To Do
Contact GSWA for more information on Education and Outreach programs at 973-538-3500 or Hazel England at hazele@greatswamp.org. You can also check the GSWA's website, www.greatswamp.org, for additional information

1. Introduction[1]

The Great Swamp Watershed Association, a private, non-profit organization headquartered in Harding Township, New Jersey, has prepared this teacher's resource guide so that area teachers can introduce their students to the natural and cultural resources of the Great Swamp and its watershed, helping to instill in them a sense of place and stewardship for their environment. Learning about these resources will help students see the role we all play in our watershed, help them to develop respect for their local environment, and learn about actions they can take to protect it.

This resource guide provides information on the following:

- Definition of a watershed and location of the Great Swamp watershed
- The natural and human history of the Great Swamp Watershed
- Threats to the Great Swamp watershed
- What you can do to protect the watershed
- Teacher resources (field trips, web sites, workshops, etc.)

Many pages of the guide contain a side bar with definitions of new terms, a "TO DO" list of suggested activities that complement material on that page, and graphics that help illustrate the concepts being discussed.

In addition to this guide, the GSWA Education and Outreach Program provide several services for area teachers and students. The program staff offers workshops throughout the year to both formal and non-formal educators. The workshops range from Project WET to Schoolyard Habitat and Development workshops. These provide educators with the relevant tools they need to promote awareness and change in their students and areas. Program staff, along with GSWA member volunteers, also can make classroom presentations using the Association's 2'x4' replica of a watershed (pictured at left). The watershed model provides an excellent way to demonstrate the causes of point and non-point source pollution, and the many ways that these types of pollution can be prevented. Finally, the GSWA office maintains a small resource library of free materials on watersheds, wetlands, point and non-point source pollution, and other valuable information that can be used to help educate you and others about watersheds and your region.

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[1] Much of the information included in this publication has been culled from *Saving Space: the Great Swamp Watershed Greenway and Open Space Plan*, by Karen Parrish and Anthony Walmsley, personal communications with local citizens, and web sites of environmental organizations.

DEFINITIONS

Hydrologic Cycle: Also known as the water cycle, this refers to the paths water moves through in its various states– vapor, liquid, and solid–as it moves throughout Earth's systems (oceans, atmosphere, groundwater, streams, etc.).

Aquifer: An underground bed of saturated soil or rock that yields significant quantities of water.

Groundwater*:* Water found in spaces between soil particles underground (located in the zone of saturation).

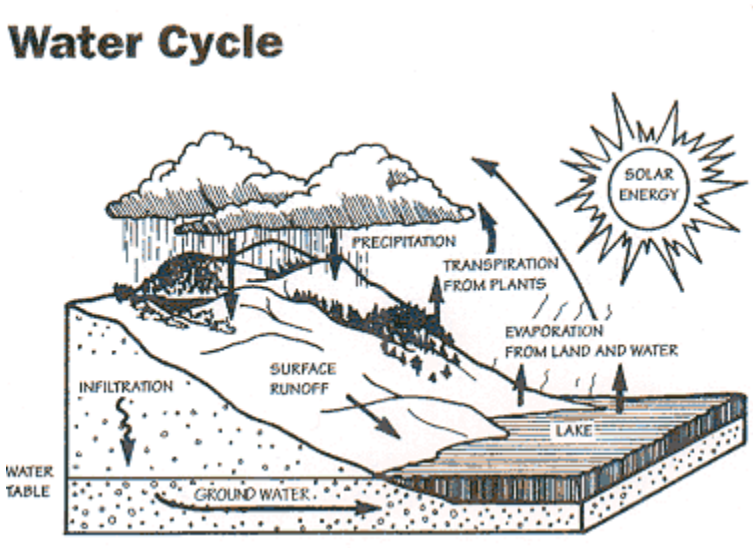
TO DO

Have students participate in the Great Swamp Incredible Journey activity (Appendix 1) to learn how water moves through the Great Swamp watershed.

2. The Water Cycle

The Earth's supply of fresh water is a precious, and very limited, resource. Although 75% of the Earth's surface is covered by water, less than 3% of that water is fresh, and only one half of one percent is readily accessible for human use.

Water continuously moves from the atmosphere to the land to the oceans and back to the atmosphere in what is known as the Hydrologic Cycle. After precipitation falls (in the form of rain, snow or ice), it may immediately evaporate from the ground, plants and trees, or water bodies back into the air. A small percentage will run off into streams and rivers, eventually making its way to the oceans. Most of the water soaks into the ground, where it either replenishes shallow aquifers that sustain streams and springs, or seeps into deeper aquifers that serve as large underground reservoirs of freshwater. Water may remain in deep aquifers for centuries, gradually moving toward and into the sea, where it evaporates again into the atmosphere.



Source: Project WET: Curriculum and Activity Guide

The Water Cycle is made up of a few key parts: Evaporation, Condensation, Precipitation, and Water collection. All these processes have key roles to keep the water cycle going. As you can see in the figure above evaporation takes place from the land and the bodies of water. The water particles are then turned into vapor or steam, then condensation takes place once the air gets cold enough and the water vapor turns back into liquid form, forming clouds. Once enough water has condensed in the atmosphere precipitation occurs. This can be in the form of rain, hail, sleet, or snow. The as the water falls back down to the earth it gets collecting in the same bodies of water and land that it evaporated from. This is why the water cycle is continuously taking place.

Despite the fact that water is constantly moving through the hydrologic cycle and thus being recycled in a sense, it is not necessarily being returned to its prior pristine state. Humans interfere with the basic processes of the water cycle in a number of ways. These interferences include depleting groundwater supplies for drinking water, agriculture and other human needs, paving over the land surface, and releasing pollutants into local streams. Once polluted or degraded, it is very difficult to restore water to the standards that must be met for human consumption. Thus pollution prevention is the most efficient and effective way to protect our water quality.

Definitions

Drainage Basin: A large watershed encompassing the watersheds of many smaller rivers and streams and draining to a major river, estuary or lake

Watershed: The land area from which surface runoff drains into a particular stream channel, lake, reservoir, or other body of water

Sub-Watershed: The land area draining to the point where two smaller streams combine together to form a larger, single stream

Catchment: The smallest watershed area, usually defined as the area that drains an individual site, such as a school or small neighborhood, to its first intersection with a stream

TO DO

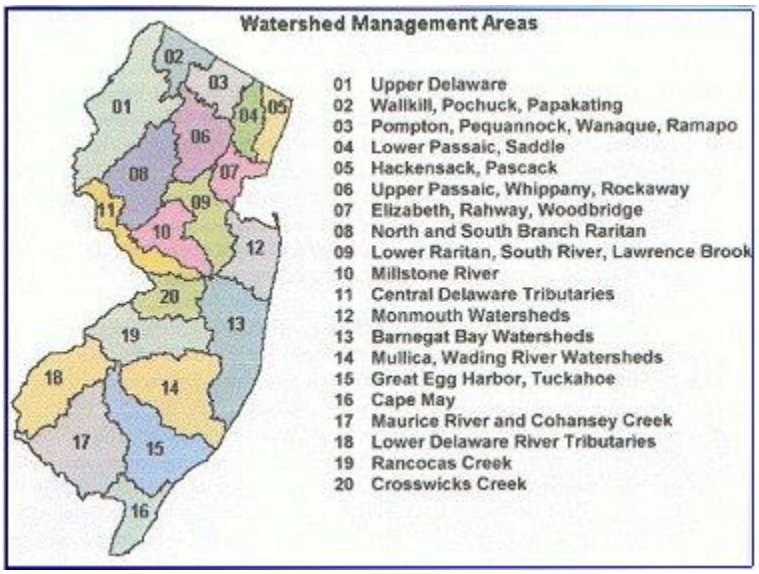
Have students create their own watershed (Appendix 2) and/or invite GSWA staff to your classroom to demonstrate point and nonpoint source pollution with our 2'x4' watershed model. Contact Hazel England, at hazele@greatswamp.org for more information on a watershed model at your school.

3. What Is A Watershed?

A watershed is any area of land that drains into a common water body such as a marsh, swamp, stream, river, lake, or groundwater. Each watershed is separated from other watersheds by high points in the terrain, such as hills and ridges. A watershed includes not only the water body or waterway itself, but also the entire land area that drains into it. For example, the watershed of a lake would not only include the lake, but also the streams entering the lake and the land area that drains into those streams. A watershed may be very small, like the drainage formed by your own driveway, or very large, like the drainage basin of the Mississippi or Nile rivers. Depending on the size of a watershed, it may be referred to as a drainage basin, watershed, or sub-watershed.

All land--including our neighborhoods, commercial and industrial areas, our forests and parklands--is in one watershed or another. Each watershed is a dynamic and unique place, where our natural resources, such as soil, water, air, plants, and animals, interact in a complex web. Yet everyday activities can impact these resources, ultimately affecting our own health, well-being and economic livelihood.

In New Jersey, the Department of Environmental Protection has begun to monitor and manage our natural resources on a watershed basis. The state has been divided up into 20 Watershed Management Areas (WMAs). The Great Swamp watershed is considered a sub-watershed of Watershed Management Area 6 which includes the Upper Passaic, Rockaway and Whippany rivers.



Source: NJ DEP

TO DO

Make photocopies of the black and white version of the Great Swamp watershed map (Appendix 3) and ask students to locate their "watershed address." If they live or go to school in the Great Swamp watershed, have them locate the sub-watershed (there are 5) they live in, go to school in, attend church in, etc. Students who do not live in the Great swamp watershed can learn their watershed address by visiting the NJ DEP web-site at http://www.state.nj.us/dep/watershedmgt/.

4. Location of the Great Swamp Watershed

The Great Swamp watershed is located in north central New Jersey, approximately 25 miles west of Times Square in southeastern Morris County and northeastern Somerset County. The 7,580 acre Great Swamp National Wildlife Refuge lies at the lowest elevations of the watershed, and is roughly 3 miles wide by 7 miles long. Many people equate the refuge with the Great Swamp watershed; however, as defined above, a watershed is the entire land area that drains to a common body of water. The Great Swamp watershed covers 55 square miles, or roughly 35,000 acres and includes parts of ten different municipalities. It measures roughly 8.6 miles south from Morristown to Long Hill Township, and roughly 7.8 miles east from Bernardsville Borough to Madison Borough. Thus, although the physical area of the Great Swamp National Wildlife Refuge is saved (as permanently protected open space), it is certainly not safe from the many pollutants that enter the swamp from the land areas surrounding it.

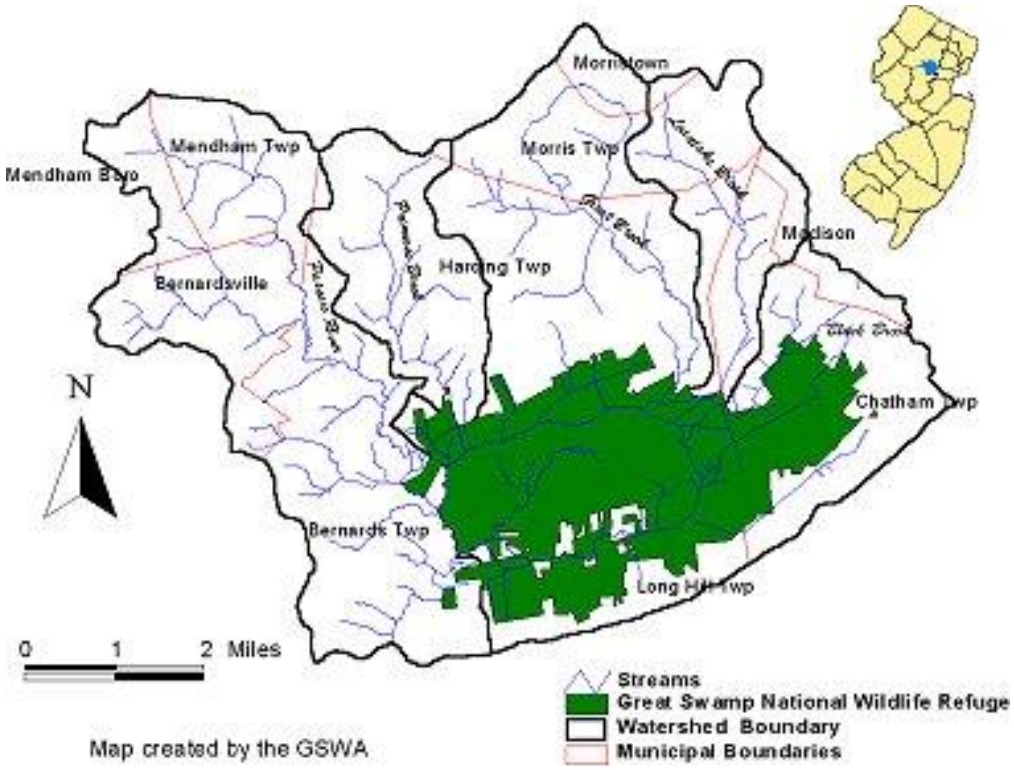


Figure: As the map of the watershed shows the Great Swamp Wildlife Refuge is not the complete Watershed as it sometimes gets mistaken to be. The Watershed encompasses a much larger area in fact.

To Do

Ask students to find out how much their population has grown since 1950. How might the increase in the population of the towns affect the watershed? What are the reasons for any changes?

Have students find out what their town is doing to protect the Great Swamp Watershed by calling the Ten Towns Committee at 973-543-0170 or have students visit their website at www.tentowns.org

Towns in the Great Swamp Watershed

The following are located partially or wholly within the Great Swamp watershed:

Municipality	Population (2009)	County	Square Miles	Percent in Watershed
Bernards Township	27,942	Somerset	23.99	24%
Bernardsville Borough		Somerset	12.94	28%
Chatham Township	10,086	Morris	9.34	81%
Harding Township	3,180	Morris	20.42	98%
Long Hill Township	8,777	Morris	12.07	53%
Madison Borough	16,000	Morris	4.19	24%
Mendham Borough	5,097	Morris	6.02	21%
Mendham Township	5,400	Morris	17.86	17%
Morris Township	21,796	Morris	15.78	28%
Morristown	18,544	Morris	2.94	31%

The ten towns listed above formed the Ten Towns Great Swamp Watershed Management Committee as an inter-municipal organization in 1995. Since then the mission of the committee is to develop and implement a watershed management plan for the Great Swamp Watershed. They strive to encourage the adoption of effective land use ordinances that preserve the watershed's water quality and quantity, diversity of the plant and animal life, as well as opportunities for recreation. All meetings for the committee are open to the public and more information can also be found on their website.

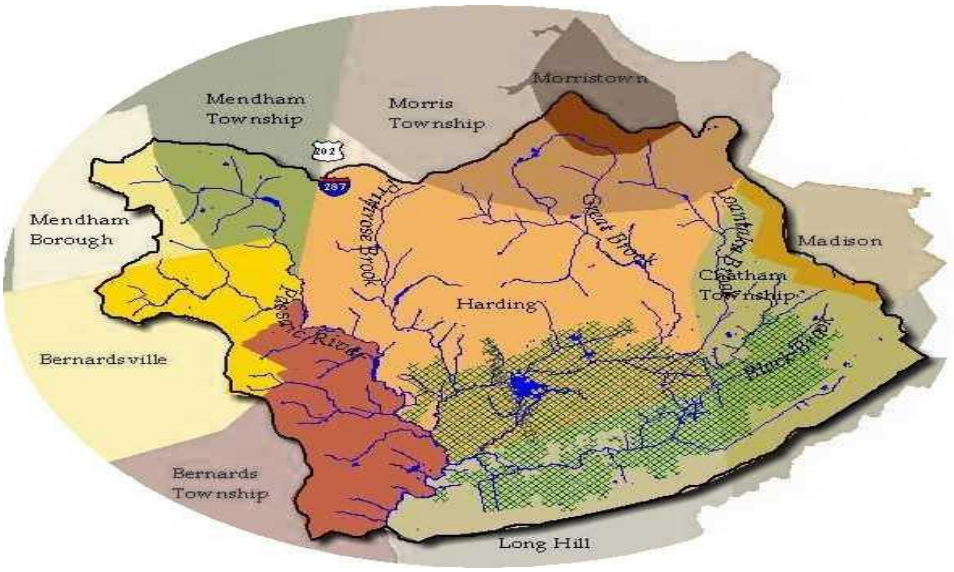


Figure: This shows how the ten towns are all associated with the Great Swamp Watershed. Each town takes a section.

DEFINITIONS
Terminal Moraine: Large mound or hill of looses and gravel deposited by the leading edge of a glacier.
Tributary: A river or stream flowing into a larger river or stream.

TO DO

Plan a field trip to the Somerset County Environmental Education Center to view their excellent exhibit "Secrets of the Great Swamp." It traces the history of the Great Swamp from early geological time to the various cultures that have occupied the swamp. Call 908 766.2489 for more information.

Have students identify the boundaries of the Great Swamp watershed using the contour lines on USGS topographic maps (see Appendix 4 for ordering information).

5. The Great Swamp Watershed: Natural And Human History

Natural History

The Great Swamp had its beginnings hundreds of millions of years ago, when the African continent collided with North America, pushing up the land mass that is now known as the Appalachian Mountains. A portion of the Appalachian Mountain chain today forms the northwestern rim of the Great Swamp watershed. This ridge line extends from Morristown southeast through the Mendhams and into Bernardsville. The Jockey Hollow section of the Morristown National Historical Park is located along this ridge line.

Roughly 210 million years ago Africa and North America began to separate once again. The stresses created by the separating land masses eventually led to successive lava flows which created the First, Second and Third Watchung Mountains. Today, the Third Watchung Mountain forms the southwestern and southeastern rims of the basin. Long Hill Township is located along the Third Watchung Mountain.

The northeastern rim of the watershed was formed most recently. About 18,000 years ago, a segment of the Wisconsin Glacier's leading edge reached the Great Swamp watershed area and stopped. Because its melt rate was equal to the southern flow of the ice, a glacial load of rock and soil was gradually deposited along its leading edge. For about 2,500 years the glacier essentially remained in this static position, melting and advancing at the same rate. This massive glacial deposit, known as a terminal moraine, runs between Morristown, Madison, and Chatham, forming the watershed's northeastern rim.

Today, the Passaic River has its headwaters in the Great Swamp watershed. There are four major tributaries of the Passaic: the Black, Great, Loantaka, and Primrose brooks. The four brooks come together in the Great Swamp, and then join the Passaic River before it exits the watershed through the Millington Gorge.

The Passaic River forms a natural border between Bernards Twp. in Somerset County and Long Hill Twp. in Morris County as it flows through the Millington Gorge

Human History

As early as 12,000 years ago, Paleo-Indians inhabited the Great Swamp basin, living in nomadic, hunter-gatherer communities. When the first Europeans arrived in the Great Swamp region in the 1600s, they encountered Native Americans such as the Lenape and Minnisink. The groups peacefully coexisted for a while; however, European diseases like smallpox and measles significantly reduced the Native American communities.

As European settlements in the area grew, demand for land increased. Many of the remaining Lenape were forced to sell their land and move west toward the Delaware River and beyond. On August 13, 1708, the New Britain Purchase, the first recorded transaction between Lenape and Europeans, was signed. Though the Lenape may have thought they were merely granting hunting and fishing rights, they actually signed away 30,000 acres to British investors for the sum of thirty pounds and assorted supplies.

During the Revolutionary War, many of the towns within the Great Swamp watershed were strategically important to the Continental Army. George Washington had soldiers build a defensive earthwork structure overlooking Morristown in May 1777, later nicknamed Fort Nonsense (due to the fact that it was never needed and many thought it was a make-work project to keep the soldiers busy). This structure and other ridge-top locations provided clear eastward views toward New York, where British troops under General Howe were quartered.

The view east today from Ft. Nonsense, Morristown National Historical Park.

After the war, the population of the watershed increased and land uses intensified. By the mid-1800s, over 400 individual land holdings existed throughout the watershed. Later in the 19th century, the region became popular for its numerous boarding houses and health resorts, vacation spots for those wishing a quick trip from New York. It was also a favorite retreat for wealthy New Yorkers, who built enormous homes on expansive estate properties. One stretch of Madison Avenue became known as Millionaire's Row after a 1902 *New York Herald* article reported that 100 millionaires lived within three miles of the Morristown green.

TO DO

Plan a field trip to Morristown National Historical Park to learn more about the role this area played in the revolutionary War. Call 973.539.2016 or visit nps.gov for more information.

Ask students to research a current land use conflict in their town or another part of the watershed. Are there any similarities with the fight to stop the jetport? See the Local Issues section of the GSWA web-site at www.greatswamp.org for a summary of land use conflicts around the watershed.

TO DO

Visit the Great Swamp National Wildlife Refuge to hike some of the trails in the Wilderness Area, or view wildlife from the observation areas. Call 973.425.1222 for more information.

Visit the Great Swamp Outdoor Education Center on Southern Blvd. in Chatham to view the interpretive displays about Great Swamp wildlife. Call 973.635.6629 for more information.

The Great Swamp Wildlife Refuge is a great place to go bird watching. The Overlook at Pleasant Plains Road provides an excellent view of different habitats and wildlife during any season.

In 1959, the Port Authority of New York proposed to build a 10,000- acre international jetport in the Great Swamp. The Authority planned to bulldoze Long Hill and portions of Chatham, Madison, and Harding to fill in the swamp and create runways. Located within the area to be demolished were 700 homes, churches, schools, and small businesses. Outraged by the proposal, hundreds of residents banded together as the Great Swamp Committee to fight the proposed jetport.

Over the next several years, members of the committee lobbied Congress, spoke at garden clubs and Rotary functions, presented slide shows on the value of the swamp's natural habitats for birds and wildlife, and most importantly, raised funds. Within five years, the Committee had bought or been given 3,000 acres of land, which had persuaded the US Department of the Interior to accept. In 1964 the Department dedicated the area as a National Wildlife Refuge to be administered by the US Fish & Wildlife Service.

Despite the formal establishment of a National Wildlife Refuge, the Port Authority continued to move forward with its plan. Citizens fought on, and in 1966, the Refuge was designated as a "Registered National Natural Landmark." Two years later, in 1968, citizens persuaded Congress to declare 3,660 acres of the Refuge a National Wilderness Area, the first so designated within the U.S. Department of the Interior. The designation of a wilderness area meant that, among other things, motorized vehicles could not be operated anywhere within the boundaries, thus forever precluding the area from becoming a jetport!

DEFINITIONS

***Ecosystem*:** A community of living organisms and their interrelated physical and chemical environment; also, a land area within a climate.

Stormwater runoff: Precipitation that flows overland to surface streams, rivers, and lakes (either directly through storm sewers).

TO DO

Use the Great Swamp Water address game (Appendix 5) to familiarize students with the different flora and fauna of the Great Swamp

DEFINITIONS

Point Source Pollution: Pollutants discharged from an identifiable point, including pipes, ditches, channels, sewers, and containers.

Non-Point Source Pollution: Stormwater runoff containing pollutants; the contamination does not originate from one specific location, and pollution discharges over a broad land area.

6. Threats To The Great Swamp Watershed

The Great Swamp National Wildlife Refuge and its surrounding watershed comprise a rare and diverse ecosystem that provides essential habitat for over 800 species of plants and animals. The 55-square-mile watershed also contains a wide variety of additional public lands, such as the Morristown National Historical Park and extensive county park lands. More importantly, the watershed serves hundreds of thousands of nearby residents who draw drinking water from the Passaic River, which rises in the Great Swamp watershed.

Although saved from becoming an international jetport, the Great Swamp today faces a future that is anything but secure. The reason: continuing, haphazard land development in the ten municipalities of the Great Swamp watershed. Partly due to the watershed's proximity to the NY metropolitan area, along with its relatively abundant protected open space, today the remaining land areas are under extreme pressure from those who wish to develop the land for residential and commercial uses. Additional unplanned development will further cover the natural landscape with roads and buildings. As it does, rainwater that once would have naturally filtered down into the earth becomes stormwater runoff, filling watershed streams with ever-higher quantities of pollutants and increasing the volume of runoff following rainstorms, leading to additional flooding downstream.

The potential for excess sediment to enter streams is greatest during site preparation and construction of a new development.

Land development is governed by different regulations in each municipality. However, the success of each town in protecting its environment varies widely. While some towns are very pro-active in protecting streams, wetlands, steep slopes and other sensitive environmental features, other towns are slower in recognizing the value of protecting their natural resources.

Even without further development, the water quality of the Great Swamp is endangered by un-remediated toxic waste sites and existing stormwater runoff, which pollute regional water supplies, degrade swamp habitats, and contribute to upstream erosion and downstream flooding. Indeed, largely because of existing water-quality degradation, the Great Swamp National Wildlife Refuge has been cited by the Wilderness Society as one of the nation's ten most threatened Refuges.

The following sections describe how human impacts translate into water quality and quantity problems in the Great Swamp watershed

Water Pollution

When we think of water pollution, we frequently picture pipes discharging chemical wastes into our rivers, or oil spills such as the Exxon Valdez. These types of pollutants are known as point sources of pollution because the pollutant can easily be linked back to its source, or point of origin. Point sources of pollution are stationary locations or fixed facilities such as an industry or municipality that discharge pollutants into air or surface water through pipes, ditches, lagoons, wells, or stacks. Common sources of point source pollution are sewage treatment plants and industrial factories.

A typical point source of pollution is industrial waste discharge from outfall pipelines, as pictured above.

Non-point source pollutants, by contrast, are difficult to track to a specific location because they come from many sources, stemming from various activities such as agriculture, household lawn care, forestry, or road traffic. Non-point source pollution occurs when precipitation falls and moves over and through the ground, picking up and carrying away natural and manufactured pollutants. These pollutants are then deposited into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. Today, non-point source pollutants have surpassed point sources of pollution as the greatest threat to our nation's water quality.

One of the main conduits of non-point source pollution: a stormwater outfall shown above delivers water and pollutants from a wide area, such as residential communities and parking lots.

An ornamental pond suffering from an influx of excess nutrients, such as phosphorous and nitrogen.

Some common sources of non-point source pollutants include:

- Excess fertilizers, herbicides, and insecticides from farms, golf courses, residential areas, and other manicured lawn areas such as office parks and ballfields.
- Oil, grease, and toxic chemicals from urban runoff and energy production.
- Sediment from improperly managed construction sites, forest lands, and eroding streambanks.
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems.

Point Source Pollution in the Great Swamp Watershed

Because there is so little industry in the Great Swamp watershed, point source pollution is not the major threat to the watershed. However, there are a number of potential or actual point sources of pollution that exist and do have an impact on the water quality of the Great Swamp. These are reviewed below before moving on to non-point sources of pollution in the watershed.

DEFINITIONS

Sedimentation*:* The settling of soil particles (sediment) to the bottom of a waterway.

Macro invertebrates: Animals that lack a backbone (invertebrate) and are large enough to be seen with the naked eye. They are a good indicator of water quality, because the most sensitive can only survive in areas of high water quality (e.g., the stonefly is highly sensitive to pollution and is only found in streams with high water quality).

Sewage: The waste and wastewater produced by residential and commercial sources and discharged into sewers or septic systems.

DEFINITIONS

Supernatant: The usually clear liquid overlying material deposited by settling, precipitation, or centrifugation.

BOD: Biochemical oxygen demand serves as a measure of the amount of oxygen used by micro organisms in breaking sewage down into stable compounds.

Sedimentation

Sedimentation is frequently thought of as a non-point source pollutant because it usually results from many combined sources, such as construction sites, poorly vegetated slopes, etc. However, when a large amount of sediment is released, either intentionally or accidentally, it can be considered a very serious point source pollutant.

A significant, detrimental release of sediment occurred in the Great Swamp watershed in 1996. A contractor working to dredge a heavily silted private pond released stormwater from a weir, thereby flushing a large amount of sediment along with it into Primrose Brook. The sediments released from the pond traveled as far as ½ mile downstream. The influx of sediment into the brook destroyed the majority of the macro invertebrate (MIV) populations living in the stream. In addition, approximately 100 trout were killed instantly along a distance of about 200 yards. Along the first 50 feet of the spill, a four foot thick layer of sediment was deposited. Clean-up was attempted by vacuuming the sediment from a 200-foot section of the brook. However, it took until 1999 for macro-invertebrate populations to re-establish their presence in this part of the stream. Now that the MIVs have begun to return, trout have also begun to reappear gradually as well. Unfortunately, silt deposits have thickened the streambed past the areas where clean-up took place, resulting in a continued negative impact on the MIV habitat.

Removal of trees and the disturbance of steep slopes greatly increases sediment runoff during rain events.

Sewage

In the past, household, commercial and industrial waste was typically disposed of directly into our nation's streams, lakes and oceans, under the assumption that it would simply be carried away and diluted by the fresh or saltwater. However, as our knowledge of human health and sanitation grew, so did our understanding that this method of waste disposal was not only bad for human health, but for the environment as well. Today, sewage from our homes and businesses is disposed of in one of two ways: through individual septic systems, or through sewage treatment plants. Although not foolproof, the treatment of our sewage before it is released into surface waters has greatly improved the quality of our water resources.

Sewage Treatment Plants

Sewage that is destined for a municipal treatment plant is transferred through sewers and pumping stations to the treatment plant. Here, treatment involves the removal of organic matter and is usually accomplished in two stages.

Primary treatment removes the heaviest solid material from sewage. At the plant, sewage first passes through a screen that traps the largest pieces of matter. It next flows into a grit chamber where coarse suspended solids and sands are removed after settling to the bottom. The liquid then flows into a primary sedimentation tank where suspended solids sink and form sludge. Primary treatment removes about half the suspended solids and bacteria in sewage and about 30% of the organic wastes.

Secondary treatment involves the flow of sewage into an aeration tank. In the aeration tank, a mixture of microorganisms such as bacteria and protozoa is mixed with the sewage and air is introduced. Activated sludge feeds on the bacterial material in the sewage and grows: sewage is then purified in the tank. Afterward the sewage is returned to settling tanks and then aerated a second time. Sludge from both primary and secondary treatments is collected from the various tanks and either burned, disposed of in landfills, or in dehydrated form - used as fertilizer.

Finally supernatant in the last settling tank is disinfected. After that, the treated effluent is discharged back into rivers or directly into the ocean. The sewage treatment process is designed to remove solid wastes, bacteria, pathogens, and some inorganic chemicals such as the nitrogen and phosphorous mentioned. It does not, however, remove other organic and inorganic chemicals or any pharmaceutical substances that might be in the sewage.

Settling tanks at the Woodland Sewage Treatment Plant in Morris Twp.

Septic Systems

An individual septic system consists of a septic tank and an underground disposal area. Pipes carry wastewater from the bathroom, kitchen and laundry to the septic system. Once in the system, heavier, more solid materials (sludge) settles to the bottom of the tank. Lighter waste materials (scum) rise to the surface. The middle layer consists of effluent, or wastewater, which is directed to a subsurface disposal area or leach field. This usually consists of an underground gravel-filled trenches or beds. This area filters out harmful microorganisms and organic chemicals over time.

Septic systems should only be constructed in certain types of soil which can filter the water at an appropriate rate. This is why "perc" tests are required by state laws before new septic systems are created. Septic systems must also be maintained

properly to prevent blockage of the system or the release of disease-causing organisms into the soil. Toxic and household hazardous chemicals should never be disposed of through a septic system as they could eventually find their way into the soil and then the groundwater. Solids and scum must be pumped out every 2-3 years on average.

Sewage Treatment Plants in the Great Swamp Watershed

Chatham Township Sewage Treatment Plant #1

TO DO

Arrange for a tour of the Chatham Sewage Treatment Plant. The plant is located on Tanglewood Lane in Chatham Township. Call 673.635.8789 for tour information.

This treatment plant is designed to take in 1 million gallons of sewage daily, but currently receives only an average of 600 to 700 thousand gallons/day. This translates to 300-400 gallons per household per day. All sewage received comes from about 2,100 residential homes in Chatham. No industrial sewage is received.

The type of treatment is activated sludge (as described above). Ultraviolet light disinfection is used rather than chlorine. Treated water is released into Black Brook, which eventually runs into the Passaic River. State standards allow a fecal coliform B.O.D. of 200; Chatham Township's level is below 4. State standards for suspended solids are a B.O.D. of 12; Chatham Township maintains a level of 6 or lower.

In September of 1999, Hurricane Floyd caused over 2 million gallons of water to flow through the plant during the storm, a level exceeding the holding capacity at the plant. The additional water was a result of stormwater finding its way through holes and cracks in the aging pipes that bring wastewater to the plant from all over Chatham Township. The heavy volume of water flowing through the sewer system caused the flush system to automatically shut off aeration to the microbes, and bypass the sand filters. This was done to prevent the microbes from being washed away into Black Brook.

Woodland Sewage Treatment (Morris Township)

TO DO

Arrange for a tour of the Woodland Sewage Treatment Plant. The plant is located off of Woodland Avenue in Morris Township. Call 673.326.7220 for tour information.

This treatment plant is designed to take in 2.8 million gallons per day of sewage, but currently receives an average of about 1.6 million gallons. The sewage comes primarily from residences, but industrial sewage from Honeywell Corporation (formerly Allied Chemical) is also treated at the plant. Honeywell pre-treats its sewage before it goes out to the Woodland Plant.

The type of treatment used is tertiary treatment with sand filters. Disinfection takes place in the form of ultraviolet light, rather than chlorine. Treated water is released into Loantaka Brook. There is no detectable coliform in treated water coming from the Woodland Plant. Their B.O.D. for suspended solids is less than 2.

While Hurricane Floyd caused the Woodland plant to receive over 4.3 million gallons of water within 3 hours, it did not experience any overflow. The Woodland facility was built in 1992 as a secondary treatment plant, and had extra tanks that were used to hold water until it could be treated and released

Rolling Knolls Landfill

A serious point source threat to the Great Swamp watershed is the Rolling Knolls Landfill, located at the end of Britten Road in Chatham Township. The land on the property utilized for dumping is approximately 187 acres. A portion of the site (about 42 acres) is located within the boundaries of the Great Swamp National Wildlife Refuge. Loantaka Brook passes nearly 2000 feet from the dump site. Black Brook passes within 500 feet of the dump; a tributary to Black Brook appears to have been filled in by the dump. Contaminants found in the surface and sub-surface soil of the site have been detected in off-site surface water, sediments, groundwater, and fish.

Use of the property as a dump reportedly began in the 1930s. This unlined landfill was known to accept both municipal and industrial waste from the surrounding areas. Local media accounts list Ciba-Geigy, Millmaster Chemical, and area hospitals as some of the industrial users of the site. Land filling operations lasted for a little over thirty years and was finally terminated in 1968, but the landfill had already done much environmental damage.

The US Environmental Protection Agency performed a field investigation of the site in February 1985. The investigation was performed to determine whether the dump should be placed on the National Priorities List and designated a "superfund" (toxic hazardous waste) site by the US EPA. The National Priorities List has the worst sites among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States.

The samples collected from the site in 1985 revealed that mercury levels in the sediment were as high as seven times the criteria used by the government to determine what is safe. Surface water concentrations of lead were more than 80 times the maximum concentration allowed under state regulations. The EPA returned to the site in 1986 to conduct more tests. Investigators bored eight holes in the ground to determine the level of waste material and soil contamination levels. They discovered numerous materials and compounds that could not be fully identified.

Later studies conducted by the US Fish and Wildlife Service and the US Geological Survey revealed even more contaminants like the presence of metals, PCBs, pesticides, and volatile & semi-volatile compounds. The Wildlife Service study turned up fish samples containing the pesticide DDT. The USGS study found concentrations of lead in shallow water along the perimeter of the landfill, and tentatively identified one of the unknown compounds discovered by the EPA as meprobamate, a barbiturate that is believed to increase the risk of fetal deformities when the mother is exposed to the drug. As a result of these findings, the EPA added this site to the Superfund National Priorities List in September of 2003.

In 2005 the EPA entered legal settlement under which potentially responsible parties agreed to conduct and pay for an investigation of on and off site soil, groundwater, and sediments. In 2007 these potentially responsible parties started to implement these work plans and they are currently in effect.

In summary, the potential or actual sources of point source pollution in the Great Swamp watershed include two sewage treatment plants, the Rolling Knolls landfill, and occasional large sediment releases. However, as mentioned at the beginning of this section, point sources of pollution are somewhat less of a concern than are the many non-point sources of pollution in the watershed. This is primarily because regulations have been put into place to safeguard against excessive emissions of pollutants from the majority of these sources.

Non-Point Source Pollution in the Great Swamp

Non-point source pollution from storm water runoff is the greatest challenge to the ecological health of the Great Swamp National Wildlife Refuge and the quality of the exceptional natural resources in its watershed. Other causes of non point source pollution are sedimentation, erosion, development, and forestry. Development particularly in recent years has increased storm water runoff which has increased non point source pollution in the Great Swamp Watershed Area. In 1993 a policy was introduced by the New Jersey Department of Environmental Protection that stated, " no net increase in stormwater runoff volume and pollutant loadings" in the watershed to help protect this ecosystem.

The following information is an overview of the important non-point sources of pollution affecting the Great Swamp watershed.

Animal Waste

Both wild and domestic animals create non-point source pollution problems through their waste products. One estimate is that an individual Canada goose can drop up to ½ pound of excrement per day, leading one local wildlife expert to comment that the handsome birds are "flying bags of Scott's Turf Builder." Large groups of birds make lawns and sidewalks a slippery mess, and their droppings contribute to high coliform bacteria levels in the lake areas they inhabit. Residents can help reduce the problem by planting shrubs or erecting 18-inch high fences around the perimeters of lakes and ponds where the geese nest. In addition, visitors to natural areas should not feed geese, as this encourages their presence and adds to the amount of waste produced.

Animal manure pollutes air, water, and land resources. Degraded stream water quality and fish kills resulting from animal manures and feed wastes are reported each year. Such pollution can result from improper practices or careless management. Beyond the concern for pollution control and compliance with state and federal standards, livestock producers are generally interested in animal manure's fertilizer value. Fortunately, using manure nutrients in crop production is a practical method of controlling pollution. So, the value of manure as a source of plant nutrients should always be given strong consideration in animal manure management systems.

Even the family dog can contribute to pollution of the local watershed. What may seem like scant amounts of dog waste, when combined with other waste, becomes a major problem for a small receiving stream. Dropping dog waste in the storm drain may create bacterial and pathogenic problems in that storm sewer line and contribute to elevated fecal coliform levels downstream wherever the sewer line discharges into a local stream. Dog waste should *always* be "taken with you" and disposed of at home in the garbage or toilet.

Sedimentation

Non-point source pollution from sedimentation occurs when wind or water runoff transports soil particles from land into a water body such as a stream or lake. Excessive sedimentation clouds the water, reducing the amount of sunlight available to aquatic plants. It also covers fish spawning areas and food supplies and clogs their gills. In addition, other pollutants such as phosphorus, pathogens, and heavy metals attach to soil particles and are transported via these particles into water bodies. Farmers and ranchers can reduce erosion and sedimentation by 20 to 90 percent by applying management measures to control the volume and flow rate of runoff. Municipalities can help reduce sediment runoff by enacting strong soil removal and sediment control ordinances and enforcing them, particularly around construction sites. And residents should not dig or move soil near a water body or leave bare soil exposed to the elements for extended periods of time.

Severe sediment disturbance around storm drain. Any rainfall event will wash excessive sediment into the storm drain where it will then empty directly into a stream.

DEFINITIONS

***Pesticides*:** Chemical compounds designed to control and kill pests. The term pesticides include herbicides (chemicals to kill weeds), insecticides (chemicals to kill insects), and fungicides (chemicals to fill fungus, etc.

***Integrated pest management (IPM)*:** A system of reducing pest problems using environmental information along with variable pest control methods. These methods include physical, mechanical, biological, cultural, and chemical means of reducing pests.

Pesticides and Fertilizers

Whether they are applied in residential or commercial settings, pesticides and fertilizers are easily transported via rainwater into nearby streams, lakes, ponds, and even underground aquifers or other groundwater supplies. In a review of studies around the nation in 1997, the US Geological Survey found that pesticides have been found in underground supplies *in most areas studied*. Chemicals that result from the original pesticide's breakdown may be even more common in our drinking water. Unfortunately, current testing requirements in NJ do not tell residents if these degradation products are present, a problem in a state where it is estimated that at least eight million pounds of pesticides are used annually (*NJ Pesticide Resource Manual for Health Professionals,* 12-1).

Many pesticides are toxic to pets, other animals, fish and plants, and may easily degrade wildlife habitat. Disturbingly, some of the most common herbicides in use today - Atrazine, Simazine, Alachlor, 2,4_D, and DCPA all pose a "cancer risk," and the last two have been linked to birth defects (*Drinking Water and Health: Facts on Pesticides in Drinking Water*, NJ Department of Health, 4-5). And in a National Cancer Institute study, home pesticide use has now been linked with childhood leukemia (*Journal of the National Cancer Institute* 79[1]:39-46). Residents should consider "least toxic" means to controlling lawn and household pests and should never engage in "calendar" methods of treating these problems (in which pesticides are applied on a regular schedule, rather than as needed).

One method for controlling pests with minimal chemical use that is gaining popularity in New Jersey is called Integrated Pest Management (IPM). IPM relies on a preventive approach: identifying pests when present in a building or lawn and determining a strategy for dealing with each one. This less invasive approach relies on managing pests by inspection, monitoring, site and sanitation improvements, and mechanical, biological, and "least hazardous" chemical controls. The following steps exemplify one type of lawn care protocol that may be used in an IPM program:

1. Gradually replace disease- and pest-*susceptible* plants and grass with disease-*resistant* plants and grass;

2. Cut grass frequently enough so that no more than one third of the blade is removed;

3. Maintain grass height at 3 ½ inches;

4. Keep records of observations, actions taken, and results;

5. Always attempt the least toxic method of control first. Do not use blanket or calendar treatments;

6. Apply lime, gypsum, and minerals based on need, determined through bi-annual soil testing;

7. Encourage the proliferation of beneficial insects that feed on harmful pests (consult the Rutgers Cooperative Extension Service at 973.285.8300 for more information on beneficial insects).

Pesticide reductions of up to 90% have been achieved at federal facilities employing IPM. In the Great Swamp watershed, several communities have adopted IPM policies for indoor and outdoor use. One example is Madison Borough, where all Borough lawns and playing fields and all indoor Board of Education properties follow IPM procedures.

Fertilizers also contribute to water pollution problems in New Jersey. Excess nitrogen runoff into lakes and ponds causes "algae blooms" that cloud the water and deprive fish and other organisms of much-needed oxygen. Periodic fish "kills" throughout the state, particularly in the summer, when oxygen demand is high, are the direct result of nitrogen runoff into the water. This problem begins at the level of individual homeowners, many of whom mistakenly think that "more is better" with fertilizer applications. Soil test kits, available at most garden centers and the Rutgers Cooperative Extension Service, can identify pH and nutrient deficiencies and should be used before blanket or calendar fertilizer application are made. Fertilizer should never be applied before a heavy rain. Apply only the amount needed for the square footage of the lawn. Avoid spilling fertilizer on sidewalks or driveways, where it will wash into storm drains.

Land Uses That May Contribute Substantially to Non-Point Source Pollution

Golf Courses

Golf courses are often identified as culprits in non-point source pollution because in the past many used large amounts of pesticides and fertilizer, as well as large quantities of water for irrigation. Today, this may not be true, depending on the management of the golf course. While any human development will have some impact on the environment, steps can be taken to minimize the adverse impact. Some golf courses have gone so far as to become urban wildlife sanctuaries.

Native plants can enhance the habitats of golf courses, attracting butterflies, birds and other wildlife.

Local golf courses engage in a number of measures to reduce non-point source pollution. Some area courses plant drought-tolerant plants and grasses in order to conserve water. Other options include planting certain native plant species and grasses, such as zebra grass, that only need to be cut once or twice per season. Native plant species can be watered once at the beginning of the season and then require only minimal inputs of water and fertilizers throughout the rest of the season. Native plants also attract local wildlife such as birds, butterflies, deer, red fox, and others.

On fairways, tees and greens, watering can be done by hand and only at night as needed. Clubs also can maintain a buffer strip of tall grasses around ponds in order to prevent fertilizers and other chemical runoff into nearby water supplies. Rather than perform preventive disease and pest treatments, golf courses should treat these problems as they arise and then with environmentally sound products.

Commercial Development

After residential land use, commercial development is the second highest consumer of developed land in the Great Swamp watershed. As a rule, office parks present many potential threats to water quality and quantity such as impervious surface runoff, overuse of fertilizers and pesticides, and destruction of the natural habitats of local wildlife. Yet many corporations are beginning to take a more pro-active stance toward protection of the environment.

An example of environmental stewardship is the Wyeth (formally American Home Products) corporate headquarters building, located in the Giralda Farms Office Park in Madison. Built in 1992, Wyeth took many steps to ensure that the construction of their office building (estimated at 201,010 square feet of impervious building and pavement surfaces) would create as little additional stormwater runoff as possible. Because the building was constructed on very permeable soils that provide excellent groundwater recharge, steps were taken to return water running off from the additional impervious surfaces, created by rooftops and parking lots, to the soil in order to allow for infiltration into the groundwater.

DEFINITIONS

Evaportranspiration: The return of moisture to the atmosphere from the evaporation of water from soil and transpiration form vegetation.

Transpiration: The process by which water absorbed through plant roots is returned to the atmosphere from the leaves.

The construction of a typical office park removes existing vegetation and replaces it with large rooftops and parking lots, thereby reducing the amount of water that can infiltrate into the ground, or be returned to the atmosphere via evapotranspiration.

7. What You Can Do To Protect The Great Swamp Watershed[2]

Preventing Non-Point Source Pollution

TO DO

Have students work with their parents to properly dispose of any unused hazardous chemicals currently stored in their home.

Have students find out whether their home has a septic system, and when it was last pumped.

There are many things individuals can do to reduce non-point source pollution and protect water quality. The following guidelines are steps that people can implement in their homes and communities:

Hazardous Household Products

Many common household products are toxic to people and the environment. Some oven cleaners, furniture polish, drain cleaners and spot cleaners are examples of potentially hazardous household products.

What you can do:

- Use alternative "green" products sold in many mainstream and health food stores.
- Buy only what you need or share the leftovers with others rather than storing them.
- Store materials in their original labeled containers.
- Dispose of unused materials and containers at hazardous waste disposal days (contact your county recycling coordinator or Department of Public Works for dates and locations).
- If your community does not already have a program for collecting household hazardous wastes, ask your local government to establish one.

Septic Systems

Many homes have septic systems to treat household wastewater. If the system is incorrectly maintained it can malfunction and pollute surface and ground water resources.

What you can do:

- Know the location of your septic system, the tank(s), distribution box, and distribution lines.
- Do not dispose of hazardous materials down drains.
- Have the tank pumped every 3-5 years.
- Do not plant deep-rooted vegetation near the system because this could clog or crack the tank and piping.

Underground Storage Tanks

Some homes have tanks to store heating oil. Leaking tanks are a threat to ground water supplies.

What you can do:

- Homeowners should have a tank tightness test performed upon tank installation and periodically afterwards.

- Beware of leakage signs: odors in well water, petroleum smell in basement, dead vegetation near tank, or unusual increase in fuel usage.
- Opt for an above-ground tank with spill containment.

TO DO

Have students test their soil for pH levels and other nutrients if it has not been tested in the past three years. Call the Rutgers Cooperative Extension at 973.285.8300 to obtain a soil testing kit.

Start a Schoolyard Habitat program to encourage native plant species and create beneficial wildlife habitat (see Appendix 7).

Lawn/Schoolyard Care

Home gardeners use an array of products to keep lawns and gardens green and weed-free. However, if fertilizers or pesticides are misapplied, the materials can run off during a rainstorm and contaminate local streams and lakes.

What you can do:

- Reduce the lawn size and plant ground covers and native plants that require fewer chemical inputs, using techniques such as IPM.
- Test your soil every three years for pH levels and nutrients before applying fertilizers. Your county Rutgers Cooperative Extension Service sells inexpensive soil test kits and analyzes the soil samples at their labs.
- Avoid getting fertilizer on driveways, sidewalks and streets.
- Follow instructions for using pesticides carefully, or consider using an alternative pest control method.
- Keep litter, leaves, and debris out of street gutters and storm drains--these outlets drain directly to lakes, streams, rivers, and wetlands. This type of waste contains high levels of nutrients that disrupt the natural balance of local water bodies.

Impervious Surface Coverage

Roads, rooftops, driveways and parking lots do not allow water to infiltrate. This impervious coverage creates increased runoff into streams that can exacerbate flooding, streambank erosion, and provide transportation for litter and other pollutants.

What you can do:

- Allow stormwater to filter into the soil by installing a gravel driveway or permeable paths and patios.
- Divert gutter down spouts into dry wells, lawns, or capture in a cistern for watering your garden.
- Stencil the storm drains in your neighborhood with the message "Do not dump - drains to _____ stream."

Pets and Wildlife

Animal waste from pets, wildlife and livestock is a source of water pollution. Animal waste contains a high concentration of nutrients and also potential for pathogens and bacteria.

What you can do:

- Clean up after your pet and dispose of waste in the trash or toilet.
- Promote and comply with "pooper-scooper" ordinances.
- Do not feed duck and geese.

Car Care

Antifreeze, motor oil and batteries contain toxic chemicals that must be disposed of properly.

What you can do:

- Do not dump automotive fluids down the storm drain, on the ground or in septic systems.
- Recycle used motor oil and batteries.
- Properly maintain your vehicle.
- Wash the car at a commercial car wash or on a grassy area so water can be absorbed into the soil.
- Use public transportation whenever possible.

TO DO

Start a storm drain stenciling project around your school. Find out what streams the storm drain leads to, and stencil a colorful design state "Drains to _____ Stream." (See Appendix 6).

Encourage students to pick up after their pets and dispose of the waste properly.

Soil Erosion

Sediment is the number one water contaminant in the nation. It can carry water pollutants, smother wildlife habitat and clog fish gills.

What you can do:

- Plant appropriate vegetation in areas that have bare soil
- Contact your regional Soil Conservation District for assistance with erosion problems.

[2] The information in this section is adapted from the Upper Raritan Watershed Association's Teacher's Guide to the Upper Raritan Watershed.

Join the Great Swamp Watershed Association!

The Great Swamp Watershed Association (GSWA) is a non-profit citizen's organization that's mission is to protect water and land in the ten towns (see table p.5) located in the 55 square mile region that is the Great Swamp Watershed. The GSWA was formed in 1981 and has grown to over 2,000 members in over 40 New Jersey municipalities. The association is dedicated to the conservation and restoration of the area's natural resources and to protecting the watershed for not only the present, but future generations.

The GSWA provides three types of services:

Education and Outreach Services:
GSWA fosters environmental awareness and promotes education for all ages. The association helps teachers bring environmental learning to life in the classroom by using models of the watershed and illustrating how people affect the area. There are also educational programs for the public introducing participants to the natural and cultural history of the area in a more hands on approach. This outreach also extends to developers helping them to take a more environmentally friendly approach when building.

Community Services:
These include acquiring land for preservation, offering programs to the public, and serving as environmental advocate before local government bodies. The GSWA also provides guidance, leadership, and resources to the watershed communities on planning, zoning, water, and land issues.

Technical Services:
The services include monitoring water quality and quantity in the streams of the watershed. As well as assessing future land development and offering legal and design guidance to help resolve local planning and zoning disputes.

Volunteer!

Volunteers are at the heart of many of the programs at the GSWA. There are many ways to get actively involved and really help in the association's efforts to protect and preserve the watershed. There are a number of volunteer opportunities such as volunteers for mailings and other office needs, water quality monitoring, ecological restoration, education and outreach to area schools, and grant writing.
If you are interested in helping out a great cause and would like to volunteer please contact Hazel England, Director of Education and Outreach at hazele@greatswamp.org or call at 973-538-3500.

If you would also be interested in volunteering at the Great Swamp Wildlife Refuge please call 973-425-9510.

8. Teacher Resources

www.greatswamp.org
The Great Swamp Watershed Association website provides information on teacher workshops, in-class presentations, free resource materials, contact information, and more. There is also an html version of this Teacher's guide on the website.

www.ga.water.usgs.gov/edu
The Water Science for Schools web-site, produced by the US Geological Survey, offers information on many aspects of water, along with pictures, data, maps, and an interactive center where you can give opinions and test your water knowledge.

www.uwex.edu/erc/gwah/

The Give Water a Hand website features the national watershed education program designed to involve young people in local environmental service projects. Following steps in the Give Water a Hand Action Guide (download it for FREE!), your class plans and completes a community service project designed to protect and improve water resources.

www.uwex.edu/erc/youth.html

This website provides educators with water education resources about programs for educators.

www.epa.gov/teachers/water.htm

The EPA Curriculum, Resources and Activities website contains ideas, curricula and activities on a variety of environmental topics. Many links to other helpful guides and activities are provided for Conservation, Human Health, Water, Ecosystems, Waste and Recycling, and Air.

www.epa.gov/OGWDW/kids

This EPA Department of Water web site provides on-line games and activities for kids on learning about drinking water. This site interactive games and activities for grades K-12 and also provides information for educators.

www.usgs.gov/wsc/

The US Geological Survey's "Science in Your Watershed" website will help you find scientific information organized on a watershed basis. This information, coupled with observations and measurements made by the watershed groups, provides a powerful foundation for characterizing, assessing, analyzing, and maintaining the status and health of a watershed.

www-k12.atmos.Washington.edu/k12/pilot/water_cycle/teacherpage.html

This website provides lesson plans for a two week module on the water cycle intended for students in 4th and 5th grade. The "Water: A Never Ending Story" module provides activities that will teach the students about each different phase water goes through during the water cycle. It is a comprehensive site that provides teachers background, discussion questions and activities with guidelines for setup.

www.earthforce.org/section/programs/green/weblinks

The Global Rivers Environmental Education Network (GREEN) website lists links to other watershed education web sites on the Internet. It provides a list of specific watershed sites as well as water education sites.

www.epa.gov/owow/wetlands

Another EPA website provides information on Wetlands Science, Education and Information Resources, including links to teaching guides and activities, educational programs, wetlands science and research and information resources available on the Internet.

www.teachnjenv.org & www.state.nj.us/dep/seeds/sect5.htm

These two websites are part of the New Jersey Department of Environmental Protection Agency. They are good sources to find more information on workshops and projects for students from K-12. These websites also supply workshop calendars that will give details of where and how to attend these programs.

www.nj.gov/dep/watershedmgt/ambassadors_members.htm

This website provides information on watershed ambassadors that can lecture and teach in your area about sources of pollution and water quality. There is information on the nearest ambassador to your area and how to contact them. For more information contact Marc Rogoff, Speakers program coordinator PO Box 402 Trenton NJ, 08625 or call at 609-292-1474

Planning Trips in the Area

www.fieldtrip.com/nj/14251222.htm

The Great Swamp National Wildlife Refuge in Basking Ridge, NJ has educational tours, slide shows, and programs available.

www.nps.gov/morr/

The Morristown Historical Park of New Jersey

www.morrisparks.net/aspparks/gswampmain.asp

The Morris County Great Swamp Outdoor Education Center provides numerous environmental programs for all age groups.

www.fieldtrip.com/nj/87662489.htm or somersetcountyparks.org

Somerset County Environmental Education Center has a variety of great school programs that are available from pre-K and up.

www.theraptortrust.org

The Raptor trust is one of the premier wild bird rehabilitation centers in the United States. They provide educational opportunities and workshops.

www.friendsofthegreatswamp.org

Friends of the Great Swamp has programs for grades K-12.

www.morristourism.org

Historic Morris Visitors Center located in Morris County.

Workshops

Project WET (Water Education for Teachers) is an interdisciplinary water science and education program for formal and non-formal educators of K-12 students. The Great Swamp Watershed Association offers this workshop, free of charge, 2-3 times per year. Website: www.projectwet.org Local contact: Hazel England, Director of Education and Outreach at The Great Swamp watershed Association, email: hazele@greatswamp.org. National Contact: Project WET foundation 1001 West Oak St. Suite 210 Bozeman MT, 59715, telephone: 406-585-2236 or 866-337-5486, email: info@projectwet.org

Project WILD is an interdisciplinary wildlife education program for grades K-12.Website: www.projectwild.org/educators.htm Contact: Liz Jackson, Public information Assistant, 605 Pequest Road Oxford NJ 07863 telephone: 908-637-4125
Project Aquatic WILD actively explores water, aquatic areas, and related development and pollution issues. Free in-service workshops can be arranged for schools and school districts. Contact: Karen Leskie, Division of Fish and wildlife NJDEP at PO Box 418 Port Republic NJ 08241 telephone: 609-748-2032

Project Learning Tree is an interdisciplinary forestry education program for grades K-12. *Contact:* Amy Mallet, Project Learning Tree, NJ Department of Environmental Protection, NJ Division of Parks and Forestry, 370 Veterans highway, Jackson, NJ 08527 732-833-9816

Natural Resources Conservation Service The US Department of Agriculture, Natural Resource Conservation Service can assist you and your students in conducting a hands-on restoration planting project at your school. Contact the Morris County District at 908-852-2576 or go to the website www.nrcs.usda.gov/

Free / Low Cost Materials

The Great Swamp Watershed Association
The GSWA maintains a small resource library for students and educators. You may stop by the office during business hours (9 am-3pm, Mon-Fri.) and pick up free information on watersheds, wetlands, groundwater, and other brochures and books. Or call 973-538-3500 to have this valuable information sent to you.

Forest Resource Education Center
You can get a free hard copy of the *NJ Community Forestry Arbor Day Activity Guide* as well as other activity information that can be easily copied and used in class. Go on the NJDEP website www.state.nj.us/dep/parksandforests/forest/community/kids.html for contact information.

NJ Department of Environmental Protection
The New Jersey Department of Environmental Protection, Division of Watershed Management encourages watershed education and outreach activities with booklets and activities emphasizing pollution prevention. Visit their web site www.state.nj.us/dep or send a request to Kyra Hoffmann at NJDEP, PO Box 418, Trenton, NJ 08625-0418. 609-633-1179

Books/Pamphlets/Videos

GSWA has a reference library for public use. If you're curious about the history of the Great Swamp, need to do research for a school project or term paper, or just want to peruse the variety of materials (books, videos, white papers, newspaper clippings, etc.) that can be found in our library, please give us a call at 973-538-3500 to let us know when you'd like to come by. If you have questions or comments, or would be interested in donating reference materials to the library, contact librarian@greatswamp.org.

Middle-High school Students

Saving Space: The Great Swamp Watershed Greenway and Open Space Plan. Karen Parrish and Anthony Walmsley. 1997. GSWA, Madison, NJ. 973.966.1900.

Provides detailed information on the history, geography, current land uses, areas of interest, critical areas, the Great Swamp Watershed Greenway and Open Space Plan, and protection options for the Great Swamp watershed.

Saved But Not Safe: The Second Battle to Save Great Swamp. 1998. GSWA, Madison, NJ.973.966.1900.

A 23 minute video which highlights three recent efforts to protect the Great Swamp. Provides excellent background on the problems of stormwater runoff and non-point source pollution.

Ground Water in the Passaic River Basin. The Passaic River Coalition, Basking Ridge, NJ. 908.766.7550.

A well-illustrated 12-page pamphlet on ground water resources which provides background on ground water and aquifers in general, and specific information on the use and depletion of ground water in the Passaic River Basin.

The Ground Water Adventures of Walter Wet. Passaic Valley Ground Water Protection Committee and the Passaic River Coaltion. Basking Ridge, NJ. 908.766.7550.

The focus of this 12 minute video is ground water protection and preservation at the municipal level. The video discusses basic hydrology, aquifers, wells, pollution sources and well head protection.

Water Quality Report: The Southeast Morris County Municipal Utilities Authority. Cedar Knolls, NJ. 973.326.6880.

A bi-annual report on the quality of the water provided by the SMCMU, with additional information on drought conditions (when pertinent), water conservation tips, and more.

The Clean Water Book: Lifestyle Choices for Water Resource Protection. NJ Department of Environmental Protection. 1997

An excellent resource for background on the sources of non-point source pollution and what people can do to prevent it. After introductory chapters on water and water quality, individual chapters cover animal waste, lawn and garden care, underground storage tanks, septic systems, household hazardous wastes, car care, recreational boating, and community involvement. Each chapter has a "what you can do" section

K-8

How the Environment Works. Preston Gralla. 1994. Ziff -Davis Press, Emeryville, CA.

A well-organized and highly visual explanation of how environmental systems work. Subjects include: freshwater systems, oceans, air pollution, sources of energy, forests, rain-forests, and more.

K-4

Our Wet World: Exploring Earth's Aquatic Ecosystems. James M. Needham Collard Charlesbridge Publishing; ISBN: 0881062685

The magic of the underwater world comes alive in this children's book. The illustrations help take the reader through the many different ecosystems that constitute Earth's "wet world." From streams and rivers through marshes to the shore, each ecosystem is carefully described in clear terms that can be understood and appreciated by children ages 5-9.

Life in a Wetland (Rookie Read-About Science). by Allan Fowler. Children's Press; ISBN: 0516264176

This is a brief, easy-to-read introduction to life in and around freshwater wetlands and saltwater marshes. Clear color photographs provide visual definitions for the terminology presented in the text.

Marshes & Swamps. Gail Gibbons. Holiday House (P); ISBN: 0823415155

Gibbons introduces the concept of wetlands (swamps have trees, and marshes do not) and distinguishes between the fresh-and saltwater varieties of each. She describes the amazing array of plants and animals found in these ecosystems and explains how these areas store freshwater, prevent flooding and erosion, and serve as a refuge for migratory animals. Large, colorful illustrations dominate every page and include many interesting details; oversize labels identify most terms and species. Appended with a map of major wetland areas in the US and Canada and a page of other interesting facts, this makes an excellent introduction for primary-grade students.

Swamp (One Small Square Series). Donald M. Silver. McGraw-Hill; ISBN: 0070579261

Young readers won't be swamped with incomprehensible data during this amazingly accessible wade through a small square of wetlands, filled with exotic wildlife. Here is a fascinating look at the characteristics of swamp life-and the reasons why its survival is so important.

Glossary

Aquifer: An underground bed of saturated soil or rock that yields significant quantities of water.

BOD: Biochemical oxygen demand serves as a measure of the amount of oxygen used by micro-organisms in breaking sewage down into stable compounds.

Catchment*:* the smallest watershed area, usually defined as the area that drains an individual site, such as a school or small neighborhood, to its first intersection with a stream.

Drainage Basin: A large watershed encompassing the watersheds of many smaller rivers and streams and draining to a major river, estuary or lake.

Ecosystem*:* A community of living organisms and their interrelated physical and chemical environment; also, a land area within a climate.

Evapotranspiration*:* The return of moisture to the atmosphere from the evaporation of water from soil and transpiration from vegetation.

Groundwater*:* Water found in spaces between soil particles underground (located in the zone of saturation).

Hydrologic Cycle: Also known as the water cycle, this refers to the paths water moves through in its various states–vapor, liquid, and solid–as it moves throughout Earth's systems (oceans, atmosphere, groundwater, streams, etc.).

Impervious surface coverage*:* Surfaces that do not allow stormwater runoff (water) to seep into the ground, such as sidewalks, roadways, driveways, and rooftops.

Integrated pest management (IPM)*:* A system of reducing pest problems using environmental information along with variable pest control methods. These methods include physical, mechanical, biological, cultural and chemical means of reducing pests.

Macro invertebrate*:* An animal that lacks a backbone (invertebrate) and is large enough to be seen with the naked eye. They are a good indicator of water quality, because the most sensitive can only survive in areas of high water quality (e.g., the stonefly is highly sensitive to pollution and is only found in streams with high water quality).

Non-Point Source Pollution*:* Widespread overland runoff containing pollutants; the contamination does not originate from one specific location, and pollution discharges over a broad land area. Water pollution that cannot be traced to a specific source.

Pesticides*:* Chemical compounds designed to control and kill pests. The term pesticides includes herbicides (chemicals to kill weeds), insecticides (chemicals to kill insects), and fungicides (chemicals to kill fungus), etc.

Point Source Pollution*:* Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels and containers of various types.

Sedimentation*:* The settling of soil particles (sediment) to the bottom of a waterway.

Sewage: The waste and wastewater produced by residential and commercial sources and discharged into sewers or septic systems.

Stormwater runoff: Precipitation that flows overland to surface streams, rivers, and lakes (either directly or through storm sewers).

Sub-watershed*:* The land area draining to the point where two smaller streams combine together to form a larger, single stream.

Supernatant*:* The usually clear liquid overlying material deposited by settling, precipitation or centrifugation.

Terminal Moraine: Large mound or hill of loose sand and gravel deposited by the leading edge of a glacier.

Transpiration: The process by which water absorbed through plant roots is returned to the atmosphere from the leaves.

Tributary: A river or stream flowing into a larger river or stream.

Watershed: The land area from which surface runoff drains into a particular stream channel, lake, reservoir, or other body of water.

Appendix 1. An Incredible Journey Through the Great Swamp Watershed

An *Incredible Journey Through the Great Swamp Watershed* is adapted from the Incredible Journey activity in the Project WET Curriculum and Activity Guide (see Teacher Resources section for more information on Project WET). In the activity, students act as water molecules, moving from one part of the water cycle to another based on clues they find at each "station."

Materials:

- clues (provided with this exercise)
- business size envelopes or larger
- dark colored marker
- tape

To prepare the activity, cut the clues into individual strips. Each clue has a station location written on the back. Label each envelope with a station name and place the relevant strips in the envelopes (e.g, all the Primrose Brook clues go in the Primrose Brook envelope). Students can illustrate the stations if they wish. Tape or place the envelopes around the room or activity area so that students can see and reach into them easily.

Procedure:

1. Tell students that they are going to become water molecules moving through the water cycle. Have the students identify the different places water can go within the water cycle, and the state (vapor, liquid or ice) that water molecules would be in at different stages of the cycle. Discuss the conditions that cause the water to move (water movement depends on energy from the sun, electromagnetic energy, and gravity). Students should discuss the form in which water moves from one location to another. Most movement from one station to another will take place when water is in its liquid form. However, any time water moves to the clouds, it is in the form of water vapor, with molecules moving rapidly and apart from each other.

2. Review the various stations water can move through in this particular activity: Clouds, Plants, Animals, Rivers (Black, Great, Primrose and Loantaka Brooks and the Passaic River), Lakes (ponds), Groundwater, Soil, Person, Water Treatment Facility and Great Swamp National Wildlife Refuge. Since there are no glaciers in the Great Swamp they will not be visiting any as part of this activity.

3. Have students line up at the cloud station (the starting place for this activity).

4. Tell students they will be demonstrating water's movement from one location to another. When they move as liquid water, they will move in pairs, representing many water molecules together in a water drop. When they move to the clouds (evaporate), they will separate from their partners and move alone as individual water molecules. When water rains from the clouds (condenses), the students will take a partner and move to the next location.

5. Have the first student in line choose a strip of paper from the envelope. If the strip says that water vapor remains in the cloud, he or she should go to the back of the line and wait their turn to try again. If the strip says to go to another station, the student should latch on to the next person in line (because water in its liquid or frozen state must be made up of at least two molecules) and head for the next station. The next person in line then chooses a strip (each strip should be returned to the envelope before the students move on to the next station) and so on.

6. Students should keep track of their movements. This can be done by having them keep a journal or notepad to record each move they make, including stays. Alternatively, students may record their journeys by leaving behind personalized stickers at each station. Another approach has half the class play the game while the other half watches. Onlookers can be assigned to track the movements of their classmates. In the next round the onlookers will play the game, and the other half of the class can record their movements.

7. Tell students the game will begin and end with the sound of a bell (or buzzer or whistle). Begin the activity!

8. After an appropriate amount of time, signal that the activity is over. Have a few students read over their list of where they traveled as a water molecule. To follow up on the exercise, students might write a creative story about their journey and what it was like to move from one place to another. Or they might discuss how their journey would have differed during another season (e.g., summer versus winter).

9. **Adaptation** - affix red stickers to the Suburbia clues that have been polluted with pesticides, fertilizers and oil to indicate pollution. If a student selects one of these strips, he or she becomes permanently polluted (demonstrating how difficult it is to clean water once it has been polluted). Place a red sticker on those students. If a molecule (student) that has been polluted later joins up with another, unpolluted molecule, that second molecule will also become polluted and should have a red sticker placed on him or her. How many molecules (students) have been polluted by the end of the activity? To follow up, have students research how water becomes polluted and what opportunities exist for it to be cleaned as it moves through the water cycle.

Appendix 2. Create Your Own Watershed

A three-dimensional model of a watershed is one of the best ways to demonstrate the watershed concept to your students. With a three-dimensional model, you can demonstrate how water runs from peaks and ridges, to low points such as valleys, wetlands and other depressions. In addition, with the use of a few household kitchen items, such as cool-aid and cocoa you can demonstrate how pesticides and sediment are washed off the earth's surface during rain events and into our lakes, rivers and oceans.

Materials:

- spray bottle with blue-colored water
- a large aluminum roasting pan
- numerous rocks of various sizes
- several pieces of white scrap paper or newspaper
- one kitchen-size white trash bag
- Cocoa and cool-aid mix

Procedure:

- Wrap the rocks in newspaper and place on the bottom of the roasting pan to create an uneven surface (the topography of your watershed).
- Cover the rocks with the white trash bag, being careful to tuck the edges under the rocks (use a few rocks on top to hold the trash bag in place).
- Ask the students where they think water that falls on this watershed will flow
- Spray the model with the blue-colored water until water begins to run-off the higher points and pool in the lower areas (depressions).
- To show how pollutants are washed off the land surface, sprinkle cocoa and cool-aid in key locations (where erosion or pesticide use might occur) - then spray the model again until the pollutants run-off into the depressions.

This activity can be done as a class, or in smaller groups. If small groups create their own watersheds, have the groups compare their results at the end.

To make a permanent model, use the above supplies, but substitute paper-mache material for the white trash bag. Once the paper-mache has dried thoroughly, paint the model with white water-proof paint. The model can now be re-used with numerous classes.