Sonoma County Multijurisdictional Hazard Mitigation Plan Update 2021

Appendix C. Mapping Methods and Data Sources

C. MAPPING METHODS AND DATA SOURCES

DAM FAILURE INUNDATION MAPPING

Dam breach inundation maps, including inundation boundaries and depth grids, were downloaded from the California Department of Water Resources' (DWR) website - https://fmds.water.ca.gov/maps/damim/. As required by California Water Code section 6161, the Division of Safety of Dams (DSOD) at DWR reviews and approves inundation maps prepared by licensed civil engineers and submitted by dam owners for extremely high, high, and significant hazard dams and their critical appurtenant structures. Inundation maps are based on a hypothetical failure of a dam or critical appurtenant structure and the information depicted on the maps is approximate. The dams and failure scenarios are as follows:

- Annadel No. 1 (National Dam ID CA00056) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 11/15/2018.
- Cook No. 2 (NID CA01056) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 7/30/2020.
- Delta Pond (NID CA01272) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 3/13/2019.
- Dutcher Creek (NID CA01362) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 7/14/2020.
- Fern Lake (NID CA00007) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 3/7/2019.
- Foothill Regulating Park (NID CA01057) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 2/4/2019.
- Foss Creek North Area (NID CA01431) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 3/19/2020.
- Lagunita (NID CA00992) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 3/6/2019.
- Lake Helen (NID CA01060) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 10/1/2020.
- Lytton (NID CA01042) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 3/22/2019.
- Lytton (NID CA01042) - Scenario shows an inundation extent for a sunny day failure of Northern (Auxiliary) Dam. File downloaded from DSOD website generated on 3/22/2019.

- Mallacomes (NID CA00591) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 1/11/2019.
- Matanzas Creek (NID CA00794) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 8/19/2020.
- Merlo (NID CA01313) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 12/5/2019.
- Middle Fork Brush Creek (NID CA00793) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 12/24/2020.
- Piner Creek (NID CA00792) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 12/24/2020.
- Piner Creek (NID CA00792) - Scenario shows an inundation extent for a sunny day failure of Saddle Dam 1. File downloaded from DSOD website generated on 12/24/2020.
- Santa Rosa Creek Reservoir (NID CA00795) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 8/18/2020.
- Suttenfield (NID CA00010) - Scenario shows an inundation extent for a sunny day failure of Main Dam. File downloaded from DSOD website generated on 4/29/2019.
- Suttenfield (NID CA00010) - Scenario shows an inundation extent for a sunny day failure of Saddle Dam 1. File downloaded from DSOD website generated on 4/29/2019.

Additional dam inundation areas data for Azalea, Fountaingrove, Lake Ralphine, and Warm Springs Dam was provided by Sonoma County. This data was originally used in the County's 2011 Hazard Mitigation Plan.

EARTHQUAKE MAPPING

Liquefaction Susceptibility

The Liquefaction dataset provided by the County presents a map and database of Quaternary deposits and liquefaction susceptibility areas the urban core of the San Francisco Bay region within the County of Sonoma. It supersedes the equivalent area of U.S. Geological Survey Open-File Report 00-444 (Knudsen and others, 2000), which covers the larger 9-county San Francisco Bay region. The report consists of (1) a spatial database, (2) two small-scale colored maps (Quaternary deposits and liquefaction susceptibility), (3) a text describing the Quaternary map and liquefaction interpretation (part 3), and (4) a text introducing the report and describing the database (part 1).

The nine counties surrounding San Francisco Bay straddle the San Andreas fault system, which exposes the region to serious earthquake hazard (Working Group on California Earthquake Probabilities, 1999). Much of the land adjacent to the Bay and the major rivers and streams is underlain by unconsolidated deposits that are particularly vulnerable to earthquake shaking and liquefaction of water-saturated granular sediment. This new map provides a consistent detailed treatment of the central part of the 9-county region in which much of the mapping of Open-File Report 00-444 was either at smaller (less detailed) scale or represented only preliminary revision of earlier work.

Like Open-File Report 00-444, the current mapping uses geomorphic expression, pedogenic soils, inferred depositional environments, and geologic age to define and distinguish the map units. Further scrutiny of the factors controlling liquefaction susceptibility has led to some changes relative to Open-File Report 00-444: particularly the reclassification of San Francisco Bay mud (Qhbm) to have only MODERATE susceptibility and the rating of artificial fills according to the Quaternary map units inferred to underlie them.

The report is the product of cooperative work by the National Earthquake Hazards Reduction Program (NEHRP) and National Cooperative Geologic Mapping Program of the U.S. Geological Survey, William Lettis and & Associates, Inc. (WLA), and the California Geological Survey. An earlier version was submitted to the U.S. Geological Survey by WLA as a final report for a NEHRP grant (Witter and others, 2005). The mapping has been carried out by WLA geologists under contract to the NEHRP Earthquake Program (Grant 99-HQ-GR-0095) and by the California Geological Survey. For detailed information about the map the USGS has an open report, "Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California. U.S. Geological Survey Open File Report 2006-1037 Version 1.1. http://pubs.usgs.gov/of/2006/1037/

National Earthquake Hazard Reduction Program (NEHRP) Soils

NEHRP soils information is derived from a shear wave velocity (Vs30) data produced by the California Geological Survey in 2015. The Vs30 data represents simplified geologic units that have been correlated to the time-averaged shear-wave velocity in the upper 30 meters of the earth's surface. The geologic units were compiled from published maps that range in scale from 1:250,000 to 1:24,000. (Wills, et. al., 2015)

Probabilistic Peak Ground Acceleration Maps

Probabilistic peak ground acceleration data, by Census tract, are generated by Hazus 4.2 SP03. In Hazus' probabilistic analysis procedure, the ground shaking demand is characterized by spectral contour maps developed by the U.S. Geological Survey (USGS) as part of a 2018 update of the National Seismic Hazard Maps. USGS probabilistic seismic hazard maps are revised about every six years to reflect newly published or thoroughly reviewed earthquake science and to keep pace with regular updates of the building code. Hazus includes maps for eight probabilistic hazard levels: ranging from ground shaking with a 39 percent probability of being exceeded in 50 years (100-year return period) to the ground shaking with a 2 percent probability of being exceeded in 50 years (2,500-year return period).

Shake Maps

A shake map is designed as a rapid response tool to portray the extent and variation of ground shaking throughout the affected region immediately following significant earthquakes. Ground motion and intensity maps are derived from peak ground motion amplitudes recorded on seismic sensors (accelerometers), with interpolation based on estimated amplitudes where data are lacking, and site amplification corrections. Color-coded instrumental intensity maps are derived from empirical relations between peak ground motions and Modified Mercalli intensity. For this plan, shake maps were prepared by the USGS for four earthquake scenarios:

- An earthquake on the Hayward fault with the following characteristics:
  - Magnitude: 7.57
  - Epicenter: N 38.08 W 122.41
  - Depth: 7.1 km
- An earthquake on the Maacama fault with the following characteristics:
  - Magnitude: 7.55

  - Epicenter: N 39.18 W 123.14
  - Depth: 7.2 km
- An earthquake on the Rodgers Creek-Healdsburg fault with the following characteristics:
  - Magnitude: 7.19
  - Epicenter: N 38.48 W 122.69
  - Depth: 8.4 km
- An earthquake on the San Andreas fault with the following characteristics:
  - Magnitude: 8.04
  - Epicenter: N 38.4 W 123.11
  - Depth: 6.6 km

FLOOD MAPPING

Flood hazard areas are a combination of areas from the countywide effective FEMA Digital Flood Insurance Rate Map (DFIRM), the Preliminary FIRM (PFIRM), and the County's Russian River Flood Modeling. The DFIRM is dated March 7,2017 with latest incorporated LOMR effective June 19, 2020. The PFIRM is dated May 15, 2020.

The Russian River Flood Modeling data, produced by Sonoma County and QSI, includes polygon features and water depth rasters for each flood stage. The following metadata was provided by the County:

- The polygon features within this dataset represent the extent of modeled water surfaces within the Russian River Modeling and Buildings study area. The water surface extents were estimated using HEC RAS 5.0.1 hydrologic modeling software. The projection is CASP 2 with horizontal datum NAD83(2011), vertical datum NAVD88 (Geoid 12A), and the units are US Survey Feet.
- The water depth digital elevation model (DEM) represents the difference between water surface elevation models and bare earth (all vegetation and man-made structures removed) digital elevation models. The water surface elevations were estimated using HEC RAS 5.0.1 hydrologic modeling software. Each pixel is three feet by three feet and represents an average height above ground for that area. QSI collected the LiDAR and created this data set for the Russian River Modeling and Buildings study area. The projection is CASP 2 with horizontal datum NAD83(2011), vertical datum NAVD88 (Geoid 12A), and the units are US Survey Feet. See Process Steps for derivation of raster datasets.

LANDSLIDE MAPPING

Susceptibility to Deep-Seated Landslides data provided by the California Geological Survey. The map, and associated data, show the relative likelihood of deep-seated landsliding based on regional estimates of rock strength and steepness of slopes. On the most basic level, weak rocks and steep slopes are most likely to generate landslides. The map uses detailed information on the location of past landslides, the location and relative strength of rock units, and steepness of slope to estimate susceptibility to deep-seated landsliding (0 to X, low to high). The USGS 2009 National Elevation Dataset (NED) with 10-m grid size was used as the base map. This landslide susceptibility map is intended to provide infrastructure owners, emergency planners and the public with a general overview of where landslides are more likely to occur. (Wills, et. al., 2011)

SEA LEVEL RISE MAPPING

Projected sea level rise data are from the USGS Coastal Storm Modeling System (CoSMoS), accessed via the Our Coast Our Future web platform (Point Blue Conservation Science and USGS). The data for Sonoma County is a seamless mashup of v2.1 (inner bay), and v2.0 and v2.2 for different stretches of the outer coast. The projections were generated using the latest downscaled climate projections and calibrated hydrodynamic models by the CoSMoS project team led by Patrick Barnard, at the USGS Pacific Coastal and Marine Science Center.

TSUNAMI MAPPING

Initial tsunami modeling was performed by the University of Southern California Tsunami Research Center funded through the California Emergency Management Agency by the National Tsunami Hazard Mitigation Program. The tsunami modeling process utilized the MOST (Method of Splitting Tsunamis) computational program (Version 0), which allows for wave evolution over a variable bathymetry and topography used for the inundation mapping (Titov and Gonzalez, 1997; Titov and Synolakis, 1998). The bathymetric/topographic data that were used in the tsunami models consist of a series of nested grids. Near-shore grids with a 3 arc-second (75- to 90-meters) resolution or higher, were adjusted to “Mean High Water” sea-level conditions, representing a conservative sea level for the intended use of the tsunami modeling and mapping. A suite of tsunami source events was selected for modeling, representing realistic local and distant earthquakes and hypothetical extreme undersea, near-shore landslides.

Local tsunami sources that were considered include offshore reverse-thrust faults, restraining bends on strike-slip fault zones and large submarine landslides capable of significant seafloor displacement and tsunami generation. Distant tsunami sources that were considered include great subduction zone events that are known to have occurred historically (1960 Chile and 1964 Alaska earthquakes) and others which can occur around the Pacific Ocean “Ring of Fire.” In order to enhance the result from the 75- to 90-meter inundation grid data, a method was developed utilizing higher-resolution digital topographic data (3- to 10-meters resolution) that better defines the location of the maximum inundation line (U.S. Geological Survey, 1993; Intermap, 2003; NOAA, 2004). The location of the enhanced inundation line was determined by using digital imagery and terrain data on a GIS platform with consideration given to historic inundation information (Lander, et al., 1993). This information was verified, where possible, by field work coordinated with local county personnel.

The accuracy of the inundation line shown on these maps is subject to limitations in the accuracy and completeness of available terrain and tsunami source information, and the current understanding of tsunami generation and propagation phenomena as expressed in the models. Thus, although an attempt has been made to identify a credible upper bound to inundation at any location along the coastline, it remains possible that actual inundation could be greater in a major tsunami event. This map does not represent inundation from a single scenario event. It was created by combining inundation results for an ensemble of source events affecting a given region. For this reason, all of the inundation region in a particular area will not likely be inundated during a single tsunami event. (State of California, 2009)

WILDFIRE MAPPING

Sonoma County Wildfire Hazard Index data developed by Sonoma County PRMD, Sonoma County, FireSAFE Sonoma, Tukman Geospatial, Digital Mapping Solutions, and Wildland Resource Management. The Sonoma County Wildfire Hazard Index is a model that predicts relative wildfire hazard on the landscape. Higher index values represent a higher relative hazard. The index is based on inputs that inform potential fire behavior, inputs that represent fire probability occurrence in any 1 pixel, and a model of wildfire suppression difficulty. For a full description of input and methods, go to the story map: https://storymaps.arcgis.com/stories/a64d596a8be941c8b28263718880e433. The hazard index reflects landscape conditions through the 2018 fire season.

REFERENCES

Barnard, P.L., Erikson, L.H., Foxgrover, A.C., Finzi Hart, J.A., Limber, P., O'Neill, A.C., van Ormondt, M., Vitousek, S., Wood, N., Hayden, M.K., and Jones, J.M., 2019. Dynamic flood modeling essential to assess the coastal impacts of climate change. Scientific Reports, Volume 9, Article #4309, 13 pp., http://dx.doi.org/10.1038/s41598-019-40742-z.

Intermap Technologies, Inc., 2003, Intermap product handbook and quick start guide: Intermap NEXTmap document on 5-meter resolution data, 112 p.

Lander, J.F., Lockridge, P.A., and Kozuch, M.J., 1993, Tsunamis Affecting the West Coast of the United States 1806-1992: National Geophysical Data Center Key to Geophysical Record Documentation No. 29, NOAA, NESDIS, NGDC, 242 p.

State of California. 2009. Tsunami Inundation Map for Emergency Planning; produced by California Emergency Management Agency, California Geological Survey, and University of Southern California – Tsunami Research Center; dated December 9, 2009.

Titov, V.V., and Gonzalez, F.I., 1997, Implementation and Testing of the Method of Tsunami Splitting (MOST): NOAA Technical Memorandum ERL PMEL –112, 11 p.

Titov, V.V., and Synolakis, C.E., 1998, Numerical modeling of tidal wave runup: Journal of Waterways, Port, Coastal and Ocean Engineering, ASCE, 124 (4), pp 157-171.

USGS. 2006. Maps of Quaternary Deposits and Liquefaction Susceptibility in the Central San Francisco Bay Region, California. Open-File Report 2006-1037. Version 1.1. U.S. Geological Survey in cooperation with the California Geological Survey.

U.S. Geological Survey, 1993, Digital Elevation Models: National Mapping Program, Technical Instructions, Data Users Guide 5, 48 p.

Wills, C.J., Gutierrez, C.I., Perez, F.G., and Branum, D.B., 2015, A next-generation Vs30 map for California based on geology and topography: Bulletin of the Seismological Society of America.

Wills C.J., Perez, F., Gutierrez, C. 2011. Susceptibility to deep-seated landslides in California: California Geological Survey Map Sheet 58.