Chapter 3
PROJECT SETTING

For the purposes of this Watershed Plan, the Cape Cod Watershed includes all land on Cape Cod (Barnstable County) except the Massachusetts Military Reservation. No sites were identified within the boundary of the Massachusetts Military Reservation, and this area was excluded from the Project. This is a total of 243,740 acres (380.8 square miles). The Project area includes all or parts of the fifteen communities on Cape Cod.

3.1 REGIONAL IDENTITY

The Cape is a peninsula, reachable by car only by driving over one of the two bridges that cross the Cape Cod Canal. Because the Cape is geographically isolated, residents have a common identity and a strong sense of being separate from the rest of the state. People who live on the Cape recognize their interconnectedness and dependence on one Cape-wide sole source aquifer, and they are willing to work to maintain the strength and value of their common resources. The Barnstable County economy is fairly well-balanced among tourism, light industry, and retail sales, but tourism, with its associated use of natural resources, is vital to the Cape's economic success. Access to clean water, clean beaches, historic and artistic attractions and attractive town centers makes the Cape the attractive place that it is. As water quality in any one part of the Cape deteriorates, the entire region loses.

The Cape's natural environment is very similar to that of other northern Atlantic coastal sites, such as Block Island, Long Island, and coastal regions of New Jersey. It is dominated by pitch pine-jack pine woodlands; has cedar swamps, coastal salt ponds, and the world's largest known quaking bog found on a barrier beach; and is home to globally rare and endangered habitats, such as heath and sandplain grasslands and Atlantic White Cedar swamps. Development takes its toll on these rare habitats, but habitat loss is not a new phenomenon. For example, Atlantic White Cedar swamps only grow in a 100-mile-wide band along the shoreline of the Atlantic and the Gulf of Mexico. They are now globally rare. They were once abundant, but were largely destroyed, along with the rest of Cape Cod's native forests, for lumber and fuel and through the conversion of land to agriculture. The largest cedar swamp remaining on the Cape (11.9 acres) is at Marconi Station in Wellfleet.

3.2 CLIMATE

Winters on Cape Cod are cold, and summers are warm, but the ocean moderates extremes of temperature (USDA 1993). Average daily temperature varies from 29.6°F in January to 70.4°F in July, with an annual average of 49.6°F. Total annual precipitation is approximately 45 inches, and there is an average of 24 inches of snow annually. The climate is humid, and precipitation falls in roughly equal amounts throughout the year.

3.3 AIR QUALITY

Barnstable County is currently designated as a moderate nonattainment area for 8-hour ozone (U.S. EPA 2005). EPA defines nonattainment as an area that "does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant." Cape Cod is also located in the Ozone Transport Region, which consists of the mid-Atlantic and northeastern states extending from northern Virginia to Maine.

3.4 GEOLOGY

Barnstable County was formed during the last continental glacial period and the rise in sea level that followed glaciation (USDA 1993). The moving ice scraped, ground, and picked up the bedrock of southern New England, and deposited it as the glacial and postglacial sediments of Cape Cod. The rock debris, called drift, was carried south by the ice and deposited along the ice front. Later, as the sea drowned these glacial land forms, the drift along the shoreline was eroded and re-deposited as beaches and pits. Windblown sand was deposited as dunes.

Outwash plains are the most common glacial landform. Their downstream ends have all been washed away by marine erosion. The surface of the outwash plains is interrupted by kettle holes that were originally the sites of ice blocks buried by outwash deposits. In some areas these kettle holes are deep enough to expose the water table. Except for cranberry bog reservoirs formed by damming a stream, almost every pond on the Cape is a kettle hole. Water levels in these ponds rise and fall as the water table fluctuates. Some ponds have a defined outlet stream, but very few are stream-fed.

3.5 SOILS

Virtually all soils on Cape Cod (approximately 94 percent) are deep, excessively drained or well-drained sands formed primarily in outwash plains (USDA 1993). In these areas the seasonal high water table is generally greater than six feet below the surface. Low-lying areas of fresh-water wetlands and tidal marshes make up about 6 percent of the land on the Cape.

Soils defined as prime and important farmland occupy 22,456 acres on Cape Cod. Highly erodible cropland occupies 380 acres and potentially highly erodible cropland 789 acres.

3.6 GROUNDWATER

Cape Cod derives its water supply from a sole source aquifer that extends as deep as 400 feet below the ground surface (Cape Cod Commission 1999). The U.S. Environmental Protection Agency (EPA) designated this aquifer as a sole source aquifer, which means that it supplies 50 percent of the drinking water consumed in Cape Cod and has limited federal protection. Any activities that have the potential to contaminate the aquifer are subject to EPA review. Current threats to Cape Cod's groundwater include poorly functioning septic tanks, agricultural runoff, and road runoff (Cape Cod Commission 1999). Groundwater on Cape Cod discharges directly to coastal marshes, bays, and estuaries; excessive nutrients

and bacteria from poorly functioning septic systems, for example, can affect water quality in those receiving waters.

3.7 SURFACE WATERS

Watershed/Hydrology

Cape Cod is located in the Atlantic Coast Pine Barrens ecoregion. It is surrounded by Cape Cod Bay, Buzzards Bay, Nantucket Sound, and the Atlantic Ocean. Surface waters on Cape Cod include small streams, ponds, salt marshes, freshwater marshes, and bogs. Large rivers do not occur on the Cape because watersheds are small, owing to the peninsular landform and highly permeable sandy soils. Cape Cod has 109 miles of stream and nearly 1,000 freshwater ponds, many of which are used for agricultural irrigation and recreation. These ponds, which cumulatively cover nearly 11,000 acres, range in size from less than an acre to 735 acres, with the 21 biggest ponds having nearly half of the total Cape-wide pond acreage (Cape Cod Commission 2006). Floodplains occupy 109,000 acres on Cape Cod.

For the purposes of this Plan-EIS, the Cape Cod Watershed is defined as the land area of Cape Cod except for the Massachusetts Military Reservation. The Cape Cod Watershed, therefore, includes many smaller hydrologic watersheds draining to the tidal waters around the Cape.

Water Use Classification

The state of Massachusetts categorizes all waterbodies under a designated use classification system, which, as a minimum, protects all waters for recreation; aesthetic value; and fish, shellfish, and wildlife protection and propagation. Additional protections are provided by specific use classifications. Designated uses in Cape Cod waters are:

Class A	Public water supply Outstanding resource water	Long Pond, including tributaries and outlet stream
Class B	Public water supply, agricultural irrigation, and industrial cooling and process	All other freshwaters
Class SA	Shellfish harvesting without depuration	Coastal and marine waters—open shellfish areas
Class SB	Shellfish harvesting with depuration	Coastal and marine waters—restricted shellfish areas

Important to the water quality assessment of shellfish areas are the Massachusetts water quality standard for fecal coliform bacteria, which is specific to each designated use class (CMR 2004):

Class A	Fecal coliform bacteria shall not exceed an arithmetic mean of 20 organisms/100 mL in any representative set of samples, nor shall 10 percent of the samples exceed 100 organisms/100 mL.
Class B, Class SA, Class SB (waters not designated for shellfishing)	Fecal coliform bacteria shall not exceed a geometric mean of 200 organisms/100 mL in any representative set of samples, nor shall 10 percent of the samples exceed 400 organisms/100 mL.
Class SA (waters approved for open shellfishing)	Fecal coliform bacteria shall not exceed a geometric mean of 14 organisms/100 mL in any representative set of samples, nor shall 10 percent of the samples exceed 43 organisms/100 mL.
Class SB (waters approved for open shellfishing with depuration)	Fecal coliform bacteria shall not exceed a geometric mean of 88 organisms/100 mL in any representative set of samples, nor shall 10 percent of the samples exceed 260 organisms/100 mL.

In 2006, the state proposed amendments to its water quality standard for fecal coliform; the proposed changes are currently being reviewed by EPA for approval. Key changes to this standard include the use of *E. coli* and *Enterococci* as indicator organisms rather than general fecal coliform class (DEP 2005a).

Water Quality

The Massachusetts Department of Environmental Protection produces a biennial water quality report (the 305(b)/303(d) report, named after sections of the federal Clean Water Act that require states to prepare it) with its assessment of whether the waters of the state are meeting their designated use classifications (DEP 2004a). The state compares water quality and biological data from its waters to the state water quality standards to determine if the designated uses are being met. A water body that does not meet the standards is considered "impaired," and the state must develop a strategy to reduce the total amount ("load") of a pollutant being discharged to that water body in order for it to meet its designated use. This strategy is called a Total Maximum Daily Load or TMDL.

After assessing each state waterbody, the Department of Environmental Protection places it in one of five categories: Category 1—unimpaired and not threatened for all designated uses, Category 2—unimpaired for some uses and not assessed for others, Category 3—insufficient information to make assessments for any uses, Category 4—impaired or threatened for one or more uses but not requiring the calculation of a TMDL, and Category 5—impaired or threatened for one or more uses and requiring a TMDL.

Massachusetts' assessment of waterbodies on Cape Cod in the most recent water quality report (DEP 2004a) indicates that no waterbodies are listed under Category 1 because the Massachusetts Department of Public Health has issued a statewide health advisory for mercury pertaining to the consumption of finfish (primarily largemouth bass and smallmouth bass) in freshwater streams (MA Department of Public Health 2006). Five waterbodies are listed under Category 2 as having attained the uses of shellfishing and

recreation but have not been assessed for other uses: Bassing Harbor, Centerville Harbor, Chatham Harbor, Nauset Harbor, and Red Brook. Twenty-six waterbodies are not assessed (Category 3) due to insufficient information, and two waterbodies are listed under Category 4 as impaired because of the presence of exotic species: Bearse Pond, Long Pond.

There are 80 waterbody segments on Cape Cod classified as Category 5, including 18 ponds (3,710 acres) and 62 stream segments (33 square miles of stream habitat). Appendix C-2 lists the state's assessment of these Category 5 waterbodies. The causes of impairment differ among these streams, but include excessive concentrations of metals, pathogens, nutrients, organic enrichment, turbidity, and noxious aquatic plants. For each pollutant causing impairment in these Category 5 waterbodies, the State must prepare a TMDL that details the State's approach for reducing the pollutant entering the waterbody. To date, the State has prepared:

- Final TMDL for nitrogen in Stage Harbor, Sulphur Springs, Taylors Pond, Bassing Harbor, and Muddy Creek (DEP 2004b),
- Draft TMDL for pathogens for all of Cape Cod (DEP 2005b) and
- Draft TMDL for pathogens in Buzzards Bay (DEP 2005c).

Stormwater runoff is a significant contributor of fecal coliform bacteria to the waters of Cape Cod (DEP 2005b). The Draft TMDL for pathogens in 66 impaired segments on Cape Cod requires load reductions from the following sources:

- stormwater runoff (regulated under EPA's permit program for municipal separate storm sewer systems)
- stormwater runoff (not regulated)
- illicit discharge to storm drains
- leaky sanitary sewer lines
- failing septic systems
- point source discharge from wastewater treatment plants
- sanitary sewer overflows

Portnoy and Allen (2006) suggest that tidal restrictions of salt marshes may create water quality conditions behind the restrictions that favor accumulation and growth of fecal coliform bacteria.

Wastewater

Approximately 85 percent of Cape Cod is serviced by individual septic systems (EOEA 2004). The other 15 percent is served by sewer systems. Falmouth (810,000 gallons per day (gpd) capacity; discharge to groundwater), Chatham (440,000 gpd capacity; effluent is denitrified), Barnstable (4.2 million gpd capacity), and Provincetown (500,000 gpd capacity) have public sewer systems (DEP 2005b).

Stormwater

Most of the towns on Cape Cod are included in EPA's program to control stormwater runoff from urban areas. These towns have been issued a National Pollutant Discharge Elimination System (NPDES) permit for stormwater, which requires each town to develop and implement a stormwater management plan that addresses public outreach/education, public participation/involvement, illicit discharge detection and

elimination, construction site runoff control, post-construction runoff control, pollution prevention, and good housekeeping activities (EOEA 2004). Implementation of these programs will take several years; however, all participating towns covered by NPDES phases are required to fully comply with their permits by 2008.

3.8 AQUATIC LIFE

Fish

The tidal and inland waters of Cape Cod serve as important habitat for anadromous fish, which spend most of their adult lives in salt water and migrate to freshwater streams, rivers, and lakes to reproduce. Anadromous juvenile fish spend varying lengths of time in freshwater before migrating to saltwater, where they mature. The anadromous fish return to spawn by the same route they followed to the ocean as juveniles and return to the same location in which they hatched. Some anadromous fish die after spawning (most salmon species), and others will migrate to freshwater rivers several times in their lives to spawn (WHRC 2005). Anadromous fish species within Cape Cod include American shad (*Alosa sapidissima*), rainbow smelt (*Osmerus mordax*), tomcod (*Microgadus tomcod*), sea run trout (*Salmo salar*), sea lamprey (*Petromyzon marinus*), and river herring, which comprises two closely related members of the family Clupeidae: alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) (Reback *et al.* 2004). Self-supporting runs of Atlantic salmon in the United States persist in eastern Maine, but there are no salmon runs within the Cape Cod Watershed (DMF 2005).

River herring have been the focus of the DMF's restoration efforts on Cape Cod, where there are 41 herring spawning ponds, covering about 5,400 acres. The coastal range of blueback herring extends from Nova Scotia to Florida, and the coastal range of the alewife extends from Labrador to South Carolina. Both species undertake upriver spawning migrations during the spring and are capable of spawning in riverine and lacustrine (lake, pond) environments. Good spawning areas are capable of supporting 1,100 herring per acre. Alewives begin spawning when temperatures reach 51°F, and blueback herring begin spawning when temperatures reach 57°F, typically three to four weeks later than alewives. Both species cease spawning when water temperatures reach 81°F. The freshwater habitat serves as a nursery area for most of the summer. In the fall, juvenile river herring migrate to the ocean to mature. Maturity occurs at three to five years. When mature, the river herring return to their natal streams to spawn. Alewives have the potential to live as long as ten years, and blueback herring live for approximately eight years (Reback *et al.* 2004).

Catadromous fish have the opposite migration pattern of anadromous fish; they spend most of their adult lives in freshwater and migrate to saltwater to spawn. The only catadromous species in the United States is the American eel (*Anguilla rostrata*). American eels spawn in the Sargasso Sea (part of the Atlantic Ocean, located between the West Indies and the Azores) in the spring. Eels typically spend one year at sea before migrating inland all along the United States coast. They then spend 5 to 20 years in freshwater rivers and lakes before returning to the Sargasso Sea to spawn, after which they die (NOAA 2005a).

Overfishing, pollution, water diversion, and habitat degradation have reduced populations of anadromous fish in Massachusetts (Reback *et al.* 2004). Blockage of migration routes by dams and other structures across rivers and streams has eliminated access to large areas of potential spawning habitat. Barriers to migration (e.g., dams and poorly aligned culverts or bridges with an abrupt change in the stream bed elevation) prevent or restrict the movement of anadromous species upstream and downstream and cause

some migratory populations to become landlocked (NOAA 2005a). Fishways, also referred to as fish ladders or fish passes, are structures placed on or around man-made barriers to assist the natural migration of anadromous and catadromous fish. Most fishways enable fish to pass around the barrier by swimming and leaping up a series of low steps into the waters on the other side of the barrier (NOAA 2005a). Over time, however, many of the existing fishways on Cape Cod have deteriorated or failed, eliminating or reducing the ability of the fish to move upstream to spawning or nursery habitats. DMF (2004) estimates that in Massachusetts there are more than 100 active river herring runs and 175 fish passage structures, of which 46 percent are in deteriorated condition and 50 percent function inadequately. DMF identified 93 existing fish passage structures and approximately 43 active river herring runs in Barnstable County

Although dams are one of the most serious factors in declining anadromous fish runs, other habitat factors have also been of concern. These include increased water temperatures and siltation of spawning areas due to the removal of riparian vegetation, siltation caused by sanding of roads in winter, and algal growth on spawning sites due to eutrophication (NOAA 2005a). According to DMF, the spring 2005 spawning season was one of the worst on record. Far fewer numbers of herring, shad, salmon and other species made their way to their spawning grounds than usual.

DMF has the authority within the Commonwealth to provide suitable passage for anadromous fish. DMF created the Anadromous Fish Dynamics and Management Program in 1984 to investigate and manage the anadromous fish resources of the Commonwealth (DMF 2005). DMF emphasizes fishway maintenance, reconstruction, replacement of fishway passage facilities with more advanced design, and stocking fish. DMF's propagation strategy for river herring is to collect adult fish from productive populations just prior to spawning and to transport them to a new potential spawning ground that has been made accessible. To maintain continuity of year classes, DMF typically stocks a single system for four to five years. This technique has been successful for river herring (Reback *et al.* 2004), but has had no success on Cape Cod for American shad and rainbow smelt.

Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act requires that management plans for federally managed fisheries identify as essential fish habitat those areas that are necessary to fish for their basic life functions. The National Marine Fisheries Service, regional Fishery Management Councils, and federal and state agencies work together to identify the essential habitat for each fish species and to develop conservation measures to protect and enhance that habitat (NOAA 2005b). The Act also requires that federal agencies consult with the National Marine Fisheries Service on all federal actions that may adversely affect essential fish habitat. Essential fish habitat is defined as "...those waters and substrate [the underlying bottom] necessary to fish for spawning, breeding, feeding, or growth to maturity" (NOAA 2005b).

The New England Fishery Management Council was created by the Magnuson Stevens Fisheries Conservation and Management Act to manage living marine resources in New England. The Council is responsible for the creation of management plans for fisheries in federal waters off Massachusetts (NOAA 2005b). All tidal waters off Cape Cod could potentially be designated as essential fish habitat for the species listed in Appendix C-3. Areas designated as essential fish habitat can be viewed on the internet site of the National Marine Fisheries Service, <http://www.nero.noaa.gov/hcd/index2a.htm>.

Benthos

Benthic animals live on and within bottom sediments. The benthic community represents an important ecological component in an aquatic system by serving as food for many higher organisms, including finfish, crabs, and some species of waterfowl. Shellfish also serve an important ecological function by filtering the surrounding water and removing sediment, nutrients, algae, and bacteria. Freshwater mussels, an important component of riverine ecosystems, are particularly sensitive to pollution and siltation, which have caused their decline in many streams and rivers.

Most of Cape Cod's shoreline, except areas that are subject to heavy wave action, is potentially rich shellfish habitat. Shellfish species of commercial or recreational value found within the project areas in Cape Cod waters include:

Bay scallop	*Argopecten irradians*
Blue mussel	*Mytilus edulis*
Oyster	*Crassostrea virginica*
Quahog	*Mercenaria mercenaria*
Razor clam	*Siliqua patula*
Sea (surf) clam	*Spisula solidissima*
Soft shelled clam	*Mya arenaria*

The ecological health of shellfish beds depends on successful larval recruitment, optimal sediment types, and preferred salinity ranges. Variations in these factors contribute to natural fluctuations in shellfish populations, both in time and location (WHRC 2005). Shellfish beds are also susceptible to damage from human activities such as physical destruction during construction projects, siltation from excessive sediment loads in runoff, and toxic substances in runoff and wastewaters.

Contamination of shellfish waters by disease-causing organisms poses serious public health risks because shellfish will filter out and accumulate these microscopic organisms. The DMF Shellfish Program protects public health by closing contaminated beds to harvesting when the water quality criteria for Class SA and SB waters are not met. Public health protection is further provided through sanitary classification in accordance with the provisions of the National Shellfish Sanitation Program. DMF assigns sanitary classifications to shellfish growing areas as a result of sanitary surveys that include evaluations of pollution sources that may affect an area, hydrographic and meteorological characteristics, and water quality (DMF 2002). Based on its monitoring of shellfish waters, DMF categorizes shellfish beds as:

- Approved: shellfish beds are open daily throughout the year.
- Conditionally approved: monitoring indicates that microbial pollution standards are not met and the beds are temporarily closed during the year.
- Restricted: shellfish waters could only be harvested if shellfish were subjected to suitable purification processes.
- Conditionally restricted: shellfish beds that meet the criteria for "Restricted" classification except under certain conditions described in the Cape Cod watershed water quality management plan (DEP 2002).
- Prohibited: shellfish beds are closed to harvest for human consumption during anytime of the year

Shellfish managers also temporarily close certain shellfish beds during the winter months to allow them to rebound from active harvesting of the bed. This management strategy maintains the resource for the long-term growth and viability of the shellfish population.

3.9 SALT MARSHES

Salt marshes are widely recognized features on the Cape Cod landscape. These grass-dominated tidal wetlands occupy about 6,800 acres on Cape Cod and are found throughout the Cape's 15 towns. Cape Cod salt marshes are influenced by twice daily tidal inundation. Tidal flooding creates distinct vegetation patterns within these marshes. Marsh areas that are inundated by tidal waters on a daily basis are called low marsh and are dominated by saltwater cordgrass (*Spartina alterniflora*). Marsh areas inundated monthly by spring tides are termed high marsh and are dominated by salt hay grass (*Spartina patens*) and spike grass (*Distichlis spicata*). A transitional area is typically found between salt marshes and the adjacent freshwater wetlands or uplands. Plant species found within this zone typically include switchgrass (*Panicum virgatum*) and invasive common reed or phragmites (*Phragmites australis*) (Cape Cod Commission 2001). Salt marshes on Cape Cod are typically found behind barrier islands, within drowned river valleys, or along the fringe of sheltered coves.

Salt marshes provide habitat for estuarine invertebrates, fish, birds, and mammals (Padgett *et al*. 1998), and they are nursery grounds for several types of commercial fish and shellfish fisheries (Roman *et al*. 2002, Simas *et al*. 2001). Fish species that use salt marshes as nursery areas include mummichog (*Fundulus heteroclitus*), silverside (*Menidia menidia*), menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix)*, and winter flounder (*Pleuronectes americanus*). In addition, salt marsh grasses have been shown to protect shorelines from erosion (Lindau and Hossner 1981), as well as play roles in nutrient cycling and pollution filtration (Niering and Warren 1980). Salt marshes within large watersheds that are in close proximity to urban areas have the potential to be a significant sink for heavy metals such as zinc, copper, and lead, preventing contamination of estuarine waters (Griffin *et al*. 1989).

NRCS created a Science Advisory Committee to advise it on a methodology for determining the functional values of salt marshes in the Cape Cod Watershed. The Committee developed a list of seven functions that are characteristic of Cape Cod salt marshes:

Function	Description
Shoreline stabilization	Salt marshes maintain existing shorelines and prevent erosion due to sea level rise and subsidence
Maintain tidal marsh elevation	Stable marsh elevations support tidal marsh hydrology and vegetation
Nutrient, organic carbon, and sediment flux	Salt marshes import and export nutrients and organic carbon via tidal flushing, deposition, and erosion
Resident and nonresident nekton[1/] utilization	Salt marshes provide habitat for non-migratory fish and shellfish

Function	Description
Bivalve species utilization	Salt marshes provide substrates that support a variety of bivalve species
Bird species utilization	Salt marshes are utilized by resident and migratory birds
Maintain characteristic plant community composition	Salt marshes support a native plant community

[1/] swimming marine animals, such as fish

Despite these functions and their value to the local ecology and economy, salt marshes on Cape Cod have seen extensive declines. Current estimates suggest that 36 percent of the 28,000 acres of salt marsh historically present on Cape Cod has been lost or severely degraded over the past several hundred years, resulting in a loss of the functions and values that these wetlands provide (Tiner *et al*. in press). Marshes that were not completely filled were often altered by construction of roadways and rail beds, ditching for mosquito control, and diking for farmland.

Construction of a roadway across a tidal creek often results in the installation of a culvert to allow tidal exchange between the upstream marsh and the downstream estuary or coastal waterway. Many of the roadways across Cape Cod salt marshes were built with undersized culverts that restrict the inflow of salt water to the marsh and the drainage of fresh water from the marsh. In many cases, these culverts can further restrict a natural tidal regime through complete or partial collapse, sediment clogging, and debris accumulation. The Cape Cod Commission and the Buzzards Bay Project National Estuary Program have identified 182 marshes that have been degraded due to tidal restriction (Cape Cod Commission 2001).

Mosquito ditching has altered many Cape Cod salt marshes by draining the upper reaches. The linearity of mosquito ditching creates unnatural hydrological conditions that accelerate drying of the marsh between tidal flooding events. Cape Cod marshes were often diked to provide farmland, resulting in little or no tidal water entering the marsh system.

Tidal restriction has had a profound effect on Cape Cod salt marshes. Undersized, poorly functioning culverts have caused many salt marshes to experience changes in the vegetative structure, such as a change to a freshwater or brackish wetland type. Many of Cape Cod's restricted marshes have experienced a rapid expansion of phragmites, an invasive species.

Changes in salt marsh vegetation are another result of tidal restriction. Many Cape Cod marshes have experienced changes in vegetative communities due to the ponding of freshwater on the marsh surface, often as a result of inadequate freshwater drainage from the marsh. Vegetation changes often result in unvegetated tidal flats, decreased water quality, and less frequent wildlife usage. Loss of vegetation may also expose deteriorating marsh soils to increased erosion and subsidence, resulting in persistent open water.

Tidal restriction has decreased the water quality of the marshes themselves and of Cape Cod's estuaries. Poor tidal exchange, combined with excessive nutrient inputs, results in eutrophic conditions within many of Cape Cod's coastal bays and fringing marshes (Cape Cod Commission 2000). Extensive stands of

phragmites slow water movement and contribute large amounts of organic matter to water bodies, which can contribute to decreased dissolved oxygen concentrations.

Cape Cod's tidally restricted salt marshes experience less wildlife usage than unrestricted marshes (Cape Cod Commission 2000). Undersized and poorly functioning culverts limit fish passage into salt marshes. As mentioned earlier, tidal restriction promotes the expansion of phragmites stands. Marshes dominated by phragmites have lower habitat quality than salt marshes for a variety of wildlife (Gulf of Maine Council on the Marine Environment 2005). Monotypic stands of phragmites provide little foraging habitat for birds.

3.10 THREATENED AND ENDANGERED SPECIES

The federal Endangered Species Act of 1973 protects plant and animal species considered to be in danger of extinction and their habitats. An endangered species is defined as any species that is in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range (USFWS 2005). The Fish and Wildlife Coordination Act also includes provisions for the protection of bald and golden eagles and endangered species of fish and wildlife, and the Bald and Golden Eagle Protection Act prohibits pursuing, wounding, killing, or capturing of bald and golden eagles.

The Massachusetts Endangered Species Act was enacted in 1990 and revised in 2005. The Act and its implementing regulations (321 CMR 10.00) protect rare species and their habitats by prohibiting the "take" of any plant or animal species listed as endangered, threatened, or of special concern by the Massachusetts Division of Fisheries and Wildlife. In reference to endangered or threatened animal species, take is defined as harassing, harming, pursuing, hunting, shooting, hounding, killing, trapping, capturing, or collecting. Disrupting the nesting, breeding, feeding, or migratory activity of listed bird species is also considered a take. In reference to plant species, take is defined as collecting, picking, killing, transplanting, or cutting. Permits for taking protected species for scientific, educational, conservation, or management purposes may be granted by the Division of Fisheries and Wildlife.

There are 69 animal and 63 plant state and/or federally listed threatened or endangered species found in Barnstable County (DFW 2003). The complete list is available in Appendix C-5, but the following list summarizes the types of threatened and endangered species that inhabit Cape Cod.

Type of Organism	Number of Threatened and Endangered Species on Cape Cod
Fish	4
Amphibians	3
Reptiles	3
Birds	21
Marine Mammals	1
Segmented Worms	1
Freshwater Mussels	4
Crustaceans	1
Insects	31
Vascular Plants	63

Four towns on Cape Cod are in the "top 10" in Massachusetts for the largest number of state-listed rare species records. The Town of Barnstable is one of only five towns in the state with more than 100 records of rare species. In addition, the National Oceanic and Atmospheric Administration identified two endangered whale species, three threatened whale species, two endangered sea turtle species, and two threatened sea turtle species that occur seasonally in waters off the coast of Massachusetts (Appendix C-5; see letter from M.A. Colligan, April 20, 2006, in Appendix A).

3.11 COASTAL ZONE

Under the Federal Coastal Zone Management Act of 1972, federal agencies are required to determine whether their activities are "reasonably likely to affect any coastal use or resource" and to minimize the potential impacts of their actions by complying with enforceable state policies to the fullest practical extent. If an activity is not fully consistent with an enforceable policy, the Federal agency must describe in its consistency determination the legal authority that prohibits full consistency. States and U.S. territories with marine or Great Lakes shorelines were given the opportunity to develop management plans for coastal resources.

The Massachusetts Coastal Zone Management Plan details the state laws, regulations, policies, and programs with which federal agencies must comply. The Plan comprises nine enforceable policies: water quality, habitat, protected areas, coastal hazards, port and harbor infrastructure, public access, energy, ocean resources, and growth management. The Massachusetts coastal zone includes all of Barnstable County (CZMP 2006).

3.12 LAND USE

Table 3-1
Land use distribution for Cape Cod Watershed

Land use	Acres	% of watershed
Cropland	1,951	0.8
Forest	78,557	32.2
Developed land	102,144	42
Grassland	805	0.3
Other (wetlands, open land, etc.)	60,283	24.7
Total	243,740	100.0

Data extrapolated from MassGIS 1999 land-use information**.**

For local and state officials, the main natural resource concern on Cape Cod is the rate of residential development. In 1971, development covered 60,000 acres. By 1999, this had increased to 103,000 acres, a 72 percent increase. Development now covers nearly half of the non-federal land on the Cape, and the pressure to build continues unabated. Land ownership on Cape Cod is estimated to be 75 percent private, 12 percent federal, and 13 percent state or town.

3.13 DEMOGRAPHICS

Barnstable County is the third fastest growing county in Massachusetts (EOEA 2004). Population on the Cape increased 224 percent from 1970 to 2000, and the Cape Cod Commission estimates that, with no additional growth management or land protection, the Cape will reach full build-out with 37,000 more houses and at least 50,000 more people by 2030.

Table 3-2
Demographic statistics

	Cape Cod	Massachusetts
Population	222,230	6,349,097
Number households	94,822	2,443,580
Median household income	$45,933	$50,502
Median house value	$178,000	$182,800
Percentage minority residents	5.8%	15.5%
Percentage age 65 and over[4/].	23%	14%
Percentage in poverty (1999)	4.6%	6.7%
Percentage involved in tourist-related occupations	31.3%	22.4%
Percentage involved in natural resource occupations (farming, fishing, forestry)	0.7%	0.2%

Data from 2000 US Census.

Although the Cape's median household income is approximately 10 percent lower than the state's median household income, poverty rates on Cape Cod are lower. Minority populations are also significantly lower on the Cape than elsewhere in the state. This may be because the Cape has very few heavily urbanized areas and generally attracts an older population, with a high percentage of retirees. People 62 years and over account for 26.4 percent of the Cape's population, but only make up 15.7 percent of the overall state population. The median age of the Cape population is 44.6 years, and median age of the state overall is 36.5. Of the state's 20 oldest communities with demographically older populations, 11 are on Cape Cod.

3.14 ECONOMY

It is noteworthy, as shown in Table 3-2, that nearly one-third of the Cape's workers are involved in tourist-related occupations, but the fraction employed in those occupations statewide is just over one-fifth. It is also notable that a much higher percentage of people on Cape Cod (more than three times the overall state percentage) work in the natural resources sector. Although Cape Cod accounts for approximately 5 percent of the state's land area, it has over 10 percent of the total number of individuals working in the natural resources sector. This clearly reflects the Cape's geographic setting, with hundreds of miles of shoreline and several hundred thousand acres of shellfish beds.

Farming

There are about 285 farms on Cape Cod; the average farm size is 21 acres. Based on the 2002 NASS Agriculture Census, there are 15 minority farmers, 57 female farmers and 40 limited-resource farmers on Cape Cod.

Commercial Fishing

DMF promotes and develops commercial fisheries through research, technical assistance, and the collection of statistics. Currently the American eel is the only anadromous or catadromous species that is commercially fished within the Project area. River herring have been commercially fished, but a 3-year moratorium through 2008 has temporarily stopped that fishery. The American eel is not a major commercial fish, however, and is not considered a quota-managed species by DMF (2006a).

Since the early 1800s, shellfish resources have played a key role in shaping Cape Cod's cultural and economic development. The total shellfish growing area for Cape Cod is 413,000 acres, which is used by commercial and recreational shellfishermen (DMF 2000). Commercial shellfish landings are reported annually by Massachusetts DMF (Table 3-3). Shellfish landings in 2002 were markedly higher than in other recent years, primarily for ocean quahog, mixed quahog, softshell clam, and bay scallop.

Table 3-3
Barnstable County commercial shellfish landings and economic values (2001-2004)

	2001	2002	2003	2004	
SPECIES	Pounds	Pounds	Pounds	Pounds	Value ($)[2/]
Bay Scallop	201,719	452,315	264,110	116,871	747,974
Oyster	74,085	84,040	130,304	173,364	138,691
Quahog (Cherrystone)	616,716	453,947	309,628	269,074	37,670
Quahog (Chowder)	531,931	443,960	265,375	455,580	113,895
Quahog (Littleneck)	1,268,803	1,012,368	901,288	754,902	1,283,333
Quahog (Mixed)	2,078,958	5,112,517	2,494,780	1,858,533	no data
Razor Clam	6,103	89,176	261,693	363,703	592,835
Soft Shell Clam	2,676,338	5,758,973	2,573,834	2,275,472	3,640,755
Other Shellfish[1/]	528,076	2,061,287	723,766	1,622,807	1,914,912[3/]
Total	7,982,729	15,468,583	7,924,778	7,890,252	8,470,065

Source: Dean (2006a and 2006b).
[1/] Species not reported in shellfish beds of project sites: conch, mussels, ocean quahog, sea scallops, mussels, etc.
[2/] Values are calculated from 2005 costs/pound dollars.
[3/] Value calculated from average cost/pound ($1.18) of other shellfish in 2005.

3.15 RECREATION

Recreational Fishing

The DMF Bureau of Recreational Fisheries maintains the anadromous fish resources of Cape Cod by reestablishing, augmenting, and enhancing anadromous runs. The Bureau also manages the Commonwealth's sport fisheries for important game fish. Catadromous and anadromous species fished for recreational purposes and the regulations governing the fishery are (DMF 2006b):

Fish Species	Season (open-closed)	Size Limit	Possession Limit
American eel	All Year	6 inches	50 fish
Shad	All Year	None	6 fish
Smelt	June 15 – March 15	None	None
Striped Bass	All Year	28 inches	2 fish
White Perch	All Year	8 inches	25 fish

Harvest, possession, sale, and use of river herring are prohibited until 2009 (DMF 2006b).

Recreational shellfish landings are not included in DMF's comprehensive shellfish database. Some recreational data are collected by individual towns and reported to DMF; however, this is a voluntary program and therefore considered a partial listing. Reported recreational shellfish landings were somewhat higher in 2001 than all subsequent years, with approximately 1,000,000 pounds of shellfish reported (Table 3-4).

Table 3-4
Barnstable County recreational shellfish landings and economic values (2001-2004)

	2001	2002	2003	2004	
Species	Pounds	Pounds	Pounds	Pounds	Value ($)
Bay Scallop	12,432	73,600	10,249	11,240	2,023[1/]
Oyster	54,608	31,941	39,142	73,350	102,690[2/]
Quahog (Cherrystone)	34,524	29,546	25,775	22,120	[3/]
Quahog (Chowder)	30,839	27,711	30,070	29,121	[3/]
Quahog (Littleneck)	104,998	82,618	74,005	81,315	[3/]
Quahog (Mixed)	693,912	385,827	280,624	317,952	no data
Razor Clam	1,290	1,250	200	1,370	63.36[4/]
Soft Shell Clam	83,917	102,590	72,863	72,118	2,207[5/]
Other Shellfish[6/]	3,994	3,243	5,479	14,949	---
Total	1,020,514	738,326	538,407	623,534	106,983

Source: Churchill (2006a and 2006b)
[1/] DMF reported values = $9/50 pounds for in-shell
[2/] DMF reported values = $1.40/pound
[3/] No values attributed to these species in 2004
[4/] DMF reported values = $1.85/40 pound bushel (bushel = 195 razor clam shells)
[5/] DMF reported values = $1.53/50 pound bushel (bushel = 547 soft shell clam shells)
[6/] Species not reported in shellfish beds of project sites: conch, mussels, ocean quahog, etc.

Beaches

There are over 390 public beaches in Barnstable County. The town health departments monitor water quality at beaches weekly during the summer months (June – August). Water quality standards for bathing beaches are expressed in terms of the concentration of *Enterococci*, a subset of fecal streptococci or *Escherichia coli*, a fecal coliform (Barnstable County Department of Health 2005):

- Marine Water: No single sample shall exceed 104 *Enterococci* colonies per 100 mL and the geometric mean of the most recent five (5) samples within the same bathing season shall not exceed 35 colonies per 100 mL.
- Fresh Water: (1) No single sample shall exceed 61 *Enterococci* colonies per 100 mL and the geometric mean of the most recent five (5) samples within the same bathing season shall not exceed 33 colonies per 100 mL; or (2) No single sample shall exceed 235 *E. coli* colonies per 100 mL and the geometric mean of the most recent five (5) samples within the same bathing season shall not exceed 126 colonies per 100 mL (DEP 2005a).

In 2005, several beaches on Cape Cod were temporarily closed to the public due to high concentrations of fecal coliform bacteria (Table 3-5) (Barnstable County Department of Health 2005). Most closures were in effect for only a few days until follow-up sampling indicated that the criteria had been met again; however, two beaches in Chatham were permanently closed until further notice due to fecal coliform bacteria (Town of Chatham 2005). Stormwater runoff is the dominant cause for elevated fecal coliform concentrations on public beaches (Barnstable County Department of Health 2005). Runoff carries pollutants from roads and other paved surfaces directly to the surface water of beaches and ponds. Waste from pets and wild animals (seals, seagulls, ducks and geese) is another possible cause of contamination.

Table 3-5
Results of beach monitoring in Barnstable County for 2005

Town	No. beaches	No. samples[1/]	No. failures[2/]	% Closure
Barnstable	42	546	14	3
Bourne	10	130	1	<1
Brewster	13	169	2	1
Chatham	17	---	---	---
Dennis	23	299	4	1
Eastham	16	240	24	10
Falmouth	23	299	10	3
Harwich	25	325	3	<1
Mashpee	9	117	1	<1
Orleans	12	156	2	1
Provincetown	18	273	28	10
Sandwich	11	143	3	2
Truro	15	200	5	3
Wellfleet	19	247	0	0
Yarmouth	27	351	5	1
Total	280	2,650	85	3

[1/] Total number of samples measured for fecal coliform during June-August.
[2/] Total number of samples that failed to meet fecal coliform water quality standards during the sampling period, leading to temporary closures.

3.16 NATURAL AREAS

National Estuarine Research Reserve

The National Estuarine Research Reserve program is a partnership between the National Oceanic and Atmospheric Administration and coastal states to protect estuarine land and water for long-term research and education. The only reserve on Cape Cod is the Waquoit Bay Reserve, which is located in the towns of Falmouth and Mashpee on the south shore of the Cape (Figure 2-1). This reserve is approximately 2,600 acres in size and encompasses open waters, barrier beaches, marshlands, and uplands (NERR 2006).

National Wildlife Refuge

The Eastern Massachusetts National Wildlife Refuge Complex comprises eight ecologically diverse refuges that include inland and coastal wetlands, forests, grasslands, and barrier beaches. The U.S. Fish and Wildlife Service manages the refuges to conserve and protect a diversity of native wildlife habitats and species. The Mashpee National Wildlife Refuge, located in the towns of Mashpee and Falmouth (Figure 2-1), is the only refuge located within the Project boundary in Cape Cod. This refuge consists of 5,871 acres and preserves salt marshes, cranberry bogs, Atlantic white cedar swamps, freshwater marshes, and a vernal pool (USFWS 2001).

Cape Cod National Seashore

The Cape Cod National Seashore (Figure 2-1) comprises 43,608 acres of shoreline, salt marshes, freshwater kettle ponds, and uplands and a wide diversity of species supported by these habitats. The Resource Management Division monitors the health and potential threats to natural resources at the Seashore. Annual resource management programs include protecting nesting habitat for piping plover and restoration of salt marsh habitats and herring river areas. The seashore offers six swimming beaches, 11 self-guiding nature trails, and a variety of picnic and scenic overlooks (NPS 2006).

3.17 CULTURAL RESOURCES

Native populations have inhabited Cape Cod since the re-establishment of plant and animal communities after glacial ice left the area some 13,500 years before present (BP). Radiocarbon dating places the first people in New England at approximately 10,000 BP. The people hunted caribou and smaller animals found in the sparse, tundra-like environment and lived in small, mobile groups. Very little archaeological evidence dating to this Paleo-Indian period is found in New England.

Prehistoric occupation of Cape Cod increased in the Middle Archaic Period, 8000-6500 years BP. The people inhabited sites near the headwaters of freshwater streams and glacial outwash channels at a considerable distance from the coast. These early environmental zones suggest that these sites were used to harvest anadromous fish, whose present-day spawning patterns are believed to have been established by this time. In the Late Archaic Period, 6000-3000 years BP, there was an even greater increase of

activity as human populations established across the area. People were organized in mobile groups that took advantage of new habitats and seasonally abundant resources.

In the Woodland Period, 3000 BP to 450 BP, people lived in semi-permanent villages, where they exploited the many resources available since archaic times and began cultivating plants. Pottery manufacturing developed around 1000 BP in New England. After 1000 BP, stable food supplies and increased use of permanent settlements led to a population increase. Archaeological and historical evidence suggests that Woodland era sites consisted of large villages and smaller peripheral sites surrounded by agricultural fields. Many of the small peripheral sites were occupied to take advantage of seasonally available food and to seek lithic materials for stone tool manufacture. Woodland archaeological sites can be quite large and are found frequently across New England.

In the Contact Period, beginning about 450 BP, Europeans began to arrive along the shores and eventually settled the area. Permanent European settlement is recognized with the establishment of Sandwich in 1637. Settlements in Barnstable, Yarmouth, and Eastham followed shortly thereafter.

By the time the Europeans arrived, native peoples had extensively settled Cape Cod. Although the population of the Native Americans is difficult to estimate, it is safe to say that at least the outer Cape was extensively settled. Good information on the mid and inner Cape areas is not available; however, populations were undoubtedly present during the period. Ethno-historical accounts also verify that populations existed in the Sandy Neck area of Sandwich, as well as Barnstable and Yarmouth. Early explorers such as Champlain and Gosnold spoke of settlements with cornfields, wigwams and palisades, but none of these have been verified archaeologically. As of 1987, eleven contact period sites were known in the area. Most of these sites are located on the outer Cape; five sites are burial places, with the remainder being deposits from which European materials were recovered.

The Plantation Period begins with the landing of the Pilgrims in 1620 through 1692. During this period, Native American populations suffered significant population losses from diseases brought by Europeans. Displacement from traditional settlements also occurred during this time due to encroachment of the Europeans. A sizable native population remained in the area despite the devastating effects of disease. Core areas of native populations survived in the Barnstable and Eastham areas. During this time, Europeans tended to cluster in defined settlement areas. The four primary population centers were Sandwich, Barnstable, Yarmouth, and Nauset (now Eastham/Orleans). Numerous National Register Historic Districts and properties in the project area reflect this historic settlement.

Transportation on the Cape for both Native Americans and Europeans was based on the trail system developed by the Native Americans. As the Cape was settled more intensively, these trails were converted to cart paths or roadways. A less clearly defined road system developed on the Outer Cape where settlement was more dispersed (Bradley *et al*. 1987).