Photo Credit: **Nathan Johnson, Orion (Wellfleet Shellfish website)**

A. Geology, Soils and Topography

1. Geology

The Wellfleet area of Cape Cod was formed some 12,000 years ago during the final glacial era of the Wisconsin Stage of the Pleistocene Epoch (Strahler, 1966). Overlying the area's bedrock is approximately 400 feet of glacial sand and gravel (Chamberlain, 1964). Wellfleet is a plain resulting from morainal outwash. Strahler (1966) suggests there was an interlobate moraine between Cape Cod Bay and the South Channel glacial lobes, which was situated east of the present arm of the Cape.

As a glacial ice mass receded, boulders and ice blocks were deposited on the scoured countryside. Granite rocks can still be seen scattered throughout Wellfleet. The larger ice blocks formed kettle holes and hollows after glacial retreat. The ice blocks melted slowly and outwash materials deposited around them. The resulting depressions filled with water to form ponds. Hollows were open and were unable to retain water because of sectional erosion. Great Pond, Duck Pond, and the ponds east of the Herring River are examples of the kettle ponds. Hollows are more numerous, and Dyer's Hollow, Cahoon's Hollow, and Snow's Hollow are typical examples.

Present geography is also the result of postglacial modifications. Channels in outwash deposits evolved into rivers such as the Herring and Blackfish Creek. Rising sea level punctuated by storm wave action cut deeply into the coastline forming the steep marine scarps (e.g. Indian Neck) on both bay and ocean shorelines. Wave action introduced another modification - shoreline sediment drifting. In the last century, Bound Brook Island, Griffin Island, Great Island and Great Beach Hill were all independent islands. However, due to southerly sediment movement and accretion, these "islands" were connected by narrow strips of land called tombolos. Jeremy Point was also formed from wave washed sand transported down the bay shore. The point constantly changes configuration with storm action.

Another modification of Wellfleet's coastal zone was the formation of mud flats and salt marshes as sea level rise slowed about 4,000 years B.P. (Before Present). River and tidal silts were deposited and densely compacted, resisting the effects of erosion. With time and the stabilizing effects of vegetation like marsh grasses, shoreline deposits evolved into supratidal area and the first stages of terrestrial plant succession.

2. Soils

Soils maps and data for Wellfleet were obtained from the U.S. Soil Conservation Service (currently Natural Resources Conservation Service). Soils are mapped on the basis of properties such as natural permeability, texture, slope and other features which can be interpreted to determine the limitations of a particular kind of soil for a specific purpose. Soils are depicted on Map 3, *Geology and Soils,* and soil limitations for specific land use are given in Table 16, *Soil Limitations for Specific Urban Land Use*.

Table 16 Soil Limitations for Specific Urban Land Use

SOIL LIMITATIONS FOR SPECIFIC URBAN LAND USE

Soil Type	Septic System	Sanitary Landfill (trench)	Building	Acreage (% of total Acreage)
Freetown & Swansea Muck	Severe-wetness	Severe-wetness-	Severe-wetness	170 (2.6%)
Ipswich & Pawcatuck Muck Peats	Severe-floods	Severe-floods	Severe-floods	1057 (16.4%)
Udipsamments, sloping	Severe-filter	Severe-sandy	Severe-slope	66 (1.0%)
Beaches	Severe-floods	Severe-floods	Severe-floods	162 (2.5%)
Freetown course sand	Severe-wetness	Severe-wetness	Severe-wetness	141 (2.2%)
Carver Course Sand				
0-3% slope	Severe-	Severe-	Slight	52 (0.8%)
0-8% slope	rapid	rapid	"	58 (0.9%)
3-8% slope	filter	filter	"	1286 (19.9%)
8-15% slope	"	"	Moderate	1892 (29.3%)
15-35% slope	"	"	Severe slope	1050 (16.3%)
Birdsall Silt Loam (-3% slope)	Severe-wetness	Severe-wetness	Severe-wetness	138 (2.1%)
Urban Land	- Not Rated -			311 (4.8%)
Sanitary Landfill (discontinued)	- Not Rated -			13 (0.2%)
Sand Pits	- Not Rated -			21 (0.3%)

Major factors limiting growth in the Town of Wellfleet, as in other Cape towns, are the limitations of on-site septic systems and contamination of the fragile water supply. In general,

soils fall into four major categories; muck, peat, silt and sand. The following is a description of the major soil types:

Carver Series. These are excessively drained soils that formed in deep deposits of coarse and very coarse sand. They are on outwash plains and terraces. Carver soils have sand and loamy sand surface soils, and coarse sand or very coarse sand subsoils. They contain only small amounts of gravel and are stone-free. The rapid permeability of the coarse sandy material causes these soils to be droughty. Carver soils are closely associated with the excessively drained Hinckley and Windsor soils. These soils are extremely acid and highly erosive; water moves rapidly downward.

Freetown and Swansea Mucks. Consists of nearly level, deep, very poorly drained organic soils in depressions and low flat areas of uplands and glacial outwash plains and terraces. They formed in 16 to 51 inches of black, highly decomposed organic material (muck) with moderate to rapid permeability, over sandy or loamy mineral material with very rapid permeability. They have a water table that is at or near the surface most of the year. Major limitations are related to wetness and low strength.

Birdsall Series. These are very poorly drained soils that formed in deep deposits of very fine sand and silt. They occur in depressions and on low-lying flat areas. Birdsall soils have gray or black surface soils, and gray subsoils. They are water-logged most of the year due to high water table or lack surface drainage.

Udipsamments (Dune Lands). Consists of highly quartzitic sand, gently sloping to very steep, deep excessively drained to poorly drained soils on coastal sand dunes. They formed in wind-deposited sand blown from nearby beaches. Udipsamments are vegetated sand dunes and are subject to deflation and deposition by the wind.

Urban Land. Consists of areas where the soil has been altered or obscured by buildings, industrial areas, paved parking lots, sidewalks, roads and railroad yards. These structures cover 75% or more of the surface area. Slopes range from nearly level to steep.

Ipswich & Pawcatuck Series. These are very poorly drained soils that formed in deposits of organic material over sandy material. They are on level tidal marshes adjacent to the ocean or on estuarine marshes, and they are regularly flooded by salt water. Soils have mucky peat surface and subsurface layers. They are underlain by loamy sand or sand at depths ranging from 16 inches to more than 51 inches. These soils are saturated with salt water all of the time.

Soils with wetness problems (muck, peat and saturated sands) account for about 1,560 acres, or 24% of town land (land inside the National Seashore has not been considered). About 345 acres (5%) is classified as Urban land, or developed with structures over more than 75% of the surface area. Steeply sloped land (surface slope over 15 to 35%) or surface slope so steep that construction is impractical, amounts to about 1,050 acres (16%). The remaining land, about 3,445 acres or 55%, consists of sand deposits.
Importantly, although these remaining 3,445 acres comprise soils that would be classified as appropriate for septic leaching under Title V, extremely high permeability allows effluent

(especially nitrates) to percolate freely and potentially affect groundwater supplies. In addition, soils and slopes which are currently unsuitable for construction, may become so in the future with engineering improvements and a greater demand for a quickly dwindling number of buildable lots. The use of composting and other alternative waste treatment systems will help to reduce the impacts of residential development even further but may also allow development on soils which were formerly unsuitable for leaching areas. Geology and soils are shown on Map 3.

B. Landscape Character

Wellfleet is a narrow arm of land, extending out into the Atlantic. Probably its single most important asset, from a tourist point of view, is the Ocean beach below a dramatic sea cliff of glacial outwash. Fortunately for the town, this asset is well protected from development by the Cape Cod National Seashore. Its many fresh water kettle ponds are also an important recreational resource. While the National Seashore protects these from development, they are in danger of eutrophication from over use. This is much more difficult to control, as more and more people come into the town every summer, and go off in search of just such spots for swimming. For the rest of the Wellfleet, its small town, village character is valued by visitors and year round residents alike. The marshes and wetlands contribute not only to the scenic character of the town, but also are absolutely essential to support the shell fishing industry, which is by far Wellfleet's largest year round occupation. The Herring River, in Wellfleet, was the largest estuary on outer Cape Cod, before it was diked at the turn of the 20th century. It is still the longest all natural (i.e., no man-made "ladders") herring run on the Cape. A plan to restore the river is discussed in greater detail in Section 4F. - Water Resources. The town's character can be summarized as that of a rural fishing and retirement village which, in the summer, becomes a tourist haven.

C. Water Resources

1. Salt Water Bodies

Wellfleet's landscape character and 44 miles of salt water shorefront are a primary focus of informal outdoor activities and form the background for the town's tourist-based economy. Primary among these are shellfishing (commercial and recreational), recreational finfishing, boating, boardsailing, surfing, swimming, and walking. These activities are spread throughout the town's marine areas including the beaches of the Atlantic Ocean, and Cape Cod Bay. Major bayside public bathing beaches are at Indian Neck, Mayo Beach, Pleasant Point, Duck Harbor, The Gut, and Powers Landing. On the Atlantic Ocean within the Cape Cod National Seashore are Newcombs Hollow, Cahoons Hollow, White Crest, and LeCount Hollow (Maguire's Landing) beaches. The primary boat facilities are found in Wellfleet Harbor at the Marina. There are 217 slips, 270 moorings (350 cap), two launching ramps and boat storage areas as well as restroom facilities. With state funding, the boat ramp is being completely rebuilt and is scheduled for completion in September 2005. Sailing occurs everywhere, although more often on the calmer, more accessible bayside waters.

Surfcasting for bluefish and striped bass is a popular pastime along the beaches on the Bay and Ocean sides. Deep sea fishing is conducted by both private boats and charters which sail from the pier at Wellfleet Harbor. Off-road vehicles are not allowed on any beaches except by commercial shellfishermen who use their trucks to haul equipment and shellfish to and from grants off Indian Neck, Field Point, Mayo Beach, Blackfish Creek, and Chipman's Cove.

The Town of Wellfleet conducted a study of water quality of its embayments specifically regarding nitrogenous and bacterial pollution. The $250,000 grant was administered through the Massachusetts Mini Bays Program, Wellfleet being the only harbor on Cape Cod to receive such a grant. The Town is presently hosting a State Estuaries Program study of the potential for nitrogen loading and eutrophication to its coastal bays and is the second year of data collection. To date the main findings have been that water quality problems are due more to confinement of waters by diking than they are to human use, septic leaching, and surface water runoff. Town meeting has recently voted further funds to continue to study this problem in order to find ways to solve it. Human uses, particularly domestic waste-water disposal, do impact water quality and almost all of Wellfleet's land area contributes via groundwater discharge to a coastal embayment, salt pond or estuary. Hence, land use throughout much of town can affect the quality of saltwater bodies.
(See Section 4F for further discussion of Herring River See also, the Coastal Resources Element of the Local Comprehensive Plan, 1995)

2. Fresh Water Bodies

The town's primary freshwater resources are its 13 kettle ponds, totaling over 284 acres of surface area. These ponds are all located within the National Seashore boundaries, with five having public access managed by the Town of Wellfleet. The kettle ponds of the Cape Cod National seashore are a unique and fragile resource with ecological, aesthetic, and recreational value. These ponds, dependent solely on the fluctuation in the aquifer's water table for their own surface level, often expose a wide shore during the summer when the water table is low. These exposed shorelines comprise the unique habitat called "coastal plain pondshores," which harbor rare and endangered plants, such as Plymouth gentian and long-beaked bald rush, and rare animals, such as the comet darner and New England bluet (damselflies). For several years now, the National Park Service has conducted and coordinated monitoring and research programs on the kettle ponds to investigate the status of pond water quality. These and other studies indicated there are five major areas of concern for pond water quality: (1) excess nutrient addition resulting in cultural eutrophication (cultural eutrophication is the term used to describe human induced addition of nutrients in excess of their natural quantity and rate of availability; (2) sediment addition from shoreline erosion; (3) possible public health hazards from bacterial contamination; (4) possible chemical pollution; and (5) potential acid rain impacts. (from CCNS data). The two most pressing of these are eutrophication, due to shoreline development and recreational use of the ponds, and acidification due to both cultural and natural causes.

Seven of the ponds are greater than ten acres in size, which classifies them as Great Ponds of the Commonwealth. The public owns Great Ponds and is entitled to access, while other ponds can

be owned privately by surrounding landowners and public access can be prohibited. Ownership and special characteristics of these ponds are detailed below.

Recreationally, the most important swimming ponds are Gull, Great, Long, Higgins, Dyer and Duck Ponds, each with a town landing. Swimming programs take place at Gull Pond for six weeks during the summer for children and adolescents three - 16 years old. Although boats can be used at all ponds in Wellfleet, gasoline-powered motors are prohibited. Therefore, pond boating is limited to canoes, kayaks, rowboats, sailboats, and other small craft.

A totally natural anadramous fish run extends up the Herring River corridor into the "Gull Ponds Chain" (Gull, Herring, Higgins, and Williams ponds) which serves as the headwaters of the river. Blueback and alewife herring, as well as white perch, spawn in all four. Catadromous American eels also use the run. Although the annual run of the herring represent an important ecological element of the river and provide a unique cultural attraction, herring can accelerate eutrophication by eating the zooplankton which normally feed on algae. Without this zooplankton, the algae is free to grow relatively unchecked. In addition, dying herring may contribute nutrients to the water.

3. Surface Water Quality

Most of Wellfleet's waters are generally of high quality, though problem spots exist. The Massachusetts Department of Environmental Protection[3] lists nearly all of the marine (salt) waters of Wellfleet as Class SA, the top salt water ranking, meaning they are an "outstanding resource" whose purity should be suitable for all types of water recreation, including swimming and shellfishing. The one exception is the Herring River, recently classified on the DEP 313d List of Impaired Waters for low dissolved oxygen, acidity and metals; all three water quality problems are the result of the long period of diking and wetland drainage; efforts are underway to restore the river's water quality along with tidal flow and salinity (see below). All freshwater ponds are included in Class B, the top freshwater ranking for ponds not used as a source of a public drinking water supply. These ponds must be maintained at a high level of purity and are not supposed to be degraded by point source discharges, such as sewage outfalls. In fact, it is non-point sources of pollution (road runoff, septic systems, lawn maintenance, etc.) that are the more potent threat to water quality of ponds and bays in Wellfleet.

Recharge areas are land areas that collect precipitation and release it to the ground water system and to surface water bodies, such as ponds, streams and bays. Recharge areas are much more relevant on Cape Cod, where sandy soils readily transmit groundwater, rather than land surface watersheds that contribute most water to ponds and bays off-Cape. Land uses within recharge areas significantly influence surface water quality.

Eutrophication is the process by which a pond experiences algal blooms, oxygen depletion, fish kills, noxious odors and visual deterioration as a result of excessive nutrient inputs (usually from runoff and septic systems).

Freshwater ponds on the Cape tend to be naturally acidic due to a lack of alkaline materials in the soils, and accelerated acidification is apparent in several ponds. Between 1983-85 the Acid Rain Monitoring Project, coordinated by the University of Massachusetts at Amherst, sampled 3370 surface waters throughout the state and found, using only pH as a criteria, that 5.5 percent were acidified, 16.8 percent were critical, 20 percent were endangered and 21.7 percent were highly sensitive (in descending order of degradation.) In Wellfleet the following ponds were found to be "acidified"[4], according to the ARM Project: Duck, Dyer, Great, Kinnacum, Long, and Northeast; however, paleolimnological research has shown that these ponds have become quite acidic since their formation, well before anthropogenic "acid rain" (Portnoy et al. 2001). Ironically, the high acidity keeps the pond waters attractive for swimming because the water looks very clear and feels "soft".
In relation to this issue, scientists at the Cape Cod National Seashore have discovered some yellow perch are showing signs of mercury poisoning due to long range atmospheric transport. Mercury tends to be mobilized more readily in acidic ponds (Portnoy et al. 2001). Fish in Dyer, Great, Wellfleet, and Duck Ponds have shown lesions on their head, otherwise known as "hole in the head disease". Although the exact cause is uncertain, it is likely associated with stress related to low pH and mercury toxicity.

As previously described, saltwater bodies are generally excellent in quality except where tidal flushing is restricted as it is in Herring River, Duck Creek and in some other sections of the harbor. The pier which blocks the mouth of Duck Creek diminishes the amount of tidal flushing which can occur and noticeably higher pollution has resulted. Some areas of high shellfish concentrations sometimes show increased nutrient counts perhaps due to wastes excreted by both the shellfish themselves and by foraging waterfowl. For example, although water near Field Point shows no bacterial problems it does show extremely dense macro algae blooms which have a detrimental impact to the area, in addition to their positive impact as a food source. Eutrophication is a common result of nitrogenous water pollution and dense algal growth. Although the waters here are kept generally oxygen rich and flushed clean by regular tidal ebb and flow, algal blooms are still sometimes thick enough to prevent shellfish from setting in certain places and to foul the undersides of boats. Nitrogen counts increase dramatically near Field Point in July and August when warmer temperature, increased waterfowl, and a seasonal population increase probably contribute to the increased readings.

This increased nitrogen level during the summer is a water quality issue which needs to be monitored. Contribution from human sources, including terrestrial and marine septic systems needs to be controlled (this has been partly addressed by the designation of Wellfleet Harbor as a No-Discharge Zone). Title 5 regulation changes should do a decent job of limiting increases in this potential source of pollution, although the use of alternative septic treatment systems is recommended wherever possible.

4. Floodplains

[4] These ponds had pH measurements ranging between 4.4 and 4.83.

Wellfleet participates in the Federal Flood Insurance Program, which requires that new shorefront development meet engineering standards for flood proofing, but does not prohibit development. Flood velocity zones, or V-zones, are land areas where storm surge or direct wave action occurs. All of Wellfleet's westward facing barrier beaches, as well as the entire Atlantic side is within a velocity zone. The bays at the mouth of Blackfish Creek and Fresh Brook are also within V-zones.

Landward of the velocity zones are other flood-prone areas, A-Zones, in which standing water can be expected during 100-year storm events. B-zones are between the limits of the 100-year flood and 500 year flood; or certain areas subject to the 100 year flooding with average depths less than one foot or where contributing drainage area is less than one square mile; or areas protected from the base flood (FEMA). These areas consist mostly of salt marshes and shorefront uplands.

In the coming decades, flooding and erosion will be increasingly exacerbated due to global warming. This phenomenon is predicted to cause current rates of sea-level rise to increase as the polar ice caps melt and seawater undergoes thermal expansion. Accelerated sea-level rise could result in the loss of large amounts of open space in Wellfleet in the coming decades, particularly in low-lying wetlands and shoreline uplands. The first areas to be submerged will basically coincide with the 100 year floodplain, lands which are currently important open space for the town. Sea level rise will also mean an increase in the frequency and severity of damaging storms. The town must consider this issue when examining long-term public investment in shoreline facilities, such as in siting new parking lots. Perhaps even more importantly, the town needs to adopt an aggressive new strategy to protect shorelines from development, bulkheading, revetments, etc. so that upland-fringing salt marshes can retreat uphill, and survive, with rising sea level; otherwise our salt marshes will be trapped between the rising sea and upland development and will disappear.

5. Wetlands

Wetlands, both fresh and salt water types, are the food factory and habitat for most of Wellfleet's wild animals. Fortunately, Wellfleet is blessed with a diversity of wetland types and sizes scattered throughout the Town.

A salt marsh's high productivity makes it excellent feeding and nursery habitat for birds, shellfish, and finfish. About two-thirds of commercially-important finfish spend some of their life cycle feeding or spawning in or near salt marshes.[6]

Wellfleet's vegetated wetlands are extensive, extending in all directions from the waters of Wellfleet Harbor. The Harbor's many inlets, bays and islands represent one of the largest estuarine systems on the Cape. It is protected from the onslaught of direct ocean waves by the

[6] Sterling, Dorothy, Association for the Preservation of Cape Cod, Our Cape Cod Salt Marshes, (Orleans MA, 1976), p. 21.

peninsula of Great Island and Jeremy Point. This is the origin of the herring run and the recipient of water flowing from inland freshwater tributaries. Most of the well developed salt marshes in Wellfleet are in the protected areas on the lee side of islands and spits including Indian Neck, Lieutenant's Island, and behind barrier beaches. The Herring River and Blackfish Creek corridors represent the furthest inland extent of this extensive marsh system. As previously discussed, the interior marshlands of the Herring River have been tremendously impacted by diking. Restoration of these marshlands is being actively studied by the National Park Service, Massachusetts Audubon Society, the Town and other cooperators.

As with Wellfleet's ponds, freshwater wetlands are dependent on groundwater discharge rather than surface water runoff. Wellfleet's wetlands are at low elevations, close to the water table and the sand and gravel soils readily transmit groundwater through wetlands. Both salt marshes and freshwater wetlands play an important role in filtering out contaminants, especially nitrogen before groundwater discharges into the Harbor. The Town's fringing salt marshes also buffer storm surges, thereby protecting coastal structures. In addition to town administration of the Massachusetts Wetlands Protection Act, the Town simultaneously administers two local environmental protection by-laws:

1. Stormwater By-law - no surface water can be directed towards a water body. Natural drainage is permitted but no constructed drainage systems are allowed.

2. Floodplain By-law - further restricts building in the floodplain.

These bylaws help to protect further the integrity of valuable wetland resources in the Town of Wellfleet.

5.1 Special Wetland Resources

a.Freshwater Wetlands

Atlantic White Cedar Swamps

The 1990 Critical Habitats Atlas for Cape Cod[7] identifies one wetland area in Wellfleet which is dominated by Atlantic White Cedar (*Chamæcyparis thyoides*) located in the Cape Cod National Seashore near Marconi Station/Beach. This is the archetypical site for this habitat in the entire Park and the most well known cedar swamp on Cape Cod. Cedar swamps are highly acidic and are uncommon throughout the Cape. Regionally, cedar swamps were once much more extensive before the trees were harvested for shingles and fence posts in earlier centuries or swamps were converted to cranberrying. Of the 6,000 acres of cedar swamp thought to exist at the time of the Pilgrim's landing on Cape Cod,[8] only 135 acres persist today.[9]

[7] Association for the Preservation of Cape Cod, Cape Cod Critical Habitats Atlas 1990.
[8] Cape Cod Commission, Monomoy Capacity Study: Summary Report, July 1996, p. 92.
[9] University of Massachusetts-Amherst, Glenn Motzkin, Atlantic White Cedar Wetlands of Massachusetts, 1991, pp. 11.

Other small stands of Atlantic white cedar occur south of Paine Hollow Road and in the swamplands of the upper Herring River east of Route 6. The significance of Wellfleet's cedar swamps for both wildlife habitat and education argues for continued efforts to insure their protection. Cedar swamps are sensitive to water table drawdown, e.g. through nearby municipal groundwater withdrawal.

Vernal Pools

Vernal pools were officially recognized as critical habitat in 1987 when the Massachusetts General Court amended the Wetlands Protection Act to include their protection. These small temporary ponds are crucial breeding grounds for woodland amphibians, such as Eastern spadefoot toads and salamanders. Spotted salamanders are the most common amphibian found in Wellfleet's vernal pools.

As with other wetlands, these habitats are susceptible to acidification and to the effects of groundwater withdrawal. Although wetlands on Cape Cod are naturally acidic, especially sensitive wildlife begin to show signs of toxicity at certain levels. Groundwater withdrawal, however, is the more immediate threat to the viability of vernal pools and inhabiting wildlife because of their extreme sensitivity to water level fluctuation. There are several certified vernal pools dotting the entire town of Wellfleet. These are shown on Map 7, *Wetlands and other Significant Natural Resource Areas* and Map 10D, *MNHESP 2003 Vernal Pools*. The National Park Service is conducting ongoing studies within its boundaries on the hydrogeology, biology, and water chemistry of vernal pools.

b. Saltwater Wetlands

Tidal Flats

Another significant, though often overlooked, wetland resource in Wellfleet is tidal flats.[10] Wellfleet has broad expanses of estuarine flats, which are portions of the beds of salt ponds or estuaries exposed at low tide. They are particularly productive for shellfish populations (see discussion of fisheries in Section 4E). There are also large expanses of marine flats of the type found in open coastal areas, primarily along Cape Cod Bay. Both of these types of flats are an important recreational resource in the town. The firm, hard footing of the flats is popular for activities ranging from shellfishing to walking to kite flying. Threats to the flats include overuse by pedestrians and off-road vehicle (ORV) compaction. ORVs are used regularly by shellfishermen tending their grants. Potential impacts include disturbance of wildlife, particularly shorebirds, and the destruction of marine organisms which live in the mud. Oil and gas leaks are another potential hazard with no effective means of monitoring except through

[10] Massachusetts Coastal Zone Management Office, Barrier Beaches, Salt Marshes & Tidal Flats: An Inventory of the Coastal Resources of the Commonwealth of Massachusetts, 1985, p. 12.

strict vehicle checks. A management plan for the Fox Island Conservation Area in Wellfleet recommended that ORVs be checked before entering the beach area in order to help prevent this potential pollution. This sort of vigilant monitoring may be necessary in other places to insure the continued viability of both the shellfish resource and the shellfish trade.

c. Streams and Water Courses

Wellfleet has three notable tidal riparian corridors: Herring River, Blackfish Creek, and Fresh Brook. Each courses east to west through the bottom of old glacial outwash channels, providing freshwater inputs to Wellfleet's portion of Cape Cod Bay. [A large fraction of freshwater discharge to the Bay occurs as diffuse groundwater seepage along the shore.] Whereas Herring River originates in the Gull Pond chain, the other two have no headwater ponds. Instead they emerge from lowlands lying to the east of the harbor within the National Seashore. Protection of their headwaters will help to insure their continued health. Although both of these rivers are diked off by Route 6, culverts help to maintain normal waterflow and only the highest tides reach this far east. Sixteen years ago, road runoff problems from Route 6 were mitigated during construction work done by the state. Catch basins and leaching pits were constructed to capture direct runoff before it reaches the wetland areas. Only in emergency situations will any overflow be allowed to occur (J. Chatham).

Surface waters of the Herring River suffer from summertime oxygen depletions and perennial acidity and toxic metals, all caused by diking, drainage and the lack of tidal flushing. The National Park Service and State and university cooperators have studied the river's ecological problems and options for habitat restoration since 1980. Throughout the 18th and 19th centuries the Herring River was a major focus of Wellfleet political, social and economic life, with salt hay farming, shellfishing and a herring run whose annual auction paid the salaries of all elected town officials (Wellfleet Annual Reports). In 1908 a dike was constructed at Chequessett Neck road to control mosquitoes and create arable land. In the nearly 100 years since then, the upper reaches of the river, including its associated marshlands, have converted to either Phragmites (an invasive exotic plant) marshland or upland forest. Attention was first drawn to the problem in October 1980 when National Park Service and Mass. Division of Marine Fisheries biologists and local fishermen documented a massive mortality of American eels due to extremely low pH (high acidity). Since that time, the Park Service has been working with the Department of Environmental Protection, Coastal Zone Management, the Town of Wellfleet, and Massachusetts Audubon on correcting the problem. Although the cause is simple, correcting it is not. Outstanding questions regarding tidal restoration include the potential for flooding of golf course fairways and two residences, saltwater intrusion into domestic wells, effects of fecal coliform and sedimentation on downstream shellfish grants, and the stability of The Gut. Recent research has shown that opening or removal of the Herring River Dike will not affect domestic water supplies (Martin 2004), The Gut, nor sediment on shellfish grants (Doherty 2004); nevertheless, the NPS and US Geological Survey are monitoring both the groundwater salt/fresh interface and sedimentation in the Harbor. This discussion was recently reinvigorated through public presentations of this research. The future of the Herring River and its associated marshlands will depend on thoughtful planning by these collaborating agencies. It will take extensive public education to adequately explain why a seemingly radical change is necessary to preserve one of the most important features of the town. As of 2005 various agencies and organization are

working on the Herring River restoration Project. One step was taken in the process when the Annual Town Meeting in April 2005 voted to acquire approximately 25 acres of the Chequesset Yacht and Country Club. This land will be allowed to revert to its natural state and therefore will not be adversely affected by the proposed opening of the Herring River dike. In taking this step the town showed its interest in having the Herring River Restoration Project go forward.
As reported by the Cape Cod Times, this project received a large boost recently "when the U.S. Senate Appropriations Committee approved $500,000 towards the purchase of 25 acres of a Wellfleet Golf Course" (CCT, Doug Fraser, 7-04-05). This grant would be added to the town's contribution of $1.25 million (half of the $2.4 million purchase price), which was recently approved to be borrowed from Land Bank funds contingent upon the remaining funds being raised through grants and donations (Ibid.).

The culverts under Route 6 for blackfish Creek and Fresh Brook do not allow for normal flow. These areas are considered Tidally Restricted. The Cape Cod Atlas of Tidally Restricted Salt Marshes published in 2001 by the Cape Cod Commission contains excellent maps and descriptions of the problems here and elsewhere and can be found at their website at: http://www.capecodcommission.org/tidalatlas/ .

d. Groundwater Resources

In 1982 the U.S. Environmental Protection Agency designated all of Barnstable County as a Sole Source Aquifer in recognition of the region's complete reliance on groundwater as its potable water supply. Wellfleet draws its water from two lenses, the Chequessett (shared with Truro) and the Nauset lens (shared with Eastham and Orleans) - see Map 6, Lower Cape Cod Water Lenses. These lenses provide water for all of Wellfleet. In 1992 the Lower Cape Water Management Task Force was formed. It consisted of representatives from the towns of Eastham, Wellfleet, Truro, Provincetown, the Cape Cod National Seashore, and the Cape Cod Commission. Its aim was to look at water resource issues on the lower Cape, using hydrogeological, rather than political, boundaries as the parameters for decision making. They looked at the four groundwater lenses of the lower Cape: Chequesset, Nauset, Pamet, and Pilgrim. In Wellfleet, where the vast majority of drinking water is supplied by private wells, water protection is a very local issue, related directly to the land use in the immediate vicinity of each well as much as it is to the larger recharge area. The Lower Cape Water Quality Task Force looked at data collected between 1985 and 1994 from over 6,000 private wells in the area, mapped the information and analyzed nitrate distribution across town. The presence of nitrate served as the basic indicator of water quality; currently the Cape Cod Commission holds a 5 ppm (mg/L) planning limit, while the federal limit is 10 ppm (mg/L). When nitrate levels exceed 5 ppm, there is cause for concern while water containing nitrate concentrations greater than 10 ppm is considered unpotable. From 1985 to 1994, one out of three wells in Wellfleet center exceeded the 5 ppm nitrate threshold. **The most important finding was that nitrate concentrations, and therefore water quality problems, increased proportionately with housing density.** Wellfleet Center, where the greatest housing density exists, is the only known water quality problem area, with respect to nitrate. This trend is further supported by looking at adjacent towns of Eastham and Truro. The northern central part of Eastham, which has a higher

density than Wellfleet, was another problem area whereas Truro, with the lowest population density on Cape, has the best water quality.

With a median lot size of 1/3 of an acre and almost urban density, water pollution potential is notably higher in the Center. In planning for Wellfleet's Future, it is clear that water quality depends directly on the density of development allowed. Most towns require one acre zoning for new subdivisions to insure protection of their water supplies, although this brings with it a more sprawling sort of development which has broader impacts to wildlife, scenery, and land values. In its local comprehensive plan, Wellfleet encourages cluster zoning for these reasons, although this may necessitate sewering or waste water treatment systems. A sewer and wastewater treatment system has been considered for years for the central district of Wellfleet**.**

The Task Force also looked at potential sites for future municipal wells, taking into consideration water quality and the impact of water extraction on other natural resources. The site which was identified is just south of Dyer Pond, near the boundary of the Cape Cod National Seashore. . The South Dyer site shows up clearly as an area free of contamination and inclusive of both Town-owned land and seashore restricted land. The findings and recommendations of this Task Force's final report are summarized below.

- Most private wells in Wellfleet provide high quality drinking water
- The number of wells that provide high quality drinking water will decrease in the future
- Cross-contamination (instances where groundwater contaminated with effluent intercepts a well) periodically occurs in all areas of the Outer Cape.
- Wellfleet Center and the Route 6 corridor of Eastham are areas which are approaching the point where "lot by lot" measures are not long term solutions.

Although there are 37 potential municipal drinking water well sites on the lower Cape, the study determined that the South Dyer Pond site would be the best location for a well which could serve Wellfleet Center and perhaps other areas of town, should water quality become irreversibly impaired there in the future. The South Dyer Wellhead Protection District has been roughly located and approved by the state. It is likely that any future public water supply system for Wellfleet will be located here. Secondary sites for wells identified in the report include the Coles Neck, Duck Pond, or Great Pond sites. Map 8, *Wellfleet's Wellhead Protection Districts*, shows both the South Dyer and Cole's Neck Wellhead Protection Districts.

Although groundwater quantity in Wellfleet is presently ample for domestic, small-volume wells, municipal withdrawal could lower water levels and cause ecological damage to surface waters such as kettle ponds and vernal pools. This can occur where wells are located too closely to surface waters or rates of withdrawal are too high (Water Quality Task Force). Extensive pumping for human use can dramatically alter the levels of ponds and other wetlands to their detriment and, if located near the seashore, can cause salt water intrusion as well. Several private wells exceeded the target sodium threshold level of 20 mg/L over a decade ago. Now in 2005 and a projected water use increase of over 1,000% by buildout, it is extremely important to identify and develop water supply sources that will accommodate this expectedly high demand while protecting against salt water intrusion and other contaminant sources

Since the major percentage of Wellfleet's land lies within the Cape Cod National Seashore, it is clear that water resource management must be a cooperative effort between the town and the Federal Government. Establishing an arrangement which simultaneously meets the needs of the town and protects the resources of the Park is essential for the future of Wellfleet.

Wellfleet, because of its small median lot size (one third of an acre) has several parcels which are designated as Nitrogen Sensitive Lots; that is, both private well water supply and septic systems are located on the same lot. In these cases, the State's revised Title V septic regulations require the use of alternative denitrification technology when a system fails and needs replacement or improvements. Wellfleet's only water protection overlay district establishes protective radii between 100-200 feet around wells on Nitrogen sensitive lots. The size of the radius depends upon environmental factors and usage. Placement of septic within these zones is discouraged; alternative septic systems are often employed when lot characteristics prohibit full Title 5 systems. There are several alternative systems currently available and in use in Wellfleet including Ekofin Bioclere, Recirculating Sand Filters, and Peat Filters. Although effective at reducing nitrates, these systems cannot control chemical and microbial pollutants. They are also more expensive to install and maintain. Often, however they are the best and only solution to the problem of nitrogenous pollution.

D. Vegetation

The Town includes a wide diversity of habitats for native flora and fauna. There is a strong maritime influence because of the proximity to the coast and salt spray from winter storms. The soil is generally sandy with little organic matter, except in hollows and around wetlands. Wellfleet was essentially treeless at the turn of the century because of historic forest clearing. The existing forest is second growth and no mature forest community exists in Wellfleet.

Oak-Hickory woodland, one of the rarest habitats on Cape Cod is found in South Wellfleet. A climax woodland, it is comprised of white *(Quercus alba)* and black oak *(Q. velutina)* and mockernut hickory (*Carya tomentosa*); it was the original forest community found by the Pilgrims when they landed. A woodland of beech *(Fagus grandifolia)*, another climax forest tree, is developing around the headwaters of the Herring River.

The dominant forest type in Wellfleet is pitch pine *(Pinus rigida)* which is an early successional woodland tree. In many areas the oak woodlands, comprised of black and white oaks, are slowly succeeding pitch pine and replacing them. Historically, fire, mostly man created, slowed the spread of growth of the oaks. This no longer is the case and many fire dependent communities, including heathlands, are becoming increasingly rare.

Today, the threat to forestland is primarily from displacement by residential development. Since the 1950's, when residential development on Cape Cod began to skyrocket, there has been a steady decline in forested land in Wellfleet as indicated by the numbers below:

Table 17 Forestland Area in Wellfleet 1951-2000

FORESTLAND AREA IN WELLFLEET 1951-2000	
YEAR	**ACRES**
1951	8,094
1971	7,374
1980	8,080
1984	6,915
2000	6,441

Source: MacConnell Land Use updates, University of Massachusetts

The predominant pine/oak forests, by themselves, are often considered of limited value from a wildlife standpoint because of their short height, crown density and the poor quality of the dominant soil association. When a wetland, cranberry bog or power line plant community occurs adjacent to the woodlands, the wildlife value of both the open and wooded areas is greatly enhanced for many species. "Forest-interior" species (those that depend upon large blocks of unfragmented woodland, such as neotropical migrant breeding songbirds) will primarily use the woodlands within the Cape Cod National Seashore as well as out on Great Island peninsula.
The habitat significance of the woodlands of the Seashore is important in that it is one of the few remaining large tracts of contiguous wooded land on Cape Cod. As such, it may be considered one of only a few true wildlife reserve areas. Most woodlands on the Cape are too fragmented to provide this function. Rather, they, like the woodlands of more urban sections of Wellfleet, provide cover, food, and migration corridors on a more local scale.

The recreational value of these wooded areas, particularly within the seashore, is notable as well. For much of the off-season, the great recreation areas of the beaches are not as popular as one might expect because of the exacerbated cold there. Woodlands offer important shelter and relief from the bitter winds off the Bay and Ocean.

The most mature stage in the development of the sand dune community is the coastal maritime forest. Well protected from salt spray, but still subject to occasional exposure are species associated with a mature maritime forest of black oak, black cherry, pitch pine, quaking aspen, red cedar, and sassafras. The majority of Wellfleet's maritime forest and open space, including the dune land, lies within the National Seashore boundary.

There are three rare habitat types located around Wellfleet which represent some of the rarest plant communities in Massachusetts. These include coastal shrublands above the marine scarp of the Cape Cod National Seashore dominated by scrub oak *(Quercus ilicifolia)* and huckleberry *(Gaylussacia baccata),* coastal heathlands such as those on Bound Brook Island and within the Seashore, characterized by broom crowberry *(Corema conradii)* and bearberry *(Arctostaphylos uva-ursi),* and sandplain grasslands, such as the one at Massachusetts Audubon's Wellfleet Bay Wildlife Sanctuary, which are identified by the presence of little bluestem grass *(Andropogon scoparius)* .

Wellfleet's numerous freshwater habitats include the kettle ponds, some of the real treasures of Wellfleet. These are naturally acidic ponds characterized by steep sides and deep bottoms with sparsely vegetated shores. They are oligotrophic, or low in nutrients and organic productivity, making their waters very clear. Located adjacent to the kettle ponds are numerous wetlands such as white cedar swamps, red maple swamps, vernal pools and other types of freshwater wetlands. On the east side of Route 6 the Herring River forms an extensive freshwater system and Wellfleet's largest estuary .

Salt marsh represents a significant coastal habitat type, and is an extensive high inter-tidal area consisting of salt marsh grasses *(Spartina alterniflora, S. patens and Distichlis spicata),* sedges *(Scirpus robustus),* rushes *(Juncus gerardi)*, seaweeds and few succulent plants *(Limonium carolinianum, Solidago sempervirens)* and shrubs *(Iva frutescens).* Salt marshes are located behind the barrier beaches and around most of the small embayments which are part of Wellfleet Harbor.

Beaches are located on the Atlantic Ocean, Cape Cod Bay and within Wellfleet Harbor. Most are characterized by fine sand of glacial origin that has been sorted and ground by waves and winds. There are numerous, small barrier beach systems scattered around Wellfleet Harbor as well as two major barrier beaches, one at the northern end of Indian Neck and the second south of Great Beach Hill in the Cape Cod National Seashore

Dune systems are found in three areas of Wellfleet, on the bayside, between Great Beach Hill, Great, Griffin and Bound Brook Islands these dunes are known as tombolos and link each island. On the oceanside and the bayside, wind deposited sand creates sand dunes on top of the coastal banks on both side of Wellfleet but are particularly noticeable in the Marconi area. The beach and dune systems are areas in which productive vegetation is minimal. Its close relationship and proximity with the ocean make it an area prone to instability. Salt water spray, wind velocity, and lack of absorbable fresh water close to the surface make plant survival almost impossible. The dominant plant species of the sand dune is the American beach grass. An intricate network of roots and rhizomes anchors the sand which holds the dune surface in place. Other species that can tolerate wind and salt are the beach pea, the seaside goldenrod, and the dusty miller.

Tidal Flats are comprised of fine silts, mud or sand in the area between low water and the break in the lower berm of the beach. Flats generally are devoid of vegetation but may have seaweeds if large rocks or shells are present. Also, both eelgrass *(Zostera marina)* and widgeon grass (*Ruppia maritima)* patches are present. Eelgrass may be the rarest of all the plant communities in Wellfleet and the most threatened.

Rare plants in Wellfleet protected under the 1991 Massachusetts Endangered Species Act include those listed as Endangered, Threatened and Species of Special Concern, in descending order of rarity. State regulations prohibit the taking or habitat alteration of these species without a state permit.

Much of the information regarding vegetative communities has been gathered over the years by town, Massachusetts Audubon and Cape Cod National Seashore staff and volunteers. In addition to this data, there has recently been a regional study of vegetative communities, *The Cape Cod Wildlife Habitat Conservation Project*, which identified and mapped significant vegetation types across Cape Cod.

Cape Cod Wildlife Habitat Conservation Project[15]

The central goal of the Cape Cod Wildlife Habitat Conservation Project, conducted by The Compact of Cape Cod Conservation Trusts, Inc., is *to preserve and enhance biodiversity on Cape Cod*. To achieve this ambitious goal, the project focused upon the identification, mapping and ranking of natural communities, including existing areas held for conservation or other open space purposes. Existing sources were utilized to identify and map 32 distinct community types[16]. By integrating principles of landscape ecology and conservation biology, the project acknowledges the importance of both habitat quantity *and* quality. Although "bigger is usually better" since larger areas provide greater opportunities to sustain populations, protection of smaller areas, such as sites that contain vernal pools or rare habitat types are also important for maintaining overall diversity. Thus, the project has attempted to determine the habitat requirements for the more than 400 species that are known or expected to occur within Barnstable County and map these habitats in order to determine priority areas for protection[17].

The results of this analysis provide a comprehensive view of the best *potential* wildlife habitats on Cape Cod based upon natural community type (i.e. vegetation cover, geologic and hydrologic features), size, condition and landscape context[18]. One of the greatest threats to wildlife populations on Cape Cod is the continued fragmentation of habitat resulting from land development practices. This project presents an opportunity to lessen the impact of habitat loss by identifying the most important remaining areas in need of protection for use by those interested in preserving the Cape's wildlife diversity.

Summary of Regional Results and Recommendations

15 Much of this section was taken verbatim directly from the project's final report entitled *Cape Cod Wildlife Conservation Project: A Strategy for Preserving Natural Diversity*, published by The Compact of Cape Cod Conservation Trusts, Inc. and reorganized and adapted for use in this Plan. For a copy of the complete report, contact The Compact at 508-362-2565.

16 This number is approximate and may include other community types not mentioned.

17 Does not include fish or marine species.

18 No wildlife surveys were conducted in conjunction with this project.

- 32 habitat types were identified and mapped. 7,754 individual areas or habitat "patches" were mapped which contained a total of approximately 160,000 acres, or 61 percent of the Cape's land area[19].
- Town-by-town summary tables were prepared which identify the total amount of each habitat type (in acres) mapped and illustrate the distribution of habitat types across the region.
- Most of the highest ranking habitat areas are contained within six large "core" areas which include the Massachusetts Military Reservation, the Sandy Neck/Chase Garden Creek complex in Barnstable/Yarmouth, Punkhorn Parklands in Brewster, Nickerson State Park in Brewster/Orleans, Monomoy National Wildlife Refuge and much of the Cape Cod National Seashore.
- Other significant areas include Bournedale in the northwestern corner of Bourne, Town Neck Beach and marsh system in Sandwich, the town conservation lands in East Sandwich/West Barnstable area, Quivet Neck/Crowe's Pasture in Dennis and Brewster, Namskaket Creek in Brewster/Orleans, and Herring River/Boat Meadow Creek in Eastham,
- Roughly half (46 percent) of the identified habitat areas are protected as open space by public agencies or private organizations. Some of these areas may not be adequately protected or managed to maximize conditions for wildlife.
- In general, wildlife habitat is highly fragmented on Cape Cod as a result of land development for residential, commercial, recreation, transportation and other uses. Overall, the average "patch" size mapped, irrespective of habitat type, was approximately 20 acres.
- Forested woodlands are the most common habitat types on the Cape, accounting for 60 percent (104,368 acres) of the total mapped area. The dominant woodland community type is the mixed pitch pine -oak that is characteristic of much of the dry upland sites in the Upper and Mid-Cape region.
- Woodland habitats support the greatest potential number of breeding species (134) than any other habitat type found on Cape Cod. Grasslands and heathlands (52) and wooded swamps (45) support the next highest potential number of species, respectively.
- The most important breeding habitats for the protection of state-listed rare species (Endangered, Threatened, or Special Concern) are coastal plain pondshores, vernal pools, and barrier beaches and dune systems.
- Sandplain grasslands, coastal heathlands, and pitch pine/scrub oak barrens are important rare habitats found on the Cape which also provide habitat for a number of state listed species. Fire suppression, development and natural succession have reduced these open habitats dramatically. Today, these habitat types represent only about two percent of the total area mapped.
- Due to the scarcity of the grassland and heathland communities, there are few opportunities to protect more of these habitat types through outright acquisition. Some expansion and enhancement of these habitats may be achieved through the active management and habitat restoration efforts.

19 Total area includes both protected and unprotected areas as well as the undeveloped portions of properties that may contain some development, such as one dwelling unit on a multiple-acres parcel.

Approximately 30,000 real estate parcels were identified that contained one or more habitat types. The total area associated with these properties is approximately 138,000 acres. These included existing protected areas, as well as undeveloped and under-developed properties of two acres or greater.

Each parcel was ranked for its conservation value. The criteria used to determine conservation value were parcel size, habitat value, surrounding land uses (context), and percent upland.

Parcel Ranking Summary: Cape Cod Totals

Ranking	Number of Parcels	Acres	% Acres Protected
Maximum	1,633	42,763	86 %
High	11,388	61,591	48 %
Medium	13,382	31,174	16%
Low	2,810	2,923	8%
Total	29,213	138,451	52%

- More than half (52 percent) of the total acreage associated with parcels containing some wildlife habitat are protected. According to the ranking, the Cape has managed to protect most (86 percent) of the highest ranked properties.
- Roughly half of the total area associated with protected parcels occurs in the following towns: Barnstable, Bourne, Eastham, Sandwich, Truro, and Wellfleet.
- The land area associated with the remaining unprotected parcels is 66,467 acres. The distribution in terms of the habitat ranking is as follows: 5,867 acres in the Maximum category, 31,876 acres in High category, 26,040 acres in Medium category, and 2,683 acres of Low category.
- The towns with the largest amount of unprotected acreage in the Maximum parcel category are: Mashpee (1,412 acres), Harwich (883 acres), Bourne (743 acres), Falmouth (640) and Barnstable (458 acres). This represents 70 percent of the total acreage in the Maximum category Cape-wide.
- A significant number of opportunities exist to preserve additional habitat areas through land acquisition and other conservation techniques, but few large, unprotected properties remain. The mean size for all parcels evaluated is 4.74 acres. The largest parcel ranked occurs within the Massachusetts Military Reservation in Bourne and is nearly 9,000 acres.
- The greatest opportunity for protecting additional acreage falls within parcels that are ranked in the High and Medium categories. Many of these properties are located adjacent to existing protected open space and may present opportunities to expand existing areas or provide a linkage between habitats using buffers or linear corridors.

Habitat Classification Results and Summary Statistics

The project has identified and mapped 32 wildlife habitat types based on vegetation, hydrology, or geologic features. The classification scheme resulted in the delineation of 21 wetland and

eleven upland habitat types or natural communities. The project did not support any fieldwork and therefore relied upon existing information and some local knowledge to identify community types. Numerous sources were consulted, including the Cape Cod Commission, Mass GIS, Department of Environmental Protection, MA Natural Heritage and Endangered Species Program, Association for the Preservation of Cape Cod and The Compact's panel of Scientific Advisors. GIS mapping technology was used to integrate geographic data from the different sources and distinguish habitat types.

Habitat Descriptions

The Wildlife Conservation Project began with a detailed mapping of each major habitat type found Cape Cod. Habitats types were described based on definable natural community characteristic including dominant vegetation cover, hydrology and/or geology. In and of themselves the maps proved to be useful tools for understanding the occurrence and distribution of the remaining wildlife habitats on the Cape. For the first time, these maps show the proximity of developed and undeveloped areas at a scale which is useful for local planning purposes. What they did not show was which of the remaining habitat areas are the most important for conserving wildlife. In order to accomplish this, the Compact had to develop a method for comparing the relative value of these areas to wildlife. Since it was beyond the scope of the project to determine this information from field surveys, the Compact sought to assemble the best available, existing information to approximate these values.

Thirty-two community types have been identified and mapped from existing sources. The 32 community types identified include salt marsh, barrier beach, barrier beach/dunes systems, coastal beach, coastal dune, coastal bluff, rocky inter-tidal shore, tidal flat, ponds and lakes, streams and riparian corridors, fresh marsh, shrub swamp, wooded swamp deciduous, red maple swamps, wooded swamp coniferous, Atlantic white cedar swamp, wooded swamp mixed, coastal plain pond shores, vernal pools, bog, cranberry bog, sandplain grassland, coastal heathland, grassy heath, cultural fields, pitch pine-scrub oak barrens, pitch pine-oak woodland, white pine-hardwood woodland, American beech woodland, oak-hickory woodland and unclassified woodlands. Other "significant woodland communities" were included where small stands of unique tree species were known to exist

Although mostly upland forest, there are significant differences in the occurrence and distribution of many of the other habitat types found on Cape Cod. Each town has its own unique mix or "natural signature" reflected in the mosaic of community types present. To some extent, these variations reflect the patterns of development in each town as well as the amount and location of existing open space. But there are also geographic differences that are related to geologic conditions, topography, exposure and soil characteristics that provide an environment which allows some community types to thrive while prohibiting the establishment of others altogether. These regional differences define the natural landscape and help point out the opportunities for protecting biodiversity by emphasizing which towns contain the most of each community type.

For more specific information relevant to Wellfleet's wildlife habitats, contact The Compact of Cape Cod Conservation Trusts Inc. for a copy of the report at 508-362-2565.

E. Fisheries and Wildlife

1. Fisheries

Wellfleet Harbor has long been a major source of oysters and clams (both quahogs and soft shells). The evidence indicates that the exploitation of this resource long preceded the advent of the European on these shores. Wellfleet Harbor has provided a habitat especially favorable to marine fauna, particularly to shellfish, which have unusually high rates of growth as well as appearing to proliferate into unusually large populations. The harbor enjoys a unique set of features when taken all together. A ten-foot tidal range gives the harbor better than a 70% flush rate on a twice daily basis. Further this flow over the generally shallow and originally clean hard sand bottom causes a complex system of rapid tidal currents of relatively warmer water. Into this water mass flow a number of estuaries and streams of varying sizes—Herring River, Mayo's Creek, Duck Creek, Loagy Bay and Blackfish Creek with their bays and marshes as well as Sewell's Gutter, Power's Landing Meadow, Margaret's Meadow, and Middle Meadow. These all contribute a large amount of fresh water which lowers the salinity progressively as you move up harbor, until in the area of the Town Pier the salinity is 7 - 10 parts per thousand lower than the water off Jeremy Point. This complex system of streams, wetland and marshes which stretch inland to within a half mile of the Atlantic Ocean comprise rich nursery and feeding habitats for marine fish, shellfish and birds. This unique array of natural advantages existed eons before the Pilgrims arrived. However it took only one and one half centuries to deplete the resource to the point of extinction of the original Wellfleet oyster. It was only through relaying of oysters harvested in the Chesapeake Bay that the resource was reestablished. This process of depletion and reseeding took place again in the 19th century. The "native" beds of today are all scions of stock brought in from the Chesapeake and other beds to the south.

Over the years we have done serious mechanical damage to the hydrodynamics of the harbor and its rivers and estuaries:the construction of the railway embankment across Duck Creek, the dike across Herring River, the widening and extending of Shirt Tail Point, the dike across Mayo's Creek, the breakwater, the rail and highway embankments in Blackfish Creek. These and similar projects were undertaken with little or no knowledge of their individual and cumulative environmental impact. Reversing the damage done by the historical restriction of the tides will take many decades, but is worth pursuing if only for the benefit of Wellfleet's important shellfish resource. Map 9A, *Wellfleet Harbor Shellfishing Areas,* shows the location of shellfish resources in Wellfleet Harbor.

Commercial shellfishery

The total value of the shellfishing industry to Wellfleet is over $2.75 million annually. Fifty-five percent of this crop comes from the "wild" fishery, while 45% comes from the practice of aquaculture. The "wild" fishery consists of harvesting the bivalves generally where they have

grown, without any intervention except the dumping of an occasional load of cultch. The Colonial Ordinances allow the free use of intertidal lands for fishing, fowling and navigating. Oysters are picked up from those areas in the harbor where they thrive. Quahogs are dug where they mature and the deeper harbor is under constant pressure from draggers. This fishery is closely managed by the Shellfish Constable with a view towards limiting the harvest to the extent that the resource remain self renewable. This is done by setting quantity limits, area limits, and seasonal closures.

Aquaculture

Historically Wellfleet has supported the aquaculturist through the process of licensing areas in the harbor which have been generally perceived as non-productive of shellfish. These grants, after a reasonable trial period, are licensed for ten years, and usually renewed upon expiration. This allows the license holder to plan for the future.

About twenty years ago the growing of quahog seed on a commercial basis became economically feasible. This enables the aquaculturist to buy seed, handle the seed in a manner which would optimize growth, and increase productivity. In fact, the last twenty years have seen threefold increase in the output of quahogs from licensed areas. As more areas are approved for licensing this methodology for growing quahogs will continue to enhance production.

The historic practice with oysters has been to pick seed oysters out of the open areas and relay them in licensed areas. In addition cultch has been laid by the town as well as by license holders. The town has laid cultch where, in the opinion of the Shellfish Constable at the time, it would catch the best set. License holders have laid cultch in their own areas. The success of the restocking of Chipman's Cove is an example of how well this practice works when conditions are good. QPX may present future problems to the aquacultural economy and should be recognized as a potential hazard to the industry.

More lately, new methods of encouraging the veliger (larval state of the oyster) to attach itself to a medium, which will allow for continuous control of the growth and development of the oyster, have emerged. The most commonly used and most successful device is the so called Chinese Hat. These are covered with a substrate of mortar with a high lime content. They are then placed in areas of the harbor which are deemed to have a high passage rate of the veligers. After the veligers attach themselves to the lime they are left for the balance of the season in situ. The lime is removed from the device with the spat and bagged for winter storage. Using coarser bags the spat is allowed to grow to a size which can be laid directly on the bottom, where they will remain until they are harvestable. This promising development should do for the oyster crop that which the advent of commercial seed did for the quahog.

There has been some success in trapping soft-shelled clam seed, but it remains primarily a sporadic and "wild" harvest.

There are sporadic crops of bay scallops, and do not presently lend themselves to aquaculture therefore they remain in the wild harvest. Maps 9B, *Wellfleet Harbor South Shellfishing License*

Areas, and 9C, *Wellfleet Harbor North Shellfish License Areas*, show the locations of leased grant areas in Wellfleet.

Fin fishing

Fin fishing in Wellfleet harbor is primarily recreational . The fish caught are the fluke, winter flounder, scup, tautog, and the more sporting bluefish and striped bass. The alewife may be making a comeback in the Herring River as a result of the cooperative efforts of the National Seashore and interested parties in the Town of Wellfleet.

Management

Ever since the seminal work by Dr. David L. Belding in 1906, Wellfleet has had a Shellfish Management Plan of some kind in place. Today the Oyster Task Force Plan remains in effect while the Wellfleet Harbor Shellfish Management Plan is undergoing a major up-dating. The stated objective of the Plan is "the restoration and management of the fishery resources, the development of extensive and intensive aquaculture and enhancement of anadramous fisheries...".

Specifics include

1. Maintain biological diversity in Wellfleet harbor.
2. Restore economically important marine animals by improved habitat management.
3. Enhance the propagation of the wild populations of oysters, quahogs, soft-shelled clams, and bay scallops .
4. Protect and enhance the natural populations of alewives, eels, razor clams, sea worms and other protected species.
5. Prevent further encroachment on the salt marshes and estuaries.
6. Prevent or mitigate the pollution of the waters of the harbor.
7. Resolve conflicting interests among shellfishermen, swimmers, boaters and other recreational users.
8. Promote scientific research supportive of the shellfishing industry.

Issues

1. Rights of upland owners versus the needs of the shellfishing industry.
2. Impact of non point source pollution on rivers, marshes and estuaries.
3. Effects of the accumulation of "black mayonnaise" north of Shirt Tail Point.
4. Impact of the desalinization of Herring River.
5. Resolution of any questions pertaining to the uses of the west side of Wellfleet harbor.

Appendix J, *Draft 2005 Harbor Management Plan – Overview Statement*, includes several points relevant to the management of the Harbor and its shellfish resources.

2. Wildlife

Wellfleet is located at the juncture of two major wildlife zones: the Virginian and the Acadian biogeographic regions. Cape Cod separates the warm Gulf Stream waters of Nantucket Sound

(northern edge of the Virginian zone) from the cold Labrador Current coursing down through the Gulf of Maine into Cape Cod Bay (southern edge of the Acadian zone.) The Cape Cod Bay shoreline is the innermost area recently proposed by the National Marine Fisheries Service as critical habitat for the federally-endangered North American right whale.

Wellfleet Harbor is one of only five Cape embayments identified as important wintering areas for black ducks, a National Species of Special Emphasis.[12] Shore birds include terns (common, least and an occasional roseate) and piping plovers, all listed as protected rare species in Massachusetts.

While a complete inventory of birds is not available for Wellfleet, other important or interesting breeding birds include osprey, northern parula warbler, pine warbler, orchard oriole, eastern bluebird, savannah sparrow, sharp-tailed sparrow, eastern meadowlark, red-tailed hawk, killdeer, woodcock, horned lark, ruby-throated hummingbird, eastern phoebe, great horned owl, willet,.[13]

Mammals in Wellfleet include the common assemblage of adaptive species: red and gray squirrel, white-tailed deer, raccoon, red fox, rabbit, skunk, otter, opossum, shrew, muskrat, bat, weasel, woodchuck, mice and voles. In recent years, a top-of-the-food-chain predator, the eastern coyote, has extended its range throughout all of Cape Cod and is seen throughout Wellfleet, particularly along salt marsh edges, where they stalk mice and voles. The main threat to the coyote is alarm by an uninformed citizenry; there is little evidence that coyotes will bother humans, though pets may be stalked and perhaps attacked.

Wildlife corridors enable animals, particularly upland mammals, to migrate to new territories in search of food or breeding grounds. Biologists estimate that undisturbed linear areas of 300 feet in width are necessary for many species to feel comfortable moving undetected through an area. Owing to the dispersal of residential development throughout the town and its continuing saturation, wildlife corridors are fewer and narrower than perhaps they should be. The Cape Cod National Seashore provides a uniquely large contiguous area of unfragmented woodland wildlife habitat. The Great Island peninsula provides a more isolated though smaller preserve while the marshlands surrounding Wellfleet's bayside waters provide extensive habitat for numerous shoreline species. An unusually diverse array of coastal habitats provides for a correspondingly high diversity of coastal organisms. Outer Cape Cod, though somewhat isolated from the mainland, nevertheless attracts many typically "mainland" birds and mammals, and is especially important to migratory species. In addition, its unique geographical position and ocean-moderated climate, are in part responsible for the presence of many plants and animals at the limits of their geographical range.

Wetlands and wetland-dependent flora and fauna predominate. Most important game animals, as well as "passively" enjoyed songbirds, raptors, colonial water birds, reptiles, amphibians, and of course fish, depend on wetland habitats for food and cover. Coastal swamps, marshes and wet

[12] U.S. Fish and Wildlife Service, Concept Plan for Preservation of Black Duck," cited in U.S. Environmental Protection Agency, "Priority Wetlands in New England," September 1987, p. 55.

[13] Richard Veit & Wayne Petersen, Birds of Massachusetts, Massachusetts Audubon Society, 1993.

meadows are habitat for deer, muskrat, raccoon, red fox, cottontail rabbits, woodcock, and migratory waterfowl among hunted species. The shrubby borders of coastal marshlands and kettle hole swamps provide outstandingly good feeding and nesting cover for songbirds and small mammals. In addition, the beneficial contribution of organic detritus from these coastal marshes to estuaries and nearshore marine systems is well appreciated.

Several agencies compile information on rare, threatened or endangered species. The Massachusetts Natural Heritage Program (Department of Fisheries and Wildlife) maintains an ongoing inventory of rare, threatened and endangered plants and animal species, as well as the geographic location of critical ecosystems. The U.S. Fish and Wildlife Service also conducts field investigations on nationally significant species. Scientific staff of Cape Cod National Seashore and Massachusetts Audubon Society monitor rare species within the park. Also, many local people provide information to these agencies based on extensive observation. Table 18, *MNHESP Rare Species List for Wellfleet*, includes the most recently updated lists of known rare plants and animals in Wellfleet as documented by the Massachusetts Natural Heritage and Endangered Species Program.

Table 18 MNHESP Rare Species List for Wellfleet

RARE SPECIES IN WELLFLEET			
Taxonomic Group	**Scientific Name**	**Common Name**	**State Rank**
Amphibian	*Hemidactylium scutatum*	Four-Toed Salamander	SC
Amphibian	*Scaphiopus holbrookii*	Eastern Spadefoot	T
Reptile	*Clemmys guttata*	Spotted Turtle	SC
Reptile	*Malaclemys terrapin*	Diamondback Terrapin	T
Reptile	*Terrapene carolina*	Eastern Box Turtle	SC
Bird	*Accipiter striatus*	Sharp-Shinned Hawk	SC
Bird	*Charadrius melodus*	Piping Plover	T
Bird	*Circus cyaneus*	Northern Harrier	T
Bird	*Pooecetes gramineus*	Vesper Sparrow	T
Bird	*Sterna antillarum*	Least Tern	SC

Bird	*Sterna dougallii*	Roseate Tern	E
Bird	*Sterna hirundo*	Common Tern	SC
Bird	*Sterna paradisaea*	Arctic Tern	SC
Snail	*Ferrissia walkeri*	Walker's Limpet	SC
Dragonfly/Damselfly	*Enallagma laterale*	New England Bluet	SC
Dragonfly/Damselfly	*Enallagma recurvatum*	Pine Barrens Bluet	T
Butterfly/Moth	*Abagrotis nefascia benjamini*	Coastal Heathland Cutworm	SC
Butterfly/Moth	*Catocala herodias gerhardi*	Gerhard's Underwing Moth	SC
Butterfly/Moth	*Cicinnus melsheimeri*	Melsheimer's Sack Bearer	T
Butterfly/Moth	*Hemileuca maia*	Barrens Buckmoth	SC
Butterfly/Moth	*Lithophane viridipallens*	Pale Green Pinion Moth	SC
Butterfly/Moth	*Oligia hausta*	Northern Brocade Moth	SC
Butterfly/Moth	*Oncocnemis riparia*	Dune Noctuid Moth	SC
Butterfly/Moth	*Papaipema sulphurata*	Water-Willow Stem Borer	T
Butterfly/Moth	*Psectraglaea carnosa*	Pink Sallow	SC
Butterfly/Moth	*Atrium favonius*	Oak Hairstreak	SC
Vascular Plant	*Carex striata var brevis*	Walter's Sedge	E
Vascular Plant	*Corema conradii*	Broom Crowberry	SC
Vascular Plant	*Dichanthelium commonsianum*	Commons's Panic-Grass	SC
Vascular Plant	*Eleocharis obtusa var ovata*	Ovate Spike-Sedge	E

Vascular Plant	*Helianthemum dumosum*	Bushy Rockrose	SC
Vascular Plant	*Mertensia maritima*	Oysterleaf	E
Vascular Plant	*Opuntia humifusa*	Prickly Pear	E
Vascular Plant	*Rhynchospora scirpoides*	Long-Beaked Bald-Sedge	SC
Vascular Plant	*Sagittaria teres*	Terete Arrowhead	SC
Vascular Plant	*Spartina cynosuroides*	Salt Reedgrass	T
Vascular Plant	*Sphenopholis pensylvanica*	Swamp Oats	T
Vascular Plant	*Utricularia striata*	Fibrous Bladderwort	T
Vascular Plant	*Utricularia subulata*	Subulate Bladderwort	SC

Source: Natural Heritage & Endangered Species Program, Massachusetts Division of Fish and Wildlife

Data have been collected about the fauna of Wellfleet by the staff at the Cape Cod National Seashore and the Massachusetts Audubon Society as well as individuals reporting to the Massachusetts Natural Heritage and Endangered Species Program. Maps 10A, B, C, and D show the locations of significant and/or rare habitats and wildlife. Following is a description of notable rare species:

Diamondback terrapin *(Malaclemys terrapin)* is a state listed threatened species which reaches its northern limit in Wellfleet. Terrapins nest in the upland areas adjacent to extensive salt marshes. The Wellfleet Bay Wildlife Sanctuary, Lieutenant Island, Indian Neck and Great Island all have significant numbers of nesting terrapins.

Box turtle *(Terrapene carolina)* is a species of special concern in Massachusetts whose population declines as roads and houses increase. The densest concentration of box turtles in the state is found in South Wellfleet.

Spadefoot toad *(Scophiopus h. holbrooki)* is the most endangered amphibian in Wellfleet and is listed by the State as endangered. Its annual cycle is connected to vernal pools and spadefoots are confirmed from six locations including the center of town. These fossorial creatures live as deep as 8 feet underground and emerge only after hours of torrential rains.

Four-toed salamander *(Hemidactylium scutatum)* is the smallest salamander in Massachusetts and is listed as a Species of Special Concern. Usually associated with shallow pools, red maple

and white cedar swamps and sphagnum wetlands, four-toed salamanders have been found at either end of Wellfleet. As adults they are terrestrial.

Least Terns *(Sterna albifrons)* , the only species of tern to nest in Wellfleet, are found south of Little Beach Hill and on Marconi Beach in the Cape Cod National Seashore and a small colony at the Wellfleet Bay Wildlife Sanctuary. Least terns are a Species of Special Concern in Massachusetts.

Piping plovers *(Charadrius melodius)* are a federally protected species and listed as threatened. Never a common shore nesting bird, piping plovers all but disappeared by the 1970's. Diligent conservation work by the State, Federal Government and MAS has brought back the piping plover here in Massachusetts. Plovers nest at Marconi, Great Beach Hill and Little Beach Hill beaches and at the Wellfleet Bay Wildlife Sanctuary.

Barrens Bluet Damselfly *(Enallagma recurvatum)* is a State listed Threatened Species which is found around coastal plains ponds. One of 10 state populations has been found in Wellfleet, adults can be seen flying in June. Bluets need clean ponds with emergent vegetation.

Barrens Buck Moth *(Hemileuca maia)* is a State listed Threatened Species of expansive shrub heathland. Loss of habitat is the biggest threat for this 2" moth. Wellfleet has one of only four documented populations on Cape Cod

Broom crowberry *(Corema conradii)* inhabits sandy pine and bear oak barrens and is especially abundant in several areas of Wellfleet. It is increasingly rare due to the development of these upland sites. Broom crowberry is a State listed Species of Special Concern.

Prickly pear *(Opuntia humifusa)* occurs in Wellfleet and in only ten other sites throughout the State. This hearty cactus is found in the open heathlands and disappears as the habitat is lost. Prickly pear is a State listed Species of Special Concern.
In addition, the Massachusetts Audubon Society is presently preparing a herpetological atlas for Massachusetts, which should be consulted for additional information.

F. Scenic Resources and Unique Environments

1. Scenic Resources

The assessment of scenic landscape quality is a difficult task. Though the subjective approach may resonate more harmoniously with most residents and visitors on Cape Cod, it is important to attempt to answer questions like "why is this beautiful?" or "what makes this piece of land more beautiful than that parcel, which is half as expensive?" These are worthwhile questions and their answers may mean the difference between land preservation and development. The challenge is to combine the advantages of a purely objective representation with the equally necessary subjective determination of visual beauty.

There are as many methodologies for scenic resource assessment as there are scenic resources. There is one study, however, which is most relevant to Wellfleet's landscape. This study, the

Massachusetts Landscape Inventory, evolved from the efforts of the Department of Environmental Management (DEM) and the Nature Conservancy, which began by seeking to identify and locate the state's important natural features. An advisory committee composed of public and private conservation professionals, academics, a consulting naturalist, and the DEM staff "sought a system of visual assessment that would provide an accurate statewide survey of scenic areas". To this end, they did a thorough literature search and ended up basing their work on two precedents: Scotland's Scenic Heritage, which offered similarity of cultural history and values, and the U. S. Forest Service Method of assessment, which breaks components of landscape beauty down into objectified visual criteria. This study focused on two variables ; landscape complexity and visual / cultural compatibility.

With an objective basis of visual criteria, the advisory team was left to their personal assessments. The result is a cooperative but subjective determination of the presence or absence of specific, predetermined objective criteria. These criteria are partly based on public opinion research, i.e.; "visual / cultural compatibility".

For every square mile of Massachusetts, landscapes were annotated as either Distinctive, Noteworthy, or Common in order of descending uniqueness. The state was broken down into physiographic regions, with the Coastal Plain region composing all of Cape Cod and the Islands. Whereas one may suppose the bias to be towards the declaration of Distinctive landscapes, only 4% of the state was labeled as such. Noteworthy landscapes comprise 5% and the remaining 91% was deemed common, though this does not imply unimportance.

2. Unusual Geologic Features

Wellfleet enjoys three separate Distinctive areas: the bluffs on the Atlantic shore, the Wellfleet Center area, and Great Island peninsula. Noteworthy landscapes cover the barrier beaches north of Great Island on the bayside, the marshlands around Blackfish Creek and Fresh Brook, and the Gull Pond Chain area. Not surprisingly, all of these landscapes have immediate views to coastal resources. Most of the interior of Wellfleet is considered a common scenic landscape (see Map 11, Scenic Landscape Inventory).

Wellfleet offers beautiful views of several landscape types including marsh, woodland, beach, dune, open water, and sky. In addition, the cultural landscape, enhanced by views of fishermen working their plots, boats hauling their catch, people walking the shore, and wharves punctuating the horizon, adds remarkably to the visual and personal satisfaction of those who visit this area. This aspect is extremely important to scenic resource assessment. The combination of natural and cultural scenery is the sort of beauty people want to experience when they come to Cape Cod, and the sort of beauty this Open Space and Recreation Plan seeks to preserve. As the inventory states, " The most important justification for surveying and preserving prime landscapes is that scenic beauty - and the environmental and social well-being it reflects - is a basic human need." (DEM) Open space planning in Wellfleet should reflect that need by incorporating scenic assessment in its open space protection efforts. Following is a partial list of Wellfleet's most special environments. These are illustrated in Map 4, *Unique Environments.*

3. Cultural and Historic Areas and Unique Environments (described together in this section)

1. **Pine Barrens habitat**, an increasingly rare plant community in Massachusetts, remains somewhat common in Wellfleet and the Outer Cape. A pine barren is a mosaic of scrub oak, pitch pine and huckleberry which often forms dense thickets. It is a community which has adapted to fire and disturbance, but because it usually grows on level sandy soils, it is prime for development. Birds such as towhees, whip-poor-wills and rare moths and butterflies are common to this habitat and are declining state wide.

2. **Kettle Ponds** are steep sided, deep water ponds which have little or no emergent or pond shore vegetation. Wellfleet has several of these fragile pond communities. They are low pH depauperate communities, and because they are closed systems they can be easily disrupted. They are important as recharge areas for our aquifers and often have many rare plants and animals associated with them.

3. **Vernal pools** are a poorly protected freshwater habitat. Because they are temporary bodies of water, isolated in low spots in woodland, they are easily overlooked and deemed to be insignificant. These fish-free environments are required by fairy shrimp, spotted salamanders, wood frogs and a variety of insects.

4. Wellfleet has two **globally significant plant communities**, the coastal heathland and the sandplain grassland, which form extensive open treeless habitats. These two habitats are rare in Massachusetts mostly confined to Nantucket, Martha's Vineyard and the Outer Cape. These open rugged environments of pioneering species are essential habitat for a declining number of species. The suppression of fire and development have been the major reason for the decline of these habitats.

5. The entire **Wellfleet Harbor Area** has been designated by the state as an **Area of Critical Environmental Concern (ACEC)**. One of only 10 such areas in the Commonwealth (five of them are on Cape Cod), ACEC's are state designations for areas which have "unique natural and human resource values whose protection requires regional as well as local consideration. ACEC designation does not add bureaucratic layers; instead, it intensifies review by government agencies and the public, and boosts performance standards. These performance standards protect an ACEC's marine productivity, habitat value, water quality, and storm buffering capability". These areas are designated as important to the entire state. An ACEC designation only affords more strict review and does not prohibit or eliminate existing uses. The program is administered by the Massachusetts Executive Office of Environmental Affairs (EOEA) Coastal Zone Management Office.. Several offices within the EOEA have regulations relating to ACEC's. "Within the Department of Environmental Quality Engineering (DEQE)" which is now the Department of Environmental Protection, " three Divisions administer programs that affect ACEC's" (CZM publication):
   - Wetlands Division (through the Wetlands Protection Act)

- Waterways Division (permits the licenses for dredging and construction work below the high tide line)
- Division of Water Pollution Control (discharge permits and water quality standards)

Two Department of Environmental Management programs have provisions for ACEC's:

- Wetlands Restriction Program
- Ocean Sanctuaries Program

There are also some provisions within the Massachusetts Environmental Policy Act (MEPA), and some federal agencies outside the EOEA, such as the U.S. Army Corps of Engineers, that must work within the ACEC guidelines outlined by Massachusetts Coastal Zone Management. The Wellfleet Harbor ACEC enjoys a wealth of critical habitats, the protection of which is necessary in order to insure the continued balance and well-being of several species and of this area.

6. The **"Indian Neck Ossuary"** is an extremely important archaeological site in Wellfleet on the Indian Neck peninsula which is so named because the land was set aside by the English colonial government as "Indian land" because of its long previous inhabitation by them. What is surprising, however, is the discovery of an "ossuary" on Cape Cod. An ossuary is a type of community burial ground in which the bones of several individuals are buried together. Based on what archaeologists know of the Hurons in Ontario, who constructed numerous ossuaries, these structures typically reflect a sedentary population. Many think they served as the focus of rituals which were designed to "reassert social ties among villages that had budded from a single ancestral village as its population grew." (Scientific American; 1988) Every eight to twelve years outlying villages would collect remains and return bones to the ancestral village in a ceremonial burial. This is a surprising a find on Cape Cod because the prevailing theory has been that Cape Cod natives migrated seasonally, erecting only temporary camps along the shore. Most ossuaries in Ontario were located within 100 yards of a primary year round settlement lying in close proximity to several outlying villages. The ossuary find, as well as an examination of shell remains which indicated a largely wintertime taking of shellfish, has pointed to a more established coastal habitation, perhaps lasting year round in some cases. If true, this more permanent habitation of the shore was thought to have begun at least as early as the Late Archaic period (ca. 1000 B.C.). The ossuary is arguably the most important archaeological discovery on Cape Cod. The evidence suggests that "by the Late Woodland " ..... " and probably earlier, a cultural system that included permanent settlements had developed on the outer Cape" with Nauset Bay, High Head, and Wellfleet Harbor being the three primary settlements. This interesting academic debate is also important because it suggests that there could be several more, yet undiscovered archaeological sites here, both on the mainland and beneath the flats which were formally upland areas. The sites' existence also proves that this area has a long history of human habitation and that the natural resources here have supported life for thousands of years. This reality supports a sense of place which speaks of humans connecting with their environment in a sustainable way. It reminds us that we need to care for the land here not just for ourselves today, but for those who came before and for

those who will come afterwards. The land outlasts us all. Archaeology reminds us how fleeting our stay here is, and it reminds us that our impact upon the land lasts a very long time. Map 17 shows locations of some of the known archaeological resources of Wellfleet particularly in the Indian Neck area where the ossuary is found.

7. The **Herring River**, with its tributaries Bound Brook, Duck Harbor, Pole Dike Creek and Mill Creek, once formed the largest estuarine system on the outer Cape. The mainstream originated from headwaters in the Gull Pond Chain (Gull, Higgins, Williams, and Herring) and meandered for almost three miles southwesterly to Wellfleet Bay through a floodplain that comprised over 1,000 acres of productive saltmarsh, the largest contiguous saltmarsh in town. Up until the turn of the century, organic production from the estuary and marshlands was sufficient to maintain a thriving shellfish, eel, and herring fishery. The annual proceeds from the herring fishery paid salaries of all elected town employees.

   Initial alteration to tidal flow in the basin began with construction of railroad dikes around 1860. With the reported intentions of eliminating mosquito breeding habitat and creating arable land, the entire estuary was diked off from tidal flow around 1908. In subsequent campaigns against mosquitoes, the diked and subsequently desalinized river system was intensively channeled, ditched and drained, especially in the 1930's. Unfortunately, the immense value of saltmarshes to shellfish and finfish production was not widely appreciated until the 1960's. Intensive wetland drainage continues, all but eliminating habitat upstream of the dike.

   Although the present upland meadow/shrub cover type does comprise habitat for a variety of riparian plants and animals, diking and drainage have eliminated extensive wetlands and severely degraded wetland water quality (Portnoy and Soukup). The adverse effects have been expressed in accelerated plant succession and periodic fish kills.

   Fortunately, the potential commercial, recreational, and aesthetic value of the estuary is still apparent. Recent studies of the saltmarshes just seaward of the dike show organic production to be as high as anywhere in the state. This area represents the northernmost location for diamondback terrapin turtles over the entire Atlantic coast and important feeding and nesting habitat for a once overly harvested species in recovery. The rare salt reed grass (Spartina cynosuroides) also occurs in low numbers just upstream of the dike. For the benefit of the rare species, and for various other environmental, economic, and aesthetic reasons that are well documented, the Herring River Basin would benefit greatly from the planned restoration of tidal flow as discussed in Section 4C. The planning which is currently underway is essential to the future health of one of Wellfleet's most important and unique features.

8. **Wellfleet's Central District**, in most respects, has a well preserved 19th century quality, so much so that in 1989 it was placed on the National Register of Historic Places. Most of the buildings date from the early to middle 1800's, including some 40 art galleries and a variety of craft shops. Uncle Tim's Bridge spans Duck Creek and leads to Hamblin

Park from which there are impressive views of Wellfleet Harbor, the marina, and Cape Cod Bay. The town pier, built in 1960, consists of about six acres of automobile parking, two boat launching ramps, and 185 slips for seasonal boat use as well as the year round commercial fishing fleet. Two hundred and thirty moorings in Chipman Cove, adjacent to the pier, are available from June to November. The west end of Main Street has fine examples of Greek Revival houses, while on School Street there are original 18th century Cape houses. The Congregational Church tower houses the town's clock - unique in the world for tolling time using the system of ship's bells rather than the conventional 12 hour system. Taken as a whole, there are no other places left on Cape Cod that look so much like a 19th century fishing village as does the center of Wellfleet.

9. Both **bayside and ocean beaches** in Wellfleet are widely popular. The town provides public access and, in season, life guard services at four beaches along the Atlantic side of Wellfleet. In addition, there are three Wellfleet Bay and one Cape Cod Bay beach, each with public access, for the use of swimmers, surfers, fishermen, and small boat owners.

10. **Chequessett Neck, Great Island, and Billingsgate** provide unique opportunities for learning about and experiencing the history and ecology of Wellfleet. A road built in the 1950's leads to the town pier along the edge of the harbor to Great Island, an unspoiled area where Cape Cod National Seashore conducts nature walks during the summer. In the winter, harbor seals sun on Jeremy Point - the tip of Great Island. At low tide, Billingsgate, site of late 19th century Wellfleet settlements, can be seen off the end of Great Island. The drive along Chequessett Neck affords views of Wellfleet Harbor and Cape Cod Bay that are nothing short of spectacular.

G. Environmental Challenges

Many of the environmental challenges which Wellfleet faces are a direct result of its development pace and pattern over the past three hundred years. As Wellfleet enters the new millennium, it is increasingly important to reduce the impacts of increasing development through planning which incorporates the protection of conservation land.

1. As described in earlier chapters, the biggest, persistent problems are environmental and public health issues related to wastewater disposal and drinking water quality. Because of its relatively low population density and political climate, sewers have not yet been installed. Wellfleet continues to rely solely on on-site septic systems. Though most of the town's soils are highly permeable, there are still failed systems due to overloading, particularly during the summer. Because the soils are highly permeable, nitrates and viruses are readily transmitted off-site to surface waters, particularly ponds and streams, and ground water. There is insufficient depth to ground water on many lots, leading to the design of "mounded" systems, which can be aesthetically displeasing to many people as well as enabling development to go where it otherwise should not. Although many lots are currently using alternative wastewater treatment systems, pollution in the most densely developed portions of Wellfleet is a pressing issue which will only be alleviated through serious planning measures which reduce pollution sources, improve waste treatment systems, provide public sewering, and/or provide a municipal water supply.

Until these things happen, Wellfleet's drinking water quality in the central district is extremely tenuous.

2. As this is being written in 2004 the town landfill is in the process of being capped. Wellfleet may explore the usefulness of the landfill for conservation and recreation purposes, though nothing has been decided as yet and the site's minimal size (5-6 acres) limits its possibilities.

3. A third issue relates to the impact of continued development on biodiversity and open space availability in general, since there is no local mechanism for requiring dedication or reservation of open space to match the amount of lots being developed. Relative to other Cape towns, there are very few potential subdivisions which would exceed 30 acres in size and fall under the purview of the Cape Cod Commission as Developments of Regional Impact (DRIs). Residential DRIs must dedicate 60 percent of the parcel to open space use; commercial DRIs, 40 percent. Perhaps with the approval of the town Local Comprehensive Plan, development agreements for subdivisions of any size can be instituted by the Planning Board. Commercial developments currently undergo site plan review with input from multiple town boards and agencies.

4. Resource management problems include illegal trash dumping in conservation areas; unauthorized off-road vehicle use in conservation areas; upgrading specific facilities; and, resident Canada geese fouling the golf course and waterways throughout the year.

5. One of the most significant resources of Wellfleet is the harbor. Over the last decade, the Town has been very aggressive in studying this resource and protecting it. Also, by providing a pump-out facility for boaters and replacing storm drains flowing into the harbor, coliformcounts after rains have decreased significantly. However, there is still the problem of nitrogen loading, especially in the smaller embayments of Blackfish Creek, Loagy Bay and Chipman's Cove. Excess nitrogen acts as a fertilizer for marine systems, causing algae to proliferate and eventually die, in turn leading to dissolved oxygen depletion in the water column. This, of course, is detrimental to marine fish and shellfish. For the long-term health of the harbor, it is critical for the Town to adopt a water shed protection plan that incorporates some type of de-nitrifying septic system.

6. Tidal restrictions on Duck Creek, Blackfish Creek, Mayo Creek, and the largest on Herring River are serious problems that, sooner or later, Wellfleet will have to address (see above discussions). In addition to eliminating estuarine habitats and salt marsh functions such as pollution control and storm buffering, tidal restrictions cause severe water quality problems so that most diked marshes have few aquatic animals, except for mosquitoes.