4.3.4 Earthquake

2024 HMP Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2018 and 2023.

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the earthquake hazard in Burlington County.

Hazard Description

An earthquake is the sudden movement of the Earth's surface caused by the release of stress accumulated within or along the edge of the Earth's tectonic plates, a volcanic eruption, or a human-caused explosion (FEMA 2001). Most earthquakes occur at the boundaries where tectonic plates meet (faults); less than 10 percent of earthquakes occur within plate interiors. New Jersey is in an area where the rarer plate interior-related earthquakes occur. As plates continue to move and plate boundaries change geologically over time, weakened boundary regions become part of the interiors of the plates. These zones of weakness within the continents can cause earthquakes in response to stresses that originate at the edges of the plate or in the deeper crust (Shedlock 1997).

The location of an earthquake is commonly described by its focal depth and the geographic position of its epicenter. The focal depth of an earthquake is the depth from the Earth's surface to the region where an earthquake's energy originates, also called the focus or hypocenter. The epicenter of an earthquake is the point on the Earth's surface directly above the hypocenter (Shedlock 1997). Earthquakes usually occur without warning and their effects can impact areas of great distance from the epicenter (FEMA 2001).

According to the U.S. Geological Survey (USGS) Earthquake Hazards Program (USGS 2021), an earthquake hazard is any disruption associated with an earthquake that may affect residents' normal activities. This includes surface faulting, ground shaking, landslides, liquefaction, tectonic deformation, tsunamis, and seiches; each of these terms is defined below; however, not all occur within the Burlington County planning area (USGS 2012):

- *Surface faulting*: Displacement that reaches the earth's surface during a slip along a fault. Commonly occurs with shallow earthquakes—those with an epicenter less than 20 kilometers.
- *Ground motion (shaking):* The movement of the Earth's surface from earthquakes or explosions. Ground motion or shaking is produced by waves that are generated by a sudden slip on a fault or sudden pressure at the explosive source and travel through the Earth and along its surface.
- *Landslide*: A movement of surface material down a slope.
- *Liquefaction*: A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like the wet sand near the water at the beach. Earthquake shaking can cause this effect.
- *Tectonic Deformation*: A change in the original shape of a material caused by stress and strain.
- *Tsunami*: A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major sub-marine slides, or exploding volcanic islands.
- *Seiche*: The sloshing of a closed body of water, such as a lake or bay, from earthquake shaking.

Location

Earthquakes are most likely to occur in the northern parts of New Jersey, where significant faults are concentrated; however, low-magnitude events can and do occur in many other areas of the State. The National Earthquake Hazard Reduction Program (NEHRP) developed five soil classifications defined by their shear-wave velocity that impact the severity of an earthquake. The soil classification system ranges from A to E, as noted in Table 4.3.4-1, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses.

Table 4.3.4-1. NEHRP Soil Classifications

Soil Classification	Description
A	Hard Rock
B	Rock
C	Very dense soil and soft rock
D	Stiff soils
E	Soft soils

Source: FEMA 2021

The New Jersey Department of Transportation (NJDOT) compiled a report on seismic design consideration for bridges in New Jersey, dated March 2012 (Anil Agrawal 2012). In the report, NJDOT classifies the seismic nature of soils according to the American Association of State Highway and Transportation Officials (AASHTO) Guide Specifications for Bridge Seismic Design. For the purpose of seismic analysis and design, sites can be classified into Soil Classes A, B, C, D, E and F, ranging from hard rock to soft soil and special soils (similar to the NEHRP soil classifications with an additional class F); refer to Table 4.3.4-2.

Table 4.3.4-2 NJDOT Soil Classifications

Soil Classification	Description
A-B	Rock sites
C	Very dense soil
D	Dense soil
E	Soft soil
F	Special soil requiring site-specific analysis

Source: Anil Agrawal 2012

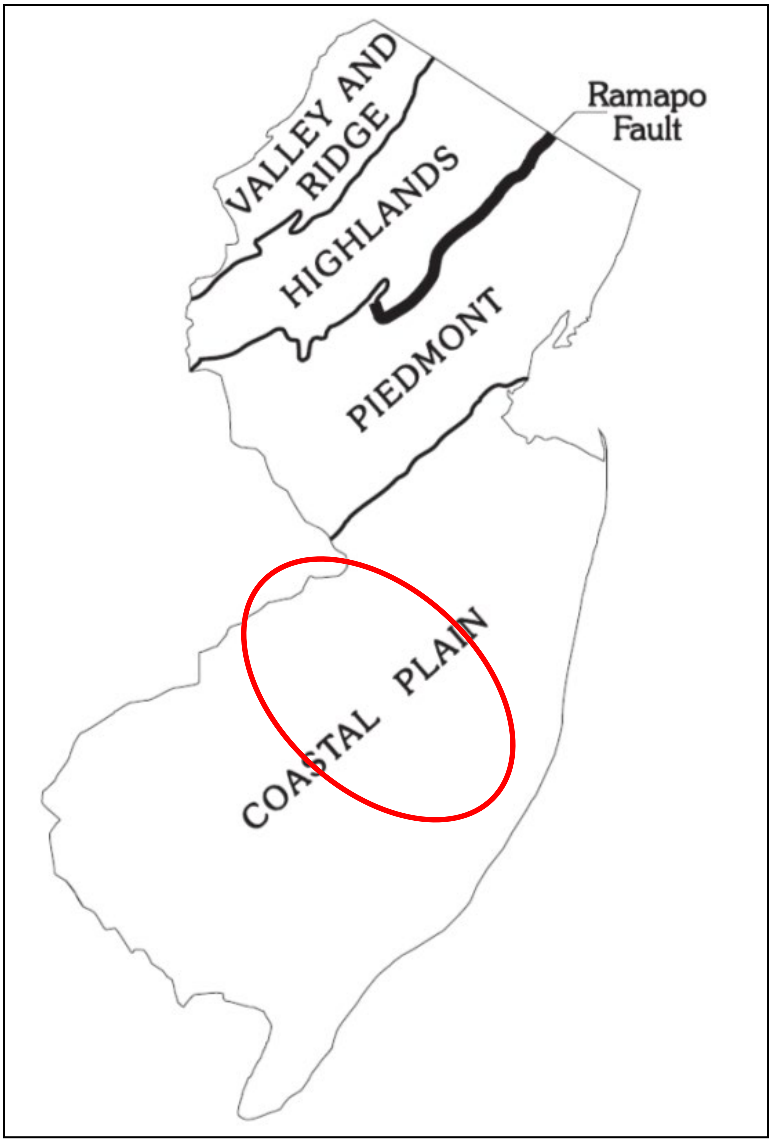
NJDOT also developed a Geotechnical Database Management System that uses logs from soil borings across the state used to classify soil sites. Through this analysis, NJDOT developed a map of soil site classes according to ZIP codes in New Jersey where each ZIP code was assigned a class based on its predominant soil condition. In Burlington County, most ZIP codes were rated as either Category C or D (NJOEM 2019).

Liquefaction has been responsible for tremendous amounts of damage in historical earthquakes around the world. Shaking behavior and liquefaction susceptibility of soils are determined by their grain size, thickness, compaction, and degree of saturation. These properties, in turn, are determined by the geologic origin of the soils and their topographic position. In terms of liquefaction susceptibility, the majority of Burlington County has low to no susceptibility (NJDEP 2021).

Liquefaction occurs in saturated soils. When liquefaction occurs, it reduces the strength of the soil and its ability to support foundations for buildings and bridges. Shaking from earthquakes often triggers an increase in water pressure which can trigger landslides and the collapse of dams. For information regarding dam failures, refer to Section 4.3.1 (Dam Failure). Earthquakes also contribute to landslide hazards. Earthquakes create stresses that make weak slopes fail. Earthquakes of magnitude 4.0 or greater have been known to trigger landslides.

Fractures or fracture zones along with rocks on adjacent sides have broken and moved upward, downward, or horizontally are known as faults (Volkert 2015). Movement can take place at faults and cause an earthquake. Earthquake epicenters in eastern North America and the New Jersey area, however, do not typically occur on known faults. The faults in these areas are the result of tectonic activity from over 200 million years ago. One of the most well-known faults in the State is the Ramapo Fault, which separates the Piedmont and Highlands Physiographic Provinces. As indicated in Figure 4.3.4-1, Burlington County might feel the effects of an earthquake along the Ramapo Fault; however, the fault itself is not located within County borders (Volkert 2015).

Figure 4.3.4-1. Physiographic Provinces of New Jersey and the Ramapo Fault Line



Note: Burlington County's location is indicated by the red oval

Source: NJDEP 2009

Extent

An earthquake's magnitude and intensity are used to describe the size and severity of the event (NJOEM 2019). Magnitude describes the size at the focal point of an earthquake, and intensity describes the overall severity of shaking felt during the event. The earthquake's magnitude is a measure of the energy released at the source of the earthquake. Magnitude was formerly expressed by ratings on the Richter scale but is now commonly expressed using the moment magnitude (Mw) scale. This scale is based on the total moment release of the earthquake (the product of the distance a fault moved, and the force required to move it) (USGS 2012). The most commonly used intensity scale is the modified Mercalli intensity scale. Ratings of the scale, as well as the perceived shaking and damage potential for structures, are shown in Table 4.3.4-3. The modified Mercalli intensity scale is generally represented visually using shake maps, which show the expected ground shaking at any given location produced by an earthquake with a specified magnitude and epicenter An earthquake has only one magnitude and one epicenter, but it produces a range of ground shaking at sites throughout the region, depending on the distance from the earthquake, the rock and soil conditions at sites, and variations in the propagation of seismic waves from the earthquake due to complexities in the structure of the earth's crust. A USGS shake map shows the variation of ground shaking in a region immediately following significant earthquakes. Table 4.3.4-4 displays the MMI scale and its relationship to the areas peak ground acceleration (PGA).

Table 4.3.4-3. Modified Mercalli Intensity Scale

Mercalli Intensity	Description
I	Felt by very few people; barely noticeable.
II	Felt by few people, especially on upper floors.
III	Noticeable indoors, especially on upper floors, but may not be recognized as an earthquake.
IV	Felt by many indoors, few outdoors. May feel like a passing truck.
V	Felt by almost everyone, some people awakened. Small objects move; trees and poles may shake.
VI	Felt by everyone; people have trouble standing. Heavy furniture can move; plaster can fall off walls. Chimneys may be slightly damaged.
VII	People have difficulty standing. Drivers feel their cars shaking. Some furniture breaks. Loose bricks fall from buildings. Damage is slight to moderate in well-built buildings; considerable in poorly built buildings.
VIII	Well-built buildings suffer slight damage. Poorly built structures suffer severe damage. Some walls collapse.
IX	Considerable damage to specially built structures; buildings shift off their foundations. The ground cracks. Landslides may occur.
X	Most buildings and their foundations are destroyed. Some bridges are destroyed. Dams are seriously damaged. Large landslides occur. Water is thrown on the banks of canals, rivers, and lakes. The ground cracks in large areas.
XI	Most buildings collapse. Some bridges are destroyed. Large cracks appear in the ground. Underground pipelines are destroyed.
XII	Almost everything is destroyed. Objects are thrown into the air. The ground moves in waves or ripples. Large amounts of rock may move.

Source: USGS 2021

Table 4.3.4-4. Modified Mercalli Intensity and PGA Equivalents

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	<.17	Not Felt	None
II	.17 – 1.4	Weak	None
III	.17 – 1.4	Weak	None

Modified Mercalli Intensity	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy

Source: USGS 2021
Note: PGA = Peak Ground Acceleration

The ground experiences acceleration as it shakes during an earthquake. The peak ground acceleration (PGA) is the largest acceleration recorded by a monitoring station during an earthquake. PGA is a measure of how hard the earth shakes in a given geographic area. It is expressed as a percentage of the acceleration due to gravity (%g). Horizontal and vertical PGA varies with soil or rock type. Earthquake hazard assessment involves estimating the annual probability that certain ground accelerations will be exceeded, and then summing the annual probabilities over a time period of interest. Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures, as noted in Table 4.3.4-5.

Table 4.3.4-5. Damage Levels Experienced in Earthquakes

Ground Motion Percentage	Explanation of Damage
1-2%g	Motions are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
Below 10%g	Usually causes only slight damage, except in unusually vulnerable facilities.
10 - 20%g	May cause minor-to-moderate damage in well-designed buildings, with higher levels of damage in poorly designed buildings. At this level of ground shaking, only unusually poor buildings would be subject to potential collapse.
20 - 50%g	May cause significant damage in some modern buildings and very high levels of damage (including collapse) in poorly designed buildings.
≥50%g	May causes higher levels of damage in many buildings, even those designed to resist seismic forces.

Source: NJOEM 2019
Note: %g Peak Ground Acceleration

National maps of earthquake shaking hazards provide information for creating and updating seismic design requirements for building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land use planning. After thorough review of the studies, professional organizations of engineers update the seismic-risk maps and seismic design requirements contained in building codes. The USGS updated the National Seismic Hazard Maps in 2022 and are currently working on a 2023 update.

A probabilistic assessment was conducted for the 500- and 2,500-year mean return period (MRP) in Hazus 6.0 to analyze the earthquake hazard for Burlington County. In summary, a 500-year MRP is an earthquake with 0.2 percent chance that mapped PGAs will be exceeded in any given year. A 2,500-year MRP is an earthquake with 0.04 percent chance that mapped PGAs will be exceeded in any given year.

The Hazus analysis evaluates the statistical likelihood that a specific event will occur and what consequences will occur. Figure 4.3.4-2 and Figure 4.3.4-3 illustrate the geographic distribution of PGA (%g) for the 500- and 2,500-year MRP events by Census-tract.

Figure 4.3.4-2 Peak Ground Acceleration (PGA) 500-Year MRP for Burlington County

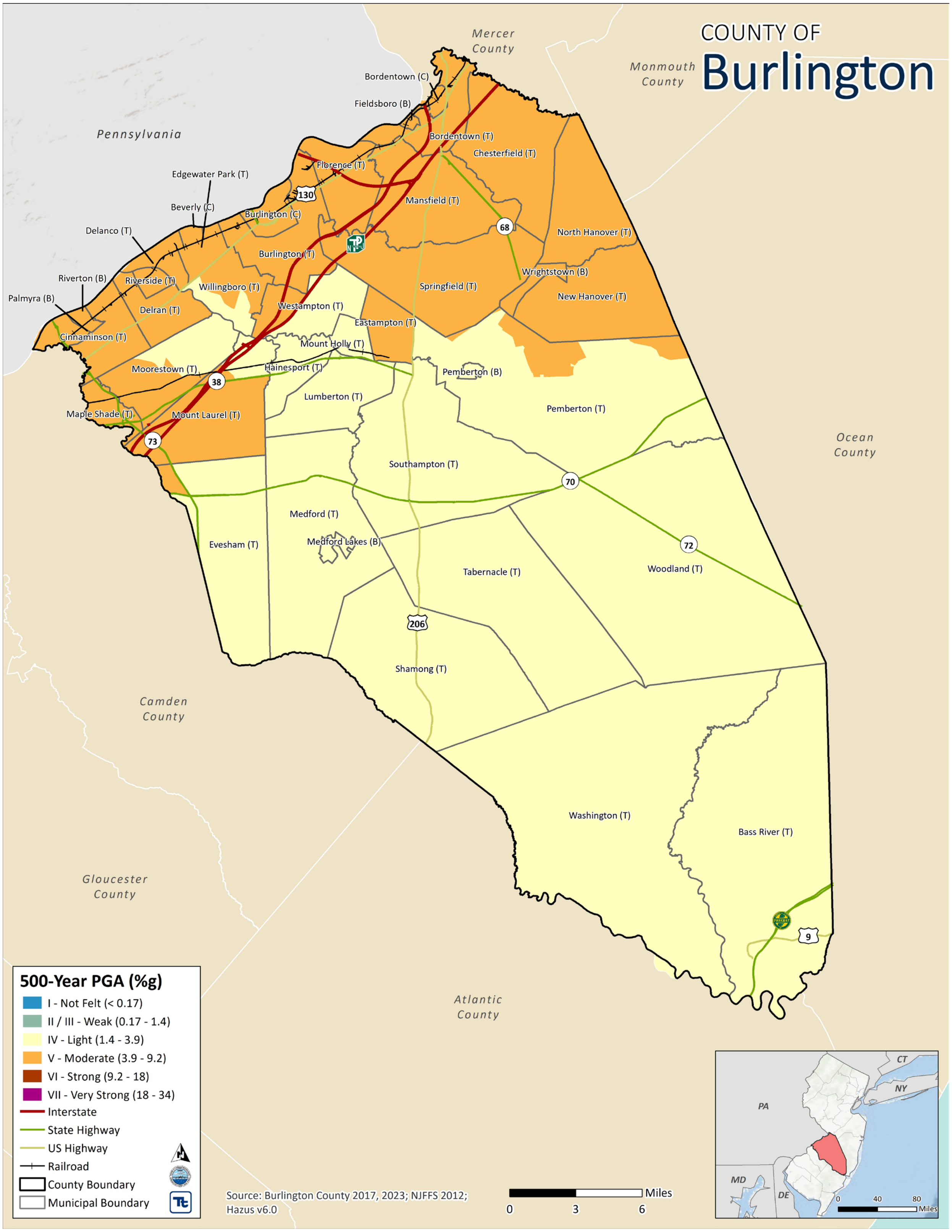
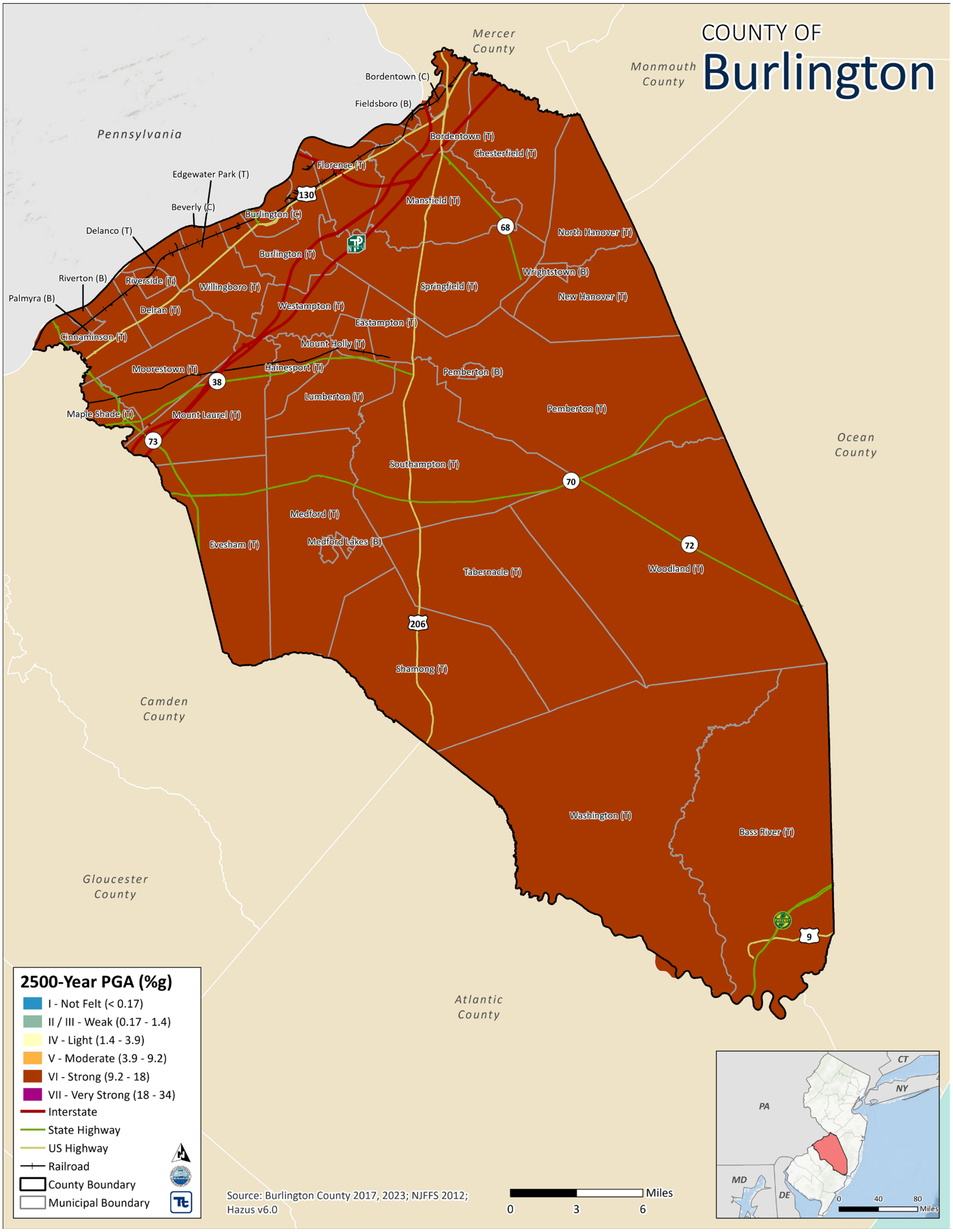


Figure 4.3.4-3 Peak Ground Acceleration (PGA) 2,500-Year MRP for Burlington County



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Previous Occurrences and Losses

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2023, the State of New Jersey was not included in any FEMA earthquake-related major disaster (DR) or emergency (EM) declarations (FEMA 2023).

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2018 and 2023, Burlington County was not included in any earthquake-related agricultural disaster declaration (USDA n.d.).

Previous Events

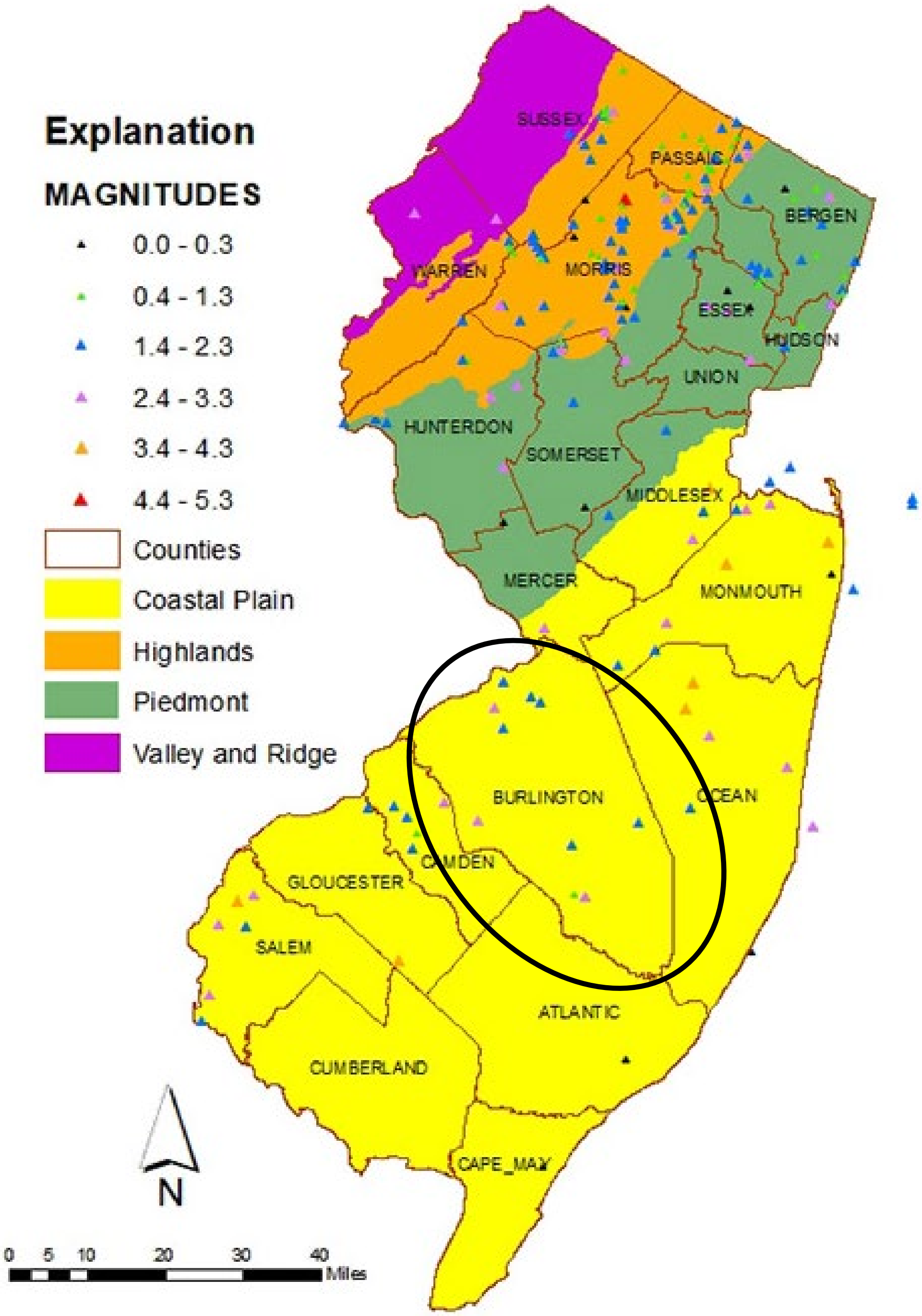
Historically, New Jersey and Burlington County have not experienced a major earthquake. However, there have been a number of earthquakes of relatively low intensity. The majority of earthquakes that have occurred in New Jersey have occurred along faults in the central and eastern Highlands, with the Ramapo fault being the most seismically active fault in the region (Volkert 2015). Small earthquakes may occur several times a year and generally do not cause significant damage. The strongest earthquake with an epicenter in Burlington County was a 3.0 quake in Medford Lakes in 1980.

According to the New Jersey Geological and Water Survey (NJGWS), records for the New York City area, which have been kept for 300 years, provide good information for estimating the frequency of earthquakes in New Jersey. Earthquakes with a maximum intensity of VII have occurred in the New York City area in 1737, 1783, and 1884. One intensity VI, four intensity V's, and at least three intensity III shocks have also occurred in the New York area over the last 300 years (Stover 1993). Figure 4.3.4-4 illustrates earthquake events where the epicenters were located in Burlington County. The figure shows that 10 earthquakes had epicenters in the County.

In Burlington County, between 2018 and 2023, there were three earthquakes that had an epicenter in the County. In addition, a 4.4 quake in Dover, Delaware in 2017 was felt in Burlington County. For events prior to 2013, refer to Appendix G (Supplementary Data). Please note that many sources were researched for historical information regarding earthquake events in Burlington County; therefore, not all earthquake events that have impacted the County may be included. Additionally, not all sources may have been identified or researched. Loss and impact information could vary depending on the source.

For the 2024 HMP update, known earthquake events that impacted Burlington County between August 2018 and May 2023 are listed in Table 4.3.4-6. For events prior to August 2018, refer to the 2020 Burlington County HMP.

Figure 4.3.4-4 Earthquakes with Epicenters in New Jersey, 1783 to 2019



Source: NJGWS 2019

Note: The black circle indicates the location of Burlington County. Several earthquakes have had epicenters in Burlington County.

Table 4.3.4-6. Earthquake Incidents in Burlington County, 2018 to 2023

Date of Event	Event Type	Location	Declaration Number	Burlington County Designated?	Description
June 21, 2018	1.6 Earthquake	Tabernacle Township	N/A	N/A	A "microquake" was centered near Southampton. No damage was reported.
September 17, 2018	1.2 Earthquake	Washington Township	N/A	N/A	No losses and/or damage reported for this event
June 9, 2021	2.4 Earthquake	Borough of Tuckerton	N/A	N/A	Burlington County residents felt ground shake from a nearby 2.4 magnitude earthquake in the Borough of Tuckerton, Ocean County.

Source: NJGWS 2019; FEMA 2023; USGS 2023

Probability of Future Occurrence

Earthquakes cannot be predicted and may occur any time of the day or year. Major earthquakes are infrequent in the State and may occur only once every few hundred years or longer, but the consequences of major earthquakes would be very high. Based on the historic record, the future probability of damaging earthquakes impacting Burlington County is low.

According to USGS and NJGWS, Burlington County has experienced 10 earthquakes with epicenters in the County. The table below shows these statistics, as well as the annual average number of events and the percent chance of earthquakes occurring in Burlington County in future years (NJGWS 2019). In addition to earthquakes centered within the County, numerous earthquakes located outside of the County have also directly and indirectly impacted Burlington County. However, since impacts of these earthquakes are difficult to quantify, they are not considered in Table 4.3.4-7.

Table 4.3.4-7. Probability of Future Occurrence of Earthquake Events

Hazard Type	Occurrences Between 1877 and 2023	% Chance of Occurring in Any Given Year	Recurrence Interval (in years) (# Years/Number of Events)
Earthquakes with Epicenter Inside County	10	6.85%	14.6

Source: NJGWS 2023

In Section 4.4 (Hazard Ranking), 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 Steering Committee and Planning Committee, the probability of occurrence for impactful earthquake events in the County is considered 'unlikely'.

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5 °F (1.9 °C) increase in the State's average temperature, which is faster than the rest of the Northeast region (2 °F [1.1 °C]) and the world (1.5 °F [0.8 °C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7 °F (2.3 °C to 3.2 °C) (NJDEP 2020).

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year. Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent. By the end of this century, heavy precipitation events are projected to occur two to five times more often and with more intensity than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls. Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (NJDEP 2020).

The potential impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. The National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes (NJOEM 2019). The lack of glaciers in New Jersey and the surrounding area make it unlikely that glacier retreat will increase the occurrence of earthquake in Burlington County.

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts (NJOEM 2019).

Vulnerability Assessment

A probabilistic assessment was conducted for the 500-year and 2,500-year MRP events through a Level 2 analysis in Hazus v6 to analyze the earthquake hazard and provide a range of loss estimates. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess earthquake risk.

Impact on Life, Health, and Safety

The entire County may experience an earthquake. However, the degree of impact is dependent on many factors including the age and type of construction people live in, the soil type homes are located on, and the intensity of the earthquake. Whether directly or indirectly impacted, residents could be faced with business closures, road closures that could isolate populations, and loss of function of critical facilities and utilities.

According to the 2020 U.S. Census, Burlington County had a population of 461,860 people. Overall, risk to public safety and loss of life from an earthquake in the County is minimal for low magnitude events. However, there is a higher risk to public safety for those inside buildings due to structural damage or people walking below building ornamentations and chimneys that may be shaken loose and fall because of an earthquake.

According to the 1999-2003 summary report *Earthquake Risks and Mitigation in the New York / New Jersey / Connecticut Region*, a strong correlation exists between structural building damage and number of injuries and fatalities from an earthquake event. Further, the time of day also exposes different sectors of the community to the hazard. For example, Hazus considers the residential occupancy at its maximum at 2:00 a.m., where the educational, commercial, and industrial sectors are at their maximum at 2:00 p.m., with peak commute time at 5:00 p.m. Whether directly impacted or indirectly impact, the entire population will have to deal with the consequences of earthquakes to some degree. Business interruption could prevent people from working, road closures could isolate populations, and loss of functions of utilities could impact populations that suffered no direct damage from an event itself. Overall, Hazus estimates that there are no fatalities caused by the 500-year MRP event, but a total of 23 injuries and 2 hospitalizations (Table 4.3.4-8). The 2,500-year MRP event totals 5 causalities, 248 injuries, and 32 hospitalizations (Table 4.3.4-9). For both events, the 2:00 p.m. time of day has the greatest impact on the County's population.

Table 4.3.4-8. Earthquake Population Impacts Based on Time of Day, 500-Year MRP

Level of Severity	Impacts by Time of Day - 500-Year MRP 2:00 AM	2:00 PM	5:00 PM
Non-Hospitalized Injuries	2	16	5
Hospitalizations	0	2	0
Fatalities	0	0	0

Source: Hazus 6.0

Table 4.3.4-9. Earthquake Population Impacts Based on Time of Day, 2,500-Year MRP

Level of Severity	Impacts by Time of Day - 2,500-Year MRP 2:00 AM	2:00 PM	5:00 PM
Non-Hospitalized Injuries	32	155	61
Hospitalizations	2	24	6
Fatalities	0	4	1

Source: Hazus 6.0

As a result of a significant earthquake event, residents may be displaced or require temporary to long-term sheltering. The number of people requiring shelter is generally less than the number displaced as some displaced persons use hotels or stay with family or friends following a disaster event. Hazus estimates that there will be zero displaced households and zero persons seeking short-term sheltering caused by the 500-year MRP event. Further, Hazus estimates that there will be 7 households displaced and 0 persons seeking short-term sheltering caused by the 2,500-year MRP event (Table 4.3.4-10).

Socially Vulnerable Populations

Populations considered most vulnerable to earthquake events are those located in/near the built environment, particularly those near unreinforced masonry construction. Of these most vulnerable populations, socially vulnerable populations, including the elderly (persons over age 65) and individuals living below the poverty threshold, are most susceptible. Factors leadings to this higher susceptibility include decreased mobility and financial ability to react or respond during a hazard, and the location and construction quality of their housing. According to the 2021 5-year ACS estimates, there are 27,947 total persons living below the poverty level, 78,093 persons over the age of 65 years, 23,350 persons under the age of 5 years, 9,103 non-English speakers, and 51,899 persons with a disability in Burlington County, as displayed in Table 4.3.4-11.

Table 4.3.4-10. Estimated Displaced Households and Persons Seeking Shelter Caused by the 500-Year and 2,500-Year MRP Earthquake Events

Jurisdiction	500-Year MRP Earthquake Event		2,500-Year MRP Earthquake Event	
	Displaced Households	Persons Seeking Short-Term Sheltering	Displaced Households	Persons Seeking Short-Term Sheltering
Bass River (T)	0	0	0	0
Beverly (C)	0	0	0	0
Bordentown (C)	0	0	0	0
Bordentown (T)	0	0	0	0
Burlington (C)	0	0	0	0
Burlington (T)	0	0	0	0
Chesterfield (T)	0	0	0	0
Cinnaminson (T)	0	0	0	0
Delanco (T)	0	0	0	0
Delran (T)	0	0	1	0
Eastampton (T)	0	0	0	0
Edgewater Park (T)	0	0	1	0
Evesham (T)	0	0	2	0
Fieldsboro (B)	0	0	0	0
Florence (T)	0	0	1	0
Hainesport (T)	0	0	0	0
Lumberton (T)	0	0	0	0
Mansfield (T)	0	0	0	0
Maple Shade (T)	0	0	0	0
Medford (T)	0	0	1	0
Medford Lakes (B)	0	0	0	0
Moorestown (T)	0	0	1	0
Mount Holly (T)	0	0	0	0
Mount Laurel (T)	0	0	0	0
New Hanover (T)	0	0	0	0
North Hanover (T)	0	0	0	0
Palmyra (B)	0	0	0	0
Pemberton (B)	0	0	0	0
Pemberton (T)	0	0	0	0
Riverside (T)	0	0	0	0
Riverton (B)	0	0	0	0
Shamong (T)	0	0	0	0
Southampton (T)	0	0	0	0
Springfield (T)	0	0	0	0
Tabernacle (T)	0	0	0	0
Washington (T)	0	0	0	0
Westampton (T)	0	0	0	0
Willingboro (T)	0	0	0	0
Woodland (T)	0	0	0	0
Wrightstown (B)	0	0	0	0
Burlington County Total	**0**	**0**	**7**	**0**

Source: Hazus v6.0
Notes: Values are rounded down

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Table 4.3.4-11. Burlington County Socially Vulnerable Populations by Municipality

	Decennial Population 2020		American Community Survey 5-Year Population Estimates (2021)									
			Population Over 65		Population Under 5		Non-English Speaking Population		Population with Disability		Population Below Poverty Level	
Jurisdiction[a]	Jurisdiction Total	% of County Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total
Bass River (T)	1,355	0.3%	248	18.3%	67	4.9%	0	0.0%	175	12.9%	95	7.0%
Beverly (C)	2,499	0.5%	292	11.7%	183	7.3%	0	0.0%	249	10.0%	300	12.0%
Bordentown (C)	3,993	0.9%	772	19.3%	216	5.4%	16	0.4%	422	10.6%	227	5.7%
Bordentown (T)	11,791	2.6%	1,601	13.6%	472	4.0%	289	2.4%	1,092	9.3%	194	1.6%
Burlington (C)	9,743	2.1%	1,301	13.4%	661	6.8%	208	2.1%	1,251	12.8%	1,422	14.6%
Burlington (T)	23,983	5.2%	3,526	14.7%	1,497	6.2%	385	1.6%	2,366	9.9%	2,185	9.1%
Chesterfield (T)	9,422	2.0%	760	8.1%	578	6.1%	153	1.6%	423	4.5%	165	1.8%
Cinnaminson (T)	17,064	3.7%	3,103	18.2%	929	5.4%	208	1.2%	1,661	9.7%	584	3.4%
Delanco (T)	4,824	1.0%	1,297	26.9%	191	4.0%	42	0.9%	676	14.0%	322	6.7%
Delran (T)	17,882	3.9%	2,570	14.4%	1,047	5.9%	723	4.0%	1,548	8.7%	902	5.0%
Eastampton (T)	6,191	1.3%	557	9.0%	264	4.3%	0	0.0%	478	7.7%	488	7.9%
Edgewater Park (T)	8,930	1.9%	1,571	17.6%	700	7.8%	367	4.1%	1,465	16.4%	1,645	18.4%
Evesham (T)	46,826	10.1%	8,574	18.3%	2,237	4.8%	749	1.6%	4,504	9.6%	1,476	3.2%
Fieldsboro (B)	526	0.1%	82	15.6%	64	12.2%	0	0.0%	62	11.8%	36	6.8%
Florence (T)	12,812	2.8%	2,122	16.6%	645	5.0%	260	2.0%	1,460	11.4%	827	6.5%
Hainesport (T)	6,035	1.3%	1,327	22.0%	58	1.0%	0	0.0%	744	12.3%	250	4.1%
Lumberton (T)	12,803	2.8%	2,048	16.0%	661	5.2%	107	0.8%	1,490	11.6%	805	6.3%
Mansfield (T)	8,897	1.9%	2,506	28.2%	394	4.4%	330	3.7%	1,465	16.5%	181	2.0%
Maple Shade (T)	19,980	4.3%	2,897	14.5%	1,159	5.8%	694	3.5%	2,433	12.2%	1,971	9.9%
Medford (T)	24,497	5.3%	5,151	21.0%	1,085	4.4%	31	0.1%	2,775	11.3%	724	3.0%
Medford Lakes (B)	4,264	0.9%	879	20.6%	211	4.9%	0	0.0%	407	9.5%	26	0.6%
Moorestown (T)	21,355	4.6%	3,480	16.3%	837	3.9%	603	2.8%	1,654	7.7%	807	3.8%
Mount Holly (T)	9,981	2.2%	1,199	12.0%	454	4.5%	133	1.3%	1,624	16.3%	958	9.6%
Mount Laurel (T)	44,633	9.7%	8,299	18.6%	2,011	4.5%	889	2.0%	4,203	9.4%	1,689	3.8%
New Hanover (T)	6,367	1.4%	311	4.9%	214	3.4%	29	0.4%	192	3.0%	116	1.8%
North Hanover (T)	7,963	1.7%	532	6.7%	975	12.2%	125	1.6%	631	7.9%	481	6.0%
Palmyra (B)	7,438	1.6%	1,077	14.5%	190	2.6%	44	0.6%	961	12.9%	616	8.3%
Pemberton (B)	1,371	0.3%	282	20.6%	56	4.1%	47	3.4%	308	22.5%	140	10.2%

Jurisdiction[a]	Decennial Population 2020		American Community Survey 5-Year Population Estimates (2021)									
			Population Over 65		Population Under 5		Non-English Speaking Population		Population with Disability		Population Below Poverty Level	
	Jurisdiction Total	% of County Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total	Number	% of Jurisdiction Total
Pemberton (T)	26,903	5.8%	4,306	16.0%	1,429	5.3%	1,092	4.1%	4,006	14.9%	2,518	9.4%
Riverside (T)	8,003	1.7%	1,039	13.0%	354	4.4%	754	9.4%	972	12.1%	1,257	15.7%
Riverton (B)	2,764	0.6%	554	20.0%	80	2.9%	5	0.2%	187	6.8%	72	2.6%
Shamong (T)	6,460	1.4%	1,313	20.3%	324	5.0%	0	0.0%	671	10.4%	136	2.1%
Southampton (T)	10,317	2.2%	3,153	30.6%	293	2.8%	125	1.2%	1,551	15.0%	589	5.7%
Springfield (T)	3,245	0.7%	479	14.8%	129	4.0%	65	2.0%	311	9.6%	160	4.9%
Tabernacle (T)	6,776	1.5%	1,524	22.5%	380	5.6%	0	0.0%	747	11.0%	233	3.4%
Washington (T)	693	0.2%	138	19.9%	8	1.2%	8	1.1%	87	12.6%	21	3.0%
Westampton (T)	9,121	2.0%	1,139	12.5%	263	2.9%	81	0.9%	802	8.8%	268	2.9%
Willingboro (T)	31,889	6.9%	5,707	17.9%	1,916	6.0%	538	1.7%	5,100	16.0%	2,685	8.4%
Woodland (T)	1,544	0.3%	319	20.7%	49	3.2%	0	0.0%	627	40.6%	363	23.5%
Wrightstown (B)	720	0.2%	58	8.1%	69	9.6%	5	0.7%	119	16.5%	13	1.8%
Burlington County Total	**461,860**	**100.0%**	**78,093**	**16.9%**	**23,350**	**5.1%**	**9,103**	**2.0%**	**51,899**	**11.2%**	**27,947**	**6.1%**

Source: U.S. Census Bureau 2020, 2021

Note: Persons per household = 2.6

a. (B) = borough; (C) = city; (T) = township

Impact on General Building Stock

The entire County's general building stock is considered at risk and exposed to this hazard. However, soft soils can amplify ground shaking to damaging levels even during a moderate earthquake.

There is a strong correlation between PGA and damage a building might undergo (FEMA 2022). The Hazus model is based on best available earthquake science and aligns with these statements. The Hazus probabilistic earthquake model was applied to analyze effects from the earthquake hazard on general building stock in Burlington County. Refer to Figure 4.3.4-2 and Figure 4.3.4-3, which illustrate the geographic distribution of PGA (%g) across the County for 500-year and 2,500-year MRP events at the Census-tract level.

A building's construction determines how well it can withstand the force of an earthquake. The New Jersey 2019 HMP indicates that unreinforced masonry buildings are most at risk during an earthquake because the walls are prone to collapse outward, whereas steel and wood buildings absorb more of the earthquake's energy (NJOEM 2019). Additional attributes that affect a building's capability to withstand an earthquake's force include its age, number of stories, and quality of construction. Hazus considers building construction and age of building as part of the analysis. Because a custom general building stock was used for this Hazus analysis, the building ages and building types from the inventory were incorporated into the Hazus model.

Potential building damage was evaluated by Hazus across the following damage categories: none, slight, moderate, extensive, and complete. Table 4.3.4-12 provides definitions of these five categories of damage for a light wood-framed building. Definitions for other building types are included in the Hazus technical manual documentation. The results of potential damage states for buildings in Burlington County categorized by general occupancy classes (i.e., residential, commercial, industrial, etc.) from Hazus are summarized in Table 4.3.4-13 for the 500-year MRP event. Hazus estimates that there will be $51,759,371 in damage to structures caused by the 500-year MRP event, with the estimated commercial damage being the most expensive at $23,253,044, or 44.9 percent of the total damage. Table 4.3.4-14 summarizes the damage to structures for the 2,500 MRP event, which estimates that there will be $881,536,806 in damage to structures caused by the 2,500-year MRP event, with the estimated commercial damage being the most expensive at $375,150,385, or 42.5 percent of the total damage.

Table 4.3.4-12. Example of Structural Damage State Definitions for a Light Wood-Framed Building

Damage Category	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations; partial collapse of room-over-garage or other soft-story configurations.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple-wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Source: FEMA 2022

Table 4.3.4-13. Estimated Building Damage by General Occupancy for the 500-Year MRP Earthquake Event

Jurisdiction	Total Replacement Cost Value	Estimated Building Damage from the 500-Year MRP				
		Total Estimated Damage		Estimated Damage by Occupancy Class		
		Value	% of Total Replacement Cost	Residential	Commercial	All Other Occupancies
Bass River (T)	$881,423,037	$234,441	<0.1%	$39,740	$148,946	$45,754
Beverly (C)	$1,218,790,333	$445,768	<0.1%	$105,354	$266,083	$74,331
Bordentown (C)	$2,794,074,193	$890,823	<0.1%	$150,411	$583,668	$156,744
Bordentown (T)	$5,866,485,430	$1,820,469	<0.1%	$394,071	$1,207,968	$218,431
Burlington (C)	$5,813,312,405	$2,633,761	<0.1%	$400,976	$1,575,949	$656,837
Burlington (T)	$8,819,483,895	$2,963,739	<0.1%	$745,076	$1,090,090	$1,128,573
Chesterfield (T)	$2,243,175,804	$690,068	<0.1%	$288,442	$186,231	$215,395
Cinnaminson (T)	$6,206,033,564	$1,666,695	<0.1%	$551,488	$686,391	$428,816
Delanco (T)	$1,777,428,934	$458,098	<0.1%	$165,644	$143,343	$149,112
Delran (T)	$5,342,639,406	$1,559,178	<0.1%	$504,638	$525,393	$529,147
Eastampton (T)	$1,223,958,808	$372,738	<0.1%	$211,435	$66,038	$95,265
Edgewater Park (T)	$2,391,677,740	$846,786	<0.1%	$339,185	$365,339	$142,263
Evesham (T)	$11,128,366,531	$3,505,170	<0.1%	$1,365,974	$1,608,588	$530,607
Fieldsboro (B)	$241,524,257	$172,580	0.1%	$27,843	$109,014	$35,723
Florence (T)	$6,582,323,116	$1,948,963	<0.1%	$560,368	$592,609	$795,986
Hainesport (T)	$3,283,651,920	$963,267	<0.1%	$218,113	$572,556	$172,597
Lumberton (T)	$4,304,673,748	$1,242,750	<0.1%	$413,863	$532,198	$296,689
Mansfield (T)	$3,398,330,024	$1,063,149	<0.1%	$456,196	$416,110	$190,843
Maple Shade (T)	$5,835,178,181	$1,893,833	<0.1%	$436,744	$1,237,826	$219,263
Medford (T)	$10,042,226,056	$3,236,385	<0.1%	$1,024,492	$1,568,192	$643,701
Medford Lakes (B)	$967,238,228	$162,862	<0.1%	$120,170	$21,332	$21,360
Moorestown (T)	$12,232,463,125	$3,826,191	<0.1%	$851,455	$1,715,996	$1,258,740
Mount Holly (T)	$3,763,298,318	$970,188	<0.1%	$213,017	$635,587	$121,584
Mount Laurel (T)	$15,418,468,979	$4,653,361	<0.1%	$1,303,152	$2,694,660	$655,549
New Hanover (T)	$2,868,939,587	$936,998	<0.1%	$18,260	$92,111	$826,627
North Hanover (T)	$2,404,670,347	$949,433	<0.1%	$206,091	$375,828	$367,513
Palmyra (B)	$2,133,107,140	$674,488	<0.1%	$251,627	$327,764	$95,097
Pemberton (B)	$736,141,491	$227,986	<0.1%	$51,043	$136,218	$40,725
Pemberton (T)	$6,973,242,839	$2,264,391	<0.1%	$854,878	$694,878	$714,635
Riverside (T)	$2,459,954,166	$741,549	<0.1%	$153,804	$509,364	$78,381
Riverton (B)	$1,096,729,598	$343,537	<0.1%	$123,436	$131,695	$88,406

Jurisdiction	Total Replacement Cost Value	Estimated Building Damage from the 500-Year MRP				
		Total Estimated Damage		Estimated Damage by Occupancy Class		
		Value	% of Total Replacement Cost	Residential	Commercial	All Other Occupancies
Shamong (T)	$2,504,926,736	$596,163	<0.1%	$273,458	$150,988	$171,717
Southampton (T)	$4,593,018,255	$1,226,863	<0.1%	$444,274	$555,135	$227,454
Springfield (T)	$2,140,517,320	$543,235	<0.1%	$138,127	$258,505	$146,603
Tabernacle (T)	$2,200,440,237	$608,890	<0.1%	$244,681	$182,182	$182,027
Washington (T)	$604,084,949	$175,178	<0.1%	$29,791	$111,155	$34,232
Westampton (T)	$4,620,292,645	$1,225,440	<0.1%	$230,074	$431,809	$563,557
Willingboro (T)	$8,789,434,159	$2,625,547	<0.1%	$1,495,989	$532,836	$596,721
Woodland (T)	$1,333,495,831	$254,615	<0.1%	$43,305	$161,553	$49,757
Wrightstown (B)	$748,872,423	$143,797	<0.1%	$27,187	$50,917	$65,694
Burlington County Total	**$167,984,093,755**	**$51,759,371**	**<0.1%**	**$15,473,872**	**$23,253,044**	**$13,032,456**

Source: Hazus *v6.0; Burlington County, 2023; NJOGIS 2023; Microsoft BING 2022; RS Means 2022*

Table 4.3.4-14. Estimated Buildings Damaged by General Occupancy for the 2,500-Year MRP Earthquake Event

Jurisdiction	Total Replacement Cost Value	Estimated Building Damage from the 2,500-Year MRP: Total Estimated Damage		Estimated Damage by Occupancy Class		
		Value	% of Total Replacement Cost	Residential	Commercial	All Other Occupancies
Bass River (T)	$881,423,037	$3,938,622	0.4%	$737,313	$2,386,994	$814,314
Beverly (C)	$1,218,790,333	$7,057,467	0.6%	$1,941,409	$4,013,448	$1,102,611
Bordentown (C)	$2,794,074,193	$15,916,991	0.6%	$3,188,174	$9,932,423	$2,796,394
Bordentown (T)	$5,866,485,430	$31,454,030	0.5%	$7,960,927	$19,917,971	$3,575,132
Burlington (C)	$5,813,312,405	$39,140,586	0.7%	$7,020,875	$23,625,616	$8,494,095
Burlington (T)	$8,819,483,895	$48,999,707	0.6%	$13,262,811	$16,397,202	$19,339,694
Chesterfield (T)	$2,243,175,804	$12,360,662	0.6%	$5,248,969	$2,888,193	$4,223,500
Cinnaminson (T)	$6,206,033,564	$31,665,738	0.5%	$11,519,683	$11,876,653	$8,269,402
Delanco (T)	$1,777,428,934	$8,854,247	0.5%	$3,504,212	$2,444,552	$2,905,483
Delran (T)	$5,342,639,406	$27,325,629	0.5%	$10,839,670	$9,042,769	$7,443,190
Eastampton (T)	$1,223,958,808	$6,146,710	0.5%	$3,817,025	$1,044,944	$1,284,741
Edgewater Park (T)	$2,391,677,740	$13,325,692	0.6%	$5,864,624	$5,404,886	$2,056,182
Evesham (T)	$11,128,366,531	$58,035,678	0.5%	$25,072,008	$24,940,826	$8,022,843
Fieldsboro (B)	$241,524,257	$2,908,715	1.2%	$538,931	$1,739,069	$630,715
Florence (T)	$6,582,323,116	$35,558,033	0.5%	$10,653,567	$9,814,395	$15,090,072
Hainesport (T)	$3,283,651,920	$16,957,979	0.5%	$4,368,095	$9,502,839	$3,087,045
Lumberton (T)	$4,304,673,748	$21,694,563	0.5%	$7,567,165	$8,472,048	$5,655,350
Mansfield (T)	$3,398,330,024	$17,937,156	0.5%	$8,386,822	$6,266,306	$3,284,027
Maple Shade (T)	$5,835,178,181	$32,776,759	0.6%	$8,939,707	$20,537,795	$3,299,257
Medford (T)	$10,042,226,056	$51,136,276	0.5%	$19,279,018	$23,994,141	$7,863,118
Medford Lakes (B)	$967,238,228	$3,446,135	0.4%	$2,728,012	$405,135	$312,988
Moorestown (T)	$12,232,463,125	$66,459,286	0.5%	$18,067,726	$28,892,314	$19,499,245
Mount Holly (T)	$3,763,298,318	$18,131,268	0.5%	$4,609,959	$11,177,957	$2,343,352
Mount Laurel (T)	$15,418,468,979	$81,443,165	0.5%	$25,125,660	$44,687,732	$11,629,773
New Hanover (T)	$2,868,939,587	$16,325,358	0.6%	$336,407	$1,520,163	$14,468,788
North Hanover (T)	$2,404,670,347	$15,624,259	0.6%	$3,423,468	$6,057,734	$6,143,057
Palmyra (B)	$2,133,107,140	$11,752,072	0.6%	$4,826,484	$5,183,711	$1,741,877
Pemberton (B)	$736,141,491	$3,864,931	0.5%	$992,729	$2,260,643	$611,558
Pemberton (T)	$6,973,242,839	$35,423,287	0.5%	$15,233,801	$11,032,284	$9,157,202
Riverside (T)	$2,459,954,166	$13,182,719	0.5%	$3,273,083	$8,576,477	$1,333,158
Riverton (B)	$1,096,729,598	$5,900,639	0.5%	$2,552,066	$2,203,554	$1,145,019

Jurisdiction	Total Replacement Cost Value	Estimated Building Damage from the 2,500-Year MRP				
		Total Estimated Damage		Estimated Damage by Occupancy Class		
		Value	% of Total Replacement Cost	Residential	Commercial	All Other Occupancies
Shamong (T)	$2,504,926,736	$10,271,087	0.4%	$5,118,913	$2,396,926	$2,755,248
Southampton (T)	$4,593,018,255	$21,008,555	0.5%	$8,390,112	$8,545,846	$4,072,597
Springfield (T)	$2,140,517,320	$10,552,497	0.5%	$2,804,660	$4,271,476	$3,476,361
Tabernacle (T)	$2,200,440,237	$9,558,756	0.4%	$4,396,197	$2,786,816	$2,375,743
Washington (T)	$604,084,949	$2,942,541	0.5%	$552,630	$1,781,267	$608,644
Westampton (T)	$4,620,292,645	$22,618,432	0.5%	$4,911,716	$7,479,990	$10,226,726
Willingboro (T)	$8,789,434,159	$43,141,855	0.5%	$27,693,057	$8,236,406	$7,212,392
Woodland (T)	$1,333,495,831	$4,276,863	0.3%	$803,308	$2,588,904	$884,652
Wrightstown (B)	$748,872,423	$2,421,861	0.3%	$453,490	$821,978	$1,146,392
Burlington County Total	**$167,984,093,755**	**$881,536,806**	**0.5%**	**$296,004,485**	**$375,150,385**	**$210,381,936**

Source: Hazus *v6.0; Burlington County, 2023; NJOGIS 2023; Microsoft BING 2022; RS Means 2022*

Building damage as a result of the 500-year and 2,500-year MRP earthquakes was estimated for each municipality using Hazus. Table 4.3.4-15 summarizes estimated total building and content losses caused by the 500-year MRP event by building occupancy class. No buildings will be completely destroyed by the 500-year MRP event; however, up to 3 will be severely damaged and 129 moderately damaged. The majority of the losses are estimated to the residential occupancy class. Table 4.3.4-16 summarizes estimated total building and content losses caused by the 2,500-year MRP event by occupancy classes. Up to 5 buildings will be completely destroyed by the 2,500-year MRP event and up to 141 will be severely damaged. The majority of the losses are estimated to the residential occupancy class.

Historically, Building Officials Code Administration (BOCA) regulations in the northeast states were developed to address local concerns, including heavy snow loads and wind. Seismic requirements for design criteria are not as stringent as those of the west coast of the United States, which rely on the more seismically focused Uniform Building Code. As such, a smaller earthquake in the northeast can cause more structural damage than if it would occur in the west.

Table 4.3.4-15. Estimated Building Damage (Structure and Contents) from the 500-year MRP Earthquake Event

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	500-Year MRP	
			Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	135,116	None	134,062	99.2%
		Minor	970	0.7%
		Moderate	84	0.1%
		Severe	0	0.0%
		Destruction	0	0.0%
Commercial Buildings	6,297	None	6,161	97.8%
		Minor	111	1.8%
		Moderate	24	0.4%
		Severe	1	<0.1%
		Destruction	0	0.0%
Industrial Buildings	1,170	None	1,140	97.4%
		Minor	23	2.0%
		Moderate	6	0.5%
		Severe	1	<0.1%
		Destruction	0	0.0%
Government, Religion, Agricultural, and Education Buildings	6,722	None	6,593	98.1%
		Minor	112	1.7%
		Moderate	15	0.2%
		Severe	1	<0.1%
		Destruction	0	0.0%

Source: Hazus v6.0

Table 4.3.4-16. Estimated Building Damage (Structure and Contents) from the 500-year MRP Earthquake Event

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	2,500-Year MRP Building Count	2,500-Year MRP Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	135,116	None	124,011	91.8%
		Minor	9,453	7.0%
		Moderate	1,570	1.2%
		Severe	82	0.1%
		Destruction	0	0.0%
Commercial Buildings	6,297	None	5,350	85.0%
		Minor	619	9.8%
		Moderate	292	4.6%
		Severe	34	0.5%
		Destruction	2	<0.1%
Industrial Buildings	1,170	None	982	83.9%
		Minor	119	10.2%
		Moderate	60	5.1%
		Severe	8	0.7%
		Destruction	1	0.1%
Government, Religion, Agricultural, and Education Buildings	6,722	None	5,826	86.7%
		Minor	709	10.6%
		Moderate	169	2.5%
		Severe	17	0.2%
		Destruction	2	<0.1%

Source: Hazus v6.0

Impact on Critical Facilities

All critical facilities in Burlington County are considered exposed to the earthquake hazard. Refer to subsection "Critical Facilities and Lifelines" in Section 3 (County Profile) of this HMP for a complete inventory of critical facilities in Burlington County.

The Hazus earthquake model was used to assign the range or average probability of each damage state category to the critical facilities and lifelines in Burlington County for the 500-year and 2,500-year MRP events. In addition, Hazus estimates the time to restore critical facilities to fully functional use. Results are presented as a probability of being functional at specified time increments (days after the event). For example, Hazus might estimate that a facility has 5 percent chance of being fully functional on Day 3, and a 95 percent chance of being fully functional on Day 90. For percent probability of sustaining damage, the minimum and maximum damage estimated value for that facility type is presented.

As a result of a 500-year MRP event, Hazus estimates that critical facilities will be nearly 100 percent functional with negligible damage. Therefore, the impact on critical facilities is not significant for the 500-year event. Similarly for the 2,500-year MRP event, functionality will only reach as low as 79.9 percent. Table 4.3.4-17 and Table 4.3.4-18 summarize the damage state probabilities for critical facilities during the 500-year and 2,500-year MRP events, respectively.

Table 4.3.4-17. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities in Burlington County for the 500-Year MRP Earthquake Event

	Percent Probability of Sustaining Damage 500-Year MRP					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Essential Facilities									
Medical Facilities	99.0% - 99.9%	<0.1% - 0.9%	<0.1%	0.0%	0.0%	99% - 99.8%	99.9%	99.9%	99.9%
Emergency Operations Center	96.3% - 97.6%	1.8% - 2.8%	0.5% - 0.9%	<0.1% - 0.1%	0.0%	96.2% - 97.6%	98.9% - 99.3%	99.8% - 99.9%	99.9%
Police Stations	96.3% - 97.7%	1.7% - 2.8%	0.5% - 0.9%	<0.1% - 0.1%	0.0%	96.2% - 97.7%	98.9% - 99.4%	99.8% - 99.9%	99.9%
Fire Stations	96.2% - 98.1%%	1.4% - 2.8%	0.4% - 0.9%	<0.1% - 0.1%	0.0%	96.2% - 98.1%	98.9% - 99.5%	99.8% - 99.9%	99.9%
Schools	96.2% - 97.8%	1.7% - 2.8%	0.5% - 0.9%	<0.1% - 0.1%	0.0%	96.2% - 97.8%	98.9% - 99.4%	99.8% - 99.9%	99.9%
Utilities									
Communications	99.3% - 99.4%	0.6% - 0.7%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Electric Power	97.3% - 98.2%	1.1% - 1.6%	0.6% - 0.9%	0.1%	0.0%	98.2% - 98.7%	99.9%	99.9%	99.9%
Natural Gas	97.3%	1.6%	0.9%	0.2%	0.0%	98.5%	99.7%	99.9%	99.9%
Potable Water	97.2% - 98.5%	0.9% - 1.7%	0.5% - 1.0%	0.1% - 0.2%	0.0%	98.4% - 99.3%	99.8 - 99.9%	99.9%	99.9%
Waste Water	97.2 % - 98.7%	0.8% - 1.7%	0.4% - 1.0%	0.1% - 0.2%	0.0%	97.8% - 99%	99.7% - 99.8%	99.8% - 99.9%	99.9%
Transportation									
Airport	99% - 99.6%	0.4% - 0.9%	<0.1% - 0.3%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Highway Bridges	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%
Light Rail Facility	99.0% - 99.3%	0.6% - 0.9%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Rail Facility	99.0% - 99.3%	0.6% - 0.9%	<0.1%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%

Source: Hazus v6.0

Table 4.3.4-18. Estimated Damage and Loss of Functionality for Critical Facilities and Utilities in Burlington County for the 500-Year MRP Earthquake Event

	Percent Probability of Sustaining Damage 2,500-year					Percent Functionality			
	None	Slight	Moderate	Extensive	Complete	Day 1	Day 7	Day 30	Day 90
Essential Facilities									
Medical Facilities	90.5% - 96.9%	2.4% - 8.7%	0.5% - 1.8%	0.0% - 0.1%	0.0% - <0.1%	90.5% - 96.9%	97.9% - 99.2%	99.8% - 99.9%	99.9%
Emergency Operations Center	79.9% - 85.1%	9.8% - 12.7%	4.3% - 6.1%	0.7% - 1.1%	0.1%	79.9% - 85.1%	92.3% - 94.7%	98.7% - 99.2%	99.2% - 99.5%
Police Stations	79.9% - 85.6%	9.6% - 1.3%	4.1% - 6.1%	0.7% - 1.1%	0.1%	79.9% - 85.6%	92.3% - 94.9%	98.7% - 99.2%	99.2% - 99.5%
Fire Stations	79.9% - 87.1%	8.7% - 12.7%	3.6% - 6.1%	0.6% - 1.1%	<0.1% - 0.1%	79.9% - 87%	92.3% - 95.5%	98.7% - 99.3%	99.2% - 99.6%
Schools	79.9% - 85.6%	9.6% - 12.7%	4.1% - 6.1%	0.7% - 1.1%	0.1%	79.9% - 85.6%	92.3% - 94.9%	98.7% - 99.2%	99.2% - 99.5%
Utilities									
Communications	91.9% - 92.7%	6.8% - 7.5%	0.5% - 0.6%	0.0%	0.0%	99.6%	99.9%	99.9%	99.9%
Electric Power	83.8% - 86.4%	6.9% - 8.0%	5.4% - 6.5%	1.3% - 1.7%	0.0%	88.4% - 90.3%	99.1% - 99.2%	99.9%	99.9%
Natural Gas	83.7%	8.1%	6.5%	1.7%	0.0%	90.3%	98.2%	99.8%	99.9%
Potable Water	83.4% - 87.9%	6.2% - 8.2%	4.7% - 6.7%	1.1% - 1.7%	0.0%	90.3% - 94.6%	98.3% - 99.1%	99% - 99.9%	99.9%
Waste Water	83.4% - 88.7%	5.9% - 8.2%	4.4% - 6.7%	1.0% - 1.7%	0.0%	86.9% - 91.2%	97.6% - 98.6%	98.5% - 99.1%	98.8% - 99.9%
Transportation									
Airport	90.5% - 95.0%	4.7% - 8.7%	0.3% - 0.8%	0.0%	0.0%	99.4% - 99.8%	99.9%	99.9%	99.9%
Highway Bridges	99.9%	0.0%	0.0%	0.0%	0.0%	99.9%	99.9%	99.9%	99.9%
Light Rail Facility	90.5% - 92%	7.4% - 8.7%	0.6% - 0.8%	0.0%	0.0%	99.4% - 99.5%	99.9%	99.9%	99.9%
Rail Facility	90.5% - 92%	7.4% - 8.7%	0.6% - 0.8%	0.0%	0.0%	99.4% - 99.5%	99.9%	99.9%	99.9%

Source: Hazus v6.0

Impact on Economy

Earthquakes also have impacts on the economy, including loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Hazus estimates building-related economic losses, including income losses (wage, rental, relocation, and capital-related losses) and capital stock losses (structural, non-structural, content, and inventory losses). Economic losses estimated by Hazus are summarized in Table 4.3.4-19. Hazus estimates quite a difference in losses between the 500-year and 2,500-year MRP events. Inventory losses for the 500-year MRP event are $4,189,200, 4.2 percent of the 2,500-year MRP event's $99,572,300 inventory losses. Similarly, wage losses for the 500-year MRP event are $1,559,700, 9.7 percent of the 2,500-year MRP event's $15,945,700 wage losses.

Table 4.3.4-19. Economic Losses for the 500-Year and 2,500 MRP Earthquake Event

MRP	Inventory Loss	Relocation Loss	Building and Content Losses	Wages Losses	Rental Losses	Capital-Related Loss
500-year	$4,189,200	$6,098,900	$23,764,200	$1,559,700	$3,228,100	$458,800
2,500-year	$99,572,300	$78,583,600	$404,146,300	$15,945,700	$38,473,900	$5,386,500

Source: Hazus v6.0

Although the Hazus analysis did not compute damage estimates for individual roadway segments and railroad tracks, assumedly these features would undergo damage due to ground failure, resulting in interruptions of regional transportation and of distribution of materials. Losses to the community that would result from damage to lifelines could exceed costs of repair.

Earthquake events can also significantly affect road bridges, many of which provide the only access to certain neighborhoods. Because softer soils generally follow floodplain boundaries, bridges that cross watercourses should be considered vulnerable. Another key factor in degree of vulnerability is age of facilities and infrastructure, which correlates with standards in place at times of construction.

Hazus also estimates the volume of debris that may be generated as a result of an earthquake event to enable the study region to prepare and rapidly and efficiently manage debris removal and disposal. Debris estimates are divided into two categories: (1) reinforced concrete and steel that require special equipment to break it up before it can be transported, and (2) brick, wood, and other debris that can be loaded directly onto trucks with bulldozers (FEMA 2022).

For the 500-year MRP event, Hazus estimates that 13,050 tons of debris will be generated. For the 2,500-year MRP event, Hazus estimates a total of 130,598 tons of debris will be generated county-wide. Table 4.3.4-20 summarizes the estimated debris generated as a result of these events by municipality.

Impact on Environment

According to USGS, earthquakes can cause damage to the surface of the Earth in various forms depending on the magnitude and distribution of the event. Surface faulting is one of the major seismic components to earthquakes that can create wide ruptures in the ground. Ruptures can have a direct impact on the landscape and natural environment because it can disconnect habitats for miles isolating animal species or tear apart plant roots (USGS n.d.).

Table 4.3.4-20. Estimated Debris Generated by the 500-Year and 2,500-Year MRP Earthquake Events

Jurisdiction	Estimated Debris Created During the 500-Year MRP Earthquake Event		Estimated Debris Created During the 2,500-Year MRP Earthquake Event	
	Brick/Wood (tons)	Concrete/Steel (tons)	Brick/Wood (tons)	Concrete/Steel (tons)
Bass River (T)	38	20	271	280
Beverly (C)	68	42	518	623
Bordentown (C)	123	83	1,037	1,222
Bordentown (T)	251	159	2,135	2,370
Burlington (C)	496	263	3,432	3,776
Burlington (T)	485	264	3,871	3,970
Chesterfield (T)	72	28	675	428
Cinnaminson (T)	231	134	2,033	2,059
Delanco (T)	65	35	579	538
Delran (T)	386	130	2,726	1,751
Eastampton (T)	70	19	543	266
Edgewater Park (T)	118	63	941	936
Evesham (T)	547	260	4,450	3,963
Fieldsboro (B)	21	16	175	240
Florence (T)	269	131	2,253	2,013
Hainesport (T)	140	91	1,157	1,395
Lumberton (T)	139	92	1,286	1,462
Mansfield (T)	133	63	1,138	942
Maple Shade (T)	300	182	2,419	2,782
Medford (T)	634	273	4,499	3,784
Medford Lakes (B)	28	6	255	82
Moorestown (T)	877	360	6,332	5,205
Mount Holly (T)	136	89	1,171	1,318
Mount Laurel (T)	693	400	5,979	6,236
New Hanover (T)	122	88	991	1,369
North Hanover (T)	164	79	1,251	1,155
Palmyra (B)	75	52	703	834
Pemberton (B)	58	22	392	304
Pemberton (T)	577	166	3,938	2,179
Riverside (T)	110	71	945	1,074
Riverton (B)	77	26	547	359
Shamong (T)	108	33	831	460
Southampton (T)	167	90	1,409	1,331
Springfield (T)	51	34	511	531
Tabernacle (T)	139	41	929	528
Washington (T)	28	15	203	209
Westampton (T)	244	117	1,901	1,691
Willingboro (T)	531	141	3,727	1,815
Woodland (T)	41	22	295	304
Wrightstown (B)	24	12	185	179
Burlington County Total	**8,837**	**4,213**	**68,633**	**61,965**

Source: Hazus v6.0

Furthermore, ground failure as a result of soil liquefaction can have an impact on soil pores and retention of water resources The greater the seismic activity and liquefaction properties of the soil, the more likely drainage of groundwater can occur which depletes groundwater resources. In areas where there is higher pressure of groundwater retention, the pores can build up more pressure and make soil behave more like a fluid rather than a solid increasing risk of localized flooding and deposition or accumulation of silt (USGS n.d.).

Cascading Impacts on Other Hazards

Earthquakes can cause large and sometimes disastrous landslides and mudslides. Any steep slope is vulnerable to slope failure, often as a result of loss of cohesion in clay-rich soils. Unless properly secured, hazardous materials can be released, causing significant damage to the environment and people.

Earthen dams and levees are highly susceptible to seismic events and the impacts of their eventual failures can be considered secondary risks for earthquakes. The most common mode of earthquake-induced dam failure is slumping or settlement of earth-fill dams where the fill has not been property compacted. If the slumping occurs when the dam is full, then overtopping of the dam, with rapid erosion leading to dam failure is possible. Dam failure is also possible if strong ground motions heavily damage concrete dams. Earthquake-induced landslides into reservoirs have also caused dam failures. Dam failures are further discussed in Section 4.3.1 (Dam Failure) of this Plan update.

Another secondary effect of earthquakes that is often observed in low-lying areas near water bodies is ground liquefaction. Liquefaction is the conversion of water-saturated soil into a fluid-like mass. This can occur when loosely packed, waterlogged sediments lose their strength in response to strong shaking. Liquefaction effects may occur along the shorelines of the ocean, rivers, and lakes and they can also happen in low-lying areas away from water bodies in locations where the ground water is near the earth's surface.

As per the United States Search and Rescue Task force, tsunamis are formed as a result of earthquakes, volcanic eruptions, or landslides that occur under the ocean. When these events occur, huge amounts of energy are released as a result of quick, upward bottom movement. A wave is formed when huge volumes of ocean water are pushed upward. A large earthquake can lift large portions of the seafloor, which will cause the formation of huge waves (US SAR Task Force n.d).

Further Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes).

Development built in areas with softer NEHRP soil classes, liquefaction, and landslide-susceptible areas may experience shifting or cracking in the foundation during earthquakes because of the loose soil characteristics of these soil classes. However, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts than older, existing construction that may have been built to lower construction standards.

Projected Changes in Population

Burlington County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 3 percent between 2010 and 2020 (U.S. Census Bureau 2020). The New Jersey Department of Labor and Workforce Development produced populations projections by County from 2014 to 2019, 2024, 2029, and 2034. According to these projections, Burlington County is projected to have a population of 460,400 by 2024, 464,900 by 2029, and 472,700 by 2034 (State of New Jersey 2017). Persons that move into older buildings may increase their overall vulnerability to earthquakes. As noted earlier, if moving into new construction, current building codes require seismic provisions that should render new construction less vulnerable to seismic impacts.

Climate Change

Because the impacts of climate change on earthquakes are not well understood, a change in the County's vulnerability as the climate continues to change is difficult to determine. However, climate change has the potential to magnify secondary impacts of earthquakes. As a result of the climate change projections discussed above, the County's assets located on areas of saturated soils and on or at the base of steep slopes, are at a higher risk of landslides/mudslides because of seismic activity.

Change of Vulnerability Since 2019 HMP

Overall, the entire County continues to be vulnerable to earthquakes. For the 2024 HMP, the building inventory was updated using RS Means 2022 values, which is more current and reflects replacement cost versus the building stock improvement values reported in the 2019 HMP. Additional building stock updates include updates to the critical facility inventory provided by Burlington County. Updated hazard areas were used as well; since the 2019 HMP, an updated version of Hazus was released (v5.1). This updated model includes longer historical records to pull from to generate probabilistic events.