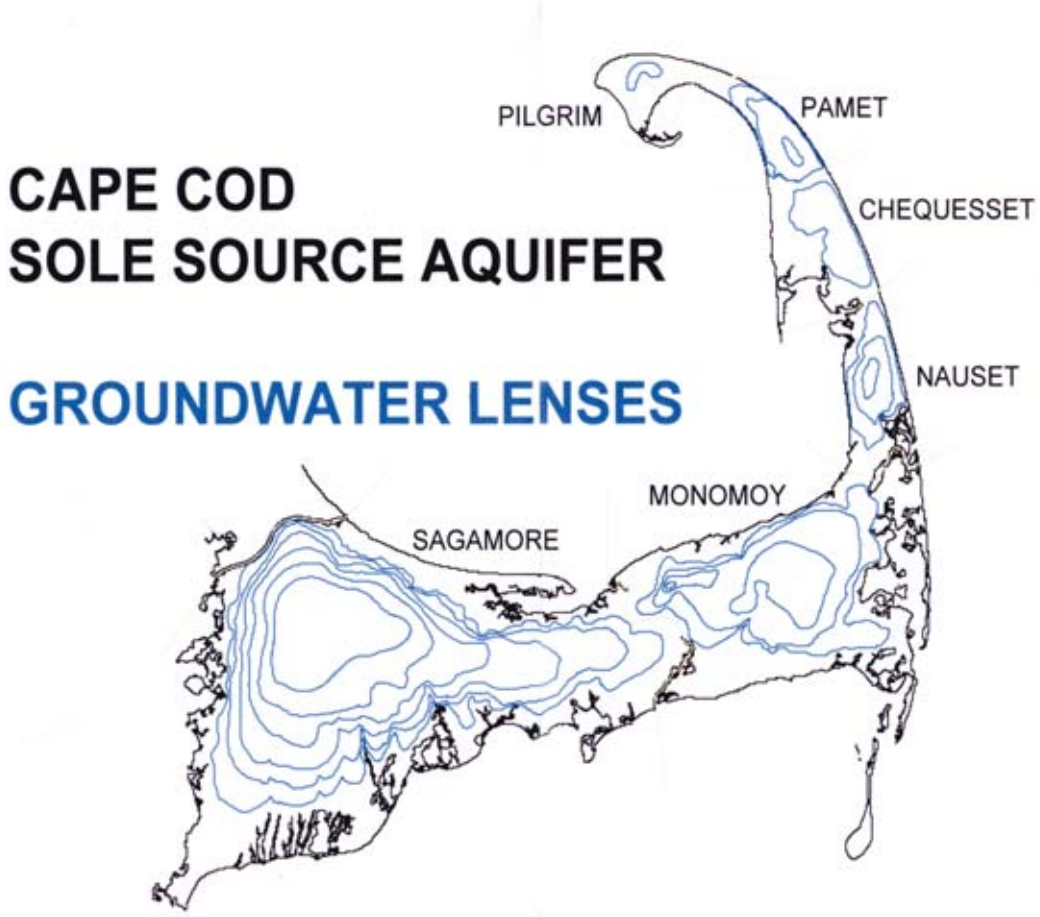
From Glaciers to Kettle Ponds

Some 10,000 years ago, as the last glacier receded from this, its southernmost reach, the Cape was formed by the deposit of sand and debris over an ancient clay base. Colder, denser blocks of ice remained embedded in the substrate, and when these finally melted, the terrain collapsed, producing hollows. These then filled with groundwater, forming the freshwater ponds and lakes of Chatham. Later, as the sea rose, forming what are now Pleasant Bay and Chatham's South Coast embayments, some of these ponds – Crows Pond, Ryders Cove, Oyster Pond and Mill Pond are examples – became connected to the ocean and Nantucket Sound.

Cape Cod Aquifers

All of our drinking water, whether from municipal water supplies or from private wells, comes from the rain and snow that falls on Cape Cod and soaks into the sandy soils left by the glacier. The entire layer of groundwater beneath the Cape is referred to as the Cape Cod Sole Source Aquifer and is made up of six separate freshwater lenses. Lenses can be thought of as mounds of groundwater bordered by marine water at the edges, bedrock on the bottom, and separated from each other by tidal rivers or inlets that cut across the Cape peninsula. Groundwater is the subsurface water located beneath the water table, in soils and geologic formations that are fully saturated.



The drinking water for Chatham and adjacent towns to the north and west is drawn from one large aquifer that lies beneath these towns. This large aquifer is called the Monomoy Lens. This lens is approximately 300 feet thick. deeper than the height of the Provincetown Monument, and is the sole source of drinking water for over 40,000 homes and businesses in six towns. More than five million gallons are pumped out each day in the off-season. When our population triples in the summer, so does the water consumption. The soil types and geologic deposits are relatively continuous and allow water to move through them at a speed averaging one foot per day. Flow from the middle of the Monomoy Lens to the shore – a distance of more than 3.5 miles – takes over 18,000 days, or nearly 50 years. Contaminants that are introduced into the lens and degrade water quality can ruin our drinking water for more than a generation.

In 1982, the Environmental Protection Agency designated the Cape's water supply as a "Sole Source Aquifer." This designation recognizes that the Cape's groundwater is our only source of drinking water.

About 40% of the annual rainfall seeps into the ground to replenish our aquifer.

Chapter 1

A Water Primer

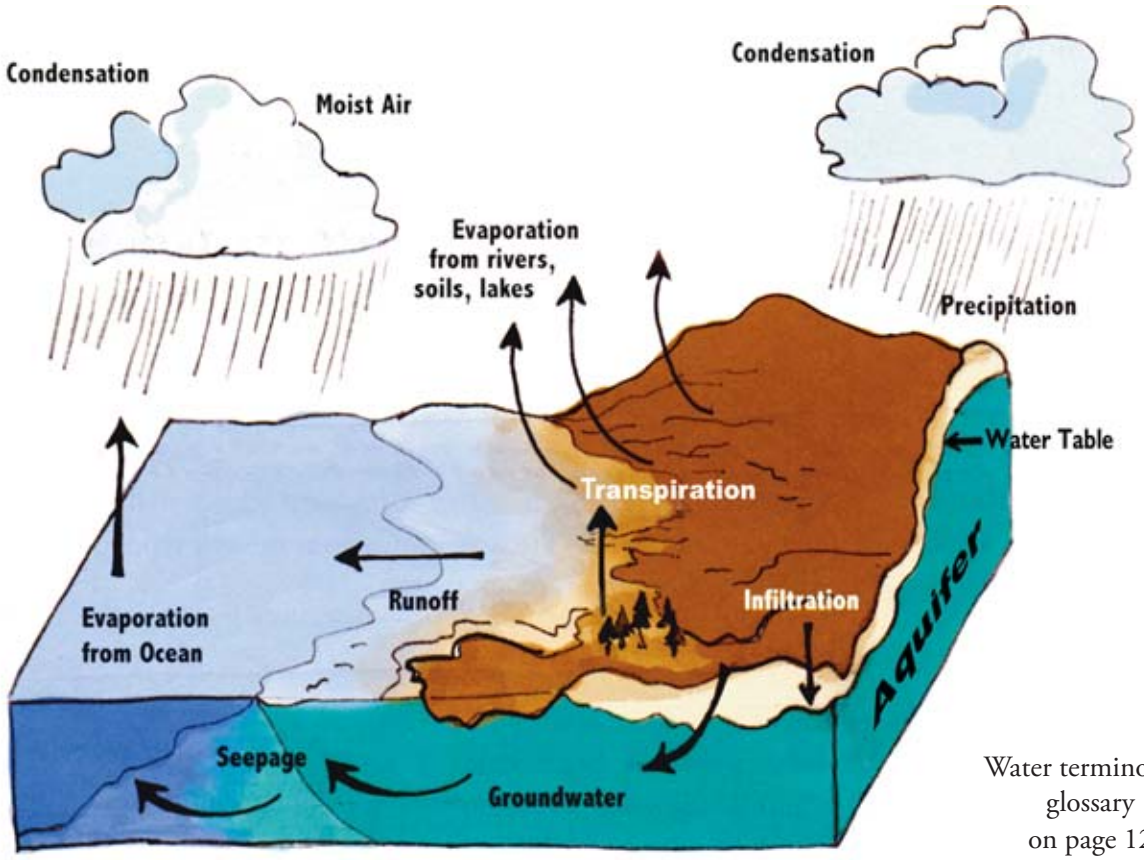
Our Beautiful Blue Planet

From outer space, the earth appears blue. Over three-quarters of its surface area is covered with water. Water is a miraculous substance. It is the universal solvent; just about every element can mix or dissolve in it. Over most of the globe, water exists in its liquid state. In constant motion and dissolving everything in its path, water is the lifeblood of our dynamic planet. This vast cycling and recycling process is called the water cycle.

The Water Cycle: What Goes Around Comes Around!

The water cycle is the journey water takes as it circulates from the surface of the earth to the atmosphere and back again. Energy from the sun evaporates water from the oceans, rivers and lakes. Plants also lose water by transpiration. Water vapor eventually condenses, forming tiny droplets in clouds. When the clouds meet cooler air, precipitation (rain, sleet or snow) is triggered and water returns to the sea and land, and the process begins again.

Water falling on the land either infiltrates into the soil, flows downhill as runoff into the wetlands, ponds and streams or evaporates back into the air. Once underground, water is either absorbed by plants and trees at the surface, or soaks deep enough to reach and recharge the underground sediments that are saturated with water, the aquifer. The surface of the groundwater in the aquifer is the water table.



Water terminology
glossary
on page 12

ARE YOU FLUID IN WATER TERMINOLOGY?

Aquifer: Underground sediments saturated with water.

Condensation: The process by which water vapor (a gas) in the air turns to liquid water. Condensing water forms clouds in the sky.

Evaporation: The process by which liquid water becomes water vapor (a gas). Water vaporizes from the surfaces of oceans and lakes, from the surface of the land, and from melts in snow fields.

Groundwater: Water stored in or moving through the aquifer.

Infiltration: The process by which rain or snow enters the ground and drains into the soil

Precipitation: The process by which water (in the form of rain, sleet, snow or hail) falls from clouds in the sky.

Recharge: The process by which precipitation moves through the soil and reaches the groundwater, replenishing the aquifer.

Seepage: The process by which water in the aquifer moves into rivers, estuaries and the ocean.

Transpiration: The process by which some water within plants evaporates into the atmosphere. Water is first absorbed by the plant's roots, then later exits by evaporating through pores in the plant.

Water table: Underground, the top level of soil permanently saturated with water. A household well taps into water below the water table.

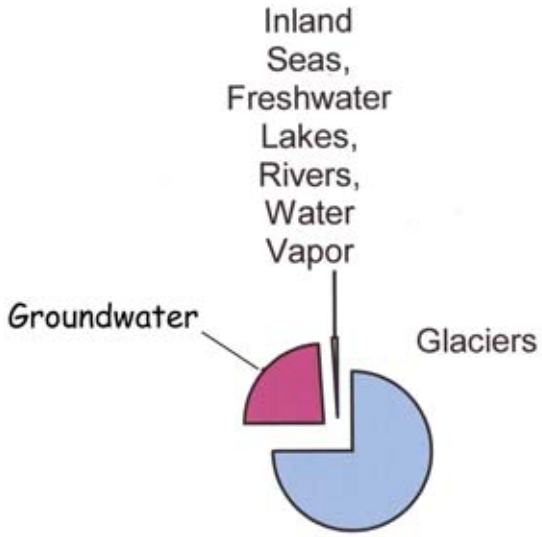
The human body is 70% water. Our eyes are 99% water. Plants contain from 70% to 90% water.

Earth never gets any new water; it just changes form. The water you drink today might have watered the gardens of ancient Egypt.

Waters of the World

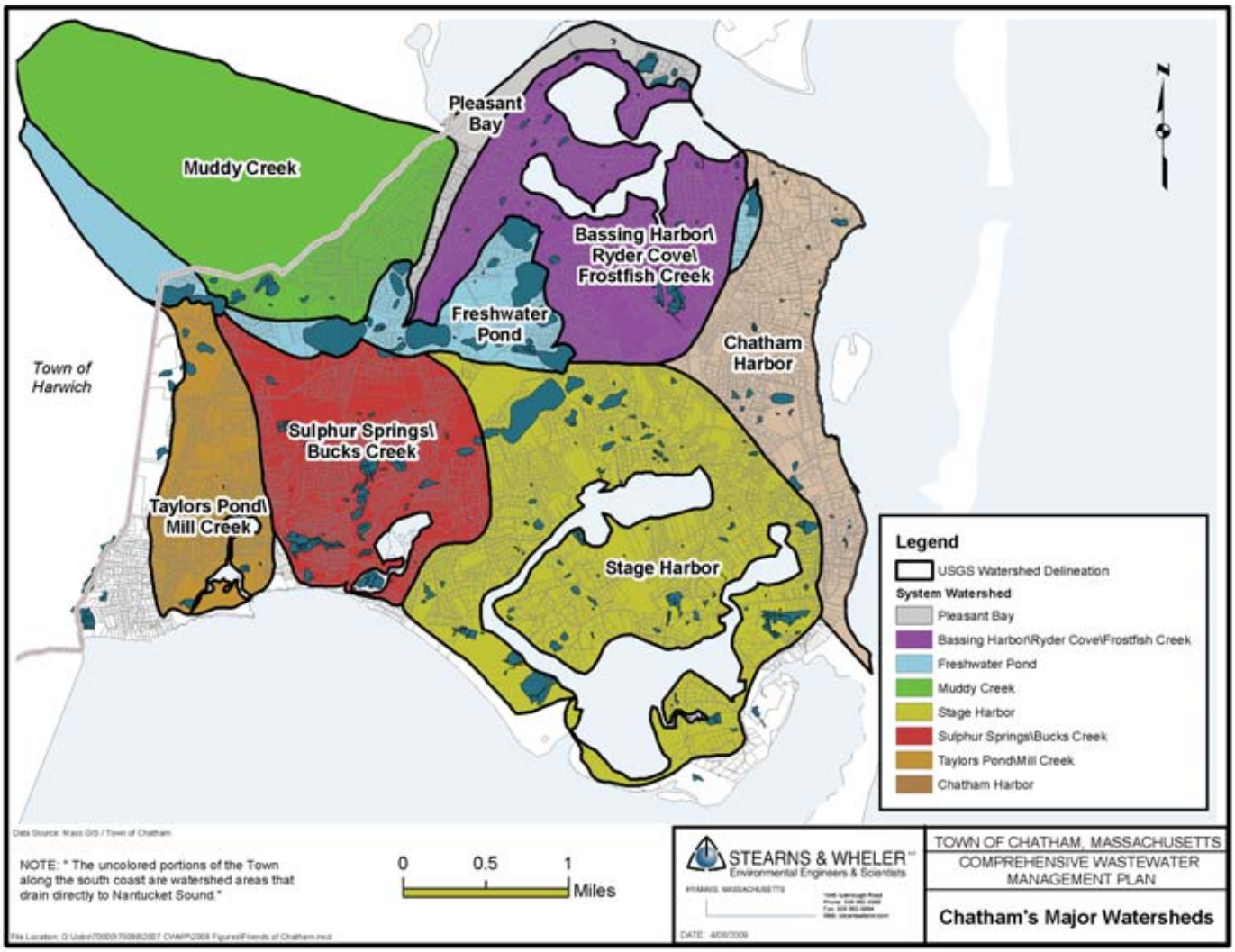
If 40 cups represented all the water in the world, all of it except for 1 cup would be found in the oceans. That one cup consists of the waters illustrated here.

Non-Ocean Waters of the World



Watersheds: Pathways to Our Waterways

Rain and snow falling on Chatham average 44 inches of fresh water each year. The precipitation either is absorbed by the plants and trees at the surface, percolates through the surface layers and recharges the aquifer, runs off the surface directly into our estuaries and ponds or evaporates back into the air. Other sources of recharge to the aquifer are septic systems and drainage from impervious surfaces. The ground water in the aquifer moves laterally out to our ponds and estuaries. Freshwater ponds, marshes and estuaries are destinations for all the ground and surface water flowing through each watershed. The watersheds associated with each estuary and freshwater pond are shown on the figure below. Locate your home on the map and trace the path your groundwater takes to the coastline.



Groundwater typically discharges into a pond on one side and the pond water recharges the lens on the other side. As groundwater flow reaches the coastline, it discharges directly into the estuary as fresh water seepage. Because of this interconnection, all uses of water – whether for drinking, swimming, boating, shellfishing, or finfishing – are dependent on maintaining the quality and quantity of water in the aquifer.

Barry Commoner's First Law of Ecology states that: "Everything is connected to everything else." What you do on your land may have widespread impact beyond the boundaries of your property.

We all live upstream!

Why Should We Care About Watersheds?

Water is the universal solvent. While dissolving essential minerals, it makes them available to the microscopic life that forms the base of aquatic food chains. Water also dissolves and carries pollutants into the ground and into our freshwater ponds, estuaries, and offshore waters. These pollutants range from the nitrogen and phosphorus in our septic systems and fertilizers, to gasoline additives and fecal matter in our storm water runoff.

You are part of the larger environment.

Even if you don't live right on the water, your everyday activities impact the water bodies in your watershed as nutrients and pollutants travel through runoff and groundwater. As the groundwater beneath your property makes its journey to our coastlines, it carries along your contributions in the form of nutrients or hazardous compounds.

Drawing by Kassie Foss

There are many ways to contaminate water . . .

How Does Discharge from a Watershed Affect the Ecosystems of our Waters?

Chatham relies on clean, productive and aesthetically pleasing waterways for tourism, recreational swimming, boating and commercial finfishing and shellfishing. There are two main types of pollution that are of concern for Chatham's waterways: nutrients and bacteria.

Drawing by Kassie Foss

Nutrients enable plant life to grow

Nitrogen Affects our Saltwater Embayments

In a saltwater pond or estuary, the marine plants at the base of the food chain require nutrients in order to grow and reproduce. The excessive supply of nutrients to an ecosystem is called eutrophication. In general, algal growth in salt water is stimulated by nitrogen. When a watershed supplies too much of the nutrient nitrogen:

- Microscopic phytoplankton (microalgae) increase dramatically, causing the water to become "cloudy" and, in extreme cases, green or brown.
- Slime algae increase on the surfaces of pilings, rocks, and eelgrass blades.
- Drift algae (macroalgae) grow to excess, break loose, and pile up onto the shore or eelgrass beds.

Eelgrass is a vital component of shallow estuaries. It is a rooted marine plant that provides habitat for bay scallops, blue crabs, tautog, winter flounder, and tomcod, among others. Because eelgrass is very sensitive to poor water quality and algal growth on its leaves, its decline is a warning bell that must be heeded.

Shellfish help to improve water quality as they feed by filtering microscopic particles from the water. One study has calculated that 100,000 rapidly growing oysters can cancel the nitrogen pollution from 27 people living in the watershed.

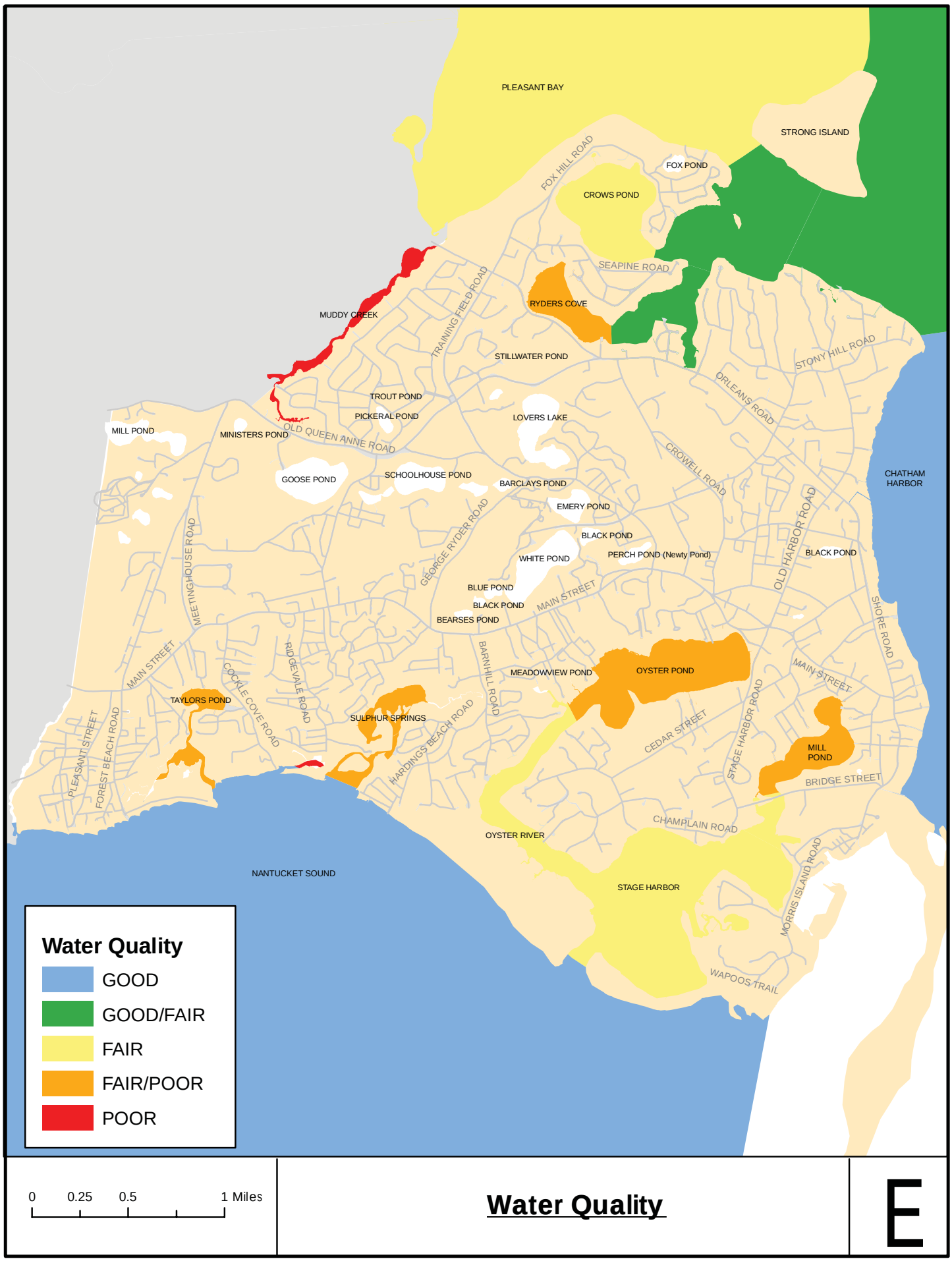
Fertilize Your Estuaries and Salt Ponds with Nitrogen Only if You Like Them Green!

The rampant growth of microscopic algae causes the green, murky look that makes salt ponds and sea water uninviting and ecologically unhealthy. This excess plant material, when it decomposes, takes oxygen out of the water, suffocating marine life. Algae blooms also reduce the amount of sunlight that can penetrate the water. Valuable marine plants like eelgrass cannot photosynthesize in cloudy water and soon die off. In the last decade, eelgrass meadows have disappeared from nearly all of Chatham's waters.

Chatham is blessed with many square miles of salt and brackish coastal ponds, marshes, bays, and harbors that are at risk from nutrient overloading. The water quality in every coastal waterway is affected by the addition of nitrogen from its watersheds.

Where Does Nitrogen Come From? Us!

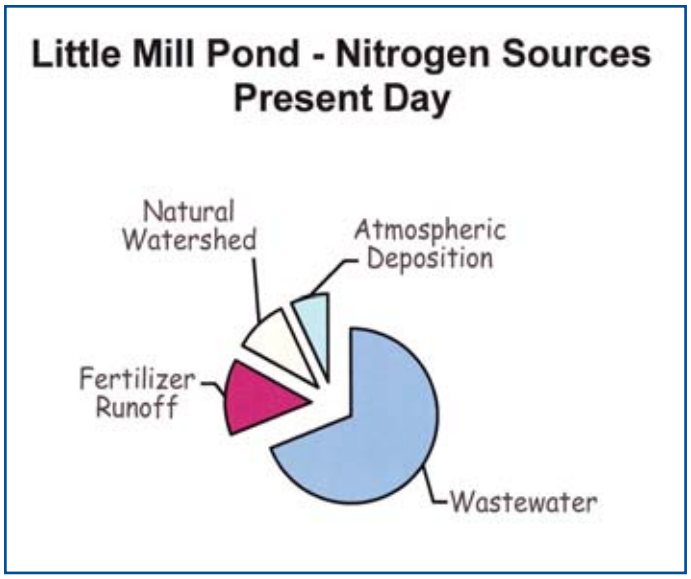
The most significant source of nitrogen that we can control is human wastewater. Although your septic system removes about a quarter of the nitrogen present in urine, the wastewater that leaves your leaching field is still highly concentrated with nutrients – 100 times more concentrated than the desired levels of nitrogen in coastal waterways. For most of the estuaries, wastewater is the source of more than half the annual nitrogen input.


PLEASANT BAY
STRONG ISLAND
FOX HILL ROAD
FOX POND
CROWS POND
SEAPINE ROAD
RYDERS COVE
TRAINING FIELD ROAD
MUDDY CREEK
STILLWATER POND
STONY HILL ROAD
ORLEANS ROAD
TROUT POND
PICKERAL POND
LOVERS LAKE
MILL POND
MINISTERS POND
OLD QUEEN ANNE ROAD
CROWELL ROAD
CHATHAM HARBOR
GOOSE POND
SCHOOLHOUSE POND
BARCLAYS POND
EMERY POND
GEORGE RYDER ROAD
MEETINGHOUSE ROAD
BLACK POND
PERCH POND (Newty Pond)
BLACK POND
WHITE POND
OLD HARBOR ROAD
BLUE POND
MAIN STREET
BLACK POND
BEARSES POND
SHORE ROAD
MAIN STREET
RIDGEVALE ROAD
COCKLE COVE ROAD
BARNHILL ROAD
MEADOWVIEW POND
OYSTER POND
MAIN STREET
TAYLORS POND
SULPHUR SPRINGS
CEDAR STREET
STAGE HARBOR ROAD
MILL POND
PLEASANT STREET
FOREST BEACH ROAD
HARDINGS BEACH ROAD
BRIDGE STREET
CHAMPLAIN ROAD
OYSTER RIVER
NANTUCKET SOUND
STAGE HARBOR
MORRIS ISLAND ROAD
WAPOOS TRAIL
Water Quality
GOOD
GOOD/FAIR
FAIR
FAIR/POOR
POOR
0
0.25
0.5
1 Miles
Water Quality
E

Another important source of nitrogen is the atmosphere, which is polluted by auto exhaust and smokestack emissions from power plants and heavy industry. These contaminants travel from as far away as the Midwest or as nearby as the local power plant. While atmospheric deposition may contribute up to 60% of the annual nitrogen pollution in an estuary, it is difficult for us to control.

Fertilizers used on lawns, gardens and golf courses are also sources of nitrogen. If too much is applied or if the ground is heavily irrigated after being fertilized, the nitrogen will dissolve in the water and travel beyond the reach of the grass roots and into the groundwater.

The breakdown of nitrogen sources for Little Mill Pond is typical of the proportions found in other Chatham embayments.



Water quality of estuaries due to nutrient loading has been assessed by the Chatham Water Watchers in support of the Massachusetts Estuaries Project. A simple summary of the data is shown in the Figure on the opposite page.

Phosphorus, Another Nutrient, Affects Our Freshwater Ponds

Protecting our ponds' water quality is of prime importance to maintain these ecosystems. Development and land use can impact the water quality by introducing pollutants from septic systems, lawns and storm-water discharges into the water or onto pond edges. In freshwater bodies, phosphorus is the critical nutrient. As phosphorus from various sources enters a freshwater system, plant growth is stimulated, and if excessive, eutrophication occurs.

Phosphorus sources include wastewater, street runoff, and soil erosion. Phosphorus has been removed from laundry detergents but is still found in many automatic dishwasher detergents. It is usually wastewater systems within a few hundred feet of the pond that are the primary phosphorus sources. Because phosphorus, unlike nitrogen, is actively bound up in the soil, the effects of phosphorus on freshwater systems can be minimized by setback requirements for septic systems. Establishment of natural vegetated buffers around pond shorelines is an important tool in protecting the water quality of our many ponds.

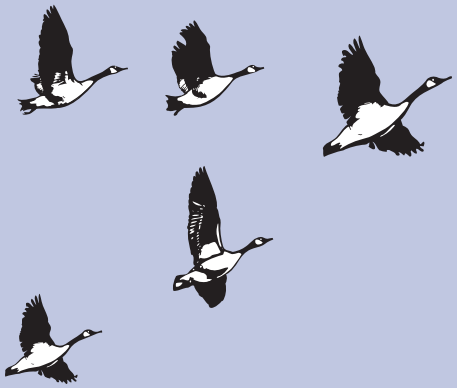
In 1998, the town's Water Quality Laboratory initiated a pond monitoring program. The intent of the program is to determine the current status of the major ponds in Chatham, provide data to support pond management initiatives, and to provide long-term monitoring. Though there is limited information concerning the water quality in the ponds, many are showing signs of impact to varying degree, with Lover's Lake and Stillwater Pond considered highly degraded. The program is focusing on the Great Ponds and Black Pond-east due to the proximity of the golf course.

Bacteria Are Harmful To Our Health

Bacterial contamination poses a constant threat to swimming areas and shellfish beds. Cockle Cove Creek has been closed to swimming for several years due to high bacterial readings, primarily from natural sources. The form of bacteria associated with beach closing is *enterrococci*, commonly found in the fecal material of warm-blooded animals, including humans. Most enterrococci bacteria is believed to enter water bodies via storm water runoff or from natural sources (wildlife/waterfowl) rather than septic systems.

Increased boating activities associated with accelerated growth has also contributed to local coastal pollution through sources such as outboard motor combustion, boat sewage discharge and fueling spills. Many of these discharges contain nitrogen and most include bacterial as well. Coastal waters have been degraded to the point where some shellfish areas are closed to shellfishing on a seasonal basis every year. These seasonal closures are most commonly the result of natural conditions, including increased water temperatures that prolong bacterial survival and increased wildlife/waterfowl activity. Examples of seasonal shellfish closures in Chatham include Bucks Creek, Mill Creek and Oyster Pond. Recent efforts to manage storm water runoff into Oyster Pond have resulted in the reopening of approximately 12 acres of the Pond, on a seasonal basis, that had been closed year-round since the mid 1980's.

WHY WE SHOULD NOT FEED WATERFOWL



- Feeding causes waterfowl to concentrate in unnaturally large flocks, interrupts migration patterns, and may create non-migratory, permanent flocks.
- The overpopulation of wild waterfowl may cause the closure of shellfish beds and swimming areas due to bacterial pollution from their droppings.
- Large bird populations are also a source of nutrient pollution to the ponds.
- Feeding waterfowl is prohibited by Chatham's Board of Health Regulations.

Cape Cod Neighbor

Drawing by Kassie Foss

The Horseshoe Crab:
A Survivor of Ancient Seas

The Atlantic Horseshoe Crab (*Limulus polyphemus*) is found in our estuaries and along coastal beaches. Harvest of these animals for bait is prohibited in Pleasant Bay and the Monomoy National Wildlife Refuge. Their blood cells are used to detect bacterial contaminants in pharmaceuticals and medical devices and their spanned eggs are an important food source for migrating shore birds. If you see a Horseshoe Crab on its back in the surf, to save them, "Just Flip 'Em Over."

OUR NATIVE AMERICAN HERITAGE

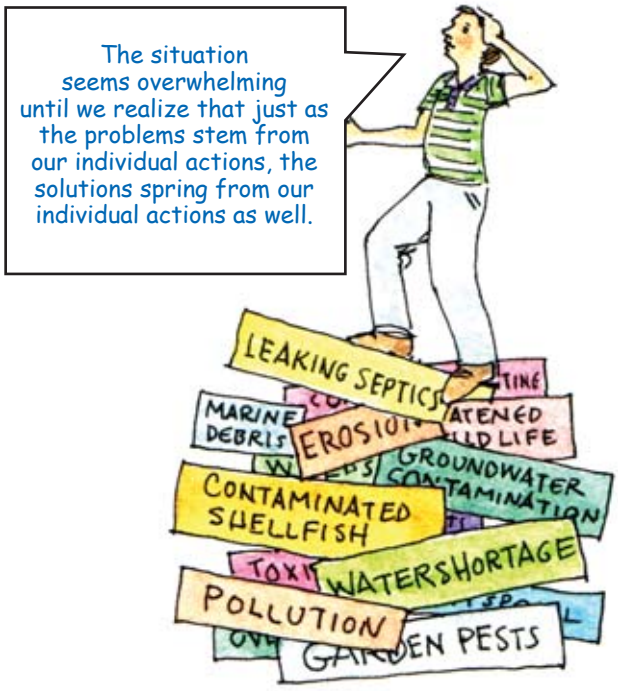
Very few Native Americans were left in Chatham by the time it was settled by Englishmen. Most had died from diseases contracted from the earlier explorers. For a while the settlers lived side by side with the natives, but the Monomoyicks left only faint echoes of their existence in present day Chatham. Part of their legacy is in words that linger to the present day, mostly names of persons and places. Monomoy is, of course named for Monomoit which was the original name of the Chatham area, but most present Native American words are street names, probably given long after the native population had died out. We do not know the meaning of the words in most cases.

Street names include:
Absegami, Cotchpinicut (named after an island in North Chatham explored by Champlain, now completely washed away), Menekish, Monomesset, Monomoit, Monomoyick, Nonuantum, Patuxet, Potonumecot, Quasson (may have been named for Mattaquason's son John Quason), Seaquanset, Tisquantum (the Native American name for Morris Island, now a street there), Wapoo, Wequasset, Wonkipit.

Other Wampanoag words:
Mattaquason, name of Monomoyick sachem from whom William Nickerson first bought land.
Quahog means "shut tight" in Wampanoag.

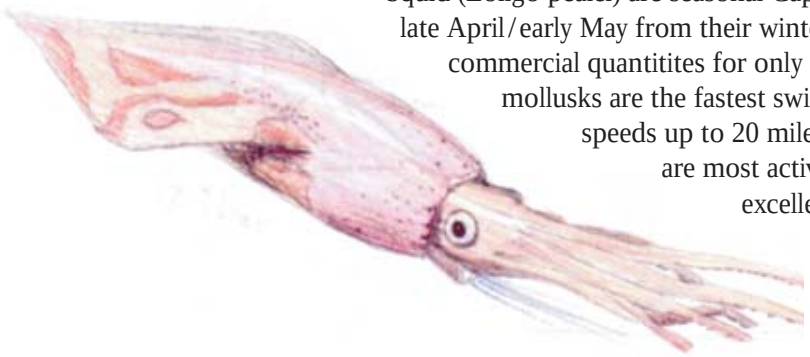
EARLY SETTLERS

William Nickerson of Yarmouth was the first Englishman to buy land in Chatham in 1656 through an agreement with the Monomoyick sachem Mattaquason. After much litigation with Plymouth Colony, he finally received deeds for his original purchase in 1672 and subsequently bought more, until he owned 4000 acres in Monomoit. Other settlers followed. Gradually the settlers cut down the forests of oaks, pines and walnuts for wood for farms and cleared the thickets of huge cedars for cranberry bogs. Apparently the few Native Americans left in the settlement lived near the saltwater, where they farmed and fished, and the English settlers lived near the freshwater ponds so they would have plenty of water for their cattle. They lived peacefully together, but the native population and culture slowly disappeared until there was only one full blooded Native American left on the Lower Cape. His name was Micah Rafe (or Ralph) and he died in 1816.



Cape Cod Neighbor

Squid: A Mollusk of a Different Color



Squid (Loligo pealei) are seasonal Cape visitors. They arrive in Chatham waters in late April/early May from their winter offshore home. They are caught in weirs in commercial quantitites for only one week in May in Nantucket Sound. These mollusks are the fastest swimmers in the invertebrate world, achieving speeds up to 20 miles an hour. Caught at night on jigs when they are most active, they are fished for bait, but also make excellent food. An effective predator and an elusive prey, squid can change colors and squirt ink to intimidate their enemies.

Cape Cod Neighbor

Herring: Swimming Against the Flow

Silver Herring (Alosa pseudoharengus), also known as alewives and Blueback Herring (*Alosa aestivalis*) spend much of their lives in the open ocean. They eat plankton and swim in large schools, covering great distances throughout the Atlantic. As anadromous fish (species that live most of their life in the ocean but return to spawn in fresh or brackish waters), these two herring species return each Spring to some of our freshwater ponds and streams. In Chatham, the only place to witness this mass migration is at the Ryder's Cove Herring Run to Stillwater Pond and Lovers Lake.