5.4.2 DROUGHT

This section provides a profile and vulnerability assessment for the drought hazard.

HAZARD PROFILE

This section provides profile information including: description, location and extent, previous occurrences and losses, and the probability of future occurrences.

Description

The Climate Prediction Center (CPC) of the National Weather Service (NWS) defines drought as a deficiency of moisture that results in adverse impacts on people, animals, or vegetation over a sizeable area (CPC, 2004). According to the New Jersey State Hazard Mitigation Plan (NJ HMP), drought is a period of drier-than-normal conditions that results in community water issues (NJ HMP, 2012). Other climatic factors, such as high temperatures, prolonged high winds and low relative humidity, can aggravate the severity of a drought. These conditions are caused by anomalous weather patterns when shifts in the jet stream block storm systems from reaching an area. As a result, large high-pressure cells may dominate a region for a prolonged period, thus reducing precipitation.

There are four different ways that drought can be defined or grouped:

- Meteorological drought is a measure of departure of precipitation from normal. It is defined solely on the degree of dryness. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location.
- Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, reduced ground water or reservoir levels, etc. It occurs when there is not enough water available for a particular crop to grow at a particular time. Agricultural drought is defined in terms of soil moisture deficiencies relative to water demands of plant life, primarily crops.
- Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply and occurs when these water supplies are below normal. It is related to the effects of precipitation shortfalls on stream flows and reservoir, lake and groundwater levels.
- Socioeconomic drought is associated with the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. This differs from the aforementioned types of drought because its occurrence depends on the time and space processes of supply and demand to identify or classify droughts. The supply of many economic goods depends on weather (e.g., water, forage, food grains, fish, and hydroelectric power). Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply (National Drought Mitigation Center, 2012).

Extent

The extent (e.g., magnitude or severity) of drought can depend on the duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. The intensity of the impact from drought could be minor to total damage in a localized area or regional damage affecting human health and the economy. Generally, impacts of drought evolve gradually and regions of maximum intensity change with time. The severity of a drought is determined by areal extent as well as intensity

and duration. The frequency of a drought is determined by analyzing the intensity for a given duration, which allows determination of the probability or percent chance of a more severe event occurring in a given mean return period.

Several indices developed by Wayne Palmer (Palmer Drought Severity Index [PDSI] and Crop Moisture Index [CMI]), as well as the Standardized Precipitation Index (SPI), are the most useful for describing the many scales of drought. Other indices include accumulated departure from normal stream flows, low-flow frequency estimates and changes in water storage, groundwater levels and rates of decline, and lake levels. Most commonly used indices that are used to measure or identify the severity and classification of past and present droughts primarily include, but not limited to, the following:

Palmer Drought Severity Index

The Palmer Drought Severity Index (PDSI) was developed in 1965, and indicates the prolonged and abnormal moisture deficiency or excess. The PDSI is an important climatological tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. It can be used to help delineate disaster areas and indicate the availability of irrigation water supplies, reservoir levels, range conditions, amount of stock water, and potential intensity of forest fires (NWS CPC, 2005).

The PDSI has become the semi-official drought index. It is the most effective in determining long-term droughts; however, it is not good with short-term forecasts. Table 5.4.2-1 lists the Palmer Classifications. Zero is used as normal and drought is shown in terms of negative numbers. For example, -2 is moderate drought, -3 is severe drought and -4 is extreme drought. The PDSI also reflects excess precipitation using positive numbers (NOAA, Date Unknown).

Table 5.4.2-1. PDSI Classifications

Palmer Classifications	
4.0 or more	extremely wet
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

Source: NDMC, Date Unknown

Crop Moisture Index

The CMI, developed by Wayne Palmer in 1968, can be used to measure the status of dryness or wetness affecting warm season crops and field activities. It gives the short-term or current status of purely agricultural drought or moisture surplus and can change rapidly from week to week (NWS CPC, 2005). The CMI responds more rapidly than the PDSI so it is more effective in calculating short-term abnormal dryness or wetness affecting agriculture. CMI is designed to indicate normal conditions at the beginning and end of the growing season; it uses the same levels as the Palmer Drought (NOAA, Date Unknown).

The Standardized Precipitation Index (SPI) is a probability index that considers only precipitation. It is based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. The SPI is computed by NCDC for several time scales, ranging from one month to 24 months, to capture the various scales of both short-term and long-term drought (Heim, 2008).

National Drought Mitigation Center

The National Drought Mitigation Center (NDMC) helps develop and implement measures to reduce societal vulnerability to drought, stressing preparedness and risk management rather than crisis management. Most of the NDMC's services are directed to state, federal, regional, and tribal governments that are involved in drought and water supply planning. The NDMC produces a daily drought monitor map that identifies drought areas and ranks droughts by intensity. U.S. Drought Monitor summary maps are available from May 1999 through the present and identify general drought areas and classification droughts by intensity ranging from D1 (moderate drought) to D4 (exceptional drought). Category D0, drought watch areas, are drying out and possibly heading for drought, or are recovering from drought but not yet back to normal, suffering long-term impacts such as low reservoir levels (Table 5.4.2-2).

Table 5.4.2-2. NDMC Drought Severity Classification Table

Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (%)	USGS Weekly Streamflow (%)	Standardized Precipitation Index (SPI)	Satellite Vegetation Health Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.	-1.0 to -1.9	21-30	21-30	-0.5 to -0.7	36-45
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested	-2.0 to -2.9	11-20	11-20	-0.8 to -1.2	26-35
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed	-3.0 to -3.9	6-10	6-10	-1.3 to -1.5	16-25
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	-1.6 to -1.9	6-15

Category	Description	Possible Impacts	Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (%)	USGS Weekly Streamflow (%)	Standardized Precipitation Index (SPI)	Satellite Vegetation Health Index
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies	-5.0 or less	0-2	0-2	-2.0 or less	1-5

Source: NDMC, 2002
Note: Additional indices used, mainly during the growing season, include the USDA/NASS Topsoil Moisture, Crop Moisture Index (CMI), and Keetch Byram Drought Index (KBDI). Indices used primarily during the snow season and in the West include the River Basin Snow Water Content, River Basin Average Precipitation, and the Surface Water Supply Index (SWSI).

Drought Impact Reporter

The Drought Impact Reporter (DIR) is an interactive tool developed by the NDMC to collect, quantify, and map reported drought impacts for the U.S., which is one of the resources used to identify known drought events throughout Burlington County for this Plan (NDMC, 2012).

North American Drought Monitor

The North America Drought Monitor is a cooperative effort between drought experts in Canada, Mexico and the U.S. to monitor drought across the continent on an ongoing basis. The Drought Monitor concept was developed as a process that synthesizes multiple indices, outlooks and local impacts, into an assessment that best represents current drought conditions. The final outcome of each Drought Monitor is a consensus of federal, state and academic scientists. Maps of U.S. droughts are available from this source from 2003 to the present (NCDC, 2012).

Drought Indicators of New Jersey

After a severe drought event in New Jersey occurred during 1998 and 1999, the NJDEP analyzed factors affecting the State's water resources and its response to the situation. During this drought event, the State's ability to manage the situation was made difficult because they did not have a way to compare the severity of drought in different portions of the State and then communicate the information to the public.

In response to these difficulties, the NJDEP developed a unique set of indicators specifically designed to monitor regional water supply sources in the State. The indicators were designed to do the following:

- Integrate large amounts of data about water supply sources
- Communicate to the public and decision makers and provide accurate information
- Be reasonable
- Be based on real-time data
- Be distributed quickly over the internet

There are drought indicators for precipitation, streamflow, reservoir levels, and groundwater levels. Each is assigned to one of four conditions: near or above normal; moderately dry; severely dry; or extremely dry; a color is associated with each condition (Table 5.4.2-3). The State is divided into six drought regions (Figure 5.4.2-1) and indicators are evaluated for the water supply sources important to each

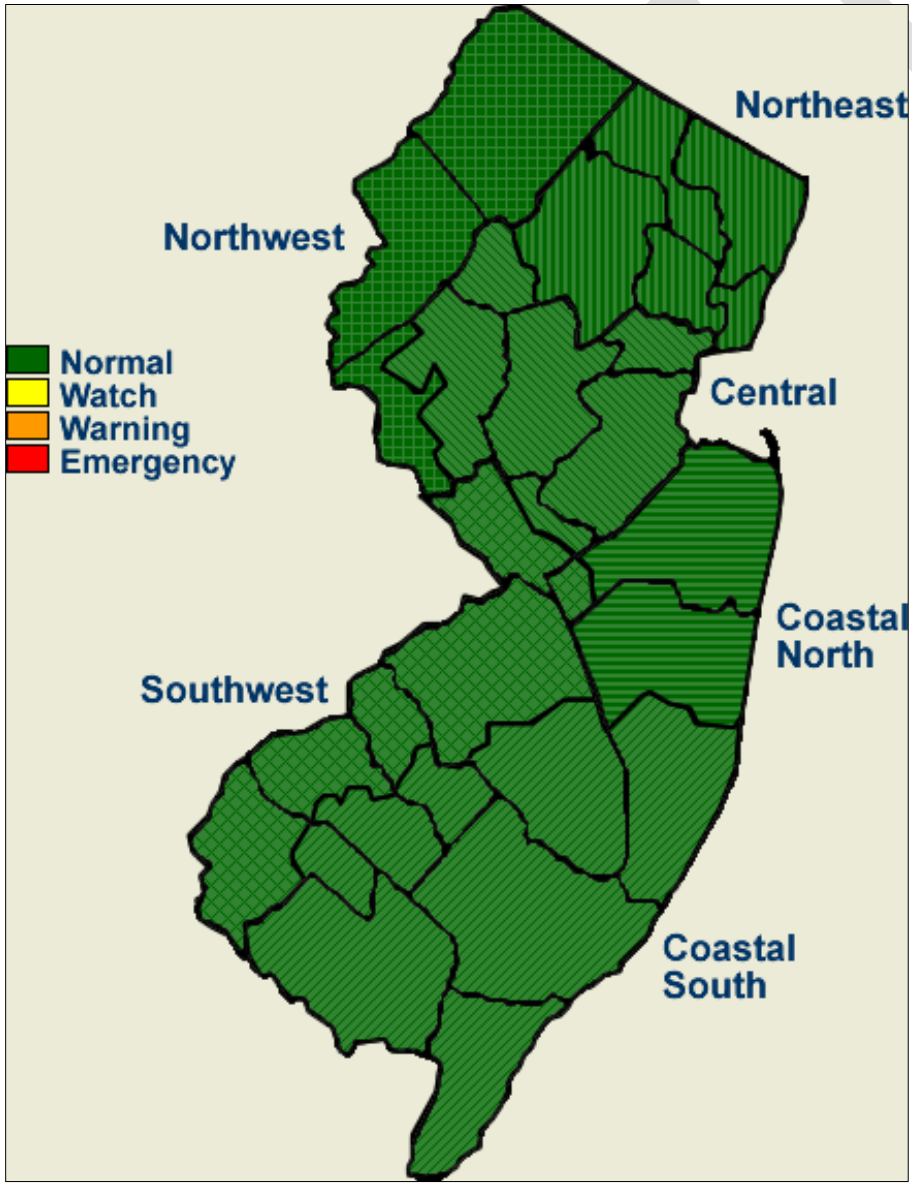
region. The indicators are updated weekly during dry periods and bi-weekly in normal and wet periods. These indicators are intended to be used to evaluate water supply droughts, not other types of drought (Hoffman and Domber, 2003; Hoffman, 2010). Burlington County is located within the southwest and coastal south drought regions.

Table 5.4.2-3. Drought Indicators for New Jersey

Color	Drought Status Indicator
Green	Near or above normal
Light Yellow	Moderately dry
Dark Yellow	Severely dry
Red	Extremely dry

Source: NJDEP, 2013

Figure 5.4.2-1. Drought Regions of New Jersey



Source: NJDEP, 2006

Extent in Burlington County

In summary, the magnitude and severity of drought in Burlington County can be extensive, for the following reasons:

- *Crop failure* is one common effect of drought. With active agriculture extending from the Pinelands throughout northern Burlington County, the County has always been one of the leading agricultural counties in the nation. According to the Burlington County Cross-Acceptance Report, nearly 17 percent of the County's acreage is devoted to agricultural purposes. Burlington County is ranked the second largest blueberry-producing and the third largest cranberry-producing county in the U.S. There are more acres devoted to farming in Burlington County than any county in the State, primarily in vegetable, fruit and timber production. Water for irrigation is sourced 97 percent from surface water sources and accounts for 61 percent of all water withdrawn in the county per year. Surface water is particularly susceptible to periods of drought (Burlington County HMP, 2008).

- *Water supply shortages* are a second effect of drought. Burlington County public supply and domestic self-supply are sourced primarily from groundwater (65 percent). Groundwater is fairly resistant to drought conditions; however, the remaining 35 percent is sourced from surface water, which is more susceptible to the effects of drought. The expected likelihood of future losses associated with reductions in water supply from underground aquifers would be low. The expected likelihood of future losses associated with reductions in water supply from surface water sources would be higher because surface water sources (such as reservoirs and rivers) are much less resistant to periods of drought and are more susceptible to being impacted (Burlington County HMP, 2008).

- A third common effect of drought is *fish and wildlife mortality*. Burlington County is largely rural and has diverse populations of fish and wildlife. Its wetlands, scrub pine and oak woodlands, and Atlantic white cedar forests shelter a wide variety of wildlife, while abundant creeks, estuaries and aquifers provide essential water resources. Nine different threatened and endangered species reside in Burlington County. The New Jersey Pinelands, which cover approximately 64 percent of the County's land area, is the largest Pine Barrens complex in the world. It supports globally rare communities and species and is an area of national significance, supporting: five federally listed threatened and endangered species, 17 federal candidate species and species of concern, and 54 state listed threatened and endangered species. Because so much of the land area in Burlington County is undeveloped, fish and wildlife habitat is fairly high and therefore losses to fish and wildlife could likely be high (Burlington County HMP, 2008).

- A fourth common effect of drought is *wildfires*. Due to Burlington County's largely undeveloped nature, fuel is plentiful for wildfires, particularly in the Pine Barrens. In Burlington County, fuel tends to be most plentiful in areas where development densities are lowest; this works to reduce possible property damages and loss of life; however, the wildland-urban interface would be particularly vulnerable as well as transportation routes such as the Garden State Parkway which traverse the Pine Barrens. Wildfires are a unique hazard addressed separately in this plan (Burlington County HMP, 2008).

Feedback provided by local jurisdictions on the extent of the drought hazard in their communities includes:

- *Township of Tabernacle* OEM notes that the bulk of the economy of the Township rests in farms, while the remainder is mainly residential. The magnitude or severity of a drought event would be high due to the farmlands. There is no public water supply in the Township (residents and farms rely on private wells) (Burlington County HMP, 2008).
- *Township of Florence* noted that through years past they have had to put in place a strict water conservation program and monitoring of water storage levels (Burlington County HMP, 2008).
- *Township of Mount Laurel* has reported that drought conditions have occurred in their jurisdiction in the past, and some of their major concerns include: Township water supply, tree damage, parks and recreation facilities, and wildfires (Burlington County HMP, 2008).
- *Township of Cinnaminson* has reported putting in place strict water conservation programs and water storage level monitoring during past drought events (Burlington County HMP, 2008).
- *Mansfield Township* reports that past drought conditions have not been severe enough to pose a hazard to their community (Burlington County HMP, 2008).
- Extent of the hazard in Evesham is limited because lands are mostly forested (though there is some farmland) (Burlington County HMP, 2008).
- *Township of Delran* notes that the extent of their wildfire hazard is not limited to just the Pine Barrens. They indicate that open space preservation land is often allowed to grow wild, and a drought could produce wildfires that could pose a danger to its visitors and adjacent properties (i.e., the Town notes that this could be the case with the Anderson Peach Farm) (Burlington County HMP, 2008).
- *Burlington City* estimates that the extent of the hazard in their municipality could be increased if the water intake on the Delaware River at the water treatment plant were to be impacted (Burlington County HMP, 2008).

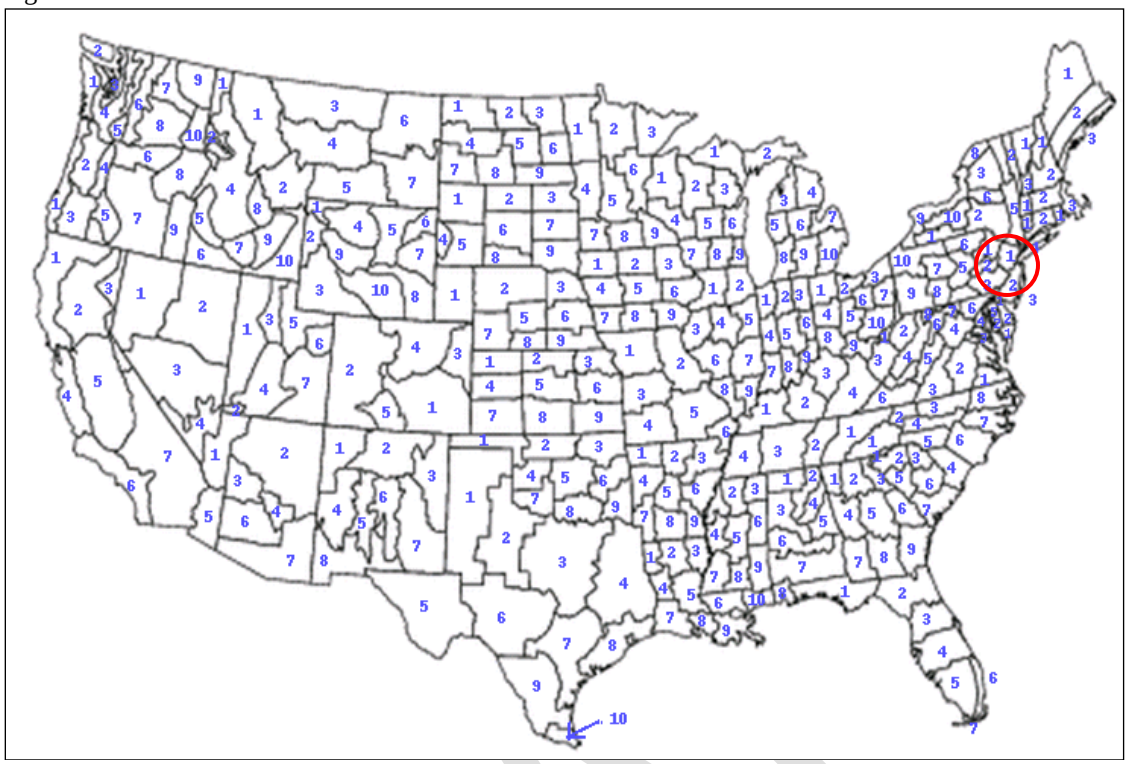
Location

The location of drought events throughout the State of New Jersey and Burlington County are further identified below.

Climate divisions are regions within a state that are climatically homogenous. The National Oceanic and Atmospheric Administration (NOAA) has divided the U.S. into 359 climate divisions. The boundaries of these divisions typically coincide with the county boundaries, except in the western U.S., where they are based largely on drainage basins (Energy Information Administration, 2005).

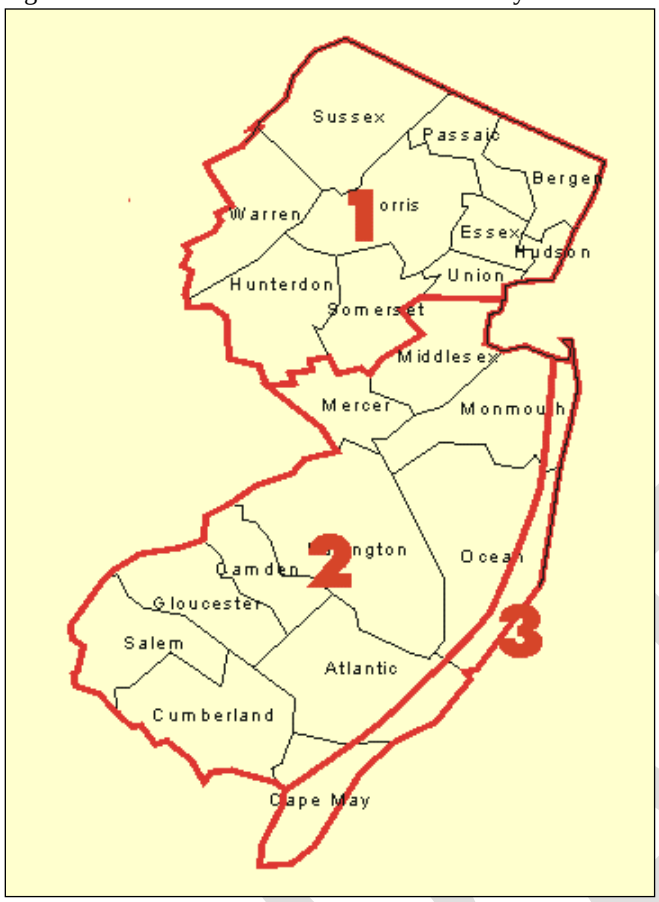
According to NOAA, the State of New Jersey is made up of three climate divisions: Northern Climate Division, the Southern Climate Division and the Coastal Climate Division. Burlington County is located within the Southern Climate Division (NOAA, Date Unknown). Figure 5.4.2-2 shows the climate divisions throughout the U.S. and Figure 5.4.2-3 shows the climate divisions of the State of New Jersey.

Figure 5.4.2-2. Climate Divisions of the U.S.



Source: NOAA, Date Unknown
Note (1): The red circle indicates the approximate location of Burlington County, Climate Division 1.
Note (2): 1 = Northern Climate Division; 2 = Southern Climate Division; 3 = Coastal Climate Division

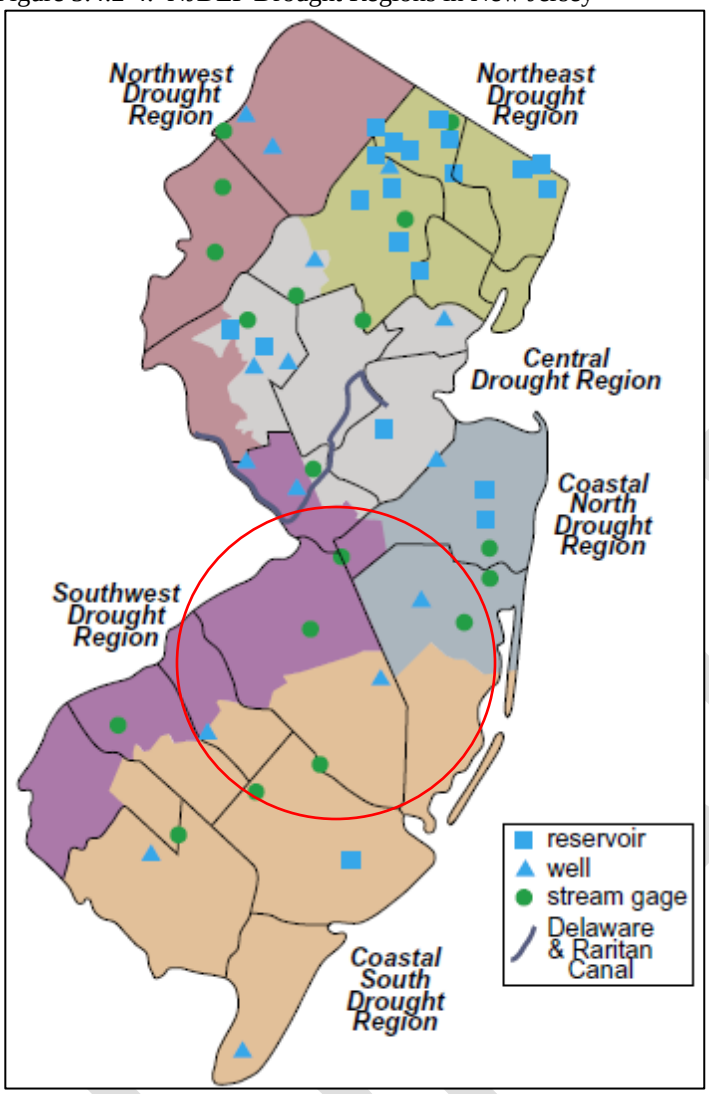
Figure 5.4.2-3. Climate Divisions of New Jersey



Source: Climate Prediction Center (CPC), 2005
Note: 1 = Northern Climate Division; 2 = Southern Climate Division; 3 = Coastal Climate Division

According to the New Jersey Geological Survey (NJGS), the New Jersey Department of Environmental Protection (NJDEP) divides New Jersey into six drought regions that are based on regional similarities in water-supply sources and rainfall patterns. These boundaries usually correspond to natural watershed boundaries. Regional boundaries match municipal boundaries in order to facilitate enforcement of potential water-use restrictions. The drought regions allow New Jersey to respond to changing conditions without imposing restrictions on areas that are not experiencing water shortages (Hoffman and Domber, 2003). The NJDEP indicates that Burlington County is within the Southwest and Coastal South Drought Regions (Figure 5.4.2-4).

Figure 5.4.2-4. NJDEP Drought Regions in New Jersey



Source: Hoffman and Domber, 2003
Note: The red circle indicates the approximate location of Burlington County. The County is located within the Southwest and Coastal South Drought Regions.

Groundwater is the primary source of water supply in Burlington County. According to the USGS Hydrologic Atlas 730-L for Segment 11 (which includes New Jersey, in addition to the states of Delaware, Maryland, North Carolina, West Virginia, Pennsylvania, and Virginia), published by Henry Trapp, Jr. and Marilee A. Horn in 1997, precipitation is the source of all freshwater in New Jersey. Most of the precipitation that is not evapotranspired runs directly off the land surface to streams or reaches streams after temporary storage in lakes, reservoirs, wetlands, and soils. A small part of precipitation infiltrates the land surface and percolates downward to recharge aquifers. In Burlington County, the aquifer is known as the Northern Atlantic Coastal Plain Aquifer System. Burlington County obtains its water supply from this aquifer system, which consists of several aquifers that are vertically stacked (Burlington County HMP, 2008).

NJDEP Source Water Assessment Reports show that Burlington County is supplied by 74 different Community Water Supply Systems, which together collect water through a network of 240 wells and three surface water intakes. Sixty-five percent of the wells pump from the Potomac-Raritan-Magothy

aquifer; twenty-seven percent pump from the Mount Laurel-Wenonah aquifer; and the remaining eight percent pump from the Englishtown, Piney Point, Kirkwood-Cohansey, and Vincentown aquifers. Of the three surface water intakes, two are located on the Delaware River and one is located on the Rancocas Creek. While no reservoirs are a direct water supply source, many reservoirs function to maintain water levels in rivers which have surface water intakes.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with drought events throughout the State of New Jersey and Burlington County. With numerous sources reviewed for the purpose of this HMP, loss and impact information for events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during the HMP research.

According to NOAA's NCDC storm events database, Burlington County experienced 49 drought events between 1950 and April 30, 2013. No other drought event indicated monetary damages according to NCDC. According to the Hazard Research Lab at the University of South Carolina's Spatial Hazard Events and Losses Database for the U.S. (SHELDUS), between 1960 and 2013, two drought events occurred within the County. The database indicated that drought events and losses specifically associated with Burlington County and its municipalities totaled over $5 million in crop damages. However, these numbers may vary due to the database identifying the location of the hazard event in various forms or throughout multiple counties or regions.

Between 1954 and 2013, FEMA declared that the State of New Jersey experienced two drought-related disaster declarations: one major disaster (DR) and one emergency (EM); both were classified as water shortages. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the New Jersey HMP, FEMA, and other sources indicate that Burlington County has been declared as a disaster area as a result of two drought-related events (FEMA, 2013).

Based on all sources researched, known drought events between 1950 and 2013 that have affected Burlington County and its municipalities are identified in Table 5.4.2-4. Not all sources have been identified or researched; therefore, Table 5.4.2-4 may not include all events that have occurred throughout the County and region. Events previously reported in the 2008 County HMP are sourced as "Burlington County HMP".

Table 5.4.2-4. Drought Events Affecting Burlington County Between 1950 and 2013

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
1965	Drought / Water Shortage	DR-205	Yes	No reference and/or no damage reported.	FEMA
1980	Drought / Water Shortage	EM-3083	Yes	No reference and/or no damage reported.	FEMA
March 1995 – August 1995	Drought	N/A	N/A	March thru May 1995, three consecutive months of below normal precipitation. One of the driest springs on record for most of inland New Jersey. June 1995 brought statewide precipitation of 30 to 50 percent of normal, with Burlington and Ocean counties being the driest. August 1995 was one of the 10 warmest August's on record, and also one of the driest.	Burlington County HMP
June 1997 - October 1997	Drought	N/A	N/A	Unseasonably dry weather with below normal rainfall, which became worse during the summer months, forced the Delaware River Basin Commission to declare a drought warning on October 27th.	Burlington County HMP
July 1998 – September 1999	Drought	N/A	N/A	One of the driest periods on record. Estimated statewide agricultural losses of $80 million. Stream flows some of the lowest recorded. Average precipitation was about 50 percent of normal, state wide. NJDEP declared extreme drought. DRBC declared drought warning stage 2.	Burlington County HMP
October 2000	Drought	N/A	N/A	One of driest Octobers on record for 16 of New Jersey's 21 Counties, including Burlington. Dry weather did not cause appreciable agricultural damage, but falling leaves left the affected areas susceptible to forest and brush fires.	Burlington County HMP
April 2001 – May 2001	Drought	N/A	N/A	Unseasonably dry, particularly in the second half of April and the first half of May when many areas received very little precipitation. The NJ State Forest Fire Service imposed a statewide ban on open, controlled fires. Lack of precipitation forced many farmers to delay planting soybeans and initiate irrigation for peaches and corn. Grains and grasses were either stunted or grew at a slow pace. On May 1st, in Bordentown Township, sparks from a passing train ignited a dozen brush fires, damaging one barn. On May 15th, in Florence, 100 acres burned.	Burlington County HMP
October 2001 – November 2002	Drought	N/A	N/A	On November 21, 2001, flow along the Mullica River at Batsto in Burlington County was at a new record low and only 14 percent of normal. In December 2001, the Delaware River Basin Commission was forced to reduce the amount of water released from its reservoirs in to the Delaware River. In January 2002,	Burlington County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				the North Branch of the Rancocas Creek at Pemberton was flowing at only 29 percent of its normal rate. In February 2002 record low stream flows for calendar days were set for the Rancocas Creek, Crosswicks Creek, Oswego Creek, and Mullica River. Winter wheat crop struggled, as did evergreen farms. Irrigation ponds well below normal. In March 2002 Burlington County had a seven week backlog for deepening wells. Winter 2001-2002 half of the ponds in the Mullica River Basin went dry with associated negative impacts to fish and wildlife. In August 2002, on the Fort Dix military reservation, the sun's heat ignited ammunition and sparked a wildfire which consumed about 3,000 acres. In September 2002 Federal Farm Disaster Declaration. Many New Jersey farmers suffered losses of 50 percent or more for 2002.	
September 2005	Drought	N/A	N/A	Unseasonably warm and dry month across the state of New Jersey. Lack of rain affected both the agriculture and water supplies. The governor declared a drought watch on September 13th. Because of the higher cost for fuel, irrigation costs increased. The heat damaged the leaves of temperature sensitive plants such as lettuce, parsley and cilantro. The lack of rain reduced the size of lettuce, cabbage, leeks and arugula. The sun helped cause blistering of tomatoes, peppers, squash and beans. Some tree leaves were showing signs of scorching, especially along their edges. Dogwoods and maples showed signs of water stress. Milk production was down because of the affect the heat had on the cows. As one farmer was quoted, operational costs were up about 20 percent and yields were down 25 percent.	Burlington County HMP
May to July 2006	Drought	N/A	N/A	Burlington County entered a drought was noted as abnormally dry by the Drought Monitor on March 21, and the southern part of the county was lifted to Moderate Drought status on April 18. The drought watch on the northern half of the county was lifted on June 6th, and on the southern portion on June 27th. Resumption of significant precipitation in June led to lifting of watch on July 3, 2006.	NOAA-NCDC, NDMC
August to December 2008	Drought	N/A	N/A	An unseasonably dry August occurred across the state of New Jersey with the greatest departures from normal in the central part of the state. This exacerbated crop damage that was already inflicted by the heat and the large hail storm in the southern part of the state on August 10th. The combination of the June heat and the August hail storm and drought led the	NOAA-NCDC, NDMC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				United States Secretary of Agriculture Edward Schafer to declare ten central and southern New Jersey Counties a natural disaster on September 22nd. Burlington County entered a drought watch under abnormally dry conditions on July 22, 2008. The southern portion of the county was taken off watch on August 12th, but went back on watch status on September 2nd. The majority of the county was taken of watch status on November 18th, and the remaining areas by December 2nd.	
June to October 2010	Drought	N/A	N/A	The state of New jersey was placed on drought watch on June 29th. On July 13th, Burlington and other counties were lifted to Moderate Drought status. All areas of the county except for a small portion in the northwest corner remained at least on drought watch through August, with the southern portion of the county remaining in a moderate drought. NJDEP asked all state residents to voluntarily conserve water. The hot and dry summer taxed reservoir stream and groundwater levels. Shallow groundwater (private) wells were also starting to show stress. Statewide it was the 4th warmest September on record since 1895 with an average temperature of 69.2 degrees. On September 7, more than half of the county including the northern, eastern, and southern areas, was declared in a severe drought. This was lowered to moderate drought on October 5th. The drought watch was lifted from the western part of the county on October 26th, and on the rest of the county by December 14h.	NOAA-NCDC, NDMC

Source(s): NOAA-NCDC, FEMA, Burlington County HMP
FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
K Thousand ($)
M Million ($)
N/A Not Applicable
NCDC National Climatic Data Center
NDMC National Drought Mitigation Center
NOAA National Oceanic and Atmospheric Administration
NJ New Jersey
NJDEP New Jersey Department of Environmental Protection

Probability of Future Events

Past drought occurrences are expected to be a sound indicator of the probability of future drought occurrences for Burlington County. Certain parts of the country are more susceptible to being impacted by a drought than others are. Arid parts of the country tend to be at greater risk of experiencing long-term droughts, while more humid parts of the country tend to be more susceptible to short-term droughts. According to the USGS Division of Water Resources, Burlington County and its jurisdictions fall within what is described as a "humid region" and is more likely to experience a short-term drought (Burlington County HMP, 2008).

It is estimated that Burlington County will continue to experience direct and indirect impacts of drought and its impacts on occasion, with the secondary effects causing potential disruption or damage to agricultural activities and creating shortages in water supply within communities.

In Section 5.3, the identified hazards of concern for Burlington County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for drought in the County is considered 'occasional' (likely to occur within 100 years, as presented in Table 5.3-3).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For the drought hazard, all of Burlington County has been identified as the hazard area. Therefore, all assets (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable to a drought. The following text evaluates and estimates the potential impact of the drought hazard on Burlington County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Essentially, all of Burlington County is vulnerable to drought. However, areas at particular risk are areas used for agricultural purposes (farms and cropland), open/forested land vulnerable to the wildfire hazard, densely-populated areas where communities rely on surface water supplies (above ground reservoirs) for industrial, commercial, and domestic purposes, and certain areas where elderly, impoverished or otherwise vulnerable populations are located.

Data and Methodology

Sufficient data was not available at the time of the study to estimate damages due to drought. According to FEMA's How-To #2, current loss estimation methodologies are not available for estimating drought damages. If this information should become available in the future, it could be incorporated into future updates of the plan. While one could make some blanket assumptions at this time to use various tools for loss estimation, this would likely yield erroneous data given the high degree of variation in type and density of development. Acting upon such rough estimates could result in an unwise use of limited resources. At this time, vulnerability is being expressed in qualitative terms in terms of types of damages.

In general estimated damages due to future droughts in Burlington County could be high. Types of damages are discussed qualitatively below.

Impact on Life, Health and Safety

Droughts conditions can cause a shortage of water for human consumption and reduce local fire-fighting capabilities. According to the New Jersey HMP, counties most often affected by a drought are densely populated areas that rely on above-ground reservoirs for their water supply. Areas more resistant to drought conditions are less densely populated and rely on groundwater or surface water sources (NJ HMP, 2011).

Water supply shortages are an effect of drought. Burlington County public supply and domestic self-supply are sourced primarily from groundwater (65 percent). Groundwater is fairly resistant to drought conditions. However, the remaining 35 percent is sourced from surface water, which is more susceptible to the effects of drought. The expected likelihood of future losses associated with reductions in water supply from underground aquifers would be low. However, the expected likelihood of future losses associated with reductions in water supply from surface water sources would be higher because surface

water sources (such as reservoirs and rivers) are much less resistant to periods of drought and are more susceptible to being impacted.

A second common effect of drought is fish and wildlife mortality. Burlington County is largely rural has diverse populations of fish and wildlife. Its wetlands, scrub pine and oak woodlands, and Atlantic white cedar forests shelter a wide variety of wildlife, while abundant creeks, estuaries and aquifers provide essential water resources. Nine different threatened and endangered species reside in Burlington County. The New Jersey Pinelands, which cover approximately 64 percent of the county's land area, is the largest pine barrens complex in the world. It supports globally rare communities and species and is an area of national significance, supporting: five federally listed threatened and endangered species, 17 federal candidate species and species of concern, and 54 state listed threatened and endangered species. Because so much of the land area in Burlington County is undeveloped, fish and wildlife habitat is fairly high and therefore losses to fish and wildlife could likely be high.

A third common effect of drought is wildfires. Due to Burlington County's largely undeveloped nature, fuel is plentiful for wildfires, particularly in the Pine Barrens. In Burlington County, fuel tends to be most plentiful in areas where development densities are lowest; this works to reduce possible property damages and loss of life; however, the wildland-urban interface would be particularly vulnerable as well as transportation routes such as the Garden State Parkway which traverse the Pine Barrens. Wildfires are a unique hazard addressed separately in this plan.

Impact on General Building Stock

No structures are anticipated to be directly affected by a drought event. However, droughts contribute to conditions conducive to wildfires and reduce fire-fighting capabilities. Approximately 37.2% of the land in Burlington County is forested (Burlington County GIS Land Use Land Cover 2007 data). Risk to life and property is greatest in those areas where forested areas adjoin urbanized areas (high density residential, commercial and industrial) or wildland/urban interface (WUI). Refer to the Wildfire Risk Assessment for more detailed information on the vulnerability of the built environment to the wildfire hazard.

Impact on Critical Facilities

It is expected that critical facilities will continue to be operational during a drought event.

Impact on the Economy

New Jersey agriculture ranks third in economic importance to the State. According to the NJ State HMP, the market value of agricultural products sold in the State in 2008 was $1.1Billion. As noted, agricultural resources need ample water supplies for successful production, relying on natural precipitation and the supply and demand of surface and groundwater resources, both of which become limited or compromised during times of drought. A prolonged drought can have a serious economic impact on a community (i.e., a lessened crop yield, financial loss to the farmer). The entire agricultural industry in Burlington County is vulnerable to the drought hazard.

Crop failure is one common result of drought. With active agriculture extending from the Pinelands throughout northern Burlington County, Burlington has always been one of the leading agricultural counties in the nation. Burlington County is ranked the second largest blueberry-producing and the third largest cranberry-producing county in the United States. There are more acres devoted to farming than any county in the state, primarily in vegetable, fruit and timber production. Water for irrigation is sourced

97 percent from surface water sources and accounts for 61 percent of all water withdrawn in the county per year. Surface water is particularly susceptible to periods of drought.

According to the 2007 Agriculture Census, Burlington County has 906 farms totaling 85,790 acres. Of these, 715 farms and 53,650 acres are used for cropland with 624 farms and 48,823 acres used for harvesting crops. The number of farms that irrigate land is equal to 203, and they irrigate a total of 12,620 acres. The market value of all agricultural products sold in Burlington County is $86,302,000, with $80,533,000 generated from crops and $5,769,000 generated from livestock, poultry and other products. Agricultural losses, specifically losses to crops, in Burlington County could be significant during a drought.

Increased demand for water and electricity during drought conditions may result in shortages and a higher cost for these resources (FEMA, 1997). Industries that rely on water for business may be impacted the hardest (e.g., nurseries, golf courses, places of recreation). Even though most businesses will still be operational, they may be impacted aesthetically. In addition, because droughts vary in geographic extent and severity, Burlington County may also be impacted by supply/price of food for crops grown outside of the immediate area.

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Future growth could impact the amount of potable water available due to a drain on the available water resources. Other areas that could be impacted include agriculture and recreational facilities such as golf courses, farms, and nurseries.

Effect of Climate Change on Vulnerability

The changes in global climate that are projected to occur in the coming decades will have significant impacts on New Jersey. Impacts related to increasing temperatures are already being felt throughout the State.

Several agencies, organizations, and academic institutions have addressed the potential effects of climate change on New Jersey. The New Jersey Climate Adaption Alliance facilitated by Rutgers University provided a description of climate change in New Jersey, the report included past changes that have been documented from historical observations as well as expected changes based on projections of temperature, precipitation and sea level through the end of the century. Among other findings the report states that projections are that short-duration warm season droughts are likely to become more common [Horton et al 2011]. However, the increase in frequency of droughts ranges from only slightly more likely under the low emissions scenario [IPCC 2000] to as frequent as once per year under the high (A1F1) emissions scenario [Frumhoff et al 2007] (New Jersey Climate Adaption Alliance, 2012).

The Union of Concerned Scientists also prepared an overview of how climate change may affect New Jersey. According to the Union rising summer temperatures coupled with little change in summer rainfall are projected to increase the frequency of short-term (one- to three month) droughts (The Union of Concerned Scientists, Date Unknown).

Both projections would increase stress on both natural and managed ecosystems across New Jersey.

Additional Data and Next Steps

Historic data available indicate that droughts can impact Burlington County and impact the local economy. For future plan updates, localized concerns and impacts will be collected and analyzed. Mitigation efforts could include development of a drought contingency plan, development of "triggers" for drought related actions, or provision of incentives to influence active water conservation techniques.