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Regional Wastewater Management Plan
Environmental Assessment - Water Quality

MARCH 2013

COUNTY OF BARNSTABLE
MASSACHUSETTS

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Introduction

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Cape Cod is a sand-and-gravel remnant of the last continental deglaciation that occurred from 15,000 to 20,000 years ago. The Cape is a series of broad, gently sloping outwash plains that are truncated by long, linear moraine deposits found along the present-day Route 6/Mid-Cape Highway and Route 28/MacArthur Boulevard. The glacial deposits are approximately 150 to 900 feet thick from Buzzards Bay to Provincetown, and are generally coarse to medium sand, becoming finer materials at depth. The coarse sands are extremely permeable, making for a high-yielding groundwater system.

The groundwater of Cape Cod is bounded at the top by the water table, which is ubiquitous across the Cape—a sharp transition zone between fresh and marine water at the shore and bedrock below (Figure EAW-1). The groundwater system is recharged solely from precipitation, at a rate of 27 inches per year (approximately 60% of precipitation). The groundwater system is in dynamic equilibrium between recharge and discharge to the surrounding marine waters and flows at approximately 1 foot per day due to gravity. Groundwater located further inland has greater distances to travel to get to the shore, therefore, the accumulation of recharge over the ages mounds up.

The mounds of groundwater are relatively thin and convex and therefore are referred to as "lenses" of groundwater. The Cape Cod aquifer system is composed of six separate lenses, as shown in Figure EAW-2.

GROUNDWATER FLOW

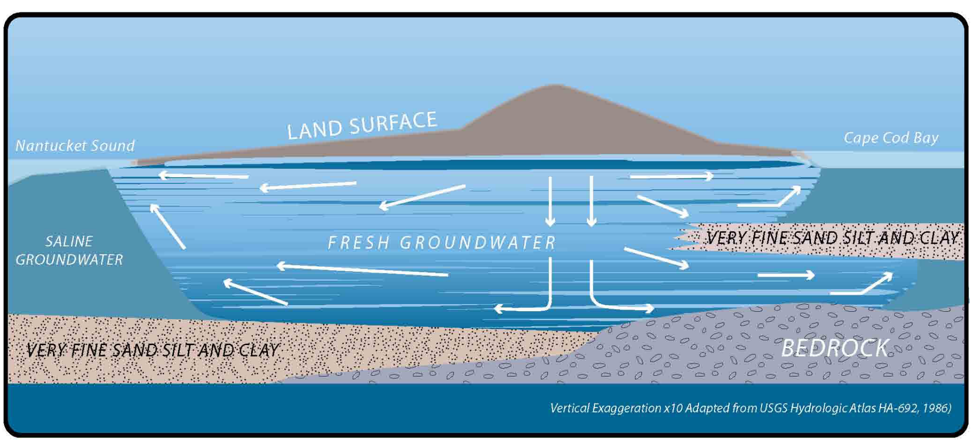


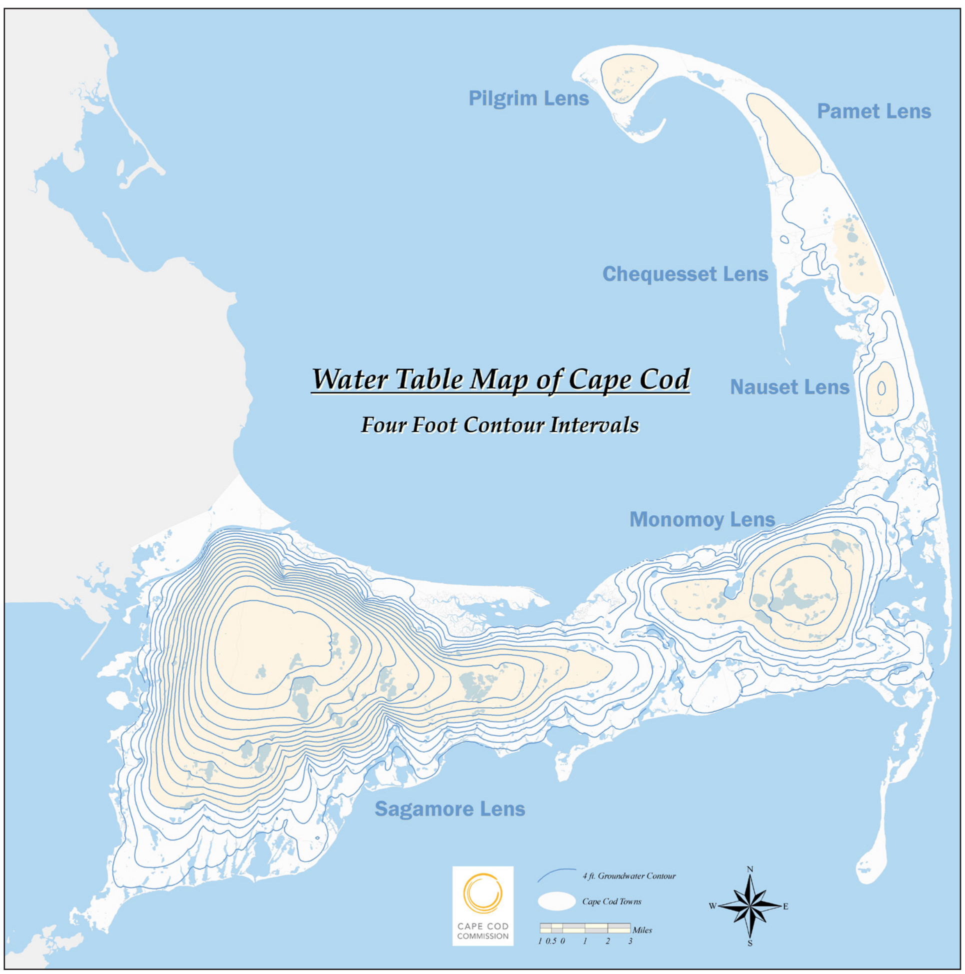
FIGURE EAW-1: Groundwater Flow Dynamics on Cape Cod

SOURCE: US Geological Survey (USGS), 1986

The topographic lines of the aquifer are referred to as "water table contours," which are used by hydrogeologists to plot the exact flow of groundwater. Over the years this effort has led to the use of complex groundwater models to predict and answer many questions about how the aquifer responds to new stresses, such as pumping and the discharge of wastewater.

The Cape Cod Aquifer is extremely susceptible to contamination from various land uses and activities. The aquifer has been seriously impacted in the past from military activities, gas stations, landfills, and a host of other activities. These examples have led to multiple strategies at all levels of government to protect the aquifer, spawning a vigorous industry for the assessment and clean-up of contaminated groundwater. The groundwater of Cape Cod is extremely well protected except for impacts due to the prevalence of residential septic systems.

FIGURE EAW-2: The Cape Cod Aquifer System



SOURCE: Cape Cod Commission GIS

Marine Water

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WATERSHEDS

There are 105 watersheds to the surrounding marine waters. Of those, 57 are watersheds to major coastal embayment systems. The coastal embayments are located at the margin of the aquifer, where they are the ultimate receiver of the aquifer's groundwater discharge. Similar to water supply wells, the watersheds to the embayments are defined by groundwater flow of the aquifer. The watersheds to the coastal embayments extend up to the top of the water table lens. As such they comprise nearly 79% of the land area of Cape Cod (Figure EAW-3). This is not too surprising, given that coastal watersheds stretch from the coastline all the way up to the groundwater divide, which is located along the spine of the peninsula. About 21% of Cape Cod is not in a watershed to a marine embayment, but a watershed where groundwater discharges directly to open coastal water, such as the Cape Cod Canal, Nantucket Sound, Cape Cod Bay, and Atlantic Ocean. These are called "direct discharge areas" and are important areas to consider for potential wastewater discharges since the nitrogen loads would not impact the coastal embayments.

EUTROPHICATION

The impact of wastewater on coastal embayments is a major cause for concern on Cape Cod. Coastal embayments are primary habitats for shellfish, are spawning grounds for commercially important fish stocks, and are primary recreational areas. Since pollutants from land use development, including wastewater, find their way into the groundwater and ultimately to the coast, coastal embayments receive nutrients and other pollutants discharged within their watersheds.

The key nutrient of concern for coastal embayments is nitrogen. Nitrogen can be used as a fertilizer, prompting plant growth that subsequently feeds animals that graze on the plants, and finally bigger animals that feed on the grazers. Eelgrass is the dominant plant in healthy embayment

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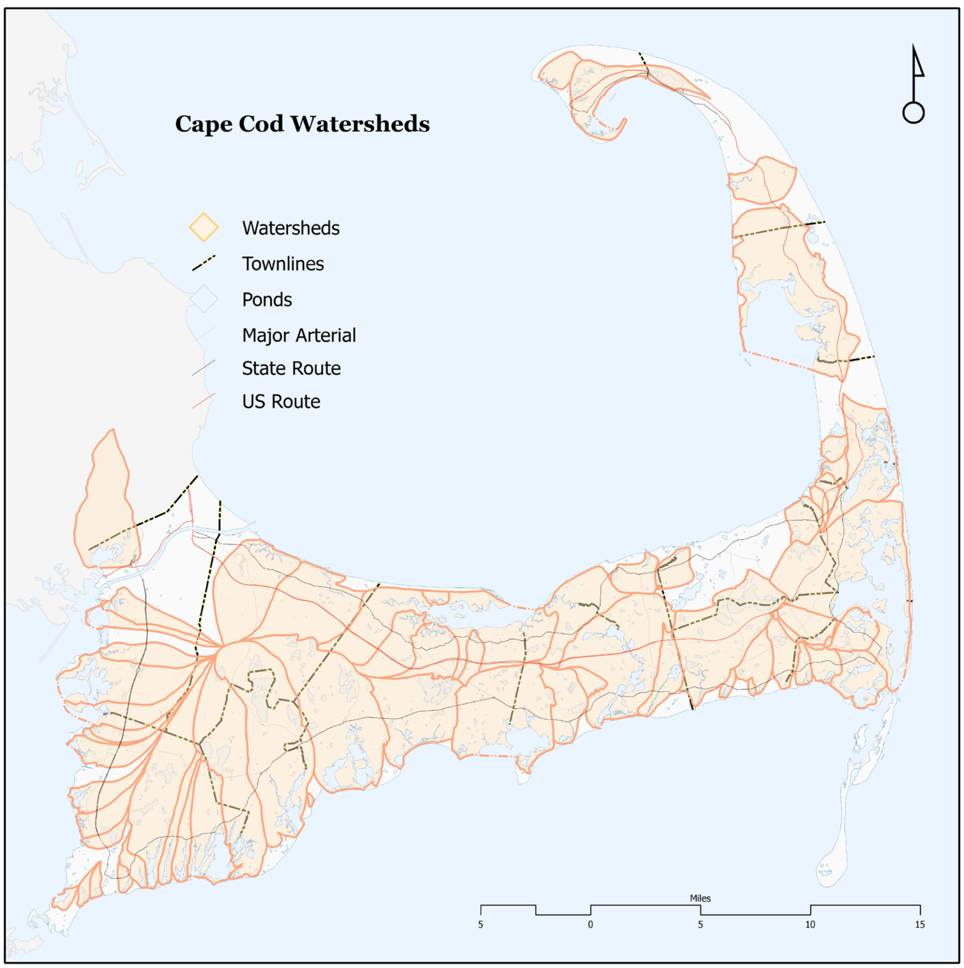
ecosystems, usually surviving on sparse amounts of nitrogen and providing habitat for all the animals living in the embayments. A healthy coastal ecosystem needs some amount of nitrogen to power this cycle. When too much nitrogen is added to an embayment, however, excessive amounts of algae are produced, resulting in large algal mats that replace the eelgrass and destroy the animal habitat, eventually leading to a loss of shellfish. This process is called "eutrophication" (Figure EAW-4). In some cases severe conditions of anoxia have occurred that result in fish kills and aesthetically unpleasing conditions. The nitrogen load that changes a healthy system to a eutrophic condition is defined as a critical threshold—more often referred to as a Total Maximum Daily Load (TMDL) under the federal Clean Water Act—that requires the restoration of impaired surface water bodies. For more information on the federal Clean Water Act, see the Regulatory and Planning Initiatives section.

FIGURE EAW-3: Cape Cod Watersheds to Coastal Embayments



SOURCE: Cape Cod Commission GIS

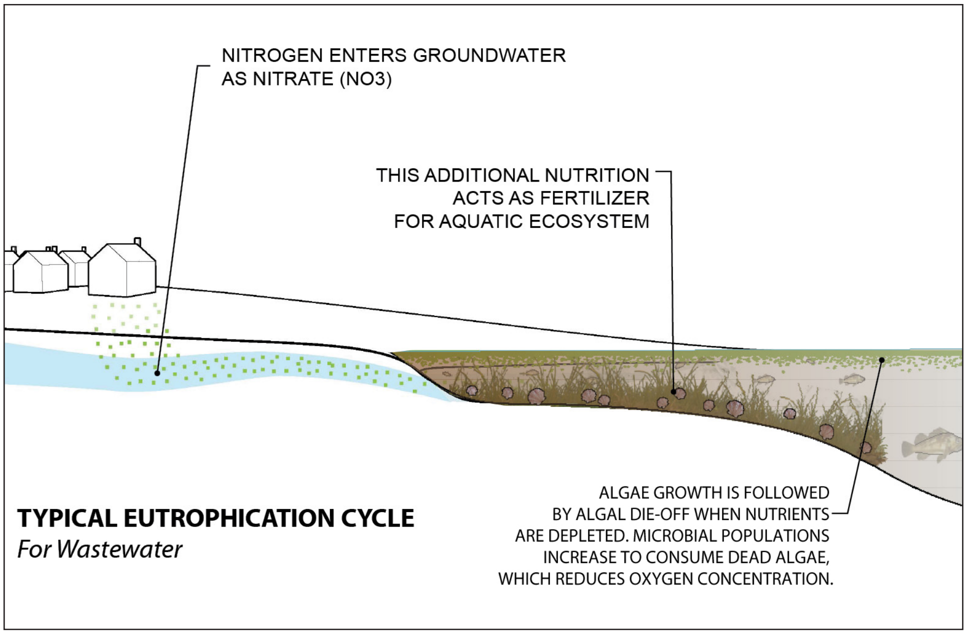


FIGURE EAW-4: The Process of Eutrophication

SOURCE: Cape Cod Commission

CAPE COD STEPS UP TO THE COASTAL WATER QUALITY ISSUE

Residential development in the last 25 years has sprawled across Cape Cod, consuming open space and dispersing wastewater throughout the aquifer. At the same time, groundwater, moving at an average rate of one foot per day, carries and ultimately discharges the nitrogen from wastewater to the coast. During the 1990s, ecological impacts on Cape Cod's surrounding marine embayments were widely documented (for example, Costa, 1988; Howes et al., 1999). Wastewater from septic systems was found to be the primary source of nitrogen overloading the coastal embayments, resulting in algae growth, replacement of pristine bottom environments with thick macro-algae mats, loss of shellfisheries, and, at times, fish kills (Cape Cod Commission, 1998).

Concurrent with the beginning of our awareness about coastal waters, the Cape Cod Commission adopted a regulatory requirement that proposed development projects within watersheds to embayments with water quality problems should have no-net nitrogen loading. In other words, the amount of nitrogen added by the project must be offset by an equivalent reduction. The Minimum Performance Standard (MPS) was well defined and justified by the science (for more information about the Regional

Policy Plan and MPS, see the Regulatory and Planning Initiatives section). Several Barnstable County task force committees, which reviewed the Commission's regulatory program, accepted it as a necessary interim step to halt continued degradation of the Cape's coastal water quality. Over the years, it became increasingly clear to many of the organizations involved in assessing and protecting embayments that a more comprehensive effort was necessary to link together regulatory and scientific activities and to realize solutions for many of the observed coastal water quality problems.

The general science to define critical thresholds and TMDLs has advanced considerably over the past two decades. Efforts have included defining watersheds, estimating watershed nitrogen loads, collecting water quality data, modeling tidal flushing, and evaluating ecosystem interactions between embayment species. Organizations such as the Cape Cod Commission, Buzzards Bay Project, Massachusetts Department of Environmental Protection (MassDEP), Buzzards Bay Coalition (BBC), Waquoit Bay National Estuarine Research Reserve (WBNERR), Woods Hole Oceanographic Institution (WHOI), Marine Biological Lab (MBL), the School for Marine Science and Technology (SMAST) at the University of Massachusetts-Dartmouth, and US Geological Survey (USGS) all played a role in these efforts.

MASSACHUSETTS ESTUARIES PROJECT

In 2001, the Massachusetts Department of Environmental Protection and the University of Massachusetts-Dartmouth, School of Marine Science and Technology (SMAST) began the Massachusetts Estuaries Project (MEP). The MEP was estimated to cost $12 million over six years. Funding is broad based, with half coming from the state and the other half coming from local and agency sources. Barnstable County, through the Cape Cod Commission, has provided more than $700,000 to the MEP over the last eight years as direct assistance to participating Cape Cod towns. The MEP has resulted in numerous technical reports and documents that have been approved by state, federal, and county regulatory agencies. The MEP, by providing a regionally consistent methodology, has been able to provide technical work and documents at a significant cost savings compared to what it might cost any single town to undertake similar work.

The MEP developed a rigorous "Linked Model" approach that includes components of the various disciplines necessary to understand and project how nonpoint-source nitrogen loading in a watershed translates into coastal water quality deterioration. Data input into these models includes three years of volunteer-collected coastal water quality data; tidal flushing data; bathymetric information for estuaries and freshwater ponds; pond water quality data; current and historic eelgrass coverages; water use information; wastewater treatment plant performance; landfill monitoring data; watershed delineations; sediment nutrient regeneration; and wetland nitrogen attenuation.

MEP REPORT STATUS AND FINDINGS

As of October 2012, a total of 36 MEP technical reports were complete and another 10 were pending. The technical reports are available for viewing on the [MEP website](). The results of the technical reports have

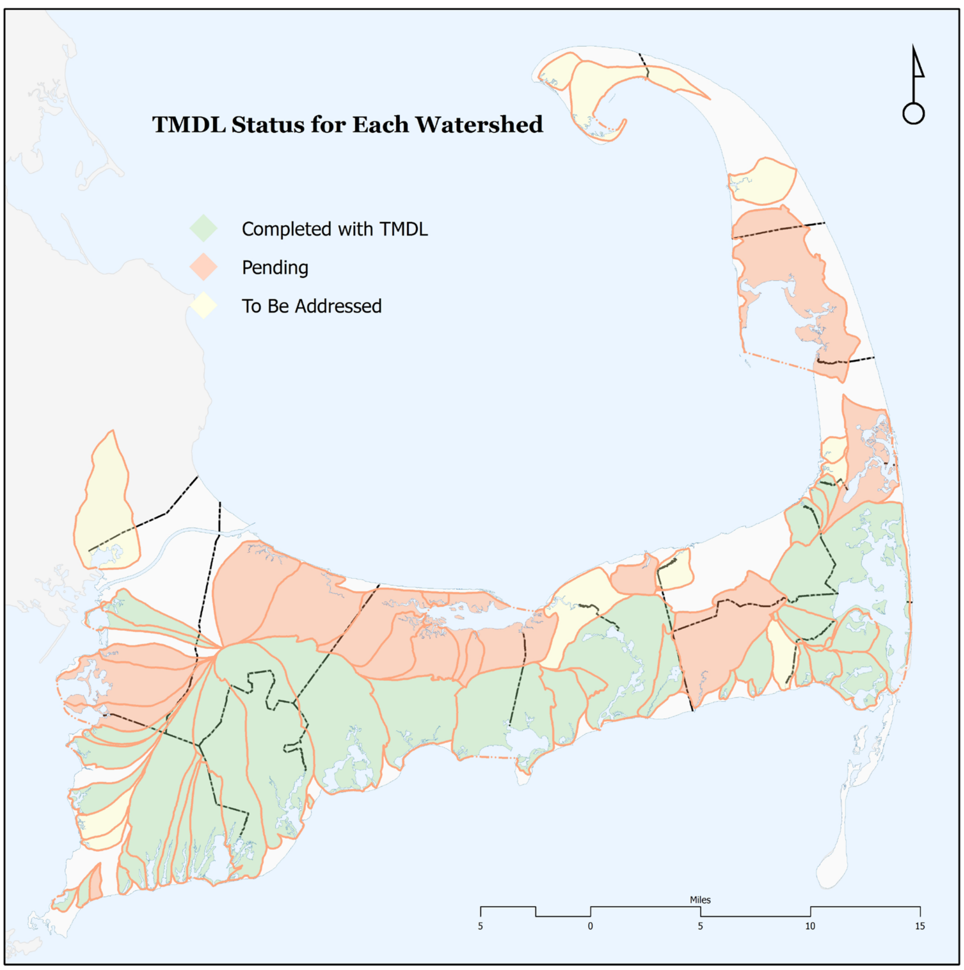


FIGURE EAW-5: TMDL Status by Watershed

SOURCE: Cape Cod Commission GIS and the Massachusetts Estuaries Project

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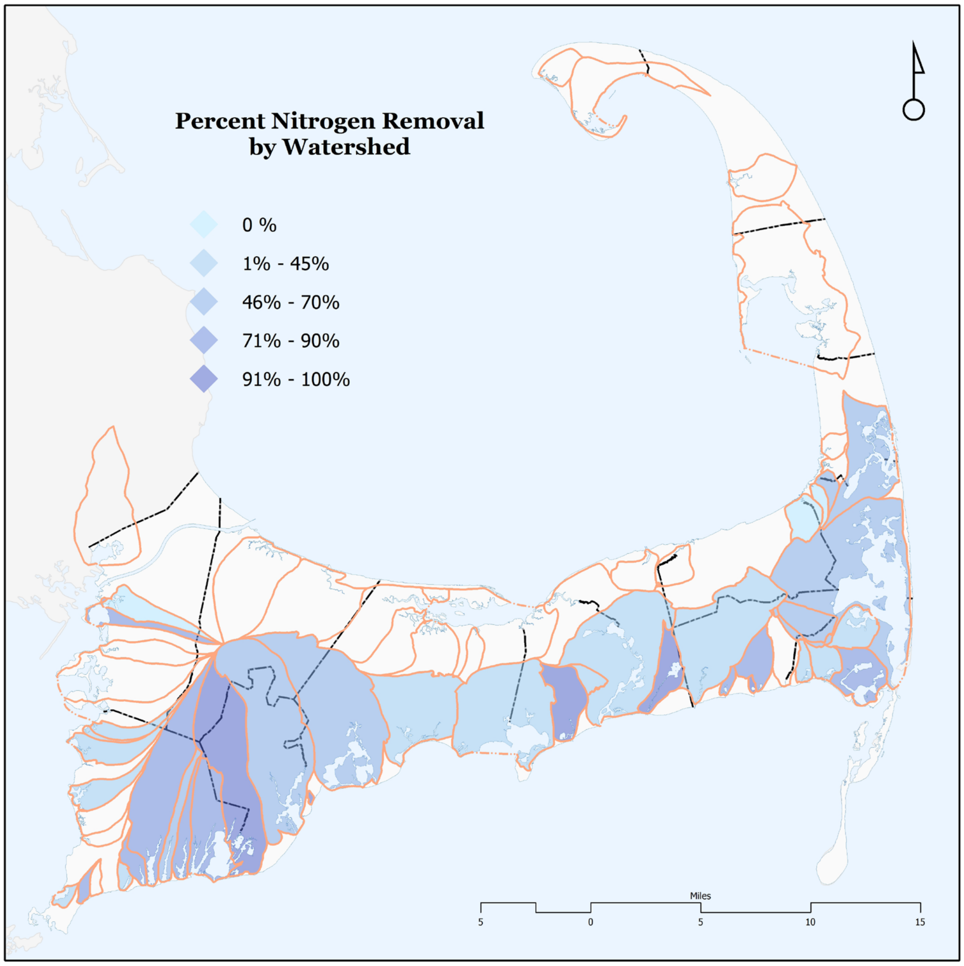

FIGURE EAW-6: Percent Removal Required to Meet TMDLs in Watersheds with Massachusetts Estuaries Project (MEP) Technical Reports

SOURCE: Cape Cod Commission GIS and the Massachusetts Estuaries Project

been adopted as the federal- and state-approved TMDLs, which makes them the basis for watershed nutrient-management planning. Figure EAW-5 shows the TMDL status by watershed. The percent of nitrogen removal required to meet these TMDLs is shown in Figure EAW-6. The TMDLs can be viewed on both the MassDEP website, and US EPA website. Although the amount of nitrogen from the watershed is an important consideration in evaluating the potential impact on these embayments, other factors such as tidal range and embayment volume play a significant role. Embayments on the southern coast are typically more susceptible to impacts because the tidal range is generally one half to one third of the range observed in Cape Cod Bay. For example, Wellfleet Harbor has a nine-foot tidal range, while Popponessett Bay has a three-foot tidal range.

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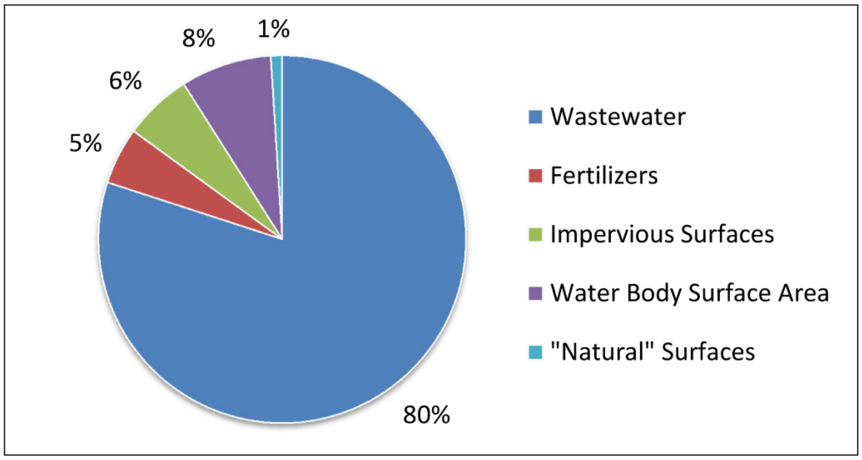

FIGURE EAW-7:
Average Cape-wide
Sources of Nitrogen

Based on information collected from the Massachusetts Estuaries Project

More water is available to dilute and remove nitrogen loads in Wellfleet Harbor than in Popponessett Bay.

Water quality testing for the MEP clearly documented that many of Cape Cod's watersheds have impaired water quality and ecological damage due to nitrogen loading in their watersheds. Nitrogen from septic systems accounts for approximately 80% of the watershed load, with stormwater and fertilizers accounting for the remainder of the locally controlled nitrogen load (Figure EAW-7). Other sources of watershed nitrogen are road runoff and fertilizers. Atmospheric deposition of nitrogen in rainfall is another source that is accounted for in the road runoff contribution for the watershed and as direct rainfall on the embayment itself.

The technical reports and TMDLs contain estimates for how much watershed nitrogen needs to be removed to meet the TMDL. Since controlling runoff and fertilizer use is difficult to implement and enforce and accounts for far less that the septic system contribution, the TMDL also specifies how much wastewater nitrogen from only septic systems needs to be removed to meet the TMDL. In many watersheds, the amount of nitrogen needing to be removed is 100% (see Figure EAW-6). When the amount of nitrogen removal required is averaged across Cape Cod, the average removal rate is more than 50%—a significant reduction to comply with the requirements of the TMDL. The consensus of opinion is that only significant wastewater infrastructure can remove the amount of nitrogen necessary to restore water quality to Cape Cod's embayments.

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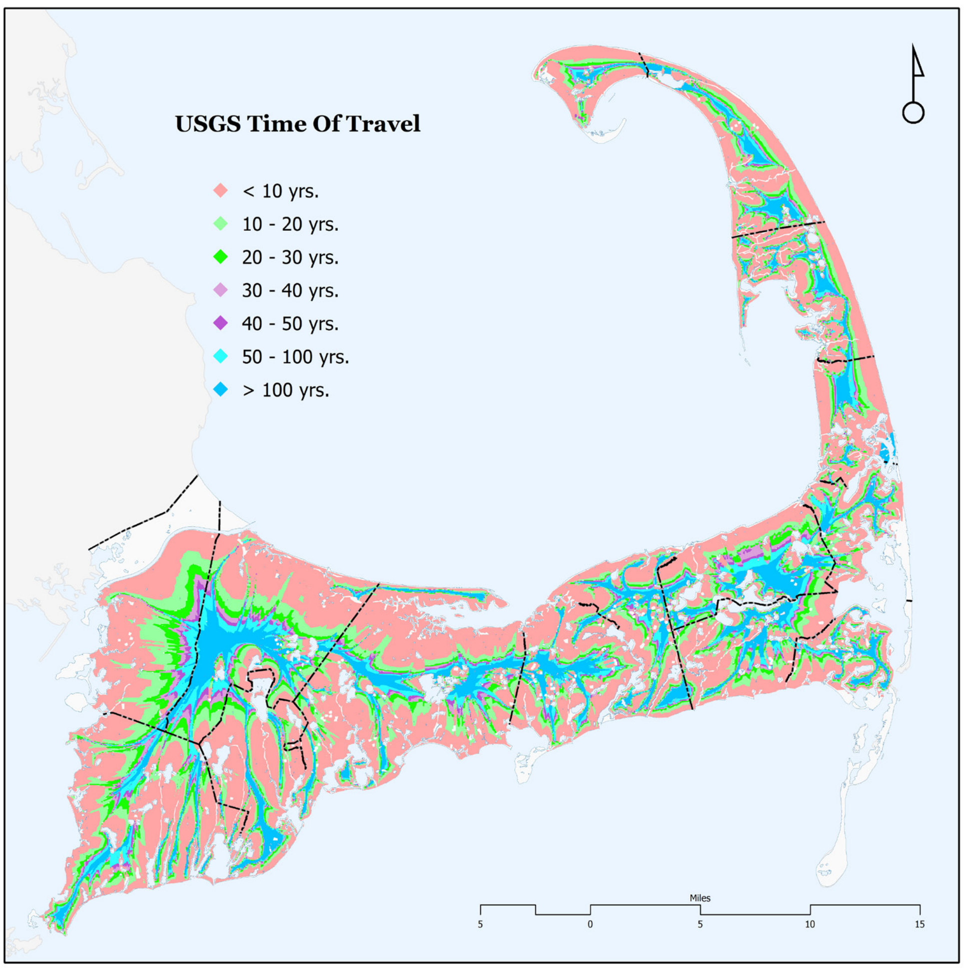
GROUNDWATER RESPONSE TIME

The hydrogeology of Cape Cod is largely composed of coarse sands with considerable permeability of a high-yielding groundwater system. The travel time for wastewater pollutants from their initial entrance into groundwater to the point when they reach an embayment is less than 10 years across almost half of Cape Cod. This presents the likelihood that wastewater treatment options, once implemented, may result in water quality improvements within 5–10 years in some of our polluted embayments. Figure EAW-8 shows the US Geological Survey (USGS) time-of-travel areas on Cape Cod, indicating the years required for a nitrogen particle to travel from its point of entrance to the groundwater to Cape Cod's coastal embayments.

FIGURE EAW-8: Time-of-Travel Areas on Cape Cod

The pink-shaded area indicates a travel time of 10 years or less.



SOURCE: US Geological Survey, 2004

Drinking Water

The Cape Cod Aquifer is one of the most productive groundwater systems in New England. It is a “sole source aquifer” providing drinking water to over 500,000 people (US EPA, 1982) and is derived from over 160 gravel-packed municipal supply wells and hundreds of private wells. The aquifer is recharged solely from rain and ultimately discharges to the surrounding embayments, if not otherwise captured by wells and groundwater-fed ponds (Strahler, 1966).

The Cape Cod Aquifer provides 100% of the Cape’s drinking water. There are 17 separate water districts or departments across Cape Cod, 158 gravel-pack water supply wells, and one surface reservoir. Approximately 85% of Cape Cod is serviced with public water. The Outer Cape communities of Truro, Wellfleet, and Eastham are serviced almost entirely with private or small-volume wells.

WATER QUANTITY

Since 2000, public community drinking-water suppliers have pumped on average about 10.7 billion gallons of groundwater per year from Cape Cod’s sole source aquifer. Figure EAW-9 shows that pumping over the last decade has fluctuated due to seasonal climatic variations, such as rainy summers, but for the most part is fairly consistent. Studies by the US Geological Survey indicate that groundwater pumping accounts for approximately 10% of the annual recharge from precipitation.

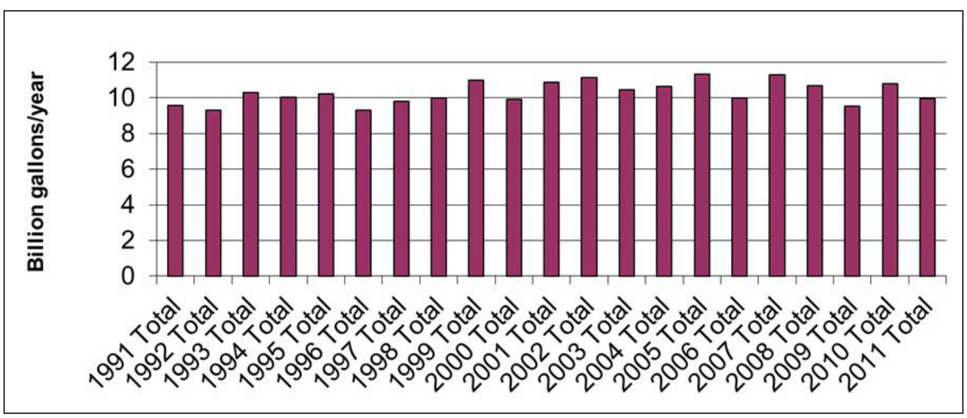


FIGURE EAW-9: Total Yearly Pumping from Cape Cod Public Supply Wells

SOURCE: Cape Cod Commission and Massachusetts Department of Environmental Protection

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Information about water use is essential to planning for wastewater infrastructure to meet current and future needs. The Cape Cod Commission analyzed water-use data from town water suppliers. The data were used to estimate water use on parcels with private wells. Approximately 85% of the parcels on Cape Cod are served by town water. The remaining 15% rely on private wells, most of which are located on the Outer Cape and in several large private well areas in West Barnstable and Sandwich. Water-use flow by parcel is fundamental data that are used to estimate wastewater generation. The MEP convention is that approximately 90% of the water used by a household ends up as wastewater. The average residential per-lot water use on Cape Cod is 169 gallons per day (gpd). The average non-residential water use is 586 gpd.

The total amount of water use was confirmed by comparing 2008 to 2010 data from water suppliers to the total amount reported in the Annual Statistical Reports that suppliers submit to the MassDEP. The results indicate that public water suppliers provide 9.3 billion gallons of water per year to Cape Cod. Applying average water-use rates for residential and non-residential uses to parcels served by private wells add 1.2 billion gallons of water per year, for a total of 10.5 billion gallons of water per year.

DRINKING WATER PROTECTION

More than 40 years ago water planners combined their knowledge of groundwater with policy mechanisms to protect Cape Cod drinking water. Adoption of wellhead protection areas (Zone IIs) was a major strategy to protect the land area that receives precipitation to recharge the pumping wells. Today each town has zoning and board of health bylaws to protect their wellhead protection areas, which are collectively shown on Figure EAW-10. In addition, the public embraced acquisition of land for protection for wellhead areas through local, regional and state actions like the Cape Cod Land Bank. The Wellhead Protection Area state regulations (310 CMR 22) and Cape Cod Regional Policy Plan minimum performance standards prohibit or limit land uses that are potentially detrimental to water quality. MassDEP regulations do not specifically prohibit large publicly owned wastewater treatment works in Zone II's, but the RPP limits their use in Zone IIs for the restoration of water quality.

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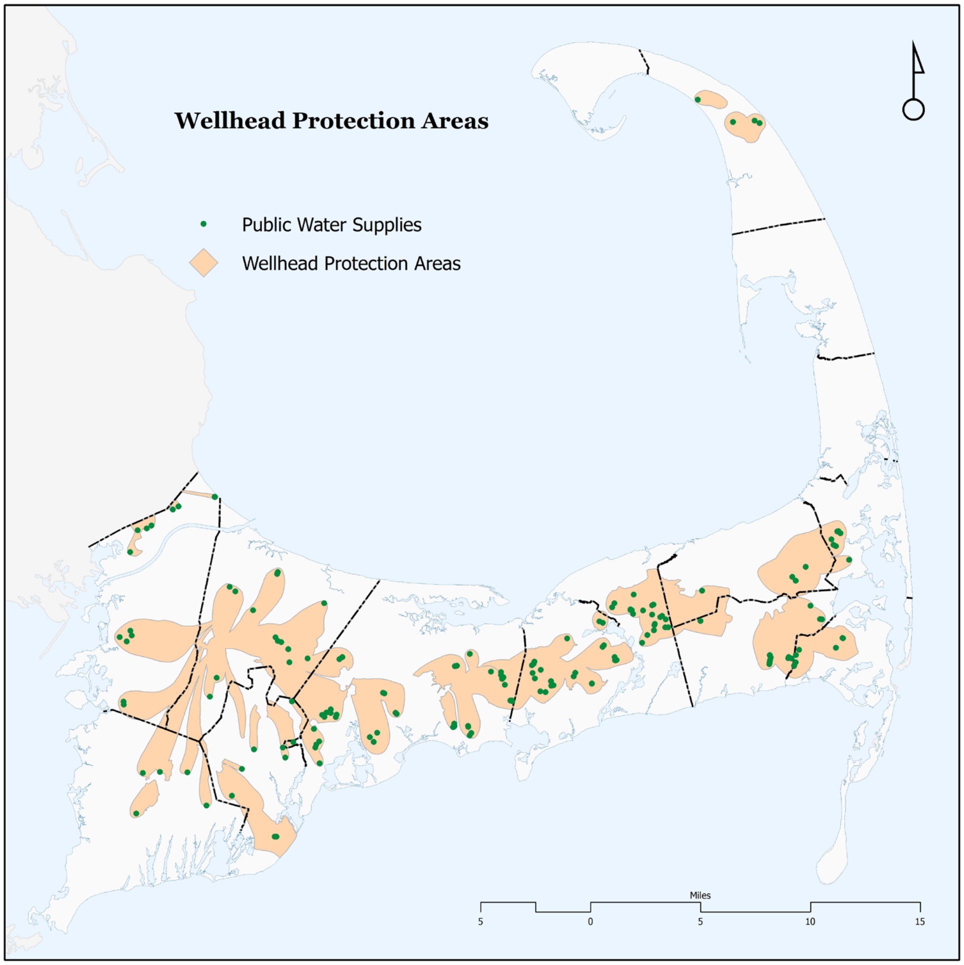

FIGURE EAW-10: Cape Cod Wellhead Protection Areas (Zone IIs)

SOURCE: Cape Cod Commission GIS and Massachusetts Department of Environmental Protection

NITROGEN IN DRINKING WATER SUPPLIES

Nitrate-nitrogen is a major component of human wastewater. Nitrogen passes through septic systems virtually untreated and is introduced to the underlying groundwater. Nitrate, is often used as an indicator of drinking water quality. A maximum contaminant limit (MCL) of 10 parts per million (ppm) of nitrate as nitrogen for drinking water supplies has been established by the US EPA and adopted by Massachusetts state regulation. The limit was established to protect infants from methemoglobinemia or "blue-baby" syndrome, a potentially fatal blood disorder that can occur when too much nitrate limits the amount of oxygen in the blood. Although inconclusive, some health studies have also linked high nitrate levels to certain types

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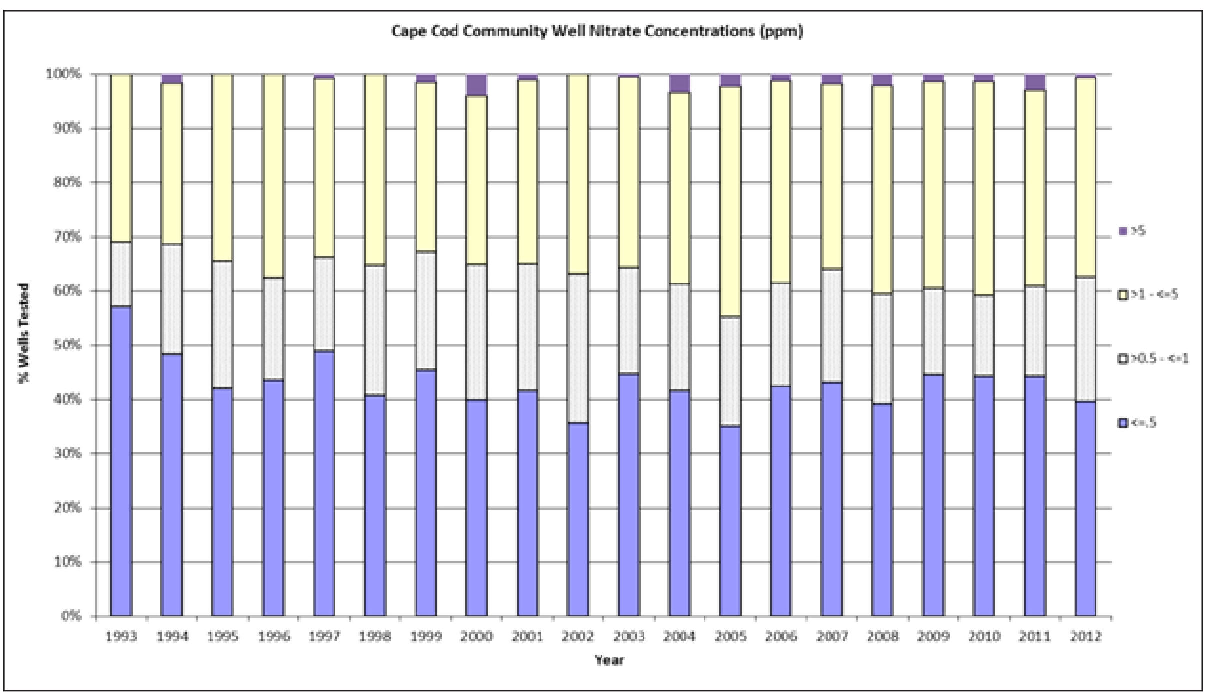
of cancer. The Cape Cod Regional Policy Plan (RPP)established a nitrogen loading concentration of 5 ppm to ensure that nitrate levels in drinking water will not approach the federal standard. This protection standard had been adopted both locally and at the state level.

The quality of Cape Cod's community public drinking water supply is generally very good, but during the past 15 years has degraded somewhat (see Figure EAW-11). Between 1993 and 2008, the percentage of public supply wells tested with nitrate levels at or below 0.5 ppm (considered very clean) fell from 57% to 42%. During the same time period the percentage of public drinking water levels with nitrate levels between 0.5 and 5 ppm (the RPP limit) increased from 43% to 55%. The percentage of wells testing above the 5 ppm standard has varied between 0% and 4% during the past 15 years and no community public supply wells have tested over 10 ppm. The 2008 nitrate concentrations in the Cape's community supply wells are shown on Figure EAW-12. In general, the wells with higher concentrations are the older ones that are located

FIGURE EAW-11: Nitrate Levels in Cape Cod Public Supply Wells, in Parts per Million (ppm)

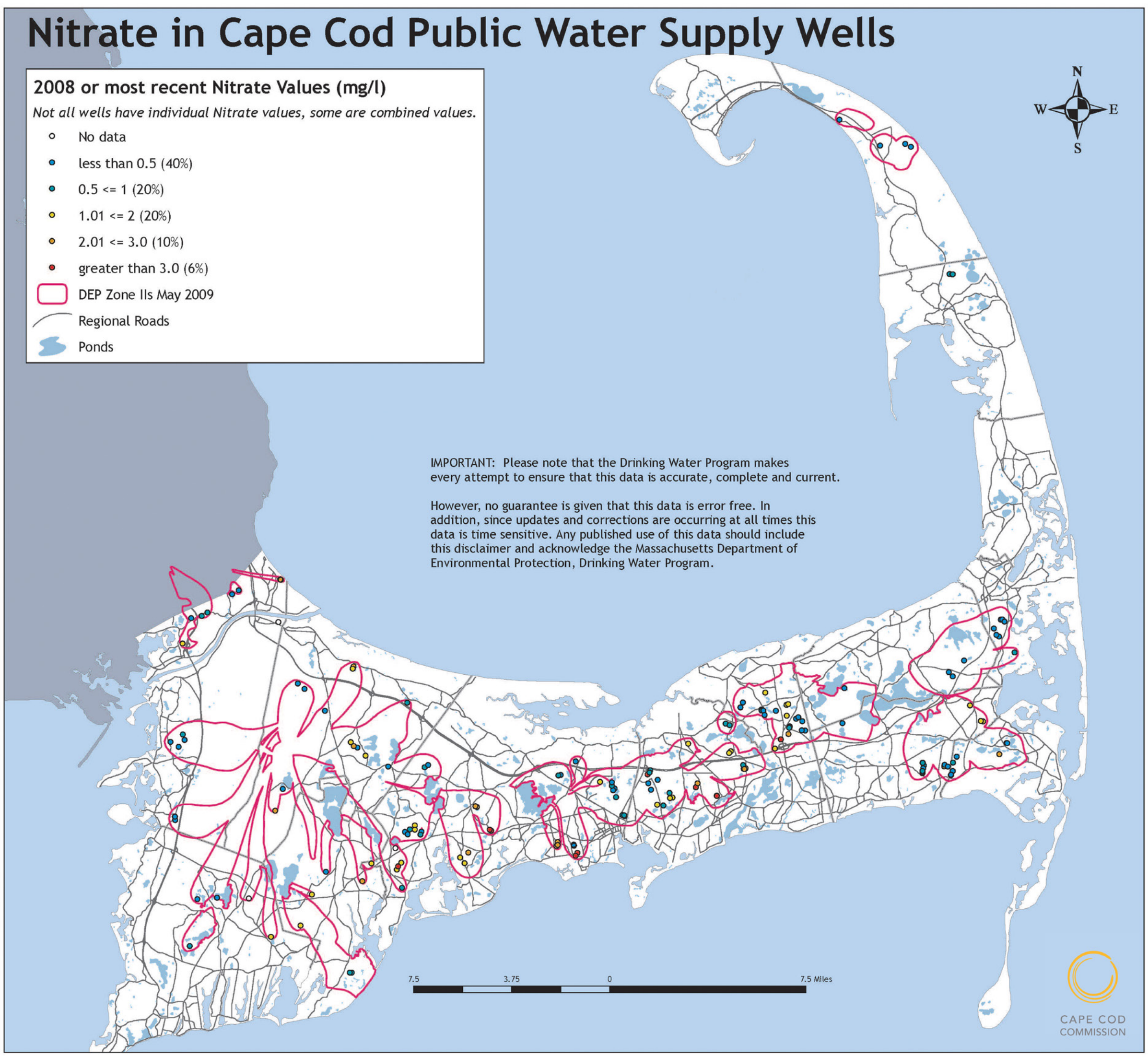
Purple >5 ppm **Yellow** >1 to ≤5 ppm **Gray** >0.5 to ≤1 ppm **Blue** ≤0.5 ppm



SOURCE: Cape Cod Commission and Massachusetts Department of Environmental Protection downgradient of high-density residential areas. However, even well-protected water supply wells have somewhat elevated concentrations of nitrate that is derived from septic systems and other non-point sources.

Small volume non-community drinking water wells, which are concentrated on the Outer Cape, are generally shallower, pump less water, and are often closer to septic systems. These wells have shown a greater degradation than the larger and deeper community wells.

FIGURE EAW-12: Nitrate in Cape Cod Public Water Supply Wells



SOURCE: Cape Cod Commission GIS and Massachusetts Department of Environmental Protection

Since 2000, the number of very clean non-community public wells with nitrate levels below 0.5 ppm has stayed around 35% compared to 42–44% of the deeper community public supply wells. The non-community wells with levels greater than 5 mg/l ranged from 7% to 15% compared to 3% of the community wells. The number of non-community wells with nitrate levels greater than the MCL of 10 mg/l has ranged from 2% to 6%. All of the wells exceeding the drinking water limit are located on the Outer Cape where wastewater disposal and private water supply often occur on the same lot. In response to poor water quality, Wellfleet invested in a public water supply system to serve its central downtown district, and Eastham has begun water supply site investigations as a first step to provide a public water system.

EMERGING COMPOUNDS: PHARMACEUTICALS AND PERSONAL CARE PRODUCTS

Nitrate-nitrogen, besides being a contaminant itself, can also indicate the possible presence of other wastewater contaminants such as disease causing organisms, solvents, cleaners, petroleum compounds, pharmaceuticals and personal care products (PPCPs), and other emerging contaminants. “Emerging contaminants” are chemicals or microorganisms that are not commonly monitored or regulated in the environment, but are suspected of having potentially adverse ecological and (or) human health effects. They can include hormones, human and veterinary pharmaceuticals, and household products such as soaps and lotions, insect repellents, perfumes and other fragrances, sunscreens, and hand sanitizers.

Numerous national studies have investigated the occurrence of these emerging compounds in wastewater, surface water, and groundwater. In 1999 and 2000, the US Geological Survey (USGS) conducted a national stream reconnaissance testing 139 streams in 30 states for 95 organic wastewater compounds (OWC; National Water Quality Assessment Program). Eighty-two of the 95 compounds were detected in at least one sample, and 80% of the streams had at least one OWC detected (Barnes et al., 2002). In 2000, USGS sampled 47 groundwater sites across 18 states. Ninety-eight percent of the sites sampled had detections of emerging contaminants, with 46 of the 83 contaminants being found at least once (Barnes et al., 2008).

During 2001, USGS analyzed 25 ground and 49 surface-water untreated public drinking water supply sources in 25 states. Ninety-six percent of the samples showed at least one emerging contaminant. The emerging contaminants were more frequently detected in surface-water than groundwater sources (Focazio et al., 2008). Generally, all of these studies have detected the presence of a variety of organic wastewater contaminants and PPCPs. The detections were more common in the stream samples (86%) and surface water samples than in groundwater (35%). Mixtures of chemicals were common and the concentrations measured were generally at low levels (often less than 1 microgram/liter, just slightly above detection levels).

In June 2004 the US Geological Survey and the Barnstable County Department of Health and the Environment (Zimmerman, 2005), sampled wastewater sources and public, semi-public, and private drinking water supplies on Cape Cod that were thought to be affected by wastewater because of previously high nitrate-nitrogen concentrations. Forty-three of the 85 PPCP and organic wastewater contaminant compounds for which the samples were analyzed were detected in the wastewater samples. Thirteen were detected in low concentrations (less than 1 microgram/liter) in the private and semi-public drinking water supplies and three, an antibiotic, an antidepressant, and a solvent, were detected in the public water supply.

In May 2010 the Silent Spring Institute reported that PPCPs were detected in 75% of 22 public water supply wells sampled. In general, wells with higher levels of nitrate with higher-density land development in the wellhead protection areas had a greater number of detections than those wells that were better protected by lower density and open space.

Although the ability to detect these emerging compounds at extremely low levels in drinking water has been greatly improved, the human health effects from these low-level concentrations are not well documented.

In the absence of better information about the actual occurrence of these compounds and the need to provide a level of protection, MassDEP recently incorporated very stringent performance standards for proposed wastewater discharges in Zone IIs. MassDEP has adopted a Total Organic Carbon (TOC) concentration of 3 mg/l. TOC is a surrogate for PPCP. Some studies have documented that PPCP will be absorbed onto particulates of carbon. It is thought that removing this carbon will provide a level of protection to the underlying aquifer and public supply wells; however,

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removing TOC to this level will require an extremely high level of treatment with 20–30% higher capital treatment costs and higher annual operation and maintenance. Investigations into the transport of PPCP have found that the majority of these compounds do not travel very far in the groundwater. In fact, monitoring wells downgradient of existing wastewater disposal sites on Cape Cod have found concentrations of TOC below the 3 ppm concentration.

Additional investigation on the occurrence of CECs in groundwater will be needed to address the wastewater disposal options for any particular selected site that is located in a Zone II. In any case, substantial costs can be saved by avoiding wellhead protection areas and Zone IIs when locating potential wastewater disposal sites.

Freshwater Ponds

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The lakes and ponds on Cape Cod formed about 12,000 years ago during the last stage of the Wisconsin glaciation. As glaciers retreated from Cape Cod, they left behind large chunks of ice. As these chunks of ice melted, the landscape above them collapsed, forming large depressions called "kettle holes." Where these depressions dip below the groundwater table, they are filled with water and create the hundreds of ponds we see on Cape Cod today (Figure EAW-13). Typically, the ponds lack a surface water inlet or outlet. Instead, the sandy sides of these ponds allow a steady inflow and outflow of water to and from the adjacent aquifer. The pond surfaces generally fluctuate up and down in response to the seasonal rise and fall of the water table, giving us a window into the aquifer. As part of the regional aquifer system, the ponds are linked to drinking water and coastal estuaries, as well as any pollutants added to the aquifer.

Cape Cod has nearly 994 ponds covering nearly 11,000 acres (Table EAW-1). These ponds range in size from less than an acre to 735 acres, with the 21 biggest ponds having nearly half the total Cape-wide pond acreage. Two hundred and eight are classified as great ponds (ponds equal to or greater than 10 acres) and approximately 40% of the ponds are less than an acre (Cape Cod Ponds and Lakes Atlas, 2003).

Regardless of size, fresh water ponds are an important part of the Cape Cod aquifer system, providing critical wildlife habitat and recreational uses including swimming, fishing, and boating. Recent property values

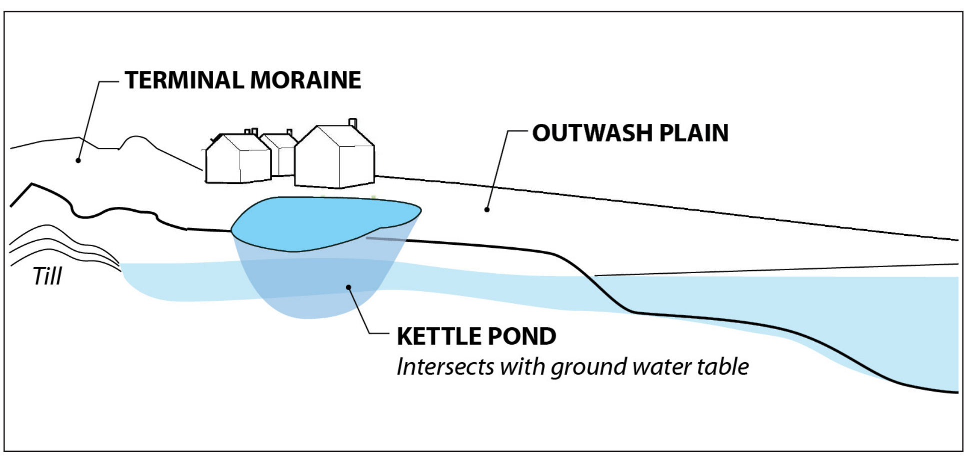

FIGURE EAW-13: Geology of Kettle Hole Ponds

SOURCE: Cape Cod Commission

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TABLE EAW-1: Cape Cod Pond Information

LARGEST PONDS		
POND	TOWN	ACRES
Long	Brewster/Harwich	743
Mashpee-Wakeby	Mashpee	729
Wequaquet	Barnstable	654
Great Herring	Bourne	373
Johns	Mashpee	338

DEEPEST PONDS		
POND	TOWN	DEPTH (feet)
Mashpee-Wakeby	Mashpee	95
Cliff	Brewster	84
Ashumet	Falmouth	84
Long	Brewster/Harwich	72
Long	Falmouth	66

MOST COMMON NAMES	
NAME	NUMBER OF PONDS WITH NAME
Mill	10
Long	9
Flax	8
Grass or Grassy	7
Round	6
Lily	6

# OF PONDS BY TOWN		
TOWN	TOTAL	>10 ACRES
Barnstable	184	27
Bourne	73	7
Brewster	76	22
Chatham	44	7
Dennis	57	6
Eastham	23	5
Falmouth	142	23
Harwich	63	20
Mashpee	56	9
Orleans	63	4
Provincetown	31	3
Sandwich	63	10
Truro	20	4
Wellfleet	29	8
Yarmouth	70	10
TOTAL:	994	165

UNIQUE NAMES
Flying Squirrel, Cat Swamp Pond, Widger Hole, Chigger Pond, Pinkwink Pond, Doanes Bog Pond, Canawa Pond

SOURCES: Cape Cod Commission GIS, Pond and Lake Stewardship (PALS) 2001 Water-quality Snapshot, Massachusetts Department of Fish and Game and sales show that demand for pond-front properties is increasing. With this increased use often comes the loss of water quality and habitat value.

Cape Cod's freshwater ponds are fragile systems, especially vulnerable to pollution and human activity. The soils lack the geological buffering to neutralize acid rain, and sandy soils allow pollutants to drain rapidly through groundwater infiltration and stormwater runoff. The slow buildup of nutrients from surrounding land use development can be difficult to detect and abate, but can literally kill a pond through the process of eutrophication. The symptoms of eutrophication are excess primary growth of algae caused by an excess of nutrients from road runoff, septic systems, and fertilizers. Eutrophication leads to an overabundance of plant life, oxygen depletion, and eventual fish mortality. Physical impacts to ponds also result from the loss of shoreline buffers as pond-front property is developed, and as shorelines erode from all-terrain vehicles and pedestrian access.

During the past few years, more attention has been focused on pond issues, perhaps because more people are living on Cape Cod and more demands are being placed on the pond resources. Local Cape Cod newspapers have described concerns over rising and falling water levels, algal blooms, and fish kills. Public debates about permitting of public drinking water supply and golf course irrigation wells and their impacts on nearby pond levels and discussions about conflicts between swimmers and watercraft users have also generated newspaper articles. The public attention has often led to the creation of watershed or pond associations by concerned citizens and subsequent management action by a town agency to resolve the issues of concern.

As the study of lakes has advanced, science has provided details about the impacts of these decisions and, more importantly, translation of the science into potential activities to repair and prevent impairments of lake ecosystems. Some local bylaws have required naturally vegetated buffers to decrease or eliminate nutrient-laden stormwater or lawn runoff. Alum or other sequestering agents have been added to ponds to cover the sediments and prevent internal regeneration of nutrients from pond sediments. Plant harvesters have been developed to remove excessive growth of aquatic vegetation and the nutrients that could be released from them as they decay. Chemists have developed herbicides that target specific invasive plant species. Some state regulations and laws have required the production of detergents with less phosphorus.

Common fish currently found in Cape Cod ponds include perch (yellow and white), brown bullhead, pumpkinseed, bass (largemouth and smallmouth), banded killifish, American eel, and alewife. Current efforts in support of sport fishing in freshwater ponds have included stocking of trout and bass.

PALS

In 2001 a coalition of groups interested in protecting ponds received from the Massachusetts Watershed Initiative a $30,000 grant to develop a Cape Cod pond stewardship strategy known as the “Ponds and Lakes Stewardship” (PALS) program.

The Cape Cod Pond and Lake Atlas, published by the Cape Cod Commission in 2003, provided a status report on the PALS program. It documented the outreach and education activities leading to the creation of the PALS program, reviewed water quality data collected by volunteers during the 2001 PALS Snapshot from over 190 ponds, used this data to develop Cape Cod-specific indicators of pond impacts, reviews data collected in previous studies, and details further efforts necessary to move pond protection and remediation forward on the Cape.

POND WATER QUALITY

Water quality in Cape Cod ponds is significantly impacted by surrounding development. Review of 2001 dissolved oxygen concentrations and comparison of 1948 and 2001 dissolved oxygen concentrations suggest that many of these pond ecosystems are not only impacted, but also seriously impaired. Based on information in the pond atlas, between 74% and 93% of the Cape’s ponds are impacted by surrounding development or uses. Based largely on dissolved oxygen information, approximately 45% of all the ponds and 89% of the deepest ponds are impaired. The findings suggest that the low dissolved oxygen concentrations observed in the ponds are not “natural” conditions, but are the reflection of 50 years worth of impacts from surrounding development and land use.

The annual PALS water-quality snapshot monitoring program has continued every year since 2001 through the continued collaboration of local county and state programming and includes a database of over 3,500 samples in all 15 towns for 195 ponds. As part of the overall PALS program, SMAST continues to provide laboratory services at no cost to towns or volunteers for the annual PALS snapshot of pond water quality.

Many towns have taken advantage of the opportunities presented by the annual PALS snapshots, and have expanded their town monitoring programs. These local efforts and additional funding by the Barnstable County Growth Management Initiative enabled a number of additional lake and pond assessments to be completed in the past decade.

These reports include town-wide and pond-specific assessments:

- Ashumet Pond (Jacobs Engineering, 2000)
- Bakers Pond, Orleans (2001)
- Long Pond, Brewster (2001)
- Cedar Pond, Orleans (2003)
- Flax Pond, Harwich (2004)
- Orleans Ponds (2006)
- Indians Pond, Barnstable Assessment (2006)
- Harwich Ponds (2007)
- Great Sands Lake, Harwich (2007)
- Barnstable Ponds (2008)
- Lovers Lake and Stillwater Pond, Chatham, (2008)
- Dennis Ponds (2009)
- Brewster Ponds (2009)
- Eastham Ponds (2009)
- Lake Wequaquet, Barnstable (2009)
- Santuit Pond (2010)
- Hinckley Pond (2012)

Water-quality degradation of Cape Cod lakes and ponds has numerous causes, but most are linked to increased nutrient loads associated with shoreline development. Management strategies that have been identified to lessen future impacts from development include in-pond restoration using alum or oxygen infusion devices; establishing minimum setbacks for septic systems, road, and lawns; providing natural buffer strips between lawns and ponds; treatment of direct and near-shore stormwater runoff; and continued public education. The state prepared a generic Environmental Impact Report on pond restoration alternatives that have been used by towns to streamline the permitting of their restoration projects. The Cape Cod Regional Policy Plan requires a 300-foot buffer for leaching systems from the pond shoreline. The 300-foot buffer is used for calculating phosphorous budgets from septic systems because phosphorous is rapidly attenuated in groundwater. If the pond is significantly impacted by surrounding septic systems, wastewater management removal of nutrients from the watershed may be required. In cases where ponds are remote and the area of housing is dense, clustered systems may be a cost-effective alternative to centralized sewering. Any management plan must include continued sampling and monitoring of conditions within the pond.

Although snapshot water-quality data taken over the past decade indicate significant ecological problems, most of the ponds still provide the majority of uses that Cape Codders desire. Bacterial testing of ponds has generally indicated healthy conditions for swimming. Fishing and boating are still popular, and recent property values and sales show that demand for pond-front properties is only increasing. But even some of these uses are impacted by ecological problems. Occasional large fish kills or algal blooms are due to excessive nutrients. Regular stocking of deep ponds sustains trout fisheries, but trout generally do not have adequate habitats to make it through a summer due to lack of oxygen in cold waters of deeper ponds. More nutrients generally favor bass fishing, but half of the 18 ponds tested for mercury now have health warnings about consumption of fish tissue. Because the appearance of these ponds is shaped by what the users observe from the surface, actions to correct these ecological impairments will depend on community and state priorities. Active discussion of ecological management strategies for these ponds may lead to refinement of pond users' expectations for habitat and recreation and future TMDLs for ponds.

Despite the data gathered by citizen monitoring groups and the assessments that document water-quality impairment, the state has listed only a few freshwater ponds on the 303d list for impaired waters for nutrients. Additional dialogue is needed between the towns, state, and county to evaluate the best use of the information collected and how it should be incorporated into the state's clean water program.