I. Forward

In 1968, the New Jersey Legislature passed a law that enabled municipalities to create conservation commissions. These commissions, later renamed environmental commissions, were created to be non-elective, advisory units that would promote the conservation and development of the natural resources within municipalities. Amended in 1972, the 1968 New Jersey law stipulated that "[t]he governing body of any municipality may by ordinance establish an environmental commission for the production, development or use of natural resources, including water resources, located within its territorial limits."[1] The State Legislature suggested that environmental commissions, as part of their conservation efforts, prepare natural resource inventories, plans and projects for recommendation of conservation measures to be included by planning boards when developing comprehensive plans for land use.[2,3]

Pursuant to the provisions of Chapter 245 of the Laws of 1968 of the State of New Jersey, on June 14, 1971, Madison adopted and approved Ordinance 13-71, which was introduced to amend and supplement the Madison Borough Code entitled "Revised Ordinances of the Borough of Madison, New Jersey," adopted May 11, 1970.[4] The Ordinance included a new article, Article 14, entitled "An Ordinance to Establish and Constitute a Conservation Commission in the Borough of Madison, County of Morris New Jersey." Article 14 established a Madison Conservation Commission (later to be called the Madison Environmental Commission) for "the protection, development, or use of natural resources, including water resources, located within the territorial limits of the Borough of Madison."[5]

The Madison Environmental Commission (MEC) began functioning in January 1972. Three years later, in 1975, passage of the New Jersey Municipal Land Use Law, which required a Land Use Plan Element incorporating resource data as part of a municipal master plan, heightened the need for municipalities to maintain an index of their natural resource information and open spaces areas for local planning purposes.[6] In 1977, an inventory of the natural resources of Giralda Farms (the former Dodge Estate) was completed and represented the MEC's first contribution to the resource data. Out of necessity for a comprehensive survey of Madison's man-made and natural resources for planning information, the MEC's first Environmental Resource Inventory (ERI) for the Borough of Madison was published in 1982.

According to the Forward to the 1982 ERI, "[i]nitially there was some reluctance to prepare an ERI in Madison because the Borough was almost fully developed." The basis for that initial reluctance in 1982 was equally evident in 2001; but it had become clear that the justification for creating the ERI in 1982 was even more of a reason for revising it in 2001, ten years later in 2011, and again in 2022. As one author of the 2001 ERI

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[1] L.1968,c.245,s.1; amended 1972,c.35,s.2; 1975,c.334,s.8; 1989,c.168,s.2. Available online: https://lis.njleg.state.nj.us/nxt/gateway.dll?f=templates&fn=default.htm&vid=Publish:10.1048/Enu

[2] "It shall keep an index of all open areas, publicly or privately owned, including open marshlands, swamps and other wetlands, in order to obtain information on the proper use of such areas, and may from time to time recommend to the planning board or, if none, to the mayor and governing body of the municipality plans and programs for inclusion in a municipal master plan and the development and use of such areas."
L.1968, c. 245, s. 2, eff. Aug. 6, 1968. Amended by L.1972, c. 35, s. 3, eff. May 25, 1972.

[3] More information about environmental commissions can be found in publications by the Association of New Jersey Environmental Commissions (ANJAC). See, for example, ANJEC. 2007. Environmental Commissioners' Handbook. 6th edition. Available online: https://anjec.org/wp-content/uploads/2019/07/EnvCommissionersHandbook-2017.pdf

[4] Available online: http://madison-nj.elaws.us/code/coor_pti_ch16

[5] § 16-1. Creation; purpose. Available online: http://madison-nj.elaws.us/code/coor_pti_ch16_sec16-1

[6] L.1975, c.291, s.49; amended 1983, c.260, s.12; 1985, c.222, s.30; 1985, c.516, s.13; 1989, c.32, s.25; 1991, c.445, s.9; 2013, c.106, s.13.

stated, “It has become apparent that the need for an ERI exists even in a mature community so that planning may be conducted on an environmentally sound basis, and the public may be aware of the various environmental constraints affecting the quality of life in Madison today.”

Since the 2011 ERI, local and global environmental changes are routinely observable. This revision does its best to update the inventory where appropriate and take advantage of the latest available technology to gather relevant data. This update of the ERI owes a debt to all previous versions (1982, 2001, and 2011) and authors.

It is critical that the Borough of Madison continue to monitor its natural resources to ensure their protection, and if possible, future expansion. In a time of changing weather patterns, more prevalent natural disasters, and a dwindling supply of natural areas, the importance of how land is “used” is more evident than ever. Sprawling development patterns, filling in wetlands, and cutting down forests, for example, have long-term and costly negative environmental and economic impacts.

Over the past ten years, major wind storms and flooding events were reminders of the importance of disaster preparedness and planning. Flooding in 2021 from Hurricane Ida demonstrated why systems for managing storm water are necessary. Power outages from Superstorm Sandy in 2012 and damaged trees and powerlines from a Nor’easter in 2011, also creating long lasting outages, were reminders of the importance of emergency preparedness and planning, related to access to electricity. The first recorded tornado in Madison, New Jersey, was reported in 2019. Arriving at night, even tornadoes with relatively low windspeeds can cause significant damages to homes and property.

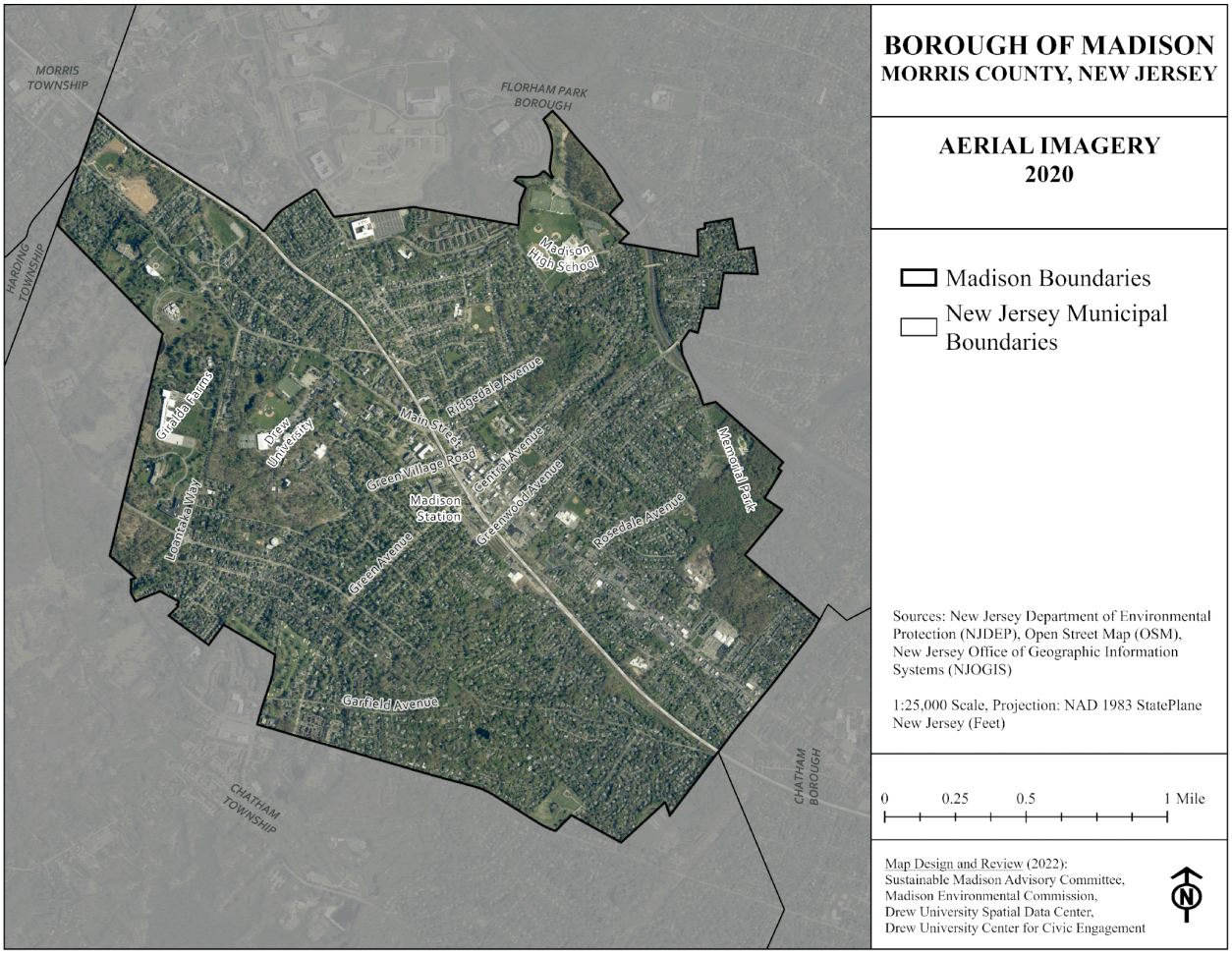
Both natural and built systems are under new stressors. Pedestrian deaths and accidents in Madison have raised awareness of the importance of pedestrian safety and the ways that design of built infrastructure, in combination with education, can protect people. Alongside safe design, energy efficiency and electric transportation infrastructure have become new priorities. New Jersey also adopted the first statewide climate education requirements for public schools.

Recommendations made in the 2011 ERI remain relevant: to protect its remaining open space areas and natural resources, the Borough can institute smart growth development techniques. At the same time, the Borough can introduce ordinances and policies that strive to conserve resources and are more sustainable. Examples include adopting a Sustainability Plan as an element of the Borough’s Comprehensive Plan, introducing green building ordinances, establishing citizen committees that run environmental programs, and creating incentives for sustainable practices (i.e., green roofs, community gardens, native plans on lawn, walk to school programs, etc.).

Building on its efforts in 1982, 2001, 2011, and 2022, Madison can also continue to inventory its natural resources over time to ensure that resource protection is moving in the right direction.

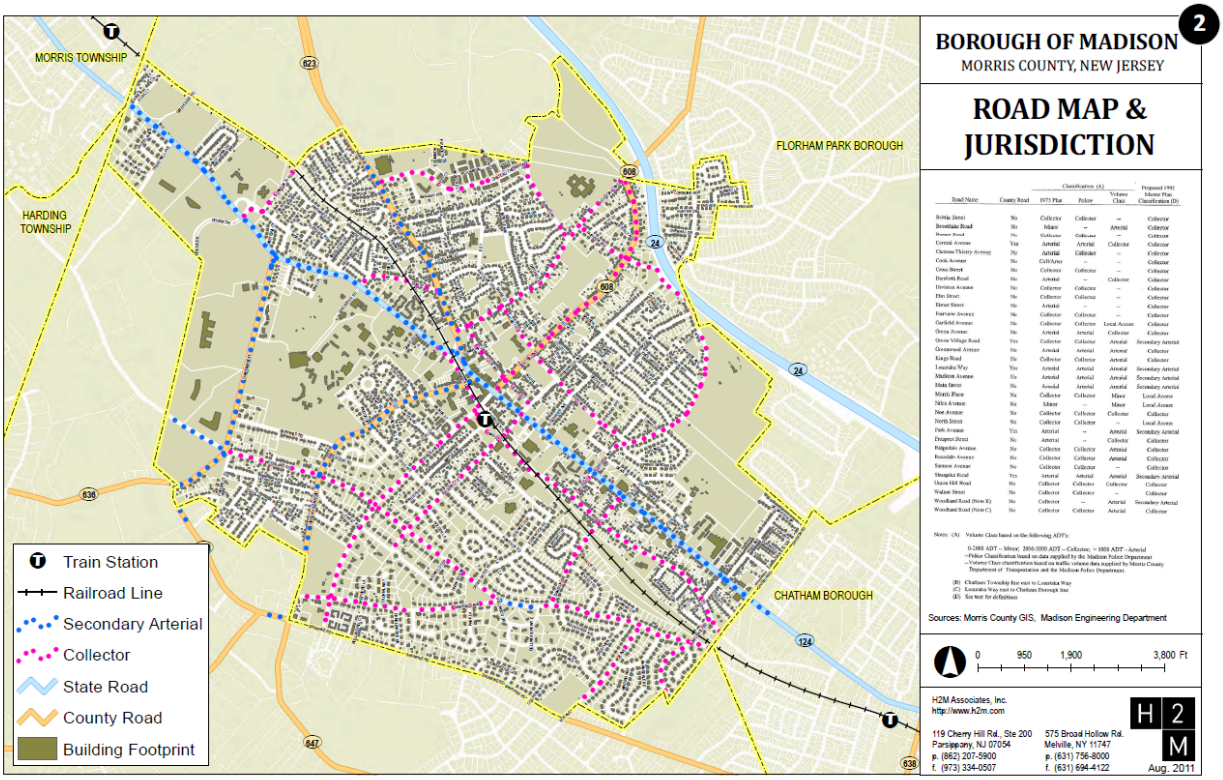
II. Introduction to Madison

The Borough of Madison lies in the southeastern section of Morris County, approximately 13 miles west of Newark, New Jersey, and 23 miles west of New York City. It is located at approximately 40° 46’ north latitude and 74° 26’ west longitude. Madison is bounded on the north by the Borough of Florham Park, on the east by the Borough of Chatham, on the south by Chatham Township and on the west by Morris Township. The land area of Madison is 4.205 square miles (See Map 1).



Map 1. State of New Jersey Aerial Imagery for Madison Borough (2020)

The Borough is located in the Newark Basin, one of the four major physiographic provinces of the State of New Jersey, and is in the Passaic River watershed. The topography is characterized by gently rolling to hilly terrain, with few slopes or grades over 10 percent. The terminal morain of the most recent advance of ice, called the Wisconsin Glaciation, curves through town. Elevation varies from 190 to 380 feet above sea level. County Route 124 (also known as Main Street, formerly State Route 24), the major east-west thoroughfare, roughly bisects the Borough as it runs from the southeast to the northwest. (See Map 2).



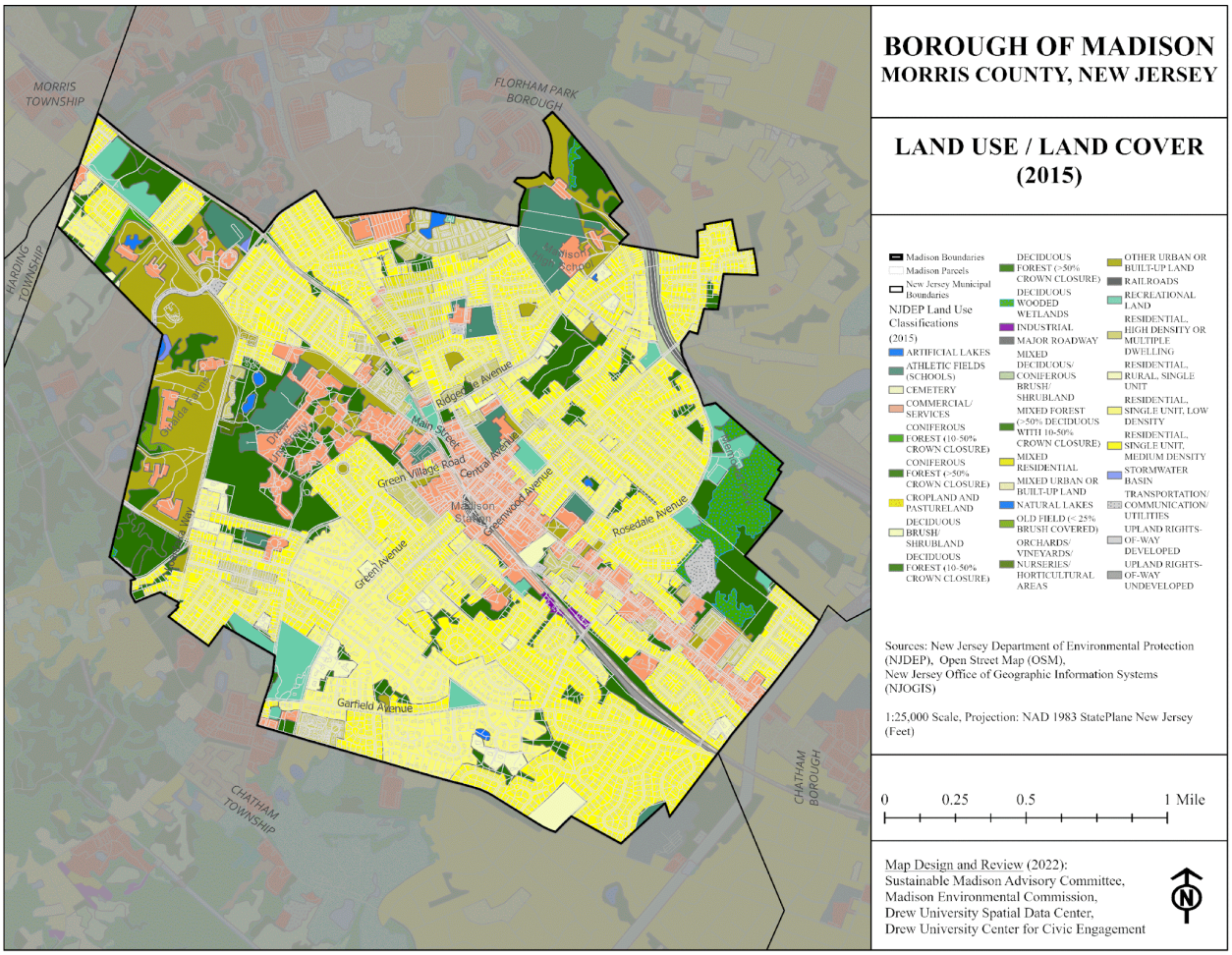
Map 2. Borough of Madison Road Jurisdictions (Reproduced from the 2011 ERI)

Madison is predominantly a single-family residential, suburban community with a central business district along Route 124. There is very little industry and almost no vacant land. The existing land use map (See Map 3) and the table below show existing land use and relative acreages of each land use category. Natural features/areas for parks and recreation, highlighted in the table in yellow, make up 20.9 percent of Borough land use, with forested areas accounting for 11.8 percent and recreation uses and school athletic fields making up 6.3 percent of Borough land area. The land classified as natural features or areas for parks and recreation declined by 15 acres between 2007 and 2015.

Land Use / Land Cover Acreages in Madison (NJDEP)

LAND USE	Acres (2007)	Percent (2007)	Acres (2015)	Percent (2015)	Change (Acres)
LAKE	8	0.3%	8	0.3%	0
RESIDENTIAL, SINGLE UNIT, RURAL/LOW DENSITY	336	12.1%	338	12.2%	3
RESIDENTIAL, SINGLE UNIT, MEDIUM DENSITY	1,121	40.5%	1,127	40.7%	6
RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING	109	3.9%	111	4.0%	2
MIXED RESIDENTIAL	38	1.4%	39	1.4%	1
COMMERCIAL/SERVICES	257	9.3%	263	9.5%	6
INDUSTRIAL	4	0.1%	3	0.1%	-1
OTHER URBAN OR BUILT-UP LAND	215	7.8%	233	8.3%	17
FOREST AREA	344	12.4%	326	11.8%	-18
FIELD/BRUSH/SHRUBLAND	9	0.3%	15	0.5%	6

WETLANDS	55	2.0%	55	2.0%	0
RECREATION/ATHLETIC FIELDS	178	6.4%	175	6.3%	-3
CEMETERY	17	0.6%	17	0.6%	0
STORMWATER BASIN	2	0.1%	2	0.1%	0
TRANSITIONAL AREAS	7	0.2%	0	0.0%	-7
TRANSPORTATION/COMMUNICATION/UTILITIES	28	1.0%	17	0.6%	-11
RAILROADS	24	0.9%	24	0.9%	0
ROUTE 24	7	0.2%	7	0.2%	0
UPLAND RIGHTS-OF-WAY	9	0.3%	8	0.3%	-1
TOTAL	**2,768**	**100%**	**2,768**	**100%**	



Map 3. Land Use / Land Cover Classifications Descripted by NJDEP (2015)

The population of Madison increased by 3.2% between 1980 and 1990 (from 15,357 to 15,850), and by an additional 4.3% from 1990 to 2000 to 16,530 residents. However, between 2000 and 2010, Madison's population fell by 4.3%, returning the Borough to its 1990 population. The U.S. Census Bureau reported 16,647 people resided in Madison in 2020, an increase of five percent over ten years.

The median age of Madison's population increased to 39.9 years in 2020, compared with 38 years in 2010, and 34.4 in 2000. Children and youth under 18 years make up 22 percent of the Borough population (3,688). There are an estimated 963 children under 5 years.

Some aspects of demographic diversity increased in 2020, according to U.S. Census Bureau statistics. Populations identifying as while alone declined, comprising 80.7 percent of Borough residents in 2020. While populations identifying as Black, Asian, Native Hawaiian or Pacific Islander, with two or more races, or as Hispanic or Latino increased in population, populations identifying as American Indian or Alaska Native declined. Measures reported by the U.S. Census Bureau are shown in the table below.

Total Population, Race and Ethnicity, Madison Borough, 2000-2020

Race and Ethnicity	2000	2010	2020	% Change (2010 to 2020)
Total:	16,530	15,845	16,647	5%
White alone	14,891	13,746	13,433	-2%
Black or African American alone	464	469	631	35%
American Indian and Alaska Native alone	7	19	-	-100%
Asian alone	592	873	1,206	38%
Native Hawaiian and Other Pacific Islander alone	33	2	10	400%
Some other race alone	166	371	175	-53%
Two or more races	377	365	1,192	227%
Hispanic or Latino	987	922	2,200	139%

Housing development in the Borough has increased since 1980. Between 1980 and 1990, housing units increased by 11.4 percent from 4,997 to 5,564, and by 3.1 percent to 5,737 units in 2000. In 2010, the total number of housing units rose to 5,775. The U.S. Census estimated the total number of housing units at 5,989 in 2020. Of those units, 5,705 (95 percent) were occupied and 284 vacant.

In 1990, the average value of single-family housing units in Madison was $286,612. In October 2001, the average residential home value had increased to $427,207. By 2006, the average home value in Madison was $664,292. In 2020, the U.S. Census Bureau estimated the median housing value at $776,000. Zillow estimated the median rent for Madison at $2,609/month.[7]

The average income in the Borough is also increasing. According to the 2000 Census, the median household income in 1990 dollars was $82,846. The Census Bureau's 5-Year Estimates show a median household income (in 2009 inflation-adjusted dollars) of $103,969. In 2020, the U.S. Census Bureau American Community Survey estimates found the median household income to be $157,188, in 2020 inflation adjusted dollars.

In summary, like many New Jersey communities, the Borough of Madison has experienced changing land use, demographic and economic conditions. Compared with 2000 and 2010, declines in forest have continued.

[7] Zillow Rentals Data. 2022. Madison, NJ Rentals Market. Available online: https://www.zillow.com/rental-manager/market-trends/madison-nj/

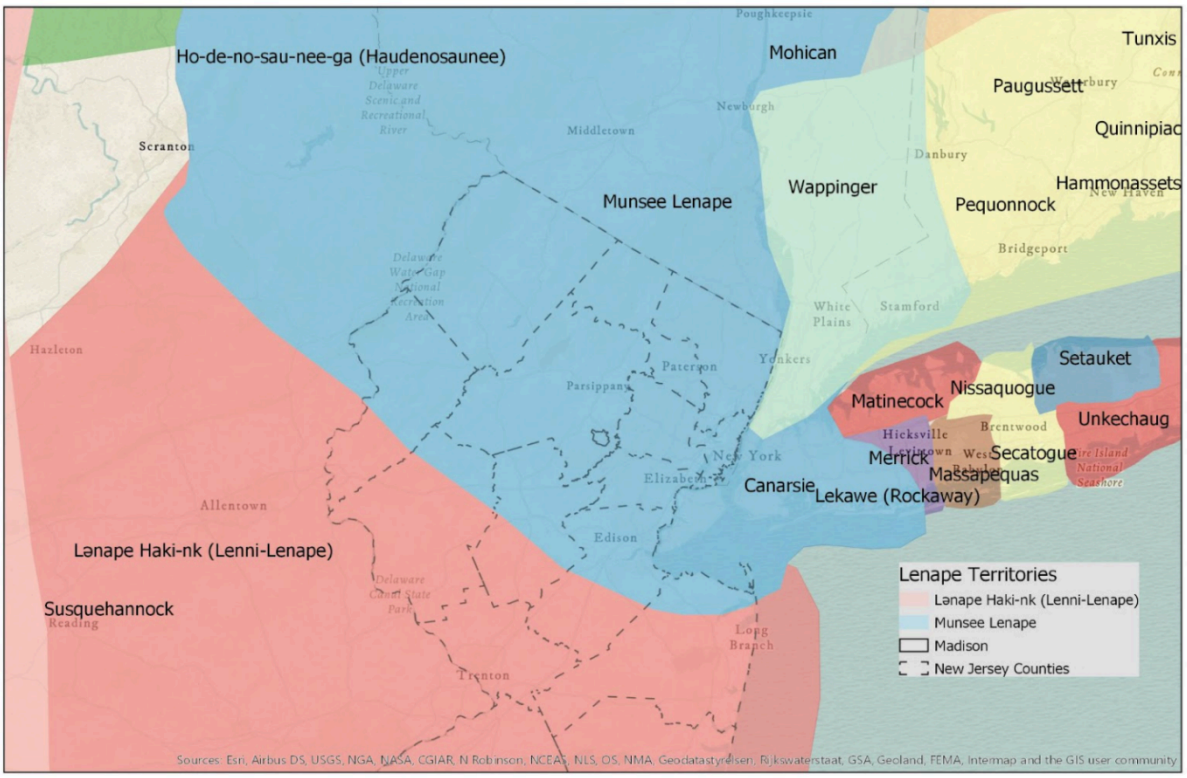
Population declined then increased slightly, and the median age continued to increase. Housing stock, housing values, and median incomes have all increased.

As the Borough updates its comprehensive plan and land use policies and ordinances, these factors should be considered, along with the Borough's long term goals and objectives toward sustainable development.

III. HISTORY

Originally a forested area with hills, swamps, and meadows, the Lenape people were the original people to inhabit the area now called Morris County. The Lenape Minisink Trail ran from the Atlantic Ocean via the roads now called Kings Road and Park Avenue, and on to the Delaware River. Native and settler artifacts are common throughout Morris County.

Map 4 overlays current New Jersey counties with historical indigenous territories. It showcases both the different indigenous peoples present in the state of New Jersey and more specifically Madison, New Jersey as outlined by the boundary. The predominant indigenous group in New Jersey are the Lenape people which are broken two into two subgroups, the Lenni-Lenape and the Munsee-Lenape.



Map 4. Native and Indigenous Territories Described by the Native Lands Digital Project[8]

In the early 1600s, Dutch settlers claimed areas now called New Jersey. English settlers contested these claims, and eventually overtook Dutch settlers to declare proprietorship of territory that the town of Madison would eventually occupy. Settlers formed Morris County in 1739. Sometime during the early 1700s a tavern,

[8] Native Lands Digital Project. 2022. Available online: https://native-land.ca/

located at the crossroads of the present Park and Ridgedale Avenues, and a cluster of nearby farms, came to be known as “Bottle Hill.”

In 1740 the future Madison was divided between two townships by a line drawn from east to west along Kings Road and Park Avenue separating Hanover Township and the newly created Morris Township. Citizens, as defined at the time as white, male, land-owners, who residing north of the line, paid taxes to Hanover, and those south of the line to Morris. This was not changed until 1806, at which time Chatham Township was created. Madison remained a part of Chatham Township until Christmas Even 1886, when Madison Borough was incorporated with definite boundaries and a government of its own.

2021 marked the first year where Indigenous Peoples’ Day was recognized as a federal holiday. In a Borough Council meeting on October 13, 2022, Councilwoman Rachel Ehrlich stated,

> I would like to acknowledge that here in Madison, we are on the traditional territory of the Lenni Lenape people … I want to explain that territory acknowledgments are a way that people insert an awareness of indigenous presence and land rights in everyday life … It’s not meant to be a token gesture, but an invitation to think about settler colonialism and its history. And with this acknowledgement, I invite everyone listening and the council to consider these issues and their impacts to our current relationship to the land and to human rights.

In follow-up reporting by the *Madison Eagle*, Ehrlich explained,

> a reminder of our colonial history and an acknowledgement that we are accountable for the ways we continue to benefit from colonialism, such as through the extractive industries that generate a portion of our power. … As Americans, we have a legal obligation through our treaty commitments to respect the sovereignty of tribal nations. And we have a moral obligation to protect native lands and end fossil fuel projects in the face of the accelerating climate crisis. I offered this territory acknowledgement to invite my council colleagues and members of the public to reflect together on the responsibilities we have to protect the climate, land, and water of the land we govern and call home.[9]

PEOPLE AND CULTURE

In 1747 “South Hanover” became populated enough for churchgoers to break off from the Presbyterian Church at Whippany and form the “Meeting House at Bottle Hill.” The first settlers of Whippany and Bottle Hill were almost all Presbyterians of English ancestry. Staunch support of church and school were part of their Puritan heritage, and the first schools in Bottle Hill predated the Revolution.

During the Revolutionary War, Bottle Hill sat midway between the militia headquarters at Morristown and the permanent military outpost at Chatham Crossing. In January 1777 the entire Continental Army under Washington’s command came into winter quarters in this area after victories at Trenton and Princeton. Units camped wherever they could around Morristown. Old accounts indicate that the main body camped in the Loantaka Brook Valley around Kitchell Road and Treadwell Avenue, and that several officers were quartered

[9] Parker-Magyar, Alex. 2021. “Madison Councilwoman offers territory acknowledgement of Lenni Lenape.” *Madison Eagle* October 19. Available online: https://www.newjerseyhills.com/madison_eagle/news/madison-councilwoman-offers-territory-acknowledgement-of-lenni-lenape/article_846beecb-20b2-5724-b6eb-ad3a2bc2381e.html

in Bottle Hill. This was the first of two winter encampments in Morristown. The second was at Jockey Hollow during the winter of 1779-1780.

By 1800 Bottle Hill consisted of about twenty small wooden houses, most of them on farms of 12 to 40 acres along the old roads. There were cider mills, due to the large apple crops, and a few gristmills. From 1801 to 1804, toll road from Elizabethtown to Sussex, creating what are now Main Street, lower Madison Avenue and Morris Place. The downtown area began to develop with houses and stores. In 1837 the Morris and Essex Railroad was constructed through the village. This line was at grade level and generally paralleled the tracks of today, which were elevated in 1916.

A small Methodist congregation was formed about 1801. The American Revolution brought Francis Vacher, a Frenchman who came over with the Marquis de Lafayette, and the French Revolution of 1789 brought Boisaubin, Duberceau, Blanchet and others of French ancestry, who were instrumental in founding the Roman Catholic Church. Irish Catholics followed in the 1840s and 1850s.

French settlers included plantation owners, such as Vincent Boisaubin, whose mansion still stands on Treadwell Avenue in nearby Chatham Township. In the 1830s they were joined by an American plantation owner, William Gibbons, who had inherited from his father vast properties in Georgia, New York and New Jersey. He built a mansion later named Mead Hall on a tract of land that was acquired by Drew University in 1867. Both houses are now listed on the National Register of Historic Places. The legacies of these places serve as a present-day reminder of the appropriation of wealth through the practice of enslaving people.

Lafayette's return visit to Bottle Hill in 1825 ended the Revolutionary War era, and the renaming of the village in 1834 as Madison ushered in a new era. By 1854, with a population of 120, Madison contained six stores and five churches: Presbyterian, Methodist, Roman Catholic, Episcopal and African Union. In 1858, when the Reverend Samuel Tuttle sold his property, he stipulated that the "Tuttle Oak" must not be removed to make way for Prospect Street. It stood in the middle of the road until 1996, when it was struck by a passing truck on the night of the town's annual Christmas parade.

Since the colonial period, a small number of African Americans have lived in current Madison. Initially composed of a small number of enslaved people, the African American community in Madison increased after the New Jersey State Legislature passed the Act for Gradual Abolition of Slavery in 1804. By 1840, a separate religious community had formed, which built the first African Union Church in 1850, a successor in 1864, and the existing Bethel African Methodist Episcopal Church in 1885.

In past years, documents like the ERI and others failed to mention the important past and present of Black Madison residents. Responding to the urgent needs of our community and society to acknowledge systemic racism in placemaking, town members created the Hidden Figures project to recognize important events related to the struggle against slavery, efforts to promote equity, and prominent Black community members in Madison's history.[10]

William Gibbons paid about $35,000 for the 205 acres called "The Forest," which later became Drew Theological Seminary in 1866, a training center for Methodist ministers. In September 1928, Drew admitted its first liberal arts students and it is now known as Drew University. One of the theology professors to work

[10] Hidden Figures of Madison. 2022. Their Stories, Our History. Available online: https://www.hiddenfiguresmadison.org/

at Drew was George Kelsey, a former professor to Martin Luther King, Jr.[11] The connection between Kelsey and King brought Martin Luther King, Jr. to campus in 1964 to present his "American Dream" speech, given to an overflowing crowd in Madison.[12]

In 1856 the first of many greenhouses for growing roses was built in Madison. For more than 100 years, rose growing thrived here, at least in part because of the good rail service— Madison has its own train station. More than 45 rose growers thrived in Madison in 1896, at which time the greenhouses included a half-million square feet of glass. At one time 40,000 to 50,000 buds were shipped via Railway Express from Madison each day. Local growers won many prizes for new varieties of roses at national exhibitions, and Madison became known as "The Rose City." In 1950, the local rose industry reached its peak. The industry gradually faded and ultimately disappeared when the final rose range in the Borough closed in 1984, the victim of cheaper imports. Several greenhouses were razed to make way for State Highway 24 and many others were leveled for housing developments.

A few people began traveling to Newark each day on the new railroad soon after it was built. By the mid-19th century Madison had been discovered as a vacation place by city dwellers seeking a healthful month in the country. Madison's clean air, pure water and beautiful vistas first attracted summer boarders. In 1862 the Morris & Essex Railroad was extended from Newark to Hoboken, providing a connecting rail link to New York City. In the years that followed, many wealthy New Yorkers began buying up farms and building estates in the vicinity of Madison. By 1880 the "Gilded Age" had begun.

It was during this period that Madison's Italian American community had its beginnings. Italian gardeners were much sought after on the estates. Their numbers grew as relatives and friends joined them to work on the estates and in the greenhouses.

Willis James bought the land for James Park, built and donated the James Public Library in 1899 (now the Museum of Early Trades and Crafts), and gave the James Building on the corner of Main Street and Green Village Road as a business building and assembly hall to be used for the financial support of the library. The 42-acre site of Madison High School was donated by the heirs of Hamilton McKay and Florence Vanderbilt Twombly, whose vast estate "Florham" included the mansion and grounds acquired in 1957 by Fairleigh Dickinson University for its Florham Park Madison campus.

Geraldine Rockefeller Dodge was perhaps Madison's greatest benefactor. She donated part of Dodge Field as a public playground. She also founded St. Hubert's Giralda as an animal shelter. Her internationally known Morris & Essex Dogs Shows were held annually on the Dodge property for 30 years, starting in 1927. Mrs. Dodge's largest gift to the Borough was the Hartley Dodge Memorial Building, dedicated in 1935 as a living memorial to her only son, Marcellus Hartley Dodge Jr., who, in 1930, soon after graduating from Princeton University, was killed in an automobile accident in France at the age of 22. The Geraldine R. Dodge Foundation currently provides financial support for many local projects and organizations.

Madison's municipal institutions were formed in the late 19th century, about the time the Borough became a legal entity. The Fire Department was formed in 1881, the Police Department in 1880, and the library in 1900. Map 5 depicts an early aerial image of Madison, New Jersey from 1930.

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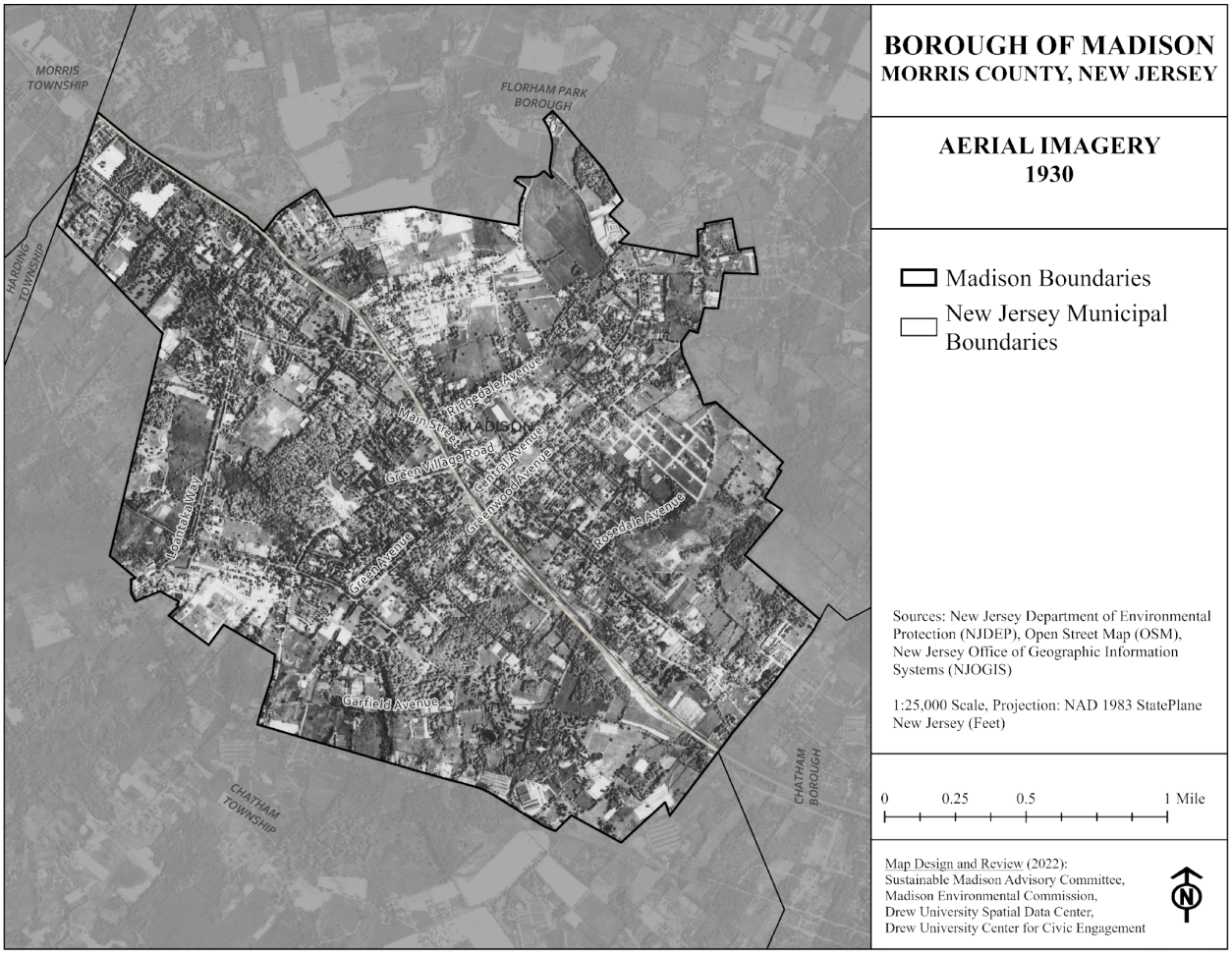
[11] Huber, H. 2020. "Madison's Master Theologian and Teacher: Dr. George D. Kelsey." Madison Historical Society Newsletter. Nov. p. 3-4. Available online: http://www.madisonnjhistoricalsociety.org/2020-november-newsletter.html

[12] Drew University. University Archive Online Exhibit: Martin Luther King, Jr. Available online: https://depts.drew.edu/lib/archives/online_exhibits/King/index.html



Map 5. 1930 Aerial Image for Madison, New Jersey

The 20th century saw Madison grow to a community of over 15,000. For a long time it remained partly rural and partly suburban. Some families have lived here for many generations. There are two universities, Drew and Fairleigh Dickinson, within the Borough's boundaries and another institution of higher education, the College of Saint Elizabeth, in nearby Convent Station.

A Bicentennial Ball was held in 1976 at the Borough Hall and the first "Bottle Hill Day" was inaugurated. It has become an annual event, along with the Little League Parade, the Memorial Day parade and the Christmas parade (held on the Friday after Thanksgiving).

The $101 million State Highway 24 finally opened for traffic in November 1992, after 40 years of planning and delays for environmental and economic reasons. The highway immediately made an impact on old Route 24, now County Route 124, as the average daily volume of vehicular traffic on new Route 24 (estimated in one early study to be 46,388) reduced the average daily number of vehicles crossing the Madison-Chatham border from 27,240 in 1990 to 18,487 in late 1992.

Development of the remaining open spaces within the Borough continued throughout the 1990s, but at least two major parcels of land were purchased for open space and parks. The Loantaka Moraine (Terminal Moraine), 23 acres in Madison at the corner of Woodland Road and Loantaka Way, were acquired by the Morris County Park Commission in December 1994 for annexation to the County's 574-acre Loantaka Brook

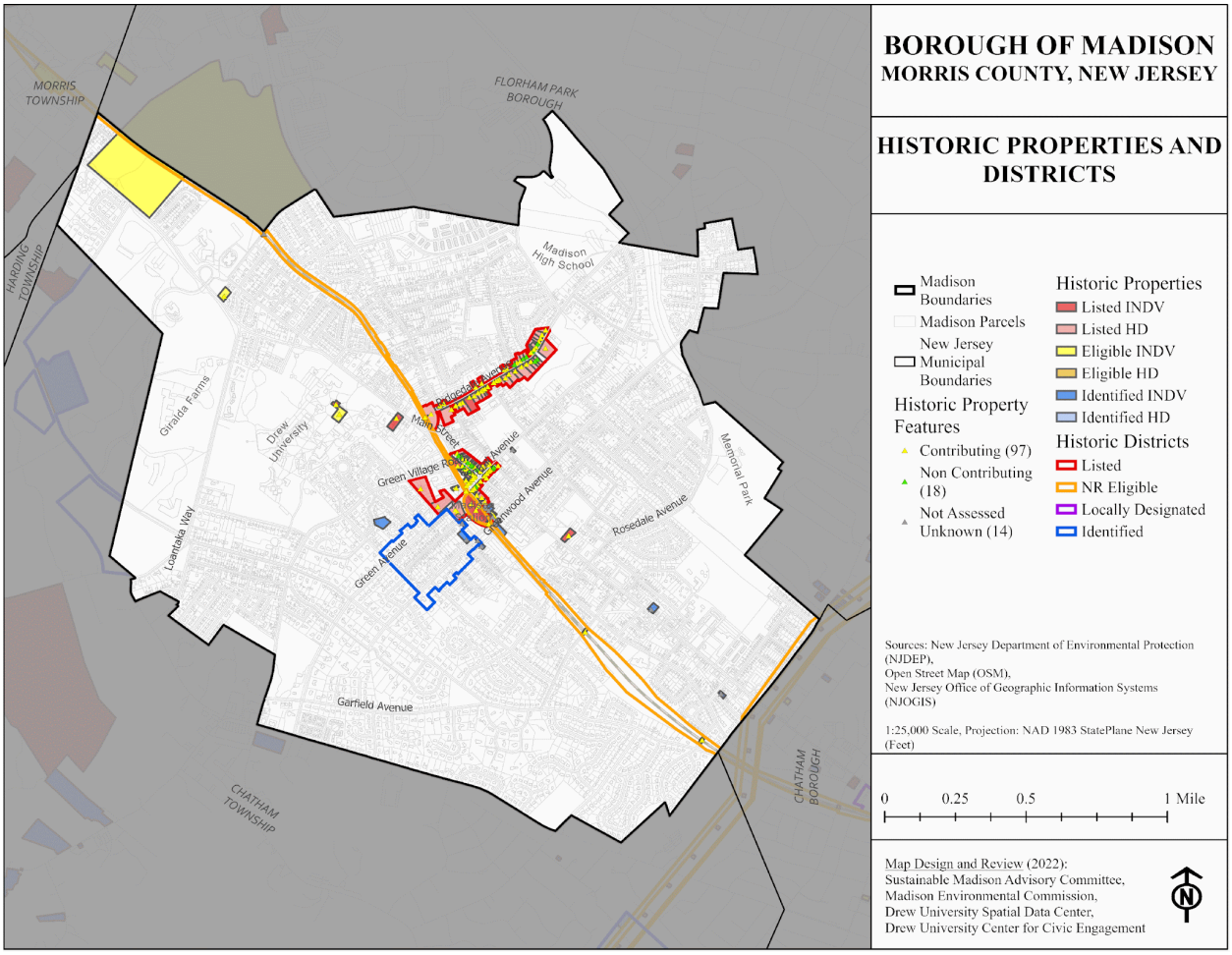
Reservation, located in Chatham, Morris and Harding Townships. In June 1997, Gibbons Pines, three acres of land on Gibbons Place, was acquired by the Borough with assistance from the Morris County Parks and Land Conservancy. At the time, these three acres represented ten percent of the Borough's remaining vacant land.

In 2010-2011, the Borough acquired two properties through annexation from neighboring Florham Park, which has reshaped the northeasterly corner of the Borough's municipal boundary. Approximately 10.16 acres owned by the Madison Board of Education was acquired, as was 55.1 acres owned by the Borough of Madison, which had served as access to the Exxon Mobile Foundation property. A survey of the property shows the property contains small areas of freshwater wetlands, which have been confirmed by NJDEP.

Map 6 displays the locations of the historic districts in the Borough. Geographic information on Historic Properties is available through the State of New Jersey – GIS Open Data. These metadata for the map explains that:

> Historic Properties are buildings, sites, structures or objects that are evaluated as historically significant. This dataset represents the point location of the individual features (one or more buildings, sites, structures, and objects) which make up historic properties that: 1. Are National Historic Landmarks, 2. Are included in the New Jersey or National Registers of Historic Places, 3. Have been determined Eligible for inclusion in the registers through federal or state processes administered by the HPO, 4. Have been designated as Local Landmarks by local government, or 5. Have been identified through cultural resource survey or other documentation on file at the HPO. The majority of features in the dataset represent categories 1, 2, and 3 above. HPO is still in the process of comprehensive digitizing for categories 4 and 5.[13]

[13] NJDEP Bureau of GIS. 2022. Historic Properties of New Jersey. Available online: https://njogis-newjersey.opendata.arcgis.com/datasets/njdep::historic-properties-of-new-jersey/about



Map 6. Historic Properties and Districts in Madison Borough

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IV. GEOLOGY

REGIONAL GEOLOGY

There are four principal physiographic provinces in New Jersey: Valley and Ridge; Highlands; Newark Basin; and Coastal Plain. Madison is located within the Newark Basin.

The Newark Basin is part of a series of basins that formed along the east coast in association with the opening of the Atlantic Ocean during the Triassic–Jurassic Periods (approximately 235 to 175 million years ago (Ma)). These basins are a result of rifting during the breakup of the continent, forming large extensional basins that had long periods of continuous deposition of sediments as rifting continued (Olsen, 1980).

The Newark Basin is a northeast to southwest trending basin that extends from Rockland County, New York to Lancaster County, Pennsylvania (VanHouten, 1988). The Basin is separated from the Highlands to the northwest by the Ramapo Fault (west of Morristown), and is covered to the southeast by the sediments of the Coastal Plain (Drake et al., 1996).

The Newark Basin is filled with red, brown, gray and black clastic and evaporite sediments. These sediments were predominantly deposited in lacustrine (lake) environments, and color changes reflect changes in lake levels and climatic changes (Olsen and Kent, 1990). The bedding planes of the deposits generally trend northeast to southwest and dip gently to the northwest. The sediments are interrupted by igneous rocks (basalt and diabase) that form the higher ridges. These ridges are commonly known as the Watchung Mountains.

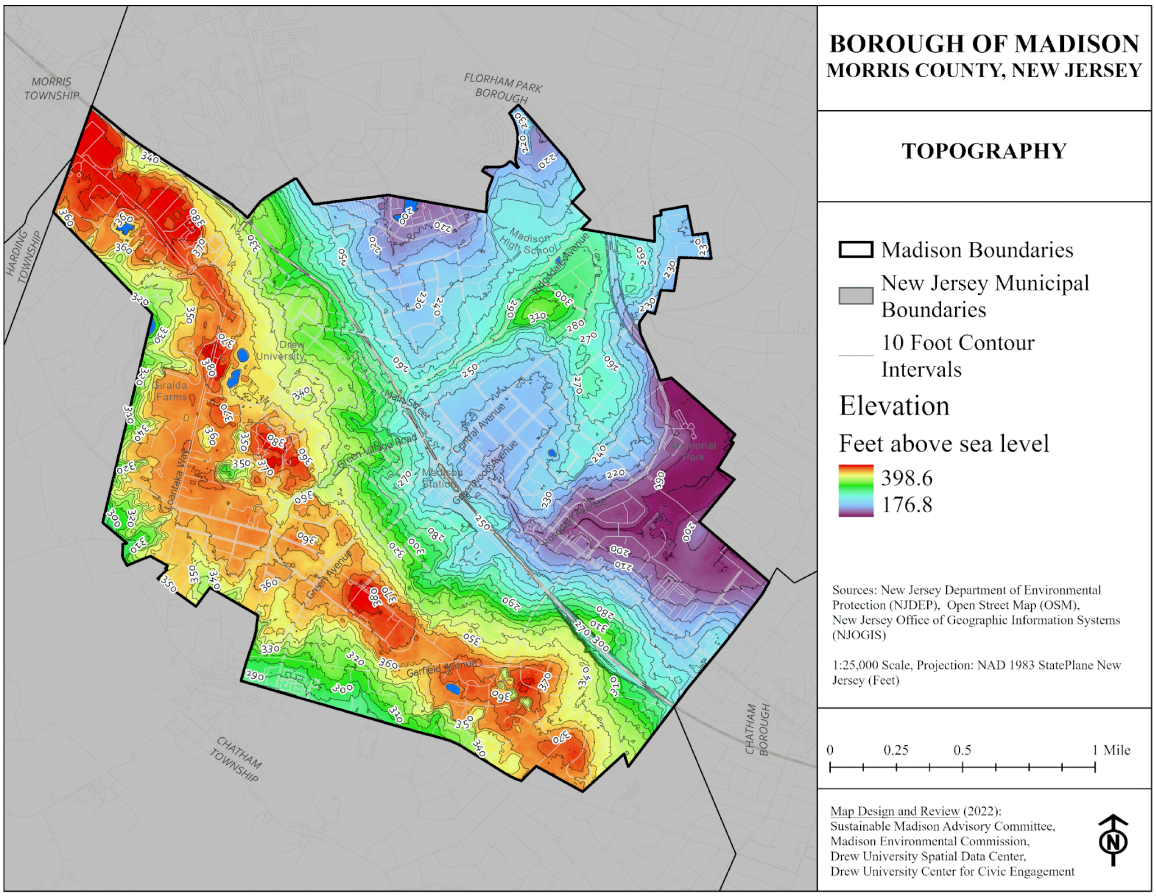
MADISON'S GEOLOGY

The shallowest bedrock in Madison is part of the Boonton Formation (Lower Jurassic Period, approximately 190 to 175 Ma), which is the youngest of the depositional cycles of the Newark Basin (Olsen, 1980). The Boonton Formation was deposited on top of the Hook Mountain Basalt (Long Hill is part of this Basalt). Madison is located on the Watchung Syncline within the Newark Basin, where flexure in the bedrock between the Hook Mountain Basalt and the Highlands caused the bedding planes to dip inward on both sides (Drake et. al.,1996). This syncline extends southwest through the Great Swamp, and north through Black Meadows and Troy Meadows.

The Boonton Formation is dominated by red and brown cross-laminated sandstones and siltstones, with units of black shale and gray mudstone (Fedosh and Smoot, 1988). However, the bedrock is not seen in Madison, as it is covered by more recent unconsolidated sediments.

After deposition of the Boonton Formation, the next major change in Madison's geology occurred around 60 million years ago during the Tertiary Period when a broad, nearly featureless plain called the Schooley Peneplain was created by streams eroding the high surrounding elevations. During this time the elevation of the plain locally was equal to the present height of Long Hill, a few miles southeast of Madison. During the Tertiary Period, the historic Hudson River flowed southward along the Newark Basin, eroding bedrock and carving water gaps through the Watchung Mountains. The Boonton Formation was eroded into a topography that includes hills and valleys under Madison's surface sediments.

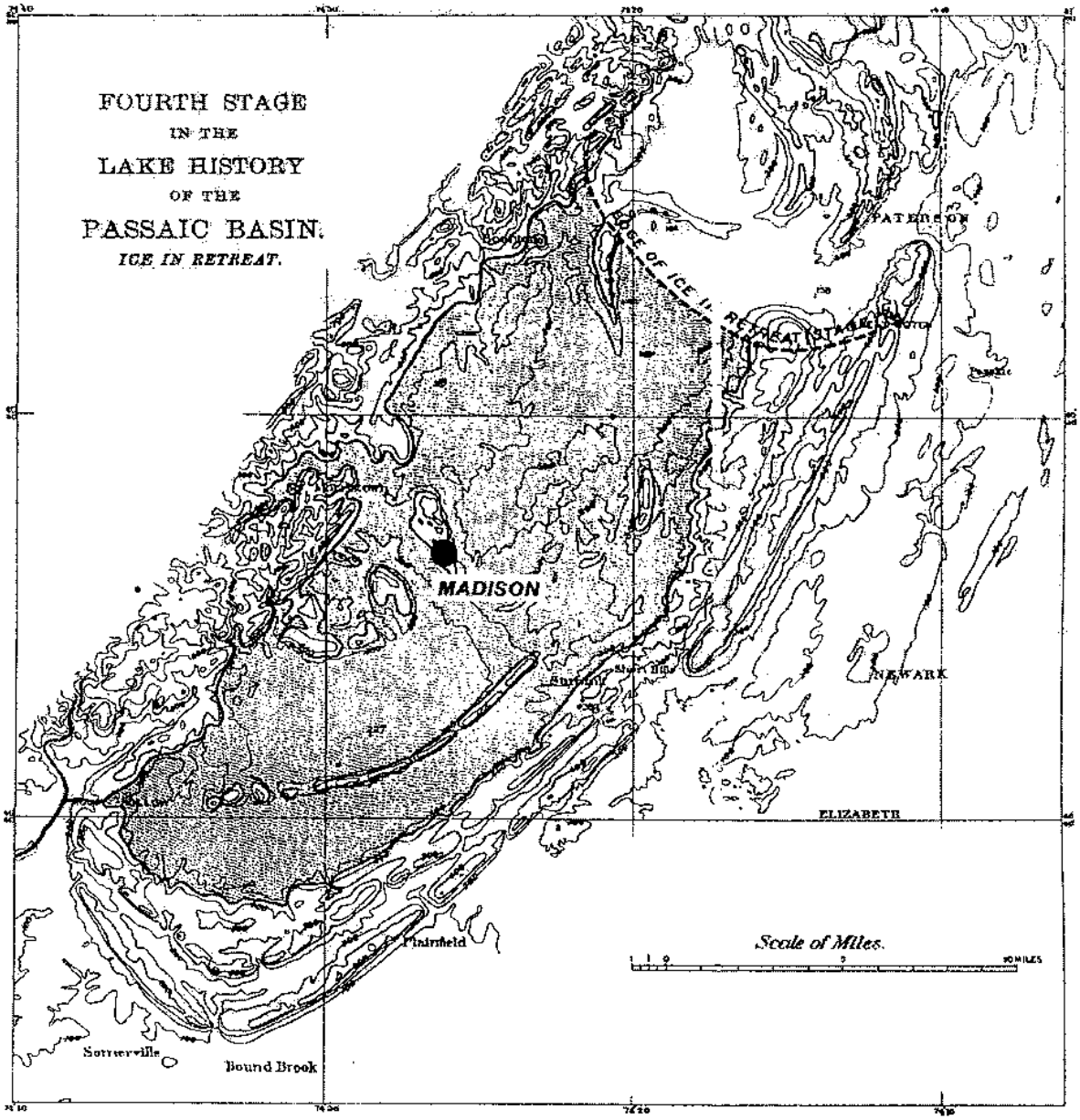
During the Pleistocene Epoch that began approximately 2 million years ago, three glacial advances reached New Jersey. Locally there is little evidence of the first two, but the last, called the Wisconsinan Glaciation, was responsible for Madison's landform as we know it today. (See **Map 7** for the topography of Madison.) The Wisconsinan Glacier began pushing southward some 80,000 years ago. The ice sheet was one mile thick in places, and probably 2,000 feet thick over northern New Jersey. As the glacier moved southward, the weight of the ice created great pressure that scoured bedrock leaving striae marks, and stripping boulders and sediment from the land surface (thereby destroying evidence of earlier glacial deposits). This material was transported by ice and by rivers flowing under, in, and above the ice sheet, and then deposited beneath and at the edge of the ice sheet.



Map 7. Digital Elevation and Contour Representation of Madison Topography

The glacier advanced from the north as far south as Chatham through Madison, Morristown, Dover and Netcong. In front of the glacier, Glacial Lake Passaic formed from its meltwaters. Prior to the advance of the glacier, the outlet of the southern basin of the Passaic River was through the Short Hills Gap. The glacier deposited sand and gravel in the gap, effectively blocking it and creating Glacial Lake Passaic between the

ice and the ancient Watchung Mountains (see Map 8). When the glacier retreated northward, the lake, fed by meltwater from the glacier, grew until it was 10 miles wide and 30 miles long. At its maximum extent, Glacial Lake Passaic drained to the south through Moggy Hollow in Far Hills. The retreating glacier finally uncovered another outlet at what is now Little Falls Gap, near Paterson, and then the lake drained out along the present course of the Passaic River. Where there was once a lake, there still are extensive marshes and swamps. The Great Swamp is one of them.



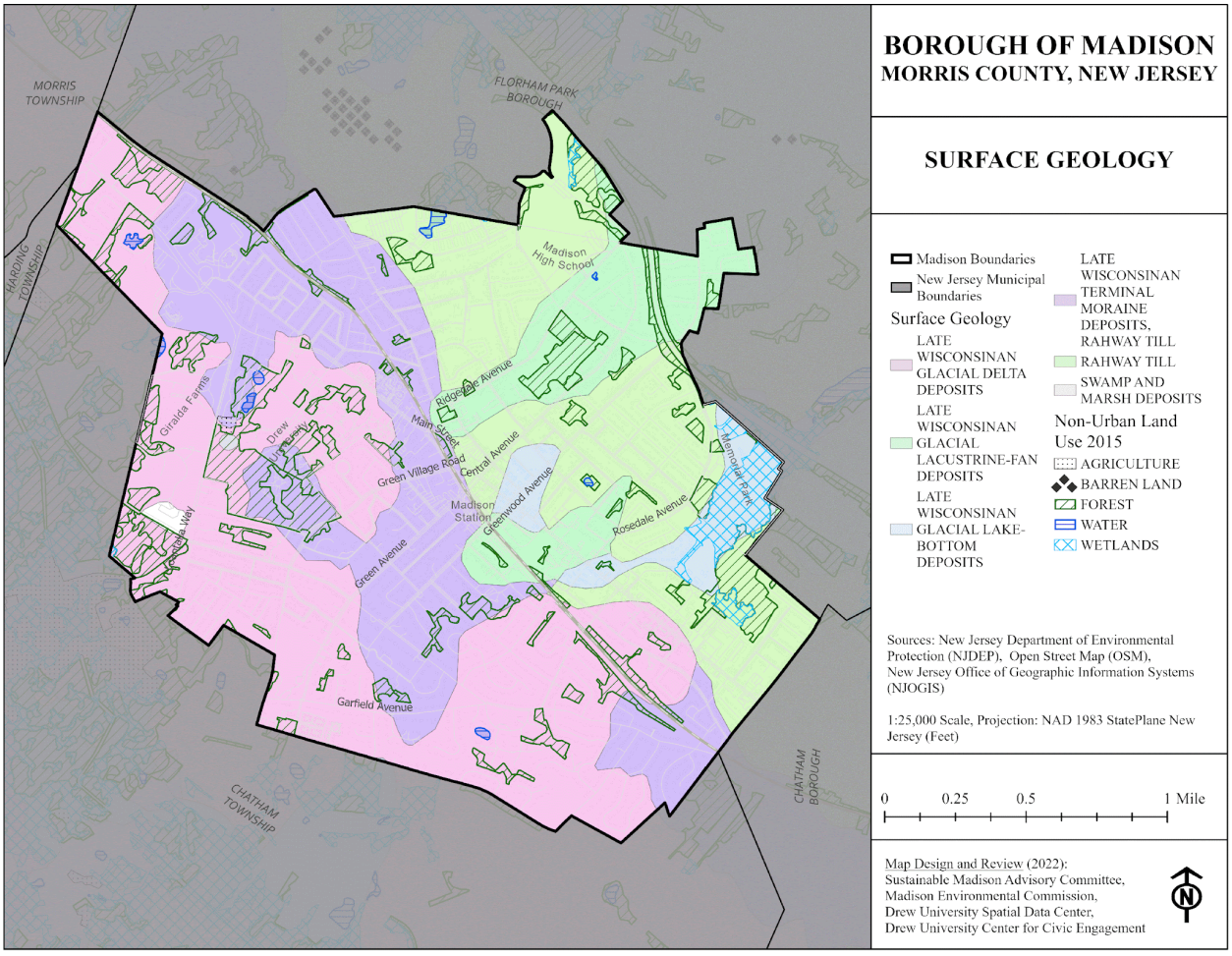
Map 8. Lake Passaic at Maximum Stage, Glacial Geology, N.J. Geological Survey, 1902

The glacial deposits had a significant impact on Madison. The bedrock surface forms a buried valley in a trend following Main Street and then Park Avenue. Within this valley is a layer of sand and gravel approximately 100 feet thick deposited either prior to glaciation or during several periods of glaciation. This

feature is commonly known as the Chatham Buried Valley Aquifer. This is the source of Madison's water supply, with wells located at the Department of Public Works area, and the North Street Area. The aquifer is discussed in more detail in the chapter on Hydrology.

Overlying the Buried Valley and bedrock are other surface glacial deposits. Surficial geologic materials are unconsolidated sediments that overlie bedrock and Coastal Plain formations, and that are the parent material for agronomic soils. In New Jersey, they include glacial, river, marine, windblown, wetland, and hillslope deposits and weathered-rock material. These materials are distinguished and mapped based on their grain size, mineral composition, bedding, physical properties, and landscape position. They are as much as 400 feet thick but are less than 30 feet thick over most of the state. Glacial deposits and weathered-rock material occur in the northern half of the state, marine deposits occur in the coastal areas of southern and central New Jersey, the other deposits occur statewide.

As shown in the Surface Geology Map and the Table below, Late Wisconsin Glacial Deposits make up most of the Borough's Surface Geology (See **Map 9**). The southern edge of the Wisconsinan Glacier is marked by a great terminal moraine, which is a ridge-like accumulation of clay, sand, gravel and boulders left when the edge of the glacier stagnated in Morris County for 2,000 to 3,000 years. The southern half of Madison ("the Hill") rests on the terminal moraine. Large portions of the northern half were also affected by the terminal moraine. It is believed that the terminal moraine once leaned against the edge of the glacier. Subsequently, as the ice receded, the terminal moraine collapsed toward the north.



Map 9. Madison Borough Surface Geology

Madison's Surficial Geology in Acres

SYMBOL	AREA	GEOLOGY NAME	ACRES
Qs	1	SWAMP AND MARSH DEPOSITS	1.9
Qwde	1	LATE WISCONSINAN GLACIAL DELTA DEPOSITS	1,009.7
Qwlb	3	LATE WISCONSINAN GLACIAL LAKE-BOTTOM DEPOSITS	119.2
Qwlf	3	LATE WISCONSINAN GLACIAL LACUSTRINE-FAN DEPOSITS	293.7
Qwmtr	2	LATE WISCONSINAN TERMINAL MORAINE DEPOSITS, RAHWAY TILL	708.3
Qwtr	2	RAHWAY TILL	627.3
TOTAL	**12**		**2,760.1**

Excavations in the terminal moraine for the National Methodist Archives Building on the Drew University campus exposed highly stratified layers of sand and clay to a depth of at least 30 feet. In July 1981, the U.S. Geological Survey drilled a borehole through the terminal moraine at an elevation of 370 feet in Niles Park at the corner of Garfield Avenue and Woodland Road. The geologic log (Figure 1) indicates the moraine contains layers of glacial till, sand, silt and clay. It is likely these layers reflect the advance and retreat of the ice edge over the area several times.

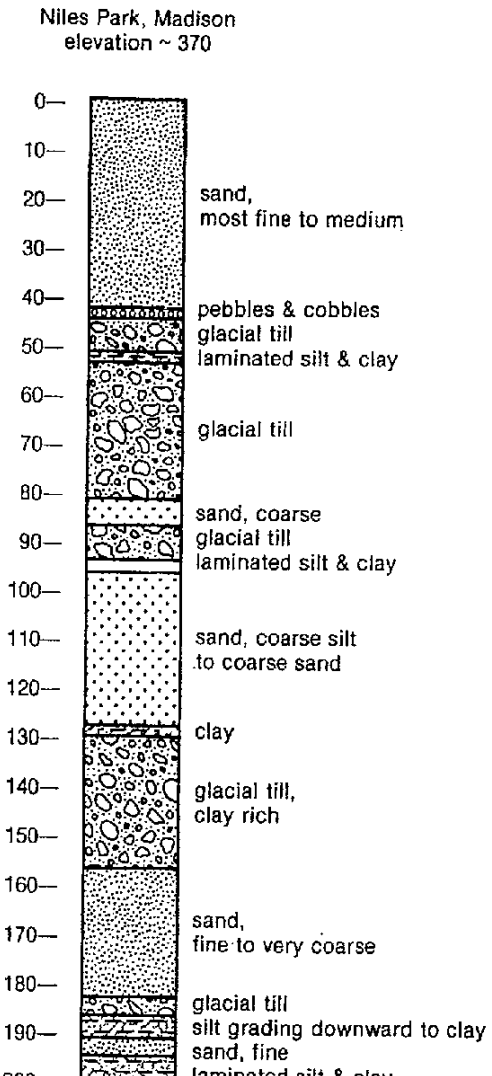


Figure 1. USGS Core Log (1981)

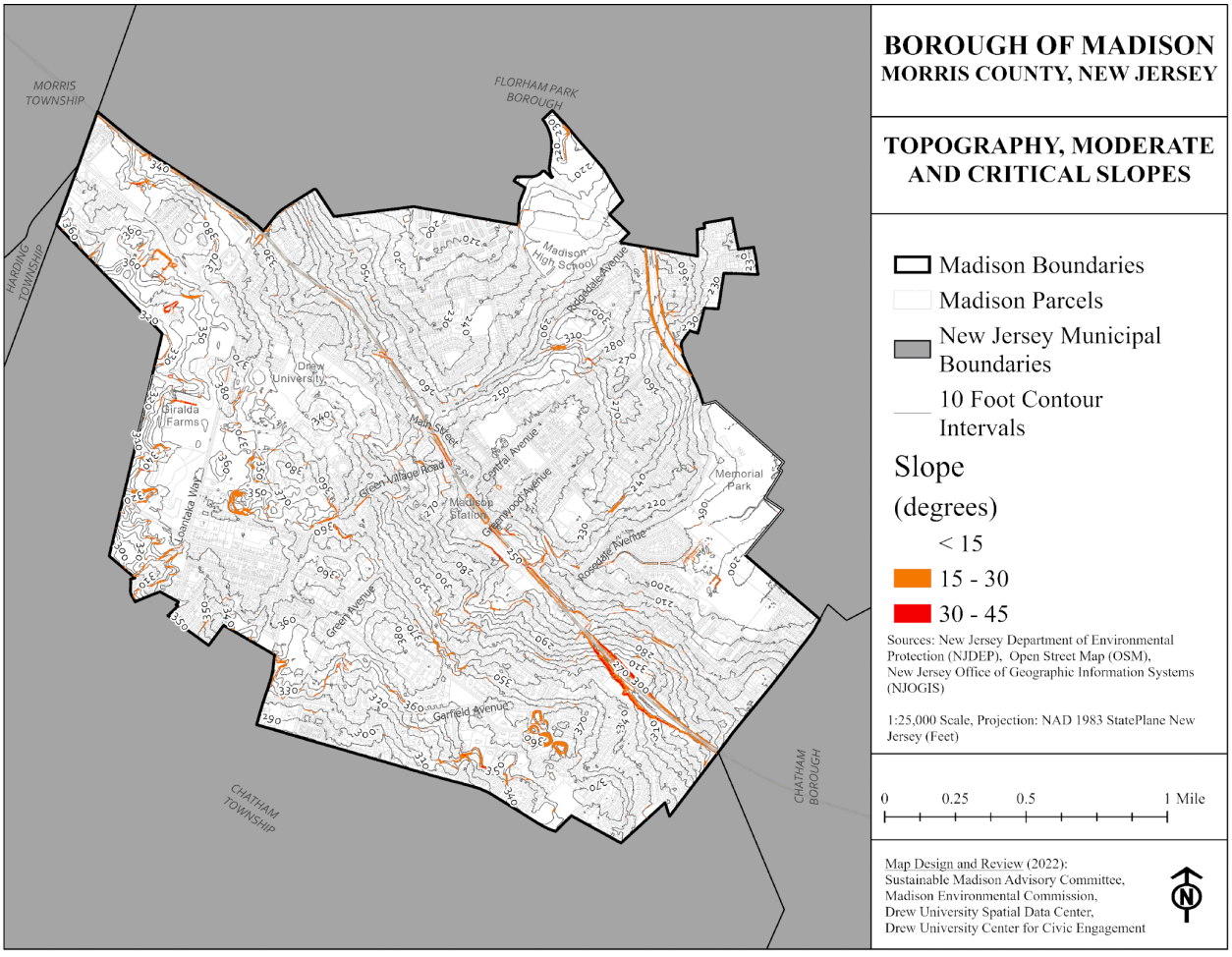
The area roughly north of Main Street is approximately a hundred feet lower in elevation than the terminal moraine area. Near the ground surface is a clay and silt layer about 20 feet thick. It covers a glacial till layer that extends down another 20 to 30 feet. The clay and silt layers are lake deposits formed in Glacial Lake Passaic. In some areas, such as along Ridgedale Avenue, the clay layer is missing or buried by a ridge of glacial outwash deposits running perpendicular to the terminal moraine.

Glacial Lake Passaic covered all of Madison, except the highest elevations that were islands. Wind and waves from the northeast eroded the shoreline into a beach, technically called a "wave-cut terrace." Remnants of this beach can be seen in the area in front of Drew University to the south of Route 124. It is traceable for over a mile between elevations of 340 to 350 feet. Large boulders found near the 340 foot elevation were carried by icebergs in Glacial Lake Passaic. One can still see a line of boulders on the southwest side of Park Avenue and Columbia

Turnpike, west of Madison. Another glacial feature in Madison is a broad flat delta or outwash plain built by streams flowing from the ice front into Glacial Lake Passaic. This plain starts at the corner of Loantaka Way and Woodland Road and extends to the northwest for about half a mile along Loantaka Way.

Several depressions, called kettle holes, are still identifiable in Madison. These were formed when large chunks of ice broke off from the retreating glacier and were subsequently buried in the outwash sediments. As the ice melted, the sediments collapsed into the empty spaces, leaving the depressions. An excellent example is the kettle hole in the southwest corner of the Drew Forest Preserve on Glenwild Road near Loantaka Way.

According to borough code, General Legislation on Land Development, Article VI on Stormwater, Wetland Protection, Steep Slopes, Flood Control and Riparian Buffer Zone, the Borough defines slopes of 15-25 percent as moderate slopes, and slopes over 25 percent as critical slopes.[14] Development is restricted on all critical slopes, and development of moderate slopes can take place on up to ¼ of moderate slope properties and is subject to review by the town. Map 10 illustrates the moderate and critical slope locations along with the 10-foot contour lines depicting elevation.



Map 10. Topography with Moderate and Critical Slopes Derived from the New Jersey Digital Elevation Model (2021)

[14] § 195-41.2 Steep slopes analysis. In General Legislation/Land Development, Article VI. Stormwater, Wetland Protection, Steep Slopes, Flood Control and Riparian Buffer Zone. Available online: https://ecode360.com/13508033

The Madison area owes its soils and landform to glacial activity. The most beneficial gift to Madisonians from this geological event is the Borough's water supply, which is described more fully in the chapter on Hydrology. Thus, events that occurred from thousands to millions of years ago influence our lives today.

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V. HYDROLOGY

The science which deals with the movement and distribution of water on earth is known as hydrology. All of the water on earth (vapor, clouds, rain, snow, glaciers, rainwater runoff, rivers, lakes, oceans, groundwater) is part of a continuous physical process known as the hydrologic cycle (see Figure 2). Water evaporates into the air from land, plants and water bodies, cooling as it rises. When this water vapor reaches the condensation point, clouds form. Eventually precipitation in the form of rain, snow or sleet occurs, often many miles from the area of evaporation. When the water falls back to earth it may either evaporate or transpire through the

trees and plants back into the atmosphere, infiltrate into the soil, or flow across the land (runoff) into streams, rivers, lakes and oceans. The continuous movement of water from oceans to atmosphere to land and back to the sea is the major flow path of the hydrologic cycle. In the subterranean portion of the cycle, underground stores of water called aquifers may discharge some water directly to surface water bodies.

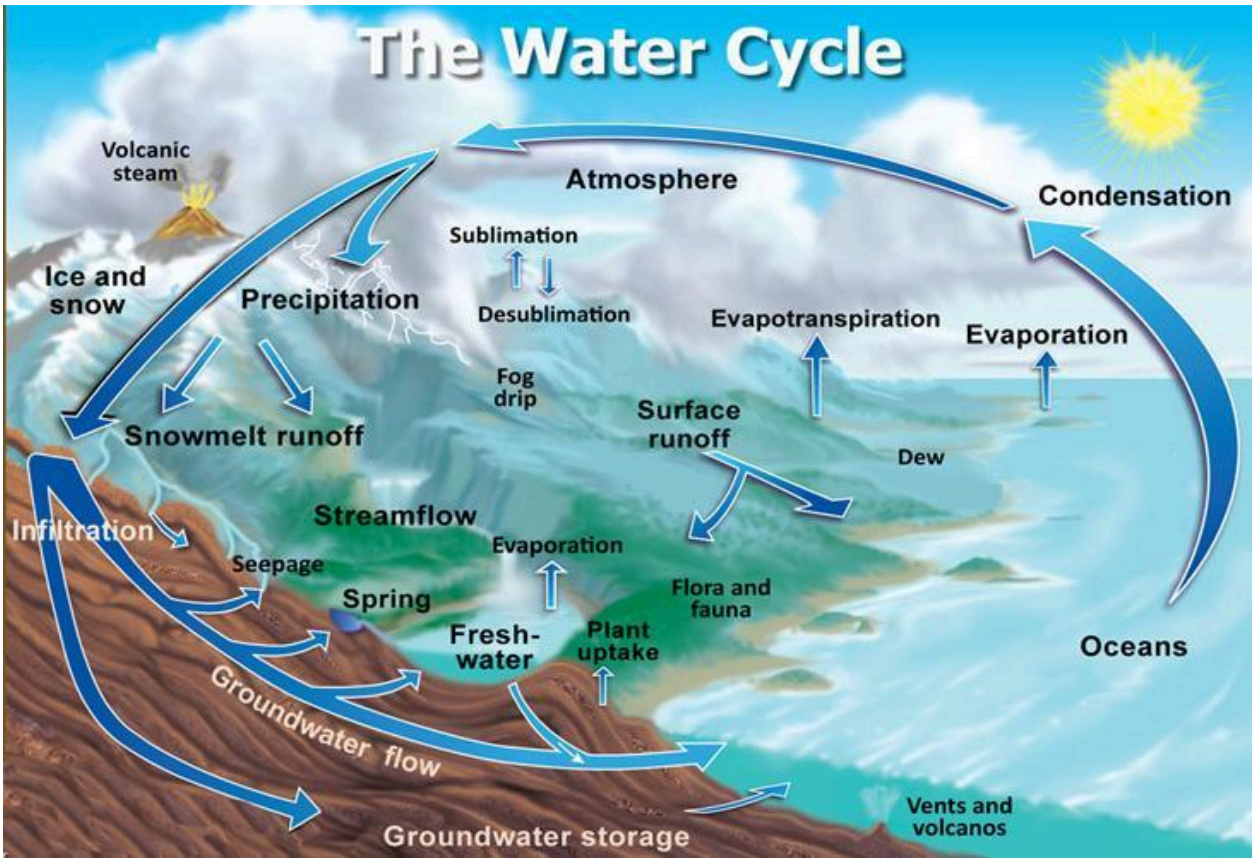


Figure 2. Hydrologic Cycle Diagram, Prepared by John Evans and Howard Periman, USGS, Public Domain (2013)[15]

The two major sources of drinking water supply are groundwater and fresh surface water. Groundwater, which is water stored and moving in the ground, is the largest single source of freshwater on earth. Surface water consists of water found in ponds, streams, rivers, lakes and reservoirs. Both groundwater and surface water are recharged directly or indirectly through precipitation. "In New Jersey, an average of 44 inches of precipitation per year replenishes the state's 6,500 miles of streams and rivers, 61,000 acres of lakes and an extensive network of underground aquifers" (NJDEP, 1988). However, average annual precipitation ranges across the state: from about 40 inches along the southeast coast to 51 inches in north-central parts of the state. Many areas average between 43 and 47 inches. Figure 3 below charts data from the Rutgers University Climate Lab.[16] Average annual precipitation rates in New Jersey have increased since data collection began in 1895.

[15] Evans, J., Periman, H. 2013. Water-Cycle Diagram. Available on WikiCommons: https://commons.wikimedia.org/wiki/File:Watercyclesummary.jpg

[16] Office of the NJ State Climatologist. 2022. Monthly Climate Tables. New Jersey (Statewide) Monthly Total Precipitation (inches). Available online: http://climate.rutgers.edu/stateclim_v1/nclimdiv/

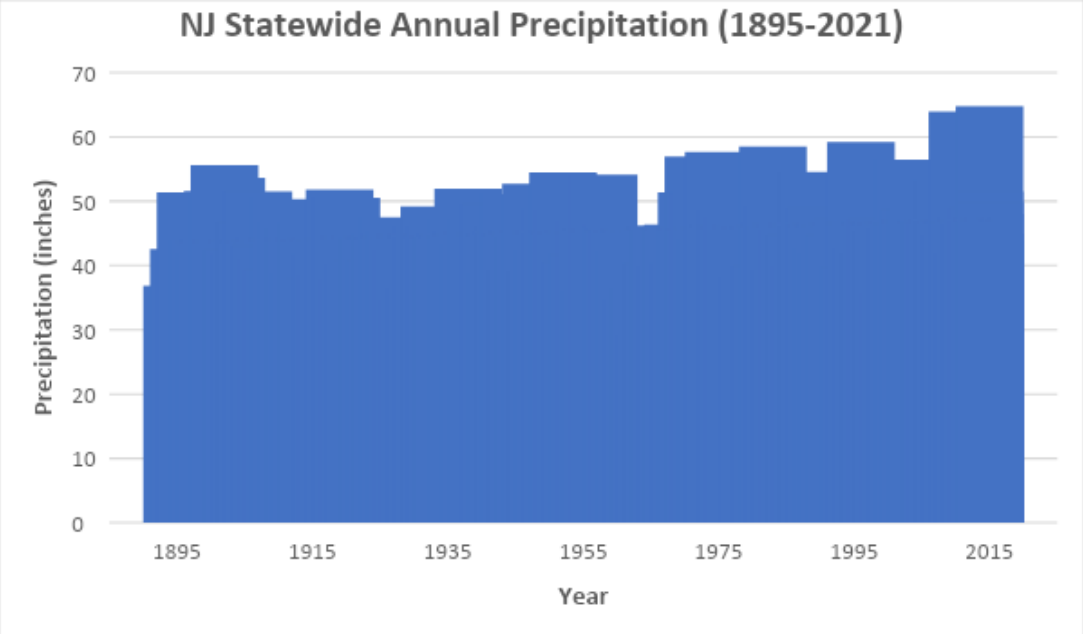


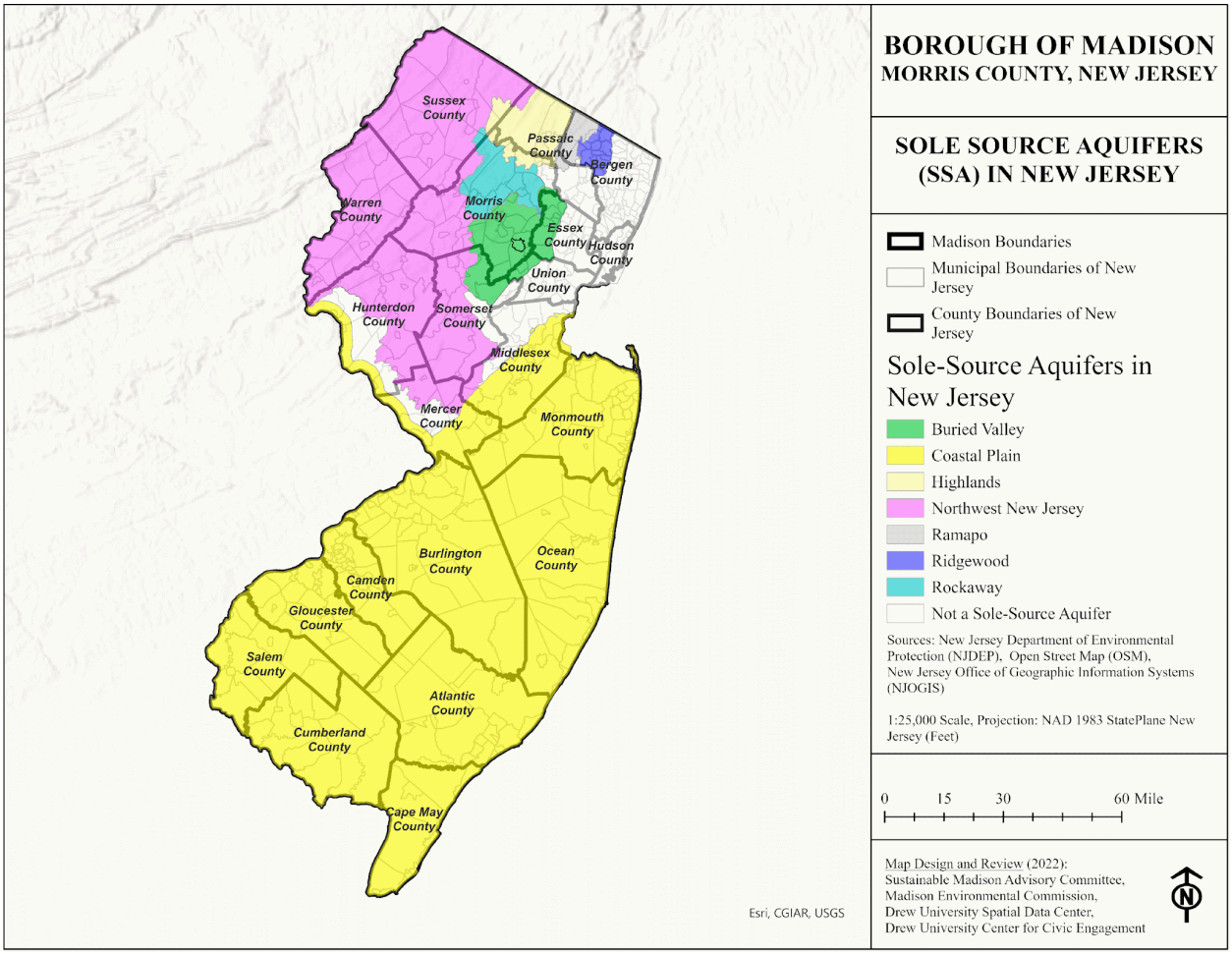
Figure 3. New Jersey Statewide Annual Precipitation in Inches (1895-2021)

The U.S. Geological Survey estimates the total amount of water on earth at 326,000,000 cubic miles or 1.44 sextillion tons. Ninety seven percent (97%) of this water is in the oceans, two percent (2%) is in the polar ice caps and glaciers, and one percent (1%) in rivers, lakes, groundwater and atmospheric vapor. The greatest amount of all available fresh water can be found in groundwater. Groundwater makes up 96.5% of the one percent (rivers, lakes, groundwater and atmospheric vapor) mentioned above. “In New Jersey, sixty percent of our drinking water comes from underground sources.” (Tucker, 1981).

GROUNDWATER

Within the Passaic River Basin, precipitation averages approximately 47 inches of water per year. “On average, evapo-transpiration accounts for about half of this water, about one-quarter runs off, and the remainder becomes groundwater” (Passaic River Coalition, 1993). When rainwater and snow fall onto the ground, some of this water infiltrates into the soil and seeps down into underlying rocks and sediments. This groundwater slowly fills cracks in rocks and spaces between sediment particles. Aquifers occur when storage of groundwater is sufficient to produce a water supply. Groundwater moves through porous soil and rock fractures by complex routes.

The aquifers underlying the Central Valley of the Passaic River in New Jersey are called the “Buried Valley Aquifers.” They occur in valleys cut in the bedrock and prior glacial deposits. During the Ice Age, the Wisconsin glacier filled these valleys with glacial outwash sand and gravel deposits. These unconsolidated deposits contain groundwater in large quantities because of the large spaces between the sand and gravel particles. The Buried Valley Aquifers are the principal source of high-quality drinking water supply for more than 600,000 people and many businesses. All of the valley aquifers in the Passaic River Basin have been designated by the U.S. Environmental Protection Agency as “sole source aquifers” in accordance with the Safe Drinking Water Act of 1974 (See Map 11). Therefore, on federally funded projects (i.e., highways, sewers), environmental impact assessment of groundwater is required.



Map 11. Locations of Sole Source Aquifers in New Jersey

The Buried Valley Aquifers occur in a series of interconnected valleys. They range from in width from 0.5 to 1.5 miles and in thickness from less than 1 foot to 100 feet. Glacial till, lake deposits of clay and silt, and swamp muck ranging in thickness from 10 to 80 feet overlie the aquifers and function as a confining layer (Meisler, 1976). Harold Meisler, a hydrologist with the U.S. Geological Survey, reported that core samples from Madison's wells show lake deposits in the layer just above the aquifer, and till above the lake deposits.

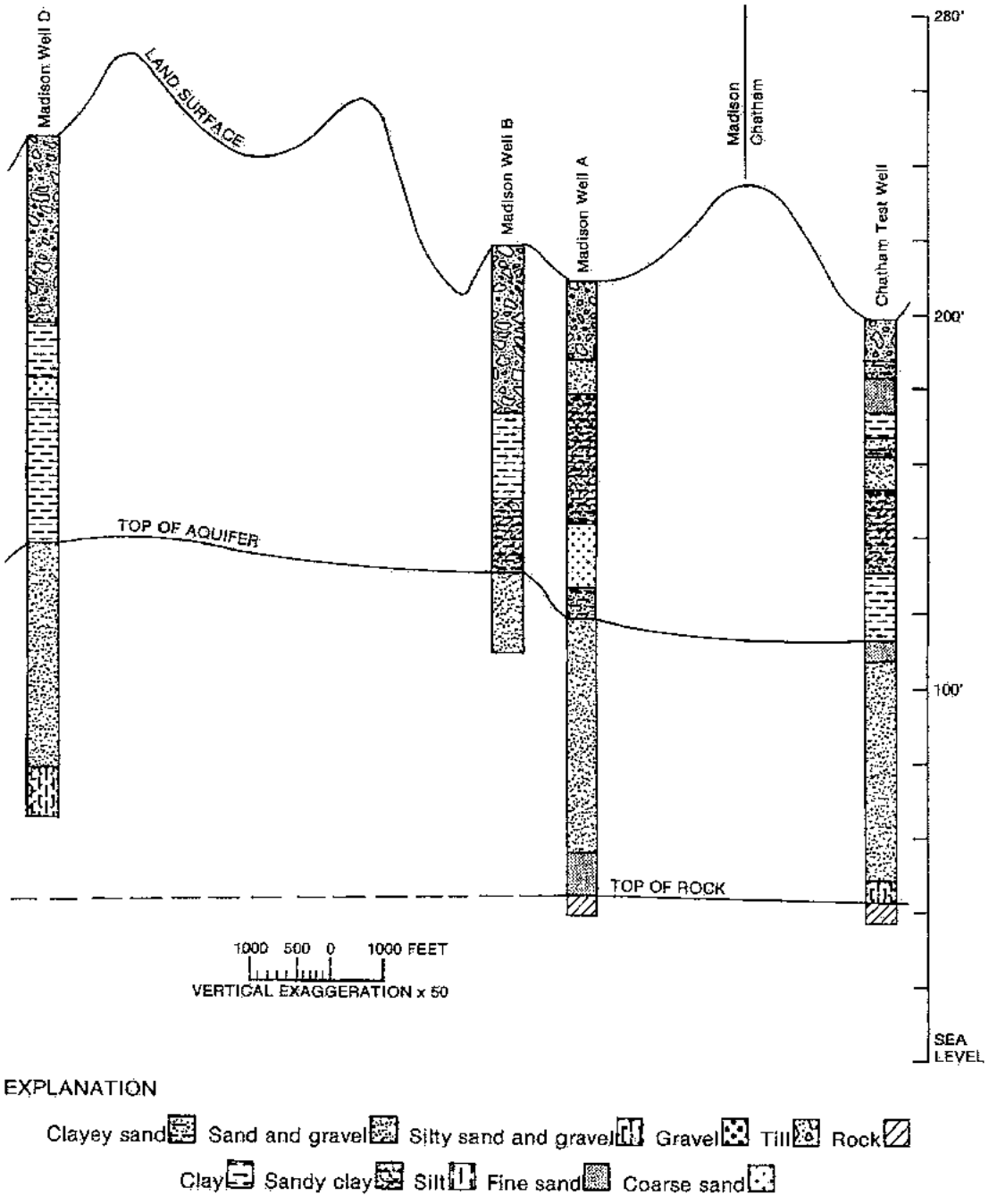


Figure 4. Geologic Section of Valley-Fill Aquifer in Madison and Chatham, Morris County, New Jersey (Source: Results of the Second Phase of the Drought-Disaster Test Drilling Program new Morristown, NJ)

The Chatham Valley Aquifer, in which the wells of Madison, Florham Park and Chatham Borough are located, traverses the other aquifers and does not coincide with a surface valley. It underlies, and in part parallels, the terminal moraine. The land surface elevations overlying the aquifer range from 180 to 240 feet above sea level. Where the aquifer is overlain by terminal moraine, the land surface elevations range from 200 to 360 feet above sea level (Meisler, 1976).

In a 1980 EPA report, 31 municipalities and twelve (12) Public Water Supply Systems, including the Madison Water Department, used the Buried Valley Aquifer System.[17]

MADISON'S WELLS & WELL HISTORY

Madison's five (5) wells (Wells "A" through "E") are the source of the Borough's drinking water. The five wells draw groundwater from the Buried Valley Aquifer System. The wells were drilled between 1952 and 1968, and are presently in use today. The Madison Water Department is a Public Community Water Supply System that manages water produced from the five wells, "and may also purchase water from the following 3 water systems: Florham Park Water Department, Southeast Morris County MUSA, and NJ American Water Company. The water, if purchased, consists of 1 ground water source and 2 surface/ground water mix."[18]

In the 1898, the first five wells in the municipal water system were drilled in Madison. These were flowing artesian wells. An artesian well is a well deriving its water from a confined aquifer under sufficient pressure for groundwater to rise above the confining strata. In some instances, the water pressure is sufficient enough to push the groundwater from the aquifer and up to the surface of the ground, giving rise to free-flowing wells.

As the groundwater level dropped, the supply of free-flowing water diminished. Later, all of the wells were linked together using a vacuum system. Ground water was sucked from the wells and pumped into twin tanks located on Midwood Terrace. Gravity flow supplied water to users throughout the Borough. Four more wells were drilled in 1912, and three more in 1929. None of these early wells are still in use.

The five wells in operation today are listed in Table X. The Borough's public water supply system (Madison Water Department, PWSID 1417001) has a water allocation permit from the New Jersey Department of Environmental Protection (NJDEP) to operate these wells with a Water Supply Firm Capacity of 5.904 MGD (million gallons per day). According to the 2011 ERI, the capacity of the each well ranges from 1.1 million gallons per day (MGD) to 1.9 MGD. A draft copy of the Water System Facility Assessment and Proposed Improvement Plan (2016) found that the Borough supplies an average of 2.1 million gallons per day (MGD) and a peak of 4.3 MGD to customers. The wells discharge into a system of underground piping which also contains two water tanks. The Madison Avenue tank holds 500,000 gallons and the Midwood Terrace tank holds 750,000 gallons (Madison Water Department, 2011 Water Quality Report).

Table X. Well Capacity of Madison Wells

Well	Year Installed	Location	Capacity (GPM)	Capacity (MGD)
A	1952	John Ave.	750	1.15
B	1955	Station Rd.	1,200	1.58
C	1955	North St.	1,200	1.87
D	1956	Loveland St.	1,000	1.73
E	1967	Main St.	1,500	1.73

[17] EPA. 1980. Support Document: Western Essex and Southeastern Morris Counties New Jersey. April. Available online through Internet Archives: https://web.archive.org/web/20080328175954/http://www.epa.gov/region2/water/aquifer/burval/buryval.htm

[18] Borough of Madison Water Department. 2022. Annual Water Quality Report. Available online: https://www.rosenet.org/DocumentCenter/View/15627/Borough-of-Madison-2022-WQR_Final?bidId=

Total			5,650	8.06

Treatability Study July 1999 by Elson T Killam Associates of Millburn NJ, and Water System Facility Assessment and Proposed Improvement Plan (Draft), January 2016, by Hatch Mott MacDonald

WATER SUPPLY & DEMAND

As reported in the July 1999 *Treatability Study* by Elson T. Killam Associates, the actual pumpage rate for each of Madison's five wells was tracked for a five-year period between 1993 and 1998. At that time, the average daily pump yield ranged from 0.01 (Well D) to 0.91 (Well C). The total average daily pump yield from 1993-1998 was 2.02 MGD. The 2016 Water System Facility Assessment recommended efficiency improvements for the wells. The wire to water efficiency measures and rating are included in Table X.

Well Efficiency Measures and Ratings

Well	Wire to Water Efficiency	GPM	Rating
A	40%	759	Low
B	59%	976	Fair
C	61%	1,108	Fair/Good
D	63%	969	Good
E	63%	1,020	Good

Water System Facility Assessment and Proposed Improvement Plan (Draft), January 2016, by Hatch Mott MacDonald

The actual water supply and operating demand is tracked by the NJDEP's Division of Water Supply. The agency determines if public water suppliers are operating in a water supply "surplus" or a "deficit." A deficit indicates a shortfall in "firm capacity" or available supplies through bulk purchase agreements. Firm Capacity means adequate pumping equipment and/or treatment capacity (excluding coagulation, flocculation, and sedimentation) to meet peak daily demand, when the largest pumping station or treatment unit is out of service.

As of 2022, the Madison Water Department was operating with a water demand well below the allocation limits, and is therefore operating at a surplus, as indicated in the figure below for a snapshot in time. The peak values indicate the highest recorded value for the last five years. In the 2011 ERI, the deficit/surplus report identified a yearly demand of 768 MGY for 2005. This is 21 MGY less than demand in 2017, though operating below the 900 MGY yearly allocation limit set by the Bureau of Water Allocation and Well Permitting.

Madison Water Department Deficit/Surplus Report[19]

MADISON WATER DEPARTMENT
PWSID: 1417001
County: Morris

Last Updated: 01/26/2022

[19] New Jersey Department of Environmental Protection, Division of Water Supply and Geoscience. Public Water System Deficit/Surplus. Reports available online, Madison PWSID: 1417001, https://www.state.nj.us/dep/watersupply/pws.html

Water Supply Firm Capacity: 5.764 MGD

Available Water Supply Limits

	Allocation	Contract	Total
Monthly Limit	108.500 MGM	N/A MGM	108.500 MGM
Yearly Limit	900.000 MGY	N/A MGY	900.000 MGY

Water Demand

	Current Peak	Date	Committed Peak	Total Peak
Daily Demand	3.110 MGD	01/2017	0.000 MGD	3.110 MGD
Monthly Demand	96.400 MGM	01/2017	0.000 MGM	96.400 MGM
Yearly Demand	781.200 MGY	2017	0.000 MGY	781.200 MGY

Water Supply Deficit or Surplus

Firm Capacity	Water Allocation Permit
2.654 MGD	12.100 MGM 118.800 MGY

WELL PROTECTION

In accordance with the 1986 and 1996 Federal Safe Drinking Water Act Amendments, all States must have a Well Head Protection Program (WHPP) in place for its public and nonpublic water supply wells. The goal of a WHPP Plan is to prevent contamination of ground-water resources. The purpose of the NJ WHPP is to minimize the risk of water supply well pollution due to the discharges of pollutants by controlling both potential pollutant sources (PPS) and the location of new wells, at all levels of government and by the private sector.

The delineation of Well Head Protection Areas (WHPA's) is a major component of the Act. A WHPA is the area from which a well draws its water within a specified timeframe. More technically, it is an area around a Public Community Water Supply (PCWS) well that delineates the horizontal extent of ground water captured by a well pumping at a specified rate over a two-, five- and twelve-year period of time. A WHPA consists of three tiers, each based on the time of travel of the ground water to a pumping well. The time it takes a given particle of ground water to flow to a pumping well is known as the time of travel (TOT). The outer boundaries of these tiers have the following times of travel:

- Tier 1 = two years (730 days)
- Tier 2 = five years (1,826 days)
- Tier 3 = twelve years (4,383 days)

NJDEP used a hydro-geological model approved by the EPA under the 2002 Source Water Assessment Plan (SWAP) program to delineate the WHPA tiers. The time of travel distance varies for each well, depending on the rate of the pumping, depth to well, hydrogeolocial flow and characteristics of the aquifer, such as transmissivity, porosity, aquifer thickness, and hydraulic gradient. If a municipality would like to develop their *own* WHPA model, the Division of Water Supply & Geosciences sets specific requirements. It must be a strong model with hydro-geological data that has been tested or observed and has changed, or a circumstance where new data is available.

The tiers are used to assess the relative risk of contamination to the well by placing a higher priority on pollution sources, prevention and remedies in the tiers closest to the wells. Potential sources of ground water contamination include storm water runoff, unsecured landfills, underground storage tanks and leaky drums, above ground storage tanks, chemical spills from industry, waste disposal lagoons, septic systems, highway deicers, road salt piles, etc. Activities that introduce pollutants within the designated WHPA are most likely to contaminate drinking water sources. Therefore, these delineated areas become a top priority in efforts to prevent and clean up ground-water contamination. Furthermore, protective land uses, such as preserved open space should be targeted for these areas. As the remediation of groundwater or development of new groundwater sources is extremely difficult and cost prohibitive, pollution prevention is clearly the most economical approach to maintaining ground water resources.

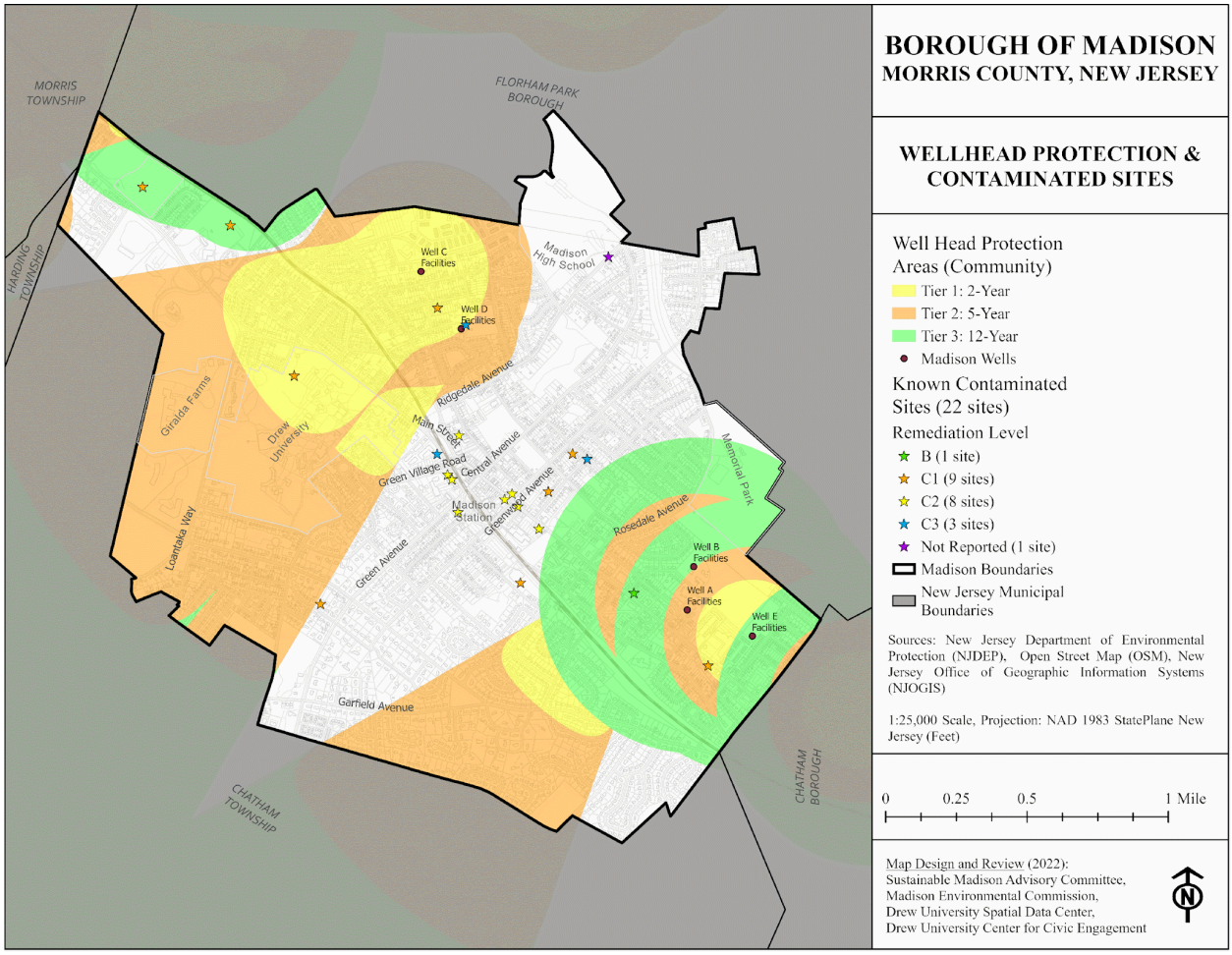
The Wellhead Protection Areas Map shows the location of the water supply wells and the wellhead protection areas, as well as their proximity to "known contaminated sites" (See **Map 12**). As indicated on the map, the protection areas (Tier 1, Tier 2, and Tier 3) do not follow municipal boundaries or political boundaries. Well protection areas for the five Madison wells extend into neighboring municipalities, and the protection areas for wells in adjacent municipalities extend into Madison. The table below lists the known contaminated sites (kcs) in Madison, using data published by NJDEP at the time of this report, and found at: http://www.nj.gov/dep/srp/kcsnj/.

Known Contaminated Sites in Madison (See Map 12)

Name	Address	Status	Remediation Level	Status Date
MADISON BORO WATER DEPT WELLFIELD	JOHN AVE & LOVELAND ST	Active	C3	2005-05-11
MADISON BORO WATER DEPARTMENT WELL D	LOVELAND ST	Active	C3	2005-06-21
18 ALEXANDER AVENUE	18 ALEXANDER AVE	Active	C1	2009-09-01
NJ FUEL LLC DBA MADISON SHELL	103 MAIN ST	Active	C2	2010-10-01
HARTLEY DODGE MEMORIAL BLDG	50 KINGS RD	Active	C2	2011-08-23
ROSE CITY HONDA	139 MAIN ST	Active	C2	2011-11-01
MOBIL R/S #30097	122 MAIN ST	Active	C2	2011-11-04
T&J SERVICE CENTER INC	31 KINGS RD	Active	C2	2012-04-02
FAIRLEIGH DICKINSON UNIVERSITY	285 MADISON AVE	Active	C1	2012-04-03
HEILMANNS GULF SERVICE	112 MAIN ST	Active	C2	2012-04-04
MANTONE'S MOBIL SERVICE STATION	14 KINGS RD	Active	C3	2012-04-30
DREW UNIVERSITY	36 MADISON AVE	Active	C1	2012-05-07
1 HOUR MODERNIZING	33 KINGS RD	Active	C2	2012-10-15
MADISON RECREATION CENTER	184 RIDGEDALE AVE	Active - RAP		2013-04-16
BAYLEY ELLARD FIELD	DANFORTH AVE	Active - RAP	C1	2013-12-23
309 MAIN ST	309 MAIN ST	Active	C1	2014-12-17
GETTY 56867	234 MAIN ST	Active	B	2016-02-16
3 GROVE STREET	3 GROVE ST	Active	C1	2016-02-26
27 SOUTH STREET	27 SOUTH ST	Active	C1	2016-09-26
MADISON AREA YMCA	1 RALPH STODDARD DR	Active	C1	2019-04-25
THE ESTATE OF ELEANOR DEBIASSE	3-5 Community Place	Active	C2	2020-02-18
40 HILLCREST ROAD	40 HILLCREST RD	Active	C1	2021-11-15

The level of remediation needed at each site is categorized as "C1," "C2," "C3," or "B" as follows:

- C1: No Formal Design - Source Known or Identified-Potential GW Contamination
- C2: Formal Design - Known Source or Release with GW Contamination
- C3: Multi-Phased RA - Unknown or Uncontrolled Discharge to Soil or GW
- B: Single Phase RA - Single Contamination Affecting Only Soils



Map 12. Wellhead Protection Areas and Known Contaminated Sites

Madison has remediated 178 sites once on the known contaminated site list.

DRINKING WATER QUALITY

Because of the Madison Water Department's designation as a public community water supply system, the Borough's drinking water quality is regulated by the NJDEP and must meet the current New Jersey Drinking Water Standards and Federal standards. These standards are listed as Maximum Contaminant Levels (MCLs) which the finished (treated and ready for distribution and consumption) drinking water cannot exceed. There are "primary standards," which are health related and "secondary standards," which are primarily aesthetic. The seven categories of contaminants, as well as Radon, are defined below:

- **Pathogens**: Disease-causing organisms such as bacteria and viruses. Common sources are animal and human fecal wastes, which can come from sewage treatment plants, septic systems, agricultural livestock and wildlife.
- **Nutrients**: Compounds, minerals and elements that aid growth, that are both naturally occurring and synthetic. Examples include nitrogen and phosphorus, which can come from sewage effluent, septic field discharges, animal waste, agricultural runoff, and residential fertilizer.

- **Volatile Organic Compounds**: Chemicals used as solvents, degreasers, and gasoline components. Examples include benzene, methyl tertiary butyl ether (MTBE), and vinyl chloride. They can be by-products of industrial processes and petroleum production, and can come from gas stations, storm water runoff and septic systems
- **Pesticides**: Chemicals used to control pests, weeds and fungus in agriculture or for residential use. 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 synthetic. Examples include arsenic, asbestos, copper, lead, and nitrate. These are salts and metals from stormwater runoff, industrial or domestic wastewater discharges, releases from contaminated sites, naturally occurring sources, oil and gas production.
- **Radionuclides**: Radioactive substances that are both naturally occurring and synthetic. Examples include radium and uranium.
- **Radon**: Colorless, odorless, cancer-causing gas that occurs naturally in the environment. At present, there is no federal regulation for radon levels in drinking water. However, exposure to air transmitted radon over a long period of time may cause adverse health effects.
- **Disinfection Byproduct Precursors**: These byproducts are formed when the disinfectants (usually chlorine) used to kill pathogens react with dissolved organic material (for example leaves) present in surface water.

The Madison Borough Water Department routinely monitors for drinking water contaminants according to Federal and State laws. In order to ensure that tap water is safe to drink, the EPA prescribes regulations which limit the amount of certain contaminants in water provided by public water systems. Food and Drug Administration regulations establish limits for contaminants in bottled water, which must provide the same protection for public health. The ''Maximum Allowed'' (MCL) is the highest level of a contaminant that is allowed in drinking water.

MCLs are set as close to the MCLGs as feasible using the best available treatment technology. Maximum Contaminant Level "Goal" (MCLG) is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that the water poses a health risk. The table below shows the monitoring results for the period of January 1st to December 31st, 2010.

Annual Drinking Water Quality Report Test Results, 2010 and 2022 Combined

Contaminant	Violation	Level Detected	Unit	MCLG	MCL	Likely Source of Contaminant	Change
MICROBIOLOGICAL CONTAMINANTS							
Coliform			P – Repeat samples were taken per Coliform Rule and no other			Coliforms are bacteria that are naturally present in the environment and are used as an indicator that other, potentially-harmful,	
2010	Y	1 positive result		0	0		None

2021	Y	2 out of 15 samples in July 2021, 1 out of 15 in Sept. 2021	positive samples were found			bacteria may be present.	
RADIOACTIVE CONTAMINANTS							
Alpha emitters							
Well A (2008)	N	1.79	pCi/L	0	15		
Well B (2008)	N	4.9	pCi/L	0	15		Non-comparable
Treatment A + B (2020)	N	2.6	pCi/L	0	15	Erosion of Natural Deposits	
Well C (2008, 2017)	N	1.4, <3	pCi/L	0	15		None
Well D (2008, 2017)	N	2.5, <3	pCi/L	0	15		None
Well E (2008, 2020)	N	2.1, <3	pCi/L	0	15		None
Radium 228 (2008)							
Radium 226 & 228 (2017 & 2020)							
Well A (2008)	N	0.12	pCi/L	0	5		
Well B (2008)	N	0.06	pCi/L	0	5		
Treatment A + B (2020)	N	3.4	pCi/L	0	5	Erosion of Natural Deposits	Non-comparable
Well C (2008, 2017)	N	0.2, 1.17	pCi/L	0	5		
Well D (2008, 2017)	N	0.09, <1	pCi/L	0	5		
Well E (2008, 2020)	N	1, <1	pCi/L	0	5		
Uranium							
Treatment A + B (2020)	N	1.2	ppb	0	30	Erosion of Natural Deposits	
Well E (2020)	N	1.18	ppb	0	30		
INORGANIC CONTAMINANTS							
Arsenic (2008, 2020)	N	Range (2008) = ND-2 Range (2020) = 1.05-1.55 Highest detected = .003, 1.55	ppb	N/A	5	Erosion of Natural Deposits; runoff from orchards, glass and electronics production wastes	Increase
Iron (2010, 2021)	N	0.1, <0.1	ppm	0.05	0.3	Natural Deposits	Decrease
Manganese (2010, 2021)	N	0.05, 0.004	ppm	0.01	0.05	Erosion of Natural Deposits	Decrease
Sodium (2020)	N	Range 17.57-45.72 Highest Detected Level 45.72	ppm		50	Natural Deposits, road salt, water softeners, sewage and fertilizers	
Barium (2008, 2020)	N	Range (2008) =0.015-0.031 Range (2020) = 0.021 - 0.052 Highest detected = 0.03, 0.052	ppm	2	2	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	Increase

***Fluoride** (2008, 2020)*	N	Range (2008) =0.05-0.2 Highest detected= 0.2, <0.05	ppm	4	4	Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories	Decrease
***Copper** (2009, 2021)*	N	0.1, 0.13 No samples exceeded action level	ppm	1.3	AL = 1.3	Corrosion of household plumbing systems	None
***Lead** (2009, 2021)*	N	3, 4.23 No samples exceeded action level	ppb	0	AL = 15	Corrosion of household plumbing systems, erosion of natural deposits	Increase
***Nitrate (as nitrogen)** (2010, 2021)*	N	Range (2010) 1.52 - 1.75 Range (2021) 1.53-1.89 Highest detected=1.75, 1.89	ppm	10	10	Runoff from fertilizer use; leaching from septic tanks; sewage; erosion or natural deposits	Increase
PFAS Per- and Polyfluoroalkyl Substances							
***PFOA** (Perfluorooctanoic Acid) 2021*	N	Range < 2-8.3 Highest detected level 8.3	ppt	14	14	Discharge from industrial, chemical and manufacturing factories, release of aqueous film foaming foam	
***PFOS** (Perfluorooctane Sulfonate) 2021*	N	Range < 2-3.7 Highest average = 3.7	ppt	13	13	Discharge from industrial, chemical, factories, release of aqueous film forming foam	
VOLATILE ORGANIC COMPOUNDS (Disinfection Byproducts)							
***ITHM** (total trihalomethanes) 2010, 2021*	N	Range (2010) 3.5- 5.4 Range (2021) 1.99-13.0 Highest average = 5.4, 9.0	ppb	N/A	80	By-product of drinking water disinfection	Increase
***HHA** (haloacetic acids) 2010, 2021*	N	Range (2021) 0-2.89 Highest average = 0, 2.0	ppb	N/A	60	By-product of drinking water disinfection	Increase
REGULATED DISINFECTANTS							
***Chlorine** (2021)*	N	Range = 0.3 - 0.4 Highest annual average = 0.3	ppm	4	4	Water additive used to control microbes	
UNREGULATED CONTAMINANTS							
***DCPA acid metabolites** (2001)*	N	Range = ND - 3.7 Highest detected = 3.7	ppb	N/A	N/A	Unregulated contaminant monitoring	

Bromide (2022)	N	Range 57.7-116.0	ppb	N/A	N/A	By-product of drinking water disinfection
Bromochloroacetic Acid (2022)	N	Range ND-.436	ppb	N/A	N/A	By-product of drinking water disinfection
Dibromoacetic Acid (2022)	N	Range 0.4-1.94	ppb	N/A	N/A	By-product of drinking water disinfection
Manganese - Entry Point (2022)	N	Range ND-6.1	ppb	N/A	N/A	By-product of drinking water disinfection
Total Organic Carbon - Pre-Treatment (2022)	N	Range ND-1300	ppb	N/A	N/A	Naturally present in the environment

As shown in the table above, the Madison Water Department was not issued violations for any contaminant above maximum levels, except one positive result for Coliform. While there is currently no federal regulation for radon levels in drinking water, radon has been detected in the finished water supply in 5 out of 5 samples tested with a sampling range of 2.2 - 3.0 pCi/L. Exposure to air transmitted radon over a long period of time may cause adverse health effects. The Safe Drinking Water Act regulations also allow monitoring *waivers* to reduce or eliminate the monitoring requirements for asbestos, volatile organic chemicals (VOCs) and synthetic organic chemicals. Madison's system received monitoring waivers for asbestos and synthetic organic chemicals.

Volatile Organic Compounds (VOCs)

In 1982, the NJDEP enacted amendments to the Safe Drinking Water Act, referred to as the A-280 Standards, which required public community water systems to monitor for various volatile organic chemicals (VOCs). In 1986 the US Environmental Protection Agency (EPA) amended the federal Safe Drinking Water Act to include MCLs for many VOCs currently being monitored under New Jersey's A-280 program. In the late 1980's VOCs were detected at several of the Borough's wells, and at many other wells in surrounding communities. The Townships of Livingston, East Hanover and Hanover, to name a few, have all provided treatment of their groundwater supplies for the removal of VOCs.

Due to the presence of the VOC contamination, the Borough proceeded with the design and construction of an air stripper facility (Killam, 1993) to treat the most contaminated wells (Wells A and B). The air stripping facility has been in operation since 1995, and has a capacity of approximately 2,100 gallons per minute or 3.0 million gallons per day. Provisions were made to allow Well E to be connected into the air stripping facility in the future, but the connection has not been made since Well E has not shown significant VOC contamination. As indicated previously, Well D has also since been equipped with a "packed tower aeration" treatment method and is now capable of treating 40% of the municipal water demands. The Borough continues to monitor the various sources of ground water supply for VOC's.

Source Water Assessment Program (SWAP)

Each year, the Madison Water Department prepares an Annual Drinking Water Quality Report, which is mailed to all Borough residents and submitted to NJDEP. In accordance with Federal Requirements, NJDEP then consolidates information from such reports from all Community Water Systems throughout New Jersey, and prepares Source Water Assessment Reports and Summaries. The Source Water Assessment Program (SWAP) is administered by the NJDEP's Bureau of Safe Drinking Water, Water Supply Administration.

The SWAP requires that Madison Water Department provide "Susceptibility Ratings" for the seven contaminant categories (and radon) for each source of water (i.e., each well and the purchased water sources) within the system. Table X below lists the ratings from the 2011 and 2022 Annual Water Quality Report and shows the number of wells and intakes rated as high (H), medium (M), or low (L) for each contaminant category. The susceptibility rating does not tell you if the water source is actually contaminated; instead, the rating reflects the *potential* for contamination of source water. The Susceptibility Ratings for 2022 were identical to ratings for 2011.

As required by the federal Safe Drinking Water Act, the Consumer Confidence Report issued annually by a water utility contains information on the results of drinking water quality tests. Public water systems are required to install treatment systems if any contaminants are detected at frequencies and concentrations above allowable levels. As a result of the assessments, DEP may customize (change existing) monitoring schedules based on the susceptibility ratings. At present, the Madison Water Department is required to monitor water contaminants on an annual basis, and water quality reports, including the Susceptibility Ratings shown below, is sent to every Madison resident annually.

Susceptibility Ratings for Madison Water Department Sources (2011, 2022)

	Pathogens			Nutrients			Pesticides			Volatile Organic Compounds			Inorganics			Radio-nuclides			Radon			Disinfection Byproduct Precursors		
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 - 5		2	3	5					5	4		1	2	3		3	2		5			2	3	
GUDI - 0																								
Surface water intakes - 0																								

According to the Water Quality Annual Report, all five wells are considered "highly" susceptible to nutrients and radon; four wells are highly susceptible to VOCs and three wells are highly susceptible to Inorganics. However, the Borough's finished water supply (treated) which is distributed as drinking water is of very high quality and currently meets the NJDEP standards as a public drinking water supply. The existing wells provide a reliable, high-quality source of water supply to the Borough. Generally speaking, the water in Madison is non-corrosive, hard and of good quality.

WASTEWATER DISPOSAL AND TREATMENT

The Madison-Chatham Joint Meeting treatment plant serves the 24,000 residents of the Boroughs of Madison and Chatham, and a small portion of Chatham Township. All of Madison's wastewater is collected and treated by the Madison-Chatham Joint Meeting. The Madison Chatham Joint Meeting was established as a small primary treatment plant in 1910 and has expanded and upgraded several times over the years (Major upgrades in 1929, 1969, 1990, and 2010). According to Christopher Manak, the Superintendent of the Madison-Chatham Joint Meeting, the plant is now an advanced treatment plant with a design capacity of 3.5 million gallons per day (MGD) with an average daily flow of 3.0 MGD.

The wastewater treatment plant works in multiple stages. In the first two (Primary and Secondary) stages, the solid and liquid wastes are separated, bacteria neutralize the impurities in the solids, and the waters are given initial aeration. In the tertiary treatment, the Molitar Water Pollution Control Facility utilizes a

three-acre stabilization pond, where additional oxygen is introduced to purify the effluent. The stages of treatment include:

1. *Screening*. A simple process that removes large materials such as wood, rocks and other items.

0. *Pumping*. Our treatment plant is located on low ground, so much of the wastewater travels via gravity to the plant. Once in the plant and depending on the topography, most treatment plants have pumps to move the wastewater from one treatment area to another.

0. *Aerating*. Bubbling oxygen through the sewage helps release some of the dissolved gases from the water into the air. It also helps larger 'grit' such as sand, coffee grounds, etc to settle out.
0. *Sedimentation*. Sludge settles out of the wastewater and is pumped out of the sedimentation tank and then processed in a large 'digester' tank.

0. *Removing scum*. As the sludge settles to the bottom, lighter items such as grease, oils, plastics and soap float to the top. Slow-moving rakes skim the material off the surface. Thickened scum is pumped into the digesters with the sludge.

0. *Final treatment and discharge*. Finally, the wastewater is treated, often with filtration and/or chlorine to remove bacteria, odors and other items. The water is now clean and discharged into a local river.

The Joint Meeting was required by NJDEP to upgrade the plant to Level 4 effluent water quality. In 1990, the treatment plant received $16.2 million in improvements, funded by low interest loans to the Boroughs by the New Jersey Wastewater Trust Program. The new plant additions would improve the effluent by remove ammonia levels from 30 milligrams per liter to less than 2 milligrams per liter and by dechlorinating the effluent to less than 0.1 milligram per liter of chlorine. The expanded facility removes 955 of the conventional impurities in the water prior to discharging the clear effluent (treated wastewater) into the Passaic River. The new sludge handling facilities thicken the activated sludge prior to conveyance to the digesters and dewater the digested sludge prior to disposal in the landfill.

In addition to treating the wastewater, the Joint Meeting sewage plant also processes the residual solid-waste material. These solids are placed in a 'digester' or large holding tank for many days. This tank acts like a stomach and using bacteria digests the solid material in a process known as anaerobic digestion. Digesting the material reduces the volume and odor and produces Methane Gas. The sewage treatment plant uses 'duel fuel' diesel engines, which run on both natural gas and methane gas that is recaptured in the plant's digester. The finished solid material is then sent to a landfill.

On May 17, 2010, the Boroughs commemorated the 100th anniversary of the joint sewage treatment plant and broke ground on a $3 million improvement project to restore and upgrade the system, funded in part by federal stimulus money. The upgrades enabled the facility to produce a portion of its own energy in the form of methane gas.

SURFACE WATER

Present-day Madison has very little visible surface water (See **Map 7**). There are five ponds: Long Pond and Round Pond are located in the Drew University Arboretum, and unnamed ponds are located on Dellwood

Parkway West, on Ridgedale Avenue across from Madison High School and between Brittin Street and Grove Street. These ponds are probably glacial in origin since they have no inlets or outlets.

There are two streams still visible within the Borough, into which empty many storm sewers and drainage ditches.

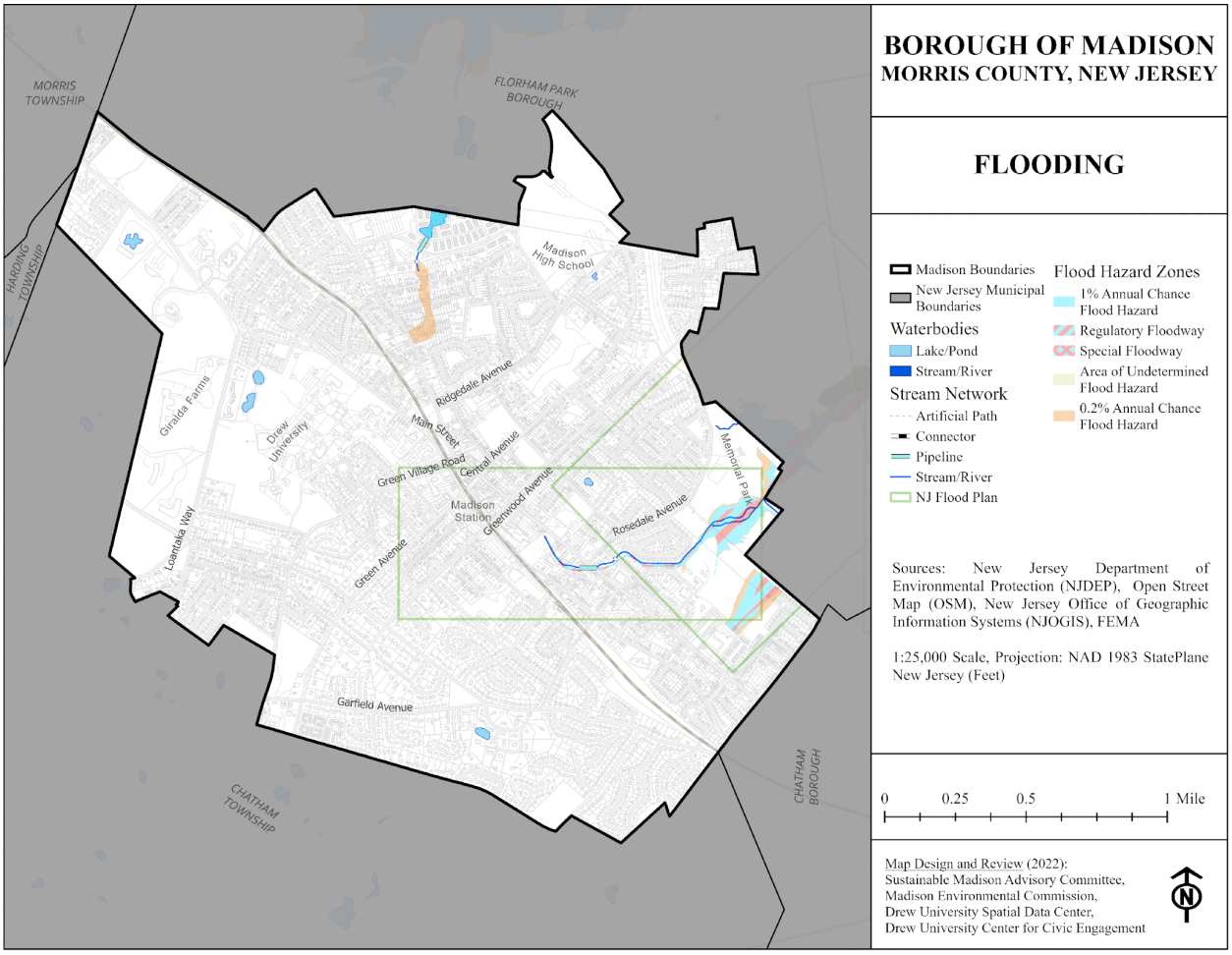
- Spring Garden Brook and its tributaries are considered Freshwater Category 2, Non-Trout producing, or **FW2-NT**.

- Black Brook (the segment within the Great Swamp National Wildlife Refuge) is also a Freshwater Category 2 Non-Trout producing stream, but is also a Category 1 waterway: **FW2-NT(C1)**. A C1 waterway is "A waterbody that is attaining all designated uses and no uses are threatened."

Black brook flows north from Anthony Drive, through the Black Meadows until it reaches the Whippany River. Spring Garden Brook flows east along Main Street and through the cemetery. During heavy storms it collects a large amount of runoff and is prone to flooding. Areas experiencing flood potential in and around Madison, as verified by FEMA's National Flood Hazard Area data, are shown on the Flooding Map (**Map 13**). Near Rosedale Avenue, the stream turns toward the northeast and flows through Memorial Park and the Brooklake Country Club golf course until it reaches the Passaic River near Brooklake Road in Florham Park. One tributary of Spring Garden Brook appears in front of the library, another originates west of Rosedale in the Knollwood section and flows eastward through a culvert into Memorial Park. There the tributary becomes an open stream and joins Spring Garden Brook.

On New Jersey's Integrated List of Waters, the Black Brook Great Swamp NWF (National Wildlife Refuge segment) received "non-attainment" status for several pollutant categories. The 303(d) List of Impaired Waters for 2020 indicated the Black Brook Great Swamp NWF had a "low" ranking for Arsenic Phosphorous.[20]

[20] US EPA. 2022. New Jersey Impaired Waters List. Available online: https://www.epa.gov/system/files/documents/2022-01/nj-2020-303d-list.pdf.



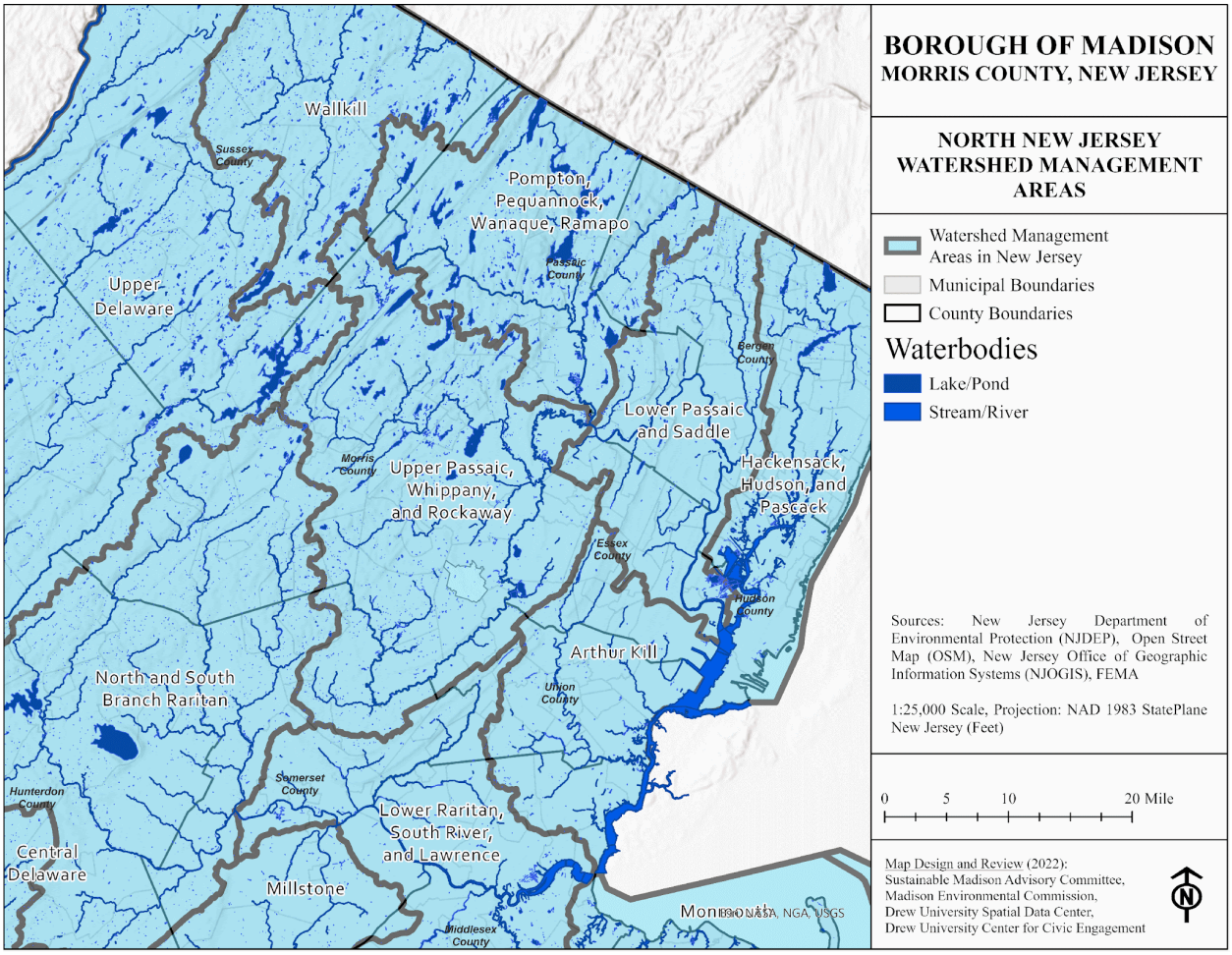
Map 13. FEMA Flood Hazard Zones and New Jersey Flood Plan Regions in Madison Borough

WATERSHEDS & SUB-WATERSHEDS

All of Madison is within the Upper Passaic Watershed Management Area (Watershed Management Area Number 6 as designated by the NJDEP and shown in Map 14). A watershed encompasses all the land that drains to a particular waterbody, and is a natural boundary. The Upper Passaic Watershed Management Area is one of 20 watershed management areas in New Jersey.

The Upper Passaic Watershed Management Area, also known as WMA6, includes the Rockaway, Whippany and upper Passaic Rivers above the confluence with the Pompton River. WMA6 is approximately 416 square miles and is about 30 miles long and 20 miles wide at the widest points. Madison is located in both Whippany and the Upper Passaic River Watersheds. 96 percent of the total water withdrawals in WMA6 are for potable water, where commercial, industrial and agricultural uses only comprise 4 percent of withdrawals. From 1990-2015, annual consumptive use peaked in 1993.[21]

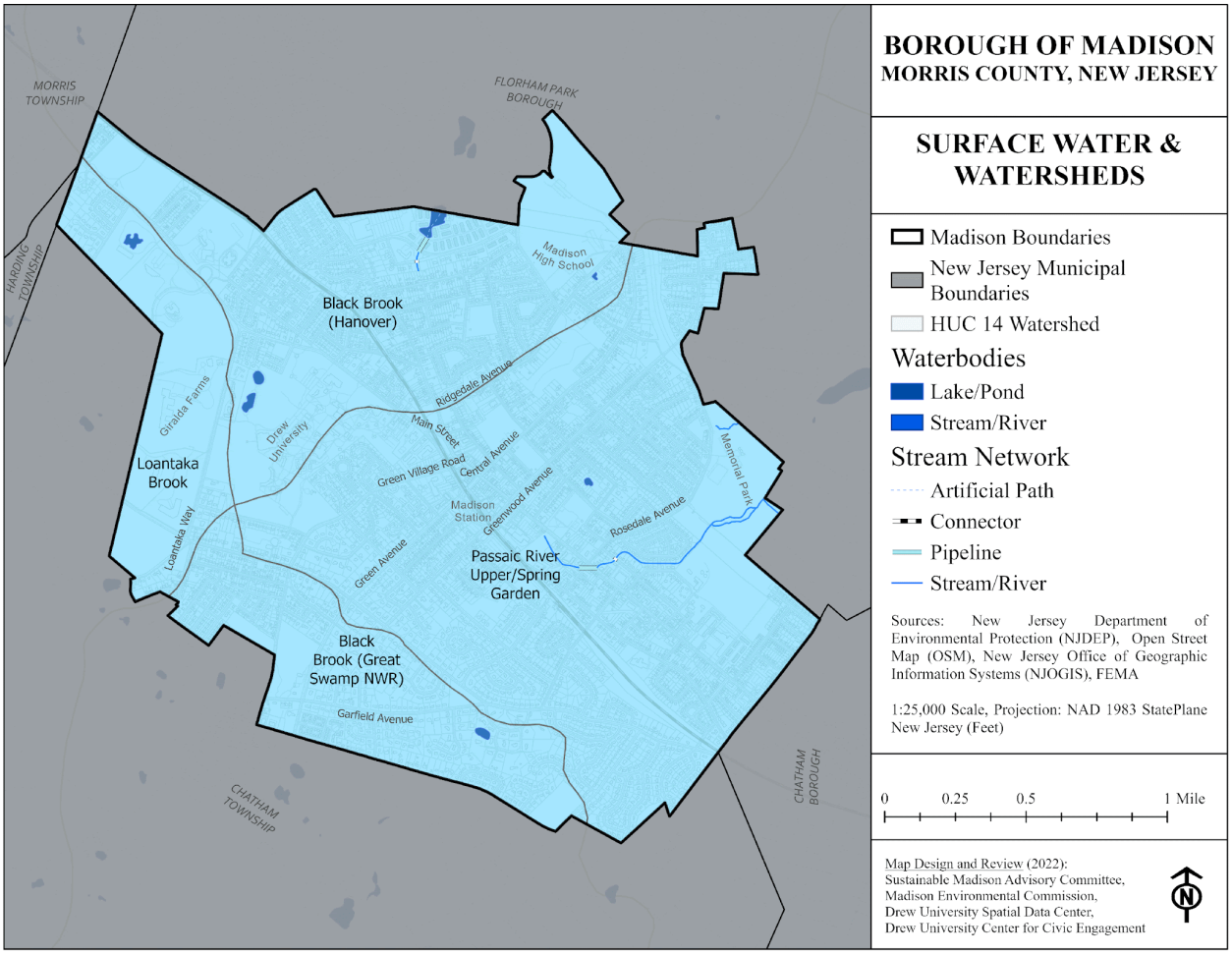
[21] New Jersey Department of Environmental Protection. New Jersey Water Supply Plan, 2017-2022. Appendix A: Characterization of Confined and Unconfined Groundwater and Surface Water Supplies. Available online: https://www.state.nj.us/dep/watersupply/wsp.html



Map 14. Water Management Areas of North New Jersey

Within Madison there are four subwatersheds. The runoff and drainage characteristics are significantly different for each of the four areas. The area boundaries or “divides” are shown in **Map 15**. The subwatersheds include the Whippany Black Brook Subwatershed, which is part of the

Whippany Watershed; the Loantaka Brook (Great Swamp) Subwatershed, which is part of the Upper Passaic Watershed; the Black Brook (Great Swamp) Subwatershed, which is part of the Upper Passaic Watershed; and the Spring Garden Brook Subwatershed, which is part of the Upper Passaic Watershed. The Loantaka Brook Subwatershed to the southwest includes 0.5 square miles in Madison and the Great Swamp Black Brook sub-watershed to the southeast includes 0.6 square miles in Madison. Both the Loantaka Brook and Black Brook (Great Swamp) enter and flow westward through the Great Swamp National Wildlife Refuge to reach the Upper Passaic River north of the Millington Gorge. The Spring Garden Brook Subwatershed area encompasses a 2.2 square milearea in the central and eastern part of Madison. This sub-watershed contains the greatest amount of impervious surface in the borough and produces the most runoff. This subwatershed drains into the Upper Passaic River near Brooklake Road in Florham Park. One square mile in the northern part of the Borough drains into small streams that flow through the Black Meadows to the Whippany River near Route 10 in East Hanover.



Map 15. Madison Sub-watersheds and Surface Water

WATERSHED MANAGEMENT TO PROTECT SURFACE WATER AND GROUNDWATER

Groundwater and surface water can be affected by both point and non-point sources of pollution. Point sources have been designated in the Clean Water Act as pollution that can be clearly identified as a discharge form a pipe, ditch or other well-defined sources. Non-point source pollution means any pollution that does not originate from a point source.

In the past, the focus had been on the effects of point sources on both ground and surface waters. Many of the point sources have been identified and permitted through New Jersey's Pollution Discharge Elimination System (NJPDES) permit process. The NJPDES permit process sets limits on what the point sources can discharge and how much. To meet the strict discharge limits of the early 1990's, point source polluters were required to upgrade their treatment processes to include state of the art treatment technologies. This had a positive effect on surface waters statewide. However, additional point source issues as well as non-point source issues still needed to be addressed. NJDEP manages point and non-point source pollutions through a process known as Watershed Management.

Watershed management is a process of protecting the lakes, streams, and wetlands in a watershed from point and nonpoint source pollution. Watershed management consists of many diverse activities including controlling point and nonpoint source pollution, monitoring water quality, adopting ordinances and policies,

educating stakeholders, and controlling growth and development in a watershed. This approach enables watershed communities to holistically address water pollution and supply issues so that comprehensive strategies can be implemented by government, the private sector and citizens. Through the creation of a comprehensive *Watershed Management Plan*, communities and citizens within the watershed develop goals, principles and implementing strategies to protect and enhance the ecological condition of a watershed. A Plan will holistically encompass topics as diverse as-- water quality, water quantity, stormwater management, wastewater management and disposal, stream buffers and stabilization, open space planning, and education. A plan should include action steps to prevent, reduce, or minimize activities within a watershed that may negatively impact water quality.

Stormwater runoff pollution is a concern in watershed management because it acts as a source of contamination to both surface and ground water. This source of pollution must be evaluated and addressed if we are to achieve regional water quality goals. Both the EPA and NJDEP have stressed the importance of controlling non-point source pollution. EPA expects municipalities to adopt narrative effluent limitations that require dischargers to use best management practices (BMPs). The EPA is also looking for municipalities to adopt certain minimum control measures. These measures include public education and outreach on storm water impacts, public involvement and participation, detection and elimination of illicit storm water discharges, regulation of storm water flows from construction sites of one acre or more, continued management of real estate development or redevelopment after the construction phase and pollution prevention for municipal operations.

NON-POINT POLLUTION

Non-point source water pollution is contamination that occurs when rainwater or snowmelt washes off plowed fields, city streets, or suburban backyards. As this runoff moves across the land surface, it picks up soil particles and pollutants such as nutrients, pesticides and fecal matter. Some of the polluted runoff may infiltrate into the soil and contaminate groundwater. The remaining runoff deposits soil and pollutants into rivers, lakes, wetlands, and coastal waters. Non-point source pollution may originate from numerous small sources that are widespread, dispersed and hard to pinpoint, control or prevent. Non-point source pollution comes from a wide variety of sources and includes a diverse set of pollutants. Sources of non-point pollution include:

- Malfunctioning septic systems
- Soil erosion from construction sites or farms
- Discharges of sewage and garbage from boats
- Cleaners, paint and antifouling compounds used on boats
- Hazardous household wastes improperly stored or discarded
- Acid rain and atmospheric deposition
- Pollution from road deicing activities
- Disposal of wastes in catch basins or storm drains
- Leaking sewer lines
- Pesticides and fertilizers misused on lawns and gardens
- Motor oil and grease dripping from cars and trucks
- Animal waste from wildlife, pets and livestock
- Litter carelessly tossed aside

Non-point source discharges to surface waters may contribute to a rather complex network of biological, chemical and physical interactions. These discharges may contain biodegradable organic material that could

deplete the dissolved oxygen in surface water. Dissolved oxygen is an important water quality parameter and its abundance enriches and usually coincides with the diversity in an aquatic ecosystem. Aquatic microbial ecosystem will utilize these organic compounds as an energy source and during this process will consume dissolved oxygen. Ammonia and nitrogen containing organic compounds also have a similar effect on surface waters. The microbes present in a stream will utilize these nitrogen-containing compounds as an energy source, using oxygen in the process. Biodegradable organic and nitrogenous compounds present in water (surface water, wastewater or stormwater) are measured as biochemical oxygen demand (BOD) and sediment oxygen demand (SOD).

Nitrogen and phosphorus may also stimulate algae growth. This may lead to a condition commonly known as eutrophication, which could increase the rate of sedimentation in a surface water system thereby affecting drainage and geomorphology. Excessive algae growth will also affect daily dissolved oxygen variability, through photosynthesis and plant respiration, causing dissolved oxygen to increase during daytime and decrease at night.

Toxic compounds (i.e. heavy metals, pesticides, carcinogens, mutagens, teratogens), pathogenic microbes, acids, bases, petroleum compounds, salts and sediments may also be present in non-point sources which could impact on the receiving waters use and ecosystem. Receiving water temperature may also be affected by these sources.

Stormwater runoff from residential areas has been found to contain contaminants such as nitrogen, phosphorous, fecal coliform, petroleum hydrocarbons, salts, metals and pesticides. These contaminants enter into and affect both surface water and groundwater. Most of these contaminants originate from the overuse and improper application of fertilizers and pesticides on residential lawns, improperly operated and maintained septic systems, and improper practices dealing with the disposal of waste.

BEST MANAGEMENT PRACTICE (BMP) SELECTION

The selection and implementation of a best management practice (BMP), whether structural or non-structural, to address a watershed concern should meet the goals and objectives of the watershed management plan. The process of BMP screening and selection generally consists of the following four steps:

1. Determine existing conditions: Analyze existing watershed and water resource data and collect data to fill gaps in existing knowledge.
2. Quantify pollution sources and effects: Utilize assessment tools and models to determine source flows and contaminant loads, extent of impacts and level of control needed.
3. Assess alternatives: Determine the optimum mix of prevention and treatment practices to address the problems of concern.
4. Develop and implement the recommended action: Define the selected system of prevention and treatment practices to address the pollution problems of concern and developing a plan for implementing those practices

Below are examples of Non-structural and Structural BMPs.

Non-Structural BMPs

1. Planning and Land Use

a) Comprehensive Plan
b) Open Space Plan
c) Zoning Plans
d) Riparian Corridor Protection
e) Environmental Resource Inventory
f) Site plan/subdivision – Site plan approval
g) Open space preservation
h) Development and Redevelopment

0. Source Controls
    a) Minimum disturbance (soil loss; sequence of construction/phase development)
    b) Alternative landscaping
    c) Fertilizer management for urban/suburban landscaping
    d) Pesticide management for urban/suburban areas (IPM)
    e) Roadway de-icing/salt reduction
    f) Street sweeping (wet and vac)
    g) Stormwater facility maintenance
    h) Pet waste maintenance
    i) Geese/wildlife control
    j) Septic system maintenance
    k) Eliminate illegal connections to storm drain / sanitary sewerage systems
    l) Management of yard waste

Structural BMP's

1. Detention Facilities
    a) Extended Detention Dry Pond
    b) Wet Pond
    c) Extended Detention Wet Pond
    d) Constructed Wetlands

2. Infiltration Facilities
    a) Dry Wells for residential areas
    b) Infiltration trench
    c) Pervious parking areas

3. Vegetative Practices
    a) Vegetative filter strips
    b) Grass swales
    c) Riparian Forest Buffers with native vegetation species
    d) Reforestation
    e) Alternative landscaping – turf conversion

4. Filtration practices
    a) Sand filters
    b) Bioretention

5. Catch basins with water quality treatment

a) Water Quality inlet
b) Stormseptor
c) Storm-treat
d) Oil/grease separator

The following is a list of items to consider when selecting the appropriate structural BMP:

- Groundwater Quality
- Groundwater Quantity
- Base flow to streams
- Stream bank erosion
- Soil permeability
- Depth to groundwater
- Depth to bedrock
- Area of drainage
- Land use, density
- Area available for BMPs
- Pollutants of concern
- Areas which may be impacted
- Flooding concerns
- Pre-development/post-development
- Maintenance requirements
- Steep slopes (> 20%)
- Aquatic habitat creation
- Wildlife habitat creation
- Landscape enhancement
- Recreation benefit
- Community acceptance
- Maximum depth
- Restricted land use
- High sediment input
- Thermal impact to receiving waters

The following watershed management organizations coordinate watershed management activities. Members typically include elected officials, residents, farmers, business owners and interested parties.

- Passaic River Coalition
- Whippany River Watershed Action Committee, and
- Great Swamp Watershed Association

RESOURCES

- Phase 2 Stormwater Management Plan for the Borough of Madison, May 2005.
- Elson T. Killam Associates, Inc., 1988, Water Quality Improvement Report, Borough of Madison, County of Morris, New Jersey.
- Killam Associates, 1993, Basis of Design Report - VOC Removal Facility for Wells A, B, and E, Borough of Madison, County of Morris, New Jersey.
- Killam Associates, 1998, Water Improvements Phase II Program, Basis of Design Report, Borough of Madison, County of Morris, New Jersey.
- Killam Associates, 1999, Treatability Study and Basis of Design Report for Wells C & D, Borough of Madison, County of Morris, New Jersey.
- Meisler, Harold, 1976, Computer Simulation Model of the Pleistocene Valley Fill Aquifer in Southwestern Essex and Southeastern Morris Counties, New Jersey, U.S. Geological Survey Water Resources Investigations.
- Passaic River Coalition, 1993, Groundwater in the Passaic River Basin, Passaic River Coalition, Basking Ridge, New Jersey.
- New Jersey Department of Environmental Protection, 1988, The Clean Water Book, NJDEP, Trenton, New Jersey.

- New Jersey Department of Environmental Protection, 1995, Whippany River Characterization Report, NJDEP, Trenton, New Jersey.
- New Jersey Department of Environmental Protection, 1998, Watershed Characterization and Assessment of the Upper Passaic, Whippany and Rockaway Watersheds, Watershed Management Area 6, NJDEP, Trenton, New Jersey.
- New Jersey Department of Environmental Protection, 2000, A Cleaner Whippany River Watershed, Nonpoint Source Pollution Control Guidance Manual for Municipal Officials, Engineers and Departments of Public Works, NJDEP, Trenton, New Jersey.
- Tucker, Robert K., 1981, Groundwater Quality in New Jersey, An Investigation of Toxic Contaminants, NJDEP, Trenton, New Jersey.

VI. AIR QUALITY

Why should people be concerned with air pollution? The answer is simple: because the impacts occur in real time. Pollutants that are released into the air can have an immediate impact on people, whereas pollutants released into water or soils may not impact people for days, weeks, months or even years.

Air is composed on roughly 78.1% nitrogen, 20.9% oxygen, 0.9% argon and 0.1% of other components. Any substance that is found in the air that is not part of its natural composition or any substance whose concentration is higher than the concentration found in the air's natural composition is considered an "air pollutant." Clean air is found in few, if any places on earth.

Air pollutants may be released in the form of either gases (most of which are colorless), or particulates (i.e., dust particles), or they can be formed in the atmosphere via chemical reactions (e.g., smog). In general, air pollution is a concern because it can degrade health, harm the environment, and cause property damage. Air pollution scientists and engineers evaluate air pollutants in terms of whether they exhibit nuisance impacts, e.g., objectionable odors or discoloration of buildings or statues, impacts on plants or animals, or short term or long-term impacts on human health. In general, human health impacts can include chemical sensitization, short term respiratory, dermal or digestive symptoms, long term exposure-type diseases or teratogenic (malformation) or mutagenic (genetic) effects. Exposure type diseases can include respiratory diseases such as emphysema, or different types of cancers. Most diseases are only contracted when there is a continual, long term exposure to higher concentrations of industrial type chemicals.

AIR QUALITY HISTORY

The presence of man-made air pollution in America is a condition that has existed for hundreds of years. The Los Angeles area smog is not a new phenomenon but was actually witnessed by the Chumash Native people hundreds of years ago as the result of their fires and the uniqueness of the Southern California topography. With the dawn of the industrial revolution in the late 18th and early 19th centuries came the beginnings of our current air quality problems. As we manufacture and consume more goods and travel more, the amount of pollutants that we dump into our air also increases. Air pollution impacts can also be exacerbated by certain meteorological conditions, such as a temperature inversion. Thermal inversions, which usually occur in valleys, are situations in which cooler air remains trapped and stagnant beneath a layer of warmer air, thus reducing the effective volume of air in which pollutants can be diluted.

The seriousness of the air pollution issue became evident through a series of incidents in the last century. In 1948 in Donora, Pennsylvania a thermal inversion caused 6,000 of the town's population (i.e., 43%) to become

ill and 20 people died due to exposure to sulfur dioxide and particulate matter. In 1952 in London the British Isles were covered by fog and a temperature inversion from December 5 through the 9th. This accounted for between 3,000 and 4,000 excess deaths, attributable to respiratory tract irritation. Then, in 1984, in an air pollution accident at the Union Carbide chemical plant in Bhopal, India thirty tons of the poisonous gas methylisocyanate escaped through a broken valve. Although there were no adverse meteorological conditions at the time, the resulting air pollution injured about 20,000 people and caused more than 2,000 fatalities.

The first air pollution regulations in the state, which required certain manufacturing and power generation facilities to register equipment that emitted air pollutants, were initiated in 1968. Then, in 1970, with the inception of the United States Environmental Protection Agency (USEPA), the federal Clean Air Act (CAA) was passed. This act was greatly expanded and clarified in 1977, and substantially expanded in 1990 with the adoption of the detailed, voluminous Clean Air Act Amendments (CAAA). To conform to the requirements of the CAA and CAAA, every state in the union has been required to develop a State Implementation Plan (SIP), which is actually a detailed program outlining how a state will come into compliance with all the USEPA air pollution criteria. Since 1968, the New Jersey Department of Environmental Protection (NJDEP) has greatly expanded the state's air pollution permitting, emission control, emissions estimation and emission proving requirements. In most instances they have executed the requirements of the CAA, but in many cases the NJDEP has developed more stringent requirements than the USEPA. Since 2001 through 2010 the NJDEP has continued to expand enforcement of these acts through stricter regulation.

Most regulations focus on continuous, routine emissions from facilities. However, as a result of the 1984 Bhopal disaster, the NJDEP developed regulations called Toxic Catastrophe Prevention Act (TCPA) to govern accidental releases. With adoption of the CAAA in 1990, accidental release permitting requirements were greatly expanded under the CAAA's Air Toxics, Title III Section 112r. Section 112r requires certain facilities to develop risk management plans and to predict the potential impact and risk of catastrophic chemical releases, irrespective of the miniscule probability of every occurring.

AIR POLLUTANT SPECIES

Since there are numerous different types of air pollutants, there are many different methods to identify and categorize these pollutants. One method is to divide pollutants according to the following categories.

- Criteria Pollutants
- Hazardous Air Pollutants
- Greenhouse Gases

Criteria pollutants were the original chemical species focus of the CAA. The USEPA developed ground level ambient (outdoor) air quality limits for these criteria pollutants and named these limits National Ambient Air Quality Standards (NAAQS). The list of criteria pollutants includes the following chemical species: ozone (0_3), carbon monoxide (CO), sulfur dioxide (SO_2) and PM_{10} (i.e., microscopic dust defined as particulate matter less than 10 microns in size). New Jersey also has limits on total suspended particulates (TSP). Areas in which air quality concentrations are below the NAAQS limits are called "attainment areas", whereas areas where the ambient air levels exceed the NAAQS are called "non-attainment areas". Because ozone is formed in the atmosphere via the chemical reaction of nitrous oxides (NO_x), and volatile organic compounds (VOCs – previously referred to as hydrocarbons) in sunlight, CAA regulations include requirements to control NO_x and VOC emissions.

The major sources of $NO_{x,}$ VOCs and CO emissions are combustion devices, i.e., power plant boilers, manufacturing facility process heaters, home and office heating systems and vehicles. Coal and oil-fired power

plants emit significantly greater quantities of pollutants than natural gas fired power plants. VOCs are also emitted from solvent and oil storage tanks, automobile painting operations, manufacturing processes, dry cleaners, restaurants, etc. Other sources of VOC emissions include everyday products such as gasoline, cleaning solvents, paints and consumer products.

Ozone

Ozone is needed in the stratosphere (i.e., the second of the five layers covering our planet) to shield the earth from potentially harmful ultraviolet radiation from the sun. At ground level (in the troposphere) where humans breath, ozone is a respiratory impactor. Ozone has also been shown to cause degradation of foliage. Morris County has been designated as a "non attainment area" for ozone, with a classification of "moderate."[22] As such, the State Implementation Plan contains numerous programs and regulations to control and reduce VOC and NO_x emissions. There are numerous requirements in State for controlling these emissions. For example, there are requirements for industrial heaters and power plant boilers to install special combustion burners, and for vehicles to remain tuned up and to limit emissions.

One problem with achieving the NAAQS levels for ozone, however, is that a significant portion of the ozone-causing NO_x and VOC emissions that affect New Jersey and other Eastern states air quality comes from long range atmospheric transport of pollutants emitted predominantly from power plants in West Pennsylvania, West Virginia and Ohio. Since ozone is a regional problem, under the 1990 Clean Air Act Amendments the USEPA identified the "Ozone Transport Region (OTR)" and established the "Ozone Transport Commission (OTC)" to evaluate and combat ozone on a regional basis. The OTC is comprised of all the New England and Mid-Atlantic States, Maryland, Pennsylvania and northern Virginia.

Air pollutants measured in New Jersey are produced internally, but also come from upwind states. New Jersey joined other upwind states – New York, Connecticut, Delaware, Massachusetts, and the City of New York - in a lawsuit against the USEPA, which reached a settlement on July 19, 2021. Under the settlement, the EPA must review State Implementation Plans for Indiana, Kentucky, Michigan, Ohio, Texas and West Virginia by April 30, 2022.[23]

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[22] US EPA. 2022. New Jersey Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants. July 31. Available online: https://www3.epa.gov/airquality/greenbook/anayo_nj.html

[23] State of New Jersey. Office of the Attorney General. 2021. "Acting AG Bruck Announces Settlement with EPA to Protect New Jersey from Air Pollution from Upwind States." Press Release. July 29. Available online: https://www.njoag.gov/acting-ag-bruck-announces-settlement-with-epa-to-protect-new-jersey-from-air-pollution-from-upwind-states/

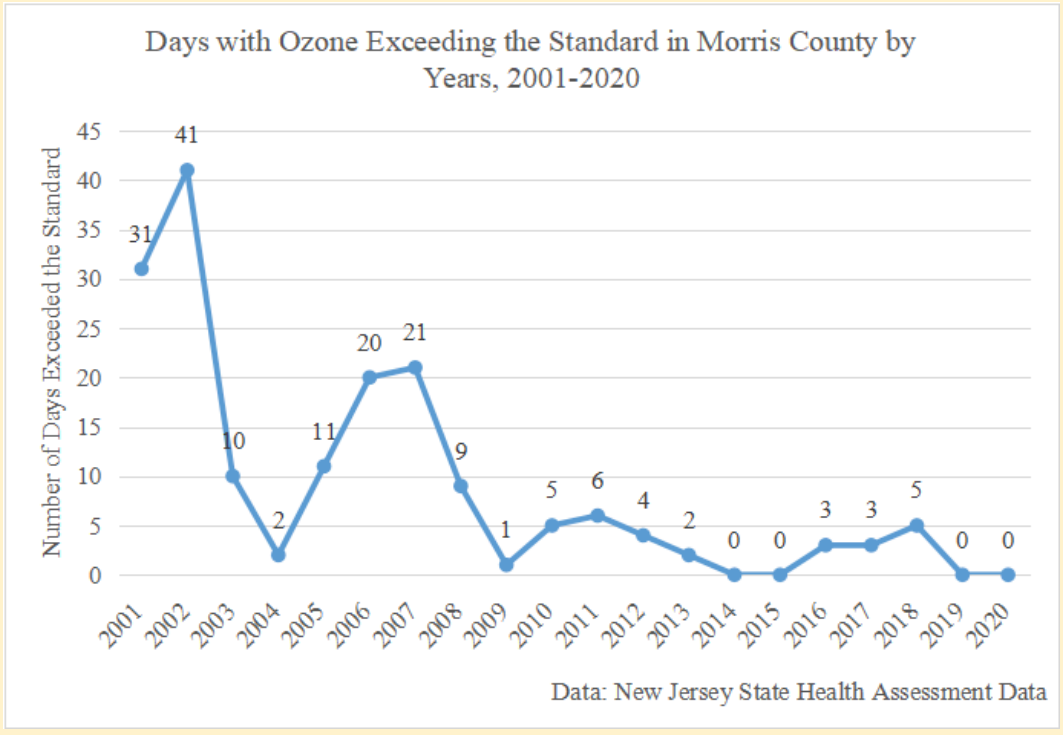


Figure X. Days Exceeding Ozone Standard in Morris County, 2001-2020

A 2022 State of the Air Report Card, by the American Lung Association, shows that all of Morris County had a "High Ozone Days" grade of C with 5 Orange days and 0 Red days.[24] This was a decline from the 2010 report, which gave Morris County an F, with 52 Orange and 4 Red Ozone days. The EPA calculates design values, which are the annual fourth-highest daily maximum 8-hour ozone concentrations averaged over three years. The 2021 value for the New York-Northern New Jersey-Long Island 0.08ppm, which exceeded the national standard for ground-level ozone of 0.07ppm. It is worth noting that two of the close air quality sites, in Chester and Newark, had 2021 design values that met the national standard: 0.062 ppm and 0.065 ppm respectively.[25]

Sulfur Dioxide

Sulfur dioxide is produced mainly as the product of burning of sulfur-containing solid or liquid fuels such as coal, fuel oil (for manufacturing, power generation and home heating) and diesel fuel. Sulfur is also emitted from municipal sewer plants since it is dispelled from the human anatomy. Sulfur dioxide in the air eventually reacts to form sulfuric acid, which is the main contributor to acid rain. (NO_x is also an acid rain contributor, but to a lesser extent). Acid rain has caused many lakes in America to become acidic and die and many forests to defoliate. The preponderance of acid rain impacts may be widespread, but are more visible in those areas where there are coal fired power plants that burn higher sulfur coals.

The US EPA design value for sulfur dioxide is the 99th percentile of the annual distribution of daily maximum 1-hour averages, averaged over three years. To meet national standards, the values cannot exceed 75 parts

[24] American Lung Association. 2022. State of the Air Report Card. Available online: https://www.lung.org/research/sota/city-rankings/states/new-jersey
[25] US EPA. Design Values 2021. Available online: https://www.lung.org/research/sota/city-rankings/states/new-jersey

per billion (ppb). The design values for the Newark Air Quality Site fell from 17 in 2012 to 2 in 2021. All of these values were well below the national standard.

Particulate Emissions

For a long time, particulate emissions have been under scrutiny for their part in impacting public health. Particulate emissions may be solid matter (dust) or liquid droplets suspended in the air. These particles float in the air and settle very slowly, with the smallest particles remaining suspended indefinitely. The degree of health damage that particulate matter does depends upon the type of particles inhaled, the number of particles inhaled, the size of the inhaled particles, and the general health of the person who has inhaled them. In general, sustained exposure to particulates can cause respiratory ailments and worsen the effects of cardiovascular disease. The smaller the particles the deeper into the lungs they penetrate. Recent studies have also started to link particulates to cancer. In addition to impacts on human health, particulates can affect visibility (of great concern in state and National forests and parks) and precipitation patterns.

Primary sources of particulates include diesel engines, power plants (especially ones that burn coal and heavy fuel oils), wood stoves, construction activities, windblown dust sources, manufacturing plants, etc. The nearest station that has up to date reporting of Particulate Emissions is Jersey City. Their chart shows them well below the National Standard. The American Lung Association gives Morris County an "A" for Particle Pollution with zero "Orange Particle Days," up from the B received in 2010.

PM2.5 design values measure the annual arithmetic mean concentrations averaged over three years. For Newark, the design values fell from 9.5 micrograms per cubic meter in 2012 to 8.6 in 2021. The 24-hour design values for PM2.5 measure the 98th percentile concentrations, averaged over 3 years. In 2021, the values for the Newark site were 21 micrograms per cubic meter, below the national air quality standards of 35.

Carbon Monoxide

Carbon monoxide (CO) is an odorless gas produced by incomplete burning of fossil fuels, wood or other carbon-containing materials. Sources include utility, industrial and residential boilers, motor vehicles and kerosene or wood-burning stoves. Short term exposure to CO results in fatigue, and can also worsen existing heart and lung disease. Parts of New Jersey, including Essex and Union Counties, have been designated non-attainment areas for CO. Since the last ERI report in 2011, most of Morris County now qualifies as an attainment area. There are two designation values for Carbon Monoxide: 1-hour and 8-hour. The 1-hour design value requires that the site not exceed 35ppm measured over 1 hour more than once per year. The Newark site design values ranged from 3.5 ppm in 2012 to 3.0 ppm in 2021. The 8-hour standard requires not exceeding 9 ppm, measured over 8 hours, more than once per year. The Newark site design values ranged from 2.8 ppm in 2012 to 2.1 ppm in 2021.

Greenhouse Gases

Scientists warn that the buildup in the atmosphere of certain gases that tend to trap in heat towards the earth's surface is resulting in the greenhouse effect, causing global climate disruption, rising land and sea surface temperatures, polar ice cap melting and coastal flooding. Greenhouse gases (GHGs) include carbon dioxide (CO_2), methane (CH_4), and NO_x. Climate change brought on by air pollution could drastically affect all life on earth.

CO_2 is a difficult pollutant to control since it is the primary product of fossil fuel combustion. NO_x is also a product of fossil fuel-fired operations, but it is produced at much lower levels, equal to only a small fraction of the quantity of CO_2 produced. To appreciably reduce $C0_2$ emissions requires a significant revamping of the U.S. energy policy, changes in air quality regulations and a reevaluation of fuel burning technologies. Fuel conservation programs and technologies, and alternative fuels programs are some of the approaches for reducing CO_2.

Methane is a product of biological activities and it is also released in small quantities from fossil fuel combustion. Landfills (garbage dumps) and livestock emissions are significant sources of worldwide methane production.

Hazardous Air Pollutants

As a result of the CAA of 1977, the USEPA began regulating certain hazardous air pollutants. The initial list of hazardous air pollutants was small, with only eight substances. Included in this list were lead, emitted primarily from automobile exhaust pipes, vinyl chloride, a component of PVC production, and benzene, a ubiquitous VOC emitted from gasoline storage tanks, automobiles, fuel tank spill remediations and manufacturing plants. Emission control requirements were pretty strict for these compounds. Then, in the CAAA of 1990 the list of HAPs were expanded so that there are now 187 individual compounds or groups on the list. Under the CAAA requirements manufacturing plants are initially required to install air pollution control devices that employ maximum achievable control technology (MACT) equipment). Eight years after installing MACT equipment, manufacturers must still review their emissions relative to “residual risk” to the population to determine whether additional controls are required.

EMISSIONS QUANTIFICATION & CONTROL

For New Jersey to demonstrate progress towards achieving NAAQS levels and compliance with the SIP programs, larger manufacturing facilities must provide the state with an annual inventory of actual emissions called an “Emission Statement.” These emission levels are compiled, and compared to the allowable potential emissions so that the state is able to modify existing programs or develop new emission reduction programs, if warranted.

In most air pollution regulations emission limits are stated and it’s up to a facility to decide on the proper air pollution control technology and equipment to achieve those limits. In some regulations, however, certain numeric control or removal efficiency criteria are stipulated, depending upon the technology chosen.

In New Jersey, potential emission levels are compared with certain criteria to determine whether a state-of-the-art (SOTA) technology review is required. Typically, sources with the potential to exceed the SOTA thresholds are required to install air pollution control equipment. However, the NJDEP’s SOTA equipment requirements are not truly as rigorous as the dictionary definition of state-of-the-art.

In addition to the state’s SOTA equipment requirements, an emission source could also be subject to a number of other USEPA control technology requirements under various regulations that include the New Source Performance Standards (NSPSs), MACT (defined previously for HAPs), or Federal New Source Review (NSR) or Prevention of Significant Deterioration (PSD).

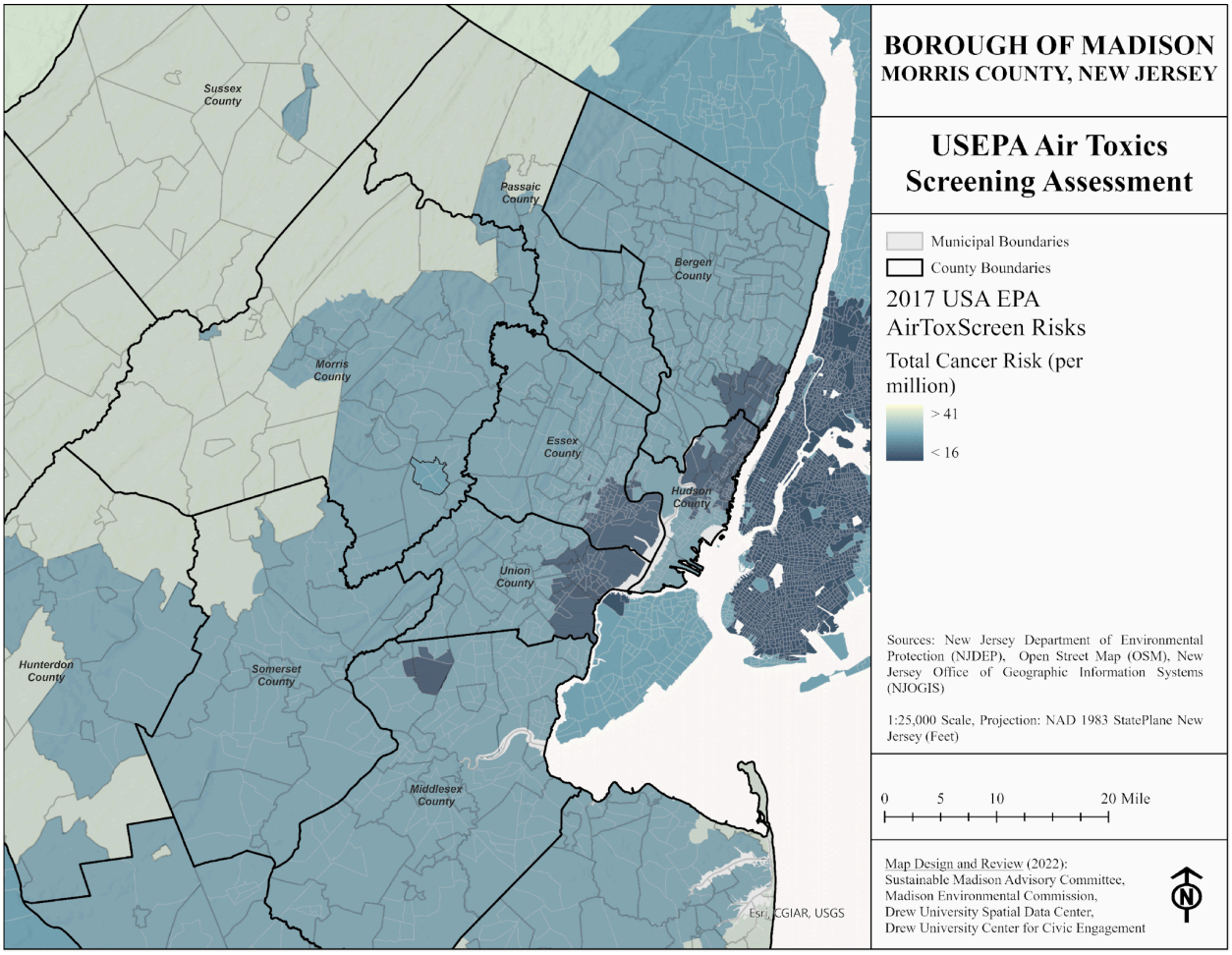
AIR POLLUTION IN MADISON

Air quality considerations are often dismissed as being of minimal concern in communities with limited industry. However, in older, more industrialized states like New Jersey small manufacturing and assembly plants are scattered throughout neighborhoods, having been sited there before many towns and townships had zoning laws. Other ubiquitous air emission generating sources are often overlooked because of their perceived non-impact include auto body painting and repair shops, universities, hospitals, and dry cleaners. Emissions from these smaller facilities have come under greater scrutiny by the NJDEP in the past decade and they are a nontrivial local source of air pollution. Most neighborhood dry cleaning establishments these days are pickup/drop-off locations for larger cleaners, who use newer cleaning equipment that contain very good air pollution control equipment.

Transport of air pollutants generated in other areas i.e., both short range (a few miles) and long range (50 miles or more) impacts on the air we breathe. As stated previously, the whole State of New Jersey is designated as a non-attainment area for ozone so we are all breathing air that fails to meet national standards. Research by USEPA connects exposure to outdoor air pollution with health risks.[26] Map 16 illustrates regional variations in total cancer risks resulting from lifetime exposure to outdoor air pollutants. The results estimate 30 cases per one million people exposed to 2017 levels of outdoor air pollution in Madison.

As a result of the Clean Air Act Amendments of 1990, the use of air pollution-causing consumer products will come under greater scrutiny in areas where the air quality does not improve. In the past 10 years there has been a significant push to regulate the production of air pollution-causing consumer products. The two initial types of these sources that were regulated were aerosol spray cans and paints. Under the 1988 Montreal Protocol, many nations around the world agreed to replace ubiquitous ozone-depleting chlorofluorocarbons (CFCs) by 2000 with low and non ozone-depleting chemicals. There was direct evidence that CFCs were responsible for the increasing size of the “ozone hole” in the stratosphere and a subsequent increase in skin cancers caused by UV absorption. CFCs were used throughout the world as the main propellant in consumer aerosol sprays (e.g., in hair sprays and deodorants) and as industrial solvents. Regarding paints, over the past 15 years the USEPA has developed paint specification requirements that limit the amount of VOCs in certain types of paints and coatings. This has resulted in the increased development and usage of non-VOC and water-based coatings.

[26] USEPA. Air Toxics Screening Assessment: 2017 AirToxScreen. Available online: https://www.epa.gov/AirToxScreen



Map 16. USEPA Air Toxics Screening Assessment, 2017, Total Cancer Risk

FUTURE SOURCES OF AIR POLLUTION

Regarding nuisance emissions such as ones that cause objectionable odors, municipal Madison, the wastewater treatment plant is about 1 mile east of the eastern border of Madison. Local Chatham residents rarely issue complaints of odors and since winds blow very infrequently towards the west, Madison residents are rarely, if ever, impacted by potential odors. In 2010, the Madison – Chatham wastewater treatment plant started an upgrade to the methane recovery tanks to capture more methane to burn off to power the facility.

Another source of potentially objectionable odors is composting operations. The only operations of such a type in the immediate area are the leaf and mulch recycling operations at the Borough maintenance garage on John Street. Occasionally, a hard, fruity odor can be smelled in town, usually under the proper atmospheric conditions either at night or in the early morning, and along the direction of the wind. This occurs due to the biological “fermenting” of the leaves and mulch, but it is not a health hazard. Leaves are no longer composted at this site.

Another considerable group of sources of air pollution that continue to receive greater state and federal attention are mobile sources i.e., automobiles, trucks, buses, boats, trains, aircraft and construction equipment. Automobiles release much lower levels of air emissions today than in years past due to better engine designs and tougher emissions testing requirements (i.e., at the state-approved inspection stations).

However, the significant growth in the usage of sport utility vehicles (SUVs) has limited both emission reductions and subsequent improvements in ambient (outdoor) air quality.

In terms of local impacts on air quality from automobiles, traffic congestion is an important factor. Prior to the opening of Route 24 in November, 1992 there was extensive traffic along the major arteries in Madison. The Route 24 opening initially displaced the traffic congestion from Main Street to the highway, but over the past several years the increased development in the general region has caused a return of much of the Main Street congestion. In addition, the traffic along much of Route 24 has become increasingly congested over the years.

ACCIDENTAL RELEASE

Industrial facilities, mainly chemical and pharmaceutical plants, usually take special care when dealing with toxic and hazardous air pollutants. However, even though extreme precautions are taken and the probability of an accidental release is small, it can still happen. The real concern is that a major release can impact people as far as 25 miles away. People may remember the noxious odor that engulfed the Borough in 1984, which was the result of a release from the Exxon Bayway Refinery in Linden, N.J. 25 miles away!

The worst accidental release in world history was the 1984 Union Carbide release in Bhopal, India in which a combination of equipment failures resulted in a release of tons of the deadly gas methylisocyanate, causing 2,000 fatalities and 20,000 injuries. In New Jersey within the past ten years an explosion at the Napp Chemical plant in Paterson in 1998 resulted in 4 fatalities among plant workers and an April 1998 release at the Morton Chemical plant in Paterson resulted in a 2 alarm fire and the release of chemicals into the community.

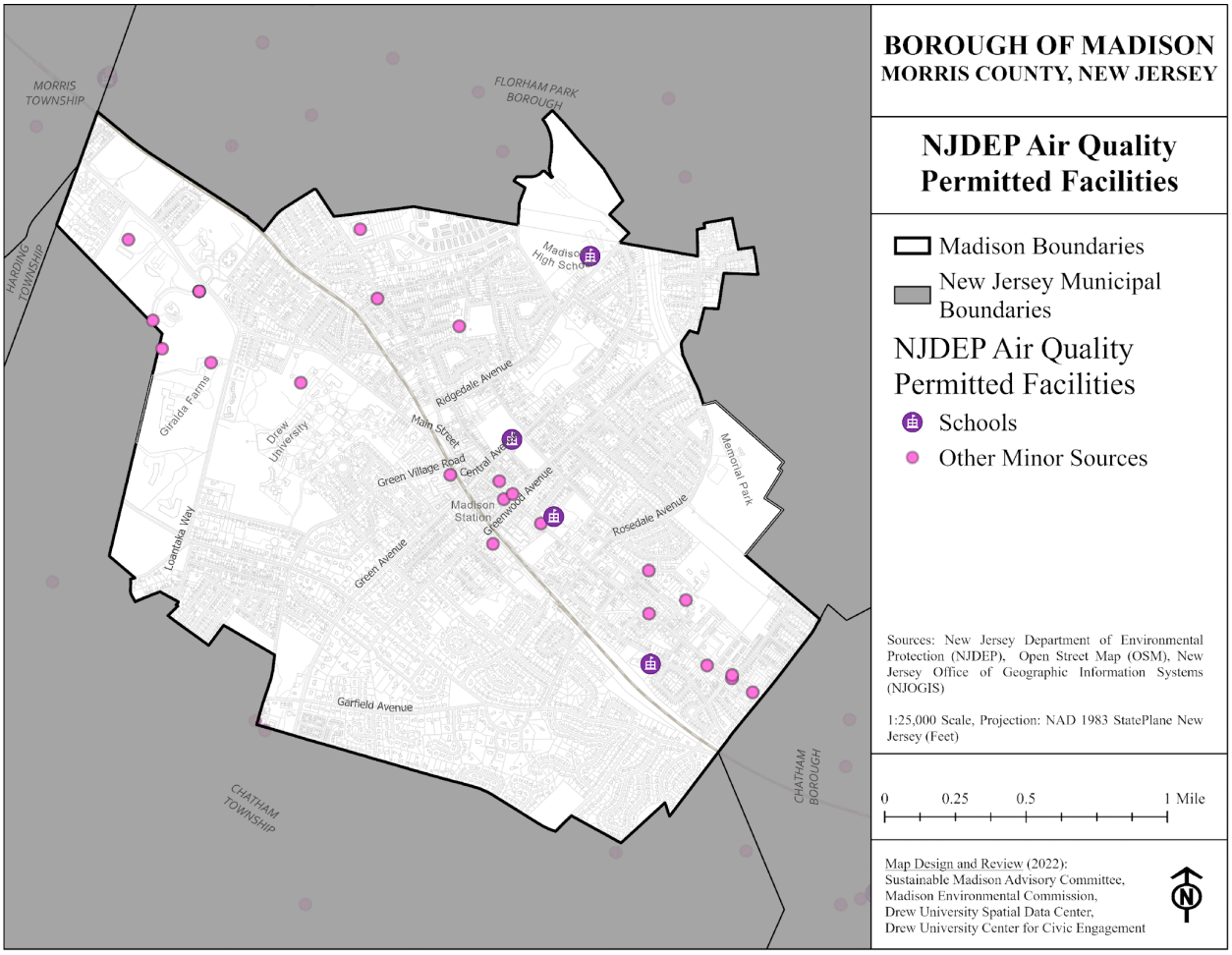
A few historical catastrophic releases in New Jersey have included the 1980 Chemical Control fire in Elizabeth, which spurred on the passage of the USEPA Superfund program, the Monsanto explosion in Kearney in 1972, which left the plant looking like it had been hit by mortar fire, and the 1971 Exxon H-Oil Explosion at the Bayway Refinery in Linden, which caused a 600-ton reactor to launch and land ½ mile away (amazingly, there were no fatalities).

For the most part, there are a minimal number of appreciably-sized manufacturing plants within a five-mile radius of Madison. The few pharmaceutical operations in the area, i.e., the Novartis facilities in Summit and East Hanover, are research facilities which used smaller quantities of dangerous chemicals and take extreme precautions to eliminate all chemical releases.

In 1987 the USEPA instituted the “Right to Know” law, which requires facilities that handle hazardous chemicals to register and report the quantities of these chemicals to the local fire departments and emergency planning councils. There are 22 listed polluters in Morris County on the USEPA Toxics Release Inventory (TRI), down from 33 in 2011. Two of them, National Manufacturing Co., Inc. and ISP Chemicals, Inc. Sutton Laboratories are located in Chatham. At this time, there have been no reported major accidental releases from either of these sites.

New Jersey also grants permits for commercial or industrial air emission sources, which can be for major or minor emissions. Map 17 shows the locations of Madison NJDEP permit holders regulated by N.J.A.P.C. 7:27.[27] There are 27 locations in Madison.

[27] NJDEP. 2022. NJDEP Air Quality Permitted Facilities of New Jersey. Available online: https://njogis-newjersey.opendata.arcgis.com/datasets/njdep::njdep-air-quality-permitted-facilities-of-new-jersey/about



Map 17. NJDEP Air Quality Permits in Madison Borough

If a chemical release or spill were to happen within the boundaries on the Borough, the Madison Fire Department's procedure is to place an immediate call to the Whippany Hazmat Team, which is the regional first responder for both the Borough and the State Police.

While Madison does not have large quantities of hazardous materials within its borders it is to be noted that there are 12 superfund sites in Morris County, the closest being the Rolling Knolls Landfill, 35 Brittin Road, Green Village.

INDOOR AIR QUALITY

Most people are concerned with the impacts of outdoor air pollution on their health. However, an outbreak of Legionnaires' disease at an American Legion convention at the Ritz Carlton Hotel in Philadelphia in 1976 helped focus attention on the problems associated with indoor air pollution.

Since outdoor air enters buildings, a lot of the outdoor pollutants, both synthetic and natural (e.g., pollen), get transported indoors. In addition, emissions can be generated from indoor activities and sources, e.g., renovations (dust), new carpets de-volatilizing chemicals, consumer products such as paints and polyurethane coatings, cigarette smoking, etc. In addition, molds and mildew can grow in areas subject to dampness, e.g.,

basements, ceilings from leaky roofs, etc. The term “sick building syndrome” was coined in response to humans showing health symptoms as a result of exposure to indoor air pollutants.

In the 1970s, as a result of the energy crises, energy efficiency was introduced to the American way of life. One of the prime areas where this was practiced was in thermal retention in buildings. Thermal retention is achieved through minimization of infiltration of outdoor air into buildings and use of larger quantities of attic and wall insulation. Unfortunately, thermal infiltration minimization also had a negative side effect, namely, of reducing the amount of outdoor air exchanges and dilution of interior generated air pollution. Subsequently, new homes today are often installed with air-to-air heat exchangers which transfer about 80% of the thermal heat value of air that is intentionally exhausted to reduce the concentration buildup of air pollutants.

Three key indoor air species that have shown to have an impact on human health and which have been evaluated extensively in New Jersey over the past 20 years are asbestos lead from paint, and radon. Asbestos is a natural fiber that was used extensively in the 20th century up until the 1970’s to insulate boilers and water pipes. It is also used in the manufacture of automobile and truck brake pads. In time, the asbestos used for building insulation can start to soften and crack, reverting to a form called “friable.” Friable asbestos can become airborne and be breathed in. Once inhaled, the long-pointed asbestos fibers can be retained in the lungs causing inflexibility of the lungs and possibly leading to respiratory diseases. In extreme cases asbestos can also be an initiation site for cancer.

Health effects caused by asbestos were clearly demonstrated in workers who worked in industries that made or extensively used products made from asbestos. Madison has removed most of the asbestos from the Hartley Dodge Memorial building during an extensive two-year renovation that was largely completed in December 2010.

Regarding lead, through much of the 20th century lead was used as an octane booster in gasoline. Once health effects of lead were demonstrated the USEPA banned lead from gasoline. Dust from lead paint may also be a source of indoor home exposure.

In the 1970’s the term, “radon” became a household word in New Jersey. Radon is the only naturally occurring radioactive element which is a gas. Technically, the term “radon” can refer to any of a number of radioactive isotopes having atomic number 86, but the predominant isotope of concern inside homes is radon-222. Radon-222 is directly created by the decay of radium-226, and has a half-life of 3.82 days. The four products which immediately follow radon-222 in the decay chain are polonium-218, lead-214, bismuth-214 and polonium-214. These elements have such short half-lives that they exist only in the presence of radon. These products are ultra-fine solids which tend to adhere to other solids including dust particles in the air and solid surfaces in a room. They adhere to lung tissue when inhaled and bombard the tissue with alpha particles, thus creating the health risk associated with radon. Radon is suspected of being a potential contributor to the formation of lung cancer.

Radon accounts for approximately 54 percent of normal everyday background radioactivity. High concentrations are associated with a geologic formation covering a good portion of Northern New Jersey called the “Reading Prong.” Houses built on the Reading Prong may have radon naturally seeping through openings in foundations such as floating slabs or sumps. If it is determined through testing that the level of radon is above a certain level, i.e., 4 pico curies per liter, the homeowner should consider a remedy to the problem such as sealing up the openings and/or venting the radon gas.

NOISE POLLUTION

Often included in companion with air pollution studies, an often-overlooked aspect of environmental resources is noise pollution. Every government-funded transportation construction project must do a noise pollution investigation to determine whether the project will cause noise impacts.

Common sources of high levels of noise include aircraft industrial equipment, construction equipment and vehicles. Regarding loud noise generated by construction equipment, idling diesel trucks, etc., this is best handled on a personal basis by contacting the Madison Police Department and Borough Health officer with a complaint.

With the continual growth of corporate headquarters and office buildings in the region, the number of take-offs and landings have continually increased at Morristown Airport. Since a number of the flight paths are directly over Madison, the number of noisy low altitude aircraft has increased markedly prompting establishment of QUEST, a non-profit group with a mission to reduce aircraft noise in Madison, particularly from Morristown Airport. In 2004, Quest working with the Morris County Freeholders and representatives of Morristown Municipal Airport produced a new map for helicopter traffic avoiding noise sensitive areas in Madison. In 2006, this working group adjusted the airplane landing approach to 3.5 degrees from 3.0. This reduced noise over Madison by keeping the planes higher in their approach pattern. Airport noise complaints are handled by calling Morristown Airport Operations Noise Abatement Office at 973-538-6400 x112.

CONCLUSION

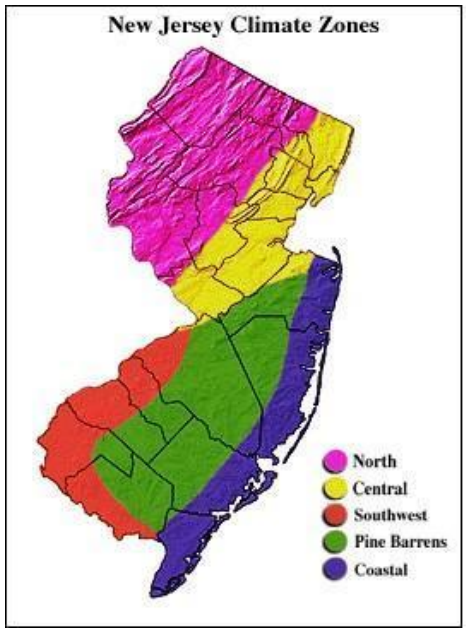
The degree of air pollution is directly related to the amount of industrial activities in the area, the amount of traffic, residential and commercial activities, and the amount of pollution that blows in from other regions. Over the years since 2000 the air quality for most pollutants has gotten better with stricter Federal and State regulation.

REFERENCES

- Air & Waste Management Association, Understanding Air Quality – Presentation A&WMA, Pittsburg, PA., November, 1998
- Radon Reduction Techniques for Detached Houses, USEPA EPA/625/5-87/019, Research Triangle Park, NC. January, 1988 pages xv and xvi.
- Radon Tagged as Cancer Hazard by Most Studies, Researchers, Chemical & Engineering News, February 6, 1989, pages 7 through 13.
- USEPA 2009 SIP Release/Disposal Report, December 2010
- USEPA Air Toxin, CO_2, NO_2, SO_2, Ozone Lead and PM
- Homefacts.com Air Quality Report for Madison, NJ and Environmental Hazards Report for Morris County, NJ
- American Lung Association.com Air Quality Report for Madison NJ

VII. CLIMATE

There are great differences in the productivity and habitability of different parts of the land surface of the U.S. These differences are largely the result of the interactions of several weather factors, including prevailing wind speeds and directions, temperature, and precipitation, with the geology or physiography of the earth. Long term conditions of these weather factors are called *climate*. When describing climate, meteorologists prefer to use scientific averages of 30 years or more. Averages based on a shorter term could be significantly different.



Map 18. New Jersey Climate Zones

New Jersey enjoys what is termed a “humid, hot-summer continental climate”. It is a beneficial and agreeable climate for human habitation because there is considerable variation in weather without the hardships caused by prolonged extremes. While the climate of the United States has been relatively stable for the last four centuries, the cumulative effects of human alteration of environmental systems is contributing to significant climate disruption.

New Jersey’s climate is mainly determined by its median position between the equator and the North Pole, its proximity to the sea and the passage of atmospheric weather systems across its surface. New Jersey is crossed by both tropical and polar air masses whose boundaries oscillate northward and southward, often tracking the jet stream, in the global procession of storm patterns. Subsequently, prevailing winds come out of the southwest in the warmer months and out of the northwest in the colder months. Tropical systems bring warm, wet weather with primarily south-westerly winds from the Gulf of Mexico up along the coast. Polar air masses are typically cold and dry, with prevailing winds from the northwest. They move across the Great Lakes and down the valley of the St. Lawrence River, often extending well into the northern part of New Jersey. Map 18 characterizes New Jersey into five climate zones.

TEMPERATURE

Temperature in Northern New Jersey can vary by approximately 45°F when comparing the coldest month (January 28.8°F) to the hottest month (July 73.9°F). Average monthly temperature has increased in the past 20 years with the highest increase occurring in the months of February and September. The smallest increase

in average temperature was during the month of January. Tables X below shows these values along with the mean temperatures from 2000 - 2020 as well as the mean temperature from 1895 - 2020.

Table X

Average Monthly Temperatures (°F) in Northern New Jersey from 2000-2020 Compared to 1895-2000			
Month	**Mean 2000-2020**	**Mean 1895-2000**	**Change**
January	28.8	28.4	+0.4
February	31.3	29.4	+1.9
March	39.2	38.3	+0.9
April	50.2	48.8	+1.4
May	60.2	59.4	+0.8
June	68.8	68.1	+0.7
July	73.9	73.0	+0.9
August	72.3	71.0	+1.3
September	65.6	63.7	+1.9
October	53.9	53.1	+0.8
November	43.5	42.5	+1.0
December	33.7	32.2	+1.5

Sources: The National Centers for Environmental Information (NCEI)
https://climate.rutgers.edu/stateclim_v1/nclimdiv/index.php?stn=NJ01&elem=avgt

Table X and Figure Y illustrate the monthly temperatures for Northern New Jersey, as well as the Maximum, Minimum, and Median temperatures for each month. As with the table above, more recent measurements indicate temperatures are higher than average for all months.

	30yr Normal (1991-2020)	Mean (1895-2022)	Median	Min	Max
Jan	28.9	27	26.9	15.9	38
Feb	31.3	28.3	28.4	14.9	37.3
Mar	38.8	37.2	37.1	27.8	48.3
Apr	49.9	48.3	48.2	42.3	54.3
May	59.9	58.8	58.9	50.9	64.9
Jun	68.6	67.3	67.7	61.4	72
Jul	73.7	72.3	72.1	67.8	77.2
Aug	71.9	70.3	70.2	64.3	75.1
Sep	64.9	63.4	63.2	58.4	69.3
Oct	53.3	52.3	52.3	45.2	60.1

Nov	43.1	41.3	41.3	34.3	47.6
Dec	34.1	31	31.4	20	44.9
Annual	51.5	49.8	49.6	45.4	54

There is a positive trend for all temperatures as they are all increasing with time. Almost all of Northern New Jersey's record breaking lowest average temperatures occurred between 1895 - 1930. The record breaking highest average temperatures have typically occurred between 1990 - 2021.[28]

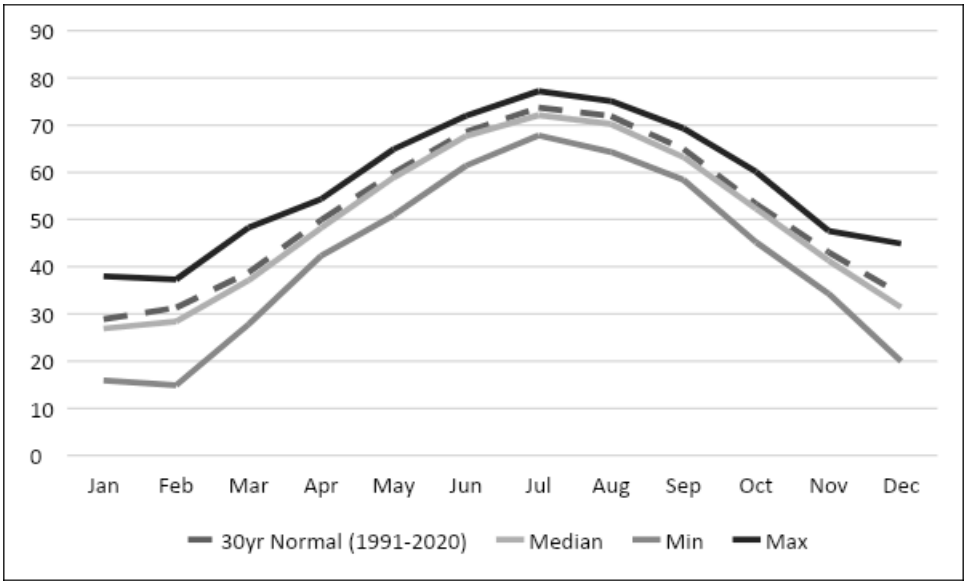


Figure X. Monthly Temperatures in Northern New Jersey, 1895-2022

Table X focuses on local temperatures near Madison. Taking values collected from Canoe Brook, located less than 5 miles from Madison, the same trends can be observed. January is still the coldest month (27.2°F) while July was the warmest month (75.7°F). Average monthly temperatures increased from 1895 - 2000 to 2000 - 2020 in every month except January, which trended downwards. This may be due to the lack of data points being collected as there were often multiple days, if not an entire month's worth, of temperatures missing. This may also account for the large increases observed in every other month with the largest change occurring in December where average temperatures have increased by almost 5°F.

Table 2

Average Monthly Temperatures (°F) in Canoe Brook, New Jersey from 2000-2020 Compared to 1895-2000			
Month	**Mean 2000-2020**	**Mean 1895-2000**	**Change**
January	27.2	28.5	-1.3
February	32.2	30.3	+1.8

[28] The National Centers for Environmental Information (2021). Monthly Climate Tables; NJ Climate Division 1 (North) Available at: https://climate.rutgers.edu/stateclim_v1/nclimdiv/index.php?stn=NJ01&elem=avgt (Accessed on: October 19, 2021).

March	40.4	38.2	+2.2
April	52.3	49.3	+3.0
May	60.4	58.8	+1.7
June	71.0	68.5	+2.6
July	75.7	73.5	+2.2
August	75.4	71.8	+3.6
September	67.9	64.5	+3.4
October	54.9	53.7	+1.2
November	44.3	42.7	+1.6
December	36.4	31.6	+4.8

Source: The National Centers for Environmental Information (NCEI)
https://climate.rutgers.edu/stateclim_v1/monthlydata/index.php?stn=281335&elem=avgt

The frost line in Madison varies from about 20 to 24 inches, depending upon such factors as exposure to the wind, vegetative cover, topography and elevation. For engineering and building purposes the Borough's Engineering Department has assumed a conservative, uniform frost line value of 36 inches. The dates of first and last frost vary from early October- November to April or May, respectively, as shown in Table X. The average annual number of frost-free days in this area is about 200 days/year.

Table X Seasonal Statistics, Frost Season Based on 32F, Canoe Brook Station

	First Occurrence	Last Occurrence	Season Length
1976-77	10/19	5/9	203
1977-78	10/18	5/4	199
1978-79	10/9	4/21	195
1979-80	10/27	4/23	180
1980-81	10/10	5/8	211
Average			**197.6**
2016-17	10/26	4/9	166
2017-18	11/11	4/21	162

2018-19	10/22	4/3	164
2019-20	11/4	4/22	171
2020-21	10/31	4/4	156
Average			**163.8**

A “heating degree day” is the number of degrees that the average daily temperature falls below 65° on that day. Heating degree days are used during the heating season for space heating calculations. Table VII-3A shows average monthly degree days over a 30-year period in comparison to more recent data.

Table VII-3A Heating Degree Days

	1971-2000	2001-2021	Difference
Jan	1133	1042	-91
Feb	962	887	-75
Mar	783	735	-48
Apr	456	392	-64
May	180	159	-21
June	25	19	-6
July	2	1	-1
Aug	4	1	-3
Sept	71	39	-32
Oct	376	288	-88
Nov	636	602	-34
Dec	976	850	-127
Mean	**5604**	**5014**	**-590**

Source: Canoe Brook Station[29]

A “cooling degree day” is the number of degrees that the average daily temperature falls above 65 degrees Fahrenheit on that day. Cooling degree days are used in warmer seasons to calculate air conditioning requirements, and are shown in Table VII-3B.

Table VII-3B Cooling Degree Days

	1971-2000	2001-2021	Difference
Jan	0	0	0
Feb	0	0	0
Mar	0	0	0
Apr	0	10	10

[29] Office of the New Jersey State Climatologist. Rutgers University. Canoe Brook: Heating Degree Days. Available Online: https://climate.rutgers.edu/stateclim_v1/monthlydata/index.php?stn=281335&elem=hdd

May	27	58	31
June	146	206	60
July	281	350	69
Aug	232	312	80
Sept	64	126	62
Oct	7	16	9
Nov	0	0	0
Dec	0	0	0
Mean	757	1079	322

Source: Canoe Brook Station[30]

The tendency toward a warmer climate will mean fewer heating days an more cooling days in Madison.

PRECIPITATION

The meteorological factor which often historically receives the great attention in local planning is precipitation. Rain and snow replenish Madison's valuable drinking water aquifer, affect steam flows, and impact on structural engineering requirements, flood predictions, wastewater treatment plant discharge runoff control measures and snow plowing requirements. Since 1895, Northern New Jersey's precipitation has varied between 30 and 72 inches annually, well above the national average of 20 inches. Morris County's annual mean is 49 inches.[31] Table VII–4 shows the mean, minimum and maximum monthly Northern New Jersey precipitation levels from 1895 through 2000.

Table VII–4 Average Monthly Precipitation in Northern New Jersey from 1895 - 2000

Average Monthly Precipitation in Northern New Jersey measured in inches (in)							
Month	*1895-2000*	*2001-2009*	*2010-2020*	*Maximum Precipitation*	*Maximum Year*	*Minimum Precipitation*	*Minimum Year*
January	3.42	2.9	3.25	9.12	1979	0.54	1981
February	3.07	2.52	3.36	6.88	1896	0.66	2009
March	3.89	4.25	4.12	8.66	2010	0.82	2006
April	3.89	3.85	3.54	9	1983	0.96	1963
May	3.92	3.49	4.31	8.43	1989	0.64	1903
June	3.92	4.43	4.37	9.49	2013	0.32	1943
July	4.68	4.25	5.25	11.37	1897	1.27	1999
August	4.47	3.76	5.13	15.67	2011	0.98	1964
September	4.05	4.02	3.81	9.5	1999	0.29	1941

[30] Office of the New Jersey State Climatologist. Rutgers University. Canoe Brook: Cooling Degree Days. Available Online: https://climate.rutgers.edu/stateclim_v1/monthlydata/index.php?stn=281335&elem=cdd

[31] Office of the New Jersey State Climatologist. Rutgers University. Morris County, NJ. Monthly Total Precipitation (in.). Available online: https://climate.rutgers.edu/stateclim_v1/nclimdiv/index.php?stn=NJ027&elem=pcpn

October	3.6	5.19	4.33	11.99	2005	0.25	1963
November	3.56	3.97	3.24	9.01	1972	0.54	1917
December	3.57	4.02	4.41	7.87	1996	0.4	1955
Total	46.04	46.65	49.12	72.49	2011	30.84	1965

Precipitation in the area is fairly well distributed throughout the year. Monthly precipitation levels typically vary from about 3 to 5 inches of rain – equivalent. However, some months can be almost devoid of precipitation, whereas in other months precipitation can exceed six inches. Typically, the heaviest rains occur during summer thunderstorms or during tropical storms or hurricanes in the early fall. Short term droughts are a part of life in New Jersey, and seemed more plentiful in the 1990s than any other time in the past 50 years. Oftentimes just a short-term phase in the frequency distribution of precipitation over time, droughts typically are dealt with in town via water rationing.

OTHER FORMS OF PRECIPITATION

Regarding other forms of precipitation, hailstorms occur very infrequently in Madison and usually only last for short durations. Snowfall varies widely from year to year, with the extremes ranging from a low of 5 inches or less to as much as 60 inches. The average annual snowfall recorded in Morris Plains from 1948 through 1990 was 32.4 inches. Maximum monthly amounts for December through March were in the 25 to 31 inches range. Snowfall rates measured at Newark Airport for the decade ending 1980 were 23.1 inches, ending 1990 were 30.05 inches, decade ending 2000 were 13.8 inches and the decade ending 2010 were 31.5 inches. The historical statewide average seasonal snow, up to 2018, is 26.2 inches.[32]

Madison's topography is such that only a few low-lying areas are susceptible to extensive flooding. The potential exists, however, for very heavy rainfall from tropical storms, local thunderstorms and significant snow events. A list of some significant rain and snow events from the past includes the following:

- Aug. 5, 1843: 15 inches of rain
- Sept. 21-23, 1882: 11 to 18 inches of rain (Hurricane)
- Aug., 1902: Rains caused flash flood in Madison
- Oct. 8-9, 1903: 10-plus inches of rain (tropical storm)
- Nov. 6-7, 1953: 20 to 30 inches of snow
- March 16-19, 1956: 30 to 40 inches snow
- Aug. 26-27, 1971: 9.8 inches of rain aver
- April 6, 1982: 12 inches of snow
- Jan. 1, 1996: 24 to 30 inches of snow
- Sept. 16, 1999: Hurricane Floyd
- Dec. 26, 2010: 14 – 20 inches of snow
- August 2011: Hurricane Irene
- October 29, 2012: Hurricane Sandy
- Sept 1-3: Remnants of Hurricane Ida

[32] Melisurgo, L. 2018. "Was this N.J.'s worst winter ever? Let's see the snowfall totals." NJ.com, March. 31. Available online: https://www.nj.com/weather/2018/03/nj_weather_snowfall_totals_winter_2017-2018_season.html

A scan of recordable events listed at NOAA's website for Morris County shows that while drought, rain, and temperature extremes have remained constant between the prior decade and this decade, events of flooding, hail storms, strong wind events and snow storms has greatly increased.

NOAA Recordable Events for Morris County	1991 -2000	2001– 2010 * *As of 10/31/10	Change
Drought	17	20	+3
Precipitation	20	20	--
Temperature Extremes	41	40	-1
Flood	29	52	+23
Hail	7	17	+10
Snow	59	110	+51
Strong Wind	0	45	+45

WIND

To assist pilots and for air pollution modeling predictions, precise, local meteorological data is preferred. However, when there is no available meteorological weather station in the immediate area, information from the closest major airport often offers the best data alternative. Since there are no precise statistics on wind direction or speed in Madison, the nearest wind recording station at Newark Airport, thirteen miles to the east, offers the most representative meteorological data applicable to Madison. However, meteorological data correlation between the Newark airport data and conditions in Madison does have some shortcomings since Madison is hilly and at an elevation between 190 feet and 380 feet (mean sea level – msl) whereas Newark Airport has a flat topography, an elevation of only 30 feet, msl, and is influenced by ocean effects.

A copy of the wind rose for Newark Airport for 2021, shown in Figure X, shows the direction and frequency of winds over the course of a year, is shown below. The wind rose vectors are best viewed as directional arrows that point in the direction the wind is going, and the longer the arrow, the more prevalent the wind is in that direction. Observing recent meteorological data, the wind blows predominantly from three directions:

- From the southwest (warmer months)
- From the northwest (colder months)
- From the northeast (occasional nor'easter)

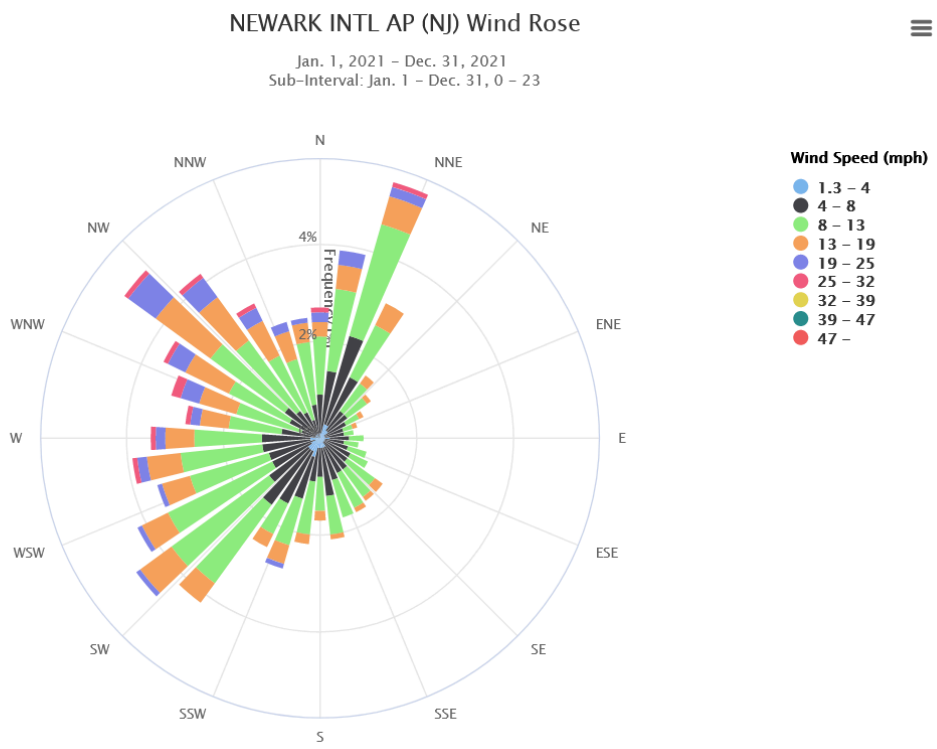
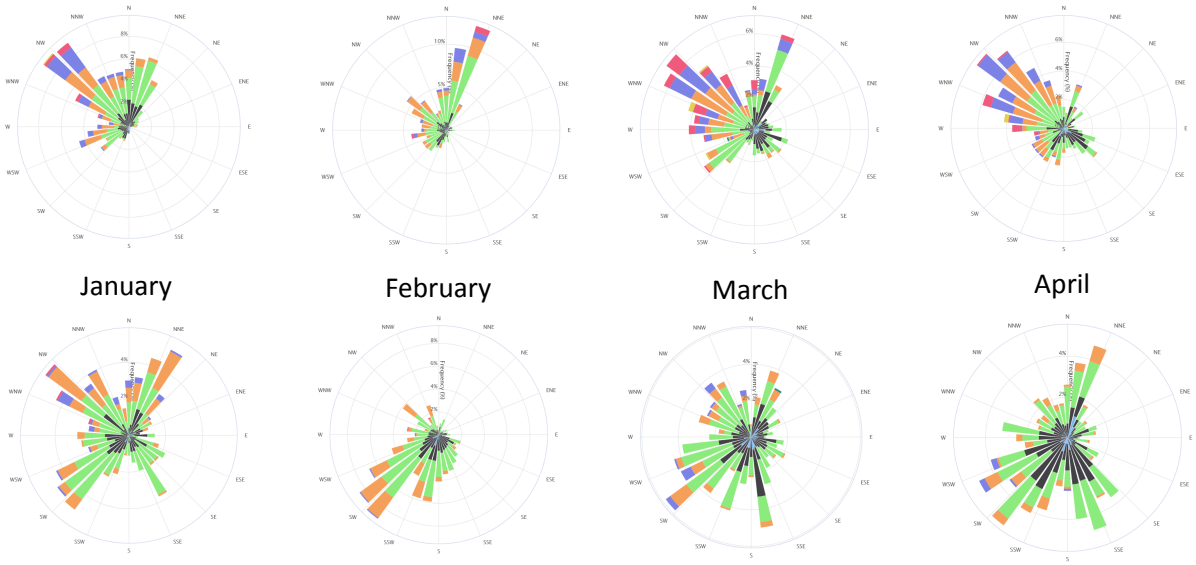


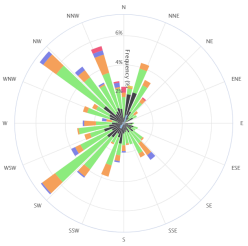
Figure X. Newark International Airport Wind Rose, 2021[33]

FigureX is a series of average monthly windrose graphs from January to December. These give a clearer picture of the wind patterns and how they change over the year.

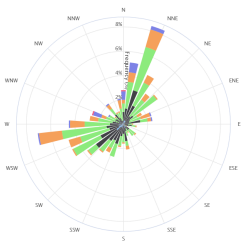
Figure VII-2B:
Newark Meteorological Data (Windrose, 2021)



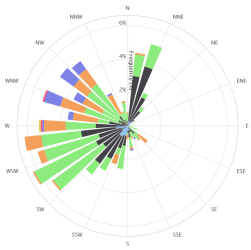
[33] Midwestern Regional Climate Center. Cli-MATE: MRCC Application Tools Environment. Available online: https://mrcc.purdue.edu/CLIMATE/



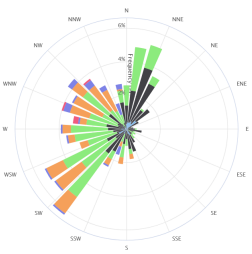
September



October



November

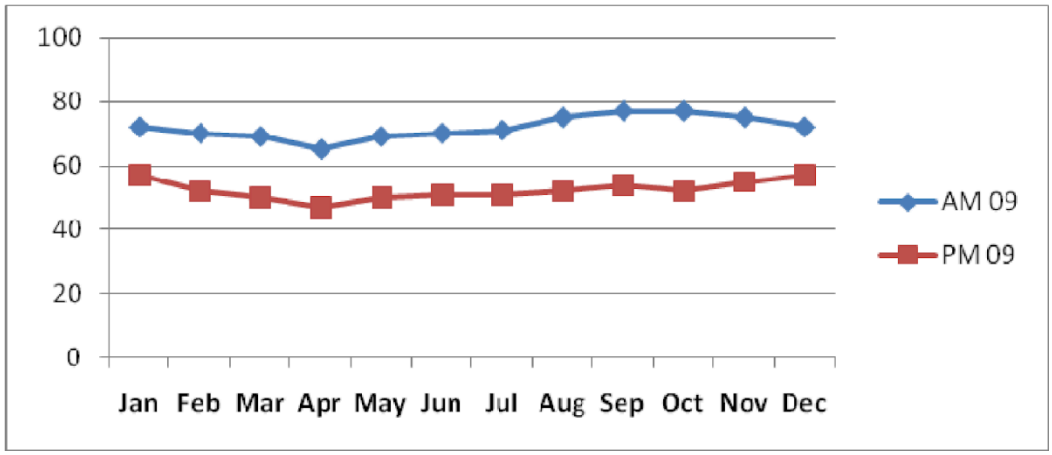


December

RELATIVE HUMIDITY

Humidity affects the level of comfort of humans and the operating ability of some types of equipment. Thus, it is an important consideration in heating, cooling and air conditioning. The U.S. Weather Service at Newark Airport is the closest official recording station of relative humidity, which relates actual water vapor present to that which could be present at "saturated conditions". Average readings over a fifteen year period (Figure VII-2) illustrate two patterns: (1) that within each day, humidity is higher during the early morning hours, declines into the early afternoon heat and then rises toward evening; and (2) that the months when humidity is highest are June through December. Figure VII-3 updated through 2010 shows AM &PM levels.

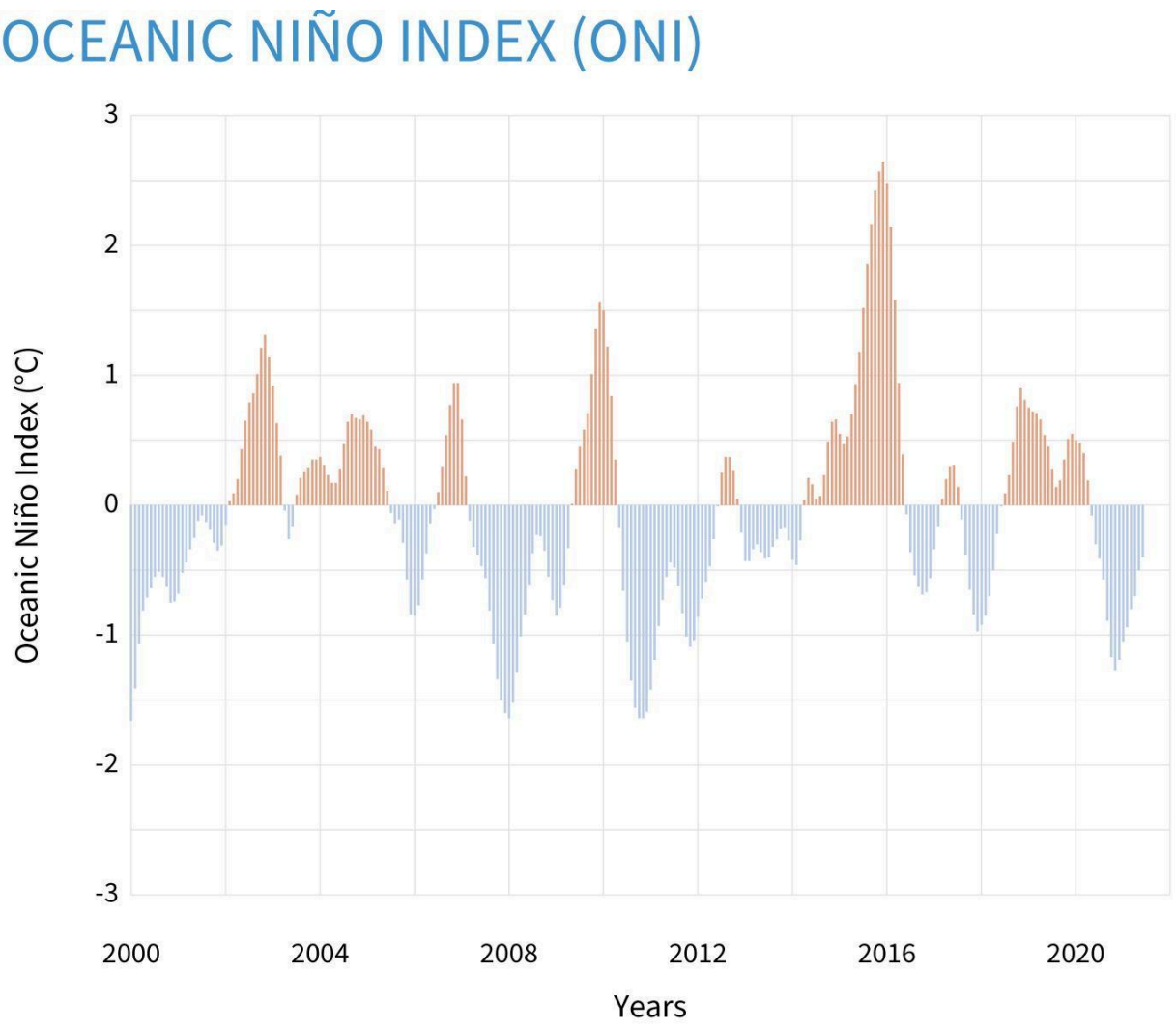
Figure VII-3 Relative Humidity Pattern at Newark Airport



EXTREME WEATHER CONDITIONS

Over decades and centuries weather can demonstrate appreciable variability. Throughout the 1990s frequent short-term extreme weather conditions hit most of the continental U.S., including Madison. While certain regions in the country were suffering from drought, at the same time others were suffering from intense rains and flood. Two ocean-atmospheric system weather phenomena in the Pacific Ocean, termed "El Nino" and "La Nina" were responsible in part for global weather disruptions. Historically only discussed by climatologists, El Nino and La Nina became the frequent topic of many a news weather reporter in the late 1980s and 1990s. El Nino is the condition characterized by unusually warm ocean temperatures whereas La Nina is characterized by unusually cold ocean temperatures in the Equatorial Pacific. These variations from more temperate conditions are climate. The impacts are seen most clearly in wintertime. In the continently

U.S. during El Nino years, temperatures in the winter are warmer than normal in the North Central States, and cooler than normal in the Southeast and Southwest. During a La Nina year, winter temperatures are warmer than normal in the Southeast and cooler than normal in the Northwest. In the Northeast, El Nino and La Nina have an effect on our climate because our prevailing winds come from the Northwest and the Southwest. However, the effects are much more subdued. The Oceanic Nino Index (ONI) has become the de-facto standard that NOAA uses to identify these events.



Source of graph: https://www.climate.gov/media/13590

Over the past few decades, as usual, New Jersey received its typical share of warnings regarding potential Caribbean-bred hurricanes. However, in 1999 one of the most ferocious storms of the century, Hurricane Floyd ("Floyd"), wreaked havoc on the East Coast. Floyd hit New Jersey on September 16, and while its intensity had weakened from a category 4 to a category 2 hurricane by time it initially hit landfall in the U.S. in North Carolina, it wasn't a typical category 2 hurricane due to its massive size and the added time that it lingered in an area. Subsequently, these conditions caused widespread flooding. In all, 73 deaths were attributed to Floyd, including four (4) in New Jersey. The town of Bound Brook witnessed the rise of the Raritan River to the second story of houses near the river, a site never before seen. In Madison, the water level rose well above the 100-year flood mark, and the highest water level in Borough history since the flash

flood of August 1902 was recorded. (Note) The flash flood of 1902 ripped through the Presbyterian cemetery, tossing caskets and bodies from about 50 graves). The Spring Garden Brook overflowed its banks, streets were flooded out and properties and basements that had never before experienced flooding were inundated.

In the winter of 1993-1994 there were a total of 16 snowstorms. This constant barrage of snow never allowed the underlying road ice to be cleared from the streets, resulting in dangerous driving conditions for most of the winter. In addition, on January 1, 1996 a single snowstorm dumped approximately 2 feet or more of snow, something unseen in a generation.

On October 29, 2012, Superstorm Sandy, downgraded to an extratropical storm, and made landfall in Atlantic County, New Jersey. The costliest storm in New Jersey history, Sandy produced coastline altering storm surge, a dozen fatalities, and damage to over 30,000 homes and businesses.[34,35,36] The impact in Madison was much less severe than for coastal regions: power outages lasted only one or two days for most residents, and one week after the storm, 95 percent of residents had power restored.[37]

On the 16th anniversary of Hurricane Katrina, Hurricane Ida made landfall in Louisiana on August 29, 2021 as a Category 4 hurricane. Remnants of Hurricane Ida had an impact on New Jersey as well, bringing flash flooding and tornadoes to state on September 1. In Madison, the fire department conducted over 70 "pump-outs" of flooded home basements and other buildings.[38] Map 19 illustrates the count of georeferenced basement pump-outs by sub-watershed.

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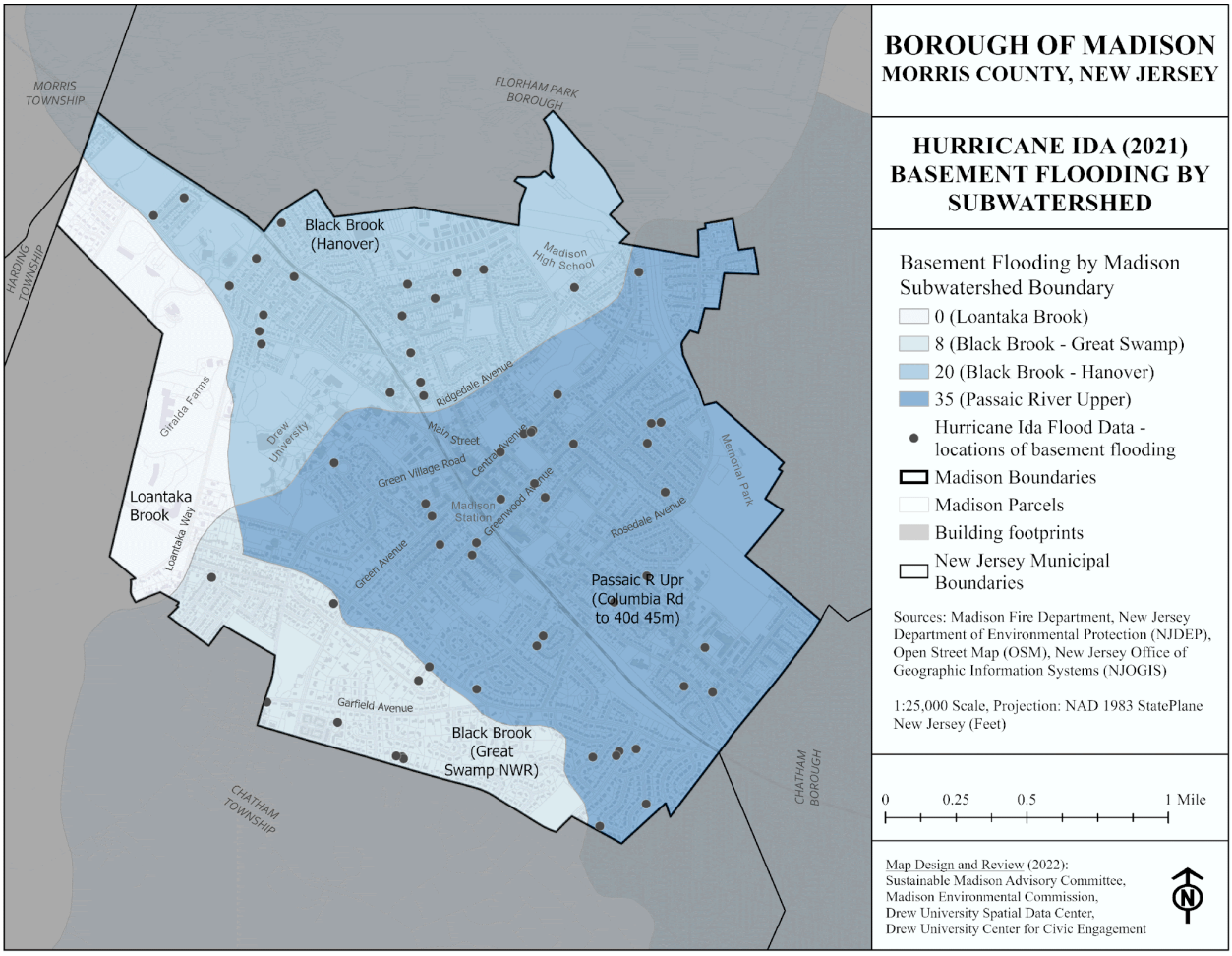
[35] Blake, E, et al. 2013. "Tropical Cyclone Report: Hurricane Sandy." National Hurricane Center. February. Available online: https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf

[36] Smith, C. 2013. Floor Statement on Sandy Supplemental. U.S. House of Representatives. Jan. 2. Available online: https://chrissmith.house.gov/uploadedfiles/floor_remarks_on_sandy_jan_2_2013.pdf

[37] Herzog, G. 2012. "Madison comes long way from Day 1." Madison Eagle, Nov. 8. Available online: https://www.newjerseyhills.com/madison_eagle/news/madison-comes-long-way-from-day-1/article_98e5707e-290d-11e2-b081-0019bb2963f4.html

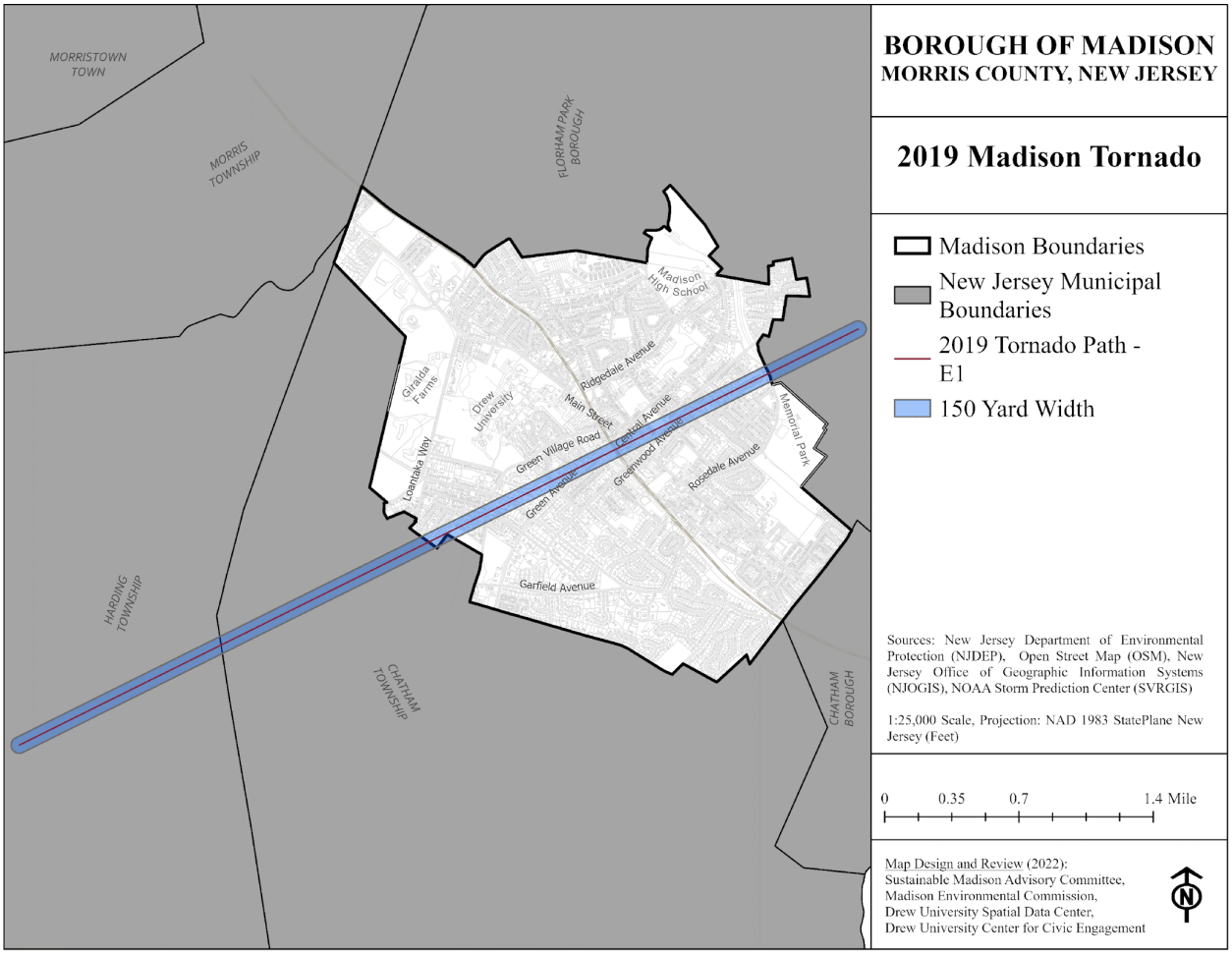
[38] Parker-Magyar, A. 2021. Madison firefighters pump out more than 70 flooded basements in Ida's aftermath." Madison Eagle Sept. 2. Available online: https://www.newjerseyhills.com/madison_eagle/news/madison-firefighters-pump-out-more-than-70-flooded-basements-in-idas-aftermath/article_35c27ad3-9c74-50eb-81d4-d2aa53b4917e.html



Map 19. Hurricane Ida Flooding Events with Response by Madison Fire Department, 2021

Tornados are rare in New Jersey and even rarer in Morris County and Madison. Most tornados occurred in the warmer months, in conjunction with thunderstorms. While no deaths occurred from these tornadoes, extensive damage to a limited number of homes frequently resulted. On Friday, November 1st, 2019, Madison Borough was hit by an EF1 Tornado, lasting only about five minutes.[39] While the tornado only lasted for a short period of time the damages were extensive. The tornado produced 85-100 mile per hour winds, resulting in downed trees and utility poles, which called for a large cleanup from Madison Borough. Map 20 depicts the direct line of the tornado; and the areas that were in closest proximity to this line experienced the most damage. However, since the tornado was not declared as a disaster, Madison did not receive money from the Federal Emergency Management Agency (FEMA).

[39] Winter, J. 2019. "Madison looking at long recovery from 5-minute tornado." *Madison Eagle* November 14, Available online: https://www.newjerseyhills.com/madison_eagle/news/madison-looking-at-long-recovery-from-5-minute-tornado/article_0e88f55a-4ee5-5a89-bbcd-60ecabcfc4a2.html



Map 20. Tract for 2019 Tornado (the only Madison Tornado in the NOAA 1950-2021 database)

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http://www.worldclimate.com/
http://www.ncs

VIII. SOILS

Soil is made up of several components, including rock particles, organic material, air spaces between the particles, and water. The source or parent material of soil is either weathered bedrock at the site, or as in Madison, material carried to its present location by glacial ice and running water. Decaying vegetable and animal matter, the organic component, mixes with the rock particles. Air and water fill the spaces between this combination of mineral and organic substances, and the end result is soil. The soil scientist defines soil to include all four components, in whatever combination, existing on a specific site between the vegetative cover and the material that was little altered by the soil-forming process. It takes thousands of years for soil to become fully developed.

SOIL CHARACTERISTICS

The physical characteristics of soils vary depending on the parent material in which they develop, the climate and the topography. The mineral component of soil is made up of particles of sand, silt and clay in different proportions. Sand particles are the largest, silt and clay are the finest. Soils are classified according to the size and percentage of the particles they contain. Single soil classes seldom exist alone; they are usually a mix of sand, silt and clay. Soil scientists use terms like sandy loam, silt loam or clay loam to describe the texture of a soil. Loam soils, for example, contain 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. In most soils the organic content rarely amounts to more than 5 percent. A rough estimate can be made by observing the color of the soil. Usually, the darker the soil, the higher the percentage of organics. Gardeners know that adding organic material to soil improves its texture and ability to retain and supply water and nutrients to plants.

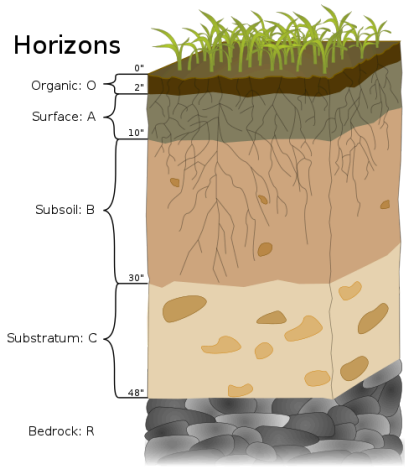


Figure X. Soil Horizons[40]

The relative amount of water and air in a soil depends on local precipitation and on the properties of the soil itself. As water moves down through the voids between soil particles, some is absorbed by the roots of plants and trees. Some of the rest eventually reaches the water table, below which all of the voids are filled. “The depth of water table below the surface of the ground varies with time, depending on long-term precipitation levels. In general, the water table reaches a high point in the late spring. The long-term average level of this high point is called the ‘seasonal high water table’. It can be determined at any specific location by color

[40] USDA. 2021. Soil Horizons. Available online: https://commons.wikimedia.org/wiki/File:Soil_Horizons.svg

changes in the soil. Longterm presence of water gives the soil a grayish color, whereas soil that has fairly steady exposure to air is a brownish or reddish color (Fraser and Morris, 1980).

Over a long period of time, water entering the soil shifts soil materials into layers called *soil horizons*, shown in Figure X. The coarsest particles in the topsoil are located in the A horizon. Clay particles are carried down into the subsoil (B horizon). The C horizon usually contains the parent material which has been changed very little by the soil-forming process. The sequence of natural layers in soil is called a *soil profile*. Engineers must be concerned with the deeper layers which remain after the topsoil has been removed from a construction site. Farmer and gardeners are more interested in the properties of the topsoil.

The infiltration capacity of a soil refers to the ability of water to enter and be transmitted through the soil when the soil is already moist. Well drained, coarse textured soils with high infiltration capacity minimize surface water runoff. Extensive root development in the surface layer also increases infiltration; bare, compacted soil increases runoff. The potential for soil erosion grows as runoff increases. "Erosion is a constant process…Even as soil is slowly built up through erosive processes in the subsoil, the topsoil is being washed away by the same erosive processes. The topsoil is the most precious part of the soil and any disturbance only accelerates the erosion" (Morris County Soil Conservation District, Environmental Newsletter 81-5). Topsoil is generated naturally at a rate of approximately one inch every 500 years. Unfortunately, New Jersey's rate of cropland erosion is the highest of all 11 northeastern states. Almost 5.5 million tons is lost annually, enough to blanket the entire city of Trenton with a layer 7.1 inches deep (Swackhammer, 1981). Some of this soil is permanently lost when it is washed into streams and rivers and eventually the ocean. The remainder is re-deposited elsewhere, leaving the area from which the soil eroded less productive and more prone to further erosion.

Analysis of Morris County soils is found in the *Soil Survey of Morris County, New Jersey* (1976, revised 1999), completed by the U.S. Department of Agriculture's Soil Conservation Service (SCS).

> The soil survey is a collection of aerial photographs…on which the distribution and kinds of soils are indicated. Detailed descriptions of each soil series found in the area are given as well as interpretations about the potential use of each soil for farming, roads, dwellings, recreation, septic systems, engineering uses, and other uses. Engineering properties such as depth to bedrock, seasonal high water table, percolation rate, drainage potential, shrink-swell potential, etc. are also included. Limitations for soil uses are expressed as slight, moderate and sever (Howell and Eby, 1981).

Slight means that soil properties are generally favorable for the intended use; moderate means that some soil properties are unfavorable but can be overcome by careful planning design and management at somewhat great costs; severe means that soil properties are so unfavorable and so difficult to correct or overcome as to require exceptional, complex or costly measures.

> The *Soil Survey* provides a detailed overview for use in general planning. Planning the actual location of a dwelling, a road, a septic system, etc. requires an onsite investigation to clarify exactly what is there…When looking at a site plan application, the reviewer uses the soil survey to determine the kinds of soil related limitations to be anticipated on a site, to plan needed onsite investigations, and to estimate the adequacy of the site plan to provide corrective measures (Howell and Eby, 1981).

The most updated soil information available for Morris County at the time of the 2011 ERI Update was retrieved through the "Web Soil Survey (WSS)" online application, which is produced by the National Cooperative Soil Survey and operated by the USDA Natural Resources Conservation Service (NRCS). NJDEP no longer produces soil GIS data, but relies on the USDA's resources. (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.)

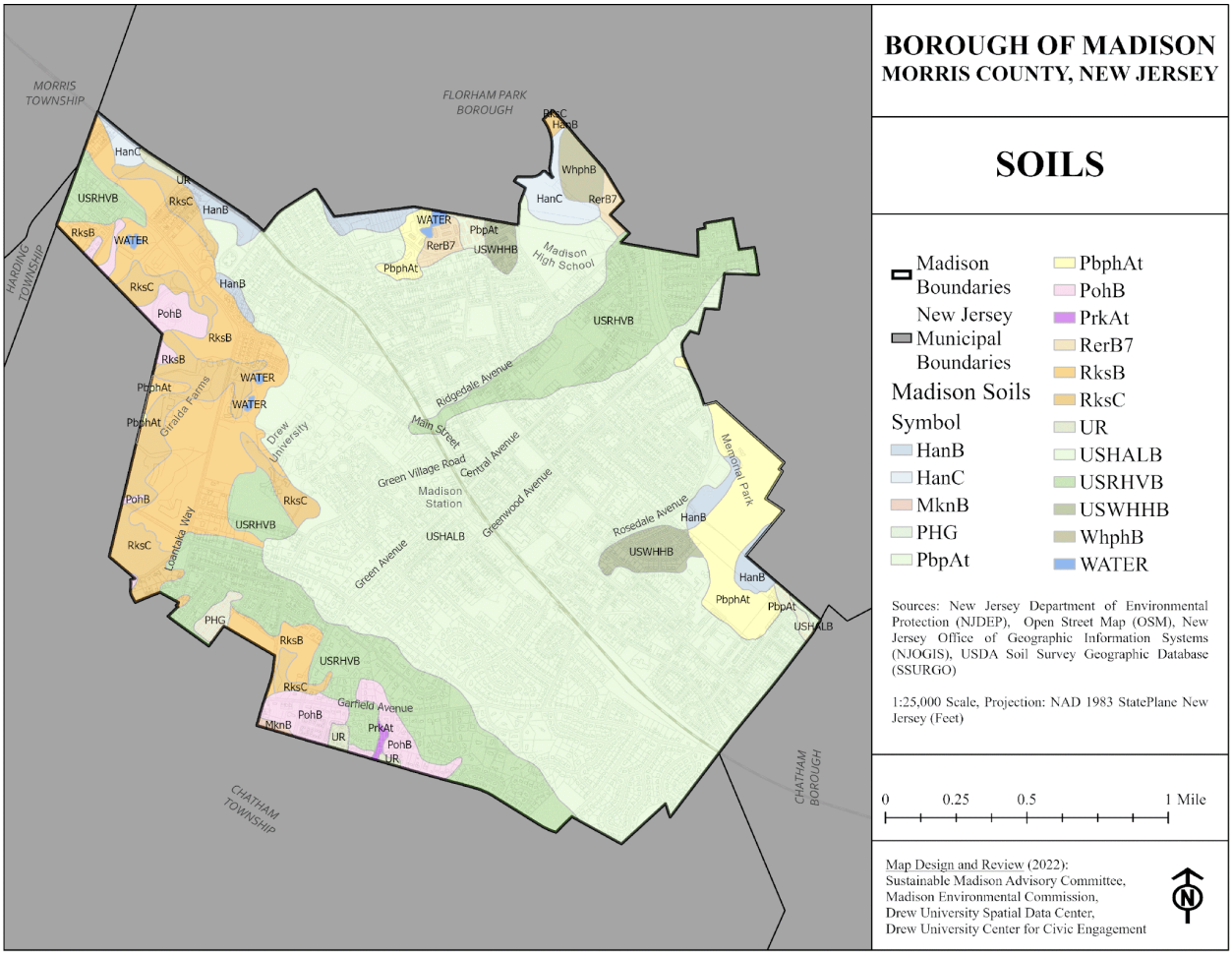
MADISON'S SOILS

The General Soil Map from the *Soil Survey* shows that Madison soils fall into two different soil associations: the Haledon-Urban land–Boonton association; and the Riverhead-Urban land-Pompton association. A soil association is a landscape with a distinctive pattern of soils, consisting of one or more major soils and several minor soils, and is named for its major soil.

The Haledon-Urban land – Boonton association are soils formed in young glacial till, and are characterized as "deep, well drained to somewhat poorly drained, gently sloping and strongly sloping silt loams, gravelly loams, and extremely stony loams that overlie basalt or shale; on uplands" (*Soil Survey*). More than two-thirds of Madison on the north side is mapped as Haledon-Urban land – Boonton association. The Riverhead-Urban land-Pompton association are soils formed in organic deposits, glacial lake sediment, or glacial outwash. This association is "deep, well drained to somewhat poorly drained, nearly level to strongly sloping gravelly sandy loams and sandy loams that overlie stratified outwash sand and gravel; on outwash plains and terraces" (*Soil Survey*). In Madison, the Riverhead-Urban land – Pompton association soils are located in a strip one-half mile wide in the southern part of the Borough extending in a northwest to southeast direction.

The soil associations may be further reduced into soil series and mapping units. These are shown in detail on **Map 21**, and also on Sheet 35 of the *Soil Survey*. Map 9 uses the SSURGO (Soil Survey Geographic Data Base) symbols. The comparison of the SSURGO and *Soil Survey* symbols is summarized in Appendix A of the *Soil Survey*. In Madison, the most common soils in the Haledon-Urban land – Boonton association are Urban land – Haledon complex (USHALB) and Urban land – Riverhead complex (USRHVB). The most common soils found in the Riverhead-Urban land-Pompton association are the Riverhead gravelly sandy loams (RksB), the Pompton sandy loam (PohB), and the Urban land-Riverhead complex (USRHVB). The following is a description of each soil series per the *Soil Survey*.

Urban land is soil that has been re-worked and the original soil profile cannot be adequately described. These occur in all areas that have already been developed and are not suited for other purposes.



Urban land – Haledon complex (USALB) – "This complex consists of poorly drained and well-drained soils that have a high proportion of silt and fine sand…The soil material is more or less gravelly and cobbly glacial deposits of material derived mainly from red and brown shale and sandstone, traprock, and granitic gneiss…The complex is about 40 percent cut and fill land and a nearly equal percentage of Haledon soils. About 20 percent is Boonton, Holyoke, and other soils." The Haledon soils have a dark-brown silt loam surface layer. In the subsoil, there is a brown, mottled silt loam, followed by a dark-brown, firm very fine sandy loam.

Urban land – Riverhead complex (USRHVB) – "This complex consists of well-drained, nearly level to strongly sloping sandy and gravelly soils. It is mainly on undulating outwash terraces…The underlying material is loose, unweathered, stratified and sorted sand and gravel outwash, mostly of granitics material that contains some shale, sandstone, quartzite, and conglomerate. Coarse fragments are mainly gravel and a few cobbles, but in places there are stones and boulders…This complex is about 55 percent soils that have been disturbed by man to the extent that the original profile no longer remains and 35 percent Riverhead soils. Making up the remaining percentage are areas of Otisville and Pompton soils." A description of the Riverhead soils is provided below.

Riverhead gravelly sandy loam (RKSB) – "The Riverhead series consist of well-drained, nearly level to strongly sloping gravelly soils… The soils formed in sandy and gravelly outwash derived mainly from granitic material that contains small amount of shale, sandstone, quartzite, and conglomerate… This soil is on wide terraces in

valleys and on knolls on broad, low outwash plains…" The Riverhead soils have a very dark grayish-brown gravelly sandy loam surface layer. Below the topsoil is a dark-brown gravelly sandy loam, a yellowish-brown gravelly sandy loam, and a yellow to pale brown gravelly loamy sand and loamy sand. The RmB and RmC have a yellowishred subsoil.

Pompton sandy loam (PohB) – "The Pompton series consists of deep, nearly level to gently sloping, somewhat poorly drained soils…They formed in sandy and gravelly glacial outwash derived mainly from red and brown shale and traprock and a small amount of other kinds of material, such as quartzite, sandstone, and conglomerate. The soils are underlain by stratified, water-sorted sand and gravel." The Pompton soils surface layer is a very dark grayish-brown sandy loam. The upper part of the subsoil is a yellowish-brown sandy loam and gravelly sandy loam. Below this is a yellowish-brown and light olive-brown, loose gravelly loamy sand.

Listing of Soils in Madison

Symbol	Soil Name	Slope	Acres	Pct Madison
HanB	Haledon silt loam	3 to 8	49.2	1.8%
HanC	Haledon silt loam	8 to 15	30.3	1.1%
MknB	Minoa silt loam	3 to 8	2.2	0.1%
PbpAt	Parsippany silt loam	0 to 3	12.3	0.4%
PbphAt	Parsippany silt loam, sandy loam substr.	0 to 3	102.6	3.7%
PohB	Pompton sandy loam	3 to 8	73.9	2.7%
PrkAt	Preakness sandy lam	0 to 3	2.2	0.1%
RerB7	Reaville deep variant channery silt loam	0 to 6	17.2	0.6%
RksB	Riverhead gravelly sandy loam	3 to 8	239.1	8.6%
RksC	Riverhead gravelly sandy loam	8 to 15	139.6	5.0%
UR	Urban land	--	9.2	0.3%
USHALB	Urban land-Haledon complex	3 to 8	1586.6	57.3%
USRHVB	Urban land-Riverhead complex	3 to 8	431.3	15.6%
USWHHB	Urban land-Whippany complex	0 to 8	38.8	1.4%
WhphB	Whippany silt loam, sandy loam substr.	3 to 8	19.4	0.7%
PHG	Pits, sand and gravel	--	8.4	0.3%
WATER	Water	--	5.1	0.2%
Total			**2,768**	**100.0%**

MADISON SOILS IN CRITICAL AREAS

Under Section 208 of the Clean Water Act passed by Congress in 1977, each state was required to develop area-wide land use plans to control non-point sources of pollution such as erosion and stormwater runoff. As a result, the *Water Quality Management Plan* (1979) was prepared under the auspices of the Department of

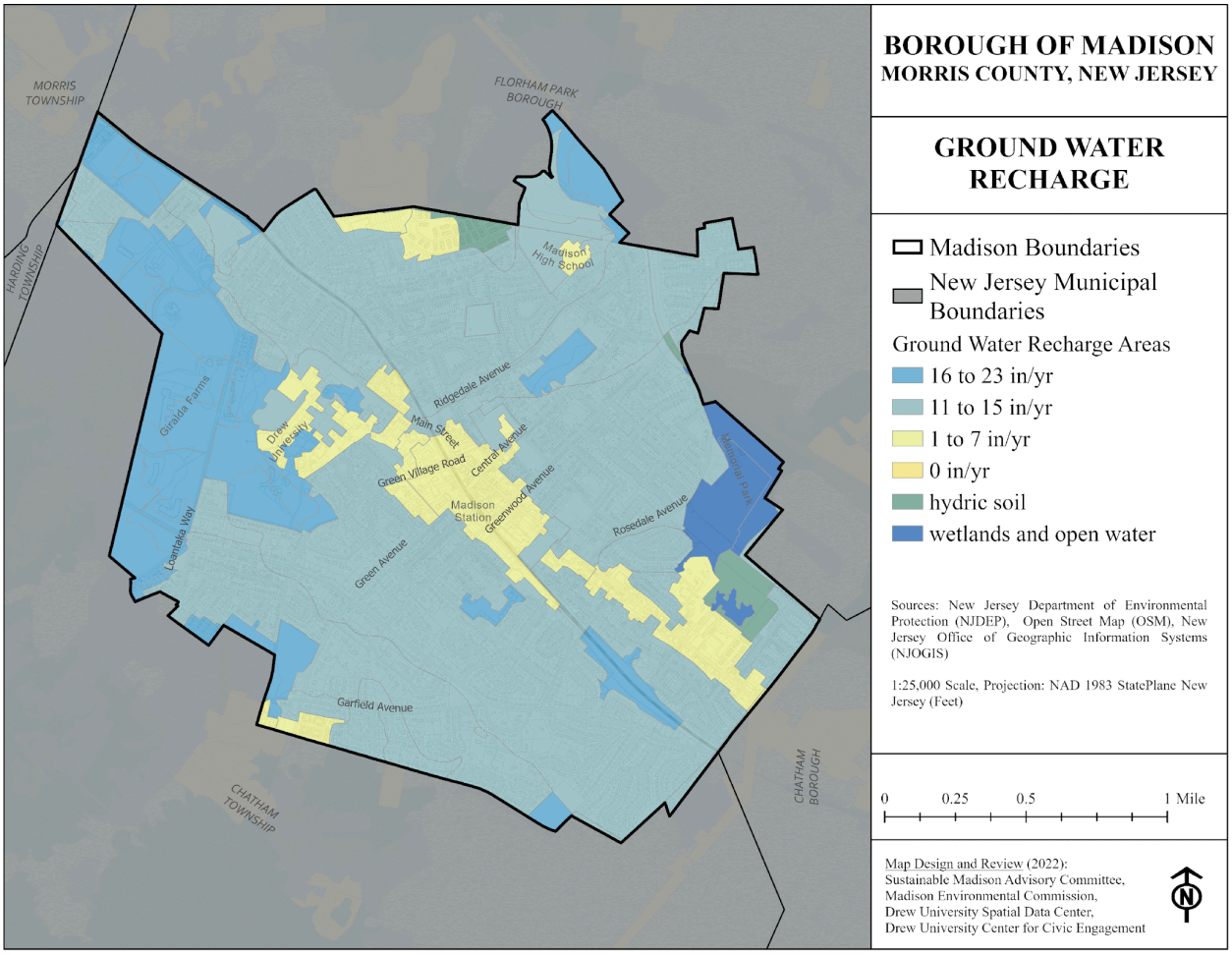
Environmental Protection, and approved by the Governor. It states that “in 208 planning, *critical areas* are sensitive natural lands and waters which when altered would lead to the degradation of water quality.”

The Water Quality Management Plan includes prime aquifer recharge soils such as Riverhead and Urban land-Riverhead, frequently flooded soils such as Parsippany, and water retention soils such as Pompton and Urban land-Whippany. A SCS soil scientist recommended that the Pompton soils be considered prime aquifer recharge soils instead of water retention soils because they are as permeable as the Riverhead soil in the substratum.

Clearly one of the important soils in Madison is the Riverhead that covers most of Giralda Farms, the land at the southwest corner of Loantaka Way and Woodland Road, the Madison golf course, the land between Garfield Avenue and Shunpike, and the land between Ridgedale and Central Avenues over to Greenwood Avenue at the Florham Park line. The main properties of this soil that affect its use are rapid permeability rates in the substratum, steep slopes, and a moderately high erosion potential. It should be emphasized that Riverhead soils are prime aquifer recharge soils. According to the N.J. Department of Agriculture soil scientist Mr. Shinder, “the hazard of groundwater pollution is severe because of subsurface layers of sand and gravel which are minimally effective in absorbing (retaining) major contaminants generally associated with urban development.”

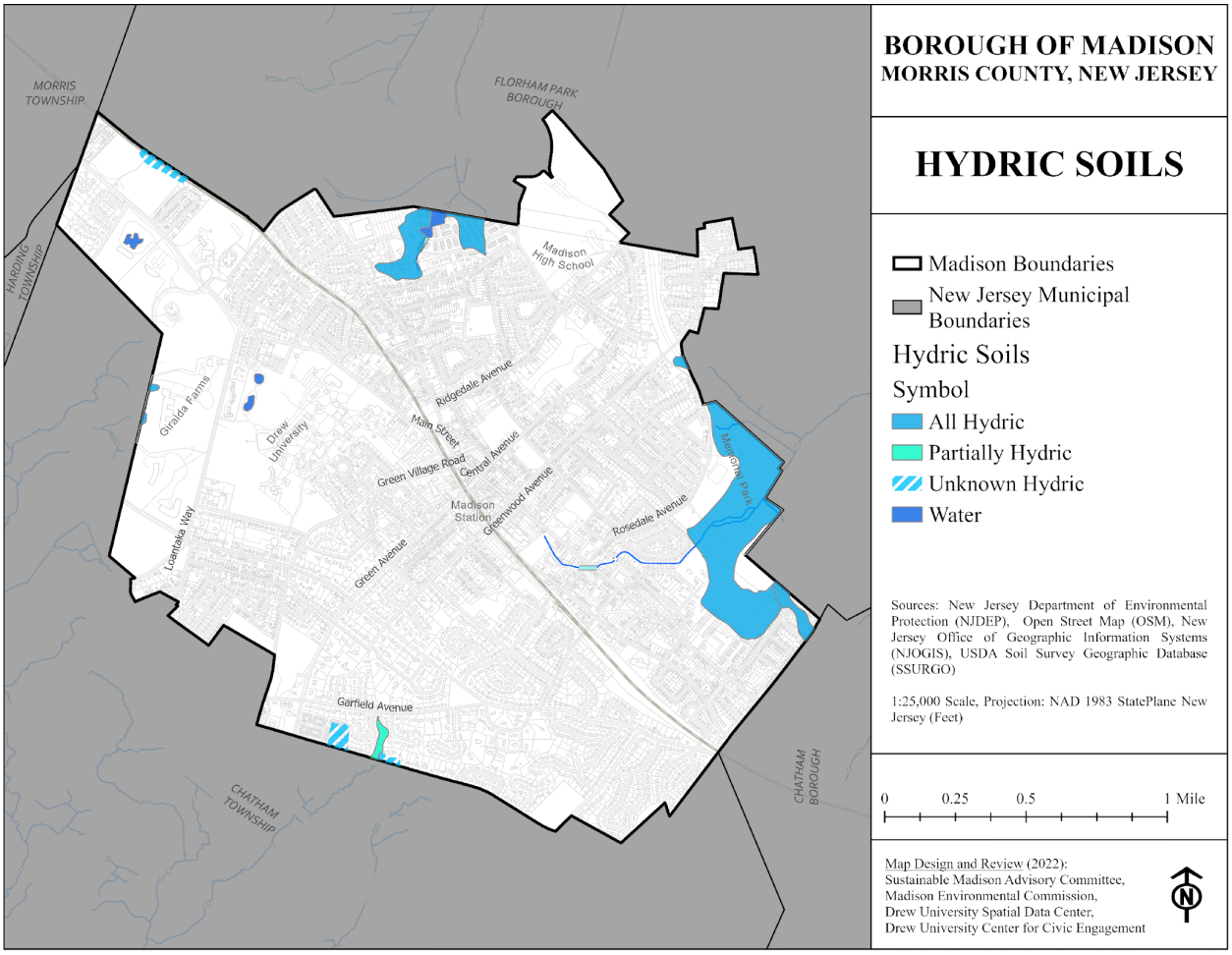
Another recommendation made by Shinder was for Urban-Haledon soils to be considered as potential aquifer recharge soils. As he explained, “these areas are called potential for two reasons: one, they are already built up and only a fraction is available for recharge; and two, the soil has a dense, restrictive layer of material below the surface which impedes the downward movement of water. As a result any aquifer recharge devices, such as retention ponds, infiltration trenches or dry wells would have to be constructed below this restrictive layer. In addition, the areas designated as Urban-Haledon have a seasonal high water table which, during wet periods, minimizes their suitability for potential aquifer recharge.”

In addition to soil types, three related measures relate closely to important soil characteristics. First, the Groundwater Recharge Areas Map (see **Map 22**) shows the wide variation in groundwater recharge rates throughout the Borough. As mentioned above, the Giralda Farms area has comparatively high groundwater recharge rates of 19 to 23 inches per year. Ground-water recharge (GWR) is defined as the water that infiltrates the ground and reaches the water table regardless of the underlying geology. It supports aquifer recharge, stream baseflow and wetlands.



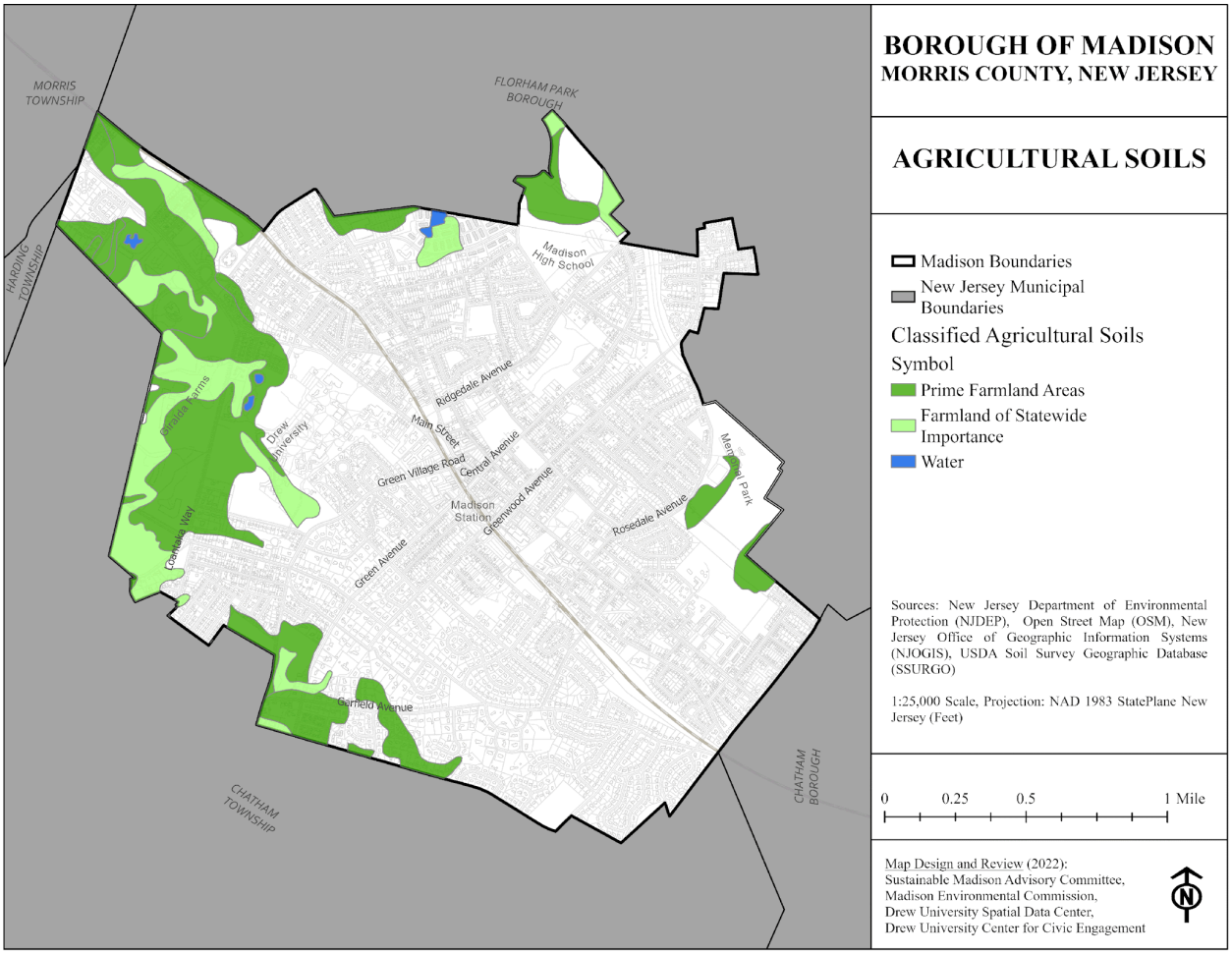
Map 22. Ground Water Recharge Areas in Madison

The Hydric Soils Map (See **Map 23**) illustrates how hydric soils are very limited within the Borough. As defined by the NRCS, a hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Soils that developed under sufficiently wet conditions can support the growth and regeneration of hydrophytic vegetation. Hydric soils maintain important functions in the environment as they have water holding capacity and also store more organic carbon.



Map 23. Hydric Soils and Water in Madison

Finally, soils of Prime Agricultural Importance are shown in **Map 24**. The northwesterly portion of the Borough has soil areas considered “prime farmland” and of “statewide importance.”



Map 24. Soils of Agricultural Significance Present in Madison

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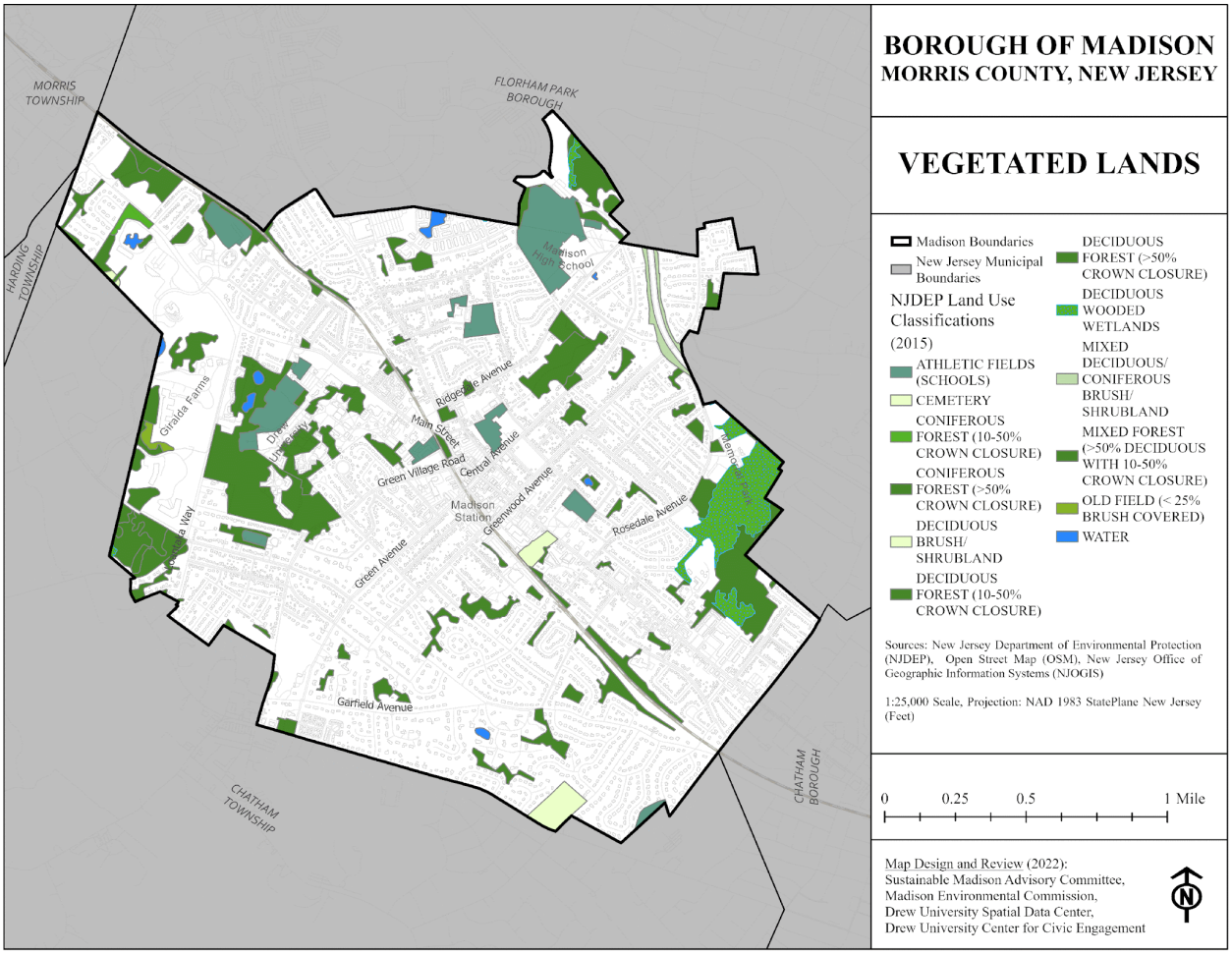
IX. VEGETATION

VALUE AND TYPE OF VEGETATION IN MADISON

Vegetation beautifies the community of Madison, anchors critical food webs that support biodiversity, and shelters songbirds and other wildlife. Aesthetic, recreational, and even psychological benefits of nature contribute to the Borough's quality of life. Vegetation also provides invaluable ecosystem services: minimizing flooding, controlling soil erosion, filtering water pollutants, recharging the groundwater that we drink, moderating extreme summer and winter temperatures, providing buffers against noise and visual pollution, storing greenhouse gases, and removing both particulate and gaseous air pollutants.

Viewed from above, the ecosystems of Madison are elucidated by **Map X** (Land Use/Land Cover), **Map 25** (Vegetated Lands), **Map X** (Open Space**)** and **Map X** (Impervious Cover). A close look reveals a variety of ecosystems which vary in their pollution-cleansing capacity, wildlife value, and biodiversity. Madison is lush with greenery, with a modest proportion of commercial development, primarily along Main Street, and almost no industrial land. Residential lands predominate, including extensive lawns and ornamental plantings. Open space includes recreational fields, a golf course, school campuses, a small cemetery, parks, and other patches of woods. The Borough has no agricultural lands. Old canopy trees can be found on residential, park, and conservation land; however, no old-growth, unlogged forests occur in the Borough. Mature, second-growth forest is present in several locations, described below, mostly in poor condition ecologically.



Map 25. Madison Vegetated Lands Described in New Jersey Land Use/Land Cover Dataset

Wetlands, which take the form here of wooded swamps rather than open marshes, are present toward the eastern end of Madison, in the 49 Acres open space tract, and in small pockets along intermittent streams. At least one vernal pool is present, in the Hepburn Woods section of the Drew University Forest Preserve. Vernal pools are wetlands that hold water only in the spring and support a distinctive group of amphibians and invertebrates. Ice-block depressions, locally known as punch-bowls or dells, punctuate the area. These small valleys do not hold water with the exception of two ponds in the Zuck Arboretum of the Drew University Forest Preserve that were lined with clay to retain water by previous landowners decades ago.

HISTORY OF MADISON'S ECOSYSTEMS

Before settlement by European-Americans, eastern North America was blanketed by forest, unbroken by open fields. Madison is situated within North America's Eastern Deciduous Forest formation, which extends from northern New England to southern Florida and westward to the prairies. Madison's pre-settlement ecosystems included oak-chestnut forest, albeit without chestnut trees lost to an invasive fungal disease decades ago, and maple-beech forest in rich soils. Forests were dominated by several species of oaks (chiefly red, black, white), American beech, sugar maple, tulip-tree, American chestnut, black birch, cherry, hickory, sassafras, and others. Wetter areas along Spring Garden Brook and other streams were dominated by red maple with pin oak, American elm, ash, swamp white oak, and sweet gum trees. These forests supported multiple layers of trees, shrubs, tree seedlings, ferns, wildflowers, with scattered patches of moss and woodland grasses. Standing dead trees and rotting logs provided valuable wildlife habitat.

The landforms, soils, and ecosystems of Madison were shaped by geological history (Chapter IV; Map 9). Madison lies within the geological region known as the Piedmont physiographic province, which is flanked by ancient Precambrian bedrock of the Highlands province to the northwest and by the younger sandy Inner and Outer Coastal Plains provinces to the southeast. Each of these regions is underlain by a distinct type of bedrock. Piedmont bedrock in is comprised of red sandstone and shale dating to the Cretaceous Period (65-135 million years ago) when dinosaurs and early mammals roamed together.

Even more influential for northern New Jersey ecosystems were multiple episodes of glaciations over the past two million years. The most recent glacial advance, which melted back from our region around 11,000 years ago, left behind a mosaic of soils and landforms atop bedrock. Map 9 (Surface Geology) shows that approximately 40% of Madison lies on deposits known as till, material laid down directly by glaciers, including a sizable area of terminal moraine, where the most recent glacial advance reached its southern terminus.

A smaller area formed at the bottom of ancient lakes, including the massive Glacial Lake Passaic; these clay-rich, poorly-drained lake deposits gave rise to wetlands in Madison as in the nearby wetland complex of the Great Swamp. Other lands were shaped by moving water as it flowed from the melting glacier, building glacial deltas similar to today's river deltas.

VEGETATION: ISSUES AND THREATS

Deforestation

New Jersey was almost completely deforested in the 1800's for farmland, timber, and fuel in the late 1700's through the mid-1800's. Few trees escaped the settler's axe, and ancient oldgrowth forests are extremely rare. The moist climate and young, fertile soils of northern New Jersey are favorable and supported the return of forest trees after logging. Studies show, however, that many wildflowers fail to return and that

forest composition is altered by forest clearance. The second-growth (i.e. post-logging) forests of northern New Jersey carry this historical legacy and tend to be depauperate in their diversity, even as they mature. Deforestation is again transforming the New Jersey landscape, this time driven primarily by suburban development since the 1950's. However, Madison has moved in recent decades moved to protect open space and to control impervious cover. Expanded construction footprints on residential lots have fallen under increased scrutiny. The 25-acre Loantaka Moraine open space was protected with Green Acres funding in 1994, and more recently two new parks, Gibbons Pines and Livesey Park, were established. In 2009 the Borough acquired and protected as 49 acres of open space, the Madison Recreational and Conservation Complex.

Invasive Plants

Unfortunately, Madison's forests are desperately degraded beneath the canopy with virtually no young trees to replace the current generation. Two major forces behind this devastation are overabundant deer and burgeoning loads of invasive plants.

Like other forests throughout of eastern and Midwestern North America, Madison's natural areas are threatened by the spread of non-native trees, shrubs, vines, and weeds. Not every introduced plant turns into an aggressive invader, but many reproduce and spread. Invaders have completely displaced ground layers of vegetation, eliminated tree reproduction, and transformed wildlife habitat throughout the Borough.

Among Madison's most problematic invaders, Japanese barberry transforms soil nitrogen to a form unavailable to woodland wildflowers; garlic mustard inhibits beneficial fungi required for establishment of tree seedlings; Norway maple suppresses diversity of shrubs and wildflowers; bittersweet and wisteria literally strangle trees and so convert forests to tangles of shrubs and vines. Scientists consider such biological invasions by plants, animals, and microbes to rank among the top threats to biodiversity worldwide. The consequences cascade throughout the food web with damage to beneficial insects and both migratory and nesting birds. Only by tackling these problematic plants can Madison hope to preserve its forest ecosystems and their beneficial services. Land managers across the state and the nation are fighting to control invasive plants. In Madison, such projects are underway in Central Green, Madison Recreational Complex (MRC), and the Drew University Forest Preserve at this time. Several states and many towns restrict the sale and planting of damaging invasive plant species.

Federal agencies and regional organizations provide detailed, up-to-date listings of invasive plants, including those of our area. New invasive plants emerge continuously; for example, the notorious southern vines kudzu and mile-a-minute plant have appeared only recently in New Jersey. Thus, current reports and websites should be consulted before plantings are made. Examples include: the Early Detection and Distribution Mapping System - EDDMapS (https://www.eddmaps.org/), the Mid-Atlantic Invasive Plant Council's database (http://www.invasive.org/maweeds.cfm) and information from the New Jersey Invasive Species Information Center (https://www.invasivespeciesinfo.gov/us/new-jersey).

Invasive Plants Currently Problematic in Madison

Trees:

- Norway maple (*Acer platanoides**)
- Sycamore-leaved maple (*Acer pseudoplatanoides*)
- Tree of heaven (*Ailanthus altissima*)
- Princess tree (*Paulownia tomentosa*)
- Black locust (*Robinia pseudoacacia*)

- Callery pear (*Pyrus calleryana**)

Shrubs:

- Japanese barberry (*Berberis thunbergii**)
- Burning bush (*Euonymous alata*)
- Privet (*Ligastrum vulgare*)
- Honeysuckle – shrubs (*Lonicera maackii, L. tartarica*, most others)

Vines:

- Japanese honeysuckle (*Lonicera japonica*)
- Oriental bittersweet (*Celastrus orbiculatus*)
- Wineberry (*Rubus phoenicalasius*)
- Wisteria, Japanese and Chinese (*Wisteria sinensis, Wisteria floribunda*)
- Multiflora rose (*Rosa multiflora*)

Herbaceous Plants:

- Purple loosestrife (*Lythrum salicaria*)
- Lesser celandine (*Ranunculus ficaria*)
- Garlic mustard (*Alliaria petiolata*)
- Japanese knotweed (*Fallopia japonica*)
- Japanese stilt grass, also called Nepalese brown top (*Microstegium vimineum*)
- Mugwort (*Artemesia vulgaris*)

* All cultivars, forms, and varieties of Norway maple, callery pear, and Japanese barberry are invasive.

Note: Consult internet sources above for updates on invasive species

The white-tail deer problem:

Another serious threat to Madison's vegetation is the white-tailed deer, whose large and growing population destroys both ornamental and wild plants. Field surveys in 2011 show that deer have eliminated most wildflowers, native shrubs, and tree seedlings from wooded lands in the Borough. Losses of ornamental plantings are substantial, and frustrated residents despair for their gardens across the state and the region. Deer are thriving not only because of a lack of predators but also because of a steady, healthy early-spring diet of grass and plantings, available long before food emerges in their natural habitat. Madison deer are known to give birth to triplets and to have two litters per season. Controlling deer damage is difficult in a populated community such as Madison. Protective deer fencing is permitting woodland recovery in small areas within the Madison Recreational Complex and Drew Forest Preserve. Similar protection combined with restoration plantings and invasive species removals are recommended for management and protection of wooded parks.

Threats from insects and disease:

Today a growing rogue's gallery of damaging insects and fungal pathogens threatens wooded areas and shade trees of the region. The invasive gypsy moth attacks oaks in particular and is deadly if outbreaks are repeated. The hemlock woody adelgid insect has nearly eliminated hemlock trees from our forests, parks, and gardens. The Asian long-horned beetle rapidly kills maples and many other deciduous hardwood trees; for example, the city of Worcester MA lost 25,000 shade trees in 2008. The emerald ash borer, an insect

lethal to the widespread genus of ash trees, has reached 15 states at the time of this report including Pennsylvania and the Hudson Valley of New York State. Other problems on the horizon include sudden oak death and beech bark disease.

ECOSYSTEM TYPE 1. LAWNS, FIELDS AND GARDENS

Madison's lawns and gardens contribute greatly to the town's beauty and quality of life. An annual May Day in Madison event brings the community together to plant, mulch, and beautify public plantings throughout the Borough. These vegetated areas all help control runoff and erosion, while promoting groundwater recharge.

Most of Madison's parks feature grassy lawns, some with shade trees and ornamental plantings: Cole Park, James Park, Edwards Field, Madison Park, Niles Park, Gibbons Pines, Livesey Park. Lawns comprise portions of other parks including Memorial Park, Summerhill Park, and the Madison Recreation and Conservation Complex. Open fields also occur on private property, not only in residential areas but also within the Giralda Farms office park, the Madison Golf Course, and campuses of public and private schools and universities. Athletic fields are depicted on **Map X** (Open Space).

Lawns and fields must be carefully managed if threats to water and air quality are to be minimized. Alternative low-maintenance ground covers are worth encouraging where possible, for the sake of environmental quality (Bormann et al. 1995: "Redesigning the American Lawn").

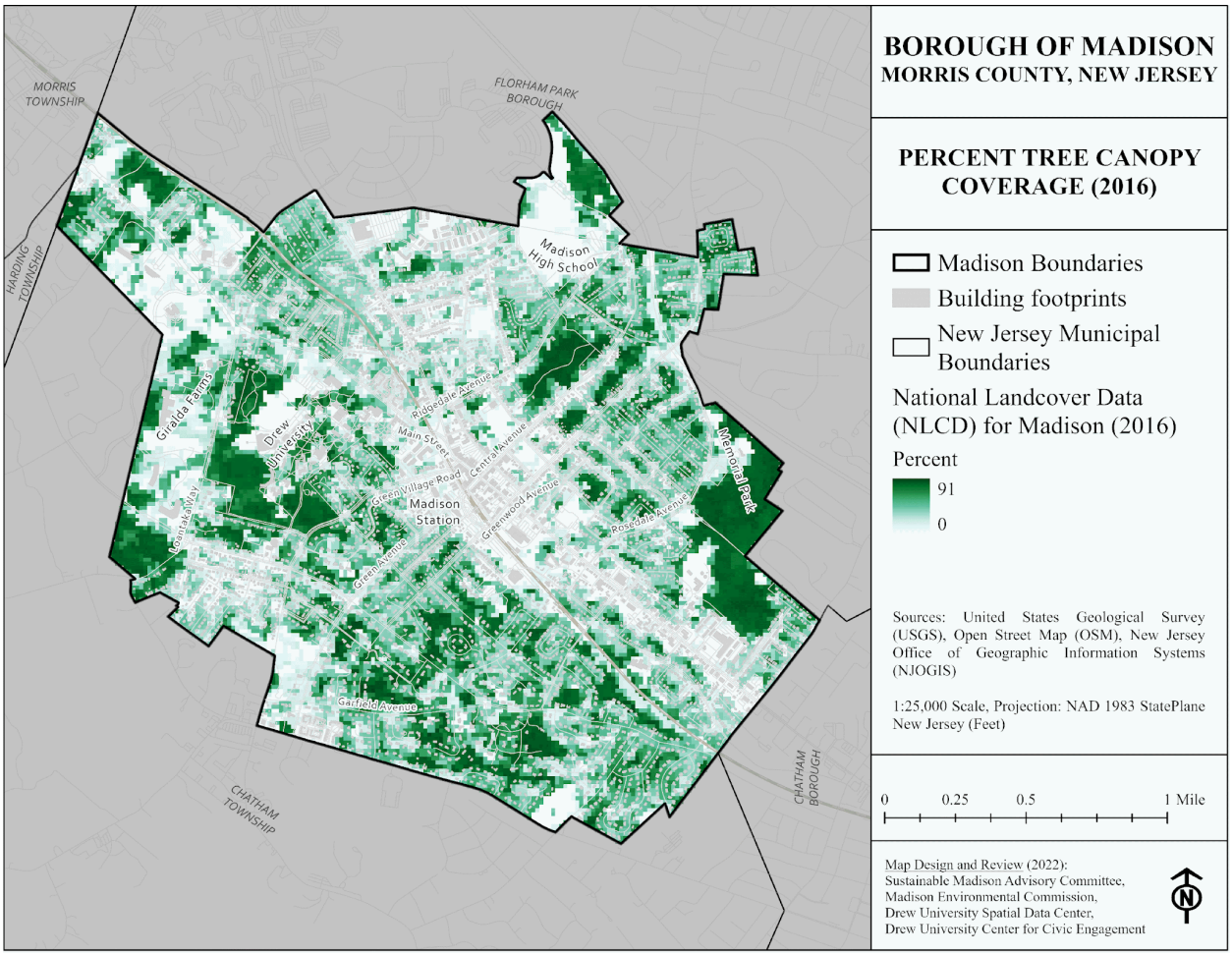
1. Lawns are treated, often excessively and unnecessarily, with chemical pesticides, particularly herbicides (which target weeds) but also fungicides and insecticides. Accurate information about pesticide toxicity is not widely available.
2. Fertilizers also move through the ecosystem and pollute waterways. They contaminate groundwater and promote explosive algal growth and a concomitant deletion of dissolved oxygen, to the detriment of aquatic animal life, and can contaminate groundwater. More fertilizer and pesticide pollution is produced per acre by lawns than by farmlands. To protect water quality, New Jersey passed in 2011 a law to regulate fertilizer application for these reasons. Information is provided at http://www.nj.gov/dep/healthylawnshealthywater.
0. Lawn mowing and leaf-blowing cause air pollution. The relatively inefficient engines of lawn machinery emit more greenhouse gases, acid rain precursors, and respiratory hazards than most vehicles today. Mechanized leaf blowers produce particularly high levels of noise pollution. Some communities, like Summit, New Jersey, have adopted regulations setting pollution standards on lawn machinery.

Ornamental garden plantings are highly beneficial to Madison's environment. They can pose a surprising environmental concern when dominated by non-native plants. Some egregious invasive plants including barberry and purple loosestrife are still sold and commonly planted. Many benign shrubs and vines emerge as invaders after a lag period of good behavior. It is difficult to predict which will turn malignant. Even those non-native plants that are not invasive provide at best an ecological dead zone. A move toward native plants would help fight the spread of invasive plants into natural areas and would help to restore elements of the lost forest ecosystem that once covered Madison (Recommended source: "Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens" by D.W. Tallamy, and his Homegrown National Park website: https://homegrownnationalpark.org/).

By emulating the region's natural areas, gardeners can promote butterflies, birds, and other desirable native wildlife. A demonstration area of native plantings in lieu of lawn is found on the Drew University campus, where students each spring convert a section of sod to a diverse ecosystem of native ferns, shrubs, and wildflowers. Information about native plant sources and benefits is available from the New Jersey Native Plant Society of New Jersey (http://www.npsnj.org/).

ECOSYSTEM TYPE 2: MADISON'S SHADE TREE POPULATION

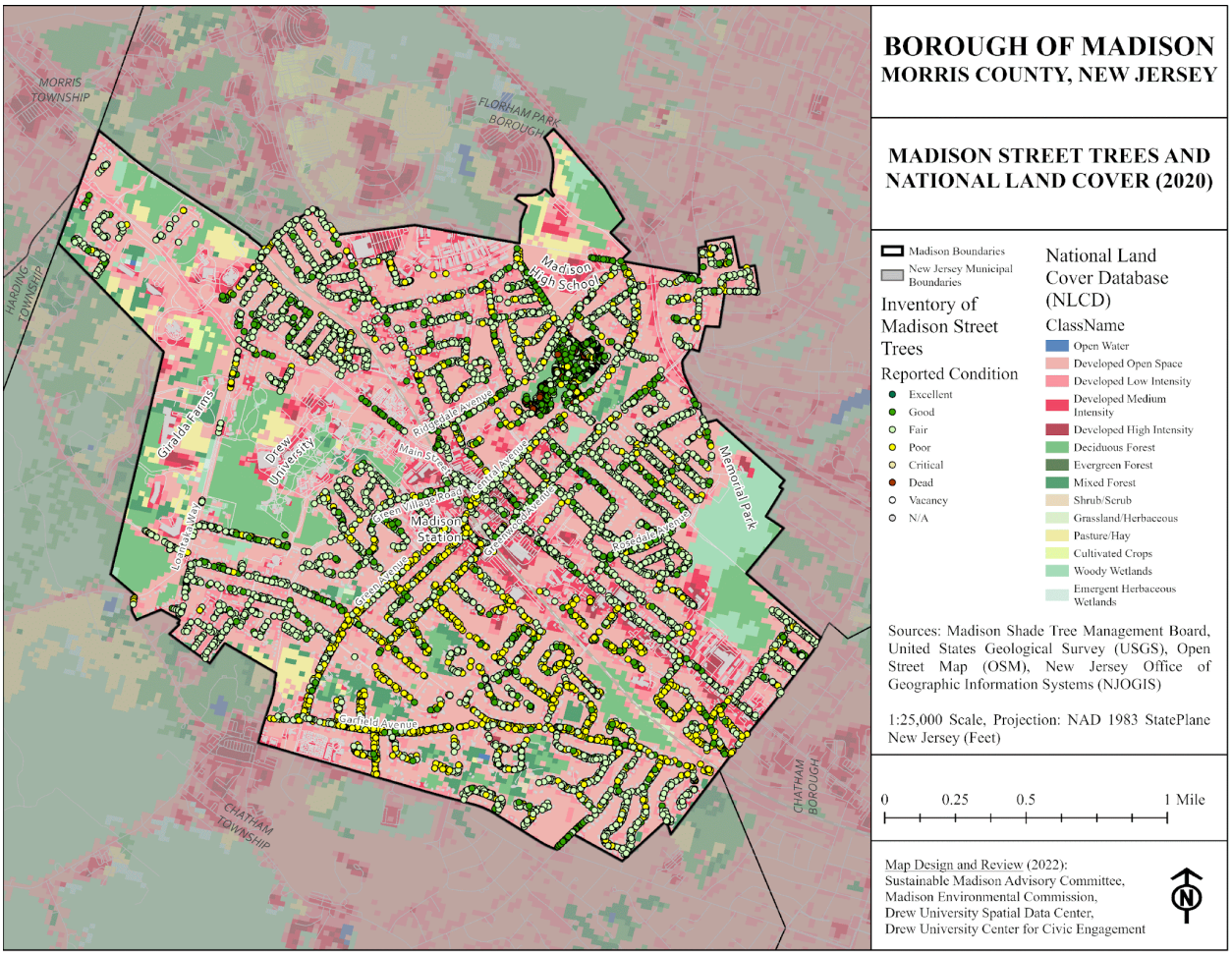
Madison's shade tree population adorns Borough streets, public buildings, parks, campuses, and private property (See **Map 26**: Tree Canopy). It includes intentional plantings, "volunteer" trees that reproduce on their own, and old trees persisting from before land development. Together these trees form a living matrix of greenery throughout the Borough. However, even in grassy suburbia, street trees face stresses from road salt, weed killers, competing lawn grasses, and drought exacerbated by warmer microclimate of open sites. Unnecessary losses also result from digging in the root zone for construction, utility work, and landscaping. Sensitive roots extend out from the trunk to (and beyond) the extent of the tree's branches and crown – the so-called drip zone.



Map 26. Madison Tree Canopy Derived from the USGS National Landcover Dataset

A population over 7,000 trees representing 178 different species provides shade on public lands and street rights-of-way of Madison. Many, though not all, are depicted in the 2021 Arbor Pro inventory displayed in

Map 27. Thousands more grow on private property but have not been inventoried. This summary focuses on the shade trees of public lands and of the street rights-of-way throughout the Borough. In these locations, Madison's active Shade Tree Management Board and its affiliated fund-raising group, the Friends of Madison Shade Trees, maintain a tree database and have planted approximately 105 trees per year for the past decade (source: Peggy Garman, Madison Shade Tree Management Board).



Map 27. Distribution and Condition Madison Street Trees and Land Cover

The composition of the shade tree population is a mixture of native trees (52% of individual trees) and trees introduced from other lands or from other parts of North America (48%). A large subset of non-native trees are invasive species that spread into natural areas (28% of all trees; see table), mostly Norway maple (675 trees), widely planted before its threat was recognized, and Callery pear (383 trees).

As noted above, the national trend toward using native species is recommended for Madison, because of damage when exotic plants spreading into natural areas and because even non-invasive species from elsewhere cannot enhance ecosystem functioning and biodiversity as native trees do.

Borough Shade Tree Population, July 2011	**No. Species***	**% of Species**	**No. Trees****	**% of Trees**
Native species	29	26%	3526	52%

Invasive species	13	11.5%	1883	28%
Other non-native species (not invasive)	70	62.5%	1442	20%
Total	**112**		**6751**	

** Cultivars and varieties within a species were combined for this tabulation*
*** Total excludes 170 trees identified only to genus for this tabulation*

Forest diversity

Another important goal is a diversified population of shade trees. Madison's shade tree population is rich in diversity, with 112 species along streets and on public lands. Many streets are, however, planted with a single species, mostly as a legacy from times before the risks became apparent. Such risks are well demonstrated in the case of Dutch elm disease. Many eastern and Midwestern towns lost entire shade tree populations to this disease because only elms had been planted. Moreover, Dutch elm disease spread rapidly through roots of adjacent trees. The landscape was stripped of its shade trees, and costs of massive tree removals drained local budgets, leaving few funds for replanting.

Pathogens and insect pests of trees

A key environmental concern is how to deal with insect pests and pathogens that attack trees. School grounds are managed, by New Jersey law, to minimize use of chemical pesticides, following the practice known as Integrated Pest Management (IPM). IPM deploys knowledge of pests and their life cycle, knowledge that permits more targeted control efforts and that prevents ineffective treatments. For private and other public lands, IPM and its components are well worth implementing. Pesticides vary widely in their toxicity and effectiveness, but many damage human health, water quality, and natural ecosystems. For example, elsewhere in the New York region, heavy spraying with malathion to battle the west Nile virus polluted Long Island sound and killed off seafood populations. With some pests, trees withstand defoliation without pesticides and resprout a new crop of leaves during the same season. In other cases, pest attack will be lethal and pesticide use cannot help. The nonprofit organization Beyond Pesticides provides helpful information about pesticide choices and risks (http://www.beyondpesticides.org).

Choosing shade tree species:

Decisions about which trees to plant in the Borough, on public and private lands, should take into account the benefits of native species (see table); the problem of invasive species (detailed above), insect enemies, and diseases. Ecological conditions should be matched carefully with the requirements of particular tree species, explained in the US Forest Service's report, "Silvics of North America."[41] Another key consideration is global warming which is changing the geographic ranges where individual species can thrive. In its Climate Change Atlas, the U.S. Forest Service has mapped projections of where our native trees will be thriving in the future under several greenhouse-gas scenarios (https://www.fs.usda.gov/ccrc/tool/climate-change-tree-atlas). To minimize losses, common sense suggests that trees at the southern edge of their range should be avoided, while trees with drought- and heat-tolerance should be favored.

Native Trees for Planting in Northern New Jersey

[41]USFS. 2016. Silvics of North America. Available online: https://web.archive.org/web/20160221095400/http://www.na.fs.fed.us/spfo/pubs/silvics_manual/table_of_contents.htm

Note: common names and genus names are often shared by unrelated trees from distant origins. Only the specified species are recommended native choices.	
Trees: Common Name (synonyms in parentheses)	**Scientific Name**
ash, black[1,3]	*Fraxinus nigra*
ash, green[1]	*Fraxinus pennsylvanica*
ash, white[1]	*Fraxinus americana*
aspen, bigtooth	*Populus grandidentata*
aspen, quaking	*Populus tremuloides*
basswood, American	*Tila americana*
beech, American	*Fagus grandifolia*
birch, black (sweet birch)	*Betula lenta*
birch, grey	*Betula populifolia*
birch, river	*Betula nigra*
birch, yellow	*Betula lutea*
black walnut	*Juglans nigra*
box elder	*Acer negundo*
butternut	*Juglans cinerea*
cedar, Atlantic white	*Chaemcyparis thyoides*
cedar, eastern red	*Juniperus virginiana*
cherry, black	*Prunus serotina*
cherry, pin	*Prunus pensylvanica*
chestnut, American [1]	*Castanea dentata*
dogwood, flowering [2]	*Cornus florida*
elm, American [1]	*Ulmus americana*
elm, slippery (red elm) [1]	*Ulmus rubra*
gum, black (sour gum, tupelo)	*Nyssa sylvatica*
hackberry, northern	*Celtis occidentalis*
hemlock, eastern[1]	*Tsuga canadensis*
hickory, bitternut	*Carya cordiformis*
hickory, mockernut	*Carya tomentosa*
hickory, pignut	*Carya glabra*
hickory, shagbark	*Carya ovata*
hornbeam (blue beech) [2]	*Carpinus caroliniensis*
ironwood (hop hornbeam) [2]	*Ostrya virginiana*
maple, red	*Acer rubrum*
maple, silver	*Acer saccharinum*
maple, sugar	*Acer saccharum*
mountain ash, American	*Sorbus americana*

mulberry, red	*Morus rubra*
oak, black	*Quercus velutina*
oak, chestnut	*Quercus montana*
oak, chinquapin [2]	*Quercus muelenbergii*
oak, northern red	*Quercus rubra*
oak, scarlet	*Quercus coccinea*
oak, southern red [4]	*Quercus falcata*
oak, swamp white [3]	*Quercus biflora*
oak, white	*Quercus alba*
oak, willow[4]	*Quercus phellos*
persimmon, common	*Diosporys virginiana*
pine, eastern white	*Pinus strobus*
pine, pitch	*Pinus rigida*
pine, shortleaf[4]	*Pinus echinata*
pine, Virginia[4]	*Pinus virginiana*
redbud, eastern	*Cercis canadensis*
sassafras	*Sassafras albidum*
serviceberry (shadblow, juneberry) [2]	*Amelanchier spp.*
sweetgum	*Liquidambar styriciflua*
sycamore, American (buttonwood)	*Platanus occidentalis*
tuliptree (yellow poplar)	*Liriodendron tulipifera*
willow, black [3]	*Salix nigra*

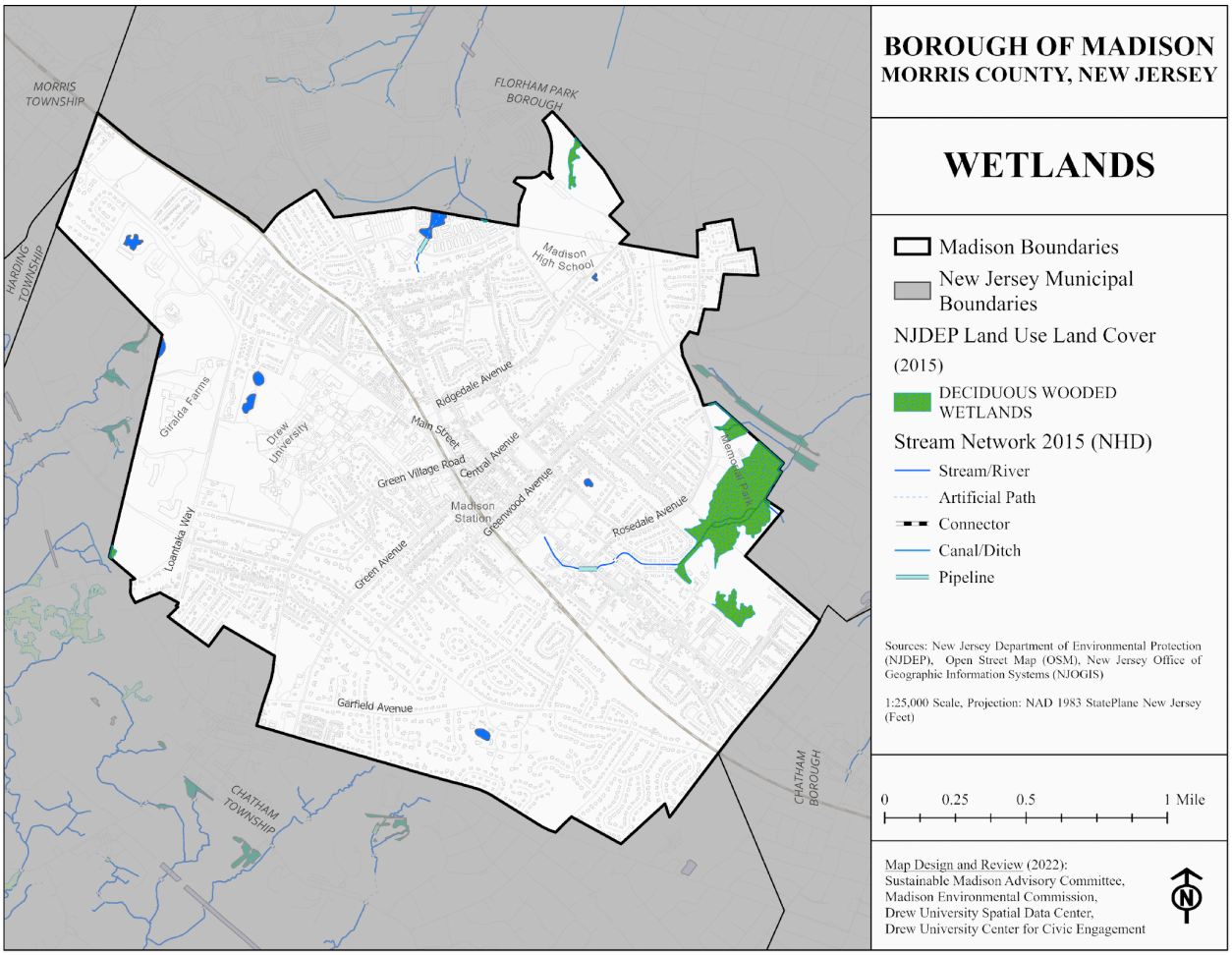
1. = Susceptible to deadly insects or pathogens
2. = Small tree
3. = Wet sites only
4. =Native to areas somewhat south of Madison

ECOSYSTEM TYPE 3. NATURAL VEGETATION: FORESTS AND WETLANDS

In addition to lawns, fields, gardens, and shade trees, Madison has several small but important remnants of natural vegetation in the form of forests, including wetland swamps. Within a suburban matrix of managed lands, forests are reservoirs of biodiversity that improve environmental quality. Below, several parks and other forested lands are described with emphasis on ecological conditions and environmental problems. (Chapter on Open Space provides a more complete list of parks and open space). These forests all exhibit overall decline in ecological integrity and diversity.

Memorial Park, Madison Wetlands, and Delbarton Area: In addition to athletic fields, the town pool, a playground and picnic grounds, Memorial Park includes forests, which continue into the adjacent Madison Wetlands conservation area and the Delbarton Area (see **Map 16**: /Open Space). These woods are wetland swamps (see **Map 28**: Wetlands), forming a floodplain for Spring Garden Brook. Tree roots and litter effectively bind the soil against erosion and filter out pollutants washed from the streets in the central and northeastern sections of Madison. When stormwater recedes, it gradually drains back into the channel of

Spring Garden Brook. This wooded floodplain is invaluable for controlling flooding here and also downstream in the floodprone Passaic River. Red maple, the tree of the Great Swamp, is most abundant, with other trees of wetlands (elm, swamp white oak, silver maple, ash, pin oak, box elder, and some sycamore) and uplands (shag-bark hickory, white oak, beech, black cherry, back walnut, tulip-tree, black birch, shag-bark hickory, sour gum) growing on lower and higher ground, respectively.



Map 28. Wetlands in Madison

Beneath the canopy, much has been lost. An impressive list of native wildflowers was recorded in 1982 by botanist Florence Zuck, who observed spring beauty, trout lily, wild geranium, blue lobelia, star-flowered false solomon's seal, dog-violet, blue flag iris, wood anemone, pink lady slipper orchids, Canada mayflower, partridge berry, spotted wintergreen, and eight species of asters. By 2011 these plants had all but disappeared. Also lost or declining since that time are native shrubs: arrow-wood, black haw, shrub dogwoods, maple-leaf viburnum, blueberry, maleberry. Here and elsewhere, a decline has occurred for spicebush, once ubiquitous throughout the region's forests. The list of native species thriving today in the forest understory is small: wetland taxa such as skunk cabbage and lizard's tale (Saururus cernuus) as well as widely scattered, Virginia creeper, jack-in-the-pulpit, wild grapevine, poison ivy, blackberry, stinging nettle.

As native vegetation disappeared beneath the canopy, invasive plants moved in. Most conspicuous in early spring is the invasive lesser celandine (Ranunculus ficaria), whose lovely yellow flowers resemble those of the native marsh marigold but with a Eurasian origin and with tenacious roots that spread aggressively. Other invaders include shrubs (barberry, burning bush, shrub honeysuckles), vines (Japanese honeysuckle,

multiflora rose, wineberry), and herbaceous plants (Japanese knotweed along roadsides and stream beds, mugwort in open areas, garlic mustard everywhere). Alongside these invasive "weeds in the woods," lawn weeds thrive along trails and in openings. Amongst the trees, the invasive Norway maple tree has a growing presence, encroaching from the east; other invasive trees are black locust and tree-of-heaven. As elsewhere Memorial Park is witnessing the combined effects overly successful deer and explosive plant invasions.

Central Green a park whose protection owes thanks to efforts of neighborhood residents, follows a stream and serves to store runoff from adjacent streets and properties. Predominating is a swamp floodplain community of native elm, silver maple, red maple, pin oak, swamp white oak, and box elder. Alongside these wetlands, upland zones support native sassafras, red oaks, white oaks, and cherry trees. Some trees are quite large in both wet and upland areas. Madison's Parks Advisory Committee is working to control an alarming infestation of invasive Japanese knotweed. Other invaders include barberry, garlic mustard, stilt grass, English ivy, bittersweet, wisteria, and multiflora rose. Under the leadership of Cathy Coultas, teams of volunteers have battled invasive plants over a period of years, with support from SLAP (Sheriff's Labor Assistance Program), and with grants for native plants from the Madison Garden Club. Native plants now present in the understory include Christmas fern, New York fern, spice bush, red bud, juneberry (Amelanchier), native viburnum shrubs, violets, and Virginia creeper. Knotweed, extremely difficult to eradicate, is still present, and herbivory by deer is high.

Summerhill Park encompasses lands of great interest historically, the site of greenhouses from the days when Madison earned its nickname "The Rose City." Old greenhouse foundations remain for exploring, overrun by a tangle of native and invasive trees, shrubs, and vines. Open mowed fields mark old homesites while woods have closed in across much of the land. Little remains of the early-successional brambles (blackberry, cat brier) and field weeds such as ragweed, Queen Anne's lace, pokeweed, and goldenrod that were still abundant in 1980. A legacy of ornamental trees and shrubs includes planted conifers (Norway, Colorado blue, and white spruce; white, scots, and Austrian black pine; cypress; douglas fir) and hardwoods (horse chestnut, white mulberry, black locust, Norway maple [in modest numbers]). Most distinctive among Madison's parks is a large population, including seedlings, of the invasive sycamore maple (Acer psuedoplatanoides). Ornamental shrubs include non-invasive lilac, spirea, siebold viburnum, and spirea shrubs as well as invasive barberry and burning bush. Worrisome infestations have begun for Norway maple, knotweed, oriental bittersweet, and wisteria. English ivy, a known threat to tree survival, is beginning to climb from old foundations into canopy trees. As elsewhere, native wildflowers, ferns, and shrubs are sparse. Majestic native trees remain from before the demise of the rose-growing industry, representing most notably white ash, silver maple, and black walnut. This park with its historic importance also has value for public education about the environment.

Parkside Park is a small wooded tract enhancing a residential neighborhood. Conditions are seasonally moist in some areas, with soils showing some evidence of flooding and with conspicuous presence of wetland trees: red maple, American elm, box elder, and ash. Other native trees such as black walnut are more mesic in habitat. The major threat is the invasive Norway maple tree, the most abundant tree species present. Below the canopy, invasive multiflora rose vines are abundant, alongside interspersed patches of invasive Japanese honeysuckle vines and of non-native (but non-invasive) periwinkle. Other conspicuous invasive plants include garlic mustard and wineberry. Trees are not reproducing in the shade of Norway maple, and few native species appear: poison ivy, pin cherry, jumpseed, and white snakeroot.

Belleau Woods is a small wooded park in a neighborhood of relatively high residential density. Like Central Green, this park surrounds a creek and includes wetland areas dominated by floodplain trees such as red maple, elm, box elder, swamp white oak, black ash, and pin oak. Drier upland areas around the park's boundary support black walnut, black locust, cherry, and the beginning of a Norway maple invasion.

Alongside native poison ivy and Virginia creeper vines, the invasive Japanese honeysuckle vine forms extensive patches, and the difficult Japanese knotwood is beginning to spread. Other invaders include multiflora rose, garlic mustard, privet, wineberry, and mugwort. A few native plants are present and available to seed a recovery if protected from deer: Virginia creeper, wild grape, jewel weed, dogbane.

Library Woodlands is a small, stream-side conservation area located between the Madison Public Library and Pomeroy Road, a gem of natural forest that is home to some of the largest white oaks and red oaks in Madison. The canopy layer of the Library Woodlands is a mixture of native deciduous trees, with American beech perhaps most abundant amongst the taller trees. Other mature trees include black birch, hickory, red maple, and the invasive Norway maple. Beneath this diverse canopy, a well-developed subcanopy of young Norway maples suggests that this invasive tree species will dominate the next generation; a few native beech and black cherry saplings are also present. The forest floor is mostly bare, punctuated with patchy undergrowth: large, expanding patches of pachysandra, a garden escapee; smaller mats of the invasive lesser celandine and invasive garlic mustard; and a new colony of Japanese barberry; and everyone's favorite native plant, poison ivy.

Drew University Forest Preserve, including Hepburn Woods and Zuck Arboretum: The campus of Drew University includes both ornamental vegetation and natural woodlands. The Drew University Forest Preserve (45 acres) is the largest expanse of woodland in Madison, officially established in 1956 in response to a joint proposal of the Garden Club of Madison and the Drew Botany Department (now Biology Department).

The importance of this forested open space cannot be overstated. The Drew campus is a major area for groundwater recharge, and the natural vegetated cover helps purify and restore the Buried Valley Aquifer from which the Borough obtains its water supply. These lands include the best example in Madison of the region's natural forests. Birds, beneficial insects, and small mammals find food and shelter in this natural acreage which is less fragmented geographically than other Borough woodlands. The Forest Preserve serves as an outdoor laboratory and research site for Drew University students and faculty as well as scientists from elsewhere. Open to the public, the Drew Forest adds to the beauty of Madison and inspires artists, musicians, writers, photographers, and nature lovers from across the community.

Most if not all of the Drew Forest was cleared for pasture, but oak trees (black, white, red, and pin) returned between 1835 and 1910, and the forest began filling with shade-tolerant beeches and sugar maples by 1890 (Webb et al. 2000). Other native trees today include tuliptree, white ash, black birch, red maple, silver maple, black cherry, black walnut, butternut, and elm.

The Drew Forest Preserve is hosting a major ecological restoration effort to bring back an example of the natural forest ecosystem for educational, research, and ecological purposes. Similar projects are underway across northern New Jersey at, for example, New Jersey Audubon's Scherman-Hoffman sanctuary, New Jersey Land Conservancy's South Branch preserve, and Great Swamp Watershed Association's Conservation Management Area.

The Drew Forest has been transformed by the same conversion from native to invasive plants plaguing other open space lands throughout the region. Shrubs and wildflowers typical of the mixed oak forest type were once prevalent; many have disappeared since 1988 (maple-leaf viburnum, white heart-leaved aster, common blue heart-leaved aster, clasping aster, witch hazel, hairy solomon's seal, twisted stalk) or declined dramatically (spicebush, may apple, beech drops, winterberry holly). No sign remains of ferns and wildflowers planted by the Madison Garden Club around 1980. An absence of beech regeneration belies claims that deer avoid this tree. Most recently, between 2008 and 2011, all tree reproduction has failed – even that of the invasive Norway maple - except where protected from deer. Remaining vegetation beneath

the canopy is sparse and entirely dominated by invasive shrubs (privet, winged burning bush, Japanese barberry), vines (bittersweet, wisteria, multiflora rose, Japanese honeysuckle, wineberry), and herbaceous plants (garlic mustard, Japanese stilt grass). Invasive bittersweet and wisteria vines have strangled many acres of trees. Norway maple's suppression of biodiversity was first documented in the Drew Forest, where a program of research has monitored this biological invasion since 1988.

Within the Drew Forest Preserve, two sections have been designated for ecological restoration, both named for prominent Madison environmentalists in honor of their support for conservation and preservation.

The *Florence and Robert Zuck Arboretum*, within the Drew Forest, was officially established in 1980 in honor of the eminent retired botany professors Zuck. The 15-acre Zuck Arboretum includes two ponds and former garden plantings of the adjacent Dodge estate, from which the University purchased the land. Vegetation is a mixture of native and ornamental plants, both non-invasive (pachysandra, periwinkle, rhododendron, and forsythia), and invasive (see above). Large trees are present, including both native oaks and ornamental conifers. A "subcanopy" layer and the undergrowth are dominated by young maples poised to take over the forest canopy in the next generation. Unlike many arboreta, the Zuck Arboretum is devoted to natural vegetation rather than ornamental plantings. Fallen logs, standing dead trees, and natural processes are valued and retained. In 1999 a self-guiding nature trail was established. Since 2000, invasive species removals have targeted Japanese barberry and garlic mustard with some success. However, past efforts to reintroduce native plants were unsuccessful. In spring 2011, a 10' fence was constructed to exclude deer from the Zuck Arboretum, in hopes of restoring the ecosystem. Native plantings resumed in 2011 with the planting of 450 native ferns (marsh, ostrich, cinnamon, and royal) at the ponds' waterline.

The *Hepburn Woods Restoration Area*, a separate 15-acre section of the Drew Forest, was designated in 2011, named for environmentalist and Madison civic leader Chris Hepburn whose generosity supported protective deer fencing not only for the Zuck Arboretum but also for the most degraded portions of the Drew Forest where large infestations of two tree-strangling vines, oriental bittersweet and wisteria, have suppressed forest development. Hepburn Woods encompasses these areas plus a research area where the invasive Norway maple is being studied, including a 1997 experiment in which trees and saplings were removed from a one-hectare area in 1997 but retained in an adjacent control area.

A major forest restoration project began in 2008 in Hepburn Woods, in partnership with the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife program and with New Jersey Audubon's Private Lands Stewardship Program. The restored forest and the project will represent a model for similar efforts that could be brought to other parks in Madison and elsewhere. The three components of this effort were:

1. Control of invasive plant species, with focus on ecosystem-dominating species: oriental bittersweet, wisteria, and Norway maple. Other invaders targeted include garlic mustard, barberry, stilt grass, and privet.
2. Construction of 10' fence for protection from deer, around both the Hepburn Woods and Zuck Arboretum, in spring 2011.
3. Planting of native plants made available through the Fish and Wildlife Service, most provided by the New Jersey penitentiary work program. In spring 2011, 1300 small seedlings were planted including four species of native shrubs (high-bush cranberry, sweet pepper bush, elderberry, and witch hazel) and 17 species of native trees (river birch, American beech, black cherry, flowering dogwood, hackberry, shagbark hickory, shellbark hickory, northern red oak, pin oak, scarlet oak, white oak, persimmon, tuliptree, white pine, sourgum (tupelo), sweet gum, and American sycamore). Additional restoration plantings are planned.

Madison Recreation and Conservation Complex: Madison's newest open space project is a 49-acre tract acquired for athletic and passive recreation, located near Madison High School at the border with Florham Park. This open space acquisition was funded for two purposes: recreation and open space conservation. Land cover is a mixture of existing athletic fields, grass covered areas mowed until recently, young woodlands, and mature forest. Wetlands are present on site (see Map, "Wetlands"). The grassy fields are ecologically disturbed with few native species and are the best sites for athletic fields and related facilities including parking lots. A double row of stately pin oak trees adorns the property's roadway and is being protected as the property is developed.

A sizable wooded tract of mature forest (northeast of the roadway that bisects the property) has high ecological value, as indicated by old, large (up to 3' diameter) canopy trees, high tree diversity, and wetland conditions across approximately 35% of mature forest zone. These features suit the forest well for passive recreation: walking, biking, nature study, environmental education. This zone is inappropriate for recreational development. Native trees present include wetland species (red maple, green ash, white ash, elm, pin oak) and typical trees of natural upland forests (white oak, black oak, beech, black birch, sugar maple, flowering dogwood, black cherry, and at least two species of hickory). Heavy deer influence is revealed by browse damage to shrubs and seedlings and by a paucity of native plants below the canopy. Invasive plants overrun the ground layers except in deepest shade, with ubiquitous carpets of Japanese stilt grass in particular and with barberry proliferating at forest edges, poised to spread further into the forest and damage the soil. Other invasive plants include garlic mustard and multiflora rose, with a small presence of Norway maple.

Younger woodlands are scattered across the complex: grading into a swamp of dense, small red maples at the southern corner of the tract; forming a buffer zone for the neighboring Cheshire Home facility (small cherry and ash saplings with scattered large ash trees); and abutting existing athletic fields (with black cherry, black birch, ash, pin oak, and sassafras trees). These open, fragmented woods hold a heavy burden of invasive species. Here as throughout the parks and open spaces of Madison there are steps to be taken to protect vegetation for its biodiversity value and for its capacity to cleanse and beautify the environment. Thus while the conservation mission of this project is implemented, ecological restoration efforts would be fruitful.

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X. WILDLIFE

Madison is a developed town with little unmanaged land. Therefore, wildlife is restricted to the several preserved woodlands located in the Borough. The Drew University forest preserve and the Arboretum provide habitats, territory, and food in the form of nuts, fruits, succulent roots, tender twigs, inner bark of trees, and leaves. Within the Zuck Arboretum are two ponds containing some amphibious wildlife that are also used as a water source for the animals living within Drew University's borders. Many animals supplement this food with herbaceous vegetable matter gleaned from nearby gardens and lawns, to the annoyance of some homeowners and the pleasure of others. Raccoons, woodchucks, opossums and rabbits are the chief foragers in this respect. Unguarded garbage receptacles are also attractive to animals looking for food. Moles are sometimes destructive to lawns as they burrow beneath the turf in search of insect larvae, grubs & worms, but they also help in keeping destructive insect populations in check.

Memorial Park and adjacent wetlands, though which Spring Garden Brook flows, offer different wildlife habitats. The muskrat constructs its home on the banks of the brook. Frogs, turtles, salamanders and newts live close to the water and on the wet floodplain forest floor. The location of Memorial Park on the northeastern border of the Borough and contiguous to another large tract of woodland provides a wider range of territory for wildlife. Deer are frequently seen here and in the surrounding areas foraging. Their population continues to increase in Madison. Inasmuch as most of the species of native animal seen anywhere in Madison are also found in Memorial Park, the accompanying list of wildlife in the park is fairly representative of the native animals in the Borough.

In 2009, 49 acres of open space were added to the inventory of Madison's open space. This land is adjacent to over 400 acres, formerly occupied by the Exxon Corporation in a complex with 600,000 sq. ft of office space. The land is partially wooded with some meadows. There is clear evidence of wildlife habitats here all similar to the other open spaces within the Borough's borders.

The white-tailed deer management is an ongoing concern in Madison and New Jersey more broadly. In 2018, the white-tailed deer population of New Jersey was estimated at 135,000, down from a high of over 200,000 in 1995.[42] In 2008, in an effort to reduce the deer herd prevalent on their property, the Giralda farms group of corporations managed by Reckson Corporation initiated a program to reduce reproduction through birth control. The following statement from the DEP explains the details of the program:

> An experimental program using GonaCon™ at Giralda Farms in Madison (Morris County) was instituted in 2005. Thirty-two percent of the females treated once with GonaCon™ became pregnant. GonaCon™ has limitations including the need to capture and handinject each animal, and granulomas formed at the injection site. At this time, chemical fertility control is still very labor intensive and not practical for large, free-ranging deer populations."

Insects have a profound influence in the environment. On the beneficial side, they are pollinators of many of the plants humans depend on for food and enhancement of his surroundings. They are important in the food chain, being a source of food for many birds and animals. In form, many of them are diverse and beautiful. However, in the course of their own life cycles, some are extremely destructive. Examples include the gypsy moth, seventeen-year locust, canker-worm – all serious defoliators; and several species of scale which attack ornamental trees and shrubs. Avoidance of spray programs for the elimination of these insects allows natural controls to operate.

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[42] NJDEP. 2019. "Wildlife Populations: White-tailed Deer." *Environmental Trends Report*. Available online: https://www.nj.gov/dep/dsr/trends/wildlife-whitetail.pdf

The following list of animals was compiled by Dr. Rosemary Hein, formerly Professor of Biology at Upsala College, for a Natural History Manual of Memorial Park which the Advisory Committee prepared for the Madison Public Schools:

AMPHIBIANS AND REPTILES IN MEMORIAL PARK

(N) – indicates nocturnal

Class Amphibia

Northern Dusty Salamander	Desognathus fuscus fuscus
Red-backed Salamander	Plethodon cinereus cinerues
Red-spotted Newt	Diemictylus viridescens
Wood Frog	Rana Sylvatica
Green Frog	Rana Clamitans Melanota
Bullfrog	Rana castesbeiana
Leopard Frog	Rana pipiens pipiens
Northern Cricket Frog	Acris Crepitans crepitans
Spring Peeper	Hyla crucifer
American Toad	Bufo americanus

Class Reptilia

Common Snapping turtle	Chelydra serpentina
Eastern Box Turtle	Terrapene Carolina Carolina
Eastern Painted Turtle	Chrysemys picta Picta
Northern Water Snake	Natrix sipedon Sipedon
Northern brown Snake	Storeria dekayi dekayi
Eastern Gater Snake	Thamnophis sirtalis Sirtalis
Eastern Ribbon Snake	Thamnophis Sauritus Sauritus
Ring Neck Snake	Diadophis Punctatus
Black rat snake	Elaphe obsolete Obsolete
Milk Snake	Lampropeltis Doliata

MAMMALS IN MEMORIAL PARK

Order Marsupialia

Virginia Opossum	DidelphisVirginiana (N)
Red Fox	Vulpes vulpes
Gray Fox	Urocyon cinereoargenteus

Order Insectivora

Short-tailed Shrew	Blarina brevicauda

Order Chiroptera

Little Brown Bat	Myotis lucifugus
Silver-haired Bat	Lasionycterus Noctivagans (N)
Eastern Pipistrel Bat	Pipistrellus Subflavus (N)
Red Bat	Lasiurus borealis (N)
Hoary Bat	Lasiurus cinerus N

Order Lagomorpha

Eastern Cotton-tail Rabbit	Sylvilagus floridanus

Order Rodenta

Woodchuck	Mormota monax
Eastern Chipmunk	Tamias striatus
Eastern Gray Squirrel	Sciurus Carolinensis
Deer Mouse	Peromyscus Maniculatus (N)
Flying Squirrel	*Glaucomy sabrinus*
Skunk	Mephitis nigra

BIRDS

The distribution of birds in an area depends upon altitude and the availability of food, water, and vegetation including trees, thickets, marshes and open fields which provide cover for nesting and protection from predators. Madison's several woodlands, many large shade trees, landscape shrubbery, laws and gardens offer adequate habitats and natural food for a large variety of birds. Five natural ponds, one man-made retention basin, and two brooks within the Borough provide water for birds. Marsh land is limited in Madison and there are no large bodies of water. Therefore, waterfowl are infrequently seen except for a few wood ducks, mallards, an occasional heron, gulls, and the Canadian Geese, new inhabitants to the area starting in the 1970s.

BIRDS RECORDED FROM THE GROUNDS OF DREW UNIVERSITY

Double-crested Cormorant	Phalacrocorax olivaceus
Great Blue Heron	Ardea herodias
Green Heron	Butorides striatus
Canada Goose	Branta Canadensis
Mallard	Anas platyrhynchos
Wood Duck	Aix sponsa
Turkey Vulture	Cathartes aura
Osprey	Pandion halieaetus
Bald Eagle	Haliacetus leucocephalus
Sharp-shinned Hawk	Accipiter striatus
Cooper's Hawk	Accipiter cooperii
Red-shouldered Hawk	Buteo lineatus

Broad-winged Hawk	Buteo platvpterus
Red-tailed Hawk	Buteo jamaicensis
American Kestrel	Falco sparverius
Wild Turkey	Meleagris gallopavo
Killdeer	Meleagris gallopavo
Spotted Sandpiper	Actitis macularia
American Woodcock	Philoheia minor
Ring-billed Gull	Larus delawarensis
Herring Gull	Larus argentatus
Great Black-backed Gull	Larus marinus
Rock Pigeon	Columbia Livia
Mourning Dove	Zenaida macroura
Eastern Screech Owl	Otus asio
Great Horned Owl	Bubo virginianus
Common Nighthawk	Chordeiles minor
Chimney Swift	Chaetura pelagica
Ruby-throated Hummingbird	Archilochus colubris
Belted Kingfisher	Megaceryle alcyon
Red-bellied Woodpecker	Melanerpes carolinus
Downy Woodpecker	Picoides pubescens
Hairy Woodpecker	Picoides villosus
Norther Flicker	Colaptes auratus
Pileated Woodpecker	Dryocopus pileatus
Eastern Wood-pewee	Contopus virens
Eastern Phoebe	Sayornis phoebe
Great Crested Flycatcher	Myiarchus crinitus
Eastern Kingbird	Tyrannus tyrannus
Tree Swallow	Iridoprocne bicolor
Rough-winged Swallow	Stelgidoptervx ruficollis
Barn Swallow	Hirondo rustica
Blue Jay	Cyanocitta cristata
American Crow	Corvus brachyrhynchos
Fish Crow	Corvus ossifravus
Black-capped Cickadee	Parus Atricapillus
Tufted Titmouse	Parus bicolor
White-breasted Nuthatch	Sitta carolinensis
Brown Creeper	Certhia familiaris
Carolina Wren	Thaothorus ludovicianus
House Wren	Troglodytes aedon
Winter Wren	Troalodytes troglodytes
Golden-crowned Kinglet	Regulus strapa
Ruby-crowned Kinglet	Regulus calendula
Blue-gray Gnatcatcher	Polioptila caerulea
Veery	Catharus fuscescens

Gray-cheeked Thrush	Catharus minimus
Swainson's Thrush	Catharus ustulatus
Hermit Thrush	Catharus izuttatus
Wood Thrush	Hylocichia mustelina
American Robin	Turdus migratorius
Gray Catbird	Durnetella carolinensis
Northem Mockingbird	Mimus polyglottos
Brown Thrasher	Toxostoma rufum
American Pipit	Anthus spinoletta
Cedar Waxwing	Bombycilia cedrorum
European Starling	Sturnus vulgaris
White-eyed Vireo	Vireo griseus
Solitary Vireo	Vireo solitarius
Warbling Vireo	Vireo gilvus
Philadelphia Vireo	Vireo philadlphicus
Red-eyed Vireo	Vireo olivaceus
Blue-winged Warbler	Vermivora Dinus
Lawrence's Warbler	Virinivora chusoptera pinus
Tennessee Warbler	Vermivora peregrina
Nashville Warbler	Vermivora ruficaill
Northern Parula	Parula Americans
Yellow Warbler	Dendroica petechia
Chestnut-sided Warbler	Dendroica pensylvanic
Magnolia Warbler	Dendroica magnolia
Cape May Warbler	Dendroica tigrina
Black-throated Blue Warbler	Dendroica caeralescens
Blackbumian Warbler	Dendroica fusca
Pine Warbler	Dendroica pinus
Prairie Warbler	Dendroica discolor
Palm Warbler	DeiidroicaXalm.aru
Blackpoll Warbler	Dendroica striata
Bay-breasted Warbler	Dendroica castanea
Black&White Warbler	Mniotilta varia
American Redstart	Setophaga ruticilla
Worm Eating Warbler	Helmithero vermivorous
Ovenbird	Seiurus aurocapillus

Northern Waterthrush	Seiurus noveboracensis
Connecticut Warbler	Oporornis agilis
Mourning Warbler	Oporornis philadelphia
Common Yellowthroat	Geothyypis trichas
Hooded Warbler	Wilsonia citrina
Wilson's Warbler	Wilsonia pusilla
Canada Warbler	Wilsonia Canadensis
Scarlet Tanager	Piranga olivacea
Northern Cardinal	Cardinalis cardinalis
Rose-breasted Gosbeak	Pheucticus ludovicianus
Indigo Bunting	Passerica cyanea
Rufous-sided Towhee	Pipiloerythrophthalmus
Chipping Sparrow	Spizella passerina
Field Sparrow	Spizella pusilla
Song Sparrow	Melospiza melodia
White-throated Spar.	Zonotrichia albicollis
Swamp Sparrow	Melospiza georgiana
Dark-eyed Junco	Junco heymalis
Bobolink	Dolichonyx oryzivorus
Red-winged Blackbird	Ageliaus phoeniceus
Rusty Blackbird	Euphagus carolinus
Common Grackle	Quiscalus quiscula
Brown-headed Cowbird	Molothrus ater
Orchard Oriole	Icterus spurius
Baltimore Oriole	Icterus galbula
Purple Finch	Carpodacus purpureus
House Finch	Carpodacus mexicanus

American Goldfinch	Carduelis tristis
House Sparrow	Passer domesticus

THREATENED & ENDANGERED SPECIES AND MADISON'S WILDLIFE ACTION PLEDGE

Wildlife is an integral part of the ecosystem on the global, regional and local level. The interactions of wildlife with other animals and plants help sustain the normal functioning of the biosphere. The health and sustainability of wildlife species affects the health and sustainability of industries such as agriculture, forestry, and fisheries that support human life. Birds, insects and other wildlife play key roles in biological processes such as seed dispersal, pollination, nutrient cycling, habitat maintenance and pest control. Wildlife that prey on other wildlife help maintain the balance of nature. Wildlife is dependent on quantity and quality of habitat for survival.

Identifying Critical Habitat

The NJDEP Landscape Project is an "ecosystem-level approach to the long-term protection of imperiled and priority species and their important habitats in New Jersey." The database is intended to be used as a planning tool both for site specific consideration and for identifying future survey areas. Species included in The Landscape Project are those that depend on the identified habitat for their survival. Migratory birds, for example, that do not rely on habitat in New Jersey for their survival would not be included.

The state or federally recognized habitat data used in Map 29 was part of the Skylands and Piedmont Plains species-based habitat layers. The Piedmont Plains layer covers the southeastern half of Madison and the Skylands layer the northwest. These layers were compiled by the New Jersey Department of Environmental Protection (NJDEP) Fish and Wildlife Division Endangered and Nongame Species Program in 2017 as part of version 3.3 of their ongoing Landscape Project.[43] Landscape 3.3 is a meticulous compilation of thousands of documented species location reports logged by expert surveys and the general public, 2012 aerial photo-based Land Use Land Cover (LULC) raster data taken by the NJDEP, and historical information.[44]

The Landscape Project ranks patches of habitat using a numeric system (0 through 5), for the purpose of identifying habitat that may be suitable for threatened, endangered and priority wildlife species. Habitat identified as Ranks 3 through 5 is considered environmentally significant by the NJDEP. Following is a description of each rank.

Rank 5 is assigned to species-specific patches containing one or more occurrences of wildlife listed as endangered and threatened pursuant to the Federal Endangered Species Act of 1973.

Rank 4 is assigned to species-specific patches with one or more occurrences of State endangered species.

Rank 3 is assigned to species-specific patches containing one or more occurrences of State threatened species.

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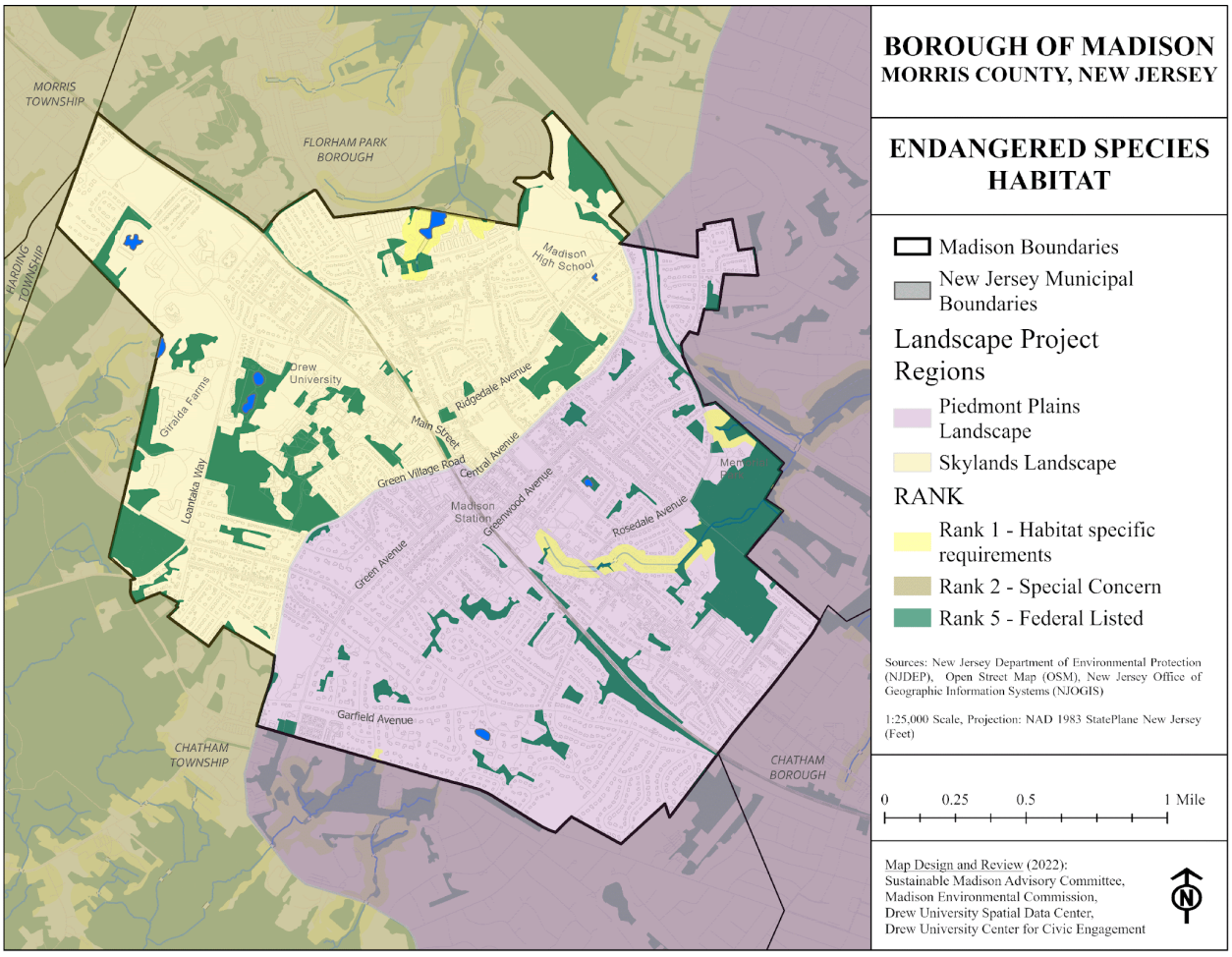
[43] New Jersey Department of Environmental Protection Division of Fish and Wildlife Endangered and Nongame Species Program, (2017) New Jersey Landscape Project Report. Version 3.3. p 4 [online]. Available at: www.state.nj.us/dep/fgw/ensp/landscape/lp_report_3_3.pdf (Accessed: 17 October 2021).

[44] New Jersey Department of Environmental Protection, "New Jersey Landscape Report," p. 7, 19-20.

Rank 2 is assigned to species-specific patches containing one or more occurrences of species considered to be species of special concern.

Rank 1 is assigned to species-specific patches that meet habitat-specific suitability requirements such as minimum size criteria for endangered, threatened or priority wildlife species, but that do not intersect with any confirmed occurrences of such species.

Rank 0 is assigned to patches that do not contain any species occurrences and do not meet any habitat-specific suitability requirements.



Map 29. New Jersey DEP Landscape Project Endangered Species Habitat Ranks

Map 29 shows the distribution of habitat by Landscape Project Rank. Areas are mapped by the highest-ranking documented species; therefore, an area identified as Landscape Project Rank 5 may also contain lower ranking species (see Threatened, Endangered and Priority Species below). Between Landscape 2 and Landscape 3.3 studies, the number of acres identified as important habitat was expanded from 350 to 426 (Table X). Major contributions to this expansion include the identification of Summerhill Park as important to federally listed endangered species, and an expansion of areas of Giralda Farms, also key to endangered species. The 426 acres in Madison identified by the Landscape Project as patches where occurrences of one or more species have been recorded (Ranks 2 and 5), represent 13% of the Borough's total area. An additional 50 acres, or 2% of Madison, have been identified as meeting habitat suitability

requirements for endangered, threatened or priority wildlife species (Rank 1), even though no occurrences have been recorded (Rank 1). In total, 15% of Madison is suitable habitat.

The patches are distributed across the following NJDEP Land Use/Land Cover types:

Table X. Madison Landscape Project Land Use Land Cover Types, 2007 and 2017

LULC Type	*Acres (2007)*	*Acres (2012)*
Forest	248	305
Urban	39	58
Water	8	8
Wetlands	55	55
Total	**350**	**426**

The Landscape Project maps habitat patches that animals use and that have general species occurrence information embedded within them, rather than pinpointing exact locations of the most sensitive wildlife sites because these may be nest sites, roost sites, dens and other sites used by species that are vulnerable to human disturbance and, in some cases, susceptible to illegal collection.

Threatened, Endangered and Priority Species

The majority of patches in Madison, totaling 426 acres, are identified as Landscape Project Rank (LPR5), indicating that occurrences of federally endangered species have been documented there. There are no documented Rank 4 or Rank 3, State endangered or endangered species, habitat, but there 1.4 acres mapped as Rank 2, species of special concern, and 50 acres as Rank 1, meeting habitat specific requirements. The table below lists the species for which occurrences have been documented in Madison, the types of occurrences and habitats, and the rank for each species. Patches are classified according to the highest-ranking species, and often more than one species is identified within the same patch. In Madison, the Indiana bat (LPR5) has the broadest habitat and occasionally shares territory with the barred owl (LPR3), the great blue heron (LPR2) and/or the wood turtle (LPR3).

Landscape Project Identified Species in Borough of Madison (2007)

Common Name	Scientific Name	Occurrence Types	Habitat	Rank/Status
Barred Owl	Strix varia	Breeding Sighting	Forest, wetlands	3 / State Threatened
Great Blue Heron	Ardea herodias	Foraging	Water, wetlands	2 / Special Concern
Indiana Bat	Myotis sodalis	Breeding Sighting Maternity Colony Non-breeding Sighting	Forest, urban, water, wetlands	5 / Federally Listed Endangered

Wood Turtle	Glyptemys insculpta	Occupied Habitat	Urban	3 / State Threatened

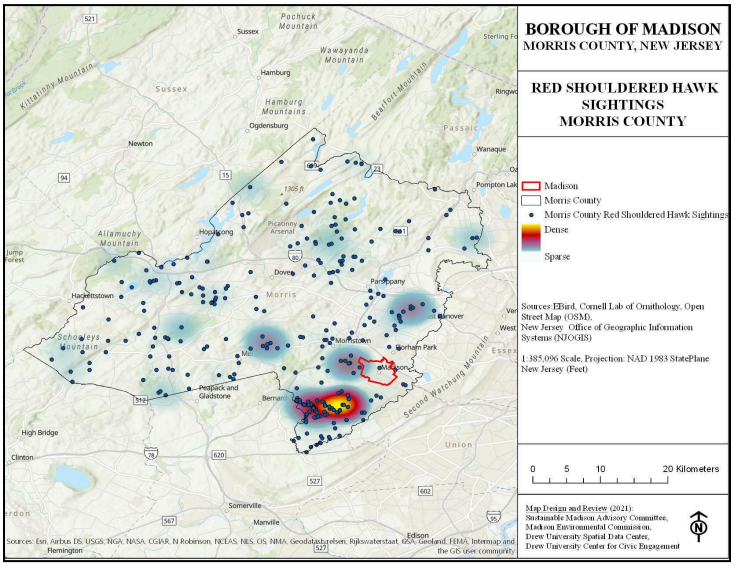
Source: NJDEP Landscape Project 3.1 (2012)

Madison's aforementioned surviving woodland, fields, and ponds provide the food, shelter, and protection from predators necessary to sustain a wide array of bird species. Drew University Forest and Zuck Arboretum alone, as of 2011, are home to at least 121 total species of birds. Of these 121 species known to exist in Madison, two are considered endangered, two are threatened, and 17 are of special concern status in New Jersey.[45]

[45] New Jersey Department of Environmental Protection Division of Fish and Wildlife Endangered and Nongame Species Program, (2012) Special Concern - Species Status Listing. p. 1-3 [online]. Available at: www.nj.gov/dep/fgw/ensp/pdf/spclspp.pdf (Accessed: 17 October 2021).

The red-shouldered hawk (Figure X[46]) is considered endangered in the state of New Jersey.[47] It can be identified by its brownish-red shoulders, black and white barred wings, black back, and drawn out, nasally cries.[48] [49] Their habitat in Northern New Jersey is made up mainly of riparian, mixed, or old growth forests with standing water and a tall, closed canopy.[50] Additionally, they are known to nest in habitats containing cooper's hawks, another bird of prey known to exist in Madison.[51] [52] The red-shouldered hawk's decline can be attributed to wetland and forest development, its reluctance to nest near residential areas, and early 20th century game bounties. The bird was added to New Jersey's list of threatened species in 1979 and reclassified as endangered in 1991 at which point it was estimated only 36 breeding pairs still existed in the state.[53] While monitoring of the species has improved since the 1990s, little data exists on conservation efforts or species population data in New Jersey.

Map X shows an eBird dataset of red-shouldered hawk sightings in Morris County. These sightings were individually recorded by members of the eBird community. Although this figure shows only one sighting of the red-shouldered hawk in Madison, there are several sightings surrounding the borough and a cluster within the Great Swamp National Wildlife Refuge (GSNWR) to the Southwest.





[46] Lin, R. (2010) *Red Shouldered Hawk perches on a tree branch.* Conserve Wildlife Foundation of New Jersey. www.conservewildlifenj.org/species/fieldguide/view/Buteo%20lineatus/

[47] New Jersey Department of Environmental Protection Division of Fish and Wildlife Endangered and Nongame Species Program, Red Shouldered Hawk, Buteo Lineatus. p. 1 [online]. Available at: www.nj.gov/dep/fgw/ensp/pdf/end-thrtened/redshldhwk.pdf (Accessed 17 October 2021).

[48] New Jersey Department of Environmental Protection, "Red Shouldered Hawk, Buteo Lineatus," p. 1.

[49] Lin, R. (2003). *The Red- Shouldered hawk perches on a tree branch* [online]. Available at www.conservewildlifenj.org/species/fieldguide/view/Buteo%20lineatus/ (Accessed: 8 December 2021)

[50] New Jersey Department of Environmental Protection, "Red Shouldered Hawk, Buteo Lineatus," p. 1-2.

[51] New Jersey Department of Environmental Protection, "Red Shouldered Hawk, Buteo Lineatus," p. 1.

[52] Madison Environmental Commission, "Borough of Madison," p. 94.

[53] New Jersey Department of Environmental Protection, "Red Shouldered Hawk, Buteo Lineatus," p. 3.

Map X: Morris County Red-Shouldered Hawk Sightings[54] Figure X. Red-Shouldered Hawk

The other bird both sighted in Madison and listed as endangered in New Jersey is the bald eagle (Figure X[55]). An iconic bird, the bald eagle is identifiable by its white head, yellow beak, and dark brown body.[56] In New Jersey, bald eagle populations are concentrated heavily in the southern half of the state around the Delaware Bay and River.[57] Scattered nests exist in similarly riparian or wet habitats. The bald eagle's decline is multifaceted, they were targeted by bounties prior to federal protection, their ability to reproduce was ravaged by DDT contamination in the 60s and 70s, and their ability to successfully nest is severely impacted by human disturbance. The New Jersey bald eagle population dropped to a single breeding pair in 1970 where it remained until 1980.[58] The 1968 state ban on DDT and efforts like the New Jersey Bald Eagle Project have since largely succeeded, however, boosting bald eagle numbers to 150 pairs by 2015. [59] **Map X** displays eBird data on Bald Eagle sightings in Morris County, NJ. While the map shows few sightings in Madison, there are several immediately outside the borough and many at the GSNWR.

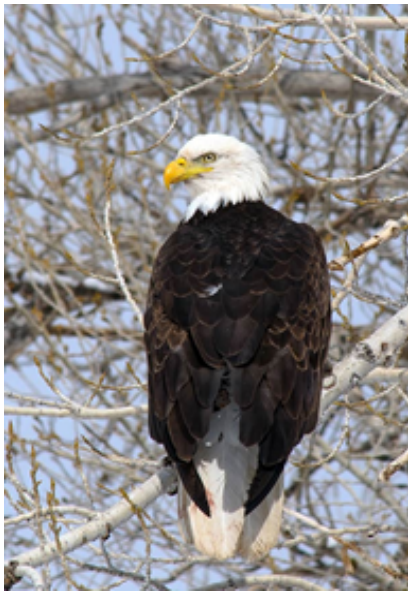
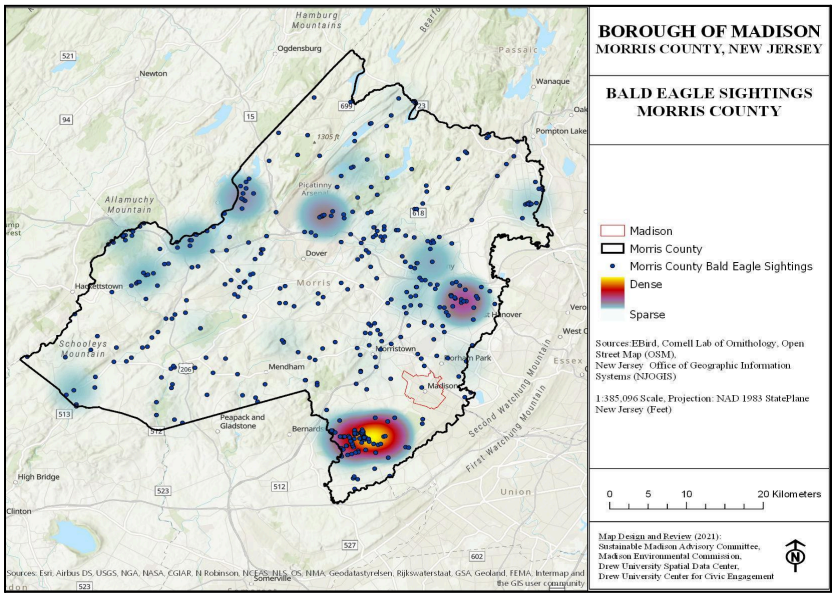


Figure X. Bald Eagle

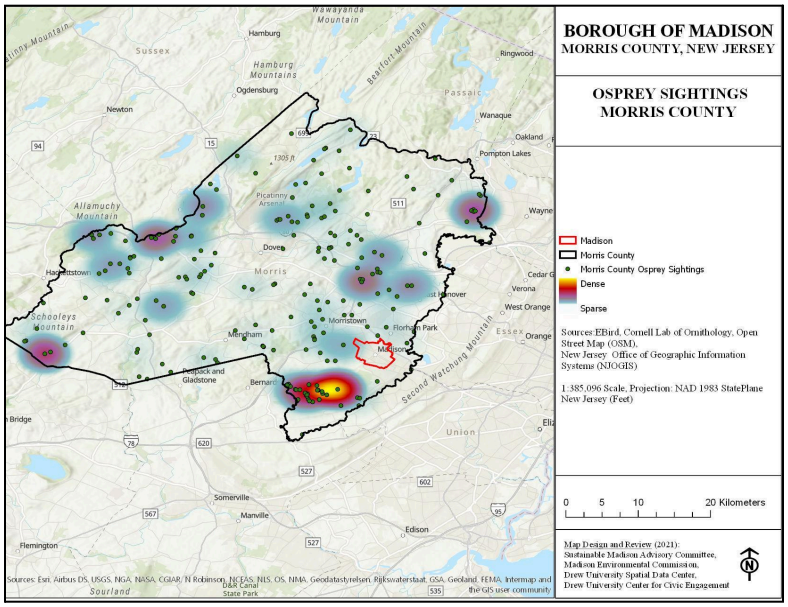


Map X: Morris County Bald Eagle Sightings[60]

[54] eBird Basic Dataset. Version: EBD_relJan-2022. Cornell Lab of Ornithology, Ithaca, New York. Jan 2022.
[55] Utah Division of Wildlife Resources. (2021) *Places to see bald eagles in Utah.* wildlife.utah.gov/news/utah-wildlife-news/1119-bald-eagle-places.html
[56] Government of Utah. *Places to see bald eagles in Utah* [online]. (2021). Available at: wildlife.utah.gov/news/utah-wildlife-news/1119-bald-eagle-places.html (Accessed: 8 December 2021).
[57] New Jersey Department of Environmental Protection Division of Fish and Wildlife Endangered and Nongame Species Program, New Jersey Bald Eagle Project 2020. p. 3 [online]. Available at: www.nj.gov/dep/fgw/ensp/pdf/eglrpt20.pdf (Accessed 17 October 2021).
[58] New Jersey Department of Environmental Protection, "New Jersey Bald Eagle Project 2020," p. 3.
[59] New Jersey Department of Environmental Protection, "New Jersey Bald Eagle Project 2020," p. 3.
[60] eBird Basic Dataset. Version: EBD_relJan-2022. Cornell Lab of Ornithology, Ithaca, New York. Jan 2022.

The osprey (Figure X[61]) is classified as threatened by the state of New Jersey. The species is distinguished by its long wingspan, dark brown back, and white underside.[62] [63] Unlike the other birds of prey listed, the osprey nests around large bodies of water in often human-built settings such as posts, blinds, or nesting platforms. The initial decline of the osprey can be attributed to habitat loss and hunting, after the mid-60s, however, DDT contamination was largely responsible. By 1974, osprey breeding pairs dipped as low as 53, and was thus redesignated as threatened by New Jersey.[64] Similar to with bald eagles, osprey revitalization efforts have slowly progressed due to the aforementioned DDT ban and osprey nesting platforms.[65]

Map X displays eBird data of individual osprey sightings in Morris County. While no osprey sightings fall within Madison, a few surround its border and, like with species mentioned prior, many were spotted within the GSNWR.



Map X: Morris County Osprey Sightings[66]



Figure X. Osprey

[61] University of Minnesota, College of Veterinary Medicine: The Raptor Center. (2022) raptor.umn.edu/about-raptors/raptors-north-america/osprey

[62] New Jersey Department of Environmental Protection Division of Fish and Wildlife Endangered and Nongame Species Program, Osprey, Pandion Haliaetus. p. 1 [online]. Available at: www.nj.gov/dep/fgw/ensp/pdf/end-thrtened/osprey.pdf (Accessed 17 October 2021).

[63] University of Minnesota. (2021). *Osprey* [online]. Available at:raptor.umn.edu/about-raptors/raptors-north-america/osprey (Accessed: 8 December 2021).

[64] New Jersey Department of Environmental Protection, "Osprey, Pandion Haliaetus," p. 2.

[65] New Jersey Department of Environmental Protection, "Osprey, Pandion Haliaetus," p. 3.

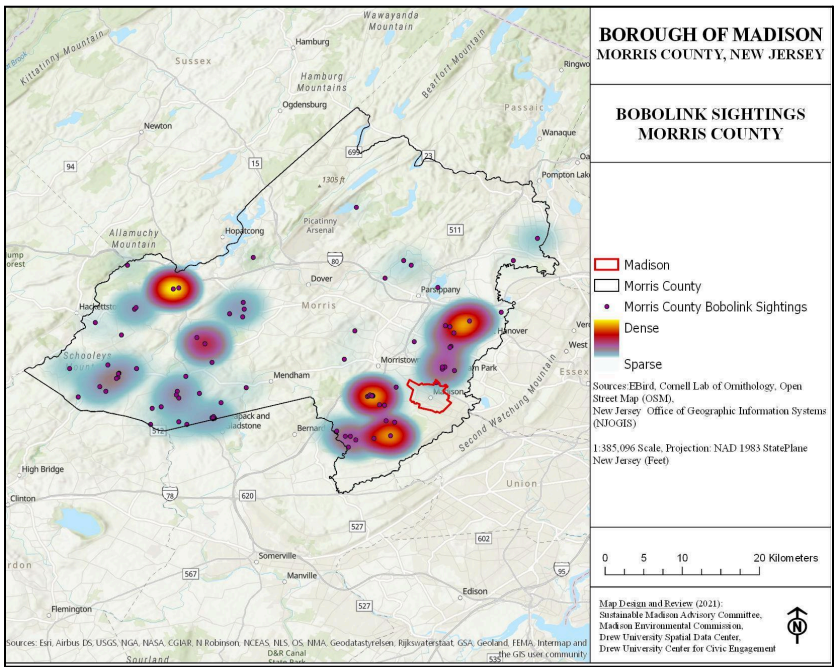
[66] eBird Basic Dataset. Version: EBD_relJan-2022. Cornell Lab of Ornithology, Ithaca, New York. Jan 2022.

Finally, the bobolink, Figure X[67], is also considered threatened in New Jersey. Male bobolinks are black save for cream colored head and back feathers while female bobolinks are a heathered pale yellow and dark brown.[68] [69] Bobolinks nest in well vegetated areas usually surrounding farmland or grassland.[70] The decline of the bobolink can be attributed to migratory killings in the American south, hunting, and the modernization of farming techniques in the 60s and 70s. The bobolink was classified as threatened in 1979.[71] While recovery efforts largely have yet to produce results, grassland recovery efforts through New Jersey's landowner incentive programs may revitalize Bobolink populations.

Map X shows bobolink sightings in Morris County according to eBird. Bobolink sightings overall are scarce in Morris County, with none occurring in Madison and few in its general surroundings. Unlike with the red-shouldered hawk and bald eagle, there is no concentration of sightings within the GSNWR.



Figure X. Bobolink



Map X: Morris County Bobolink Sightings[72]

Beyond the four species mentioned above, 17 other species found in Madison are of special concern in New Jersey. These are the Cooper's hawk, great blue heron, blackburnian warbler, black throated blue warbler, broad-winged hawk, brown thrasher, Canada warbler, common nighthawk, hooded warbler,

[67]Gilbert, J. (2010) *A female Bobolink.* Conserve Wildlife Foundation of New Jersey. conservewildlifenj.org/species/spotlight/bobolink/

[68] New Jersey Department of Environmental Protection Division of Fish and Wildlife Endangered and Nongame Species Program, Bobolink, Dolichonyx Oryzivorus. p. 1 [online]. Available at: nj.gov/dep/fgw///////ensp/pdf/end-thrtened/bobolink.pdf (Accessed 17 October 2021).

[69] Gilbert, J. (2021). *A female Bobolink* [online]. Available at: www.conservewildlifenj.org/species/spotlight/bobolink/ (Accessed: 8 December 2021).

[70] New Jersey Department of Environmental Protection, "Bobolink, Dolichonyx Oryzivorus," p. 1.

[71] New Jersey Department of Environmental Protection, "Bobolink, Dolichonyx Oryzivorus," p. 2.

[72] eBird Basic Dataset. Version: EBD_relJan-2022. Cornell Lab of Ornithology, Ithaca, New York. Jan 2022.

Nashville warbler, northern parula, sharp-shinned hawk, spotted sandpiper, veery, winter wren, wood thrush, and worm-eating warbler.[73] [74]

Madison Threatened and Endangered Plant Species



Figure X. Swamp Pink

While New Jersey's rare plants do not have formal statewide protections or recognized threatened and endangered categories, legislation to create such designations is pending as of December 2021.[75] This section will provide a brief overview of both federally recognized endangered plant species and plant species informally identified as such by the NJDEP that are known to exist in Morris County and thus may exist in or around Madison.

The only plant species federally recognized as threatened within Morris County is a flower called swamp pink (Figure X[76]).[77] Swamp pink is a perennial flower with green stems, strap-like leaves, and upright pink flower caps.[78] [79] The flower is known to grow in areas surrounding wetland and swamp habitats.[80] Swamp pink was federally listed as endangered in 1988, with a growing variety of conservation challenges threatening its habitat, including timbering, land development encroachment, water redirection, water

[73] Madison Environmental Commission, "Borough of Madison," p. 94.
[74] New Jersey Department of Environmental Protection, "Special Concern - Species Status Listing," p. 1-3.
[75] Pinelands Preservation Alliance, New Jersey Threatened and Endangered Plant Protection Act [online]. Available at: pinelandsalliance.org/new-jersey-endangered-and-threatened-plant-protection-act/ (Accessed 7 December 2021).
[76] United States Fish and Wildlife Service. (2022) *Swamp pink wildflowers in all their glory. www.njspotlightnews.org/2022/01/nj-native-plants-diverse-array-new-legislation-consumer-awareness/*
[77] NJDEP. (2014). "Rare Plant Species and Ecological Communities Presently Recorded in the NJ Natural Heritage Database." p. 5 [online]. Available at: www.nj.gov/dep/parksandforests/natural/heritage/textfiles/morris.pdf (Accessed 7 December 2021).
[78] U.S. Fish and Wildlife Service: New Jersey Field Office. "Swamp Pink Helonias Bullata." Available at: www.fws.gov/southeast/wildlife/plants/swamp-pink/ (Accessed 7 December 2021).
[79] U.S Fish and Wildlife Service: New Jersey Field Office. (2012). "Swamp Pink (Helonias bullata) [threatened]: Identification Guide." [online]. Available at: www.fws.gov/northeast/njfieldoffice/endangered/swamppink2.html (Accessed: 8 December 2021).
[80] USFWS, "Swamp Pink."

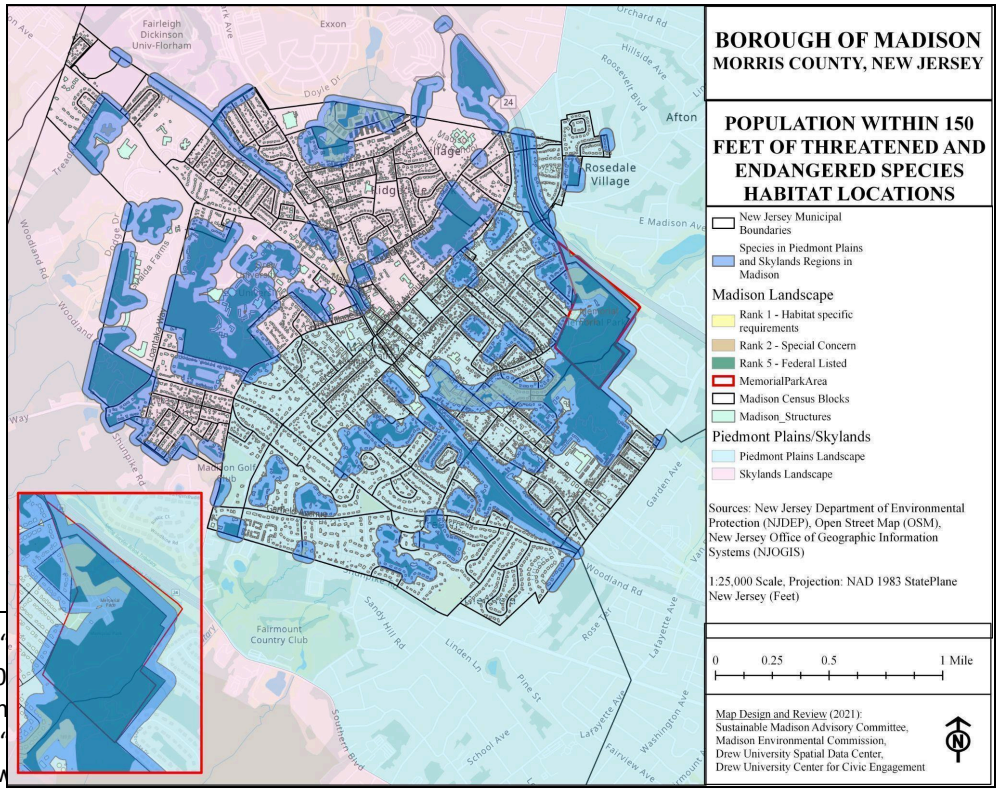
pollution, surging deer populations, and soil erosion.[81] [82] State and federal conservation efforts have responded by placing cages over the flowers' shooting buds in the Spring to protect against deer, creating action plans, and planting specimens raised in captivity throughout protected habitat.[83] [84]

Beyond this, 86 plant species native to Morris County are informally designated as endangered by NJDEP. While it would be impractical to list them all here, a full list of them can be found in this subsection's footnotes.[85]

Memorial Park Threatened and Endangered Species Habitat

This subsection is dedicated to state and federal threatened and endangered species habitat within Madison's Memorial Park. Memorial Park is a forested wetland swamp located in the southeastern half of Madison within the Madison Wetlands Conservation Area.[86] **Map X** provides a map of the Madison area and an inset box outlining the total footprint of Memorial Park which makes up 74.4 acres, or 2.68 percent of Madison's total acreage.

As mentioned above, the Memorial Park parcel is 74.4 acres, with 24.7 acres dedicated to the community pool, baseball diamonds, and a picnic area.[87] The remaining wetland acreage is home to newts, deer, turtles, salamanders,[88] and even some federally listed species such as the eastern box turtle, little brown bat, silver-haired bat, and northern cricket frog.

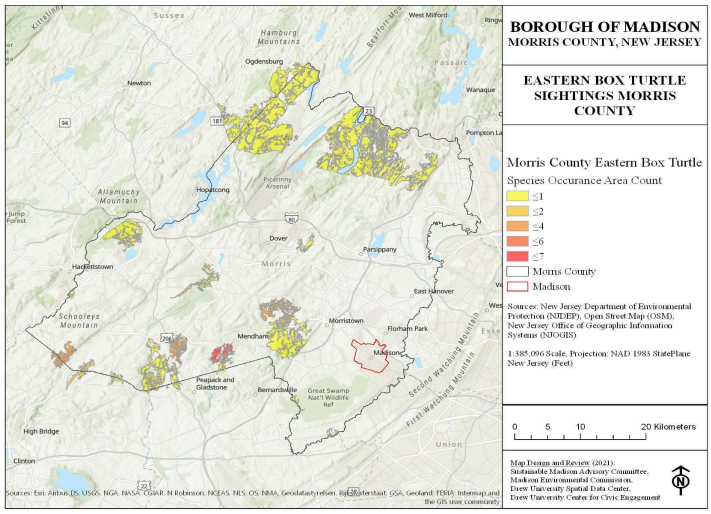


[81] USFWS, "
[82] NJCF. (20
www.njcon
[83] USFWS, "
[84] NJCF, "Sw
[85] NJDEP, "Rare Plant Species," p. 1-10.
[86] Madison Environmental Commission. (2011). "Borough of Madison Environmental Resources Inventory." Madison Environmental Commission, p 84 [online]. Available at: www.rosenet.org/DocumentCenter/View/1572/Environmental-Resource-Inventory-PDF?bidId= (Accessed: 17 October 2021).
[87] Madison Environmental Commission, "Borough of Madison," p. 100.
[88] Madison Environmental Commission, "Borough of Madison," p. 91.

Map X: Areas within 150 feet of Endangered Species Habitat (primary) and Memorial Park Endangered Species Habitat (inset)[89] [90]

Madison Special Concern Status Reptiles and Amphibians

The eastern box turtle (Figure X[91]) is known for its distinct yellow or orange color and patterned shell.[92] The species normally inhabits water-adjacent meadows and woods. Eastern box turtles are considered a species of concern in New Jersey due to habitat destruction, contact with motor vehicles, and the pet trade.[93] In an effort to decrease the species' mortality rate, the eastern box turtle came under the protection of the Convention on International Trade of Endangered Species in 1995.[94] Additionally, the NJDEP has fostered conservation through habitat protection and careful species monitoring.[95]



Map X: Morris County Eastern Box Turtle Sightings



Figure X. Eastern Box Turtle

Map X shows Landscape 3.3 species table active seasonal eastern box turtle sightings for Morris County in graduated colors. While it does not include any sightings within Madison, it does show some sightings

[89] State of New Jersey Department of Environmental Protection, Division of Information Technology, Bureau of Geographic Information Systems. NJDEP Species Based Habitat, Landscape Regions, Version 3.3 [Vector Digital Data]. Trenton, NJ: GIS Online. 2017. gisdata-njdep.opendata.arcgis.com/datasets/landscape-3-3-regions-of-new-jersey/explore?location=40.062979%2C-74.765450%2C8.64

[90] Steven Manson, Jonathan Schroeder, David Van Riper, Tracy Kugler, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 16.0 [2020 U.S. Census, Census Blocks and TIGER Line Files]. Minneapolis, MN: IPUMS. 2021. doi.org/10.18128/D050.V16.0

[91] Feinstein, J. (2010) *The Eastern Box Turtle.* Urban Wildlife Guide. www.urbanwildlifeguide.net/2010/10/eastern-box-turtle.html

[92] Wurst, B. 2021. *Eastern Box Turtle.* Available at: www.conservewildlifenj.org/species/spotlight/boxturtle/ (Accessed: 18 October 2021).

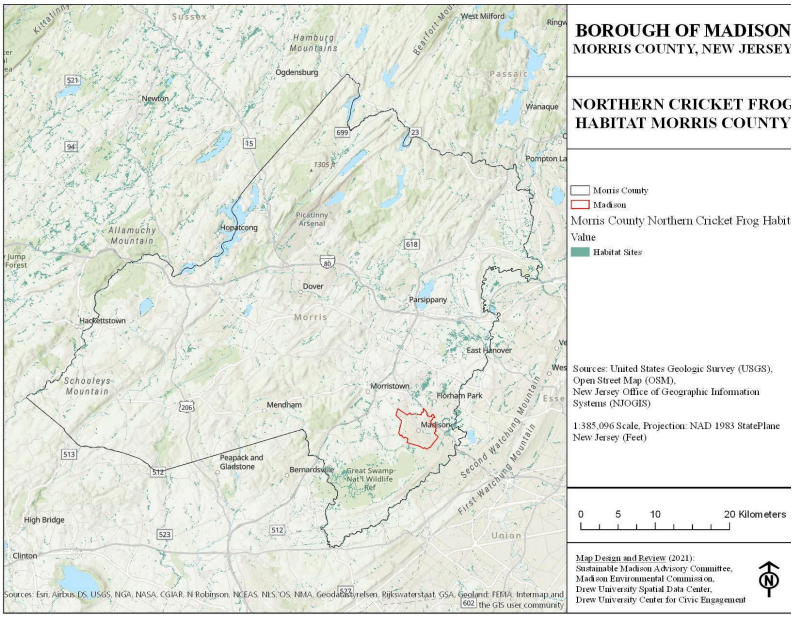
[93] Wurst, *Eastern Box Turtle.*

[94] Belzser, B. and Steisslinger, M.B. (1999). "The Box Turtle: Room with a View on Species Decline." *The American Biology Teacher,* 61 (7), pp. 510-513. Available at: www.jstor.org/stable/pdf/4450753.pdf (Accessed: 18 October 2021).

[95] Wurst, *Eastern Box Turtle.*

to the borough's immediate south along the Morris County border, to its southwest within the GSNWR, and to its west. This would suggest that the eastern box turtle could still reside in Madison albeit in a limited capacity.

The northern cricket frog (Figure X[96]) is most easily recognized by the bright green, red, or gray stripe down stripe on its back.[97] Additionally, most have warty skin and a triangle-shaped patch between their eyes.[98] These frogs are often found in marshes, ponds, or small streams. The northern cricket frog was designated of special concern due to habitat loss, insecticide and aquatic biocide pollution, extreme temperature changes, and over-predation. In order to slow their declining numbers and improve their monitoring of the species, the NJDEP's Endangered and Nongame Species Program has encouraged individuals to report any northern cricket frog sightings.[99]



Map X: Morris County Northern Cricket Frog Habitat[100]



Figure X. Northern Cricket Frog

Map X below shows 2008 to 2013 Morris County northern cricket frog habitat projections according to 2001 ground condition raster data gathered by the United States Geological Survey (USGS).[101] While there are scattered habitat sites in Madison itself, larger uninterrupted clusters can be seen North of the borough in Florham Park and Southwest in the GSNWR.

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[96] Cook, W. (2011) *Northern Cricket Frog (Acris Crepitans).* Carolina Nature, North Carolina Amphibian and Reptile Photo www.carolinanature.com/herps/ncricket.html

[97] Davenport M.J. (2016). *Northern Cricket Frog..* Available at: /www.conservewildlifenj.org/species/fieldguide/view/Acris%20crepitas/ (Accessed: 9 December 2021).

[98] Brown, L.E. and Gray, R.H. (2005). " Decline of Northern Cricket Frogs (Acris Crepitans)." In *Amphibians Declines*. University of California, p. 47. doi.org/10.1525/9780520929432-013.

[99] Davenport M.J., *Northern Cricket Frog.*

[100] United States Geological Survey, Gap Analysis Project. Northern Cricket Frog (Acris Crepitans) Habitat Map. [Raster Digital Data]. ScienceBase-Catalog. 2018. www.sciencebase.gov/catalog/item/58fa4149e4b0b7ea54524a50.

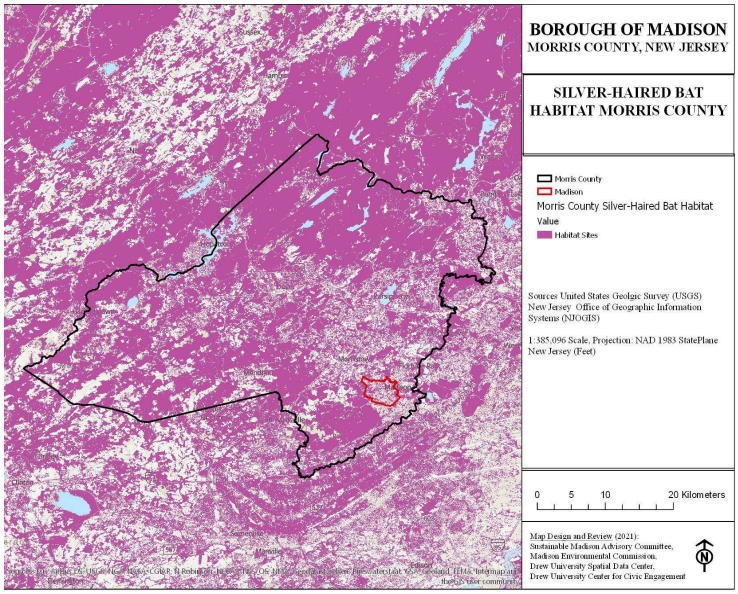
[101] United States Geological Survey, *Gap Analysis Project. Northern Cricket Frog (Acris Crepitans) Habitat Map.* Available at: www.sciencebase.gov/catalog/item/58fa4149e4b0b7ea54524a50 (Accessed: 12 April 2022).

Madison Endangered and Special Concern Status Mammals

The silver-haired bat (Figure X[102]) is a medium-sized bat with distinctive silver-tinted black fur, small hairless round ears, and a wingspan of around 12 inches.[103] [104] The nocturnal species is commonly found in deciduous and coniferous forests. The silver-haired bat is of special concern status in the state of New Jersey due to deforestation, wind turbines, and white-nose syndrome. White-nose syndrome is a fungal infection which bats contract during hibernation often in caves or mines.[105] The infection most noticeably affects silver-haired bats' faces and wings, turning them white as the name would suggest.[106] Soon after the bats' wings deteriorate and their body temperature drops causing hibernation interruptions. Conservation efforts include slowing wind turbines, hibernation protection, and the preservation of dead trees as habitat.[107] [108]



Figure X. Silver-Haired Bat



Map X: Morris County Silver-Haired Bat Habitat[109]

[102] Nehring, M. *Silver-haired Bat.* iNaturalist www.inaturalist.org/guide_taxa/335908
[103] Kopsco, H. and Hall, M. (2014). *Silver-Haired Bat.* Available at: www.conservewildlifenj.org/species/fieldguide/view/Lasionycteris%20noctivagans/ (Accessed: 18 October 2021).
[104] Naturalista. (2021). *Silver-haired bat* [online]. Available at: www.naturalista.mx/guide_taxa/335908 (Accessed: 8 December 2021).
[105] Kopsco, H. and Halls, M. (2014). *Little Brown Bat.* Available at: www.conservewildlifenj.org/species/fieldguide/view/Myotis%20lucifugus/ (Accessed: 18 October 2021).
[106] National Park Service. (2017). *What is White-Nose Syndrome?*. Available at: www.nps.gov/articles/what-is-white-nose-syndrome.htm (Accessed:14 December 2021).
[107] Kopsco, H. and Hall, M., *Silver-Haired Bat.*
[108] U.S Fish and Wildlife Service. (2019). *10 Ways to Be a Friend to Bats* [online]. Available: www.fws.gov/midwest/endangered/battips.html (Accessed: 14 December 2021).
[109] United States Geological Survey, Gap Analysis Project.Silver-haired Bat (Lasionycteris noctivagans) Habitat Map. [Raster Digital Data]. ScienceBase-Catalog. 2018. www.sciencebase.gov/catalog/item/58fa4149e4b0b7ea54524a50.

Map X shows projected Morris County silver-haired bat habitat from 2008 to 2013 according to 2001 ground condition raster data gathered by the United States Geological Survey (USGS).[110] This figure shows dense habitat areas both North of Madison and to the borough's Southwest in the GSNWR. Overall it suggests that Morris County and areas to its North are absolutely vital to the continued survival of the silver-haired bat.



Figure X. Little Brown Bat[111]

The little brown bat is a smaller bat with a 10.5-inch wingspan and fur varying from gold to red-brown.[112] [113] These bats are found in densely forested areas and manmade structures such as barns and attics.[114] The little brown bat's status is under federal review as of February 2022, however, the species is currently considered endangered by the International Union for the Conservation of Nature mainly due to white-nose syndrome.[115] Other factors that contribute to its status include habitat loss, pesticide use, climate change, wind turbines, and common

superstition.[116] Conservation efforts include protecting cave habitat, bat awareness programs, and pesticide restriction.[117] [118]

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[110] United States Geological Survey, *Gap Analysis Project. Silver-haired Bat (Lasionycteris noctivagans)Habitat Map.* Available at: www.sciencebase.gov/catalog/item/58fa4149e4b0b7ea54524a50 (Accessed: 12 April 2022).

[111]Arendt, J. (2021) *Provincial bat count to monitor for impacts of white-nose syndrome.* Vancouver Island Free Daily www.vancouverislandfreedaily.com/news/provincial-bat-count-to-monitor-for-impacts-of-white-nose-syndrome/

[112] Kopsco, H. and Hall, M., *Little Brown Bat.*

[113] BC Community Bat Project (2020). *Seeking bat roosts and bat counters!* [online]. Available at: bcbats.ca/uncategorized/seeking-bat-roosts-and-bat-counters/ (Accessed: 15 December 2021).

[114] Kopsco, H. and Hall, M. *Little Brown Bat.*

[115] Kopsco, H. and Hall, M., *Little Brown Bat.*

[116] Government of Massachusetts. (2020). *Species Spotlight: Little brown bat*. Available at: www.mass.gov/news/species-spotlight-little-brown-bat (Accessed: 15 December 2021).

[117] Kopsco, H. and Hall, M., *Little Brown Bat.*

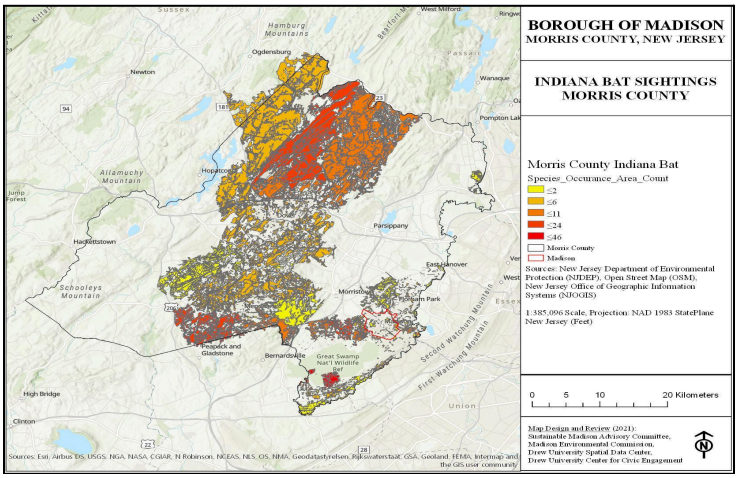
[118] U.S Fish and Wildlife Service, *10 Ways to Be a Friend to Bats*.

The third and final vulnerable species of bat found in Morris County and Madison is the Indiana bat (Figure X). The bat is nearly indistinguishable in appearance to a little brown bat save for small differences in fur color and foot structure.[119] The Indiana bat lives primarily in pastures, riparian environments, cropland borders, and forests.[120] Of all bat species present in Madison, the Indiana bat is likely most prevalent, with known year-round hibernation and maternity colonies throughout the entirety of Morris County.[121] The species was federally classified as endangered in 1973 due to the superstitious killing of hibernation or maternity colonies, white-nose syndrome, deforestation, and pesticide use.[122] Current efforts to revitalize New Jersey Indiana bat populations include the seasonal restriction of deforestation, organized hibernation protection, pesticide regulation, and species monitoring through the New Jersey field office of the U.S. Fish and Wildlife Service.[123]

Map X shows Landscape 3.3 species table active seasonal sightings of the Indiana bat for Morris County in graduated colors. The graphic supports the assertions of the US Fish and Wildlife Service in that it shows substantial numbers of Indiana bat sightings throughout Morris County. Moreover, it captures significant sightings of the species within and around Madison, establishing that the Madison area provides habitat crucial to the Indiana bat's continued survival.



Figure X: Indiana Bat[124]



Map X. Morris County Indiana Bat Sightings[125]

[119] U.S Fish and Wildlife Service: New Jersey Field Office. (2019). "Indiana Bat (Myotis sodalis) [endangered]." [online]. Available at: www.fws.gov/northeast/njfieldoffice/endangered/ibat.html (Accessed: 26 February 2022).
[120] USFWS, "Indiana Bat."

[121] USFWS, "Indiana Bat."
[122] USFWS, "Indiana Bat."
[123] USFWS, "Indiana Bat."
[124] Mann, A.and Duffey, J. (2012) *The Indiana Bat.* Gai.consultants gaiconsultants.com/the-indiana-bat/
[125] State of New Jersey Department of Environmental Protection, Division of Information Technology, Bureau of Geographic Information Systems. NJDEP Species Based Habitat, Landscape Regions, Version 3.3 [Vector Digital Data]. Trenton, NJ: GIS Online. 2017. gisdata-njdep.opendata.arcgis.com/datasets/landscape-3-3-regions-of-new-jersey/explore?location=40.062979%2C-74.765450%2C8.64

Factors Contributing to Species Decline

Air pollution is commonly attributed to threatened species' decline. Its damage is seen especially in Madison's bird species. Additionally, air pollutants such as carbon monoxide, sulfur dioxide, and mercury can result in respiratory illness, reproductive decline, and habitat destruction across all animal groups.[126] In a 2017 article titled "Air Pollution Impacts on Avian Species via Inhalation Exposure and Associated Outcomes," the authors compiled past studies and research to draw a direct relationship between birds and air pollution. They determined that birds were broadly impacted by a variety of air pollutants including the ones mentioned above and found that air pollution significantly affects bird physiology, reproductivity, and habitat.[127]

Unlike mammals, birds' respiratory systems contain a cross-current gas exchange, making them more sensitive to decreases in air quality.[128] For example, just 0.50 ozone parts-per notation can incur constricted breathing in most bird species.[129] Moreover, any exposure to sulfur dioxide can weaken birds' immune systems and adversely affect their respiration.[130] Additionally, airborne heavy metals and sulfur dioxide can change tree structures, rendering surviving forestland for most birds uninhabitable. Air pollution can also greatly affect reproductive rates by decreasing the thickness of shells and therefore the protection of bird embryos.[131] Furthermore, of the federally recognized habitat sites in Madison, nearly all are surrounded by roads and interstates,[132] significant sources of similarly damaging carbon monoxide and hydrocarbons.

Water pollution can lead to similarly devastating results. In the article, "The Need for Water Quality Criteria for Frogs," experts discuss how detrimental water contamination and poor ambient water quality is for frogs. One indicator is water acidification. It was found that amphibians which lived in acidic aquatic environments suffered from embryonic development problems, reduced growth rates, and lower survival rates.[133] Such acidification is often caused by either metal groundwater contaminants or acid rain.[134] Water quality is additionally impacted by agricultural use. Many fertilizers and pesticides contain organochlorines, organophosphates, and other harmful synthetic materials.[135] When water contaminated with these chemicals seeps from fields into rivers and streams it can kill mature amphibians and cause malformations in frog embryos.[136] Madison's wetlands and stormwater basins, which make up only 2.4% of the borough's total area, are framed by extensively developed areas as

[126] Sanderfoot, O.V. and Holloway, T. (2017). "Air pollution impacts on avian species via inhalation exposure and associated outcome." *Environmental Research Letters,* 12(8), p. 1,3. Available at: iopscience.iop.org/article/10.1088/1748-9326/aa8051/pdf (Accessed: 17 October 2021).

[127] Sanderfoot, O.V. and Holloway, T., "Air Pollution," p.2.
[128] Sanderfoot, O.V. and Holloway, T., "Air Pollution," p.1-2.
[129] Sanderfoot, O.V. and Holloway, T., "Air Pollution," p.3.
[130] Sanderfoot, O.V. and Holloway, T., "Air Pollution," p. 4-5.
[131] Sanderfoot, O.V. and Holloway, T., "Air Pollution," p. 8-9.
[132] Sanderfoot, O.V. and Holloway, T., "Air Pollution," p. 8-9
[133] Boyer, R. and Grue, C.E. (1995). "The need for water quality criteria for frogs." *Environmental health perspectives*, *103*(4), pp.353.. Available at: ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.95103352 (Accessed: 15 December 2021).
[134] Boyer, R. and Grue, C.E., 'The need for water quality," p. 353.
[135] Boyer, R. and Grue, C.E., 'The need for water quality," p. 353.
[136] Boyer, R. and Grue, C.E., 'The need for water quality," p. 353-354.

mentioned prior.[137] As a result they are under constant threat of runoff pollution potentially damaging to the amphibious species which reside in them.

About 78.6 percent of Madison's footprint is occupied by residential properties, roads, commercial businesses, and other developed land; the other 21.4 percent is dedicated to protected wetlands, recreational areas, and forests as aforementioned.[138] In "The Economics of Endangered Species," the authors explain how habitat conversion is the primary driver for species extinction. Habitat conversion is considered a land-use problem because of the high valuation of undeveloped land in densely populated or mostly developed areas.[139] [140] This high value often entices landowners to sell their land without environmental consideration.[141] At which point it is swiftly converted to farmland, homes, businesses, fuel, food sources for humans, or medications by development firms.[142] This ultimately leads to the irreversible destruction of habitats and loss of ecosystems. The prospect of continual land development in order to sustain Madison's growing borough population has the potential to erase habitats and the threatened, endangered, and special concern status species which reside in them. This threat is above all relevant due to the uncertain future of Drew University Forest and Zuck Arboretum as of February 2022.

Conclusion

This section discussed the current developed conditions within the Borough of Madison, its endangered species habitat sites, the threatened, endangered, and special concern status species which still reside there, and the extensive threats which they currently face. It was written with the hope of making data and information regarding Madison-area threatened and endangered species more accessible and inspiring local conservation efforts. With some initiative, each of the species discussed here can be restored; join the effort.

New Jersey Wildlife Action Plan (WAP)

On July 22, 2013, the Madison Borough Council approved a resolution supporting the WAP (see below). A non- regulatory document compiled with input from wildlife experts, the public and many disparate organizations representing special areas of interest such as builders and farmers, the WAP outlines strategies and goals for conserving wildlife throughout the state. The WAP "lays the foundation for better coordination of wildlife research and management among programs within the Division of Fish and Wildlife, state and federal agencies and many partners in the conservation community" and qualifies the state to receive federal funding under the State Wildlife Grants program (NJDEP). The focus is on protecting and restoring habitat with the dual goal of preventing common species from being added to the lists of at-risk species and helping populations of at-risk species to rebuild to a level where they can be removed from these lists. The WAP divides the state into conservation zones and outlines specific goals, priorities and actions within each zone. In the 2008 iteration of the WAP, Madison falls within the Northern Piedmont Conservation Zone. The closet natural area identified in this zone is the Great Swamp National Wildlife Refuge. In suburbanized areas such as Madison, the WAP stresses the importance of

[137] Madison Environmental Commission, "Borough of Madison," p. 7.
[138] Madison Environmental Commission, "Borough of Madison," p. 7-8.
[139] Innes, R. and Frisvold, G. (2009). "The economics of endangered species." *The Annual Review of Resource Economics,* 1(1), p. 486. Available at: www.annualreviews.org/doi/pdf/10.1146/annurev.resource.050708.144207 (Accessed: 18 October 2021).
[140] Innes, R. and Frisvold, G., "The economics," p. 486.
[141] Innes, R. and Frisvold, G., "The economics," p. 486-487.
[142] Innes, R. and Frisvold, G., "The economics," p. 496.

conserving “oases” that are important in supporting migratory flyways by providing opportunities for stopovers.

The goals and actions identified by the WAP include many where communities can play an important role, such as:

Maintain natural biodiversity, community integrity and structure and ecosystem function by controlling invasive and overabundant species

Protect and enhance important and unique habitats, and

Promote public education and awareness and wildlife conservation.

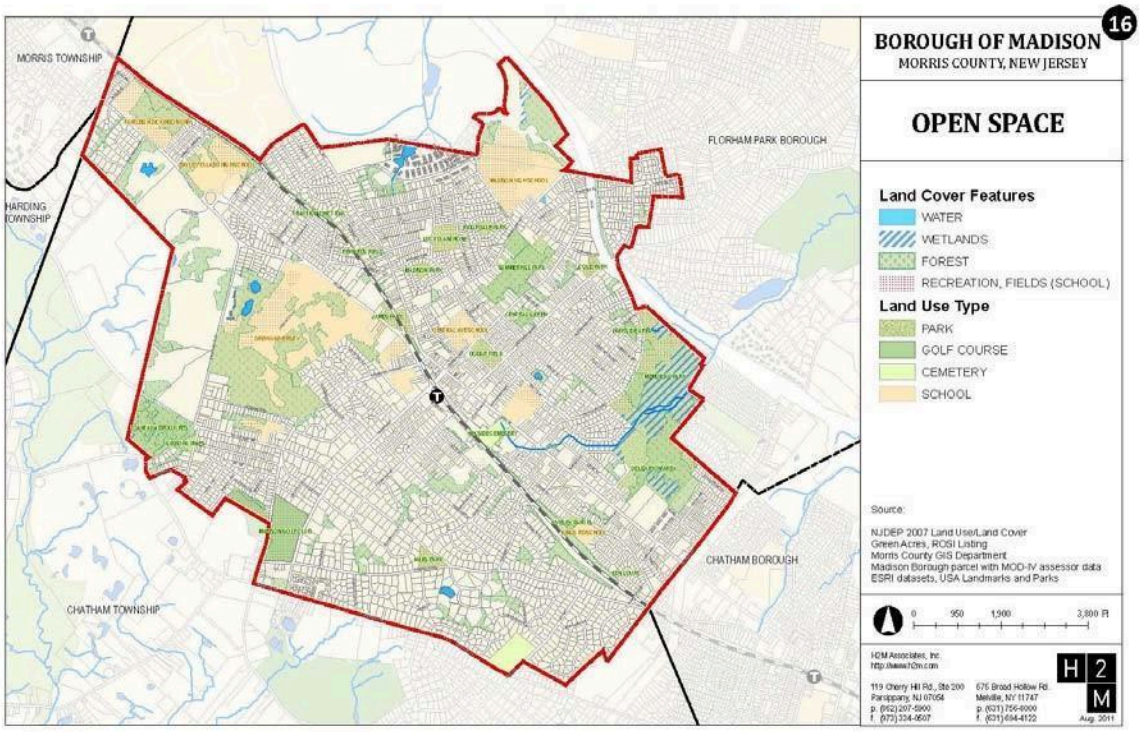
General information about the WAP can be found at
http://www.state.nj.us/dep/fgw/ensp/waphome.htm

An overview of Goals and Actions for the entire Piedmont Plains region can be found at:
http://www.state.nj.us/dep/fgw/ensp/wap/pdf/pamphlet_piedmont.pdf.

Specific goals and actions for the Northern Piedmont Conservation Zone, based on identified habitats and threats to wildlife, can be found at: http://www.state.nj.us/dep/fgw/ensp/wap/pdf/12.pdf.

XI. OPEN SPACE

According to the State’s 1968 enabling legislation, an environmental commission must maintain an index of all open areas, publicly or privately owned, in its municipality. As its first major act, the newly formed Madison Environmental Commission prepared an open space inventory in 1973. Earlier open space data was presented in the 1963 Master Plan. The Commission is charged with updated the Borough’s open space data according to the best available information. Current open space areas within Madison are depicted on **Map 16**. The Map includes properties that are listed on the Borough’s Recreation and Open Space Inventory (ROSI), which is regularly updated by the governing body in support of applications for funding open space acquisition and improvement projects. NJDEP’s Green Acre’s program maintains the ROSI database here: http://www.nj.gov/dep/greenacres/openspace.html



Like many New Jersey municipalities, Madison's open space has declined over the years, reflecting a trend toward urbanization. Open space declined by 10% between 1973 and 1983, and by an additional 7.5 % from 1982 to 2001. Much of this growth can be attributed to residential housing development. **Map 17** shows areas of the Borough that changed in land use between 2002 and 2007. Undeveloped areas (areas that were previously forested, contained wetlands or were barren) that have since been developed, are also highlighted. Madison lost approximately 13.5 acres of forested land between 2002 and 2007, including seven (7) acres that was developed for single-family residential, nearly four (4) acres for commercial use and the remaining for other urban or transitional use.

The Association of New Jersey Environmental Commissions (ANJEC) recommends that the municipal Master Plan be the vehicle for organizing the planning process for protecting open space. In the case of Madison, where the town is very developed with limited open space, planning for open space protection and expansion should be a top priority of the master planning process. For a variety of reasons, Madison has become a desirable community to live, and builders have been willing to pay premium prices for new development opportunities.

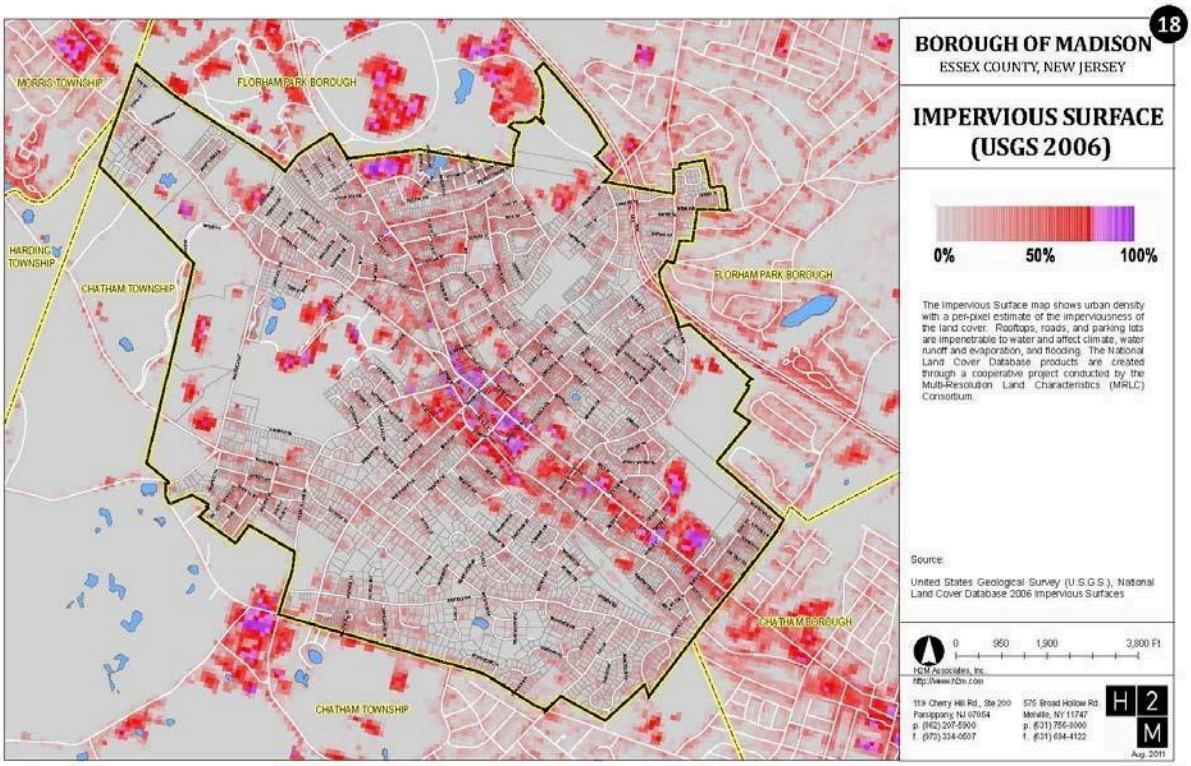
To protect its little remaining open space, the Borough should evaluate putting protections in place that would thwart incremental reductions in open space and potential subdivisions. This can be achieved by changing zoning regulations (i.e., lot size requirements, open space requirements, etc.), acquiring additional property for open space, and instituting conservation easements. Requirements that limit "tear downs" of houses for the replacement of homes with larger footprints (which also shrink actual pervious ground cover) can also be considered. A new or updated Conservation Plan Element of the Master Plan should also be considered.

The development of privately-owned, undeveloped tracts of land is perhaps the most significant reason for reductions in Madison's open space. Troublingly, the number of new open space acquisitions, has not matched the pace of development. Below is a list of large tracts of privately owned land which have experienced development sixfnce 1982:

- 29.5 acres of the 177.5 acres in Madison at Giralda Farms. Only an additional 6 acres can be developed. Plans for one additional office building at the northwest corner of the property on Loantaka Way and Madison Avenue are currently on hold.
- At Drew University a new gym was built in the mid- 1990s and a new academic arts building is currently being constructed for occupancy in 2001.
- The 15 acre Sodano Tract between Garfield Ave and Shunpike in the area between Park Lane and Olde Green House Road. A number of single family residences were built.
- The present Madison Green Village townhouse complex between Garfield Ave. and Shunpike was completed. A total of over 32 townhouses were built in 1979 – 1982.
- The 7.31 acre tract on the north side of Madison Avenue at Loantaka Way. A total of 20 single family homes were built in 1991-1992 (2 houses were demolished).
- Brannick Drive (east of Sampson Avenue south of the railroad tracks. Seven new homes were built in 1995 on the available 9.75 acres.

The actual percent decrease in the amount of open space in Madison must also consider the relative change in size in Borough area, since through annexation, the Borough has increased in total size at various times in its history. In 1990, approximately 3.5 acres were annexed from the Chatham Borough and developed with 11 houses on the street now named "Independence Court" and with four houses on Union Hill. In 1994, 16 lots in the southwest section of the borough in the "Orchard" section of town were annexed by Madison Borough at the request of the property owners. In both cases the streets were readily accessible to Madison but were not directly accessible to Chatham Borough nor Chatham Township. In 2011, an additional 49 acres of land, mostly open space, was annexed from Florham Park, including a portion of the former Exxon complex and a Madison High School property.

The impact of urbanization on Madison's land can be more easily understood by looking at historical changes in impervious coverage. Map 18 and Map 18B show impervious coverage from two separate data sources. **Map 18** offers a per-pixel estimate of the imperviousness of the land cover in Madison, with data being provided by the USGS for the year 2006. This includes all rooftops, roads, and parking lots that are impenetrable to water, and which affect climate, water runoff and evaporation, and flooding. **Map 18B** shows impervious coverage as provided by NJDEP in the 2007 Land Use/Land Cover (LU/LC) dataset. An impervious surface (IS) code was assigned to each LU/LC polygon based on the percentage of impervious surface within each polygon as of 2007. The USGS estimate is perhaps more useful, since it shows imperviousness at more detailed level. As more current data becomes available, the Borough should compare how impervious coverage has increased or decreased over time.



Map 18 illustrates how the level of impervious surface is most dense along the north-south route of East Main Street, the Borough's business district. As the community has grown, the Borough's business district has expanded along the length of East Main Street to the Chatham border. This has meant the loss of some former open space areas along the corridor. Where businesses were once concentrated in a few central core blocks, with pockets of green space in between, commercial development exists today along most of East Main Street. This could illustrate a need for small pocket parks or public plazas to serve downtown patrons. At the same time, by concentrating development along the downtown "core," and creating a thriving, mixed-use center with access to transit, shopping, and housing, the Borough is ensuring a more sustainable land use development pattern. Within the core, people can walk to their destinations without the need for a car. Concentrating development in a dense, walkable area, can also serve to preserve the feeling of "openness" within the Borough's outer residential neighborhoods.

As a developed community, few large tracts of land remain in Madison. Planners once thought of open space merely as parks and recreation areas. However, "*open space is now considered to be one means to hold together the fabric of an urbanizing environment by providing the requisite natural breaks vital to create a visual and aesthetic amenity for urban dwellers. Additionally, open space serves natural functions in providing infiltration for precipitation, cleaning the air, providing breathing space, mitigating unpleasant odors, noises, and sights*." (1) It is clear that open space has important economic functions (i.e., increased property values, resident attractors) as well as environmental benefits. In addition to protecting the few remaining large tracts of land, even the presence of small pockets of open space have enormous visual, psychological, environmental and economic impacts.

Approximately 100 acres of land in Madison is considered "recreation use," which includes areas for parks, as well as the Borough's community center, which offer's recreational opportunities. An

additional 78 acres of land are set aside for school athletic fields. Combined, the Borough's parks, recreation space (including community center uses) and school athletic fields make up approximately 6.4% of Borough land area. The principal open space areas in Madison are described below:

PUBLICLY OWNED OPEN SPACE

A. *Memorial Park*: 68.70 acres purchased in 1953 by the Borough. It is located off Rosedale Avenue north of Main Street. Planning for this park is the responsibility of the Mayor's Advisory Committee for Memorial Park. 24.70 acres have been developed with a pool area, ice skating rink, two baseball diamonds, a picnic area, a shelter, and parking areas. In 1982 a soccer field was added, and in 1999 an in-line skating track was added around the perimeter of the ice skating rink. It is important to preserve the remaining acreage as undisturbed woodland.

B. *Madison's Wetlands* consists of 51.86 acres adjacent to Memorial Park. This area is described in detail in the Vegetation chapter.

C. *Summerhill (Greenacres) Park* covers 24.81 acquired by the Borough in 1972, partially through donations and partially through purchases assisted by the State under the Green Acres program. The site is about one-third mile north of Main Street between Ridgedale and Central Avenues. No plans for development of the park have been implemented by the town.

D. *James Park* contains 6.02 acres at the intersection of Park Avenue and Main Street in downtown Madison. A gift to Madison from the James family, the park provides welcome relief from the man-made environment of traffic, sidewalks, crowded storefronts and hurrying people. The memorial flowering cherry trees, dogwoods and stately shade trees furnish an appropriate setting for the memorial monuments.

E. *Belleau Park* covers 5.47 acres between Belleau and Chateau Thierry Avenues. This former farmland now being reclaimed by forest is significant in that it provides a buffer between a large townhouses development and single family residences. It was designated as proposed parkland in the 1975 master Plan and appears on the Official map of the Borough adopted in 1977.

F. *Dodge Field* consists of 4.78 acres encompassing one town block, three blocks north of Main Street. Central Avenue Elementary School faces one side of the park, and residential housing surrounds it on the other three sides. The park contains a football field, a track, a baseball diamond with bleachers, basketball courts, a tot lot and a wading pool. It is fenced on all sides and receives heavy use.

G. *Loantaka Moraine* includes approximately 25 acres south of Woodland Road at the corner of Loantaka Way. This land was acquired in 1994 by the Morris County Parks Commission using Green Acres funds and annexed to the Loantaka Brook Reservation. This tract of land is a unique natural feature located at the edge of a delta built into glacial Lake Passaic about 20,000 years ago. It is the largest remaining section of the delta which is not developed nor can be developed. It's varied topography, characterized by steep and undulating slopes covered with old field vegetation, and the long vistas over the surrounding countryside impart a wilderness feeling to

these acres, even though they are only a modest walk from the center of Madison. A topographical sketch of the Loantaka Moraine is shown in Figure X! – 1.

H. *Central Green (off Serpico Way – formerly Floyd Street)* is 2.40 acres between Central and Greenwood Avenues designated as proposed parkland in the 1975 Master Plan. It contains secondary forest of maples, elms and wild black cherry. The area is surrounded mostly by residences.

I. The remaining publicly owned parks in Madison include the following neighborhood parks and open plots:

	Acres
Lucy D (Baseball Fields @East & Myrtle)	6.66
Niles Park (Woodland Road)	3.80
Cole Park (Greenwood Avenue)	3.40
Madison Park (within Wayne Blvd.)	1.93
Parkside (western side of Rosedale Ave.)	1.80
Delbarton Park (Delbarton Drive)	1.50
Ridgedale (Oxford Lane)	1.26
Edwards Field (Kinney Street Field)	0.81
Fen Court	0.25
Academy Street	~0.30

PRIVATELY OWNED OPEN SPACE

A. *Giralda Farms*, has been developed as an office park since 1987. It contains 180 acres of great natural beauty (177.5 of which are in Madison) which the various developers' Agreements with the Borough seek to maintain. Only 15% of these prime and potential prime aquifer recharge soils may be covered with impervious surfaces (buildings, parking areas, walks or roads). Natural features are to be preserved wherever possible, and buffers are to be created where necessary to soften the visual impact of the buildings. In 2000-2001 a new building with underground parking was constructed on Woodland Road and Loantaka Way. As of this ERI update, the building is as yet unoccupied. Only one additional building at the corner of Loantaka way and Madison Avenue may be built.

B. *Drew University Forest Preserve and Aboretum* contains approximately 50 acres of mature mixed-oak forest. While these forested areas are maintained for the benefit of the student community, faculty, administration, staff and their visitors, the public is welcome to enjoy them by arrangement. Specifics on the Forest Preserve and Arboretum are included in the Vegetation Section. In 2001-2002 a new Arts Center is being build approximately 100 yards from the Madison Avenue entrance of the school. This brings the total impervious coverage level for the Drew campus up to approximately 20 percent.

C. *Madison Golf Course* consists of approximately 27 acres of potential prime aquifer recharge soils in the "critical area" category. The 1975 Master Plan designated the golf course as proposed parkland to give to the Borough the opportunity to acquire it if the site were ever proposed for development.

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0. Koenig, Scott, Town of Madison Park Proposal for Greenacres, Cornell University student report in Landscape Architecture, December 1981.
0. Kaiser, Kim Ball, *Using the Master Plan to Save Open Space*, ANJEC Quarterly Report, Summer, 2001

XII. HOUSEHOLD RECYCLING

As defined by Wikipedia (2/26/11), recycling means: "processing used materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production".

More technically, the process of recycling creates an "operational loop" that reclaims materials from *used* products and incorporates them into *new* products. The first step includes *collecting* materials, which are handled by curbside programs, drop-off centers, buy-back centers and deposit/refund programs, and processing of materials at a materials recovery facility in which the marketable commodities are prepared for sale. The second step is *manufacturing*, in which new items are composed partially or totally of recycled materials. The final step in the recycling loop consists of organizations and consumers *purchasing* recycled products, which creates the demand to fuel the recycling loop.

Source separation, or separating recyclable waste from the solid waste stream, has in fact reduced solid waste tonnage in every community. It promotes clean, marketable materials and reduces waste disposal costs to the recycling households or communities.

The tag-line for recycling is "Reduce, Reuse, Recycle" which broadens the meaning of recycling to include source reduction, reducing the quantity and toxicity of solid waste, and reusing materials.

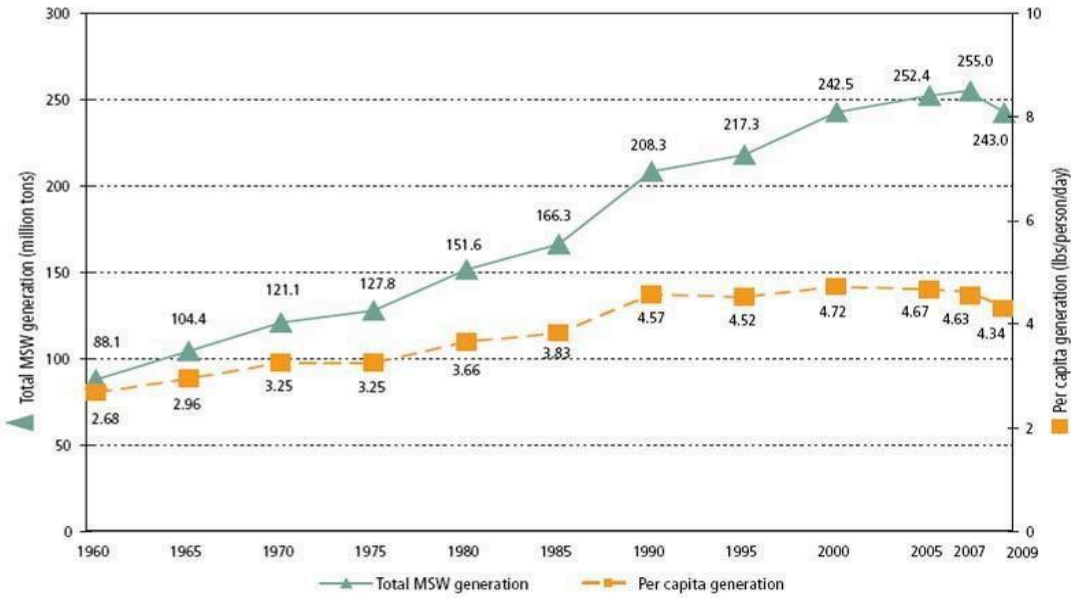
RECYCLING SUCCESS AND SOLID WASTE REDUCTION IN THE US AND NJ

As per the EPA, "In 2009, Americans generated about 243 million tons of trash and recycled and composted 82 million tons of this material, equivalent to a 33.8 percent recycling rate." This recycling rate of 33.8% is up over 5% from Madison's last recycling ERI report of 2004, which reported a national rate of 28%.

The following chart (from the same EPA report) shows total municipal solid waste generation, and the per capita rate, from 1960 – 2009. It is important to note the steady reduction of per capita municipal solid waste (MSW) from 4.72 pounds/person/day in 2000 to 4.34 in 2009. This is the only

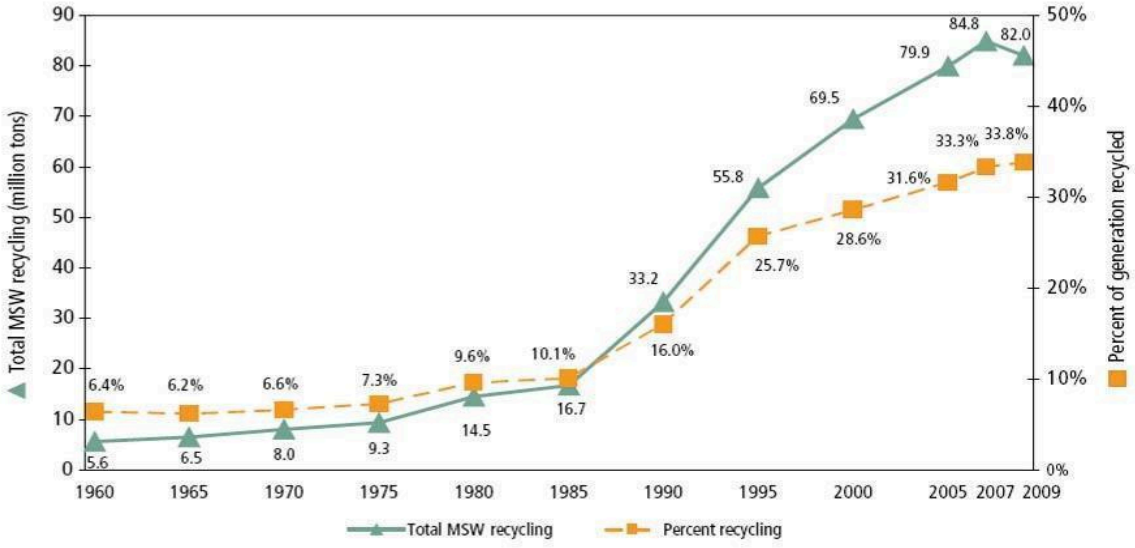
significant MSW reduction trend in the chart's 60 year history. In fact, Madison's municipal solid waste reduced significantly from 5474 tons in 2008 to 5257 tons in 2010.

Figure 1. MSW Generation Rates, 1960 to 2009



The second chart from the EPA report shows the strong increase in recycling in the United States, with the percentage of recycling tripling from 10.1% in 1985 to 33.8% in 2009.

Figure 2. MSW Recycling Rates, 1960 to 2009



NJ MUNICIPAL SOLID WASTE RECYCLING AS COMPARED TO THE UNITED STATES

The table below shows the percentage of Municipal Solid Waste this is recycled every year. In the 1990's New Jersey was well ahead of the national average. New Jersey's rate has stayed relatively

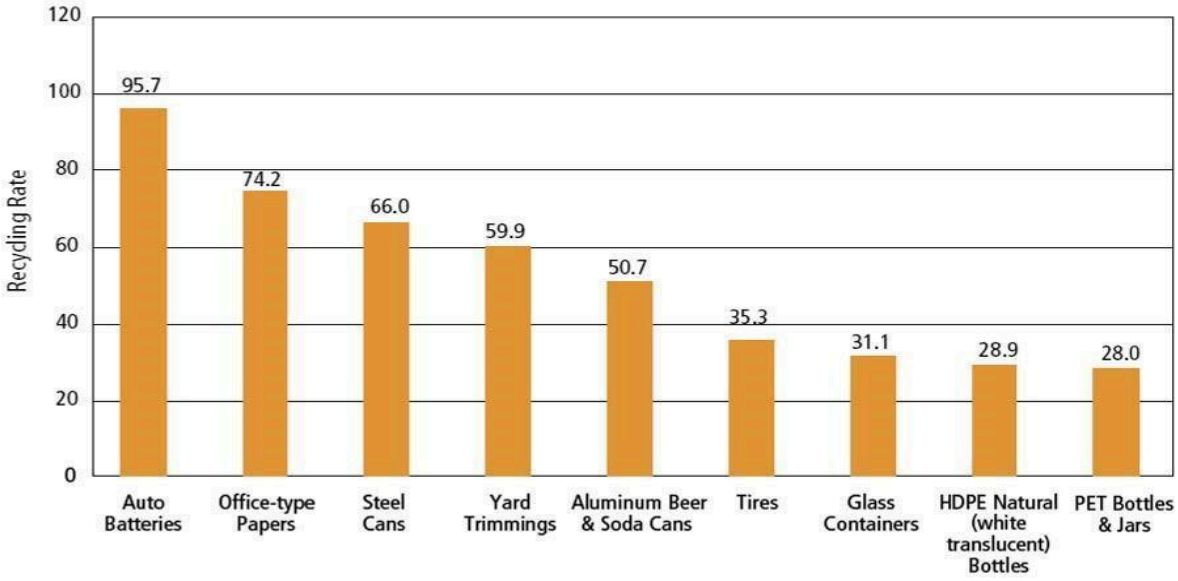
constant, while the national average has doubled over from 1990 to 2007. However, New Jersey continues to stay ahead of the MSW recycling national average, but by a much smaller margin.

Year	USA	NJ
1990	16%	34%
2000	28.6	38%
2005	31.6	34%
2007	33.3%	36.5%

NATIONAL AVERAGE MSW RECYCLING RATES BY MATERIAL

Recycling rates vary significantly by material. As can be seen from the EPA chart below, the office paper recycling rate was 74.2% in 2009, while glass containers was 31.1%.

Figure 3. Recycling Rates of Selected Products, 2009*



HISTORY OF RECYCLING PROGRAMS IN NJ

Recycling programs historically were “grass-roots” organizations and trace their recent origins to the first Earth Day in 1970. When New Jersey enacted the legislation enabling environmental commissions in 1972, “pollution control – solid waste, air and hazardous substances – were placed within the commission’s purview.”

The Recycling Act of 1981 created the Municipal Recycling Tonnage Grant Program whereby municipalities could receive a grant for the amount of materials documented as being recycled during

the previous calendar year. At that time, the program was on a voluntary basis. Approximately 250 of NJ's 566 municipalities reported recycling in 1982. The amount of recycling reported was 250,000 tons of materials.

Until the 1987 Statewide Source Separation and Recycling Act, many New Jersey environmental commissions ran the recycling programs for the municipalities. The Recycling Act required municipalities to submit tonnage reports as well as separation for recycling of 50 percent of the total municipal solid waste, including vegetative and yard waste. Each county must designate at least three materials and secure markets for them. It also bans dumping leaves at landfills. The Recycling Act gives the municipality the responsibility to:

- Pass an ordinance, naming at least three materials to be separated from residential, commercial and institutional solid waste and requiring the separation of leaves from solid waste;
- Name a recycling coordinator;
- Design a program for the collection of recyclables and a program for the collection of leaves;
- Advertise the recycling program every six months; and
- Submit an annual tonnage report to the Office of Recycling at the new Jersey Department of Environmental Protection, documenting amount of materials recycled.

RECENT NJ STATE REGULATION

An excerpt from the NJDEP website eloquently states:

"Undoubtedly, January 14, 2008 will long be remembered as one of the most important days in New Jersey's recycling history for it was on this date that Governor Jon S. Corzine signed into law the Recycling Enhancement Act (P.L. 2007, c.311). This landmark piece of legislation reestablishes a source of funding for recycling in New Jersey through a $3.00 per ton tax on solid waste accepted for disposal or transfer at in-state solid waste facilities. Solid waste being transported out of state, either directly or by railroad, is also subject to the new recycling tax. In such cases, the solid waste collector is responsible for paying the tax. The reestablishment of a funding source for recycling is especially significant, as inadequate funding has been considered one of the key reasons behind New Jersey's declining recycling rates, which have dropped precipitously over the past decade. The New Jersey recycling community has looked forward to this day ever since the expiration of the recycling tax in 1996 and views the signing of this legislation as a watershed moment in our state's recycling history."

The funds generated by the Recycling Enhancement Act are directed as follows:

- 60% to be used for recycling tonnage grants to municipalities and counties.
- 25% to counties for preparing and implementing solid waste management plans, including the implementation of the goals of the State Recycling Plan. Among other things, these funds can be used to pay for household hazardous waste collection events.
- An additional 5% to Counties for public information and education programs concerning recycling.

- 5% to the NJDEP to provide grants to institutions of higher education to conduct research in recycling.
- 5% to the NJDEP for recycling program planning and administrative expenses associated with the program.

"*Other important aspects of the new law include the expiration of the Solid Waste Services Tax (which stands at $1.65 per ton) that has been levied on solid waste disposed at landfills and the requirement that municipal and county recycling coordinators become certified through a formal course of instruction. In addition, the Recycling Enhancement Act calls for an $8,000,000 appropriation from the General Fund to the Recycling Fund for recycling grants to counties and municipalities. The Department must issue these grants within the next twelve months. While recycling funds collected in the upcoming years will be used to repay this amount to the General Fund, this monetary infusion made available by the Act will be helping reinvigorate New Jersey's programs over the short term.*"

The Recycling Enhancement Act (P.L. 2007, c.311) was further refined in 2010 under the Electronics Waste Management Act (EWMA). Effective January 1, 2011 a disposal ban was placed on computers, monitors, laptops and televisions. The EWMA requires all manufacturers that sell these items in NJ to register with the state and submit a plan to the state for the creation of recycling collection sites. In essence, the EWMA states that if a manufacturer sells electronics in NJ, then they must create an acceptable plan to recycle electronics. NJ should expect a combination of specific drop off sites as well as retailer managed recycling of electronics.

RECENT RECYCLING TONNAGE INFORMATION FOR MADISON

As a result of the Recycling Enhancement Act, Madison pays $3.00 per ton of garbage. In 2010, Madison delivered 5,156.59 tons of garbage to the Morris County Municipal Utility Authority (MCMUA) facility. It is important to note that because Morris County currently has a Waste Flow Order where municipalities are mandated to deliver all garbage generated in the town to the MCMUA tipping station, private commercial haulers that service Borough businesses are also required to abide by this Order. Thus, the 5,156.59 tons of garbage represent a very accurate number of the total garbage—commercial, industrial and residential—generated by all of Madison. At $3.00 per ton of garbage, Madison's 2010 Recycling Tax totaled $15, 469.77.

Because Madison's garbage tonnage has remained fairly consistent, so has the yearly Recycling Tax. In addition, Madison received recycling grants from the State of New Jersey totaling over $34,000 in 2009 and over $29,000 in 2010—a total of $63,000 in grant funds. This means that Madison is receiving more from the Recycling Fund then it is paying into it.

Current Recycling Tonnage Information for Various Materials

MATERIAL	**2007 tons**	**2008 tons**	**2009 tons**	**2010 tons**

Corrugated paper, mixed paper, newspaper and junk mail	3,618.7	3,183.8	3,108.0	3,657.6
Glass Containers	473.3	514.9	535.4	545.0
Aluminum Containers	33.7	37.4	35.1	54.8
Steel Containers	70.0	75.8	72.5	82.2
Plastic Containers	101.1	109.8	105.2	121.2

There are other additional categories that are included on the State Tonnage Report (30 total) and they also include: various metals; automotive materials including batteries, tires, used motor oil, auto scrap and anti-freeze; various vegetative materials including stumps, leaves, brush grass clippings and tree parts; consumer electronics; construction material including concrete, asphalt and brick; food waste, and oil contaminated soil.

New Jersey has recently enacted legislation requiring that electronic recycling be mandatory. Fortunately, Madison has been ahead of this thanks to the efforts of the Madison Environmental Commission (MEC). In 2010, the MEC created a partnership with the Borough, local merchant PC Problems and the electronic recycling firm, e-Revival. PC Problems now accepts all electronic recycling at their shop on Main Street. In turn, they bring the electronics to a container at the DPW yard that was provided by e-Revival for free. E-Revival, in turn, collects the electronics and recycles over 99% of the materials. E-Revival operates an EPA and NJDEP notified and compliant facility and is a member of the International Association of Electronic Recyclers. Their goal is zero waste and zero export.

Pictured above are PC Problems staff and members of the Madison Environmental Commission.

RECYCLING PROCEDURES IN MADISON

Madison residents' recyclable materials are collected weekly by crews from The First Occupational Center of New Jersey. Materials alternate week to week—commingled bottles and cans one week; newspapers and magazines the next and so on. Recyclables must be put out on the curbside the night prior to or by 7 am of collection day.

On commingled collection days acceptable materials include glass, aluminum, tin and steel, food and beverage containers, and plastic soda, milk, water and detergent bottles. The Borough of Madison recycles plastics 1-7. This includes yogurt cups, large jugs, margarine containers, Styrofoam egg cartons and alike. On newspaper days, acceptable materials include newspaper, junk mail, magazines, and cardboard.

Recycling by Madison businesses must be done by either using a private hauler or by bring the materials at no charge to the Madison Borough Garage on John Avenue on Mondays and Fridays between 9 a.m. and 11:30 a.m.

Special arrangements can be made for the pick up of refrigerators, air conditioners, freezers, or white goods by calling the Department of Public Works at 973-593-3088. A payment of $25 must be

submitted in advance. Pick up occurs on Fridays, except on Holidays, when pick up will occur on a Thursday.

Motor oil, used tires, and car batteries can be properly disposed of at many local service stations, or through the Morris County Household Waste program.

Household hazardous waste, which includes pesticides, herbicides, oil based paints/stains, paint thinners; antifreeze, motor oil, transmission/brake fluid and batteries cannot be recycled and have special disposal procedures. For Morris County residents, the Morris County Muncipal Utilities Authority offers two household hazardous waste collection days. A permanent site located in Flanders where hazardous materials can be brought is available by appointment only. For information, and to make an appointment, please call the County at 973-829-8006.

SOURCES OF INFORMATION

U.S. Environmental Protection Agency

The USEPA website at http://www.epa.gov/waste/index.htm is one of the most thoughtful and comprehensive waste and recycling websites in available. It is worth noting that the current EPA Commissioner, Lisa Jackson, is the immediate past Commissioner of the NJDEP.

NJ Department of Environmental Protection

The NJDEP at http://www.state.nj.us/dep/dshw/ is not as dynamic as the USEPA site, but it does contain a significant amount of information and data related to New Jersey.

FOOTNOTES

1. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf
2. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf 3 NJ Recycling Rates come from: http://www.state.nj.us/dep/dshw/recycling/stat_links/06_revised_trends_table.pdf and http://www.state.nj.us/dep/dshw/recycling/stat_links/07%20disposal%20rates.pdf

0. http://www.epa.gov/osw/nonhaz/municipal/pubs/msw2009-fs.pdf

0. Sandy Batty, Environmental Commissioner's Handbook, (4th ed.) Association of NJ Environmental Commissions: 1997, p51.

0. Sandy Batty, Environmental Commissioner's Handbook, (4th ed.) Association of NJ Environmental Commissions: 1997, p51.

0. http://www.nj.gov/dep/dshw/recycling/whatsnew/Recycling%20Act%20Signed.htm

0. http://www.nj.gov/dep/dshw/recycling/whatsnew/Recycling%20Act%20Signed.htm