TSTAP statement on the need for national tsunami hazard mapping and improved tsunami characterization in FEMA's National Risk Index

Background: The Community Disaster Resilience Zones Act (CDRZA) of 2022 states that community disaster resilience zones, which are defined by FEMA as "resilience zones which identify disadvantaged communities most at-risk to natural hazards", will be identified at the census tract level based on the FEMA National Risk Index (NRI). Designated tracts will be used to prioritize federal financial and technical assistance to communities. Tsunamis are one of 18 hazards in the NRI. Tsunami threat is mapped using various types of hazard zones and quantified using annualized frequencies that are calculated by dividing the number of historic run-up events at tide gauges by 221 years (historical tsunami record in NOAA NCEI database). County-level tsunami losses from 1996 to 2019 are used to quantify historic loss ratios for expected annualized loss estimates.

Findings: There is no national U.S. tsunami hazard zone designation; therefore FEMA assembled data and made assumptions about tsunamis without the input of state and territorial agencies charged with mapping tsunami hazards. The NOAA TSTAP believes that, as a result, the NRI misrepresents tsunami hazards in all coastal areas of the United States and its territories. Issues with NRI treatment of tsunami hazards include but are not limited to:

- The NRI tsunami hazard zone and related expected annualized loss calculations do not differentiate tsunami risk types, such as "local" waves that can arrive in minutes and cause significant loss of life compared to "distant" waves that arrive in hours where people may be able to safely evacuate;
- Using historical run-up data for the past 221 years emphasizes smaller, more recent tsunamis that are typically distant events and ignores paleoseismic and paleotsunami evidence of potentially catastrophic local events that have not occurred in modern times but could impact entire regions;
- The NRI tsunami hazard zone improperly combines maps that are based on different recurrence intervals and then assigns an annualized frequency based on historic run-up data;
- The NRI tsunami analysis does not include tsunami hazard or risk maps for many regions of the U.S., including parts of the U.S. west coast, Puerto Rico, USVI, Guam, American Samoa, CNMI, Gulf of Mexico, and East Coast. This results in a perceived absence of tsunami risk in many of these areas.
- Historical run-up data have not been consistently monitored so they provide an incomplete picture and are biased towards communities with long-term monitoring gauges. As a result, adjacent census tracts and counties with the same tsunami threat have different NRI tsunami hazard values;
- The social vulnerability parameters assigned to census data are disconnected from the context of tsunamis, resulting in the inappropriate universal application of certain attributes such as age and ability, regardless of the specific type of tsunami; and
- Historic loss ratios reflect damage of smaller recent events and underestimate potential larger events.

Implications: NRI's treatment of tsunami hazards has resulted in an inconsistent, simplistic, and lower estimation of the tsunami risk across the country relative to other hazards. This could lead to coastal communities with significant tsunami threats being excluded from potential CDRZA financial and technical assistance.

TSTAP Recommendations to Address Findings and Implications

TSTAP recommends:

1) NOAA communicates to FEMA leadership and Federal decision makers that the NRI currently misrepresents tsunami risk and that these errors can have negative impacts to community preparedness, local and county planning, mitigation funding opportunities, access to funding, and policy making.

2) NOAA supports its Federal, state, and territory partners to develop interim tsunami hazard maps for local and distant tsunami sources for NRI use based on subject matter expertise that includes consistent

hazard mapping assumptions and includes attributes relevant to the NRI (e.g., threat levels, annualized frequencies, and historic loss ratios).

3) NOAA works with its partners to develop national probabilistic tsunami maps for local and distant tsunami sources that are updated every four years to align with the building code cycle and the USGS National Seismic Hazard Map.

Supplemental Information A

Purpose of the FEMA National Risk Index (NRI) for national resilience planning and its misrepresentation of tsunami risk

Background on the NRI for national resilience investments: The FEMA National Risk Index (NRI) is a web mapping application that provides tract- and county-level data on expected annual losses to 18 natural hazards, social vulnerability, and community resilience. During a February TSTAP briefing and on their website, FEMA officials indicated that the NRI will be used to support implementation of the Community Disaster Resilience Zones Act (CDRZA), which amends the Robert T. Stafford Disaster Recovery and Emergency Act. The CDRZA will designate community disaster resilience zones which identifies disadvantaged communities most at-risk to natural hazards. Designated zones based on NRI data will receive targeted support to access federal funding (e.g., an increased federal cost-share for the Building Resilient Infrastructure and Communities program) to implement resilience projects. It will enable communities to work with Federal and private sector partners to receive financial and technical assistance.

Background on NRI treatment of tsunamis: The National Risk Index (NRI) considers a census tract or county to have a possible tsunami hazard if: (1) it has a published tsunami hazard or evacuation zone; (2) there have been recorded tsunami run-up events in the NOAA National Centers for Environmental Information (NCEI) Global Tsunami Database from 1800 to 2019; or (3) coastal flooding is possible in general for a tract/county. Tracts and counties are assigned annualized tsunami frequency values based on the number of run-up events in the NCEI database (with run-up points buffered by 500 meters) divided by 221 years, which is the length of the NCEI record.

Background on TSTAP concerns on how the NRI underestimates tsunami threats:

- **Historic run-up data emphasize smaller, more recent events that are typically distant events.** The use of historic data from the past 200 years fails to recognize the threat posed by low-frequency, high-impact, local tsunamis that have geologic and seismic evidence for concern. The use of historical run-up data for the past 221 years primarily emphasizes smaller-consequence, but higher frequency, distant events that are likely manageable by emergency managers because they provide more time for evacuation and have relatively lower impacts. Paleotsunami and paleoseismic data for these local source threats should be integrated into the NRI analysis.
- **Historical run-up data are not consistently monitored so their use provides a limited, incomplete picture of tsunami threat.** The NCEI Global Tsunami Database is not exhaustive and is largely biased towards counties and tracts that have maintained tide gauges and historical records for longer durations. Each historical data point should be evaluated to determine its accuracy and applicability to the NRI analysis.
- **Adjacent census tracts with the same level and type of tsunami threat have different NRI values due to use of historical run-up data.** Inconsistencies in run-up monitoring results in adjacent counties having different annualized frequencies in a region with a consistent tsunami threat. For example, coastal counties in northern California, Oregon, and Washington are all at risk to the same local Cascadia subduction zone (CSZ) earthquake and tsunami threat; however, the FEMA NRI shows dramatically different annualized frequencies for tsunami hazards among these counties. Historical

run-up data should be interpolated and/or extended to all portions of the coast for a region facing the same tsunami threats.

- **The NRI tsunami hazard zone does not recognize the different types of impacts from local, regional, or distant tsunami sources.** Characterizing tsunamis only by an annualized frequency and hazard zones oversimplifies the tsunami threat. For example, a Hawaii tsunami hazard zone represents the threat of waves that could arrive many hours after an Alaskan earthquake; therefore, official warnings are possible, at-risk populations can likely evacuate, and impacts are primarily limited to development in low-lying areas and maritime settings. A tsunami-hazard zone in the Pacific Northwest represents waves that would arrive in minutes after a local earthquake, could kill several tens of thousands of people, and official warning will be difficult, if not impossible, to convey in time. The existence of a local vs. distant tsunami source threat should be evaluated and the appropriate weights should be applied to tracts and counties with a higher local-source threat prior to use in the NRI.
- **The NRI tsunami hazard zone improperly combines maps based on different recurrence intervals and then assigns an annualized frequency based on historical run-up data.** The NRI combines very different types of tsunami threats into a single hazard zone, such as a ~10,000 year recurrence interval for a local tsunami generated by a CSZ earthquake (Oregon); a ~1,000-year recurrence interval for a CSZ earthquake (Washington); two evacuation zones that reflect a distant earthquake in Alaska (Hawaii), and a composite of many hazard zones that could be created from many local sources and distant earthquake sources around the Pacific Basin (California). The recurrence intervals that underlie the hazard zones vary; therefore, they do not represent a consistent tsunami hazard. The NRI ignores this context of recurrence intervals and instead assigns an annualized frequency based on incomplete, historical run-up data for the past 221 years. A tsunami hazard zone representing an accurate and consistent hazard level should be developed and used in the NRI.

Supplemental Information B

Absence and need for a National Tsunami Hazard Map

Background: States and territories (henceforth referred to as states) receive funding from NOAA's National Weather Service to NTHMP states and territories to develop tsunami inundation maps individually for their jurisdictions. The extent and type of inundation mapping and modeling varies among states, where maps are based on a single worst-case scenario (e.g., American Samoa), a mix of local and distant scenarios (e.g., Oregon), multiple distant scenarios (e.g., Hawaii), or combined deterministic and probabilistic maps based on multiple sources and recurrence intervals (e.g., California). There is no comprehensive national dataset defining tsunami hazard zones and neighboring states with the same tsunami threat interpret the threat differently. A national deterministic map with wave-arrival times for plausible scenarios could be used to determine community exposure and evacuation potential. A national probabilistic map that identifies the likelihood of inundation based on an array of seismic and non-seismic sources with varying recurrence intervals could be used to support local-to-national mitigation cost-benefit analyses (e.g., the development of vertical-evacuation structures), national loss-estimation analyses, and building code development. A national probabilistic tsunami map representing a single return period would provide a more consistent dataset for integration into the National Risk Index (NRI).

Consequences of the lack of a national tsunami hazard map:

- The absence of national tsunami hazard maps makes it challenging to educate elected officials and national policymakers about the national threat that tsunamis pose to coastal communities, potential impacts, and risk-reduction options.
- FEMA created its own map for the NRI from an annualized economic loss perspective and in doing so, it misrepresents the nation's tsunami risk that may impact communities threatened by tsunami to miss out on financial and technical assistance.

- The American Society of Civil Engineers (ASCE) created a different type of national tsunami hazard map called a Tsunami Design Zone to support a new chapter in the International Building code that requires high risk category buildings to be designed to withstand tsunami loads.
- Because FEMA and ASCE are not the authoritative sources on tsunami hazard modeling, the methods used to develop these datasets are inconsistent, incomplete, and in some cases inadequate or incorrect when characterizing tsunami hazards.

Examples of national maps and products developed to represent a consistent hazard level:

- The United States Geological Survey (USGS) has been publishing national seismic hazard maps since 1996 and revises them every four years or so based on best available science. These national seismic hazard maps are probabilistic and provide a suite of probabilities that are directly tied into building codes and decision making to reduce risk from earthquake hazards.
- FEMA has begun efforts to move away from 100-yr and 500-year flood maps and instead create probabilistic flood hazard zones to support the National Flood Insurance Program.
- There is precedent for NTHMP members to collaborate on national tsunami products. In 2015, NOAA and USGS representatives worked together to produce the U.S. States and Territories National Tsunami Hazard Assessment. This document provides qualitative assessments of tsunami threat levels based on NTHMP subject matter experts.

Development of an accurate and consistent national tsunami hazard map would vastly improve the results and useability of the NRI. The TSTAP believes that FEMA should work with other Federal agencies, such as NOAA and the USGS, as well as state and local tsunami experts to create a national tsunami hazard map.