" species that travel through or live in the area: the common loon and the common tern. Special concern species are defined by the Natural Heritage Program as: "Native species which have been documented by biological research or inventory to have suffered a decline that could threaten the species if allowed to continue unchecked, or which occur in such small numbers or with such restricted distribution or specialized habitat that they could easily become threatened in Massachusetts."

At World's End, The Trustees of Reservations property adjacent to ACEC boundary, several rare species have been identified (Reservation 2001) including Showy goldenrod (*Solidago speciosa*) and Hickory Hairstreak (*Satirium caryaevorum*) (see Appendix C).

WILDLIFE. Wildlife in and around the Weir River ACEC has not been studied extensively. Local residents and the recent Weir River Woods Trail Plan have identified several mammal, reptile, amphibious and insect species that have been spotted in or around the ACEC (Kramer 2002, Coler and Colantonio 2002). Mammals sited include: rabbits, red fox, opossum, skunks, woodchucks, squirrels, chipmunks, field mice and coyotes (Kramer 2002). The northern brown snake and the red-black salamander were the only reptile and amphibious species identified by the Weir River Woods Trail Plan, although it is noted that there is high potential for several other species based on the habitat conditions (Coler & Colantonio 2002).

A large gray seal beached itself at the east end of Straits Pond in May of 2000 (Jackson 2000). The animal was rescued by experts from the New England Aquarium and taken to an aquarium site via helicopter. Nine people were required to crate and move the 300 to 400 pound seal (Jackson 2000). The Aquarium was able to keep the sickly seal alive for a few months, but it eventually died (Kramer 2000). Gray seals are not typically found in the area of the Weir River Estuary ACEC, but

this unusual occurrence did draw community attention to the area.

BIRDS. Many species of birds are attracted to large salt marshes as they travel between northern breeding habitat and southern over-wintering areas. The Weir River ACEC is an excellent example of such habitat, containing one of the most extensive salt marsh systems in the greater Boston area and supporting over 100 resident and migratory bird species. This diverse population of birds takes advantage of the unique combination of forest, grassland and estuarine habitat available in and around the ACEC. Crustaceans, mollusks, salt marsh grasses, and aquatic vegetation provide a constant food source for these indigenous and migrant shorebirds and waterfowl. World's End is a favorite among bird watchers from all over Massachusetts, and the Straits Pond Watershed Association sponsors bird-watching walks around Straits Pond regularly.

Over the past 10 years, one "very beautiful problem" (Preer 2001) in Straits Pond has been the proliferation of mute swans, which were first introduced to the United States in the late 1800s as captive birds. Wild populations have expanded dramatically in the past 20 years, with the number of swans in Straits Pond increasing from 36 in 1999 to 77 in the summer of 2001 (Preer 2001). The waste from these large birds contributes organic nutrients into the already polluted pond, further encouraging algal growth that plagues the pond each summer. Some biologists also believe that mute swans are a threat to native waterfowl in Massachusetts.

An osprey perch was built near the landfill site in Hull around eight years ago. Hull Light Department erected the nest to prevent the birds from disturbing electrical lines. The Massachusetts Audubon society monitors the nest and bands the hatchlings once a year. Three fledglings were observed in the Hull light Department nest in the summer of 2001, indicating that osprey are successfully making use of the platform for breeding (Van Hamm 2001). Another osprey perch was erected by a citizen, Phil Thayer, and stood closer to World's End until the mid-1990s (Clinton, L. 2002).

Table 7-1 provides a list of bird species found in the Weir River Estuary, World's End and Straits Pond area through personal communications (Clinton, D. 2002), Biodiversity Days events (6/9/00), Straits Pond Watershed Association bird walks (6/26/00, 9/16/00, 11/18/00, and 6/9/01), and the Trustees of Reservations Breeding Bird Survey (2000).

The Trustees of Reservations Breeding Bird Survey of 2000 suggests that habitats like World's End are especially rich in species diversity because so much of the property is "edge" habitat where two or more habitat types meet. Most species need more than one habitat to meet all of their needs and so areas where estuaries, grasslands, and forests are all present attract a wide variety of birds (Deegan 2000). A full list of migratory

and breeding birds sited at World's End can be found in Appendix D.

Butterflies are also attracted to the World's End property. The large upland meadows support the grasses and wildflowers that caterpillars feed on and adult butterflies seek for nectar. A list of butterflies observed at World's End can be found in Appendix E.

Table 7-1. List of Birds Common to Weir River ACEC

American Black Duck	House Wren
American Crow	Killdeer
American Goldfinch	Least Tern
American Robin	Mallard
Baltimore Oriole	Mourning Dove
Barn Swallow	Mute Swan
Belted Kingfisher	Northern Cardinal
Black-capped Chickadee	Northern Flicker
Blue-grey Gnatcatcher	Northern Mockingbird
Blue Jay	Osprey
Bobolink	Northern Rough-winged Swallow
Brown-headed Cowbird	Eastern Meadowlark
Brown Thrasher	Philadelphia Vireo
Canada Goose	Pileated Woodpecker
Carolina Wren	Pine Warbler
Chimney Swift	Purple Finch
Chipping Swallow	Red-Tailed Hawk
Common Grackle	Red-winged Blackbird
Common Tern	Ring-billed Gull
Common Yellowthroat	Rock Dove
Coopers Hawk	Sanderling
Double-crested Cormorant	Red-eyed Vireo
Downy Woodpecker	Savannah Sparrow
Eastern Bluebird	Screech Owl
English Sparrow	Semipalmated Sandpiper
European Starling	Snowy Egret
Gray Catbird	Song Sparrow
Great Black-backed Gull	Tree Swallow
Great Blue Heron	Tufted Titmouse
Great Egret	Turkey Vulture
Great Heron	White-breasted Nuthatch Wren
Green Heron	White-throated Sparrow
Herring Gull	Wild Turkey
House Finch	Yellow Warbler
House Sparrow	Yellow-rumped Warbler

7.2 FINFISH

Hingham Bay is known to be a productive area that many species of fish use for breeding and as nurseries. Winter flounder, cunner, striped bass, bluefish, Atlantic mackerel, Atlantic tomcod, Atlantic silverside, grubby, pollock, red hake, skates, ninespine stickleback and northern pipefish are common species in the bay (Kreutziger *et al.* 2000, Chase 2002).

WEIR RIVER. In the 1880s, Hull was well known for its smelt fishery (Sweetser 1883), and the Weir River supported one of the largest smelt runs in the state (Iwanowicz 1973). It is reported that rainbow smelt (*Osmerus mordax*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), white perch (*Morone Americana*) and the American eel (*Anguilla rostrata*) use the Weir River as a fish run (Cecil *et al.* 1999). The alewives and blueback herring migrate

upstream from March to May. The alewives pass through the Weir River to Foundry Pond via a fishway, enter Accord Brook and ascend another fishway to spawn in Triphammer Pond while the bluebacks spawn in the river (EOEA 1986). After hatching, the fry remain upstream during the summer before migrating to the ocean between September and November. In 1978, a study by the Department of Marine Fisheries (DMF) found all of these species in Straits Pond as well as Atlantic silverside, mummichog, striped killifish, three-spine stickleback and fourspine stickleback (Kreutziger *et al.* 2000).

The Weir River is managed as a coldwater recreational fishery upstream of Foundry Pond, and between Free Street and Route 3A in Hingham, the Massachusetts Division of Fish and Wildlife stocks it with brown trout (*Salmo trutta*). Although the river is stocked outside of the ACEC boundary, it is thought that not all of the trout are caught and there are some signs of reproduction (GZA 2000) south of the dam at Foundry Pond.

In the 1999 Weir River Watershed Study (GZA 2000) samples were taken from throughout the Weir River. Fish were stunned, collected, cataloged, measured, and released. Seven species were documented throughout eight sampling sites, two of which were in the ACEC. Brown trout, brook trout, largemouth bass, red fin pickerel, bluegill, pumpkinseed sunfish and American eel were all present but the anadromous fish that the area historically supports were not found:

The species sampled represent habitat generalists and/or species common to ponds and pools. However, this system is highly fragmented due to the presence of impounded reservoirs and dewatered reaches. As a result, a number of species indigenous to southeastern Massachusetts streams with life stages dependent on riffle and run habitats were not detected by GZA, although they would normally be expected to be relatively abundant in streams such as the Weir drainage. These include: alewife, blueback herring, rainbow smelt, white sucker, and tessellated darter (GZA 2000).

STRAITS POND. A 1978 DMF survey identified a number of finfish in Straits Pond: Atlantic silverside, mummichog, striped killifish, threespine stickleback, and fourspine stickleback. A study conducted by Hull High School in the early 1990s included a fish survey of Straits Pond. Six species were found including alewife fry, stickleback, striped killifish, Atlantic silverside, mummichog, and American eel, as well as shrimp and mud snails.

7.3 SHELLFISH

Under direction of the National Shellfish Sanitation Program, DMF monitors and regulates shellfish beds. The Sanitation Program is a voluntary program designed to prevent human illness associated with the consumption of fresh and fresh-frozen shellfish. Through Sanitary Surveys (completed at least once every 12 years) and more regular annual and triennial evaluations, DMF conducts routine bacteriological testing to determine whether a bed should be closed, open, or restricted in some way to shellfishing.

Hull Bay and the Weir River contain approximately 356 acres of soft-shell clam beds (Cecil *et al.* 1999; Kreutziger *et al.* 2000), most of which is located within the Weir River ACEC. However, due to poor water quality, all beds are closed to both recreational and bait shellfishing. A number of areas are open to commercial shellfishing, but are classified as Conditionally Restricted. Therefore, subordinate diggers, under the supervision of a licensed master digger, must carry out harvesting and all clams must be depurated prior to sale. Shellfishing is prohibited in the upper Weir River due to poor water quality caused by the failure of septic systems (most houses located along the Weir River in Hingham are not sewered). A closed shellfish bed can be reopened only with demonstrable water quality improvements that meet national shellfish standards. Due to lack of time and personnel, DMF is unlikely to regularly survey unless there are obvious signs of improvement or the town Board of Selectmen request a water quality check. Twelve to eighteen months of fieldwork is required to test closed beds to ensure sampling in adverse pollution conditions such as heavy rain and any beds that are reopened become the monitoring responsibility of DMF. Due to the time commitments of testing and monitoring in combination with DMF staff and budget shortages, areas with unsewered homes (such as the Weir River Estuary) are not likely to be a high priority for reopening shellfish beds (Roach 2002).

The shellfish beds in the Weir River ACEC are illustrated in Figure 7-1 and are coded GBH 1.3 - 1.7. Over the past 20 years, most shellfish beds of the Weir River ACEC have been classified--on and off--as restricted to shellfishing, with upper reaches of the river (GBH 1.6) classified as Prohibited (Roach 1994). The other beds are less polluted than the Weir River and classified Conditionally Restricted.

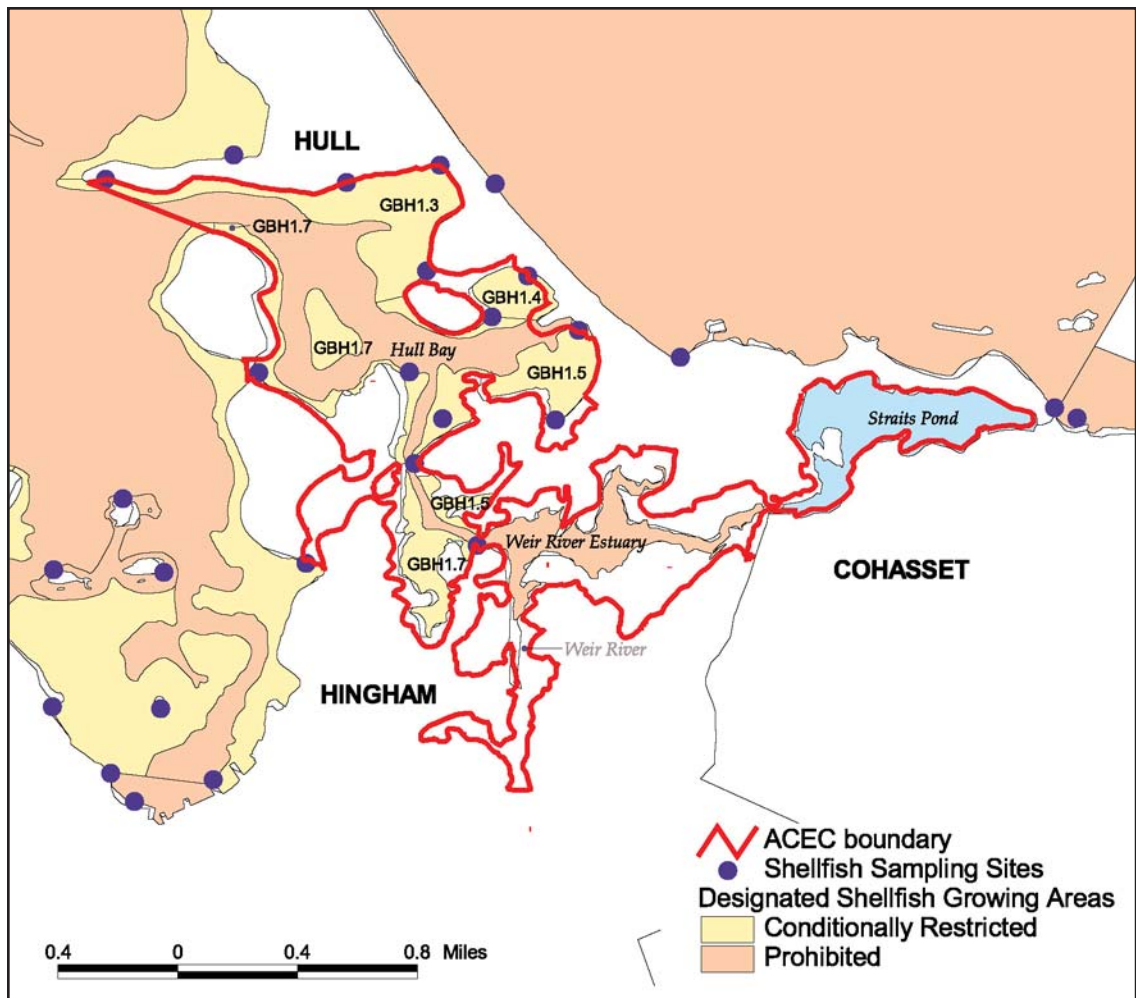


Figure 7-1. Shellfish Beds and Massachusetts DMF Sanitary Survey Sampling Locations (Data source: MassGIS).

The area directly east of Sunset Point (GBH 1.3)--known locally as "Clam Alley"--is among the most productive shellfish beds in Boston Harbor. The reasons for successful clam growth and propagation in Clam Alley are unclear, but water sampled near Sunset Point indicates "an oasis of relatively good water quality in the midst of widespread bacterial contamination," (Roach 1994).

It is important to note that the names and codes of the shellfish beds have changed repeatedly over the years, as have the National Shellfish Sanitation Program standards, the control agencies, and the shellfish bed boundaries. For these reasons, it can be a challenge to compare data over time. As an example, south of Sagamore Head is shellfish bed GBH 1.4, formerly known as BH-14.2, and, prior to that, Eatons "A" Flat (see Figures 7-2 and 7-3). Until 1970, the area was considered grossly contaminated and shellfishing was prohibited. In the 1970s, water quality was considered improved and the area was reclassified as Seasonally Restricted (Iwanowicz 1973). Yet again, in the early 1980s GBH

1.4 was reclassified as Restricted (Roach 1995), and eventually as Prohibited in 1988 when DMF began administering the Sanitation Program. Finally, in 1995 the area was reclassified as Conditionally Restricted (Roach 1995) and remains so to this day. Clams may be harvested on a seasonal basis between 1 December and 14 June and are subject to controlled depuration.

Shellfish in the ACEC support an important commercial industry in Boston Harbor. Further, they provide an important source of food for local bird populations. Clusters of blue mussels (*Mytilus edulis*), little macoma (*Macoma balthica*) and sparse populations of quahaugs (*Mercenaria mercenaria*) and American oysters (*Crassostrea virginica*) can be found along the shoreline and tidal flats of the Weir River ACEC (DMF 1995). But by far the most abundant and commercially important shellfish is the soft shell clam (*Mya arenaria*). Forty commercial diggers harvest the 3 soft-shell clam beds located within the ACEC. These beds are open for 18 months, then closed for 18 months, as regulated by the town's shellfish wardens and the state DMF (Bornhiem 2001).

A Woods Hole study (WHOI 1952) identified two areas south of Sunset Point and the flats off of World's End as the most productive clam beds in the region that now constitutes the Weir River ACEC. At the time, the remaining flats in the Weir River were heavily populated with mussel beds with only small accumulations of clams. Figure 7-3 was adapted from the report and illustrates the cleanest, most productive clam beds (shaded areas). Statistics provided by DMF (Roach 2002) indicate that in 1998, 7095 racks of clams were harvested, and subsequently purified in Newburyport, from flats located within the ACEC, accounting for 17 percent of

the total clams harvested within Boston Harbor. 2000 statistics reveal an overall decline in the size of clam harvests throughout the Harbor with 2,731 racks harvested in the Weir River ACEC (9 percent of total Boston Harbor catch).

In the early 1970s Hull had 24.4 percent of the productive soft shell clam habitat in Hingham Bay and produced 26.6 percent of the legal-sized clams in the region (Iwanowicz 1973). The most productive flat at the time was Eatons B (see Figure 7-3), producing 28 percent of the legal sized clams.

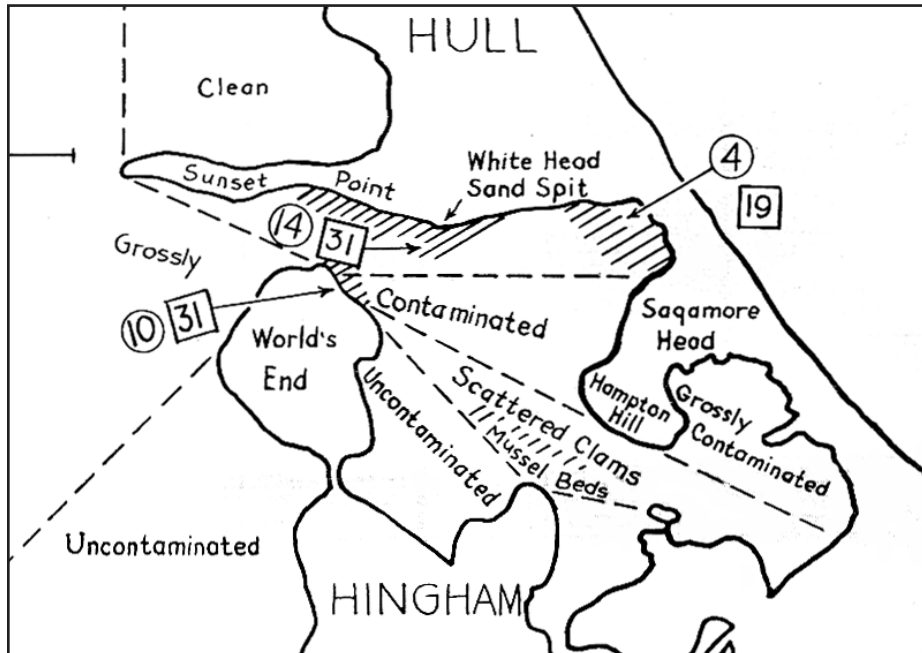


Figure 7-2. Status of Clam Beds in Southern Section of Hull and Eastern Section of Hingham (from WHOI (1952)).

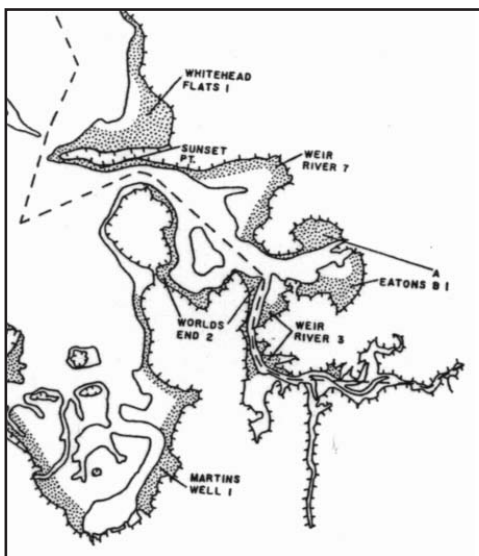


Figure 7-3. Location of soft shell clam flats in Weir River ACEC in 1970 (adapted from Iwanowicz (1973)).

7.4 AQUATIC VEGETATION

HULL BAY. The findings of various studies that have identified vegetation common to Hingham and/or Hull Bay are presented here. *Ascophyllum nodosum* was identified in Hingham Bay in the early 1970s (Iwanowicz 1973). *A. nodosum* (Figure 7-4 (a)) is a large brown rockweed common on the rocky shorelines of New England. It is characterized by strap-like fronds (1-6 feet) with egg-shaped air nodules. The plants grow slowly and can live to be several decades old.

Spartina alterniflora, smooth cord grass (a.k.a. salt water cord grass) was also identified (Iwanowicz 1973). *S. alterniflora* (Figure 7.4 (b)) is a perennial grass growing in salt water that is native to the northeastern US. The stems are hollow and stiff and the leaf blades grow 1/4 to 3/5 inches wide (Tiner 1987). It flowers in the summer months (visible with a magnifying glass) that give the grass a slight "whitish frill." *S. alterniflora* can range in height from 1-8 feet (Tiner 1987). It dominates the emergent saltwater wetlands along the coast of the Atlantic Ocean (Tiner 1999). *Spartina sp.* are considered to be among the most productive marsh plants in the world. The roots of *Spartina sp.* are the favorite food of snow geese and it is highly valued for erosion control as it's root systems help stabilize mud.

The perennial green algae, *Ulva lactuca* (sea lettuce) (Figure 7.4 (c)) is common on tidal flats in the bay (Iwanowicz 1973). It is generally pale green when young, bright green when mature, and dark green when old with a broad, crumpled blade (frond) that is tough, translucent and membranous (Boney 1966). *U. lactuca* is found throughout the year and exhibits seasonal shifts in habitat, colonizing upper shore levels in the summer but more commonly found in the mid-tide region in winter (Boney 1966). It is easily torn loose from substrate and can accumulate in large drifting masses or along the shoreline. *U. lactuca* can be a nuisance in areas that are enriched with nitrogen, copper, zinc, boron, molybdenum, and cobalt (Boney 1966). *U. lactuca* is well suited for conditions that require rapid growth, high nutrient uptake and high biomass production in low light, but it can be out competed by species that are more rugged and have better abilities to store nutrients. *Ulva lactuca* has been recognized as an extremely valuable ecological tool as a biofilter and a bioindicator.

Chaetomorpha sp. (ropeweed) is a brush-like filamentous green algae that grows in shallow, muddy, and often rocky sediments in Hull Bay (Iwanowicz 1973). It is particular to waters with variable salinity (Boney 1966).

STRAITS POND. An aquatic plant survey conducted in 1979 (IEP 1980) found that by late spring almost 50

percent of the pond's surface was covered with vegetation. *Ruppia maritima*, or widgeon grass, was identified as the dominant species (Figure 7.4 (d)), and it remains dominant today. This submerged perennial plant is native to both Pacific and Atlantic coasts, preferring saline and brackish waters to tidal fresh waters (Tiner 1987). It is a preferred food source of many waterfowl, including the mute swan. *Ruppia* is a prolific seed producer and can colonize large areas very rapidly (Maryland Department of Natural Resources 2001b). Water depth and turbidity are the major factors influencing the growth of *Ruppia* (NOAA 2001). Growth conditions are optimal when water depth is maintained between 15 and 24 inches and the concentration of suspended material (a measure of turbidity) stays below 55 parts per million (ppm). Reproductive activities are most affected by water temperature and soil salinity (NOAA 2001). Although *Ruppia* is a salt-tolerant plant and adults can survive in soils with salinity as high as 3 percent, levels above 1.12 percent are extremely harmful to germination and in many cases will cause seed mortality. Trace amounts of a similar species, *Potamogeton pectinatus* (Sago Pondweed) were also found amongst the *Ruppia* (Figure 7.4 (e)).

Dense formations of *Phragmites australis* (common reed) were documented along the shoreline (Figure 7.4 (f)). *Phragmites* is a perennial grass common to the Atlantic states, Texas, and California. It is common in brackish or tidal marshes or along the upper edges of salt marshes (Tiner 1987), and is aggressive enough to dominate a plant community, particularly in areas that have been degraded or altered by human use. The history of *Phragmites* remains unclear (Driscoll 1999). Researchers continue to study where it fits into the flora of the Northeast region and New England, whether it is a native species that formerly was not invasive in nature, how it has spread, and how much its invasive nature can be attributed to recent environmental changes of an anthropogenic nature.

Cladophora sp. were beginning to appear in the pond at the time of the survey. *Cladophora* is a type often referred to as "hair algae" characterized by branching green filaments in a variety of configurations (Boney 1966). It is present year-round is known to exhibit seasonal shifts in habitat, similar to *Ulva* (see discussion above) but has also been observed in upper shore levels in winter (Boney 1966). In scientific literature, this species has been identified as a possible shade tolerant species, which may give it a competitive edge over other species that require more light to photosynthesize (Maryland Department of Natural Resources 2001a).

Three different species of *Enteromorpha* (green nori), which are native to the Northeast Atlantic, were identified. *E. intestinalis* (Figure 7.4 (g)) is characterized by its unbranched, tubular or sac-like structures that are

usually attached to a hard substrate such as rocks or on other algae or plants. *Enteromorpha sp.* can be used as an indicator of heavy metals like lead, copper, and zinc in estuaries where there is runoff. They have the ability to withstand high concentrations of these toxins by producing extracellular compounds on or in the cell wall that bind to certain metal ions, rendering them nontoxic. The accumulation of these metals is in direct proportion to the growth rate of the algae. A small amount of *Ulva lactuca* was also found in the pond in the 1979 survey (IEP 1980).

WEIR RIVER WOODS. A trails plan for the Weir River Woods completed in November 2001 (Coler & Colantino) included an assessment of vegetation in the southern portion of the Rockaway Annex (a peninsula in southwestern Hull). The general impression of the investigator in this project was that these species were fairly representative of the salt marshes within the Weir River ACEC (Hall 2001). In this region, *Spartina alterniflora*, *Spartina patens*, *Juncus gerardii* (salt

marsh rush) and *Distichilis spicata* (spike grass) were dominant marsh grasses. *Juncus gerardii* (Figure 7.4 (h)) is an herbaceous perennial with one or two elongated leaves, growing up to two feet in height. It is common in irregularly flooded salt marshes or at less frequently flooded elevations (Tiner 1987). *Distichilis spicata* (Figure 7.4 (i)) is a slightly shorter perennial grass (up to 16 inches) with numerous linear leaves. It is also common to less frequently flooded elevations and is often times intermixed with *Spartina patens* (salt meadow cordgrass) (Tiner 1987) (Figure 7-4 (j)). *Limonium nashii* (sea lavender), a low herbaceous flowering plant with basal leaves, and other rushes (*Juncus spp.*) were found in the intertidal region. *Spartina pectinata* (Figure 7-4 (k)) was identified along the upland reaches of the marsh, along with *Iva frutescens* (marsh elder) (Figure 7-4 (l)), a deciduous shrub with somewhat fleshy leaves, and *Solidago spp.* (goldenrod). *Phragmites australis* was ubiquitous along the edge of the marsh, out-competing the tall cordgrass and other native species.

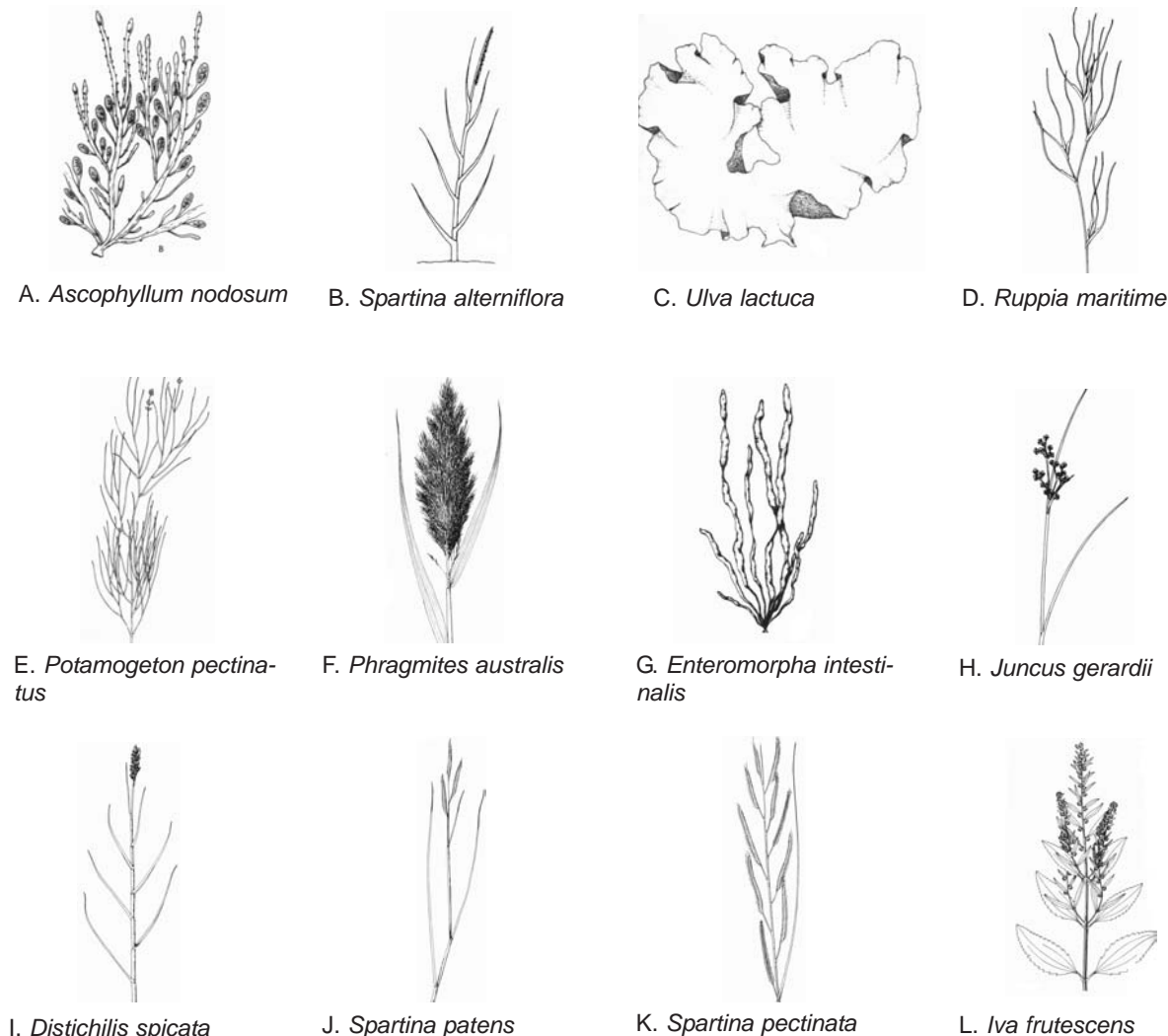


Figure 7-4. Common Plants in the Weir River ACEC (not to scale) (Tiner 1987)

7.5 MICROSCOPIC ALGAE

STRAITS POND. An array of diatoms, including *Navicula*, *Melosira*, and *Gyrosigma*, were identified during spring sampling of Straits Pond in 1979, while previous investigations during the 1960s reported high densities of the blue-green algae *Anabaina*, *Microcystis*, and *Lyngbya* (IEP 1980).

Blue-green algae--or cyanobacteria--are unicellular bacteria that tend to grow in colonies ("blooms"), forming thick green mats that float on the water's surface and can be seen with the naked eye. These algae are unlike other algae because they are related to bacteria and not to eukaryotes; they are called algae because they are both aquatic and photosynthetic. Some species of cyanobacteria produce toxins during blooms, which are classified, according to their mode of action, as hepatotoxins, neurotoxins, and skin irritants.

Anabaina is a member of the *Nostocaccae* family. It has been associated with the production of hepatotoxins and can impart an unpleasant fishy odor and taste to water. *Microcystis* is a common bloom-forming algae found primarily in nutrient enriched fresh waters and lower salinity estuaries. It is considered the most abundant producer of the hepatotoxin known as microcystin, which is proven harmful to fish and wildlife, although its effects on humans are not well understood (Foxall & Sasner 1981).

Lyngbya is a species of the largest family of blue-green algae, *Oscillatoriaceae*. *Lyngbya* is most common in tropical waters and has been responsible for a severe toxic reaction of the skin known as "swimmers' itch," and is a prime suspect in ciguatera fish poisoning (Dawson 1966).

The species composition of a blue-green algae community is sensitive to nitrogen-to-phosphorous (N:P) ratios in the water column. Small shifts in these ratios resulting from increased or decreased inputs of either nitrogen or phosphorous can have a profound impact on the dominant species of blue-green algae present. *Anabaina*, for example, occurs most frequently in waters with an N:P ratio less than 30, *Lyngbya* are most frequent in vertically mixed water bodies with an N:P ratio of 15-20, and *Melosira* rarely occurs at an N:P ratio greater than 30 (Haris 1986).

Table 7-2. Summary of Macroscopic and Microscopic Vegetation Common in Weir River ACEC

Macroscopic Vegetation	Common Name
<i>Ascophyllum nodosum</i>	Rockweed, Knotted Wrack
<i>Chaetomorpha</i> sp.	Ropeweed
<i>Cladophora</i> sp.	None
<i>Distichlis spicata</i>	Saltgrass, Alkali Saltgrass, Spike Grass
<i>Enteromorpha</i> sp.	Sea Grass, Green Nori
<i>Iva Frutescens</i>	Marsh Elder, Saltmarsh Elder
<i>Juncus gerardii</i>	Black Grass, Saltmarsh Rush
<i>Limonium nashii</i>	Sea Lavender
<i>Phragmites australis</i>	Common Reed
<i>Potamogeton pectinatus</i>	Sago Pondweed
<i>Ruppia maritime</i>	Widgeon Grass
<i>Solidago</i> spp.	Goldenrod
<i>Spartina alterniflora</i>	Smooth Cordgrass
<i>Spartina patens</i>	Salt Meadow Cordgrass
<i>Spartina pectinata</i>	Prairie Cordgrass, Marsh Grass
<i>Ulva lactuca</i>	Sea Lettuce
Microscopic Vegetation	Type
<i>Anabaina</i>	Blue-green algae
<i>Gyrosigma</i>	Diatom
<i>Lyngbya</i>	Blue-green algae
<i>Melosira</i>	Diatom
<i>Microcystis</i>	Blue-green algae
<i>Navicula</i>	Diatom

8. HYDROLOGY

8.1 GENERAL DESCRIPTION

In Boston Harbor, the tides, over any other forces, govern the movement of ocean water. The pathway of these tides is determined by two deep passages in the harbor floor known as Presidents Roads and Nantasket Roads. Combined, the tidal forces and the unique bathymetry separate Boston Harbor into two distinct regions. So distinct, in fact, that there is limited water exchange between them (McDowell *et al.* 1991).

The whole of Hingham Bay--including the Weir River ACEC--comprises the southern hydrological cell of Boston Harbor. The bay is surrounded by land except for two channels, one between Peddocks and Nut Island and the other between Peddocks and Pemberton Point. All tidal exchange is through these channels (Iwanowicz 1973), which connect with Nantasket Roads. Approximately 49.8 percent of the water in Hingham Bay is exchanged with Massachusetts Bay water during a tidal cycle with a mean tidal amplitude (i.e., difference between mean low water and mean high water) of 9.5 ft (Iwanowicz 1973).

The *Weir River* is formed at the juncture of Crooked Meadow River and Fulling Mill Brook in Hingham (Figure 5-2). It flows to the sea and becomes tidal below the dam at Foundry Pond, entering Hull where the town line splits the estuary. The tidal portion of the river is encompassed by the ACEC boundary. The low flow of the Weir River offers limited fresh water input into the estuarine system. The flow rate for the Weir River was estimated by Menzie *et al.* (1991) at 0.14 m³/s (4.94 cfs). ENSR (2002) measured the flow rates at different times of year and measured 0.033 m³/s (1.19 cfs) in May 2001 and 0.21 m³/s (7.24 cfs) in August 2001. The mean tidal amplitude of the *Weir River Estuary* is estimated at 12 feet (GZA 2000).

Straits Pond--a salt water pond that is split by the town boundary between Cohasset and Hull--is hydrologically connected to the Weir River Estuary through two tide gates located under a bridge along Nantasket Avenue, Route 228. "The watershed of Straits Pond (including the pond) is relatively small at approximately 740 acres and is mostly confined by Route 228, Cedar Street, and Forest Avenue in Cohasset, Massachusetts. Rattlesnake Run is the only significant tributary that drains directly into Straits Pond," (ENSR 2002). Flow rates out of the pond through the tide gates were estimated at 0.07 - 0.16 m³/s (2.5 - 5.8 cfs) with the gates closed, 1.0 - 1.45 m³/s (35.3 - 51.1 cfs) with the gates ¼-way open, and 1.75 - 2.81 m³/s (61.8 - 99.4 cfs) with the gates ½-way open (ENSR 2002). During the spring, when fresh

water flow is typically high, there is a significant degree of mixing in Straits Pond and the water in the pond is mostly from a freshwater source (ENSR 2002). However, flushing studies in the area indicate that summertime baseflow from Rattlesnake Run has very little effect on the water quality in Straits Pond (ENSR 2002). In addition, field surveys indicate that there is relatively no connection between Straits Pond and the underlying ground water system. Therefore, it is reasonable to assume that the source of fresh water in Straits Pond in the spring is largely from direct deposition and runoff. The long-term average surface runoff from all sources to Straits Pond is estimated at 2.21 cubic feet per second (cfs) (ENSR 2002).

8.2 FLUSHING TIME

In developed areas like Hingham, Hull, and Cohasset, estuaries are centers of human activity, and as such are subjected to a wide variety of pollutants that make their way into the system either through direct discharges (e.g., commercial and recreational boating, urban and industrial wastes), through direct discharges to the adjoining river network, or from a wide variety of indirect nonpoint source pollutants. But how much pollution can an estuary tolerate before its ecosystem is adversely affected to a significant degree? To answer this question, it is important to understand the concept of *flushing time*. A slow flushing time implies that the estuary is slow to exchange water and has the potential to build-up high concentrations of pollutants. An estuary with a rapid flushing time, on the other hand, is generally considered to have a high carrying capacity for pollutants because they are quickly transported out of the immediate system to the ocean.

Flushing time is broadly defined as the time for water in an estuary to be carried out and replaced by new water. A variety of mathematical methods and models have been developed to estimate flushing time (e.g., Knudsen method, tidal prism method). Deciding what method will work best for an estuary depends on how the fresh water inputs, wind, littoral drift, and tidal forces interact and affect circulation.

The currents in Boston Harbor and its small embayments are considered to be tidally dominant. A computer model known as the Tidal Residual and Intertidal Mudflats (TRIM) model has provided the best and most recent estimates of tidal flushing for Boston Harbor. The combination of tidal and wind effects results in flushing times of 3-10 days (Signell & Butman 1992), although the rate varies considerably around the harbor.

HINGHAM BAY AND WEIR RIVER ESTUARY. Flushing rates for Hingham Bay are estimated at 8 to 12 days (Roach 1996a). Specific data for the Weir River Estuary was not available in existing reports, but Figure 8-1, illustrates Boston Harbor and the percentage of water remaining after almost four days (ENSR 2002, IEP 1980).

exchange rate of Hingham Bay. The removal of pollutants over time, therefore, is likely due to age, settlement, and grazing more so than flushing (Roach 1996a).

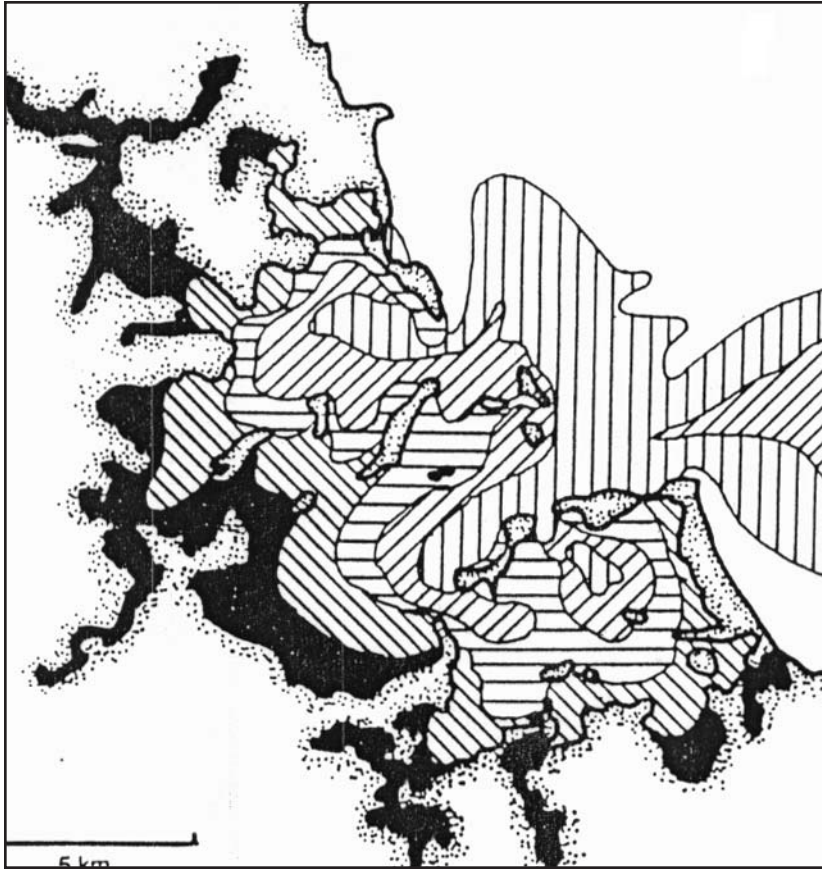


Figure 8-1. Percentage of Original Water Remaining After 3.6 Days (from MWRA (1992))

STRAITS POND. Flushing time for Straits Pond depends on the position of the tide gate and the amount of water released. A recent study of the pond's hydrodynamics found that tide gate operational records for summer 2001 indicated that after three months only about 30 percent of the water was exchanged between the pond and the Weir River estuary (ENSR 2002), suggesting a slow flushing rate. However, results of a model simulation indicate that water released from Straits Pond has the capacity to effectively exchange water with Hingham Bay provided that enough water is released from the pond intermittently, such as every fourth tidal cycle, enabling water to flush out of the inner and outer estuary before refilling the pond (ENSR 2002).

The above information suggests the ACEC is a region of reduced flushing, despite the relatively large tidal

9. WATER QUALITY

9.1 MASSACHUSETTS WATER QUALITY STANDARDS

The marine waters in the Weir River ACEC and Straits Pond are designated Class SA and the Weir River Class B according to the Massachusetts Surface Water Quality Standards (314 CMR 4.00). The ACEC is also classified as Outstanding Resource Waters (ORWs) as part of its ACEC designation. Class SA and Class B waters are both designated suitable for aquatic life and wildlife as well as primary and secondary recreation. Class B waters are also suitable for irrigation and other agricultural uses. Any actions that would prevent such activities are prohibited. Water quality criteria for Class-SA and B waters are listed in the tables below. ORWs "constitute an outstanding resource as determined by their outstanding socio-economic, recreation-

al, ecological and/or aesthetic values," (314 CMR 4.04 (3)). Within ORWs, most existing, new, or increased discharges are prohibited.

The Commonwealth of Massachusetts recently amended the bathing beach regulations, 105 CMR 445.000: Minimum Standards for Bathing Beaches (State Sanitary Code, Chapter VII). These regulations were amended to comply with the beaches bill, which was signed into law in August 2000, M.G.L. Ch. 111, Sec. 5S. All public and semi-public beaches are required to be tested by the Board of Health or authorized representative (beaches operated by the state are tested by the Massachusetts Department of Public Health). Based on EPA recommendations, the amended regulations apply different indicator organisms and standards than the previous regulations.

Table 9-1. Water Quality Criteria for Class-SA and B Waters (314 CMR 4.00).

Parameter	Class SA Standard	Class B Standard
Dissolved Oxygen	Not less than 6.0 mg/l (unless background conditions are lower)	Cold water fisheries: not less than 6 mg/l Warm water fisheries: not less than 5 mg/l (unless background conditions are lower)
Temperature	Not more than 85°F (29.4°C) or a daily maximum of 80°F (26.7°C)	Cold water fisheries: not above 68°F (20°C) Warm water fisheries: not above 83°F (28.4°C)
pH	In the range of 6.5 - 8.5	In the range 6.5 - 8.3
Fecal Coliform	Open shellfishing allowed: Not to exceed mean MPN* of 14 col/100ml No shellfishing: Not to exceed mean MPN of 200 col/100 ml, and no more than 10% samples exceed 400col/100ml.	Not to exceed geometric mean of 200 col/100 ml, and no more than 10% samples exceed 400col/100ml.
Solids	Free from floating, suspended, and settleable solids that impair use or aesthetically degrade or impair water.	Free from floating, suspended, and settleable solids that impair use or aesthetically degrade or impair water.
Color and Turbidity	Free from color and turbidity concentrations that aesthetically degrade or impair any use.	Free from color and turbidity concentrations that aesthetically degrade or impair any use.
Oil and Grease	Free from oil, grease, and petrochemicals.	Free from oil, grease, and petrochemicals.
Taste and Odor	None other than natural origin.	None other than natural origin.

* MPN, most probable number, is one of two techniques used to measure the presence of fecal coliform in water. It is also sometimes called the multiple fermentation tube technique. Bacteria counts are obtained by statistical approximation

Table 9-2. Summary of Standards for Bacteria Indicator Species as Applicable in ACEC.

Activity	Indicator Organism	Marine Water	Fresh Water
RECREATION	<i>Enterococci</i>	Geometric mean of the most recent five (5) <i>Enterococci</i> levels within the same bathing season cannot exceed 35 colony forming units (CFU) per 100 ml.	Geometric mean of the most recent five (5) <i>Enterococci</i> samples within the same bathing season cannot exceed 33 CFU/100ml.
		No single sample can exceed 104 CFU/100ml.	No single sample can exceed 61 CFU/100ml.
	<i>Escherichia coli</i>	N/A	Geometric mean of the most recent five (5) <i>E. coli</i> samples within the same bathing season cannot exceed 126 CFU/100ml.
			No single sample can exceed 235 CFU/100ml.
SHELLFISHING	Fecal coliform	Class SA Water	Class B Water
		Open shellfishing allowed: Not to exceed mean most probable number (MPN) of 14 colonies/100ml No shellfishing: Not to exceed mean MPN of 200 col/100 ml.	Not to exceed geometric mean of 200col/100 ml. No more than 10% samples exceed 400col/100ml.
		No more than 10% samples exceed 400colonies/100ml.	

In the amended regulations, fecal coliform (the collective name for organisms that inhabit the intestinal tract of warm-blooded animals) was replaced as the preferred indicator because certain non-fecal coliforms present in soil and on the surface of plants cannot be distinguished from fecal coliforms by the tests commonly used. Therefore the presence of fecal coliforms indicates contamination that could-but may not-involve serious pathogens. *E. coli* (a specific species of fecal coliform), on the other hand, is only endemic to feces and thus is a better and more consistent indicator upon which to establish standards.

The other bacterial indicator, *Enterococcus*, is a member of the fecal streptococcus group. *Enterococcus* also is believed to be a better indicator than fecal coliform and the best indicator for gastrointestinal disease. It is a good species for assessing reservoir quality, sewage-contaminated water supplies, and chlorinated water that is high in organics. *Enterococcus* is also considered the best indicator for monitoring recreational areas, espe-

cially in marine waters where *E. coli* do not survive as well. Because *Enterococcus* persist longer in the environment, however, they are not useful for pinpointing a pollution source since they can be detected a far distance from their point of origin (Bartram & Pedley 1996).

The following Figure 9-1 illustrates various sampling stations referred to in the discussions on water quality that follows. The Massachusetts Division of Marine Fisheries conducts routine sampling for the purposes of regulating shellfishing. The US Geological Survey also conducted water quality on the Weir River in 1999.

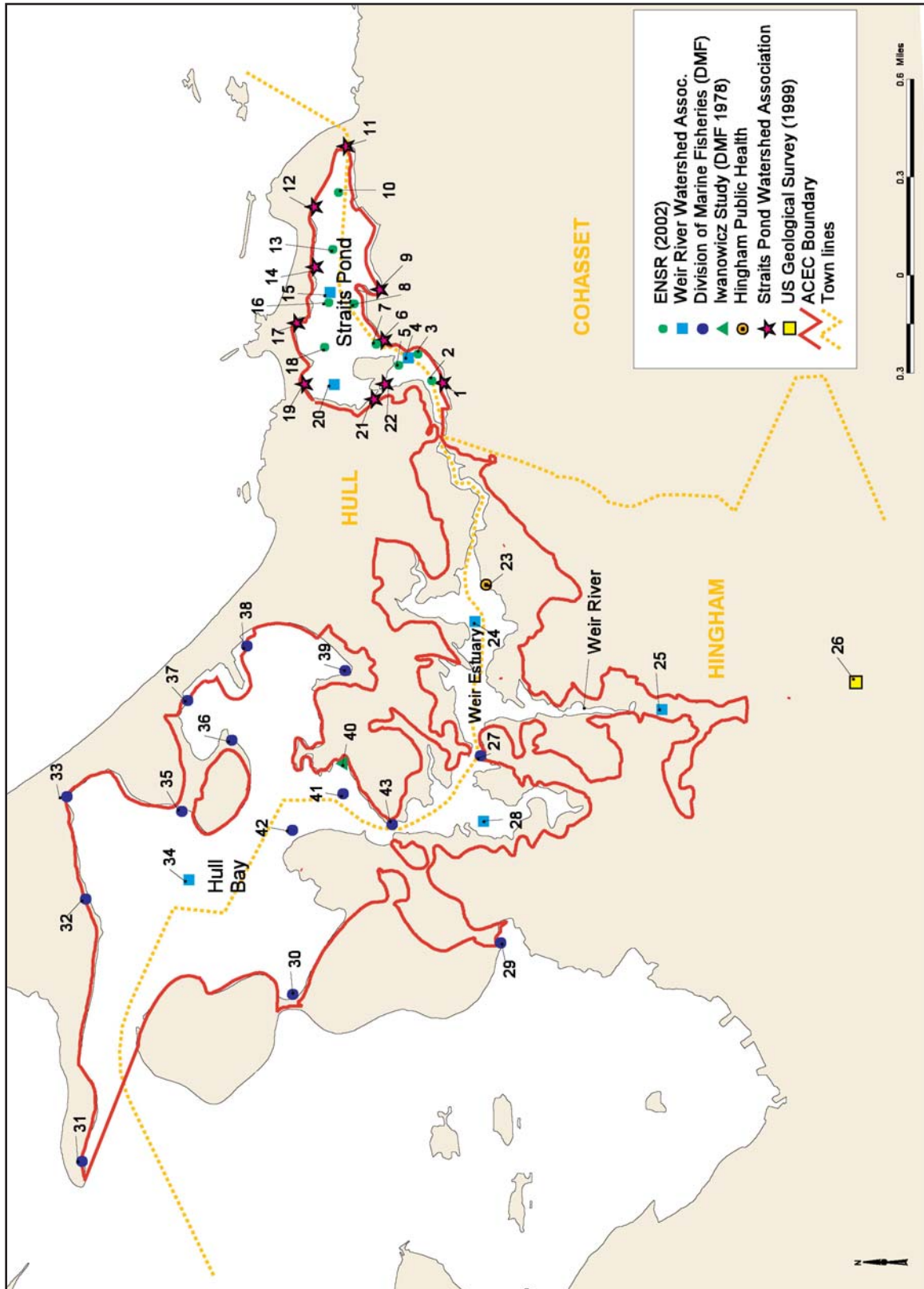


Figure 9-1. Water Quality Monitoring Stations in Weir River ACEC.

9.2 BACTERIA

A number of different species of bacteria are used to indicate the presence of harmful pathogens in water. Guidelines and thresholds (i.e., standards) for these bacteria are established by appropriate government agencies based upon how much bacteria a human can tolerate before getting sick.

The present day standard bacterial indicator applied by the Massachusetts Division of Marine Fisheries (DMF) to assess water quality for the purposes of shellfishing is fecal coliform. Shellfish beds classified as open to shellfishing must not exceed concentrations with most probable number (MPN) 14 col/100ml (see the footnote on page 27 for a description of the MPN method). Shellfish beds that are restricted to certified Master Diggers must not exceed concentrations of MPN 88 col/100ml and these shellfish must be treated by controlled depuration before they are available for consumption. Shellfish beds with concentrations that exceed these standards are closed to shellfishing.

The Department of Environmental Protection applies water quality standards to assess whether a water body is fishable, swimmable, or drinkable. These are the standards presented in Table 9-1. Again, fecal coliform is the chosen indicator of bacterial contamination. More recently, the Department of Public Health has adopted new standards for monitoring beaches, as recommended by the US Environmental Protection Agency. These standards were discussed in the previous section. Instead of fecal coliform, *Escherichia coli* and/or *Enterococcus* are used as bacterial indicators.

FECAL COLIFORM. Data gathered from 1993-1995 by DMF indicates that two sampling stations (27 and 30), both located in GBH 1.7 (Figure 7-1 and 9-1), where measurements exceeded 260 col/100 ml fecal coliform (Roach 1996b): the cove between Worlds End and Planters Hill (5.8 percent of samples) and the Borland Bridge (2.7 percent of samples). According to DMF, a gradient of increasing bacterial values extending upstream from World's End to the Borland Bridge is a recurrent trend attributed to failing subsurface sewage disposal systems located upriver, which adversely affect the lower Weir River during first flush (Roach 1996b). *First flush* refers to the initial water discharge from runoff and groundwater during the first hour or two of a rainstorm. The first flush typically contains the highest concentrations of contaminants that have been accumulating since the last rain event.

The Straits Pond Watershed Association (SPWA) has organized bacterial monitoring of Straits Pond as part of several different pond-related projects. SPWA is currently monitoring the pond with a team of volunteers, but little data was available at the time of this report. In

1991-1992, the Hull High School participated in a monitoring program as part of an effort to reduce the midge population in the pond (Beres & Burbank 1992). During the summer of 1991 and winter of 1992, students collected samples from 15 different locations. A legible map of these sampling stations was not available to illustrate in this report. Although not comprehensive, samples collected from a few stations were analyzed for fecal coliform concentrations. Samples from storm drains into the pond were also analyzed for fecal coliform. Samples were analyzed using the membrane filter technique and results were reported in colony forming units (CFU) per 100 ml. Figure 9-2 displays the data on fecal coliform. Although not statistically significant, the data collected is indicative of a water quality problem.

Straits Pond is considered Class SA water not designated for shellfishing. In accordance with state regulations 314 CMR 4.00, fecal coliform concentrations at any given location in the pond cannot exceed a geometric mean of 200 col/100ml and no more than 10 percent of the samples can exceed 400 col/ml. As indicated in the graphs, it is evident that on most days at least one station exceeded the standard, and the stations 5, 10, 11 and storm drains A, E, F, K, V, W, and X appear most problematic. According to the Midge Study (Beres & Burbank 1992), a pipe from Richard's road carried raw sewage from neighboring homes directly into the pond near station 10. In addition, several septic systems of homes near station 10 were observed to overflow during wet weather. Water samples from the USGS sampling station in the Weir River found elevated concentrations ranging from MPN 180 - 400 col/100 ml in 1999.

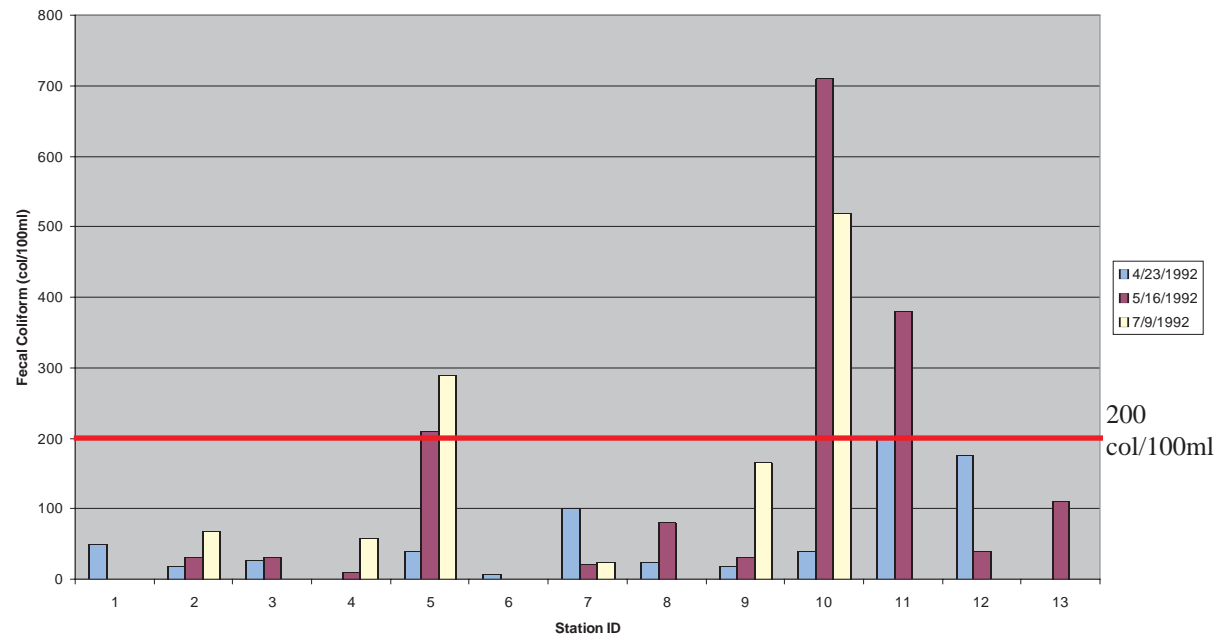
While not specific to the Weir River ACEC, other historical fecal coliform data exists for the larger area that comprises Hingham Bay. This data was not summarized here because it is outside of the ACEC boundary and because different methods were used in collecting the samples, which make it difficult to compare data. Anyone interested in this information is referred to "A Spatial and Temporal Analysis of Boston Harbor Microbiological Data," (MWRA 1991).

ENTEROCOCCUS. The Town of Hingham Department of Health conducts seasonal bacterial monitoring of its beaches for *Enterococcus*. One of these sampling stations, located at the base of Cliff Road in northern Hingham, falls within the ACEC boundaries. At no time during sampling did this station exhibit *Enterococcus* counts in excess of the state standard of 104 CFU/100 ml.

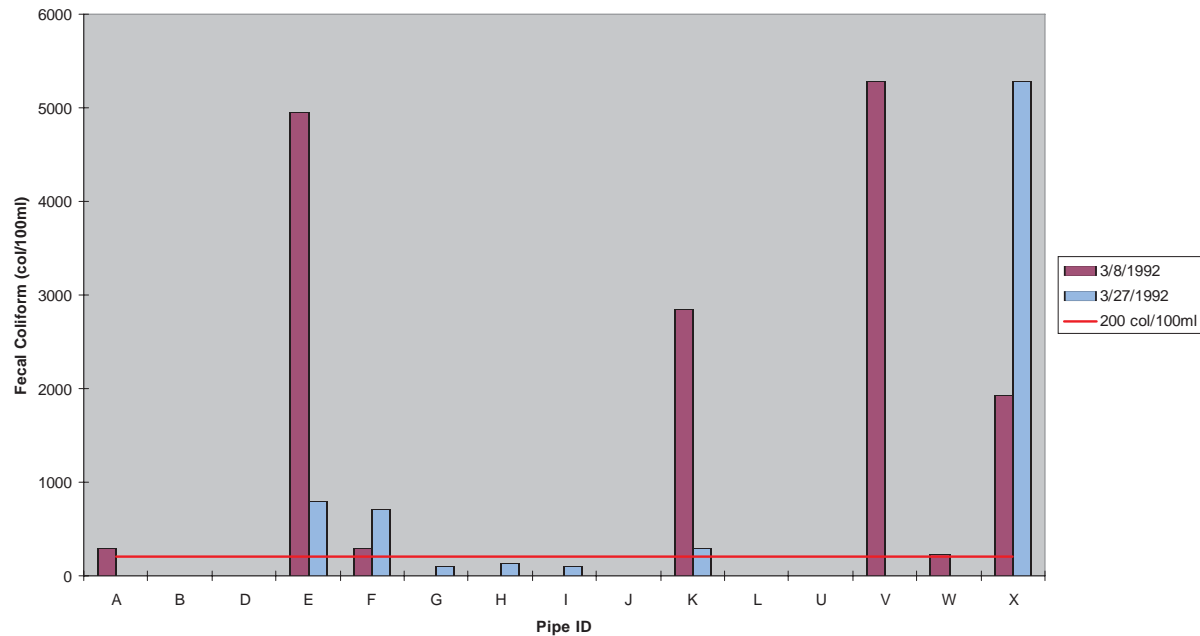
The Town of Hull Board of Health also monitors for both *Enterococcus* and fecal coliform but no stations

are located within the Weir River ACEC. Data from summer 2000 indicates that concentrations of both of these bacteria were below the regulatory limits. For

these reasons, the results are not reported in this document.



a) Samples Collected at Stations in Pond



b) Samples Collected from Storm Drain Pipes

Figure 9-2. Fecal Coliform Data for Straits Pond

9.3 SALINITY

Salinity is the concentration of all dissolved ions (i.e., salts) in a sample. Seawater has a salinity of approximately 35 o/oo (parts per thousand). Brackish water ranges upward from 1 o/oo, and brine is the term used to describe water with salinity greater than 35 o/oo.

WEIR RIVER. The river is considered brackish. Surface salinity recorded in 1970 at the mouth of the Weir River under varying tidal and weather conditions revealed a salinity range of 15.5 - 30.0 o/oo with an average salinity of 26.0 o/oo (Iwanowicz 1973). 1979 measurements showed a range varying from 11.21 - 29.39 o/oo, similar to the salinity range in Straits Pond (IEP 1980). Recently, the Weir River Watershed Association (WRWA) initiated a sampling program for the Weir River, the Weir River Estuary, Straits Pond, and Hull Bay. Surface salinity measurements in the Weir River, downstream of Foundry Pond, were 0.06 o/oo and 0.10 o/oo in April and May 2002, respectively.

WEIR RIVER ESTUARY. Data collected by ENSR (2002) in May 2001 revealed a salinity range in the estuary of 14.2 - 25.5 o/oo. August 2001 data for the same study indicated a salinity range of 25.6 - 30.9 o/oo. According to ENSR (2002), "these salinity measurements indicate that while the lower salinity of the water discharged from Straits Pond affects the salinity in the estuary downstream to George Washington Boulevard at low tide...as does the Weir River freshwater influence the salinity in the estuary...the effect is completely overwhelmed by incoming ocean water at high tide." Surface salinity measured by WRWA in the Weir River Estuary in two locations averaged 12.17 o/oo in April 2002 and 10.92 o/oo in May 2002.

STRAITS POND. The pond is described as brackish. Salinity was found to vary between 10.48 o/oo and 23.49 o/oo (IEP 1980). Salinity recorded by the Hull High School Report on Midge Mitigation Study indicated a springtime range of 4.0 - 28.0 o/oo and a summer-time range of 18.2 - 29.0 o/oo (Beres & Burbank 1992). More recent sampling by the Straits Pond Watershed Association in May 2001 revealed a pond-wide range of 16.1 - 17.8 o/oo. In addition, water samples measured by ENSR on 15 May 2001 showed a 10.26 - 11.43 o/oo range (ENSR 2002). Salinity measurements in August for the same study revealed a higher salinity in the pond ranging from 23.9 - 27.4 o/oo. Surface salinity measured by WRWA averaged 9.45 o/oo in April 2002 and 9.10 o/oo in May 2002.

"The lower salinity measurements in Straits Pond measured during May 2001 are indicative of the lack of flushing through the tide gate during the winter months. In contrast, the higher salinity in Straits Pond measured in August indicates the effects of controlled flushing

during the summer months," (ENSR 2002). No salinity gradients have been observed from surface to bottom (IEP 1980) as the pond is shallow and relatively well mixed. In Straits Pond, a relationship has been found between the low salinity of the water from January to April and a high concentration of midges later in the year (Beres 1994).

HULL BAY. Salinity measurements by DMF in Hull Bay suggest a range from 24.0 - 33.0 o/oo (Roach 1996a). Salinity measured by WRWA was 28.80 o/oo in April 2002 and 19.94 o/oo in May 2002. WRWA's vertical salinity profiles at this station indicate that the bay was still vertically mixed in April but was becoming more stratified in May, ranging from 19.94 o/oo at the surface to 27.70 o/oo at four feet below the surface. Other factors held constant, increasing the salinity of seawater causes its density to increase. High salinity seawater generally sinks below lower salinity water, which leads to layering of water, or stratification. Stratification is typical in the spring and summer months when fresh water inputs are higher and the water is less turbid.

9.4 NUTRIENTS

When assessing water quality, it is important to learn if the water contains enough phosphate, nitrate, ammonia, and other nutrients to support algae and other vegetation. All waters contain low concentrations (also called background levels) of organic nutrients from soils, air, and the life cycle of organisms. Additional organic and inorganic nutrients can be introduced from other sources such as fertilizers, wastewater, stormwater, and animal waste. As a body of water is increasingly enriched with nutrients, especially nitrogen and phosphorous, a process known as eutrophication can develop. During eutrophication, plant and algal growth increase. Over time, the water body may exhibit symptoms of eutrophication such as extensive algal slimes or scums, water discoloration, reduced circulation, a decrease in biodiversity, oxygen depletion, fish kills, foul odors, and episodes of toxicity. Eutrophication rates depend on the volume and flow rate of the water body and are generally increased by anthropogenic inputs of nitrogen or phosphorous (Terrell & Perfetti 1989).

Although nutrients such as carbon, silicate, magnesium, potassium, and calcium, are required for biosynthesis, nitrogen and phosphorous are considered the principal nutrients controlling the growth-rate of macro and microscopic plants, or primary production. Phosphorous and nitrogen are "controlling" nutrients because any addition of one or the other to a particular system increases primary production--a concept more commonly referred to as *nutrient limitation*. In fresh-

water systems, phosphorous is considered the primary nutrient limiting primary production while coastal systems are nitrogen-limited.

The nutrients and their forms that are conveniently and typically measured with proven analytical methods include: soluble orthophosphate, inorganic phosphate (orthophosphate + polyphosphate + insoluble inorganic phosphates), total phosphorous (inorganic + organic), Kjeldahl nitrogen (ammonia + organic nitrogen), and nitrate + nitrite (Allen & Kramer 1972). There are no government standards for nutrients in marine systems. In addition, ecological variations make it difficult to generalize on what a high or low concentration of a particular nutrient might be in a given system. It is usually only after a problem, such as eutrophication, develops that an excess of nutrients becomes evident.

WEIR RIVER. Sampling in 1979 revealed the Weir River to be high in both phosphorous and nitrogen, and it was suggested that the water quality of the Weir River does not meet its assigned "Class B" designation (IEP 1980). A 1987-1988 study completed by Gale Associates (1992) collected water quality data for Foundry Pond and more southern (upper) portions of the Weir River. Phosphate levels were found to be highest in October, measuring 0.303 mg/L at Tower Brook Road and 0.303 mg/l at Fulling Mill Pond.

The USGS conducted sampling of the Weir River in 1999 at a station south of the ACEC near East Street in Hingham. Total nitrogen in 1999 ranged from 0.33 - 0.67 mg/l with the peak in June. Combined nitrate and nitrite concentrations ranged from 0.31 - 0.64 mg/l with the peak in November. Total phosphorous and phosphate over the same period ranged from 0.021 - 0.044 mg/l and 0.02 - 0.04 mg/l, respectively

STRAITS POND. High levels of orthophosphate, total phosphorous and nitrogen measured in the pond in late spring 1979 suggest Straits Pond is highly eutrophic (IEP 1980). Because a surplus of both nitrogen and phosphorous was available, it was surmised that light and other nutrients were the limiting factors of plant growth in the pond (IEP 1980).

9.5 TEMPERATURE

A healthy temperature for a body of water depends on location and other physical characteristics. Changes in water temperatures beyond natural seasonal fluctuations play an important role in determining acceptable limits of certain natural elements. Since an increase in temperature increases the solubility of solids and a decrease increases the solubility of gases, temperature changes can prompt water to absorb more of certain elements than it normally would. Consequently, concentrations can become harmful, even toxic, to the ecosystem.

WEIR RIVER. Surface water temperatures recorded in 1970 at a sampling station at the mouth of the Weir River measured a year-round range from 20 - 68 °F (-6.7 - 20 °C) (Iwanowicz 1973). In 1999, temperature measured at a single USGS sampling station in the Weir River found a temperature range of 39.2 - 72.5 °F (4 - 22.5 °C). Surface temperature measured by WRWA was 60.3 °F (15.7 °C) in April 2002 and 49.3 °F (9.6 °C) in May 2002.

WEIR RIVER ESTUARY. Temperatures recorded by ENSR (2002) revealed a range of 56.5 - 60.8 °F (13.6 - 16.0 °C) in May 2001 and 68.1 - 77.0 °F (20.1 - 25.0 °C). The higher temperatures recorded in August are expected given the higher ambient air and ocean water temperatures in summer months. Surface temperature measured by WRWA averaged 56.3 °F (13.5 °C) in April 2002 and 52.9 °F (11.6 °C) in May 2002.

STRAITS POND. Recent surface temperature recorded by WRWA averaged 61.9 °F (16.6°C) in April 2002 and 53.2 °F (11.8 °C) in May 2002. Temperature recorded by the Straits Pond Watershed Association May 2001 revealed a range from 61.9 - 76.3 °F (16.6 - 24.6 °C). Temperature measurements made by ENSR (2002) revealed a range of 59.5 - 60.8 °F (15.3 - 16.0 °C) in May 2001 and 75.7 - 79.5 °F (24.3 - 26.4 °C) in August 2001. Past data indicates that summertime temperatures in the pond have reached the mid to upper 80s oF have been observed (IEP 1980).

HULL BAY. Temperatures measured by DMF in Hull Bay showed a year-round range of 29 - 79 °F (-1.7 - 26.1 °C) (Roach 1996a). Temperature measured by WRWA was (12.58 °C) 54.7 oF in April 2002 and 51.4 oF (10.8 °C) in May 2002.

9.6 pH

The pH of a sample of water is a measure of the acidity or alkalinity of the water, based on the concentration of hydrogen ions. Water with a pH value of 7.0 is considered neutral. The lower the pH, the more acidic the water is; the higher the pH, the more alkaline it is. The pH of water also determines the solubility and biological availability of nutrients and heavy metals. Metals tend to be more toxic when they are more soluble at lower pH ranges. Most natural waters have a pH ranging from 5.0 to 8.5. Water with a pH outside of this range can seriously disrupt order in an ecosystem and is cause for concern.

WEIR RIVER. pH recorded in 1970 at a sampling station at the mouth of the Weir River reveal a minimum of 7.0 and a maximum of 8.5 (Iwanowicz 1973). pH recorded in 1999 at the USGS sampling station found a limited range from 6.19 - 6.81.

WEIR RIVER ESTUARY. Measurements by ENSR (2002) revealed a pH range of 7.80 - 8.22 in May 2001 and 7.72 - 8.18 in August 2001.

STRAITS POND. Samples measured in spring 1992 indicated a 6.0 - 9.0 pH range, while summertime measurements revealed a pond-wide pH of 8.9 (Beres 1992). Measurements by ENSR (2002) revealed a pH range of 8.43 - 8.56 in May 2001 and 6.99 - 8.06 in August 2001. pH measured by WRWA in May 2002 averaged 8.43 in May 2002.

9.7 DISSOLVED OXYGEN

Dissolved oxygen analysis measures the amount of gaseous oxygen (O₂) dissolved in water. Oxygen is introduced to water through organic wastes, diffusion from surrounding air, aeration (rapid and turbid movement of water), and it is a product of photosynthesis. Insufficient dissolved oxygen can significantly degrade the quality of life in a pond, killing fish and vegetation (plants need oxygen at night when they are not photosynthesizing). The growth and reproduction of most plants and animals is unimpaired when dissolved oxygen exceeds 5 mg/l. When levels drop below 5 mg/l, however, living organisms often become stressed. If levels fall below 3 mg/l, the system is at risk of becoming hypoxic, killing many non-mobile organisms and driving mobile organisms away to healthier regions. Another condition, known as anoxia, results when dissolved oxygen levels are reduced to less than 0.5 mg/l. Even fewer species can survive in anoxic conditions.

WEIR RIVER. USGS data from 1999 found dissolved oxygen concentrations ranging from 6.2 - 10.4 mg/l. Measurements made by WRWA were 8.57 mg/l in April 2002 and 10.10 mg/l in May 2002.

WEIR RIVER ESTUARY. Samples collected by ENSR (2002) revealed a dissolved oxygen concentration range of 8.29 - 9.61 mg/l in May 2001. Dissolved oxygen measured by WRWA averaged 7.84 in April 2002 and 8.76 mg/l in May 2002.

STRAITS POND. All samples from late winter/early spring 1979 exceeded 3 mg/l with ample concentrations measured below the ice in mid February (IEP 1980). Samples from spring 1992 ranged from 5.2 - 17 mg/l. Dissolved oxygen was somewhat suppressed during summer sampling, ranging from 1.4 - 11.4 mg/l (Beres & Burbank 1992). Recent sampling by the Strait Pond Watershed Association in May 2001 revealed concentrations ranging from 9.4 - 12.85 mg/l. Samples collected by ENSR (2002) in May 2001 revealed dissolved oxygen range of 9.16 - 10.94 mg/l. Average measurements made by WRWA were 8.75 mg/l in April 2002 and 9.05 mg/l in May 2002.

HULL BAY. Dissolved oxygen measured by WRWA was 9.14 mg/l in April 2002 and 8.09 mg/l in May 2002.

9.8 HEAVY METALS AND OTHER TOXINS

STRAITS POND. Sediment samples from Straits Pond revealed significant concentrations of lead, cobalt, arsenic, and zinc (McDermott 2001) (exact measurements were not available). Chemical sprays, including DDT, lead arsenate, Aquathol, and Abate have historically been applied to treat the midges in the pond and it is likely that these toxins have accumulated concentrations in the underlying sediments of the pond.

9.9 WATER QUALITY CONCERNS AND POLLUTION SOURCES

HULL BAY. In general, Hingham Bay exhibits lower fecal coliform counts than the rest of Boston Harbor during widespread pollution events (Roach 1995). The reason for this variation is that the tidally dominant hydrology of Boston Harbor separates the Harbor into two distinct regions, effectively limiting water exchange between them (McDowell et al. 1991). For this reason, Hingham Bay is relatively unaffected by the CSO discharges that seem to adversely affect the waters in the northern harbor. The major microbial pollution sources to the bay, instead, appear to be related to urban run-off and first flush effects of storm events (Roach 1994). Other sources include migrating birds and house pet droppings (Roach 1995) and the remaining sewage outfall pipes for Nut Island, which were kept in place for by-pass purposes (Roach 1994). The Hull Sewage Treatment Plant is not considered a pollution source because of the limited amount of effluent released on a daily basis and the distance between the discharge point and the ACEC (Roach 1995).

Data from DMF provide the most complete description of pollution sources to shellfish beds in the region. In shellfish bed GBH 1.5 (Figure 7-1), four storm drain siphons, five wetland seepages, one boat ramp, two dumpsters, and a cesspool were identified as actual pollution sources to the bed. The heaviest bacterial loadings were observed from storm drain siphons (Roach 1996a). According to DMF, the boats at Nantasket Pier do not affect water quality in the neighboring shellfish beds. In shellfish bed 1.3, two storm drain siphons were identified as actual pollution sources. Also, "it is believed that GBH 1.3 and GBH 1.5 (Figure 7-1) may also be adversely impacted by first flush effects originating from upstream sources [in the Weir River]," (Roach 1996a). Shellfish bed GBH 1.7 is primarily affected by urban runoff and first flush effects, although two storm drains/culverts and three wetland discharge sites were also identified as pollution sources (Roach 1996b).

STRAITS POND. There has been considerable debate over the history of Straits Pond, also once called Nantasket Pond (Sweetser 1883). Some believe the pond once opened into the ocean but was separated from it after a road was built (Sullivan 1998). Others believe the pond was originally a salt marsh and the pond was not created until the 1890s by a commercial developer (Lupos 1999). The Cohasset Historical Society, however, has found no records indicating the pond was ever connected to the ocean (Sullivan 1998). Their research indicates the pond was originally a tidal marsh, but was dammed in the 1800s to create a reservoir for a mill (IEP 1980; Sullivan 1998). When the mill closed at the end of the century, the pond was drained and used to grow grass to feed cattle. Over time the marsh was refilled with water. The introduction and ongoing operation of a tide gate now maintains the water body as a pond.

Recorded complaints of nuisance weed growth and foul odors in Straits Pond date back over 100 years (IEP 1980). At that time, the state proposed several plans to improve conditions. But no action was taken until the 1940s, when a tide gate was installed at the outlet of the pond to raise and maintain water levels. Water quantity, however, was only part of the problem. Records from the 1950s indicate weed and midge populations were a persistent nuisance, and that numerous storm drains and sewage pipes discharged contaminants into the pond (Figure 9-3). In fact, more recent studies of contamination in Straits Pond identified malfunctioning septic systems and the concomitant septic infiltration as the most significant pollution problem (GZA 2000; IEP 1980). The organic nutrients in the sewage were of particular concern because of the dense algae and abundant midge population (*Chironomous Riparius*) in the pond. *C. Riparius* is recognized as one of the first macroinvertebrates to colonize waters containing organic pollution (Beres 1994). Runoff into the pond from 23 outfall pipes also contributes to this nutrient enrichment.

While efforts to reduce pollution have been made, including sewerage the properties around the pond (completed in 2001), problems continue. In particular, because ground water travels so slowly, it will likely take considerable time before decreases in nutrients, fecal coliform, and sewage deposits are observed (Campenella 2001; Sullivan 1998). In the mean time, the density of algae has increased over the past few years, and the midge population has ballooned to densities that make it unbearable for local residents to be outside in late summer (Campenella 2001; Sullivan 1998).

Contributing to the proliferation of algae, the pond suffers from thermal pollution. The shallow depth and slow flushing rates in the pond result in high water temperatures that encourage growth of the weeds (IEP 1980). The dense weeds further reduce circulation and, in turn,

encourage temperatures in the pond to rise. For this reason, there is some concern among residents that the new sewer connections will have little impact on the weeds (Lupos 1999).

The growing population of swans in Straits Pond has been identified as an additional source of nutrient enrichment in Straits Pond. "Adult swans weigh between 20 and 40 pounds, and each day consume 10 pounds of plant life. The nutrients in the swans' excrement, which is about the size and shape of that produced by dogs, are feeding an overgrowth of aquatic plants and algae," (Preer 2001). The swans, which are not native to America, are also considered by some to be a threat to native species populations.

Sediment contamination is another concern in Straits Pond. In 1953, the state began to treat the weeds and midges with chemical sprays, including DDT, lead arsenate, Aquathol, and Abate (IEP 1980; McDermott 1992). These toxic chemicals have been accumulating in the sediments of the pond for nearly half a century. Lead contamination has also been documented, likely attributed to runoff into the pond at a time when lead was prominent in gasoline (McDermott 2001).

WEIR RIVER ESTUARY. There is one landfill located in close proximity to the Weir River Estuary on the east side of Gosnold Street in Hull. Until 1991, when part of the landfill (Phase I) was capped with a high-density polyethylene flexible member liner, the landfill was used as a repository for municipal solid waste (Wright 2002). The remainder of the landfill (Phase II) presently is used for disposing of inorganic waste collected by the Town of Hull and waste collected during beach cleanups (Wright 2002).

Phase I of the landfill was capped with a non-permeable membrane but it was never lined. While the cap prevents vertical entry of water into the waste in the ground it is not equipped to prevent the horizontal flow of groundwater through it. Phase II, which is scheduled to be closed and capped in 2010, on the other hand, is a lined landfill with a leachate collection system and a temporary clay cap to prevent both horizontal and vertical flow (Wright 2002).

There are six shallow monitoring wells for this landfill (12 to 28 feet deep), one up-gradient and five down-gradient from the site. The most recent monitoring was completed in December 2001 and is considered typical of the previous monitoring. The monitoring program consists of general chemistry parameters (alkalinity, total dissolved solids (TDS), cyanide, chloride, nitrate, sulfate, chemical oxygen demand (COD)), hexachrome, dissolved metals (arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, selenium, silver, zinc), sodium, and volatile organic

compounds (VOCs) (methyl tertiary-butyl ether -- a gasoline additive that replaced lead and provides for higher octane). Of these chemicals, the December monitoring revealed primary maximum contaminant level (MCL) exceedences of TDS, chloride, and sulfate (Wright 2002). Background levels measured also revealed an elevated TDS, which would suggest a source other than the landfill. In addition there were secondary MCL (SMCL) exceedences of iron, manganese, sodium, and zinc and detections of arsenic and barium (Wright 2002). (Primary MCLs are enforceable EPA standards while SMCLs are non-enforceable standards that were established to manage drinking water for aesthetic considerations such as taste and color.)

While most of the de-watering and leaching from a typical unlined, capped landfill takes place within the first seven years following closure, there remains some low-impact residual landfill-related leaching from Phase I, as evidenced by recent monitoring (Wright 2002). It is

not known what the long-term impacts of Phase I of the landfill will be on the neighboring Weir River Estuary. At this time, there have been no plumes detected or pollutant profiles suggesting that more comprehensive monitoring or monitoring within the estuary are necessary (Wright 2002). It is unlikely that these impacts will be known unless DEP determines that an overall site assessment is warranted.

WEIR RIVER. While not definitive, the Foundry Pond study (Gale Associates 1992) suggested that potential sources of phosphorous include lawn fertilizers, storm drainage, septic systems, and decaying leaf litter in adjacent wetlands during fall and early winter. Bacterial pollution from failing septic systems along the Weir is also a source of pollution. In fact, the Weir River (MA74-11) from Rockland Street and the outlet of Straits Pond to the mouth at World's End is on the state 303(d) list of degraded waters for pathogen pollution.

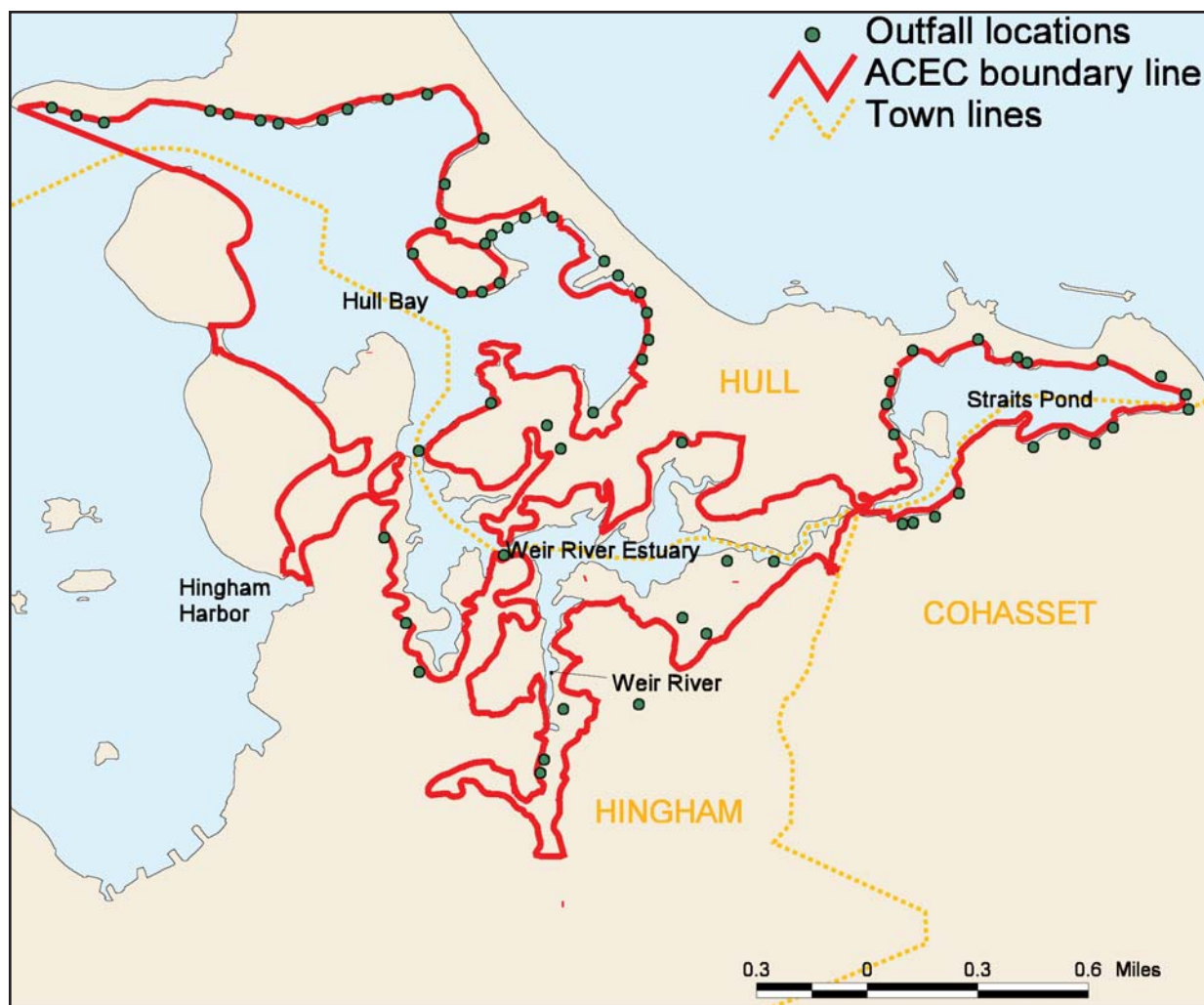


Figure 9-3. Location of Storm Drain Outfalls in Weir River ACEC (Data sources: MassGIS, Town of Hull, UHI)

10. LAND USE

Table 10-1. Land use acreage in the Weir River ACEC

	Cohasset 2.6%	Hingham 44.7%	Hull 52.8%	Total Acreage 100%
Land Classification				
Agriculture	0	12	0	12
Commercial	0	1	4	5
Forest	0	72	22	94
Open Land	0	1	5	6
Residential	0	53	29	82
Transportation	0	0	2	2
Urban Open	0	0	3	3
Wetlands	0	77	48	125
Water	25	216	397	638
Total Land Area	0	216	113	328
Total Acreage	25	432	510	966

The Weir River ACEC is comprised of 922 acres of which 285 acres (31%) are land and 637 acres (69%) are water. Land use for the land area within the ACEC is summarized in Table 10-1 and presented in Figure 10-1. The land use classification scheme and figures have been compiled from MassGIS's Land Use theme.

Of the three municipalities, Cohasset owns the smallest part of the ACEC, only 25 acres (3 percent of the total ACEC) which are within Straits Pond, where the ACEC boundary is mean high water. However, the majority of the Straits Pond subwatershed is within Cohasset (ENSR 2002), so the adjacent residential land use could have stormwater runoff impacts to the pond and the ACEC. Cohasset is a predominantly residential community of nearly ten square miles with a population of 7,075 and an overall population density of 704 persons per square mile. Several areas of the town are sewered (1,148 homes in all), including most of the area of North Cohasset adjacent to Straits Pond. Land use adjacent to the ACEC is primarily low density residential, and within the subwatershed is woodland and recreation (part of the Cohasset golf course).

Forty-two percent of the ACEC is within the Town of Hingham. Of the 389 acres of the ACEC in Hingham, 173 acres are upland, including wetlands. The Town of Hingham covers an area of 22.5 square miles and has a population of 21,751 (2000 Census) with a density of 882 per square mile. The majority of the land in the Hingham portion of the ACEC is in one of the "undeveloped" land categories: wetlands (76 acres), forest

(47.5 acres), agriculture (12 acres) and open land (1.2 acres). These total 79 percent of the land area of the ACEC in Hingham. Thirty-five acres are in single-family residential development (low density) and less than an acre is commercial.

World's End, owned by The Trustees of Reservations, is a 251-acre reserve on a peninsula of several drumlins that divides Hull Bay from Hingham Bay. Its open fields and forests in and adjacent to the ACEC comprise the largest protected undeveloped natural landscape in the area.

The greatest percentage of the ACEC is in the Town of Hull, at 509 acres or 55 percent of the total. Hull is the most densely developed of the three communities, has the greatest diversity of land uses and is fully sewered. Hull's land area is 2.53 square miles, with a population of 10,807 (2000 Census) and an overall density of 4,137 persons per square mile. This density is nearly five times higher than either Cohasset or Hingham.

In Hull, wetlands are the largest land use type in the ACEC (48 acres), followed by residential (29 acres) and forest (22 acres). Residential zoning districts in and bordering the ACEC allow a density of from two to six single-family lots per acre. Areas of multifamily development at a density of four units per acre also abut the ACEC. Commercial development and major roadways are in and adjacent to the ACEC. In particular, Nantasket Pier in Hull Bay has been an active commercial and recreational pier and commuter boat stop

and the town is planning for its redevelopment with similar types of uses.

Build-out analyses have been performed by the Executive Office of Environmental Affairs and the Metropolitan Area Planning Council for each of the three communities that share the ACEC. These analyses are done on a town-wide basis, of course, but the characterization of each community's present and future development is relevant to the future management of the ACEC. Hull, which is nearly fully developed, anticipates few changes from the relatively minor amount of new development that can be accommodated. Redevelopment of properties may be the more interesting trend. Under existing regulatory conditions, which require over one-acre per house lot, Hingham could accommodate approximately 1,300 new single-family homes and 3,500 new residents, a 16 percent increase in population. The build-out analysis for Cohasset indicates that just over 1,000 new house lots can be created

town-wide under the existing regulatory scheme with an increase in population of 2,600 people. This represents a significant increase in over the existing population, at 38 percent.

NOTE FOR LAND USE MAP

The land use map for the Weir River ACEC was produced from the MassGIS Land Use data layer. This data layer depicts a total of 37 land use classifications interpreted from 1:25,000 aerial color infrared photography from 1999. Since land use (or land cover) is determined from the aerial photographs, the perimeter of each land use area does not coincide with actual property boundaries nor does it necessarily reflect precise land uses. For example, World's End is depicted as agricultural land on this map because the maintained fields appear to be in agricultural use, and not just protected open space.

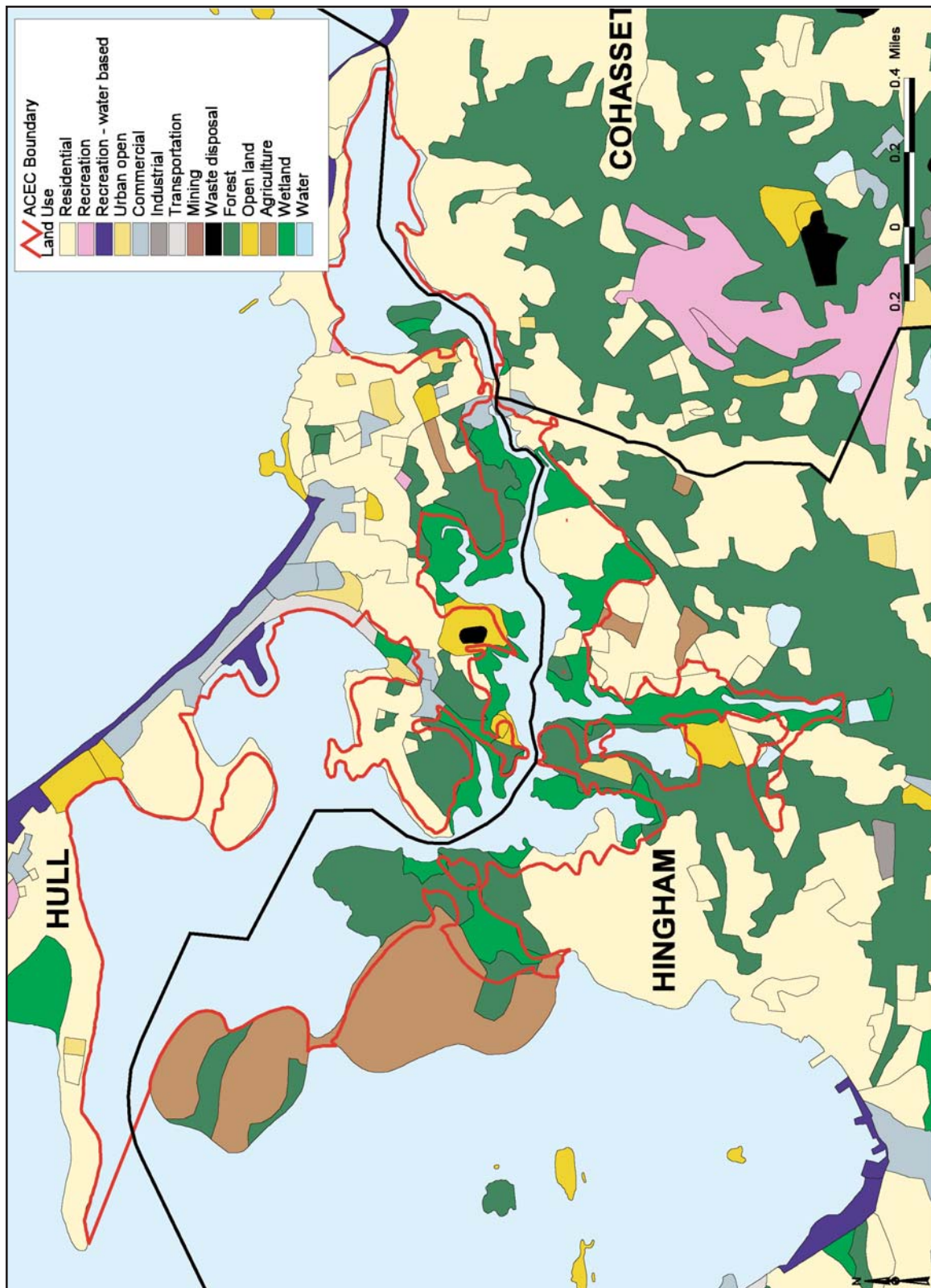


Figure 10-1. Land Use in Weir River ACEC (Data source: MassGIS).

II. OPEN SPACE AND RECREATION

From the headwaters of the Weir River to Hingham Bay, protected open space surrounds the Weir River, providing excellent recreational opportunities and a buffer from development for the watershed drainage area. The total acreage of protected open space in the ACEC is estimated at 140 acres.

The state of Massachusetts recognizes public, private and non-profit open space with varying degrees of protection from destruction and degradation. Private holdings could include agricultural properties (Chapter 61A restrictions), forested land (Chapter 61 restrictions), significant areas for water resource protection (high yield aquifers), priority areas for protection of rare species, private recreation areas, estates, major institution holdings, and less-than-fee-interests. Less-than-fee-interests are lands encumbered by conservation restrictions, wetland restrictions, watershed protection restrictions and historic preservation restrictions. Public open space includes federal, state, county, and municipal lands and facilities for conservation and recreational use. Non-profit open space is usually associated with a local land trust or similar private nonprofit. Land belonging to public institutions such as state and federal schools or universities, state hospitals, and prisons is also sometimes considered open space (EOEA 2001).

In the upper regions of the Weir River, Wompatuck State Park (3500 acres), Turkey Hill, Whitney and Thayer Woods (824 acres) and George Washington Town Forest (110 acres) in Hingham bank the river as it flows toward the estuary. Within the ACEC, World's End is the largest parcel of open space bordering the Weir River Estuary. The Town of Hull and Tufts University also own parcels of land either in the ACEC or directly bordering the ACEC. Nantasket Beach is another important adjacent open space. This beach is managed by the Metropolitan District Commission and is a major recreational attraction in the summer.

Hingham has established an Open Space Acquisition Committee and Hull selectmen have appointed a Weir River Study Committee to research open space usage around the Weir River and Estuary (See below discussion of Weir River Estuary Park).

The towns of Cohasset and Hingham voted to accept the provisions of the Community Preservation Act (CPA) at municipal elections in 2000; Hull voters turned it down. The CPA is statewide enabling legislation that allows cities and towns to create a local Community Preservation Fund with a surcharge of up to three percent of the real estate tax levy on real property in the

municipality. The funds are used for open space acquisition, historic preservation and low and moderate-income housing.

11.1 WORLD'S END

The Trustees of Reservations own and maintain this 251-acre peninsula jutting into Hingham Harbor. Fredrick Law Olmsted originally landscaped the park for a development of homes in 1886, which were never realized. The Trustees established the reservation in 1967 and in 1996 World's End was designated a part of the Boston Harbor Islands national park area. The Trustees have completed a management plan for the property in 2002 and have applied for permits to restore the 15-acre "Damde Meadows" portion of World's End from a brackish salt pond fringed with Phragmites back to salt marsh. Bird watching, cross country skiing, hiking, kayaking, fishing, horseback riding and picnicking along the shores of the Weir River are among the recreational activities offered at World's End.

11.2 TOWN OF HULL

The Town of Hull owns the salt marsh that borders the ACEC on the Hull side of the river within the ACEC, along with the 40-acre site that use to be the town landfill directly adjacent to the marshes. The Conservation Commission manages the salt marsh as conservation land (Weir River Estuary Park Management Plan, 1995). The landfill has been Phase I capped and the site is monitored bimonthly by SEA Consultants of Cambridge (Maddox 2001). The landfill is still open to limited use from beach cleanings and some municipal buildings but the bulk of the property has been planted over and could be used for recreational activity. In 1994, the town of Hull also acquired the 3-acre site along George Washington Boulevard through the MDC. Most plans for the use of Open Space in Hull consider this parcel a potential site for a welcoming center and educational facility.

The Weir River Woods is a 10.6-acre open space parcel on the southern portion of Rockaway Annex in Hull adjacent to the ACEC. The site was originally zoned for development but the area proved unsuitable to potential buyers and ended up in town ownership through unpaid taxes (Coler and Colentino 2001). Town residents voted to protect the area with a conservation easement in 1987, placing the park in the hands of the town Conservation Commission. A trail system was in place

in the 1970s but has fallen into disrepair. Hull was awarded a Coastal Access Grant from CZM and DEM in 2002 to assess the potential for recreational use and develop a management plan. Two possible access points for water recreation and several potential trails were identified.

11.3 TUFTS UNIVERSITY

Tufts University owns two parcels of open space land bordering the ACEC, just northwest of George Washington Boulevard next to the Weir River Woods. The geology department at the university purchased these parcels in 1983 as a resource for undergraduate Geology classes. One parcel is 1.67 acres and the other is 4.25 acres, totaling close to 6 acres of tidal marsh in the Weir River ACEC. Introductory Environmental Geology students took field trips to this site every year until around 2000. The section of salt marsh that the university owns once was a fresh water pond. When sea level rose to the current level, salt water inundated the pond and the area became a marsh. Geology students have been taking soil cores to study the overlaying salt-water peat and subsurface freshwater peat that indicates this change in habitat (Ridge 2002). Due to the traffic problems in and around Boston in the past few years, classes have not come to the marsh regularly, but the department hopes to revisit the site again soon (Ridge 2002).

11.4 WEIR RIVER ESTUARY PARK

The beauty and ecological importance of the Weir River has long made the area a focus of attention for local planners and citizens groups. Since the early 1990s the town of Hull has drafted several plans for a "Weir River Estuary Park" that would capitalize on the recreational and educational potential of the ACEC and create open

space to supplement and connect Nantasket Beach and World's End. . In 1994, the town of Hull, the Massachusetts District Commission, and the Executive Office of Environmental Affairs finalized an agreement to create the park. The 1995 Hull Open Space Plan envisioned that the Weir River Estuary Park would become one of the "cornerstones of Hull's open space system". Hull's 2000 Open Space Plan summarizes the history and progress of this effort, noting that the project has fallen from high priority status since 1995. The town did not take action in the late 1990s to actualize any plan but recent citizen interest indicates that the issue is still important to many residents.

A group of concerned citizens has gathered this year to revisit the park plan and bring this topic back to the forefront of Hull, Cohasset and Hingham decision-making. The Hull Selectmen have appointed a Weir River Study Committee to identify public and private land in the ACEC. The hope is to reshape the old Weir River Estuary Park plan into a realistic goal for the near future and to expand the geographic scope to include Hingham and Cohasset. Access to the estuary via the river itself will be encouraged through canoe and kayak, using the river itself as the main "trail" through the park. Land trails on appropriate properties will also be developed, as through the Coastal Access Grant being implemented in the Weir River Woods of Hull this year. Eventually, these residents would like to see the Weir River Estuary fulfill it's full potential as a wildlife habitat, a passive recreation park and an estuarine environmental learning center for students. In each Weir River Estuary Park Plan, there has been a reoccurring plan to convert the "green building" on the gateway property in Hull into an educational and welcome center. The group is currently focusing on building a contingency throughout the three towns, identifying key parcels of land, and brainstorming possible grant opportunities.

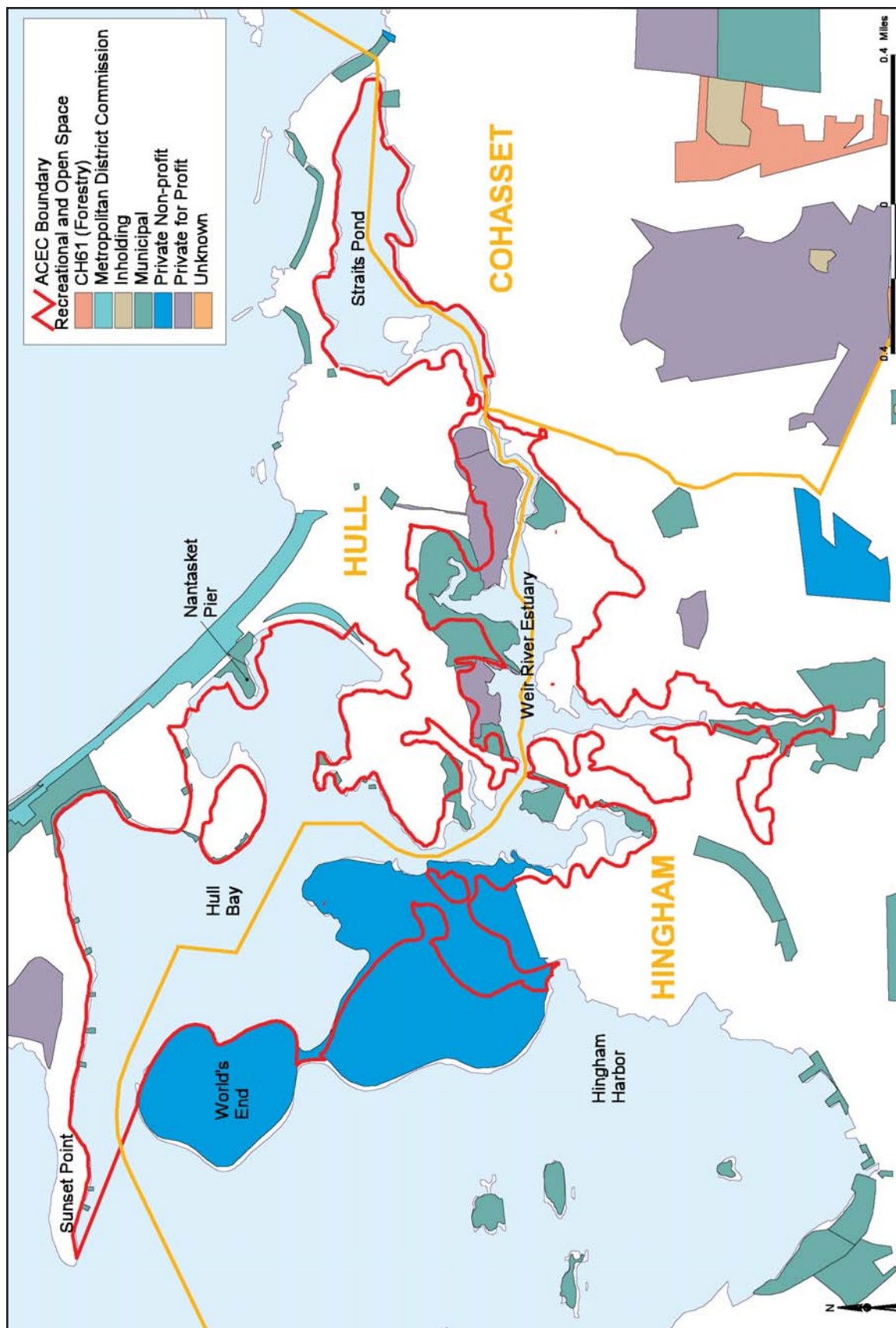


Figure 11-1. Recreation and Open Space in Weir River ACEC (Data source: MassGIS).

12. RECREATIONAL AND COMMERCIAL BOATING

Hingham and Hull are communities historically and culturally tied to the ocean and the Weir River ACEC provides shelter for many commercial and recreational boaters. Boating is common in the ACEC in the inner Hull Bay, from the tip of World's End to Rockaway Annex in Hull. A channel in the Weir River provides access to Nantasket Pier for larger boats (GZA 2000). The entire estuary and river are well suited to canoe and kayak travel and some residents use small boats all the way up the estuary to Straits Pond. Because of the shallow depth of the estuary and the residential neighborhoods along the Weir, the entire region from Sunset Point to the George Washington Bridge is a no wake zone (Souther 2001). Limited water and the low bridge passage from the Rockaway to Straits Pond make it nearly impossible for most motorboats to maneuver.

12.1 HULL

Hull has a 45-foot size limit for boats moored in town and a mooring fee of three dollars. Close to one hundred boats have mooring sites within the Weir River ACEC on the Hull side. Moorings are assigned by the harbor masters, but it is the responsibility of the owner to pay for installation and maintenance (Bornhiem 2001).

Due to the lack of transient moorings, fuel docks, marinas, and parking for visiting boaters, the Hull side of the Weir River ACEC is a waterway used primarily by the residents with adjacent properties. The closest gas station in Hull is located at the A-Street Pier and the town operates a pump out service through the Harbor Master's boat. The Hull pump out service handles approximately 2,700 gallons of waste a year (Bornhiem 2001). Proposals have been made to build a marina near Nantasket Pier with between 100-120 boat slips. The harbor master has stressed that any projects of this scope would be required to include a pump out facility. Negotiations are underway in 2002 for a

request for proposals that originally included an apartment complex and marina, although now due to zoning issues, only the marina component of the proposal is moving forward (Clerkin 2002).

Between the months of April and December, six part-time commercial lobstermen moor near Nantasket Pier. A Lobstermen Association does exist in the area and the group is active in town politics.

Forty commercial diggers harvest the 3 soft-shell clam beds located within the ACEC. These beds are open for 18 months, then closed for 18 months, as regulated by the town's shellfish wardens and the state DMF (Bornhiem 2001).

12.2 HINGHAM

No commercial fishing enterprises operate from the Hingham side of the ACEC, but recreational boaters are more prevalent due to the proximity of World's End. Twenty-three permanent moorings in the study area are registered in Hingham (Souther 2001). The closest gas dock is in Hingham Harbor and as with Hull, the Harbor Master in Hingham operates a pump-out boat. Much of the Hingham side of the river is owned by The Trustees of Reservations, so few of the moorings belong to residents living on the Weir River. Hingham has no mooring fee and each weekend in the summer and early fall several visitors congregate at the tip of World's End. Yacht clubs and private boat owners have maintained and installed the moorings around World's End and most boaters anchor or raft for one or more days. On a busy day, an estimated 250-300 boats from all over New England bring people to swim, fish and relax in the inner Hull Bay in the Weir River ACEC (Souther 2001). This density of boaters requires a more active pump out service. The Hingham harbor master and his assistants make a concerted effort to educate the public about their pump-out boat and make themselves available to the weekly crowds.

13. FUTURE RESEARCH

The Weir River ACEC has not been studied as extensively as many other coastal areas of Massachusetts. This inventory should be used as a reference for future plans and actions and as a tool to highlight where data gaps exist.

The Weir River ACEC was designated in recognition of the environmental, economic, and cultural resources that are unique to this estuary and valuable to the citizens of Hingham, Hull and Cohasset. To understand how best to plan, protect, and promote these resources, further research is needed to capture current conditions and the changes taking place over time in the estuarine system.

A consistent, well-designed water quality monitoring program for nutrients, dissolved oxygen, pH, temperature, and vegetation should be implemented in sites representative of the ACEC. Through tracking several variables, connections between potential pollution sources and changes in the biological, chemical, and characteristics of the water can be explored.

The historic fish runs on the Weir are a severely understudied resource. Few recent reports have monitored the river over time to determine the current species present in the Weir River. Their abundance, migration patterns, food sources and vulnerability to environmental disturbances should be documented and the effectiveness of current fish ladder structures needs to be determined. Regular monitoring throughout the year would be important to account for the seasonal cycles that correspond with the migration of different species.

The type of algae growing in Straits Pond should be identified and its proliferation carefully monitored.

The transition from a sea grass-dominant shallow marine ecosystem to an algae or phytoplankton-dominant system could suggest eutrophication and be a way of monitoring the overall health of the pond. Nutrient loading that leads to eutrophication may also be related to the increased number of swans on Straits Pond. Investigating the relationship between the swans and widgeon grass may help isolate the food source of the swans and determine how to mitigate the problem and allow native waterfowl to compete with the swans.

Sensitive habitats such as eel grass beds and potential and designated vernal pools need to be considered in all future management plans for the ACEC. Although sea grass beds are not located within the ACEC, any runoff, resuspension, or erosion associated with development or dredging would have a detrimental effect on this important habitat. Similarly, sites that are likely to be designated as vernal pools should be highlighted in future decisions for the management around the ACEC.

Although the towns surrounding the ACEC have spent considerable time and money to connect homes to sewage lines, many homes along the Weir River remain on septic systems. Septic failures contribute significantly to local water quality problems and, for this reason, should remain a high priority issue for all stewards of the Weir River ACEC.

The towns surrounding the ACEC and the citizen associations that work to protect the estuary should continue to seek grants to expand baseline information about the area. Attracting academic scientists and enlisting the help of local schools could also expand literature and local knowledge about the natural resources surrounding the Weir River ACEC.

LITERATURE CITED

- Allen, H. E. & Kramer, J. R.** (1972). *Nutrients and Natural Waters*. New York: John Wiley & Sons.
- Bartram, J. & Pedley, S.** (1996). Microbiological Analyses. In *Water Quality Monitoring*, pp. 383. Edited by J. Bartram & R. Ballance. Padstow: E&FN Spon.
- Beres, L.** (1994). *Straits Pond Report 1994*. Hull Environment & Service Corps.
- Beres, L. & Burbank, F. L.** (1992). *Report on Midge Mitigation Study*. Hull Public Schools.
- Bigelow, V. E.** (1898). *Narrative History of Cohasset*. West Hanover, MA: Halliday Lithograph Corporation.
- Boney, A. D.** (1966). *A Biology of Marine Algae*. London: Hutchinson Educational Ltd.
- Bornhiem, K.** (2001). *Personal Communication* to Cory Riley.
- Brennan, B.** (2000). Grass-roots group working on plan for Straits Pond. In *Cohasset Mariner*. Cohasset, March 16, 2000.
- Campenella, L. E.** (2001). Straits Pond Pollution To Be Discussed. In *The Patriot Ledger*. Quincy, March 26, 2001.
- Carlozzi, C., King, K. & Newbold, W.** (1976). *Ecosystems and Resources of the Massachusetts Coast*. Amherst: Institute for Man and Environment.
- Cecil, S., Wiggin, J., Vine, D. & Vine, D.** (1999). *Hull Harbor Management Plan for the Town of Hull*. The Cecil Group, Urban Harbors Institute, Nucci-Vine Associates.
- Chase, B.** (2002). Hull. *Personal Communication* to C. Riley.
- Clerkin, M.** (2002). Hull. *Personal Communication* to C. Lefebvre.
- Coler & Colantino** (2001). *Trails and Public Access Plan: Weir River Woods*.
- Commonwealth of Massachusetts** (1954). *Report to the Department of Public Health, the State Reclamation Board, and the Department of Public Works Relative to a Plan for the Improvement of Straits Pond in the Towns of Hull and Cohasset*.
- Dawson, E. Y.** (1966). *Marine Botany: An Introduction*. New York: Holt, Rinehart and Winston, Inc.
- Deegan, B.** (2000). *June 2000 Breeding Bird Survey*.
- DePaor, D.** (2001). Boston. *Personal Communication* with C. Riley.
- Driscoll, L.** (1999). *The History of Phragmites australis from a Paleontological and Archaeological Perspective*. [Available online at <http://omega.cc.umb.edu/~conne/leslie/historypage.htm>.]
- ENSR (2002)**. *Flushing Study of Straits Pond*. ENSR.
- EOEA (1986)**. *Designation of Portions of the Towns of Cohasset, Hingham and Hull as the Weir River Area of Critical Environmental Concern with Supporting Findings*.
- EOEA (2000)**. *Boston Harbor Watershed Homepage*. [Available online at www.state.ma.us/envir/wwi/bostonharbor.htm.]

- EOEA (2001).** *Open Space Protection*. [Available online at www.state.ma.us/envir/openspaceprotection.htm.]
- EPA (2001).** *Vernal Pools*. [Available online at www.epa.gov/owow/wetlands/types/vernal.html.]
- Foxall, T. L. & Sasner, J. J.** (1981). Effects of a Hepatic Toxin from the Cyanophyte *Microcystis Aeruginosa*. In *The Water Environment: Algal Toxins and Health*, pp. 365. New York: Plenum Press.
- Freeze, R. A. & Cherry, J. A.** (1979). *Groundwater*. Englewood Cliffs, NJ: Prentice-Hall.
- Gale Associates** (1992). *Foundry Pond Feasibility Study*. Gale Associates.
- GZA** (2000). Status of and Potential Impacts on Water Budget for the Weir River Watershed. GZA GeoEnvironmental, Inc.
- Hall, J.** (2001). *Personal Communication* with C. Riley.
- Haris, G. P.** (1986). *Phytoplankton Ecology: Structure, Function, and Fluctuation*. New York: Chapman and Hall.
- IEP** (1980). *Straits Pond Reclamation Study*. Interdisciplinary Environmental Planning.
- Iwanowicz, H. R.** (1973). *A Study of the Marine Resources of Hingham Bay*. Department of Natural Resources, Division of Marine Fisheries.
- Kreutziger, K. M., Peck, E. & Board, H. P.** (2000). *Town of Hull Open Space and Recreation Plan*. Hull Planning Board.
- Lupos, J.** (1999). Hull. *Personal Communication* with SPWA.
- Maddox, J.** (2001). DEP. *Personal Communication* with C. Riley.
- Maryland Department of Natural Resources** (2001a). Cited 2002: *Macroalgae Survey Results from Ocean Pines and Ocean City Dead End Canals*. [Available online at http://www.dnr.state.md.us/coastalbays/macroalgae/algae_2000/canal_sampling.html.]
- Maryland Department of Natural Resources** (2001b). Cited 2002: *Bay Grass Identification Key*. [Available online at http://www.dnr.state.md.us/bay/sav/key/ruppia2_final.html.]
- McDermott, W. R.** (1992). Volunteers Find Straits Pond Study Not Just For Scientists. In *The Hull Times*. Hull, December 3, 1992.
- McDermott, W. R.** (2001). Watershed Association hears several Straits Pond reports. In *The Hull Times*. Hull, March 29, 2001.
- McDowell, S., Ryther, J. & Albro, C.** (1991). *Field Studies of Nut Island Sewage Plumes and Background Properties in Boston Harbor*. MWRA Environ. Qual. Dept.
- MCH**, (1980). *Reconnaissance Survey Report: Town of Hingham*.
- McNamara, B.** (2002). *Personal Communication* with C. Riley.
- Menzie, C. A., Cura, J. J., Freshman, J. S. & Potocki, B.** (1991). *Sources of Loading and Pollutants to Massachusetts Bay*. Massachusetts Bays Program.
- MWRA** (1991). *A Spation and Temporal Analysis of Boston Harbor Microbiological Data*. Massachusetts Water Resources Authority.
- MWRA** (1992). *The State of Boston Harbor: 1991*. MWRA Environ. Qual. Dept. Tech. Rep. Massachusetts Water

Resources Authority.

National Cooperative Soil Survey (2000). Cited 2002: *Scituate Series*. [Available online at <http://www.statlab.ias-tate.edu/soils/osd/dat/S/Scituate.html>.]

NOAA (2001). Cited 2002: *Widgeon Grass*. [Available online at <http://www.csc.noaa.gov/acebasin/specgal/wid-grass.htm>.]

Preer, R. (2001). 'A Very Beautiful Problem' - Proliferation of swans prompts concerns over pollution. In *Boston Globe*. Boston, July 1, 2001.

Richardson, J. (1983). Hingham, MA. *Personal Communication* with C. Riley.

Roach, D. A. J. (1994). *A Sanitary Survey Report of Boston Harbor, The Weir River, Hull, Massachusetts, Area BH-14*. Massachusetts Division of Marine Fisheries.

Roach, D. A. J. (1995). *A Sanitary Survey Report of Boston Harbor, The Weir River Tributary, Hull, Massachusetts, Area BH-14.2*. Massachusetts Division of Marine Fisheries.

Roach, D. A. J. (1996a). *1955 Triennial Report for the Weir River DGSA GBH-1, Classification Sub-areas GBH-1.3 and GBH 1.5 in The Town of Hull, Massachusetts*. Massachusetts Division of Marine Fisheries.

Roach, D. A. J. (1996b). *1995 Triennial Report for the Weir River, DSGA GBH-1, Classification Sub-area GBH-1.7 in Town of Hingham, Massachusetts*. Massachusetts Division of Marine Fisheries.

Roach, D. A. J. (2002). *Personal Communication* with C. Riley.

Signell, R. P. & Butman, B. (1992). *Model tidal exchange and dispersion in Boston Harbor*. J. Geophysical Res. 97, 591-615.

Skehan, J. W. (2001). *Roadside Geology of Massachusetts*. Missoula, MT: Mountain Press Publishing Company.

SPWA (1992). Hull. *Personal Communication* with C. Riley.

Sullivan, M. (1998). Midges Wreak Havoc On Idyllic Setting. In *Cohasset Mariner*. Cohasset, April 16, 1998.

Sweetser, M. F. (1883). *Kings Handbook of Boston Harbor*. Boston: Moses King.

Terrell, C. R. & Perfetti, P. B. (1989). *Water Quality Indicators Guide: Surface Waters*. US Department of Agriculture Soil Conservation Service and the University of Tennessee.

The Trustees of the Reservation (2001). *Worlds End Property Profile*, DRAFT.

Tiner, R. W. (1987). *A Field Guide To Coastal Wetland Plants of the Northeastern United States*. Amherst: University of Massachusetts.

Tiner, R. W. (1999). *Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification, and Mapping*: Lewis Publishers.

Van Hamm, J. (2001). *Personal Communication* with C. Riley.

WHOI (1952). *Fifth Report on Investigations of the Shellfisheries of Massachusetts*. Woods Hole Oceanographic Institution.

Wright, S. (2002). *Personal Communication* with C. Lefebvre.

APPENDIX A

Commonwealth of Massachusetts



Division of Fisheries & Wildlife

Wayne F. MacCallum, *Director*

August 17, 2001

Cory Riley
Urban Harbors Institute
University of Massachusetts
100 Morrissey Blvd.
Boston, MA 02125-3393

Re: Weir River Area of Critical Environmental Concern
Hull, Hingham, Cohasset, MA
NHESP File: 01-9321

Dear Mr. Riley,

Thank you for contacting the Natural Heritage and Endangered Species Program for information regarding state-protected rare species in the vicinity of the above referenced site. I have reviewed the site and would like to offer the following comments.

Our database indicates that the Pied-billed Grebe (*Podilymbus podiceps*), an endangered species, has been documented in the vicinity of the site. This species is protected under the Massachusetts Endangered Species Act (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00) as well as the state's Wetlands Protection Act (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for this species can be found on our website at www.state.ma.us/dfwele/dfw.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. Should your site plans change, or new rare species information become available, this evaluation may be reconsidered.

Please do not hesitate to call me at (508)792-7270 x154 if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Christine Vaccaro".

Christine Vaccaro
Environmental Review Assistant



Natural Heritage & Endangered Species Program

Route 135, Westborough, MA 01581 Tel: (508) 792-7270 x 200 Fax: (508) 792-7275
An Agency of the Department of Fisheries, Wildlife & Environmental Law Enforcement
<http://www.state.ma.us/dfwele/dfw>

APPENDIX B

DESIGNATION OF PORTIONS OF THE TOWNS OF

COHASSET, HINGHAM, AND HULL

AS THE

WEIR RIVER AREA OF CRITICAL ENVIRONMENTAL CONCERN

WITH SUPPORTING FINDINGS

Following an extensive formal review required by the regulations of the Massachusetts Coastal Zone Management program (301 CMR 20.00) and the Massachusetts Environmental Policy Act (310 CHR 10.00) including nomination review, research, meetings, and evaluation of all public comments, I, the Secretary of Environmental Affairs, hereby designate portions of the Towns of Cohasset, Hingham, and Hull and portions of the Weir River estuary adjacent to these Towns as an Area of Critical Environmental Concern (ACEC). I take this action pursuant to the authority granted me under Massachusetts General Law c. 21A, § 2(7).

I also hereby find that the coastal wetland resource areas included in the Weir River ACEC are significant to flood control, the prevention of storm damage, the protection of land containing shellfish, and fisheries; public interests defined in the Wetlands Protection Act (MGL c. 131, § 40; 310 CMR 10.00).

I. Boundary of the Weir River ACEC

Upon review of the boundaries as recommended in the nomination letter and subsequent recommendations made in testimony received, the final boundaries generally include the Weir River estuary for its entire length including Straits Pond in Hull and Cohasset. The landward boundary, in large part, is the 100 year flood elevation as delineated by the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps and Floodway Maps. However, in certain specific locations described herein, the landward boundary may change to the mean high water (MHW) line or other artificial boundaries and excluded areas. A larger scale boundary map is on file at the CZM Office at 100 Cambridge Street, Boston, MA.

Specifically, the boundary is defined as follows: The area includes the Weir River beginning at its mouth where it empties into Hingham Bay. The closure line runs between the northern-most point of the World's End Reservation in Hingham and Sunset Point in Hull. From Sunset Point, the line follows the shore at the MHW line east and southeast to a point on the shore at the "private way" listed on the Town of Hull Assessor's Map, Sheet 33 dated December, 1939, 1"=100', which is an extension of Porrazzo (formerly Summit) Street. From this point, the boundary follows the shoreline at the 100 year flood elevation, including the portions of Hampton Hill below this elevation, to the southeasterly corner of Lot 126, Subdivision Lot 5) Sheet 34, Town of Hull Assessor's Map dated December, 1939, 1"=100', adjacent to Bay Street. From this point the boundary follows the MHW line to the southwesterly corner of Subdivision Lot 1, Town of Hull Assessor's Map dated December, 1939, 1"=100', listed as 'Town of Hull'.

From this point, the boundary defines the excluded area surrounding Nantasket Pier. The boundary follows a line, originating from the last point of reference, which is 100' seaward from the ~IHW line. At a point 150' from the northerly side of the pier, the boundary turns southwesterly and follows the outline of the pier at a distance of 150'. This line continues until it reaches a point where it is 150' from the pier and 100' from MH~ where it turns southwesterly and follows the MHW line at a distance of 100' for 150'. At this point, the line moves in a perpendicular direction shoreward to the ~IHW.

The boundary follows the revetment along George Washington Boulevard (GWB) until it reaches a point 300' from a line extended from the northerly side of Rockaway Street to the water's edge, across GWB. From this point, the boundary follows the thread of the shore at the 100 year flood elevation until it reaches the southerly lot line, extending to the water, of Subdivision Lot 53, Sheet 45, Town of Hull Assessor's Map dated March, 1950, 1"=100', listed as "public landing" at the southerly end of Onset Street. The boundary follows the shore from this point at the MHW line until it reaches the southerly lot line) extending to the water, of Subdivision Lot 3, Sheet 45, Town of Hull Assessor's Map dated March, 1950, 1"=100', listed as 'tpublic landing't and adjacent to the confluence of Orleans, Barnstable, and North Truro Streets. The boundary follows, from this point, the thread of the shore at the 100 year flood elevation in a southerly and easterly direction and includes all lands below this elevation. The line extends easterly to a point on Atlantic Avenue in Hull where Straits Pond is directly adjacent, this point defined as the northerly corner of Subdivision Lot 8, Sheet 51, Town of Hull Assessor's map dated June 2, 1944, 1"=100', where the boundary again reverts to MHW. The line extends around Straits Pond at this elevation until it reaches a point, on the Cohasset-Hull line in an area known as West Corner, where Nantasket Avenue crosses the river, at or adjacent to intersection of Nantasket Avenue and Rockland Street. At this point, the boundary reverts to the 100 year flood elevation and proceeds southerly and westerly along and under Rockland Street to the dam and fish ladder at Foundry Pond. The line follows the westerly side of the floodway along the 100 year flood elevation north and west to a point in Hingham Harbor in an area known as Martin's Well where the boundary is defined as the MHW line on the Hingham Harbor shore. At this point, the boundary reverts to the 100 year flood elevation as it proceeds north and east until it reaches the isthmus connecting Planter's Hill and World's End, where it again follows the MHW line on the Hingham Harbor shore. Upon reaching World's End, the line moves east and north around the shore of World's End until it reaches the northern-most tip, from whence the closure line began.

II. Designation of the Resources of the Weir River ACEC

In my letter of acceptance of the nomination of the Weir River as an ACEC, I indicated that our evaluation indicated that it easily met the minimal threshold for consideration. The nomination letter clearly lists the quantity and quality of the resources present.

The presence of these resources, and their relatively undisturbed nature, clearly indicate their value to the region and the state.

III. Procedures Leading to ACEC Designation

On 5 March, 1986, a letter of nomination, signed by ten citizens of the Commonwealth and pursuant to 301 CMR 20.06:15(a), was received by my office. After additional information³ which was requested 9 April, 1986, was received, the nomination was formally accepted by letter on 10 July, 1986, and the review process was begun.

Notice of the acceptance of the nomination and of an informational meeting and a public hearing was published in the Boston Globe and Patriot Ledger on 9 September, 1986, and in the Massachusetts Environmental Monitor on 10 September, 1986. Numerous informational articles appeared in the local and regional newspapers and several programs were aired on the local cable television station.

A meeting for town officials was held on 21 August, 1986, and an informational meeting for the general public followed on 18 September, 1986. The public hearing was held on 16 October, 1986, and the public comment period was held open until 1 November, 1986. Written and oral testimony was received from 20 individuals and organizations and is on file at the CZM office.

IV. Discussion of Factors Specified in Sections 6.46 of the CZM Program Regulations and 10.17(6) of the MEPA Regulations

In the review process leading to the decision on a nominated area, the Secretary must consider the factors specified in Section 6.48 of the CZM Program regulations and Section 10.17(6) of the MEPA regulations. As stated in these regulations, the factors need not be weighed equally, nor must all of these factors be present for an area to be designated. While the more factors an area contains the more likely its designation, the strong presence of even a single factor may be sufficient for designation.

Based on the information in the nomination letter, presented at the public hearing, and through written comments, and on the research of my staff, I find the following factors relevant to the designated ACEC:

Quality of the Natural Characteristics

The Weir River estuary, situated landward of the barrier beaches of the Hull peninsula, contains one of the most extensive salt marsh systems in the greater Boston metropolitan area. This approximately 100 acres of marsh, while perhaps significant for its size alone, is important in providing a rather large tract of relatively undisturbed marshland wildlife habitat. Home to over 100 migratory and indigenous bird species, as well as numerous species of small mammals, this large an area so close to a population center is, to say the least, uncommon. The estuary itself supports an active anadromous fish run and a significant shellfish resource, including both soft shell clams and mussels.

Productivity

The high productivity of estuarine salt marsh ecosystems has been well documented in the scientific literature. The plant growth within the marsh is exported by the tides and ultimately incorporated into the marine food web. The protected, shallow waters of the estuary act to a nursery to shellfish and finfish. In addition to the alewife run, the estuary provides an appro-

prate environment for significant year-round and seasonal populations of blueback herring, smelt, eel, bluefish, striped bass, and flounder. The diverse benthic population supported by the marshes and estuary is also extremely important as a food source for migratory waterfowl.

Uniqueness of the Area

Given its close proximity to a major metropolitan center with a population in excess of one million, this relatively undisturbed estuary -- and marsh complex is indeed unique. Much like the Back River ACEC nearby, this relatively large tract of marshland habitat, situated in an area subject to intense development pressure, provides the resource base necessary to maintain the diversity and productivity of an ecosystem which must, despite stringent regulation, accommodate the cumulative impacts arising from this development. While there may be smaller parcels of marshland which dot the urban landscape, the inventory of larger marshes capable of supporting these vital resources is dwindling.

Irreversibility of Impact

Changes in the salinity regime of estuaries may eliminate or substantially alter the broad mixing zone important as a nursery for juvenile fishes and shellfish. Both coastal development, which changes the runoff characteristics of the adjacent upland, and dredging of channels within the marsh, which may lead to overdrainage of watersheds, saltwater intrusion into groundwater, and disrupt nutrient inputs, can act to irreversibly alter estuarine ecosystems such as the Weir River.

Threats to Public Health through Inappropriate Use

The potential for increased runoff, which carries with it increased loadings of suspended sediment, heavy metals, hydrocarbons, and bacterial and viral contaminants, will add additional environmental stress to shellfish beds which have already shown the effects of this development. The cumulative effects of this alteration to the adjacent uplands, effects not currently taken into consideration in the state's regulatory process, may act to preclude any possibility of recovery of this once economically valuable resource.

Imminence of Threat to Resources

Despite laws and regulations to the contrary, construction on the fringes of marshes and waterways can result in incremental filling over time. This is especially true in the Weir River basin when both the Town of Hull sanitary landfill and, more recently, a private developer have been cited for just such a violation of the Wetlands Protection Act.

The intensity of development, especially within the Town of Hull, is ever increasing in the vicinity of the Weir River estuary. Written comments in support of testimony provided at the public hearing reported submissions to the municipal planning agencies of the Town of Hull for approximately 1000 new housing units and 56,000 square feet of commercial space, all within the Weir River watershed. Given the existing intensity of development in the area, the chronic and cumulative impacts associated with this proposed development activity may exceed the system's capacity to accommodate its effects.

It is hoped that this designation will serve to focus attention on the value and sensitivity of the area and will provide a guide for future development proposals.

Economic Benefits

Within the context of the metropolitan Boston area, Cohasset, Hingham, and Hull are "bedroom communities", so-called because those that work in downtown Boston chose to live in these suburban areas. These people chose to live here because of the "quality of life" provided, wishing to live in a more natural and unspoiled setting than the city can provide. As the economic base of these communities is services to the area's residents, any alteration of the area that results in a decrease in its productivity, attractiveness, and use carries with it a potential for adverse economic impact.

Supporting Factors

There has been virtually unanimous agreement on the appropriateness of the designation among local residents, environmental groups, and Boards and Commissions from the affected towns. There has also been support from State Legislators. It is therefore my strong feeling that the Weir River estuary is very appropriate for designation as an Area of Critical Environmental Concern.

James S. Hoyt
Honorable Secretary of Environmental Affairs
Executive Office of Environmental Affairs
100 Cambridge Street

Boston, Ma. 02202

Dear Sirs

We, the undersigned citizens of the towns of Massachusetts do hereby nominate the Weir River Estuary and certain adjacent watershed areas and buffer zones for designation as an Area of Critical Environmental Concern (ACEC) under the regulations of the Massachusetts Coastal Zone Management program and the regulations of the Massachusetts Environmental Policy Act. Accompanying this request is a summary of information regarding the proposed areas resources which we feel not only fulfill the minimum eligibility requirements but far exceed these requirements. Also included is a description of the proposed areas boundaries and a summary of the advantages of such a designation. The Weir River Estuary has long been recognized by both communities as a truly beautiful, valuable and unique resource. We hope you will review this nomination favorably. Thank you for your consideration.

Sincerely:

Honorable Secretary of Environmental Affairs
Re: Nomination of the Weir River Estuary as an ACEC
February 28, 1986

Proposed ACEC Boundaries

The proposed area generally includes the Weir River Estuary for the entire length of the Weir River and including Straits Pond in Hull and Foundry Pond and Triphammer Pond in Hingham, both of which include fish ladders. Specifically excluded from this proposal is the area known as Nantasket Pier and Nantasket Bay in the town of Hull.

Specifically:

The proposed area includes the Weir River beginning at its mouth where it empties into Hingham Bay between the northern most point of the Worlds End Reservation in Hingham and Sunset Point in Hull approximately 42 16'30'' - 70 52'50'' and moving east, south and east following the thread of the river, bounded by the Worlds End Reservation on the rivers west side and Hull and the Weir River Basin on the rivers east side with the specific exclusion of the area known as Nantasket Pier and Nantasket Bay - continuing south then east following the thread of the river under the Weir River Bridge bounded by Hingham on the south and Hull on the North and continuing to include all of Straits Pond in Hull and Foundry Pond and Triphammer Pond in Hingham. The area proposed for designation would include the river estuary and its banks, salt marsh and salt meadow up to the 100 year flood elevation.

Resources required for eligibility

Listed below is a summary of the areas resources which we feel meet and exceed those requirements for designation as an ACEC as set forth in regulation 6.44 of the CZM program.

1. Significant scenic site

On the west side of the Weir River and forming a portion of the proposed boundary of this ACEC request is the Worlds End Reservation in Hingham. Worlds End is one of the most stunning examples of the work and artistry of Americas greatest landscape architect, Frederick Law Olmsted. In 1890 Olmsted created a masterpiece of landscape design from three glacial drumlins, cedar swamp, marsh and magnificent rocky outcrops. In 1967 Worlds End was threatened by development. In an extraordinary effort the Trustees of Reservations raised over 450,000 dollars from public subscription on the south shore and throughout the commonwealth to purchase the property and preserve its magnificent landscape.

2. Historic Sites

The Weir River was the source of raw materials for one of the first industries in the New World. Colonial settlers gathered bog ore from the swamp lands in the Weir River watershed and shipped them 10 miles north to the iron works in Saugus. This bog ore or "gabbo" was very crude but was transformed into nails, tools and iron implements which were crucial to the survival of the embryonic settlements in the colonies. When more abundant sources of bog ore were discovered closer to Saugus and the effort of shipping ceased to be profitable~ local people dammed the river and opened their own foundries next to the source. Remnants of the colonial dam and fish ladder remain. Reportedly there are slag heaps and colonial foundations buried in the undergrowth nearby. There is also a spot called "ring bolt rock" where tackle was rigged to drag boats through a treacherous gap and up to the calmer headwaters of the Weir River. The federal government and the National Park Service saw fit to enshrine the Saugus Iron Works as a national historic park and restore it to working order as an example of one of the first manufacturing industries in this country. The state should afford similar recognition to the tangible remnants of the first source of mineral resources in the country.

3. Anadromous/Catadromous Fish Runs

The Weir River supports strong runs of several species vital in the food chain and the overall ecosystem of the estuary. Included is an alewife run leading to Foundry Pond and Triphammer Pond in Hingham. Fish ladders have been constructed at both sites through the efforts of the Hingham Conservation Commission. The modern version at Foundry Pond stands close to the remains of an ancient stone fish ladder suggesting a long standing concern for the smelt and blue back herring which are indigenous to the Weir River. In addition, virtually the entire river estuary serves as a breeding area for blue back herring, smelt and eel. In season, bluefish, striped bass and flounder are found in large numbers. The Mass. Division of Marine Fisheries stocks the river yearly with trout above Foundry Pond. In addition to comprising a significant portion of the food chain these resources have also formed a substantial recreational fishery in both Hull and Hingham and

are sold in local restaurants and markets.

4. Shellfish Beds

Throughout the area nominated there is an abundance of shellfish beds of both softshell clams and mussels. In particular there are rich beds below the confluence of the fresh water of the Weir and ledge area of Worlds End Reservation as well as the mud flats below Sagamore Hill in Hull. The mussel beds are extremely prolific and have been a traditional food source for both local and migratory bird populations to include Herons, Egrets, Mergansers, Teal, Canadian Geese⁹ Eiders, Bufflehead, Mallards, Marsh Ducks, Scaup, Goldeneye and Gulls. The softshell clam industry was a staple in the early economy and diet of both communities. Although the harvesting of shellfish was banned for several years due to the effects of pollution and contamination, efforts to improve the overall quality of the environment through the construction of sewerage treatment facilities and stricter environmental controls have resulted in a much improved quality and a resurgence in this industry. The prolific shellfish beds in the proposed ACEC provide a significant future economic and food resource.

5. Significant Wildlife Habitat

The area proposed is truly unique as a significant habitat for a wide variety of wildlife in so natural a setting and within ten miles of a major metropolitan center as Boston. Among the mammal species indigenous to the area are: Fox, racoon, muskrat, opossums and harbor seals. Additionally, the Massachusetts Audubon Society lists over a hundred species that either breed in the area or feed and rest during annual migrations. Among the species to breed in the area are Blue Heron, Snowy Egret, Marsh Ducks, Black Ducks, Mallards, Scaup, Merganser, Teal, and Red-tailed Hawks.

6. Flood Plain

Most of the area proposed for this designation lies within the flood plains for both the towns of Hull and Hingham and is subject to the rising waters of coastal storms or fresh water inundation. As was evidenced by the blizzard of 1978 and on many other occasions in history, these floodplains are of the utmost importance to protect the communities from the ravages of flood and any development in these areas must come under the closest scrutiny.

7. Coastal Estuary and Embayments

Within the area proposed for consideration is the definitive example of an estuary. The Weir River is a coastal river, part river basin and part sea which is comprised of shallow bays, salt marsh and salt meadow, lagoons, shellfish beds, and the mingling of salt and fresh water. This intertidal area is rich and abundant in marine resources and a vital link in our food chain.

8. Salt Meadow

Included in the nominated area are over 50 acres of salt meadow. This soil is waterlogged through most of the growing season. Vegetation is predominately grasses, rushes and sledges.

Resources required for eligibility

9. Salt Marsh

There are over 100 acres of salt marsh included in the area proposed for designation. In addition to reducing pollution levels in the estuary by trapping and organically binding solids, these marshes provide plant material on which the entire marine food web is dependent. Included in the vegetation prevalent in the marsh is duckweed, watershields, water lillies, bulrushes, cattails and arrowhead.

10. Coastal or recreational beaches

There are several public recreational beaches within the area proposed for designation as an ACEC. These beaches are serviced by the town of Hull, have direct access to the Weir River and serve the public.

Re: Nomination of the Weir River Estuary as an ACEC. February 28, 1986

Advantages of designation of the Weir River Estuary as an ACEC.

Those of us who have joined in this request to have the Weir River Estuary designated an Area of Critical Environmental Concern are motivated not so much by a sentimentality for nature as by a desire to serve human needs. We feel the advantages of such a designation are enormous, especially at this juncture in history when the towns of Hull and Hingham are experiencing major development, much of which is directly adjacent to the Weir River.. The protection of this great resource transcends purely local concern. We must consider the irreversibility of the impact of uncontrolled development as well as the public health threat. We believe the designation is necessary to minimize adverse effects on marine productivity and habitat, wildlife, water quality, flood control and areas of historical significance. We must avoid damage to this outstanding resource and in fact have a responsibility to protect this area for future generations, not only for the people of Hull and Hingham but for all the citizens of the commonwealth. In addition, we believe the designation will foster a greater public awareness of the Weir River Estuary and its abundance of natural beauty and resources.

February 28, 1986

APPENDIX C - WORLD'S END RARE SPECIES

From: Trustees of the Reservation (2001)

Fish and Shellfish:

Nothing is known about fish or shellfish at this time although schools of small fish have been observed in Damde Meadows but the species has not been identified. However, many species undoubtedly occur in the waters and flats that surround World's End. Anadromous fish (i.e. rainbow smelt and alewife) still migrate past World's End through the Weir River estuary (Hurley 2000). [Note: the New England Aquarium has received a grant from the National Park Service to inventory all the intertidal species within the BHI NPS Area. A potential list of 1,000 species has been developed. The results of this effort will add greatly to the intertidal knowledge at World's End]

Rare Species

Showy goldenrod, *Solidago speciosa* (WL):

Showy goldenrod grows in abundance on the outer drumlins. This watch-listed species is a very large and robust goldenrod. The flowers are among the largest for goldenrods and tend to bloom later in the year than most other goldenrods. As a result, these flowers attract concentrations of insects at World's End including migrating monarch butterflies during September.

There are 10 - 11 current documented sites for this species in Massachusetts (P. Somers personal communication). The species ranges from Berkshire Co. east to Worcester Co. with some sites in Bristol Co. The species may prefer neutral soils and its distribution at World's End may indicate more neutral pH soil conditions for the outer drumlins. Soil testing is needed to confirm soil pH. The World's End site supports an excellent population of this species. Although the species occurred historically throughout eastern Massachusetts, the World's End population represents the only extant population in the greater Boston area. The closest populations occur in Worcester Co. to the west and southern Bristol Co. to the south.



Figure #: Showy goldenrod at World's End.
Notice the many bumblebees gathering pollen.

Hickory Hairstreak, *Satyrrium caryaevorum* (WL):

The Hickory Hairstreak is rarely reported anywhere in the state, though its food plants are common (B. Cassie personal communication). The caterpillar of this butterfly feeds on hickories, especially bitternut hickory (*C. cordiformis*), (Glasberg 1999). Hickories, including bitternut are common at World's End. Bitternut hickory is especially common as an understory tree in several forested areas adjacent to fields. These areas typically have a Norway maple overstory. The hickory hairstreak prefers open fields adjacent to deciduous woods and is apparently uncommon throughout its range. Selectively

removing Norway maples may benefit the hickory hairstreak by releasing understory bitternut hickories into the canopy.

Eastern Bluebird, *Sialia sialis* (WL):

This species suffered dramatic declines in the past due to competition from exotic species (i.e. starlings and house sparrows) and widespread use of pesticides but has been increasing since the mid-1980s (Viet et al. 1993). Bluebirds require open fields and woodlands for feeding. Historically these birds used natural tree cavities but more recently they rely on nesting boxes maintained by humans. Thanks to an aggressive nesting box program at World's End, at least 5 pairs of eastern bluebirds nested at World's End in 2000 but more are suspected to nest in the many natural cavities (R. Rogers personal communication). Some bluebirds overwinter here in Massachusetts feeding on berries, especially sumac and dogwood, species common at World's End. Bluebirds can frequently be seen along the many treed avenues throughout World's End year round.

Uncommon or Decreasing Species

Bobolink:

This conspicuous bird of grasslands is a long distance migrant. Bobolinks migrate north in the spring from wintering areas in South America, mainly Argentina. This species, formerly abundant, has declined greatly due to development and reforestation of agricultural lands since the early 1900's (Veit and Petersen 1993). These birds like taller and dense grasslands thus their preference for hay fields in Massachusetts (Ells 95, Jones and Vickery 95 BO). Unfortunately this preference for hay fields makes them vulnerable to early mowing of fields which destroys nests and young (Ells 95).

As a result bobolinks are increasingly uncommon breeders in the remaining fields throughout the northeast. Fortunately this species, unlike most other grassland birds, will breed in grasslands as small as 5 acres (Jones and Vickery). In 2000 15 bobolinks were observed breeding in the fields at World's End (Deegan, 2000). The bobolinks at World's End are among the few breeding in the Boston area and southeastern Massachusetts. Historically bobolinks nested at nearby Turkey Hill and Weir River Farm. However, surveys indicate that since 2000 bobolinks no longer nest at these locations. It is hoped that ongoing grassland restoration efforts will reestablish this species as a breeder on Turkey Hill.



Figure #: Male bobolink

Eastern Meadowlark:

This species should probably be listed as a rare species in Massachusetts. Recent grassland bird surveys for the northeast suggest meadowlarks are one of the fastest declining species with only 2 sites in all of New England and New York supporting more

APPENDIX D - WORLD'S END BIRDS

Using the Checklist

The following keys have been designed by Massachusetts Audubon to apply to their sanctuaries. However, with a minor adjustment, this checklist will use the same keys to apply to the World's End Reservation.

Principal Habitat

Birds may be found almost anywhere, but this key indicates the habitat(s) in which each species is most often encountered. The habitats found at World's End are indicated in boldface.

- A. Aerial (in flight: overhead)
- O. Ocean, Harbor
- B. Beach/Tidal Flats
- S. Salt/Brackish Coastal Marsh
- P. Pond, Lake, Stream, River
- M. Freshwater Marsh, Bog, Swamp
- G. Grassland (Fields, Meadows, Pastures)
- H. Hedgerows, Thickets, Brushy Fields, Forest Edge
- F. Forest
- U. Urban
- X. Anywhere

Seasonality

Because many birds occur in particular localities only at certain times of the year, seasonality can be an aid to identification. For the purposes of this list, the seasons have been defined as follows:

Sp = SPRING = (March 1 - May 31)

Su = SUMMER = (June 1 - Aug. 15)

F = FALL = (Aug. 16 - Nov. 30)

W = WINTER = (Dec. 1 - Feb. 28)

Observability

Birds often appear to be more common or less common than they really are. This key does not necessarily reflect true abundance; rather, it indicates the likelihood of encountering each species in its appropriate habitat. An "h" indicates a species that is more often heard than seen.

A = ABUNDANT = always recorded (100%)

C = COMMON = usually recorded (75%)

U = UNCOMMON = sometimes recorded (50%)

O = OCCASIONAL = seldom recorded (25%)

R = RARE = recorded less than annually

Species that breed on the sanctuary are in boldface.

An "s" indicates species that breed on Sarah or nearby islands.

a checklist of WORLD'S END BIRDS



Observed by _____

Total Number of Birds Checked _____ Year _____

Name of Species	✓	Sp	Su	F	W	Habitat	Name of Species	✓	Sp	Su	F	W	Habitat
Red-throated Loon		R	R		O		Lesser Scaup		U	U	C		
Common Loon		U	U	U	O		Common Eider		R		C	O	
Pied-billed Grebe		R	R		P		King Eider		R		R	O	
Horned Grebe		O	O	U	O		Oldsquaw		R		R	R	O
Red-necked Grebe		R	R		O		Black Scoter		R		R	R	O
Great Cormorant		R	R	C	A		Surf Scoter		R		R	R	O
Double-crested Cormorant ¹		C	C	C	A, O, P		White-winged Scoter		R		R	C	O
American Bittern		R	R		P		Common Goldeneye		U	U	C	O	
Great Blue Heron		U	U	U	R	A, B, P	Barrow's Goldeneye		R		R	R	O
Great Egret		U	C	U		A, B, P	Bufflehead		A		C	A	O, M
Snowy Egret ²		C	C	C		A, B, P	Hooded Merganser		O		R		M
Little Blue Heron		O	O	O		A, M	Common Merganser		R		R		M
Tricolored Heron		R	R	R		P, M	Red-breasted Merganser		A		C	A	O, M
Green Heron		C	C	C		A, S, M	Ruddy Duck		R		R		M
Black-crowned Night-Heron ³		A	A	A		B, S, P	Turkey Vulture		O	O	O		A
Yellow-crowned Night-Heron		R	R	R		B, S, P	Osprey		O	O	O		A
Glossy Ibis ³		O	R	R		A, P, M	Bald Eagle		R		R		A
Mute Swan		C	C	C	R	A, P, M	Northern Harrier		O	R	O		A, G
Snow Goose		R	R		A		Sharp-shinned Hawk		U	U	R		A, H, F
Brant		C	U	U	O		Cooper's Hawk		O	O	R		A, H, F
Canada Goose		C	C	C	U	A, O, P	Northern Goshawk		R		R	R	A, F
Wood Duck		R	R	R		A, P	Red-shouldered Hawk		O	O	O	R	A, H, F
Green-winged Teal		U	O		P, M		Broad-winged Hawk		O	O	O		A
American Black Duck		A	A	A	A	O, S, M	Red-tailed Hawk		C	C	C	C	A, H, F
Mallard		A	A	A	C	O, S, M	Rough-legged Hawk		O		O	R	A, G
Northern Pintail		O	O		P		American Kestrel		C	U	C		A, F, H
Blue-winged Teal		O	O		P		Merlin		O	O			A, G, H
Northern Shoveler		R	R		P		Peregrine Falcon		O	O			A, G, H
Gadwall		O	O		P		Ring-necked Pheasant ^h		R	R	R	R	G, H
American Wigeon		R	R		P		Ruffed Grouse ^h		O	O	O	O	G, H
Ring-necked Duck		O	O		P		Northern Bobwhite ^h		U	U	U	O	G, H
Greater Scaup		U	U	C	O		Black-bellied Plover		U	U			B

Name of Species	✓	Sp	Ss	F	W	Habitat	Name of Species	✓	Sp	Ss	F	W	Habitat
Northern Mockingbird		C	C	C	O	H,F	Northern Cardinal		C	C	C	C	H,F
Brown Thrasher		O	O	O		H,F	Rose-breasted Grosbeak		O	O	O		H,F
Cedar Waxwing		U	U	U	O	A,H,F	Blue Grosbeak		R		R		H
Northern Shrike					R	G,H	Indigo Bunting		O	O	O		G,H
European Starling		A	A	A	C	X	Dickcissel		R		R		G
White-eyed Vireo		R		R		H,F	Eastern Towhee ^b		U	O	O	R	H
Solitary Vireo		O		O		F	American Tree Sparrow					U	H
Yellow-throated Vireo		R		R		F	Chipping Sparrow		U	U	U		H
Warbling Vireo		C	C	C		H,F	Field Sparrow		O	O	O		G,H
Philadelphia Vireo					R	H,F	Savannah Sparrow		U	O	U		G,H
Red-eyed Vireo		O	O	O		H,F	Fox Sparrow		R		R		H
Blue-winged Warbler		O	R	R		H	Song Sparrow		C	C	C		H
Tennessee Warbler		O		O		H,F	Lincoln's Sparrow		R		R		H
Nashville Warbler		U		U		H,F	Swamp Sparrow		U	U	U	R	P,M
Northern Parula		U		U		H,F	White-throated Sparrow		U		U	U	H,F
Yellow Warbler		C	C	C		H	White-crowned Sparrow		R		R		H,F
Chestnut-sided Warbler		O		O		H	Dark-eyed Junco		U		U	C	H
Magnolia Warbler		U		U		H	Snow Bunting					R	G
Cape May Warbler		R		O		H,F	Bobolink		U	U	O		G
Black-throated Blue Warbler		U		U		H,F	Red-winged Blackbird		A	A	A	O	P,M,G
Yellow-rumped Warbler		C		C	R	H,F	Eastern Meadowlark		U	U	O	R	G
Black-throated Green Warbler		U		U		H,F	Rusty Blackbird		R		R		G
Blackburnian Warbler		O		O		H,F	Common Grackle		A	A	A	O	X
Pine Warbler		O		O		H,F	Brown-headed Cowbird		C	C	U	R	H
Prairie Warbler		U		U		H	Orchard Oriole		C	C	C		H,F
Palm Warbler		U		U		H,F	Baltimore Oriole		C	C	C		H,F
Bay-breasted Warbler		O		U		H,F	Purple Finch		R		R	R	H,F
Blackpoll Warbler		U		U		H,F	House Finch		C	C	C	O	H,F
Black-and-white Warbler		U		U		H,F	Common Redpoll		R		R		H
American Redstart		U	O	U		H,F	Pine Siskin		R		R	R	H
Ovenbird		O		O		F	American Goldfinch		C	C	C	O	G,H
Northern Waterthrush		O		O		F	Evening Grosbeak					R	H,F
Louisiana Waterthrush		R		R		F	House Sparrow		C	C	C	C	H
Mourning Warbler		R		R		H							
Common Yellowthroat ^b		C	C	C	R	G,H							
Hooded Warbler		R		R		H,F							
Wilson's Warbler		O		O		H,F							
Canada Warbler		O		O		H,F							
Yellow-breasted Chat		R		R		H							
Scarlet Tanager		O	R	O		F							6/96

Name of Species	✓	Sp	Su	F	W	Habitat	Name of Species	✓	Sp	Su	F	W	Habitat
Semipalmated Plover		U	U			B.M	Red-bellied Woodpecker		R	R	R		F
Killdeer		O	O	O		A,B	Yellow-bellied Sapsucker		O	O			F
Greater Yellowlegs		C	C			B.M	Downy Woodpecker		A	A	A	A	M,H,F
Lesser Yellowlegs		C	C			B.M	Hairy Woodpecker		O	O	O	R	F
Solitary Sandpiper		O	U			M	Northern Flicker		A	A	A	R	G,H,F
Spotted Sandpiper		U	U			M	Pileated Woodpecker		R		R		F
Ruddy Turnstone		R	R			B	Olive-sided Flycatcher		O				H
Semipalmated Sandpiper		O	C			B.M	Eastern Wood-Pewee ^h		U	C	U		H,F
Least Sandpiper		O	C			B.M	Yellow-bellied Flycatcher		R		R		H
Pectoral Sandpiper		R	R			B.M	Alder Flycatcher		R		R		H
Short-billed Dowitcher			R			B.M	Willow Flycatcher		R	R			H
Long-billed Dowitcher			U			B.M	Least Flycatcher		O				H
Common Snipe		R	R			M	Eastern Phoebe		C	U	C		H
American Woodcock ^h		C	O	O		A,G,H	Great Crested Flycatcher ^h		C	C	U		F
Laughing Gull		O	C	U		A,B	Eastern Kingbird		A	A	A		G,H
Bonaparte's Gull			C			A,B	Tree Swallow		A	A	C		A,G
Ring-billed Gull ^h		A	A	A	A	A,O,B	N. Rough-winged Swallow		C	C	U		A,G
Herring Gull ^h		A	A	A	A	A,O,B	Bank Swallow		R	R	R		A,G
Iceland Gull				R		A,O,B	Barn Swallow		C	O	C		A,G
Glaucous Gull				R		A,O,B	Blue Jay		C	C	C	C	A,F,G
Great Black-backed Gull ^h		A	A	A	A	A,O,B	American Crow		A	A	A	C	X
Caspian Tern		R	R			A,O,B	Fish Crow ^h		O	R	R	O	A,F
Common Tern ^h		C	C	C		A,O,B	Black-capped Chickadee		A	A	A	A	H,F
Forster's Tern			R			A,O,B	Tufted Titmouse		C	C	C	C	H,F
Least Tern ^h		O	O	O		A,O,B	Red-breasted Nuthatch		R		R	R	H,F
Rock Dove		O	O	O	O	A	White-breasted Nuthatch		C	C	C	C	H,F
Mourning Dove		A	A	A	C	G,H,F	Brown Creeper		R		R	R	F
Black-billed Cuckoo ^h		O	O	O		H	Carolina Wren ^h		U	O	O	O	H,F
Yellow-billed Cuckoo ^h		O	O	O		H	House Wren ^h		U	U	U		H,F
Eastern Screech-Owl ^h		O	O	O	R	F	Winter Wren		R		R	R	H,F
Great Horned Owl ^h		O	O	O	O	F	Golden-crowned Kinglet		O		O	R	H,F
Snowy Owl				R		A,B	Ruby-crowned Kinglet		O		O		H,F
Barred Owl		R	R	R	R	F	Blue-gray Gnatcatcher		O		O		H,F
Long-eared Owl				R		F	Eastern Bluebird		U	U	U	R	G,H
Northern Saw-whet Owl				R		F	Veery		O		R		F
Common Nighthawk		O	O	O		A	Swainson's Thrush		O		O		F
Chimney Swift		C	C	C		A	Hermit Thrush		O		O		F
Ruby-throated Hummingbird		O	O	O		H	Wood Thrush		U	U	U		F
Belted Kingfisher		C	C	C	R	A,M	American Robin		A	A	A	R	G,H,F
Red-Headed Woodpecker		R	R			F	Gray Catbird		C	C	C	R	H,F

APPENDIX E - WORLD'S END BUTTERFLIES

World's End Butterfly Survey 11/00: Brian Cassie

The following butterflies have been observed at World's End:

Pipevine Swallowtail	Spicebush Swallowtail
Eastern Tiger Swallowtail	Black Swallowtail
Cabbage White	Clouded Sulphur
Orange Sulphur	Eastern Tailed-Blue
Spring Azure	Summer Azure
American Copper	Striped Hairstreak
Banded Hairstreak	Hickory Hairstreak (WL)
Gray Hairstreak	Pearl Crescent
Common Buckeye	American Lady
Painted Lady	Red Admiral
Great Spangled Fritillary	Silver-bordered Fritillary
Variegated Fritillary	Baltimore Checkerspot
Mourning Cloak	Compton Tortoiseshell
Question Mark	Red-spotted Purple
Viceroy	Little Wood Satyr
Common Wood Nymph	Common Ringlet
Monarch	Silver-spotted Skipper
Northern Cloudywing	Juvenal's Duskywing
Wild Indigo Duskywing	Peck's Skipper
Tawny-edged Skipper	European Skipper
Northern Broken-Dash	Sachem
Indian Skipper	Leonard's Skipper
Long Dash	Hobomok Skipper
Delaware Skipper	Dun Skipper

Other butterflies to be expected (probably resident) at World's End include:

Acadian Hairstreak (WL)	Edwards' Hairstreak
Juniper Hairstreak	Eastern Pine Elfin
Brown Elfin	Harvester (WL)
Aphrodite Fritillary	Eastern Comma
Eyed Brown	Appalachian Brown
Northern Pearly-Eye	Southern Cloudywing
Horace's Duskywing	Sleepy Duskywing
Dreamy Duskywing	Common Sootywing
Little Glassywing	Broad-winged Skipper

Possible (intermittently or in very small numbers) at World's End are:

Cloudless Sulphur	Bronze Copper
Southern Hairstreak	Henry's Elfin
Harris' Checkerspot	Hoary Edge
Fiery Skipper	Black Dash
Mulberry Wing	Dusted Skipper

Of the species observed thus far, five have occurred at World's End as Massachusetts record single-day, single-locality counts; namely, Pearl

Crescent (1600), Little Wood Satyr (7300), Common Ringlet (3000), Long Dash (195), and Hobomok Skipper (30) - all in June, in the meadows and/or along meadow edges.

The Pipevine Swallowtail is generally rare in Massachusetts, as its food plant does not grow here in the wild. The Hickory Hairstreak is rarely reported anywhere in the state, though its food plants are common. The Variegated Fritillary is an uncommon to rare southern immigrant, while the Sachem is a truly rare southern vagrant, for which there are only a handful of records.

Generally speaking, World's End Reservation is most important butterfly-wise for its large upland meadows, which support the grasses and wildflowers that are essential caterpillar food plants and adult nectaring plants for many of the species listed, including whites, sulphurs, coppers, ladies, fritillaries, satyrs, and skippers.