# Section 3.16: Tsunami

**2014 SHMP Update**

Tsunami is addressed in the 2014 update as a new hazard section to:

- Ensure consistency with the mitigation planning requirements detailed in 44 CFR §201.4(c)(2)(i)
- Profile the hazard and address potential risk

## 3.16.1 Tsunami Profile

Tsunamis rank high on the scale of natural disasters. Since 1850 alone, tsunamis have been responsible for the loss of over 420,000 lives and billions of dollars of damage to coastal structures and habitats worldwide. Most of these casualties were caused by local tsunamis that occur about once per year somewhere in the world. For example, the December 26, 2004 Indonesian tsunami killed about 130,000 people close to the earthquake that caused it, and about 58,000 people on distant shores.

| Hazard | Definition and Key Terms |
|---|---|
| **Tsunami** | A series of ocean waves generated by a rapid large-scale disturbance of the sea water, tsunamis do not have a season and do not occur regularly or frequently. Most tsunamis are generated by earthquakes, but may also be caused by volcanic eruptions, landslides, undersea slumps, or meteor impacts. The word tsunami is a Japanese word, represented by two characters: tsu, meaning, "harbor", and name meaning, "wave". |

### Characteristics

Tsunami waves radiate outward in all directions from the disturbance and can move across entire ocean basins. A tsunami typically causes the most severe damage and casualties close to its source, where local populations may have little time to react before the waves arrive[1]. A very large disturbance can cause local devastation and export tsunami destruction thousands of miles away. Predicting when and where the next tsunami will strike is currently impossible. In the deep ocean, a tsunami wave may only be a few inches

[1] Intergovernmental Oceanographic Commission. 2012. Tsunami, The Great Waves, Second Revised Edition. Paris, UNESCO, 16 pp., illus. IOC Brochure 2012-4.

high. A tsunami wave may come gently ashore or may increase in height to become a fast moving wall of turbulent water several meters high.

Although a tsunami cannot be prevented, the impact of a tsunami can be mitigated through community preparedness, timely warnings, and effective response. The National Oceanic and Atmospheric Administration (NOAA) has primary responsibility for providing tsunami warnings in the United States, and a leadership role in worldwide tsunami observations and research.

### Tsunami Earthquakes

Tsunami earthquakes are slow earthquakes, with slippage along the fault beneath the sea floor occurring more slowly than it would in a land-based earthquake. Tsunamis such as the 2004 Indonesian and recent Japan catastrophes occur in response to the sudden vertical uplift of tremendous volumes of water by an earthquake where one tectonic plate slides beneath another (subduction). One known method to quickly recognize a tsunami earthquake is to estimate a parameter called the *seismic moment* using very long period seismic waves (more than 50 seconds / cycle). Three deadly tsunamis from tsunami earthquakes have occurred in recent years off Indonesia (June 2, 1994; July 16, 2007; October 25, 2010) and Peru (February 21, 1996)[2].

Tsunamis occurring in deep ocean waters are small and may frequently not be seen or felt by ships at sea. As the tsunami reaches shallower coastal waters, wave height can increase rapidly. Sometimes, coastal waters are drawn out into the ocean just before the tsunami strikes. When this occurs, more shoreline may be exposed than even at the lowest tide. This major withdrawal of the sea should be taken as a natural warning sign that tsunami waves will follow.

A tsunami threat for many areas, e.g., Caribbean, can be immediate from local tsunamis that take only a few minutes to reach coastal areas, or less urgent from distant tsunamis that can take up to a day to arrive. Scientists can predict when a tsunami will arrive at various places by knowing the source characteristics of the earthquake that generated the tsunami and the characteristics of the seafloor along the paths to those places. Tsunamis travel much slower in shallower coastal waters where their wave heights begin to increase dramatically.

Of particular concern to New York State is the potential for a tsunami generated by a subterranean landslide on the continental shelf. Even small events have the potential to cause significant impact to communities along the Atlantic coastline of the state.

[2] [2] Intergovernmental Oceanographic Commission. 2012. Tsunami, The Great Waves, Second Revised Edition. Paris, UNESCO, 16 pp., illus. IOC Brochure 2012-4.

## Location

Most large tsunamis occur in the Pacific and originate along the hotbed of seismic activity (earthquakes and volcanism) referred to as the Pacific Ring of Fire. The Atlantic Ocean is home to much less seismic and volcanic activity than the Pacific and, in particular, lacks subduction zones which are the most common source of tsunami-causing earthquakes. All low-lying coastal areas in New York have the potential to be struck by a tsunami.

## Previous Tsunami Occurrences

There is no recent history of a tsunami impacting any area of New York State. The closest occurrence of a tsunami within the past century is the 1929 Grand Banks tsunami in Newfoundland, set in motion by an underwater landslide set off by an earthquake, which killed more than two-dozen people and snapped transatlantic cables.

## Probability of Future Tsunami Events

Based on the fact that there is no history of recent previous occurrences, there is no statistical probability available for future tsunami events in New York State. Since scientists cannot predict when earthquakes will occur, they cannot determine exactly <u>when</u> a tsunami will be generated. However, by looking at past historical tsunamis, scientists know <u>where</u> tsunamis are most likely to be generated. Past tsunami height measurements are useful in predicting future tsunami impact and flooding limits at specific coastal locations and communities.

In the last decade, paleotsunami and tsunami deposit field research has extended the historical tsunami record to improve risk assessments. Some scientific evidence suggests a tsunami of unknown cause may have impacted the New York City area more than 2,300 years ago, or around 300 B.C[3]. As more studies are conducted and evidence of previous events are found, better estimates of the frequency of occurrence of tsunamis in a region will be obtained.

| **Justification for Minimal Vulnerability/Loss Assessment** |
| --- |
| Tsunami occurrences are rare in the Atlantic Ocean and there are no recorded events in recent history that have impacted New York State. While there is an extremely low probability for future events, the potential severity for the highly-populated urban coastline is high. The primary means to address the risk of tsunami is in the area of preparedness measures coordinated at the local level, such as warning and evacuation plans. Consequently, it is determined that there is not sufficient evidence based on probability to justify further analysis for the 2014 plan update, but it is recommended that local hazard mitigation plans for coastal areas consider addressing tsunamis preparedness measures in future plan updates. |

[3] Steven Goodbred, Earth scientist; Vanderbilt University (BBC, May 3, 2009)

## 3.16.2 Assessing Tsunami Vulnerability by Jurisdiction

For the 2014 update, 56 FEMA-approved county mitigation plans were reviewed. The Yates County plan is the only plan that identifies tsunami as a hazard, but ranks it as the lowest hazard based on probability, scope, cascading effects, duration and impact. Although no local plans identify the population and property at risk, storm surge modeling through HAZUS-MH may provide the best current methodology for analysis of these impacts from tsunamis due to the potentially similar areas impacted by storm surge. In addition, the National Tsunami Hazard Mitigation Program (NTHMP) has initiated GIS methodology to develop tsunami inundation mapping; however, this project is still in progress as of the 2014 update.

### Local Plan Integration/ Risk Assessments

Although the probability of future occurrence is low, as identified in the HAZNY-Mitigation hazard ranking matrix, there are several criteria that should be considered when developing local plans.

- There is a slight risk for impacts in areas along the Atlantic Coast.
- There is some potential for cascading effects such as serious injury or death to large numbers of the coastal population, flooding, power failure, water contamination, property damage or loss, and economic impact.
- Evacuation procedures for local (felt events with minutes to evacuate) versus distant (non-felt events with warning time to evacuate) scenarios should be developed.

### Development in hazard prone areas

Coastal areas are under constant pressure for residential and commercial development. Although New York State does not currently have a method to assess vulnerability of areas at potential tsunami risk compared to development trends and threats, information developed through the Coastal Erosion Hazard Areas (DEC) and the Community Waterfront Revitalization Program (DOS) should be considered when determining potential development impacts to communities at risk for tsunamis.

Post-tsunami structural studies, together with laboratory wave tank experiments, are helping engineers design tsunami-resistant structures through knowledge of how waves impact coasts and scour and erode building foundations. As a result, tsunami building design provisions will be included in the International Building Code in the next few years. Tsunami inundation models, defining the extent of coastal flooding, are an integral aspect of tsunami hazard and preparedness planning. Using worst-case inundation scenarios, these models are critical to defining evacuation zones and routes so that coastal communities can be evacuated quickly when a tsunami warning is issued.

## 3.16.3 Assessing Tsunami Vulnerability of State Facilities

There is no current information available on vulnerability of state facilities to the impacts of tsunami. If future tsunami inundation models are developed, state facility datasets can be used to assess the potential risk to state facilities and infrastructure.

### Effects of Changes in development on loss estimates

Increased development in coastal areas will increase potential losses from future tsunami events, if they occur. Currently, New York State regulates development in Coastal Erosion Hazard Areas (CEHA) through permitting. The coastal areas identified for CEHA can serve as the basis for tsunami mapping models to identify coastal areas at risk based on various scenarios. As of the 2014 Plan update, the CEHA maps have been updated using LiDAR; however, the maps have not yet been released for use. Upon their release, GIS data can be used to develop tsunami inundation maps, using tsunami modeling guidance developed by the NTHMP, to estimate potential population, property and infrastructure at risk.

## 3.16.4 Estimating Potential Losses of State Facilities

There is no current information available on estimated values of state facilities in areas that could be impacted by tsunamis. If future tsunami inundation models are developed, the state facility inventory dataset can be used to assess the estimated potential losses to state facilities and infrastructure.

## 3.16.5 Data Limitations and Other Key Documents

Future modeling of tsunami inundation zones can identify potential areas of impact in the coastal areas of New York State. Even though the state is at low risk for tsunami, mapping of inundation zones will identify potential population, property and infrastructure at risk if a tsunami impacts. The NTHMP guidance specifies a set of guidelines and recommended practices to guide the determination of tsunami inundation zones in areas where there is a low hazard – based on historical occurrence of tsunami, a low risk – due to a low population and infrastructure vulnerability, or that may not have modeled inundation and evacuation maps in the near future and wish to initiate planning and prepared efforts. The NTHMP also has Map Modeling Guidelines which can be used to for local plans to tsunami assessment and mapping tools for land-use and evacuation planning.

- There is no confirmed data indicating a history of tsunami impacts in New York State
- There are currently no tsunami inundation maps or models of coastal areas.

## Key Documents

- National Oceanic and Atmospheric Administration- Tsunami; http://www.tsunami.noaa.gov/
- Intergovernmental Oceanic Commission http://www.ioc-tsunami.org/index.php?option=com_oe&task=viewDocumentRecord&docID=10237
- International Tsunami Information Center (Located in Honolulu, Hawaii, and staffed by the USA, Chile, and Japan, the ITIC is the oldest information center serving the UNESCO Intergovernmental Oceanographic Commission (IOC)'s Global Tsunami Warning and Mitigation System.)
- National Tsunami Hazard Mitigation Program, (A coordinated national effort to assess tsunami threat, prepare community response, issue timely and effective warnings, and mitigate damage.) http://nthmp.tsunami.gov/
    - APPENDIX: Suggested Topics for Mapping and Modeling Report and/or Metadata
- Preparing Your Community for Tsunamis – A Guidebook for Local Advocates, Version 2.1, February 1, 2008, Laura Dwelley Samant, L. Thomas Tobin, Brian Tucker

***Please note:*** *data obtained from the Spatial Hazard Events and Losses Database for the United States (SHELDUS™) is a county-level hazard data set for the U.S. for 18 different natural hazard event types such thunderstorms, hurricanes, floods, and tornados. For each event the database includes the beginning date, location (county and state), property losses, crop losses, injuries, and fatalities that affected each county. The data derives from the national data source, National Climatic Data Center's monthly Storm Data publications. Using the latest release of SHELDUS™ 12.0, the database includes every loss causing and/or deadly event between 1960 through 1992 and from 1995 onward. Between 1993 and 1995, SHELDUS™ reflects only events that caused at least one fatality or more than $50,000 in property or crop damages.*