WATER RESOURCES

Clean, plentiful water supplies are essential for all life on earth. Hawthorne's drinking water comes from the Brunswick Aquifers. There are fish in Goffle Brook and the Passaic River. All the businesses & residents in Hawthorne require water. An understanding of Hawthorne's water resources is critical for maintaining a healthy environment and clean drinking water in sufficient supply.

Water, in any form, ice, liquid, or vapor, or in any place, air, Earth surface, or ground, circulates by changing form and position. The sun's energy, directly or indirectly, evaporates water into the air. In the air, water vapor molecules coalesce into liquid droplets forming clouds. Water precipitates from clouds as rain, snow or sleet. When precipitation falls to the ground, the water either runs off the overland, or seeps into pores and cracks of the soil or rocks. Water in the ground may be evaporated or transpired by plants or animals back into the air; may move into lakes, streams, and rivers; or may be stored in the ground as ground water. Ground water and surface water tend to flow downhill towards the ocean. This process is known as the hydrologic cycle (**Fig. 17**).

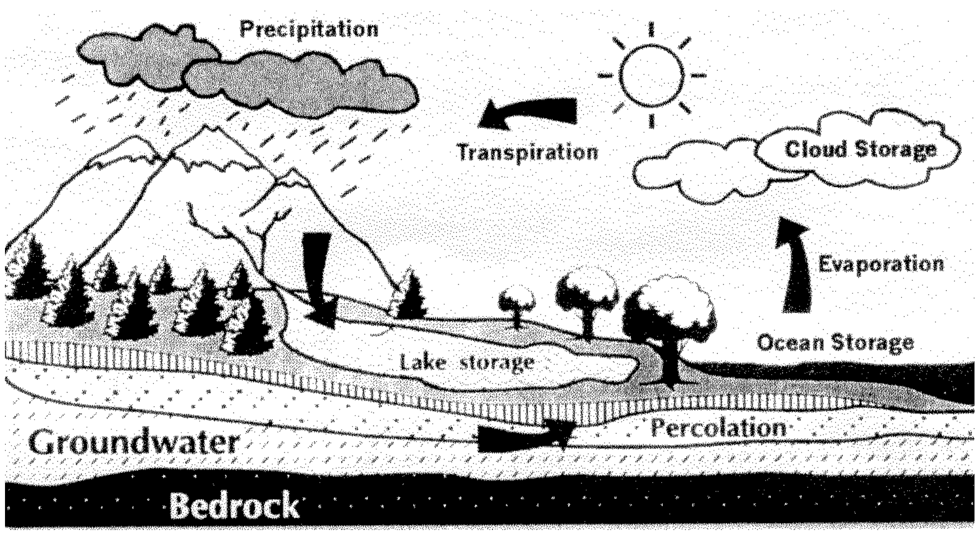


Fig. 17. Hydrologic Cycle. Diagram modified from Passaic Valley Ground Water Protection Committee's (PVGWPC) Ground Water document.

Some of the rain and snow that precipitates on Hawthorne runs off into Deep Brook, Goffle Brook or the Passaic River, and some infiltrates into the ground. Some of it even reaches the aquifer, which lies beneath the surface of Hawthorne. Water is dynamic; it moves from place to place.

Deep Brook and Goffle Brook originate in Bergen County, and flow southward into Hawthorne where they join. Goffle Brook then flows into the Passaic River. The Borough of Hawthorne lies within the Passaic River Basin. It is part of the lower Passaic River Basin, which has been designated by the State of New Jersey Department of Environmental Protection in Watershed Management Area 4 (WMA4). The Passaic River flows past Hawthorne for about three-quarters of a mile, and forms the boundary between Hawthorne and Paterson. Since water in the Passaic River as it passes Hawthorne is draining an area of almost 800 square miles, both the quantity of water flowing in the river and its quality have been impacted by many influences, which include human uses of the land and water in the watershed above Hawthorne (USGS, 1996). Thus, what happens outside Hawthorne's borders has the potential for degrading Hawthorne's water resources.

GROUNDWATER

OVERVIEW

Hawthorne relies exclusively on groundwater for its drinking water supply. The drinking water for Hawthorne is obtained by wells tapping into an aquifer. An aquifer is a geologic unit that is saturated with water and sufficiently permeable to transmit economic quantities of water to wells and springs. Hawthorne's aquifer is in the Brunswick Formation, which is one of the Newark Group Aquifers (USGS 1996). The sediments in this aquifer date back to the Triassic period and consist of sandstone, siltstone, shale and conglomerate. The Newark Basin extends from central New Jersey to adjacent parts of Pennsylvania and New York States, and is the largest early-Mesozoic basin in the eastern United States (Trapp and Horn 1997). Water generally is present in a weathered joint and fracture system in the upper 200 or 300 feet (Kasabach and Althoff 1983). Water availability is reduced below a depth of 500 feet because fractures are fewer and smaller, depending on the rock type. The shale and sandstones of the Brunswick Formation are productive aquifers and yield as much as 1,500 gallons per minute (USGS 1996).

Table 13. Active public community wells in Hawthorne, pumping capacity and well depth. Information provided by Department of Public Works.

ID#	Name/Location	Capacity (mgd)	Well Depth (feet)
1	Bamford Ave.	0.43	300
2	First Ave.	0.23	400
3	Goffle Road 1	0.25	293
4	Goffle Road 3	0.22	300
5	Goffle Road 4	0.36	315
6	Goffle Road 5	0.26	300
7	Goffle Road 6	0.36	485
8	Rea Ave.	0.23	400
9	Cedar Ave.	0.29	368
10	Maitland Ave.	0.19	400
11	Wagaraw Well 3	0.15	415
12	Wagaraw Well 4	0.11	300
13	Wagaraw Well 5	0.20	440
14	Wagaraw Well 6	0.22	388
15	Wagaraw Well 7	0.20	369
16	Wagaraw Well 8	0.30	416
17	Goffle Hill Well	0.14	350
18	Utter Ave. Well	0.25	300
19	S. Wagaraw Well 10	0.20	300
20	S. Wagaraw Well 12	0.40	300
21	S. Wagaraw Well 15	0.40	300

Drinking water in Hawthorne is obtained from twenty-one municipal wells located in areas within and adjacent to the Borough (**Table 13, Fig. 18**). The wells are located at Goffle Road, Wagaraw Road, Utter Avenue, Grand Avenue, Bamford Avenue, Goffle Hill Road, Cedar Avenue, Rea Avenue, Maitland Avenue, and First Avenue (**Fig. 18**). The wells that supply the borough range from 290 to 440 feet deep (**Table 13**). The earliest known well drilled in Hawthorne was in 1915. All wells are in working order and no problems are currently present. Hawthorne pumps from two to three million gallons per day (mgd) (**Fig. 19**) from this aquifer depending on the season. The pump capacities of the wells range from 75 to 400 gallons per minute depending on the location of the well. Hawthorne pumped less water in 2010 than it did 30 years earlier, either as a result of increased efficiency or because of decreased industrial usage or both.

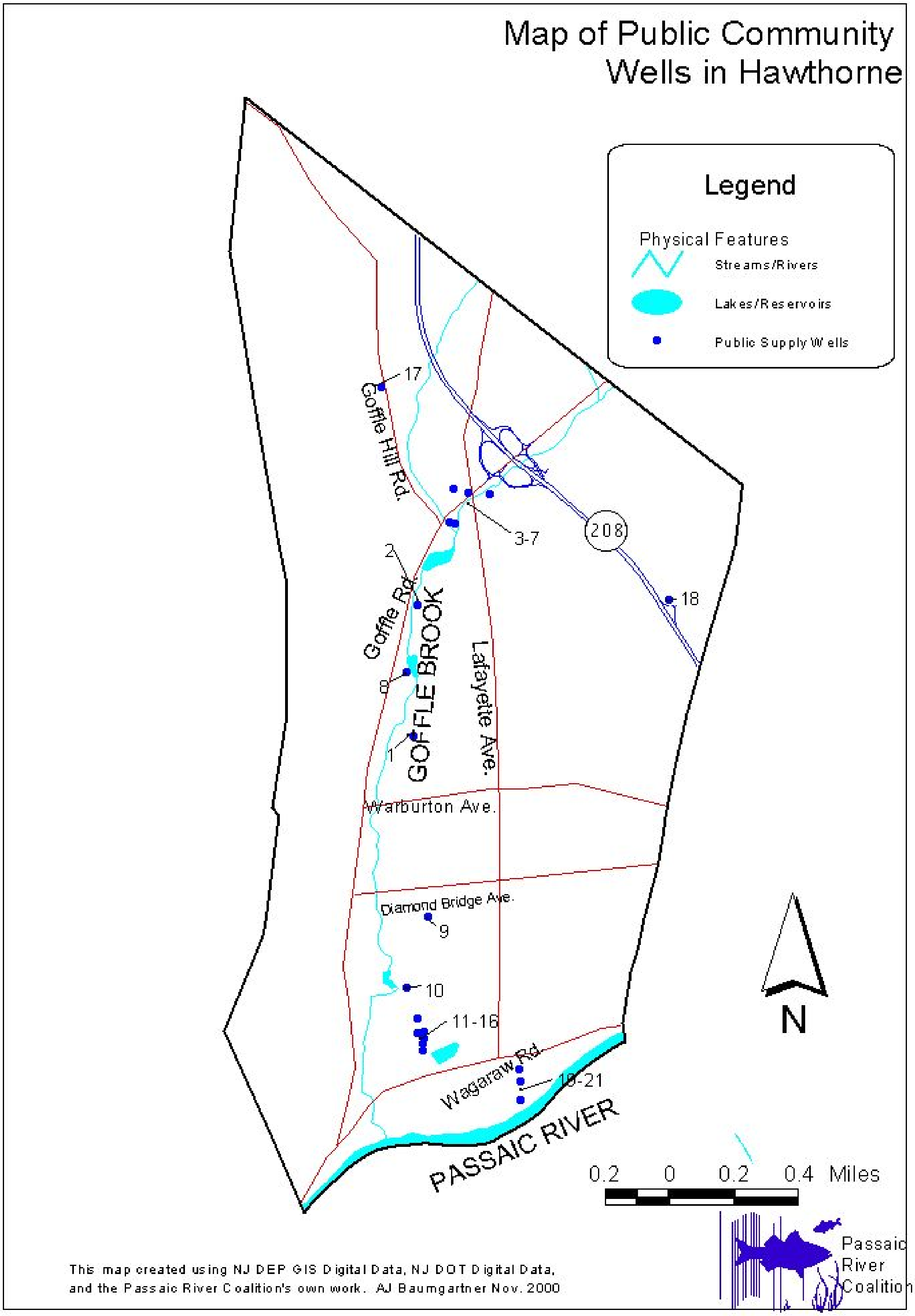
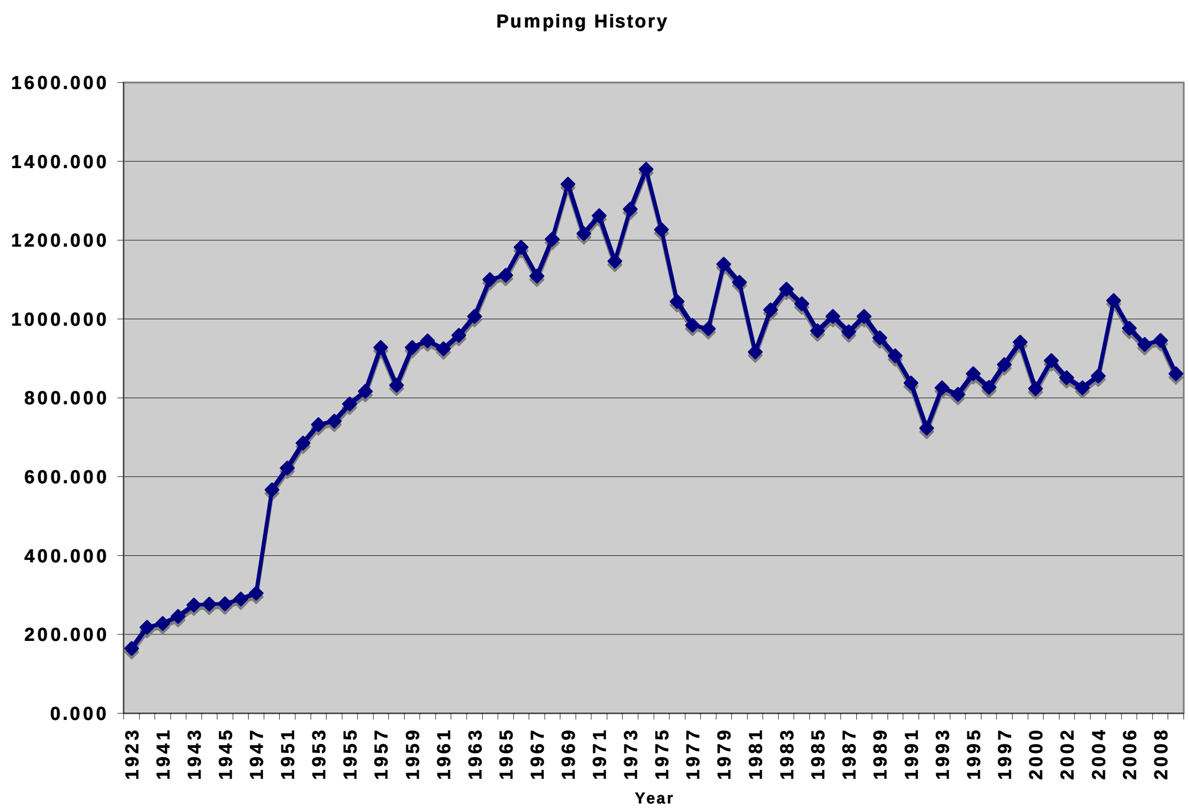


Fig. 18. Map of Public Community Wells in the Borough of Hawthorne.

The maximum amount of water pumped in recent years was 1.4 billion gallons in 1975 (3.8 mgd) (**Fig. 19**). The minimum amount of water pumped since 1953 was 720 million gallons in 1992 (2.0 mgd) (**Fig. 19**). Pumping for the years 2008 and 2009 approximated just over 900 million gallons per year (2.4 mgd).

In 1984 Hawthorne applied for a renewal permit to divert a maximum of 167 million gallons of water during any month at a maximum rate of 4,230 gallons per minute from the 21 existing wells. This permit has been renewed every five years. The total diversion, for each month from each well was reported quarterly to the New Jersey Department of Environmental Protection's Water Allocation Office along with the static water levels of wells identified in the monitoring plan. In May 2001, the Hawthorne municipality approved an Interlocal Service Agreement with North Haledon which set Hawthorne to supply water to approximately 382 home units in North Haledon (Borough of Haledon v. Borough of North Haledon, et al). Hawthorne has twenty-one municipal wells that supply approximately 19,500 people with water to the following towns: Fair Lawn, Glen Rock, Ridgewood, Wyckoff, Hawthorne, North Haledon, and Prospect Park. North Haledon has the most substantial amount of water being supplied from the Hawthorne Water Department; most of the other municipalities receive about twenty homes worth of water diversion (**Fig 20**).

Fig. 19. Average Daily Volume of Water Pumped by Year (mgd) for Hawthorne municipal wells. Graph is generated from data supplied by the Department of Public Works, Hawthorne, NJ.



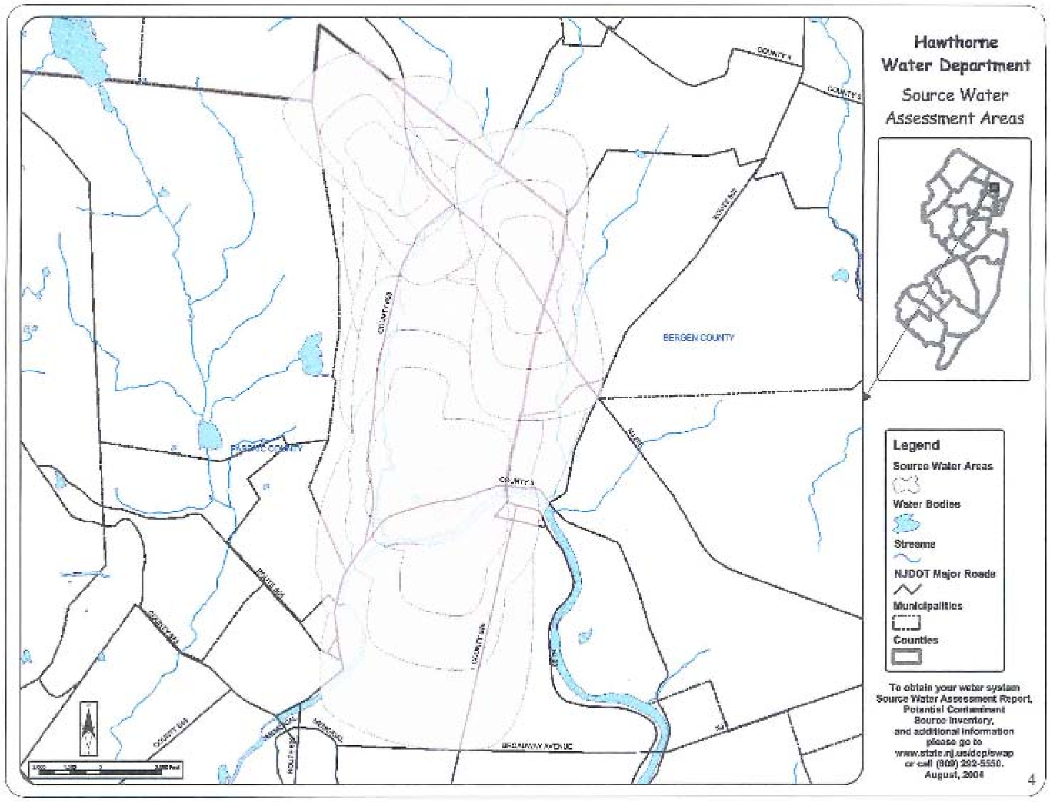


Figure 20. Area of Water Diverted. Hawthorne Water Department – Source water Assessment Area. 2004.

GROUNDWATER RECHARGE

Groundwater recharge is one of the most important factors in the sustainability of pumping an aquifer. The water in an aquifer is the result of surface water and rainwater percolating into the ground (**Fig. 21**). The water that is not taken up by vegetation, slowly makes its way deep into the ground until it reaches the zone of saturation, a depth at which all the pores (all the voids within the soil or rock) are completely filled with water. The upper limit of the saturated zone is the water table, and this marks the upper limit of the aquifer (Price 1985). It is this portion of the hydrologic cycle that replenishes the ground water. Recharge or replenishment of the ground water is critical to maintaining availability of drinking water. Recharge rates can vary widely, but for the water level in an aquifer to be maintained, recharge must be equal to withdrawal. Impermeable surfaces, such as roads, parking lots, and buildings, prevent the infiltration of water into the ground, and if impermeable surfaces overlay an area of groundwater recharge, there will be a net loss of water from the aquifer. To understand and protect groundwater resources, the New Jersey Geologic Society is in the process of mapping aquifer recharge areas using such information as rainfall data, land use, soil types, and the extent of wetlands in the area (NJGS 2001).

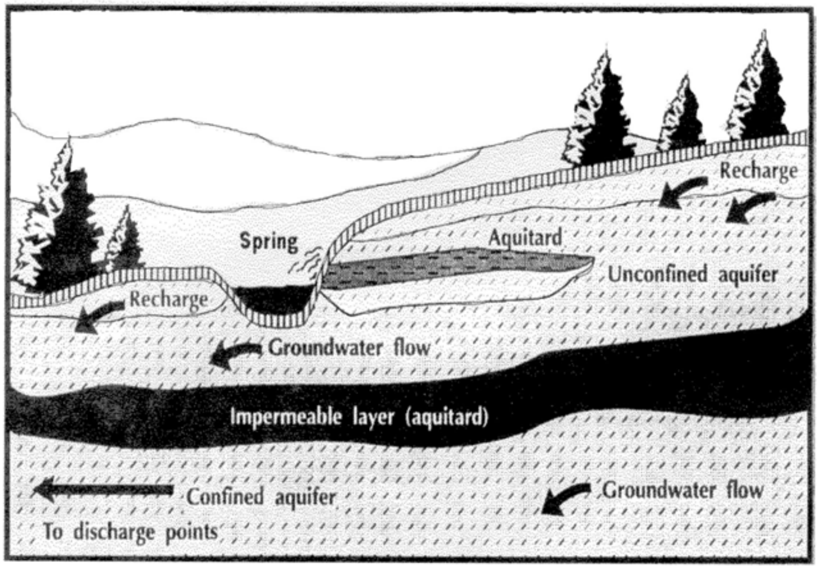


Fig. 21. Recharge of Ground Water in Aquifer. Figure is modified from PVGWPC's Ground Water document.

It is likely that the principal areas of aquifer recharge within the Borough of Hawthorne are located to the east of the First Watchung Ridge (Orange Mountain). Recharge to the First Watchung is minimal since the ridge is composed of basalt that is relatively impermeable and which slopes away from Hawthorne towards North Haledon. Since much of this area is covered by impervious surfaces, the stability of water levels in the aquifer is something that deserves investigation. As a large portion of the watershed lies upstream and outside of Hawthorne, and these areas contain soils and surficial geology that is permeable it is reasonable to assume that a significant amount of the recharge area for the aquifer lies outside Hawthorne's municipal borders. When recharge to an aquifer is insufficient, river water may provide recharge to the groundwater.

GROUNDWATER QUALITY

View of chemical air strippers attached to municipal wells at the Wagaraw site.

Generally, drinking water may reasonably be expected to contain at least small amounts of some substances that may be contaminants at designated concentrations. The presence of such substances does not necessarily indicate that the water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the Environmental Protection Agency's Safe Drinking Water Hotline: (800) 426-4791. The water in aquifers of the Newark Group generally is hard (concentrations exceeding 120 mg/L hardness as calcium carbonate) and may have locally excessive concentrations of iron (11 mg/L) and sulfate (1,800 mg/L).

As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and can pick up substances resulting from the presence of animals or from human activity. These substances include microbes, such as viruses and bacteria that may come from leaky sewage lines, pets, and wildlife. Inorganic substances, such as salts and metals, can be naturally occurring or result from urban storm water runoff, or industrial wastewater discharges. Substances picked up with runoff can also include pesticides and herbicides. To ensure that tap water is safe to drink, regardless of whether it comes from wells or rivers, the Environmental Protection Agency (USEPA), under provisions of the Safe Drinking Water Act, prescribes regulations that limit the amount of certain substances in water provided by public water systems.

There is a maximum amount of a contaminant allowed in drinking water, which is referred to as Maximum Contaminant Level or MCL. MCL's are set by the EPA for specific contaminants. Maximum Contaminant Level Goals or MCLG's are set individually by state. The MCLG for a particular contaminant is referred to as the level of that contaminant in drinking water below which there is no known or expected risk to health. This allows for a margin of safety. Hawthorne's water supply is in compliance with all MCL's set by the EPA.

The Brunswick Group Aquifer, being composed of sandstone and shale, helps to purify water as it percolates through the ground. The earth and sediments between the land surface and the well serve as a filter to purify water making ground water generally of high quality, but this filtering mechanism can be overwhelmed by pollution from the surface. The quality of Hawthorne's well water is generally good, although there have been problems with contamination in some of the wells along Wagaraw Road. The municipal wells along Wagaraw Road are located under a highly industrialized section of the Borough, and close to the Passaic River, two potential pollutant sources. Primary chemical pollutants are trichlorethane and tetrachloroethylene. These two chemicals are cited as examples of chemicals frequently found in New Jersey ground water (Novotny and Chesters 1981). The levels of these two chemicals have been relatively constant at under 5 ppb in raw water and 0-1 ppb in treated water (Lakefield pers. comm. 2000). Analysis of water from the Wagaraw Road revealed the presence of volatile organic chemicals in the water that are assumed to have come from one of the many industrial sites in the area. This water is made safe for drinking by two large chemical strippers (North Station and South Station), which are visible from Wagaraw Road. Similarly an air stripper purifies the Goffle Road wells. Purification of this type is expensive, and it is in Hawthorne's best interest to avoid contamination. All wells are treated with Calcium Hypochlorite.

There are numerous Known Contaminated Sites in Hawthorne (**Table 14**). There are also a few Known Contaminated Sites located along Goffle Brook upstream of Hawthorne that have the potential of contaminating Goffle Brook affecting the Borough of Hawthorne. Ground water can also be contaminated by leaking Underground Storage Tanks (UST's). According to the NJDEP's Bureau of Underground Storage Tanks, there are several UST's in Hawthorne (**Table 15**). Several businesses also discharge directly to the groundwater according to NJPDES Permit Records (**Table 16**).

Table 14. Active & Known Contaminated Sites in Hawthorne. Data compiled from information supplied by NJDEP Known Contaminated Sites List – Active Sites (NJDEP Data Miner 2010)

ID#	Name	Address
21014	Budget Truck Rental	10 Wagaraw Road
150954	Vacant	1173 Goffle Road
194705	Home Owner	166 Parmalee Ave.
229278	Home Owner	230 Rea Ave.
70423	Residential	42 Parker Ave.
31722	Vacant	55 Westervelt Ave.
14762	Galaxy Plastic Industries, Inc.	179 Goffle Road
37382	Kohler Distributing Co.	150 Wagaraw Road
37338	Calgon Corporation	200 Wagaraw Road
45047	Chet Decker Auto Sales	300 Lincoln Ave.
56475	McBride Frank A. Co.	233 Central Ave.
2606	Hawthorne Auto Lab	225 Diamond Bridge Ave.
385151	Vacant	90 5th Ave.
66403	Hawthorne Municipal Wells	Wagaraw Road
383604	Vacant	351 Wagaraw Road
2592	Lukoil	362 370 Lincoln Ave.
2579	Lukoil	2 Wagaraw Road
32172	Madison Sprocket & Gear Inc.	275 Goffle Road
2574	Vacant	1 Washington Ave.
489099	Passaic-Bergen Pass Service Restoration	Various Locations
54615	AJ Marvel Granet	1012 Goffle Road
21061	Seaboard Industries	185 Van Winkle Ave.
2594	Vacant	92 Lafayette Ave.
2602	Vacant	902 Goffle Road
17569	Assorted Bussinesses	220 Goffle Road
44816	Thomas Construction Co.	Thomas Road S
76296	Minifold	300 9th Ave.
52837	Ulma Form-Works, Inc.	58 5th Ave.
2573	Star Sunoco	415 Wagaraw Road
		30 Total Active Sites

Table 15. Underground Storage Tanks in Hawthorne. UST's as designated by the NJDEP Bureau of Underground Storage Tanks, 2005.

Name	Address	UST Status
Shopmeyer Brothers	10 Wagaraw Road	(1) UST In-Use
Murphey Bus Co.	248-270 Goffle Road	(2) UST In-Use
Vacant	55 Westervelt Ave.	(1) UST Abandoned
Getty Service Station	Wagaraw Rd & Lafayette Ave	(4) UST In-Use
A1 Gas, Inc.	389 Lafayette Ave.	(4) UST In-Use
Franklin Commons Condomiums	50 May Street	(1) “Other”
George Abbood & Co, Inc.	581 Lafayette Ave.	(2) UST In-Use
Goffle Hill Sewerage Pump Station	950 Goffle Road	(5) “Other”
Golddel of Hawthorne, Inc.	326 Lincoln Ave.	(5) UST In-Use
Graafsma Property	90 5th Ave.	(1) Out of Service
M & P Foreign Cars	36 Lincoln Ave.	(1) UST In-Use
Heerema Co.	200 6th Ave.	(1) Out of Service
Jer-Mar Co.	91 Royal Ave.	(1) Abandoned
Lukoil	362 70 Lincoln Ave.	(3) UST In-Use
Lukoil	716 Goffle Road	(3) UST In-Use
Lukoil	2 Wagaraw Road	(3) UST In-Use
Midas Muffler & Brakes	1093 Goffle Road	(1) UST In-Use
Obrien Imports, Inc.	801 Lafayette Ave.	(1) UST In-Use
Pan Technology, Inc.	1 Washington Ave.	(8) Abandoned
Passaic County Goffle Brooke Park	794 Lafayette Ave.	(1) UST In-Use
Pyrolac Corp	55 Schoon Ave.	(11) UST In-Use
Vishdev, Inc.	415 Wagaraw Road	(3) UST In-Use

Table 16. NJPDES Permits for discharging to the waters of Hawthorne, NJDEP.

NJPDES#	Facility Name	Address	Permit Date
NJG0170666	Hawthorne Paint Co, Inc.	66 5th Ave.	03/31/08-05/31/12
NJG0169439	Murphy Bus Service, Inc.	248-262 Goffle Road	10/10/07-05/31/12
NJG0169374	Collins & Co LLC	121-129 Wagraw Road	09/24/07-05/31/12
NJG0168467	Peerless Coatings LLC	220A Goffle Road	06/04/07-05/31/12
NJG0166642	Intek-Elite Plastics Corp	150 Fifth Ave.	06/01/07-05/31/12
NJG0161811	Shotmeyer Bros.	10 Wagaraw Road	06/01/07-05/31/12
NJG0149616	Hawthorne Boro	445 Lafayette Ave.	03/01/09-02/28/14
NJG0127230	Continental Aromatics	1 Thomas Road S	06/01/07-05/31/12
NJG0126799	Zimmer MFG Corp.	200 Central Ave.	06/01/07-05/31/12
NJG0124711	Fisk Alloy Wire, Inc.	10 Thomas Road	06/01/07-05/31/12

The NJ Department of Environmental Protection, in accordance with directions from the US EPA, has begun a Well Head Protection Program (WHPP). The purpose of a Well Head Protection Program is to protect groundwater from contamination. The NJDEP considers over 100 public community wells and probably thousands of domestic wells to have been polluted. The WHPP is designed to map existing public community wells, identify possible pollution sources (PPS) within designated areas surrounding the wells, and prevent new pollutant sources from being placed within the designated area. The designated areas within a WHPP are based upon Time of Travel of a pollutant to a well. The Tier 1 designated area is based on a Time of Travel of 2 years, which is the time deemed necessary to prevent microbial pollution from migrating to the well head (PRC and PVGWPC 1998). It is thought that within two years bacteria and viruses would no longer be viable and contaminate the well. The Tier 2 designation is based upon a five-year Time of Travel for water from the edge of the tier to the well (PRC and PVGWPC 1998). The basis of the Tier 2 designation is that should a spill/discharge of hazardous material, such as, trichloroethylene occur, there would be sufficient time to identify the problem, decide on a remediation plan, and carry the plan out. The time of travel is not based upon the assumption that the toxic will no longer be a hazard to the groundwater by five years, but rather to provide sufficient time to mitigate the problem. Tier 3 would be based on 10-15 years time of travel, during which time it is thought that dilution and attenuation of pollutants would minimize the risk of well pollution (PRC and PVGWPC 1998). Public Community Water Supply Wells are being mapped and designated by the NJDEP, although Public Non-Community Wells and Domestic Wells are not. The Borough of Hawthorne is not designated in a Well Head Protection area (NJ Geological Survey www.state.nj.us/dep/njgs..)

Ground water contamination is difficult but not impossible to clean up. Remediation of ground water contamination is not as easy to clean up as surface water contamination, and is more costly and time consuming.

SOURCE WATER ASSESSMENT

As a requirement of the 1996 Amendments to the Safe Drinking Water Act, New Jersey Department of Environmental Protection (NJDEP) performed a source water assessment of each source of public drinking water and determined each source’s susceptibility to contamination. Susceptibility is a measure of the potential exposure of a drinking water source to contamination.

The Source Water Assessment Program was designed to encourage protection of drinking water sources by providing information to state and local regulatory agencies and the public to assist in watershed assessment and planning and to enhance the public's role as "water stewards." The results provide information to allow state and local agencies to determine if increased regulatory controls, including local land use ordinances, are warranted. In addition, the basic data gathered through the Source Water Assessment Program, including the locations of the public water system wells and surface water sources, will be available for DEP program use in efforts to improve environment regulatory actions, such as cleanup decisions in the hazardous and solid waste programs.

New Jersey Department of Environmental Protection (NJDEP), in conjunction with the United States Geological Survey (USGS), performed the following steps to determine the drinking water sources' susceptibility.

• Identified the area that supplies water to a public drinking water system well or surface water intake (known as the source water assessment area). For ground water sources, this area is also known as the well head protection area. Approximately 10 percent of New Jersey is contained within a community water system well's source water assessment area. For surface water, approximately 53 percent of the state falls within a source water assessment area.

• Inventoried the significant potential sources of contamination within the source water assessment area.

• Determined how susceptible each drinking water source is to contamination.

Susceptibility to the following categories of contamination was determined:

- **Pathogens** – disease causing organisms such as bacteria and viruses. Common sources are animal and human fecal wastes

- **Nutrients** – Compounds minerals, and elements that aid growth, that are both naturally occurring and man-made. Examples include nitrogen and phosphorus

- **Volatile Organic Compounds** – Man-made chemicals used as solvents, degreasers, and gasoline components. Examples include herbicides such as atrazine, and insecticides such as chlordane

- **Pesticides** – Man-made chemicals used to control pests, weeds, and fungus. Common sources include land application and manufacturing centers of pesticides. Examples include herbicides such as atrazine, and insecticides such as chlordane

- **Inorganics** – Mineral-based compounds that are both naturally occurring and man-made. Examples include arsenic, asbestos, copper, lead, and nitrate.

- **Radionuclides** – Radioactive substances that are both naturally occurring and man-made. Examples include radium and uranium

- **Radon** – Colorless, odorless, cancer-causing gas that occurs naturally in the environment. For more information to http://www.nj.gov/dep/rpp/radon/index.htm or call (800) 648 - 0394

- **Disinfection Byproduct Precursors** – a common source is naturally occurring organic matter in surface water. Disinfection byproducts are formed when the disinfectants (usually chlorine) used to kill pathogens react with dissolved organic material (for example leaves) present in surface water.

To determine susceptibility to these contaminants, the USGS, with NJDEP assistance, developed statistical models based on extensive analysis of existing well sample data and surface water intake data. The statistical models determined the relationship between environmental factors and the probability for contamination to occur. These models identified factors, such as land use or geology, found to be significantly “linked” to a public water system source’s potential to become contaminated by one or more categories of contaminants. NJDEP and USGS looked at factors that might affect the quality of drinking water sources and separated them into two categories.

The first category consists of *sensitivity factors*, which includes items related to the construction of a well (such as whether the well is in a confined or unconfined aquifer) and naturally occurring factors (such as the geology of the unit in which a well is drawing water from or over which water flows to the surface water intake).

The second category of factors affecting a source’s potential to become contaminated consists of *intensity of use factors*. This category addresses the susceptibility to contamination resulting from human activities at the land surface. Intensity of use factors include those coming from a specific point source, such as a landfill or leaking underground storage tank, and nonpoint sources of contamination grouped by land-use characteristics, such as agriculture or urban land use.

The specific sensitivity and intensity of use factors for each drinking water source are provided in the Source Water Assessment Report.

Using the susceptibility factors, the statistical models provided numerical ratings for each source of drinking water for each contaminant category, which were then converted into high (H), medium (M), or low (L) susceptibility ratings.

The Safe Drinking Water Standards or Maximum Contaminant Levels (MCLs) were used to define the three susceptibility ratings (H, M, and L). These standards are developed based health effects, analytical and treatment factors on either acute or long-term impacts related to drinking water exposure. A low susceptibility rating means a potential contaminant level was predicted to be less than 10 percent of the MCL for that contaminant category. A medium rating was given to drinking water sources where the potential contaminant level was predicted to be equal to or greater than 10 percent and less than 50 percent of the MCL. A high rating was assigned to those sources that were predicted to have potential contaminant levels equal to or greater than 50 percent of the MCL. Sources with high susceptibility ratings are still likely to have contaminant concentrations below the MCL.

To review a summary of how the other public water systems in the State of New Jersey rated, please refer to **Table 17**, “Summary of Statewide Susceptibility Ratings for Community Water System Sources (Percent)

Table 17 Summary of Statewide Susceptibility Ratings for Community Water System Sources (Percent %) (Source Water Assessment Report Table 5, December 2004)

	Pathogens	Nutrients	Pesticides	VOCs	Inorganics	Radionuclides	Radon	DBPs
Groundwater[1]								
High	4	48	0	44	27	35	36	22
Medium	40	22	23	0	38	45	38	76
Low	56	31	77	56	35	20	26	2
Surface Water[2]								
High	100	47	13	5	81	0	0	98
Medium	0	42	34	81	19	0	0	2
Low	0	11	53	4	0	100	100	0

1 Community water systems wells in New Jersey in 2003 = 2237
2 Community water system surface water sources in New Jersey in 2003 = 64

The Source Water Assessment Summary report identifies the likelihood that a contaminant would pollute certain wells in Hawthorne. **Table 18** is Hawthorne's assessment of the groundwater aquifer.

Table 18 Summary of Susceptibility Ratings for Drinking Water Sources (Percent %) (Source Water Assessment Report Table 8, December 2004)

	Pathogens			Nutrients			Pesticides			VOCs			Inorganics			Radionuclides			Radon			DBPs		
Sources	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L
Wells = 21		17	4	15	6			15	6	21			21			17	4		21				21	
GUIDI = 0																								
Surface Water Intakes = 0																								

GUIDI = Ground water under the direct influence of surface water

The rating reflects the potential for contamination of source water, not the existence of contamination. Public water systems are required to monitor for regulated contaminants and to install treatment if any contaminants are detected at frequencies and concentrations above allowable levels. If a system is rated highly susceptible for a contaminant category, it does not mean a customer is or will be consuming contaminated drinking water.

SURFACE WATER IN HAWTHORNE

OVERVIEW

Protecting and restoring natural features and improving water quality of urban streams have many benefits both to the biotic life in the stream and to human communities that live near these streams. Urban waterways can potentially be used for recreational activities, such as fishing and canoeing, and provide opportunities for urban residents to enjoy and appreciate the outdoors. A healthy aquatic ecosystem can not only deter the spread of vector borne disease, but enhance the health of the community by reducing air pollutants.

The surface waters, which flow through Hawthorne, are Goffle Brook, Deep Brook, Diamond Brook, plus direct runoff to the Passaic River that flows along the southern boundary of Hawthorne. The Borough of Hawthorne is located in several sub-watersheds. A watershed, or water catchment area, is inclusive of all the area from which water drains to the stream. In Hawthorne, 200-300 acres contribute to Diamond Brook watershed. The largest area in Hawthorne drains into Goffle Brook, which then empties into the Passaic River (**Fig. 22**). The entire borough lies within the Passaic River Basin. Non-point source pollution is a problem in many streams and rivers today.

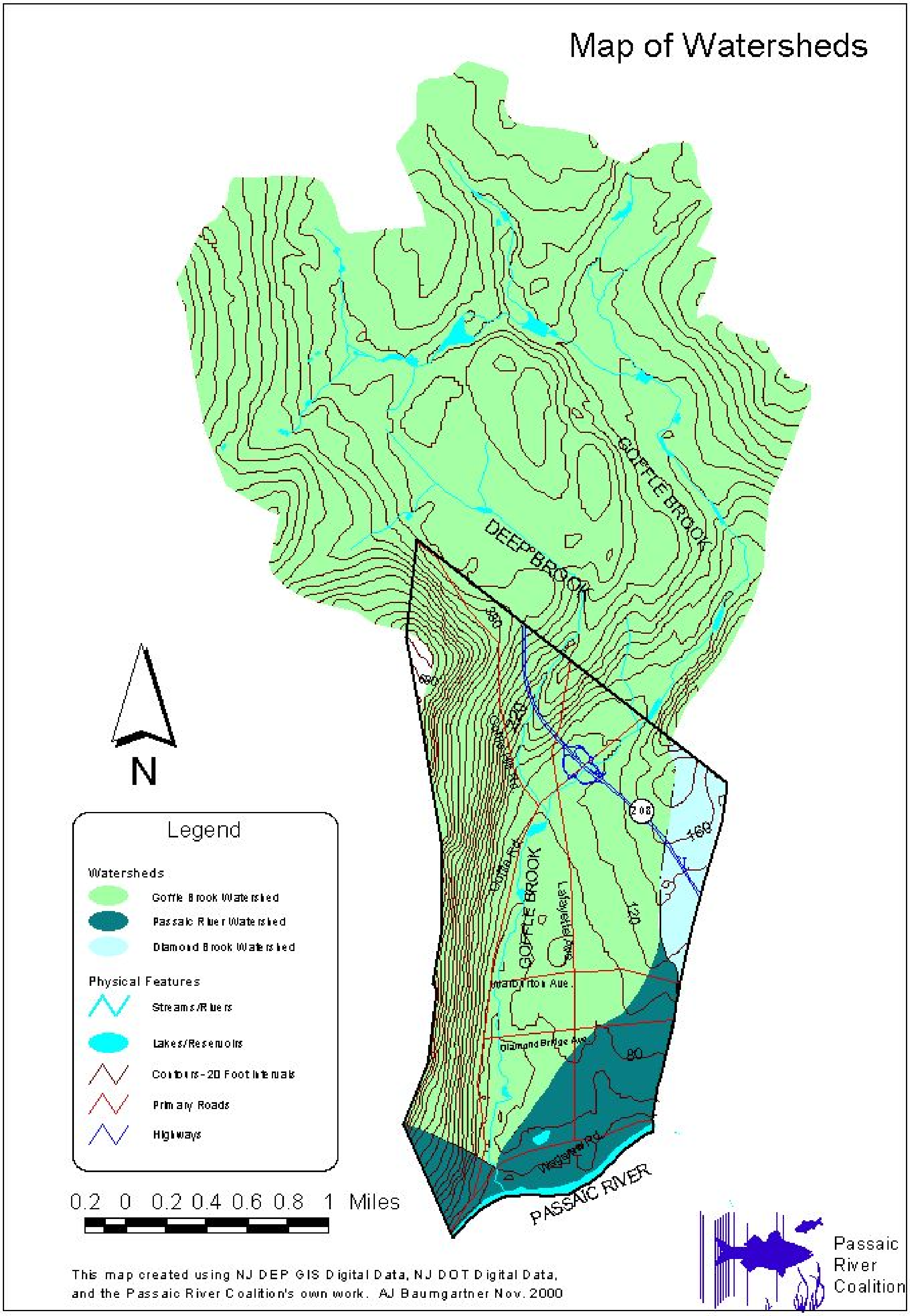


Fig. 22. Map of Watersheds in which Hawthorne is located
and the Goffle Brook Watershed.

Non-point source pollution is pollution from diverse loadings, small individually but overwhelming when in great numbers. One example of non-point source pollution is commercial lawn care. It is a prevalent practice today and is a large source of insecticide, herbicide, and fertilizer runoff in developed areas (Reiser and O'Brien 1999).

GOFFLE BROOK

Physical Characteristics. Goffle Brook and its major tributary, Depe Voll (Deep Brook), are the major surface waters in Hawthorne (**Fig. 22**), and they are part of the greater Passaic River Watershed. The total area of the Goffle Brook watershed is approximately 23.81 km^2 (9.19mi^2), and includes the towns of Ridgewood, Wyckoff, Midland Park and Hawthorne. The headwaters of both Goffle Brook and Deep Brook are located in Wyckoff, Bergen County, NJ. The upper part of Goffle Brook traverses Wyckoff, passes through Midland Park and the southwest end of Ridgewood before it enters the northern end of Hawthorne near the east side of Goffle Road. In Hawthorne, Goffle Brook flows in a southerly direction roughly parallel to Goffle Road for approximately 2.65 miles (4.3 km) to its juncture with the Passaic River, at a location approximately 1.75 stream miles (2.81 km) downstream of the Paterson Falls. The total length of Goffle Brook is approximately 6.8 miles (10.9 km) from its beginning in Wyckoff to its confluence with the Passaic River. Thus, 60 percent of the total length of Goffle Brook lies outside Hawthorne's boundaries, and 40 percent is within the Borough.

Deep Brook, the major tributary (**Fig. 22**), joins Goffle Brook near the Goffle Hill Road Bridge. Over geologic time, Deep Brook has cut a deep ravine along part of its length from just north of Union Street to the Wyckoff border. Arising in Wyckoff, Deep Brook has a total length of approximately 2.4 miles (3.9 km). Its distance from the Wyckoff border to its intersection with Goffle Brook is 0.8 miles. Therefore, 33 percent of Deep Brook lies within Hawthorne, and 67 percent of its length is in the Borough of Wyckoff, Bergen County (**Table 19**).

Table 19. Linear morphometry of Goffle Brook and Deep Brook; approximate stream miles, Sebetich Unpublished Data

	Goffle Brook	**Deep Brook**
Total length in miles	6.8 (100%)	2.4 (100%)
Length in Bergen County, miles	4.1 (60%)	1.6 (67%)
Length in Hawthorne, miles	2.7 (40%)	0.8 (33%)

Most of the land use on either side of Goffle Brook north of Lafayette Avenue in Hawthorne is commercial and highly urban. Thus the stream is heavily influenced by nonpoint source urban runoff from Bergen County along most of its length and from the Borough of Hawthorne along a shorter stream segment, including the two-mile section that runs through Goffle Brook Park. Goffle Brook travels the entire length of Goffle Brook County Park making the stream a central focus of the park. Deep Brook still (in 2010) has riparian vegetation along much of its length, but major pipes along Goffle Hill Road deliver nonpoint source runoff water directly to the stream. Further, the runoff from a major housing development located in Wyckoff is directed into Deep Brook. Between Union Street and Goffle Brook, Deep Brook is heavily influenced by urban land use, including Hawthorne's DPW site located on Goffle Road and Goffle Hill Road.

Both valleys of Goffle Brook and Deep Brook have been eroded and scoured by storm events. Increased development of housing projects and commercial structures in the watershed, both within and outside of the Borough of Hawthorne, have contributed to the substantial flooding of Goffle Brook. As new developments and runoff projects are completed, the increased runoff is transported directly into Deep Brook and Goffle Brook. Thus, erosion, sedimentation and flooding are serious problems in the two streams. To manage the watersheds more effectively and to reduce increases in runoff, erosion and sedimentation, the following should be considered:

> *On-site detention of storm water using site design measures such as natural drainages instead of storm pipes and culverts, detention wetlands, reforestation, rainwater cisterns, and buffer zones can delay the timing and reduce the volume and peaks of runoff and filter the water before it enters stream channels. Riparian restoration projects can help add stability to stream channels adjusting to greater flows. Buffer zones and greenways along waterways can prevent damages to structures from waterways that are adjusting and enlarging under the influence of urbanization. Native woodlands and vegetation can be returned to watershed slopes* (Riley 1998).

Water Quality Characteristics. Selected water quality variables measured at various times between 1980 and 2000 reflect the geological influence in the watershed (**Table 20 and 21**). The pH of both streams generally falls between 8 and 9, which is relatively high. The mean (N=9) total alkalinity of Goffle Brook was 114 mg $CaCO_3$/L, and the electrical conductivity of the same nine samples was 643 µS/cm. These high values indicate that the waters are most likely influenced by naturally high concentrations of calcium and magnesium from the geological formations in the watershed and most likely salt runoff from roadways.

Table 20. Deep Brook water chemistry. Site A was upstream of Deep Brook; Site B was downstream of Deep Brook. (Sebetich unpublished data).
TDS = Total Dissolved Solids, SRP = Soluble Reactive Phosphorus

Date	pH	Total Alkalinity (mg $CaCO_3$/L)	Conductivity (µS/cm)	TDS (mg/L)	Turbidity (NTU)	SRP (µg/L)
April 11, 1980						
Site A	8.5	64				
April 10, 1981						
Site A	8.0-8.5	100				
March 12, 1982						
Site A	6.5	95	488		34	
March 12, 1982						
Site B	8.0-8.5	107	528		39	
May 8, 1993						
Site A	8.0-8.5	124	785	327		
May 8, 1993						
Site B	8.0-8.5	113		341		
April 21, 1995						
Site A	8		544	369		
April 26, 1997						
Site A	8.5-9.0	132	624	450		
April 26, 1997						
Site B	8.5-9.0	142	665	480		
Feb. 26, 2000						
Site A	8.0-8.5	103	819	586		21.91
Feb. 26, 2000						
Site B	8.0-8.5	109	1120	802		28.34
April 8, 2000						
Site A	8.0-8.5	102	523	381		
Mean		**108.3**	**677.3**	**467.0**		
N		**11**	**9**	**8**		
S.D.		**20.6**	**203.2**	**160.1**		

Table 21. Deep Brook water chemistry.
(Sebetich unpublished data).

Date	pH	Total Alkalinity (mg $CaCO_3$/L)	Conductivity (µS/cm)	TDS (mg/L)
March 12, 1982	6.4	111	528	
May 8, 1993	8.0-8.5	131	795	335
April 21, 1995	8.5		540	366
April 26, 1997	8.0-8.5	154	656	475
Feb. 26, 2000	8.0-8.5	131	1,728	1,239
April 8, 2000	8.0-8.5	123	682	490
October 2, 2009	8.0-8.5		687	
Mean		**130**	**802.3**	**581**
N		**5**	**7**	**5**
S. D.		**15.7**	**454.9**	**373.9**

Phosphorus (P) is an important element that is commonly used as a water quality indicator in freshwater streams and lakes. The higher the P concentration, the lower the water quality. Deep Brook and Goffle Brook are not monitored on a regular basis for nutrients; however, some observations of phosphorus have been measured (Sebetich, unpublished data). In February 2000, Deep Brook had a phosphorus concentration of 6.55 µg/Liter. Goffle Brook had a P concentration of 21.91 µg/Liter just upstream of Deep Brook, and a concentration of 28.34 µg/Liter downstream of Deep Brook. A concentration of P above 20 µg/Liter tends to lead to eutrophic conditions in freshwaters. Based on these few data points, the P concentration in Goffle Brook is over three times that in Deep Brook, indicating that Goffle Brook has been more severely impacted by urban runoff and land use than Deep Brook. This evidence seems to indicate a lack of concern for water quality in Goffle Brook. In Bergen County, as well as in the northern end of Hawthorne, Goffle Brook is practically invisible to residents, as it has been relegated to a disposal system. The stream passes mostly unnoticed as it flows through industrial areas, parking lots, shopping centers, varied commercial properties, and along railroad tracks until it emerges as a highly visible stream in Goffle Brook Park in Hawthorne. By then the stream has accumulated the undesirable runoff products from the aforementioned land uses that have degraded the stream water quality. Ongoing and planned land development in Hawthorne will further contribute to stream degradation as the added runoff is directed into Goffle Brook.

The shallow pond impoundment of Goffle Brook, located near Goffle Hill Road, has been highly impacted by the nutrient and bacterial load from geese, ducks and seagulls for decades. These birds are encouraged to use the pond and surrounding land by the constant feeding by people. The resulting nutrient (nitrogen and phosphorus, primarily) loadings along with the fecal bacterial contamination contribute to the decreased water quality of the pond and stream. Thus the birds are major contributors to the surface water pollution, and may be a potential threat to human health and to the health of dogs that regularly drink from the stream. An adjacent municipality, the Borough of North Haledon has established an ordinance that prohibits the feeding of migratory waterfowl at their ponds. The New Jersey Department of Environmental Protection's Division of Fish and Wildlife have also initiated a special Winter Canada Goose Season from January 19 - February 15, 2010, because of problems due to their overabundance and also due to their negative impact on the migratory Atlantic Geese population (NJDEP 2010).

Only in Goffle Brook Park is the stream considered a recreational asset; however, the land use impact on Goffle Brook extends for miles upstream into Midland Park, Ridgewood and Wyckoff, where it tends to be out of sight and out of mind. Goffle Brook will continue to be the major surface water component of Hawthorne, and perhaps it is time to develop a Stream Watch Program to survey the entire watershed, coordinate with the relevant Bergen County communities, and work towards ecologically sound land use modifications that will help improve the water quality of the stream system in the coming decade.

One of the most popular activities in Goffle Brook Park takes place on the first Saturday in June, when the Hawthorne Chamber of Commerce sponsors a Fishing Derby for children at the Goffle Brook Pond. The event, first begun in 1988 to get children interested in fishing, has grown in popularity over the years with participation of over a hundred children each year. The Chamber of Commerce stocks the pond with sunfish, bass, and trout and provides prizes for the heaviest and largest fish, and most fish caught to several age groups.

Biological Characteristics.

Macroinvertebrates. Stream water quality can be inferred from on the number and kinds of macroinvertebrates and fish (Barbour et al. 1999). Macroinvertebrates include such organisms as aquatic insects, snails, worms, leeches and crustaceans. Because specific types of these organisms are sensitive to changes in water quality, and others are not, the presence and absence of these little invertebrates may be used as indicators of stream water quality (Lenat and Crawford 1994, Kennen 1999). An investigation (Sebetich 2009) was conducted using macroinvertebrates and fish to begin a baseline comparison of water quality between Goffle Brook in Hawthorne and Bear Swamp Brook Mahwah, NJ. The two stream systems compare the difference between a stream in a rural area and in urban area. The study found that urbanized areas are more likely to have lower quality streams than higher quality streams.

Biodiversity of macroinvertebrates was lower in both Deep Brook and a section of Goffle Brook (between Lafayette Avenue and Goffle Hill Road) than it was in Bear Swamp Brook (**Table 22**). However, the biodiversity increased in Goffle Brook downstream of the pond in Goffle Brook Park. The macroinvertebrates were identified only to their taxonomic order, but even this degree of investigation revealed the presence of two higher water quality indicators (Stonefly and Hellgramite) in Bear Swamp Brook, but not in Goffle Brook (**Table 22**). Continued long-term monitoring of macroinvertebrates in Goffle Brook and Deep Brook is encouraged. An educational stream watch program for the Hawthorne K-12 students could be established that would create a biological database that could be used to help maintain and improve stream water quality.

Table 22. List of organisms sampled in Deep Brook, Goffle Brook, Bear Swamp Brook (Sebetich 2009).

Common Name	Order	Deep Brook 10/2/09	Goffle Brook 10/2/09	Bear Swamp Brook 10/16/09
Mayfly	*Ephemeroptera*	-	-	+
Stonefly	*Pleoptera*	-	-	+
Caddisfly	*Fricoptera*	+	+	+
Beetle	*Coleoptera*	-	+	+
Bug	*Hemiptera*	-	+	+
Dragonfly/Damselfly	*Odonata*	-	-	+
Hellgramite	*Megaloptera/Neuroptera*	-	-	+
Blackfly	*Diptera*	+	+	-
Cranefly	*Diptera*	-	+	+
Midge	*Diptera*	-	+	-
Crayfish	*Decapoda*	-	-	+
Snail	*Stylommatophora*	+	+	-
Leech	*Arhynchobdellida*	-	+	-
Flatworm	*Platyhelminthes*	-	+	-
Earthworm	*Opisthopora*	+	+	+
Millipede	*Spirostreptida*	+	+	+
Centipede	*Scolopendromorpha*	+	+	-
Ant	*Hymenoptera*	-	-	-

Fish. Fish populations may also be indicators of stream water quality. (Chan et al. 2000) analyzed fish data collected from Goffle Brook in 1968 and 1993, and classified the stream as "poor" based on the fish species sampled. Baseline sampling of fish populations in Goffle Brook and Bear Swamp Brook has been conducted (Sebetich 2009), and will continue to be periodically by Sebetich. A list of fish species sampled is shown in **Tables 23** and **24**. Most sampling in Goffle Brook ranged in differences with Bear Swamp Brook. Specifically, Brooktrout was found in Bear Swamp Brook, but not Goffle Brook. On the other hand, Catfish, Large-mouth bass, American Eel, Sucker, Bluegill, Black nose dace, Sculpin, & Shiner were all found in Goffle Brook, but not Bear Swamp. American eel is a catadromous fish that leaves freshwater to spawn in the Atlantic Ocean; the young eels can migrate up the Passaic River and into Goffle Brook.

Table 23. Fish Sampled in Goffle Brook, near the Goffle Hill Road (Data from Sebetich, unpublished)

Date	Common Name	Scientific Name
May 25, 1999	Blacknose dace	*Rhinichthys atratulus*
	Golden shiner	*Notemigonus crysoleucas*
	Pumpkinseed	*Lepomis gibbosus*
	Tessellated darter	*Etheostoma olmstedi*
	Bluegill	*Lepomis macrochirus*
April 8, 2000	Blugill	*Lepomis macrochirus*
	Pumpkinseed	*Lepomis gibbosus*
	White sucker	*Catostomus commersoni*
October 2, 2009	Catfish	*Siluriformes*
	Large-mouth Bass	*Micropterus salmoides*
	American Eel	*Anguilla rostrata*
	Sucker	*Catostomus*
	Bluegill	*Lepomis macrochirus*
	Black nose dace	*Rhinichthys atratulus*
	Sculpin	*Scropaeniformes*
	Shiner	*Notemigonus*

Table 24. Fish sampled Deep Brook, Goffle Brook, and Bear Swamp Brook, October 2 & 16, 2009. + indicates sampled, - indicates not sampled. Data from Sebetich 2009.

Common Name	Order	Goffle Brook & Deep Brook 10/02/09	Bear Swamp Brook 10/16/09
Catfish	*Siluriformes*	+	-
Large-mouth Bass	*Perciformes*	+	-
American Eel	*Anguilliformes*	+	-
Sucker	*Perciformes*	+ (3)	-
Bluegill	*Perciformes*	+(7)	+ (several)
Black nose dace	*Cypriniformes*	+	+(many)
Sculpin	*Scorpaeniformes*	+	-
Shiner	*Cypriniformes*	+	+(many)
Unknown	*N/A*	+	-
Brooktrout	*Salmoniformes*	-	+(4)

The fish species sampled in Goffle Brook included only tolerant species; therefore, based on fish, the stream did not have high water quality (Sebetich 2009). The fish data that has been obtained up to now provides a good baseline, but more intensive, long-term sampling of fish populations at various locations in Goffle Brook is recommended to help the municipalities of both Bergen and Passaic Counties focus on maintaining water quality in their streams.

While surveys of invertebrate and vertebrate aquatic life are sensitive indicators of water quality, they cannot easily be used to indicate the causes of water pollution. Ecosystem degradation as defined on the basis of such measurements is the first step in establishing the pattern of pollution. That first step, though, needs to be followed by a thorough investigation of possible chemical and biological pollutants in the stream.

PASSAIC RIVER

The Borough of Hawthorne lies within the Passaic River Basin. It is part of the Lower Passaic River Basin, which is also known as Watershed Management Area 4 (WMA4). The Passaic River flows past Hawthorne for about three-quarters of a mile, and forms the boundary between Hawthorne and Paterson. Since water in the Passaic River as it passes Hawthorne is draining an area of almost 800 square miles, both the quantity of water flowing in the river and its quality have been impacted by many influences, which include human uses of the land and water in the watershed above Hawthorne (USGS 1996).

The upper Passaic River begins in a marshy area of Mendham (elevation 600 feet above sea level) as a network of small streams (Brydon 1974). It then travels in a slight southeasterly direction, establishing the boundary between Somerset and Morris counties. As the Passaic River flows through Bernards Township, it picks up waters from two tributaries, the Great Brook and Black Brook, after they drain the Great Swamp. The Passaic River then travels north. During this change of direction the river also changes from a fast moving stream to a slow moving river. The drop in elevation for the next forty-five miles is only approximately one foot per mile, which decreases its velocity. As the Passaic River flows in a northerly direction, it forms another county boundary between Morris and Union Counties, and then between Morris and Essex Counties. A major tributary to the Passaic River is the Rockaway River, which joins the Passaic at Pine Brook as the Passaic travels along the curve of Hook Mountain. At Two Bridges (elevation 159 feet), the Pompton River, another major tributary, joins the Passaic River.

It travels in an easterly direction for about four miles, again dropping only one foot in elevation. At Little Falls there is a steep drop of sixteen feet, and in a very short distance the river loses a total of 40 feet in elevation. From Little Falls it is a five and one-half mile northeastern trip to the Great Falls at Paterson. The Great Falls as they cut through the First Watchung Ridge are the second largest falls east of the Mississippi dropping seventy feet. It is after this dramatic drop in Paterson that the river, continues east to Hawthorne and then travels south to Newark Bay (approximately 25 miles south of Hawthorne), again serving as a boundary marker (between both Passaic and Bergen counties and Essex and Hudson counties). Hawthorne is 10 miles upstream from the Dundee Dam, where the Passaic River is dammed and Dundee Lake was created. Below Dundee Dam is the upper limit of tidewater for the Passaic River. At Garfield (3 miles below Dundee Dam), the Saddle River joins the Passaic. This last stretch of the Passaic flows through heavily industrialized areas (Newark, East Newark, and Harrison) curving northeast and then southeast, before joining the Hackensack River and entering into Newark Bay (Brydon 1974) (**Fig. 23**).

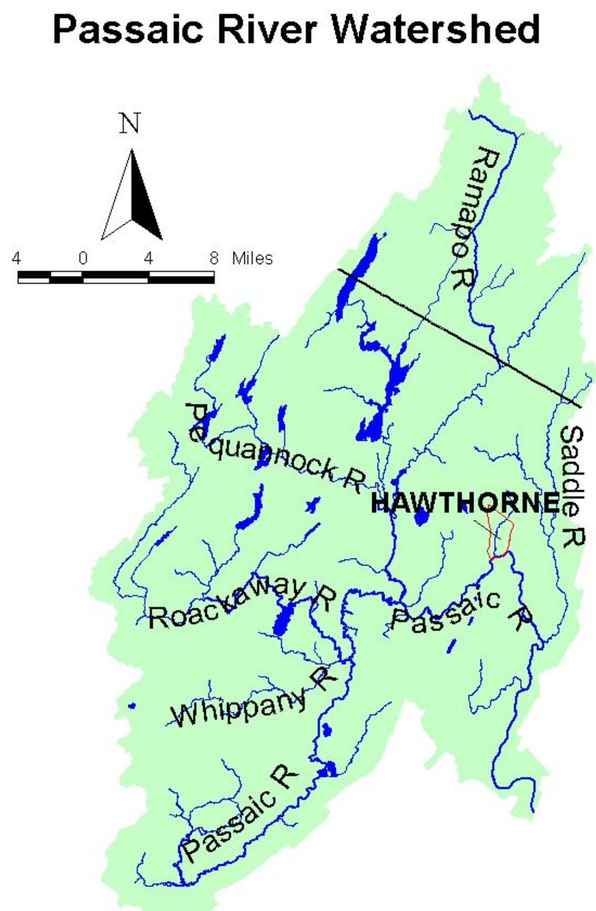


Fig. 23. Map of the Passaic River Watershed. Map displays tributaries and location of Hawthorne (red). Passaic River Coalition.

A watershed is all the land from which water drains into a river or lake. The watershed of the Passaic River is 935 mi^2 in totality. The watershed of the Passaic River at Hawthorne is over 800 mi^2. A majority of the river's watershed is in the Highlands area of New Jersey. In this area the Passaic River is classified as a trout production river, identifying its high quality. At several spots in the upper Passaic, the river and tributaries are dammed and the water is used for drinking purposes. The Passaic River in the Central Passaic River Basin travels through the region known as the Great Meadows, a remnant of Glacial Lake Passaic; much of the area is wetlands. In the Lower Basin, the Passaic River travels through a highly urbanized area. The type of land and land use through which a river travels has a significant impact on the river. It is over this land that the additional water will flow, pick up pollutants or nutrients, and join the river.

Water Quality Characteristics. The New Jersey Department of Environmental Protection (NJDEP) listed the Passaic River at Little Falls (upstream of Hawthorne) and at Elmwood Park (downstream of Hawthorne) as in exceedance of water quality criteria for fecal coliform, total phosphorus, and ammonia (NJDEP 1998). These pollutants impair the use of the Passaic River for primary contact, that is swimming, and for aquatic life support. In addition, aquatic life in the Passaic River at Hawthorne may be impaired because of excessive levels of arsenic, cadmium, chromium, cyanide, copper, lead, mercury, nickel, silver, thallium or zinc (NJDEP 1998).

Chemical data from the U.S.G.S. on the Passaic River at Elmwood Park (**Table 25**) indicates that at this stretch the river is slightly basic (mean pH = 7.8) with a mean total alkalinity of 69 mg $CaCO_3$/L. Average specific conductance was 368 µmhos and phosphorus averaged 338 µg/L for data available. As the Passaic River at Elmwood Park is downstream of Hawthorne (5.3 miles), the readings are conceivably higher than readings on the Passaic River in Hawthorne because of the input from other sites along the course of the river prior to the sampling site in Elmwood Park.

Table 25. USGS Water Quality Data for the Passaic River.
Sampled at Elmwood Park Station #01389880.

Year	pH	Total Alkalinity mg $CaCO_3$/L	Specific Conductance µmhos	Phosphorus (P) µg/L
1976	7.1 (N=17) Range 6.4-7.4	48 (N=15)	293 (N=15)	340 (N=15)
1981	7.6 (N=11) Range 7.0-8.3	Not available	416 (N=11)	560 (N=11)
1992	8.2 (N=5) Range 7.6-8.1	77 (N=5)	501 (N=5)	310 (N=5)
1993	8.1 (N=5) Range 7.3-8.7	73 (N=5)	497 (N=5)	180 (N=5)
1994	7.9 (N=5) Range 7.5-8.1	78 N=5)	436 (N=5)	300 (N=5)
Mean	**7.8**	**69**	**368**	**338**

The water quality of the Passaic River is degraded. The river has been used for waste disposal since the beginning of this century. The upper Passaic River is fairly clean as it flows through the Great Swamp and the Millington Gorge, and deteriorates after that due to the large amount of human activity, including industry, along the river. There is hope for the river because in recent years a lot has been done to clean up wastewater going into the river and along the riverfront. Old industrial sites have been cleaned up and redeveloped stopping the toxins from entering the river system. The lower amounts of permissible discharges have also had a very positive effect on the river. Only time and money and effort will help make the Passaic River overcome years of neglect.

Biological Characteristics. Most likely anadromous fish, which travel upstream to spawn, such as shad and striped bass, were part of the aquatic biota of the Passaic River at one time. The Passaic River was actively fished prior to European settlement, as evidenced by weirs built by Native Americans, which were probably based on migratory fish runs. The importance of migratory runs continued with the Colonial settlers, as evidenced by the fact that shad runs up the river were reported daily (Brydon 1974). As many as 500 shad might be caught in a trap at one time in early times after settlement (Brydon 1974). During that time period, sturgeon also migrated upstream to the foot of the Great Falls. In 1817 one of the largest sturgeon ever reported was caught in the Passaic River, weighing 130 lbs., and headlined in the newspaper as “The Monster Taken” (Brydon 1974).

Due to human impact, many species of fish in the Passaic River became rare, while other more pollution tolerant species proliferated. Fish species sampled in the Passaic River at Little Falls and Paterson in 1980 indicated poor water quality (**Table 26** and **Table 27**). Water quality in the Passaic River has improved since 1980. There has been a resurgence of some species of fish indicative of good water quality, such as small mouth bass, northern pike and channel catfish. Northern pike and channel catfish stocked in the Upper River have been found down river as far as Dundee Dam, indicating improved water quality in the more urban reaches of the Passaic River (Papson 2001 pers. comm.). Below Dundee Dam, shad, stripers and river herring have been caught (Papson 2001 pers. comm.). The upsurge in fish populations, especially fish intolerant of highly polluted water, is an important statement regarding the benefits and possibilities of environmental concern. As in Goffle Brook, a Biotic Index based on macroinvertebrates was prepared for the Passaic River. Macroinvertebrate assessments for the Passaic River at Hawthorne indicate that the river is moderately impaired for aquatic life (NJDEP 1998).

Table 26. Fish Sampling of Passaic River, 600 yards downstream of the Lackawanna Bridge, Paterson, September 10, 1980. Data supplied by Bob Papson, Bureau of Freshwater Fisheries, Lebanon, NJ.

Taxon	**Number**	**Percent by Number**	**Weight (pounds)**	**Percent by Weight**
Carp	9	11.10	22.30	64.80
Carp (young of the year)	9	11.10	0.20	0.60
Carp (TOTAL)	*18*	*22.20*	*22.50*	*65.40*
White sucker	13	16.00	8.80	25.60
Goldfish	15	18.50	0.40	1.20
Banded Killifish	1	1.20	--	--
Spottail Shiner	17	21.0	0.20	0.60
Satinfin Shiner	5	6.20	0.10	0.30
American eel	12	14.80	2.40	7.00
TOTAL	**81**	**99.9%**	**34.40**	**100%**

Table 27. Fish Sampling of Passaic River, between Elmwood Park Marina and Route 80 Bridge, Elmwood Park, September 24, 1980. Data supplied by Bob Papson, Bureau of Freshwater Fisheries, Lebanon, NJ.

Taxon	**Number**	**Percent by Number**	**Weight (pounds)**	**Percent by Weight**
Carp	110	61.80	250.50	94.90
Carp (young of the year)	20	11.20	0.70	0.30
Carp (TOTAL)	*130*	*73.00*	*251.20*	*95.20*
Largemouth bass	3	1.70	2.90	1.10
White sucker	20	11.20	9.20	3.50
Golden shiner (Adults)	1	0.60	0.10	<0.10
Golden shiner (young of the year)	12	6.70	--	--
Golden shiner (TOTAL)	*13*	*7.30*	*0.10*	*<0.10*
American eel	1	0.60	0.50	0.20
Banded Killifish	1	0.60	--	--
Pumpkinseed (young of the year)	10	6.00	0.20	0.60
TOTAL	**178**	**100%**	**264.00**	**100%**

FLOODING

Flooding is a chronic problem in the Borough of Hawthorne, especially in areas such as on Wagaraw Road, where Goffle Brook enters the Passaic River. There has also been considerable flooding north of Lafayette Ave. (near the intersection of Rock Rd.) with ensuing damage to commercial and residential property. North of Route 208, where Goffle Brook is narrow and channelized, flooding problems are present.

View of flooding on Rea Avenue during Tropical Storm Floyd, 1999.

Part of the problem is that many of the natural flood prevention areas, both within Hawthorne and also further upstream in the watershed, have been developed and their flood mitigation abilities destroyed. These natural flood mitigation areas would be wetlands, riparian corridors, the flood plain area, and wetland areas upstream within the watershed. Discussion of wetlands, floodplains, and riparian corridors have overlapping concepts as much of their characteristics and benefits are similar.

RIPARIAN CORRIDORS

Riparian corridors are a combination of floodplains and wetlands occurring adjacent and following a stream or river (Mitsch and Gosselink 1993) and are occasionally flooded by these rivers and streams. These corridors have a high water table due to their proximity to the river or stream. There are variations in the amount of water these riparian corridors exhibit based on the intensity of the flood, duration of the storm event, and the number of previous flood events, but there is a fairly predictable probability of flooding in these areas from year to year. A riparian corridor is the intersection between upland and aquatic ecosystems and are highly dynamic in transferring energy and material in between the two ecosystems (Mitsch and Gosselink, 1993).

Wildlife habitats are an important benefit of riparian corridors. The corridor provides access to rivers and streams for drinking, and this may be especially important in winter when other water sources are frozen and unattainable. The corridor functions as an ecotone or transition zone between the river and the wetland, the river and upland, the wetland and the upland and the river channel and backwater habitats, providing habitats for many species.

Riparian corridors of native vegetation provide protection of streams from runoff. When land is cleared to the banks of the river, the water becomes silty due to erosion, leading to decreased flows, increased temperatures, and harm to the aquatic life. For example, with an increase of silt, trout populations decline because the habitat of the eggs and fry of Salmonidae are in the gravel, and an increase in silt clogs the air spaces within the gravel. The eggs and fry die by suffocation, as do many of the invertebrates upon which the older fish feed (Hynes 1970).

The protection of the stream from runoff also helps decrease pollution to the stream, because pollutants from the soil and rain are trapped and filtered on the forest floor. The settling out process that soil and vegetation provides helps to decrease the sediment load, the nutrient load and pesticides to the river. This flow of pollutants and nutrients from diffuse sources into a river or lake is called nonpoint source pollution. Much of the ecological water problems today are not a result of point source pollution, such as, an industrial establishment dumping chemicals into the water, but rather the diffuse and overloading pollution from runoff. Fertilizer entering a water body can cause an increase in algal production that minimizes the health, beauty and lifespan of the river or lake. On the other hand, nutrients that travel through a forested or vegetated riparian corridor are taken up by the plants, and stored in the vegetation. Nitrogen will then be converted to nitrogen gas by bacteria and returned to the atmosphere. Microorganisms on the forest floor also help to breakdown pollutants to less harmful materials. Pollutants, such as oil and grease from streets and parking lots, attach to erosional sediments and are ingested by aquatic organisms, thus becoming harmful to the entire food chain. By the reduction of pollutants entering streams, life within them can flourish. Overhanging tree branches provide shade while their falling leaves provide an important link in the river food chain. The higher the temperature of water, the less dissolved oxygen it can hold, so the shade and lower temperatures provide more oxygenated water, which is crucial to many species of fish.

The benefits of trees and vegetation adjacent to the stream also apply to water quantity concerns. During a heavy precipitation event, rainwater can be soaked up by the soil and the trees, thereby decreasing the heavy flow to downstream areas. During drought or low water conditions, water can seep out from the soil to the river providing flow.

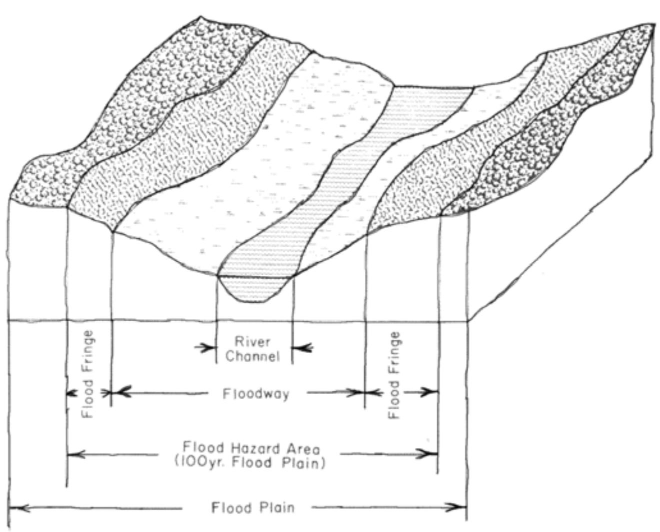
The provision of riparian corridors is of prime importance and should be considered in any development or redevelopment plan. Protecting and restoring riparian corridors provides a cooling system, habitat and food source for life in streams. The economic benefits of riparian corridors are many. The cost of river cleanups is decreased, and provision of clean drinking water to many people is increased when ecological planning is enforced. Three billion dollars worth of flood damage occur in this country every year (NJDEP 2001). The ability of riparian corridors to help decrease flooding, and maintain a more even flow of water is an economic factor that should be considered.

FLOODPLAINS

View of the Goffle Brook floodplain following Tropical Storm Floyd, 1999. Floodplain provides storage area for floodwaters.

Floodplains, or the area adjoining the channel of a natural stream that has been or may be covered by floodwater, encompasses the riparian corridor but also all that land that might be inundated by flood (**Fig. 24**). Delineation of the floodplain is based on the area covered by water during a 100-year flood. A 100-year flood is based on the occurrence of a flood event that would be expected to occur once in 100 years. Land use in the floodplain is regulated by the NJDEP, under the Flood Hazard Area Control Act, The purpose of the Flood Hazard Area Control Act is building in the floodplain puts life and property at that site, and also further downstream, at risk. Floodplains provide nutrient sinks, water storage to help alleviate downstream flooding, areas for aquifer recharge/discharge and wildlife habitat (Brinsen et al. 1983). Hawthorne's floodplains can be seen in **Fig. 25** and would be considered temporarily or intermittently flooded wetlands, meaning the area is flooded for brief periods but otherwise water table may be below surface.

Fig 24. Diagram of Floodplain as delineated by the NJ Flood Hazard Area Control Act.



WETLANDS

Wetlands can be defined as areas with standing water present on either an intermittent or permanent basis (Mitsch and Gosselink 1993). Features of wetlands are the presence of water either at surface or within the root zone, unique soil conditions which support hydrophilic (water-loving) vegetation species and slow decomposition due to anoxic (lacking oxygen) conditions. A majority of northern New Jersey's wetlands were formed after the retreat of the Wisconsin glacier approximately 18,000 years ago (Tiner 1985). During the post-glacial period, wetlands formed in former glacial lake basins, such as The Great Swamp, as the ice retreated and the glacial lakes drained. Wetlands may recharge groundwater aquifers, prevent floods, protect shorelines, and act as purifiers, cleansing wastes, and contaminants from upstream (Mitsch and Gosselink 1993). Very little wetlands still exist in Hawthorne today (**Fig. 25**). The Haledon Wet Variant soil is considered a wetland soil (Tiner 1985), but much of that area is now developed. Wetlands still exist along the Goffle Brook in Goffle Brook Park, a small amount in 8-Acre Woods, and the largest wetland area in Hawthorne is along Goffle Brook west of the High School.

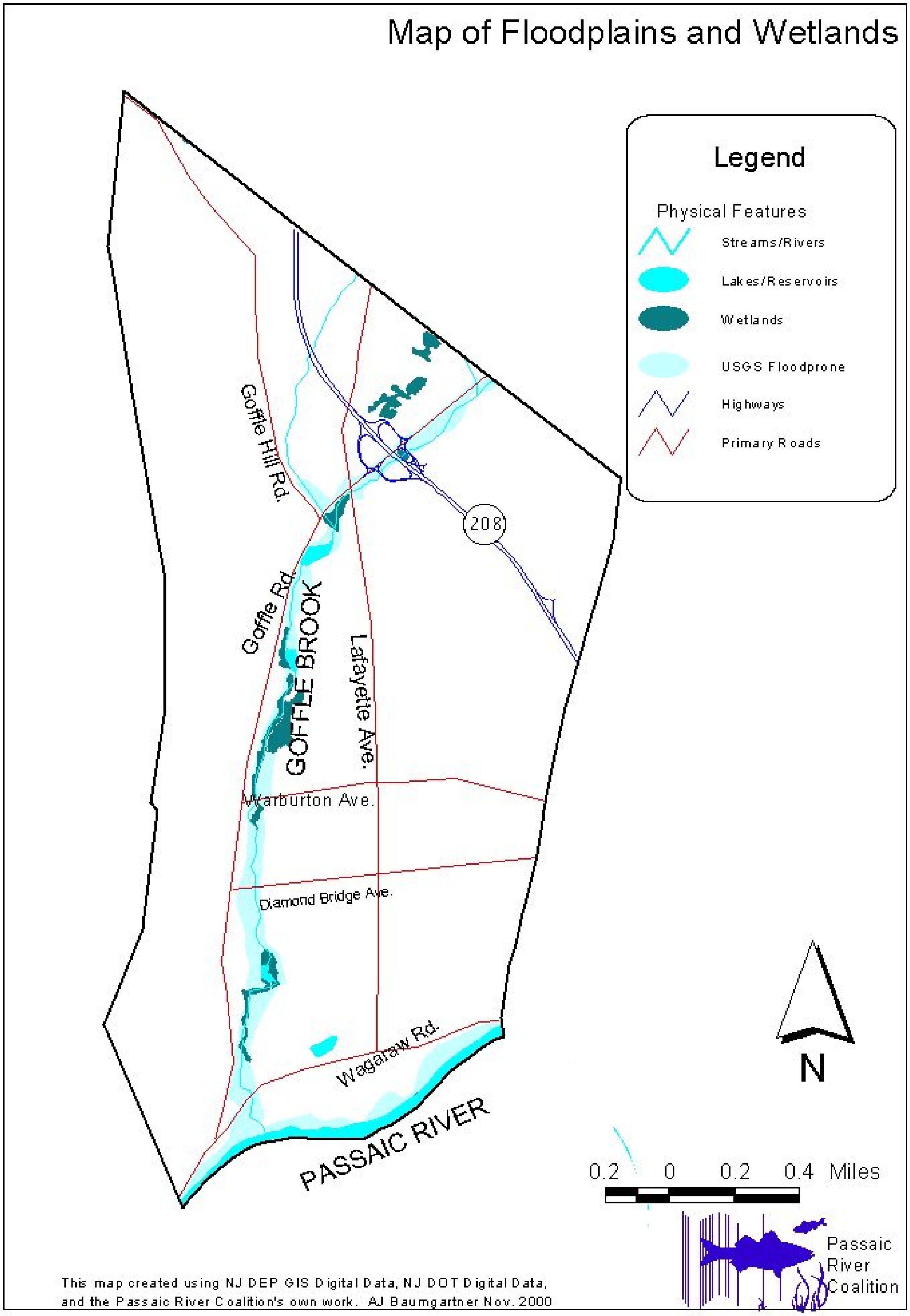


Fig. 25. Map of Floodplains and Wetlands in the Borough of Hawthorne.

FLOOD PREVENTION

While removal of vegetation may increase flood peaks (Darnell et al. 1976), naturally vegetated riparian corridors, wetlands, and the absence of buildings within floodplains provides water storage during a flood and can serve to moderate and reduce. The water will be slowly released via ground water and seep back to the stream during low water flow. Protection of the banks of the stream from erosion can be accomplished with soil bioengineering methods (Riley 1988). Wetlands and floodplains can influence water flow by intercepting stormwater runoff and providing stormwater storage, thereby decreasing sharp runoff peaks to slower discharges over longer periods of time (U.S. Army Corps of Engineers). Mitigation of floods is dependent on the size of a wetland area, the distance the wetland is located downstream, intensity of the flood event, the availability of an upstream wetland, or the lack of upstream storage areas (U.S. Army Corps of Engineers).

Although much of the area along Goffle Brook has already been developed, any redevelopment plans should be required to provide a stream setback to help provide wetland/riparian corridor/flood hazard areas, for flood protection, stream protection and provision of wildlife habitat.