

# Tsunami Modeling and Mapping: Guidelines and Best Practices

## Part II: Tsunami Inundation Maps<sup>1</sup>

National Tsunami Hazard Mitigation Program  
Mapping and Modeling Subcommittee

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A key outcome specified in the National Tsunami Hazard Mitigation Program (NTHMP) 2009-2013 Strategic Plan was the development of “tsunami inundation maps that support informed decision making in tsunami- threatened communities.” To achieve this goal, the NTHMP Coordinating Committee charged the Mapping and Modeling Subcommittee (MMS) in 2009 with establishment of inundation map guidelines. The Coordinating Committee further specified that, to ensure that tsunami inundation maps support informed decision making in tsunami-threatened communities, all NTHMP funded models and new map products should meet these guidelines by 2012. The current NTHMP Strategic Plan further enforces the motion that all models and maps funded by NOAA/NWS grants should meet NTHMP guidelines except where they conflict with state/territory-mandated laws or policies.

### Purpose

The purpose of this guidelines and best practices document is to establish minimum requirements that should be met to develop accurate, consistent, and cost-effective tsunami hazard and risk assessments across state and territorial coastal boundaries. Included here are guidelines on map content, methodology, and documentation requirements for inundation maps and best practices that recommend methods, procedures, or useful information that can be applied to optimize the maps. In addition to this document, the MMS has developed *Tsunami Inundation Modeling and Checklist for Evaluating Tsunami Modeling and Mapping Reports and/or Metadata*, a supplement containing content recommendations for metadata, project reports, or other forms of documentation related to model and map development (<http://nws.weather.gov/nthmp/publications.html>).

### Intended Audience

These guidelines and best practices are intended for tsunami inundation map producers with the intent of providing the best attainable products to support state and Federal planners and emergency managers in making informed decisions. Though these guidelines apply to federally funded NTHMP partners, it is also recommended that they be adopted for use by other entities with an interest or intent for producing tsunami inundation maps.

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<sup>1</sup> Formerly titled *Guidelines and Best Practices for Tsunami Inundation Mapping for Evacuation Planning*

<sup>2</sup> The draft of this document was developed by the National Tsunami Hazard Mitigation Program Mapping and Modeling Subcommittee (MMS) April 29, 2009. It was revised by a working group of the MMS in May 2009 and reviewed and finalized by the MMS January 26, 2010. It was reformatted as part of the “Tsunami Modeling and Mapping: Guidelines and Best Practices” series in September 2016. As part of this process, all content associated with evacuation maps was removed as it has been incorporated into *Tsunami Evacuation Maps* from the Mitigation and Education Subcommittee.

## Expected Results

The outcome of adherence to the guidelines and best practices set forth for tsunami inundation mapping will result in more uniform and understandable products. These guidelines and best practices may also serve communities or regions where formal tsunami mitigation efforts are in the development stage.

## ***Tsunami Inundation Mapping Guidelines***

In these guidelines, “tsunami inundation map(s)” refers to cartographic (paper) maps, spatial imagery, interactive and static web-based maps, and other digital maps that delineate the landward extent of flooding from tsunamis. The purpose of producing tsunami inundation maps is to aid the development of derivative tsunami hazard mitigation products that save lives and reduce property loss. Examples of tsunami hazard mitigation products include tsunami evacuation maps, land-use planning maps, regulatory maps, probabilistic tsunami hazard (PTH) maps, tsunami animations, flow depth and velocity time series, among others. These guidelines address the minimum requirements to develop consistent and reliable tsunami inundation maps. Guidelines for tsunami evacuation maps can be found in *Tsunami Evacuation Maps* (<http://nws.weather.gov/nthmp/publications.html>) from the Mitigation and Education Subcommittee.

## Map Types

These categories reflect the availability and resolution of data used to estimate tsunami inundation.

- Type 1 — Maps developed for areas with limited data availability (e.g. grid resolution > 90 m).
- Type 2 — Maps developed using data sufficient to resolve all bathymetric and topographic features (~10 m resolution)
- Type 3 — Site-specific maps developed using data with the level of resolution depending on the tsunami impact projects (structures, dunes, tide currents, typically 10 m or better resolution).

## Tsunami Inundation Maps

Map products may include printed maps, digital map files, or interactive web-based maps. For NTHMP efforts:

- Tsunami inundation maps should include a title, scale, geographic location (coordinates), intended use, and appropriate explanatory information.
- Tsunami inundation maps should be accompanied by technical documentation on how modeled results were transferred onto the tsunami inundation maps. Intended use and/or limitations of the map should be included.
- Maps with maximum tsunami inundation should show the landward limit of inundation that encompasses all tsunami scenarios considered, including any documented past inundation.
- If there are significant uncertainties in the tsunami model results, the landward limit of inundation should be considered to be extended further in-land from the maximum modeled extent. These uncertainties could stem from the numerical calculations, physical assumptions on the tsunami source, and potential erosion processes. Discrepancies between modeled runup and field observations have been found to be

10-20%, e.g. in narrow gullies (NTHMP, 2012). Use judgment to avoid underestimation of inundation.

- Erosion potential of sand dunes or other unconsolidated geomorphologic features should be considered.
- Maps should be developed using the best available data for the area of coverage (e.g., use highest resolution LiDAR data, best bathymetry, current deformation models, best geologic paleoseismic data). The use of alternate information should be explained in documentation.
- Tsunami inundation maps should be reviewed and field checked for consistency with existing topography before publication.
- Tsunami inundation maps should be developed and produced at a scale sufficient to resolve important features identified as relevant to emergency planning.
  - Digital map databases should be fully documented with standards-compliant metadata.
- Developed tsunami sources are to be provided to the MMS in order to be included into the tsunami source databases.

## **Tsunami Map Re-Evaluation**

Tsunami hazard mitigation map products should be re-evaluated when:

- A tsunami occurs that has implications for tsunami inundation in the map area;
- A new credible and potentially significant source is identified;
- Every 5-10 years, or when significant development in modeling technology occurs;
- In the case of a Type 1 map, when bathymetric and topographic data of sufficient resolution and accuracy become available; or
- Significant value can be added or serious deficiencies are identified.

If no change is expected, then new modeling or inundation mapping may not be beneficial and, therefore, is not required.

## ***Tsunami Inundation Mapping Best Practices***

### **Tsunami Inundation Maps**

- Local knowledge, historical documentation, and/or paleotsunami data that are available for historical events should be used in developing or verifying inundation lines. If paleotsunami data are used to adjust inundation lines, then changes in paleotopography should be discussed and resolved.
- Maximum tsunami inundation lines should be visually adjusted as appropriate around small features that are not adequately resolved within the DEM grid.
- Technical documentation describing the approach and methodology used to develop the maps should fully document all data sources and include:
  - Complete descriptions of the tsunami sources used as inputs for numerical modeling,
  - Appropriate description or reference to the numerical model used for tsunami simulations, and
  - Description of the procedure followed to transfer model data from tsunami simulations to the tsunami inundation map.

- Where possible, tsunami inundation maps should include information on maximum flow depth, flow speed, and maximum momentum flux.
- Collaboration between Federal, state, and local agencies is encouraged to provide opportunity to review inundation maps to help identify errors and discrepancies. When identified, the causes should be determined and addressed appropriately. Technical reports and/or map marginalia should include explanation of the limitations and uncertainties.
- Digital maps should include appropriate scale limitations and be displayed on a suitable base map, as determined by state emergency management or scientific personnel.

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*This document is part of the “Tsunami Modeling and Mapping: Guidelines and Best Practices” series. All the documents in this series are available on the NTHMP website at*

*<http://nws.weather.gov/nthmp/publications.html>:*

- *Part I: Tsunami Inundation Modeling*
- *Part II: Tsunami Inundation Maps*
- *Part III: Tsunami Inundation Determination for Non-Modeled Regions*
- *Part IV: Tsunami Evacuation Maps*
- *Checklist for Tsunami Modeling and Mapping Reports and/or Metadata*