

The Effects of Historic Tsunamis on the Island of Oahu, Hawaii

GIS Final Project: Fall 2019

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Background:

The Hawaiian Islands are beautiful, tropical, hot spots of biodiversity that are occasionally affected by Tsunamis. First, the 1946 Aleutian Islands Earthquake in Alaska caused a tsunami to destroy wartime airbases in Kahuku, Northeast Oahu. The following 1952 Kamchatka Earthquake in Russia, 1957 Earthquake in the Andreanof Islands of Alaska, 1960 Earthquake in southern Chile, and the 1964 Earthquake of Prince William Sound Alaska cause evacuations and much damage to the Island of Oahu.

Goal:

The goal of this project is to assess the distance of flooding inland due to 5 historic tsunamis on the Island of O'ahu, Hawaii. I plan to find the average flooding for each of the 5 earthquakes visually represented as maps of the island. I will find the percent of land flooded and compare the flooded areas of each tsunami using DEM tiles of Oahu and Tsunami wave height data for each of the five tsunamis. Then I will use Critical Habitat Ecosystem data to assess the damage each tsunami caused to Critical habitats on Oahu.

Data Sources:

- DEM Tiles: from USGS Earth Data, ASTGTM v003, ASTER Global Elevation Model 1 arc second, PI: U.S./Japan ASTER Science Team.
Type: raster
<https://lpdaac.usgs.gov/products/astgtmv003/>
- Wave height data: Readings of tsunami wave heights at various locations from the 1946, 1952, 1957, 1960 and 1964 Hawaii tsunamis.
Feature layer by HawaiiStateGIS
<http://files.hawaii.gov/dbedt/op/gis/data/tsunhts.pdf>
- Critical Habitat Ecosystem Data: From the Hawaii Statewide GIS Program
<http://files.hawaii.gov/dbedt/op/gis/data/criticalhab.pdf>

Data Processing:

Coordinate system: GCS WGS 1984

Datum: WGS 1984

Units: Degree and Meters

Map Scale: 1:125,000

Method:

I will use raster calculator to subtract the average wave height from average sea level to find the difference in wave height and elevation, then create a binary raster using raster calculator conditional statement. The result will be a binary map clearly showing where flooding occurred on the Island of Oahu.

Process:

Step 1: Retrieve DEM

I retrieved DEM tiles, saved them to my Project folder, and then opened a new Arc document. I loaded the tiles into ArcMap as seen in Figure 1.

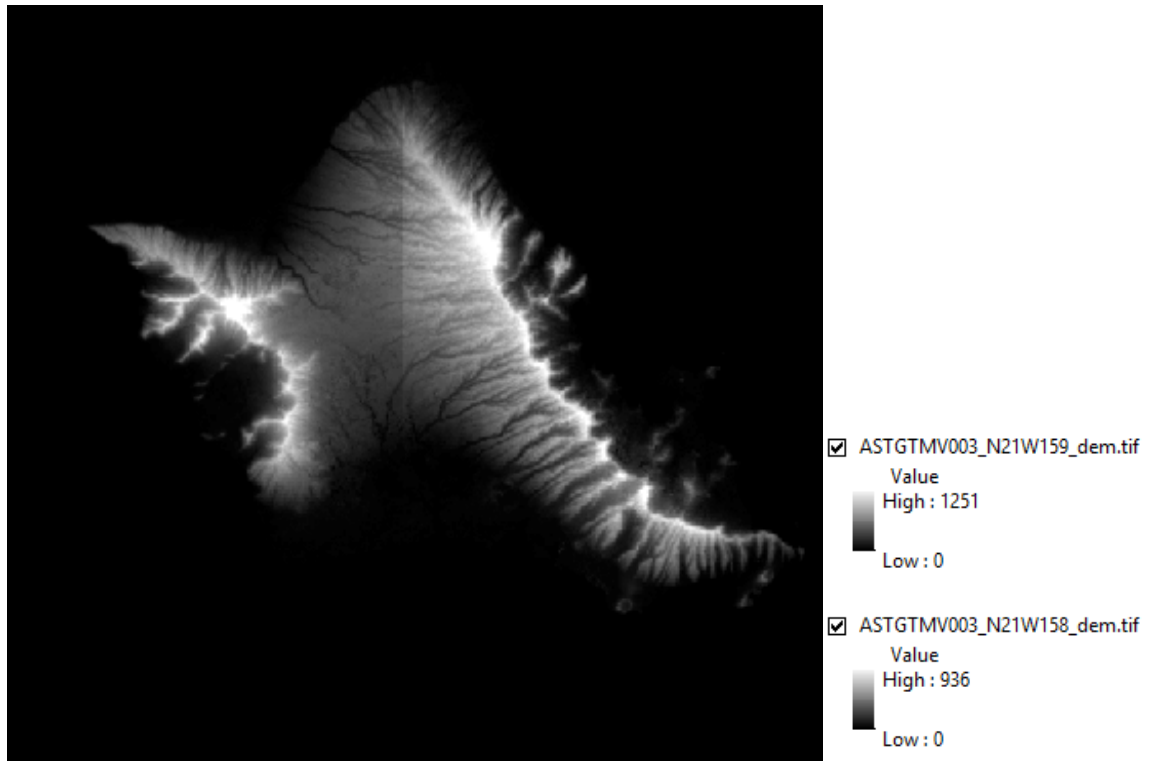


Figure 1: DEM tiles from UGSG ASTER

Step 2: Mosaic

I created a dataset for my new tiles using the Create Raster Dataset under Data Management in the toolbox, I then combined them using the Mosaic tool under Data Management in the toolbox. Figure 2 shows the tile combined.

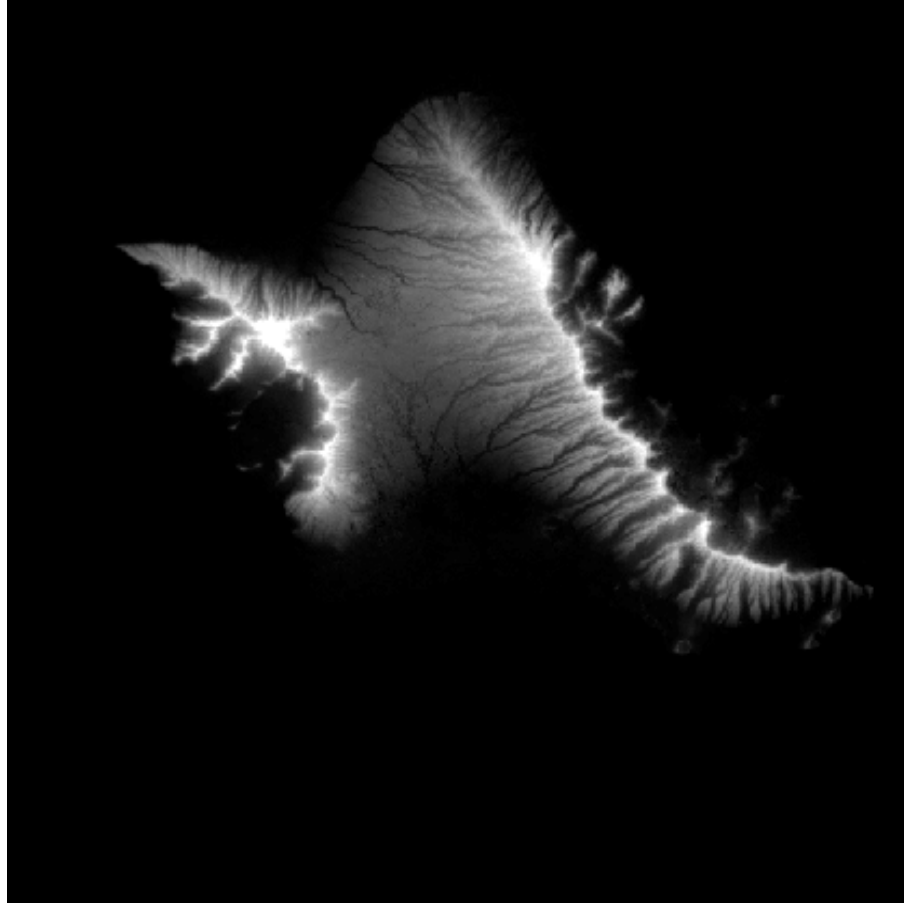


Figure 2: Mosaic tool

Step 3: Project, Classify, and Contour

Next, I used the Project tool under Data Management to project my Figure 2 DEM raster into the Coordinate System: NAD 1983 UTM Zone 4N. I then classified my DEM to 100m intervals. I used the exclusion tool, within classify, to exclude any data below 0. I also created a Zero elevation contour using the contour tool, which represents the mean sea level as shown in figure 3.

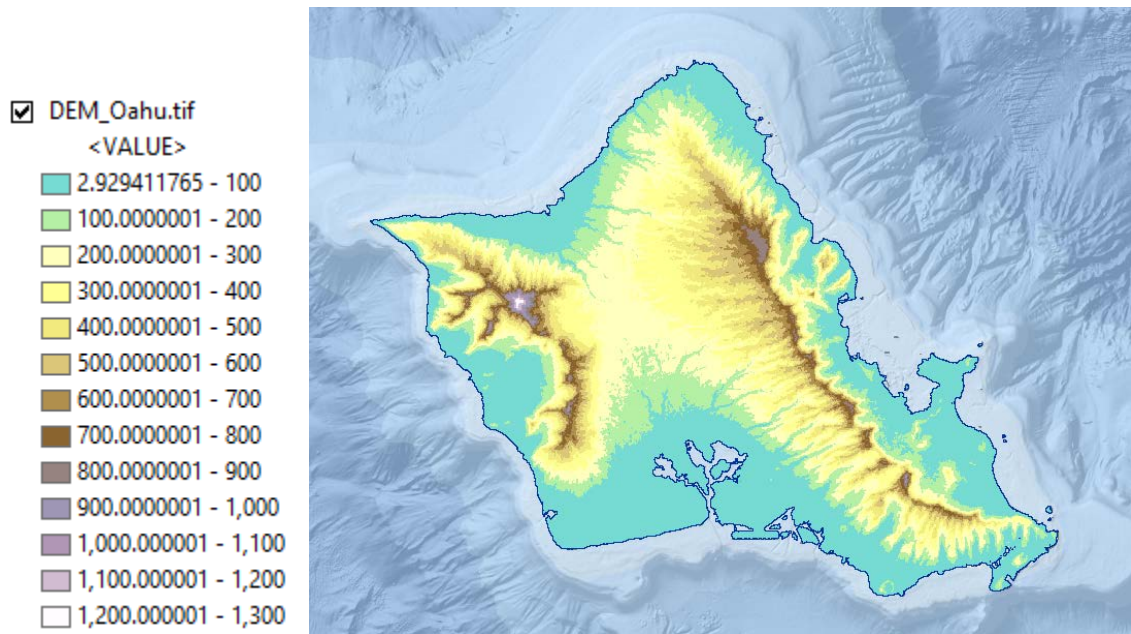


Figure 3: Project, Classify, and Contour tools

Step 4: Slope

Then I used the slope tool on my DEM raster. The result is shown in figure 4.

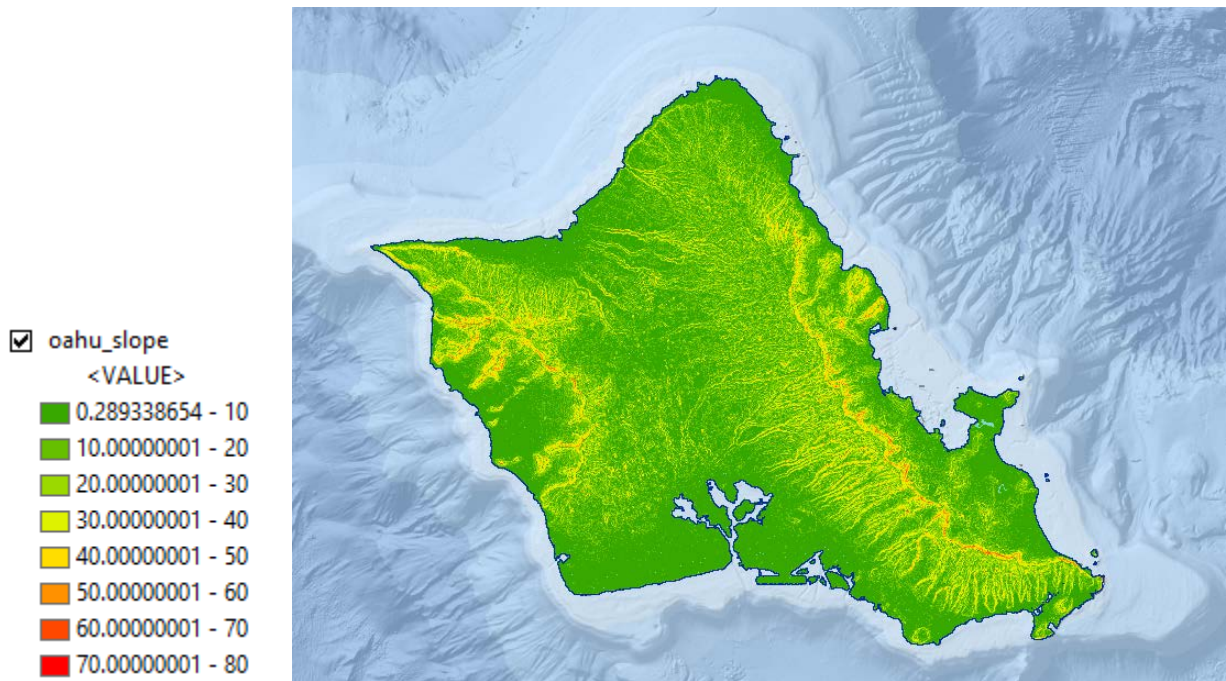


Figure 4: Slope tool

Step 5: Wave Height Data

Next, I gathered Wave Height data from the Hawaii Statewide GIS Program. The data came with all 5 Tsunamis in one vector layer, so I used my selection tool to separate the data into the 5 tsunamis as 5 new vector layers. Figure 5 shows the point data of Wave Heights. Each different color represents a different tsunami.



Figure 5: Selection tool

Step 6: Raster Calculator

Next, I used raster calculator to subtract the average wave height from the dem, for each Tsunami. Figure 6 shows the tool window with the Map Algebra expression for my 1946 Data Frame. Figure 7 shows the resulting map.

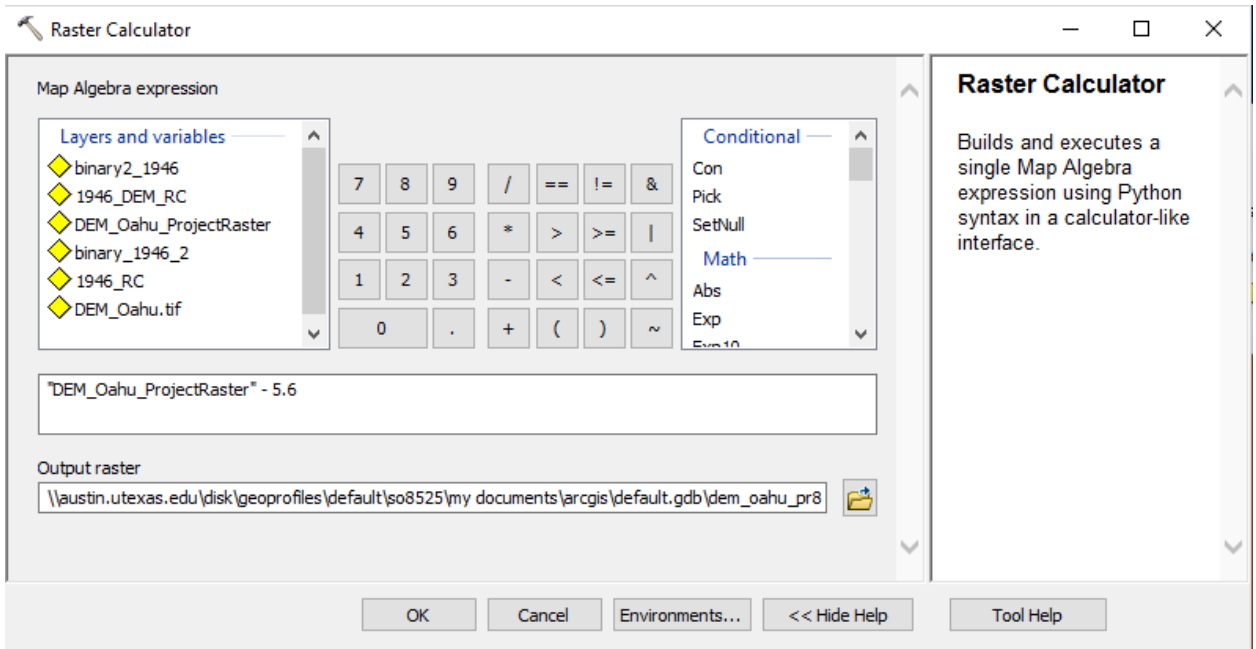


Figure 6: Raster Calculator tool

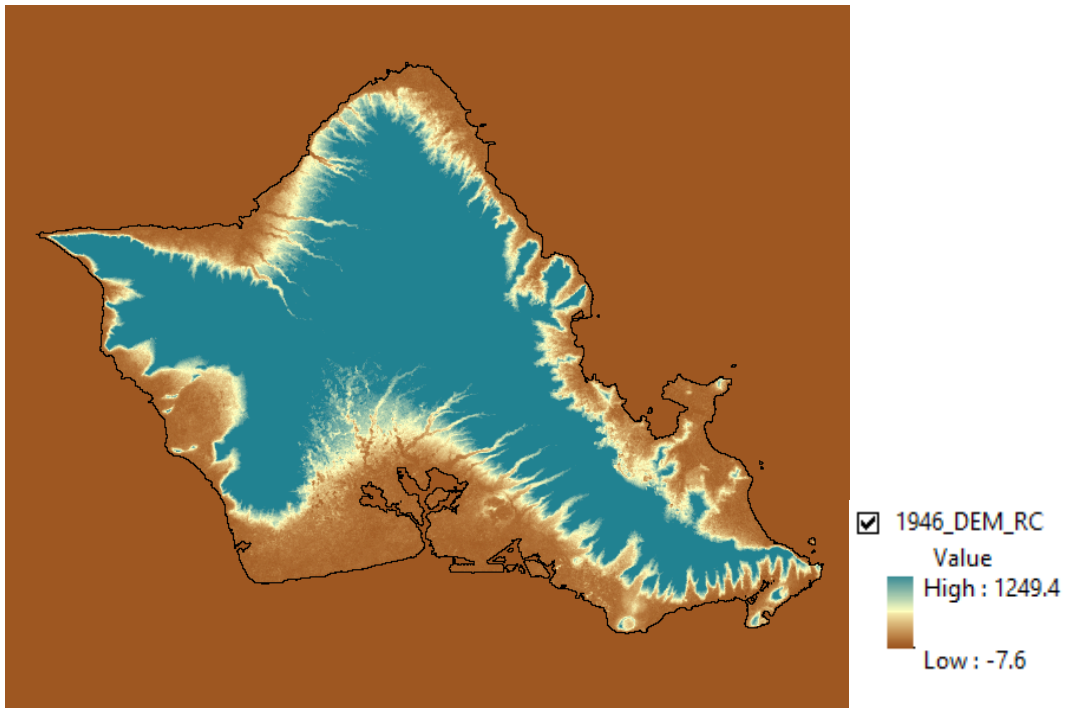


Figure 7: Map resulting from Raster Calculator

Step 7: Raster Calculator

I used raster calculator tool to create a binary raster from the raster created in the first half of this step. The statement I used was `Con("1946_RC"<=0,1,0)`.

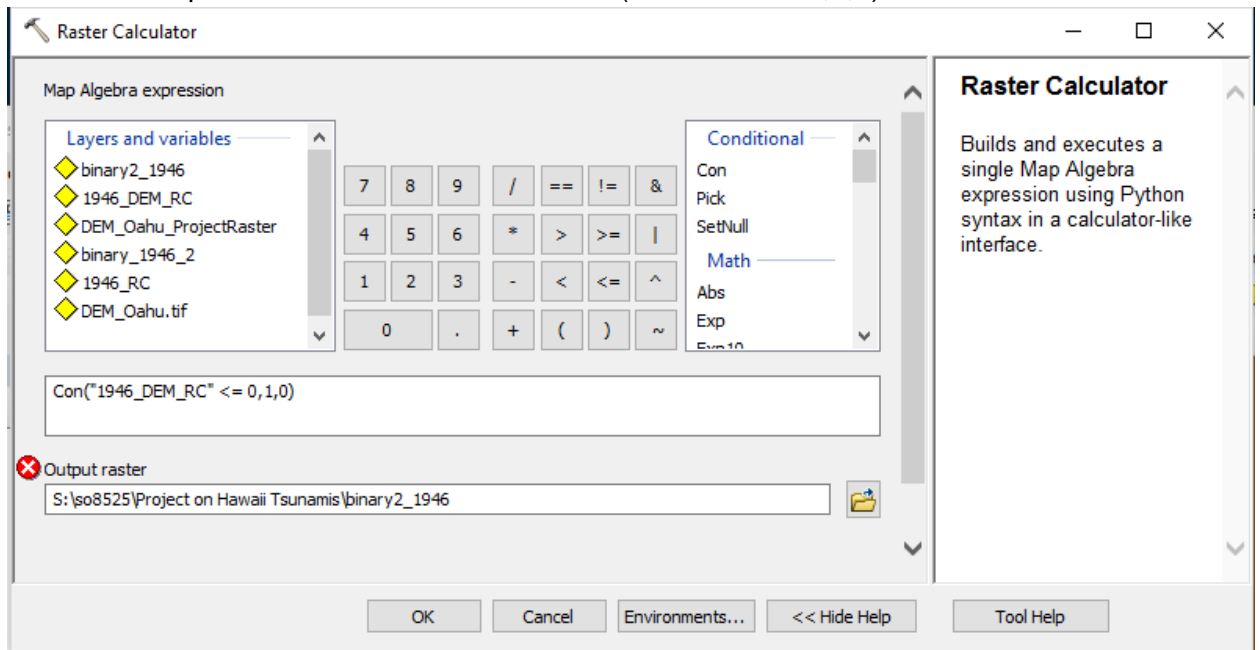


Figure 8: Raster Calculator

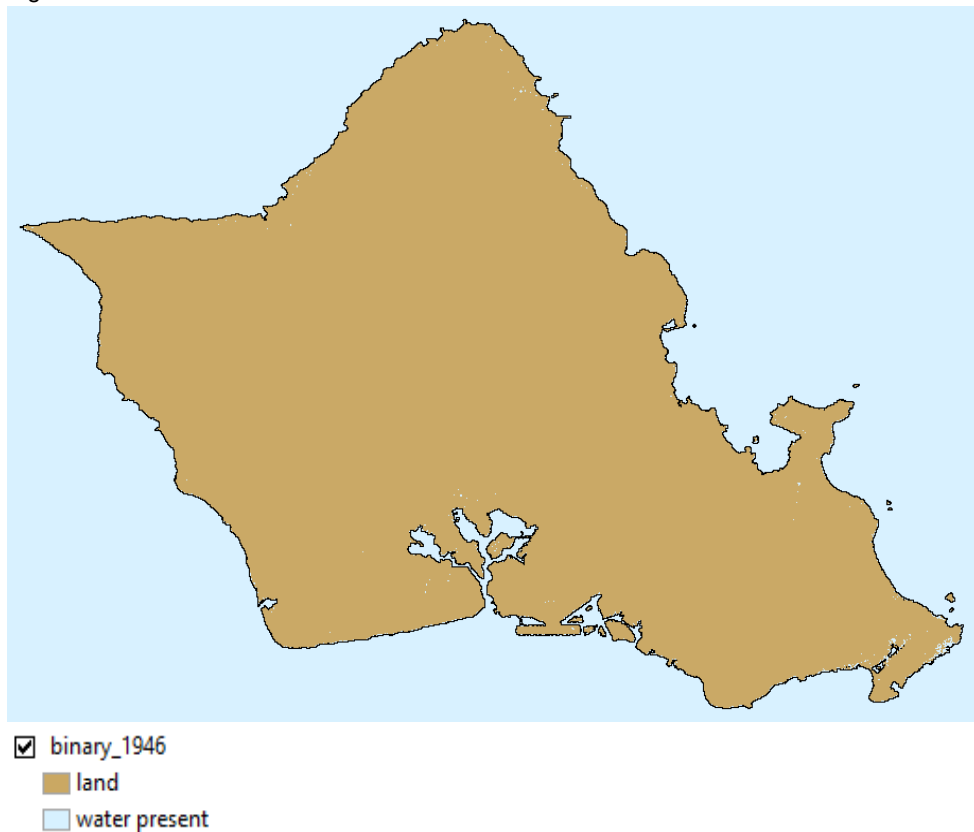


Figure 9: Binary Map from Raster Calculator tool calculation

The resulting binary map is difficult to see, so I decided to pick a location to get closer in order to see the flooding more closely. I chose the Southeast corner of O'ahu. I then repeated this step for each of my five Data Frames.

Step 8: Mask

In this step, I went back to correct. I created a polygon of my shoreline elevation. I added a mask, by using environments in the main toolbar under geoprocessing by going to Raster Analysis and setting the mask to SL_Contour (my sea level contour polygon).

Step 9: Extract by Mask

Next, I used the Extract by Mask tool to extract; binary_1946, binary_1952, binary_1957, binary_1960, and binary_1964 (my binary layers for each 5 data frames) to my mask set as my contour polygon.

Step 10: Critical habitat Ecosystems

Next, I decided to test some other data from the Hawaii Statewide GIS website to see what some impacts of the tsunamis were. I added data on Critical Habitat Ecosystems. The resulting map is shown in figure 10

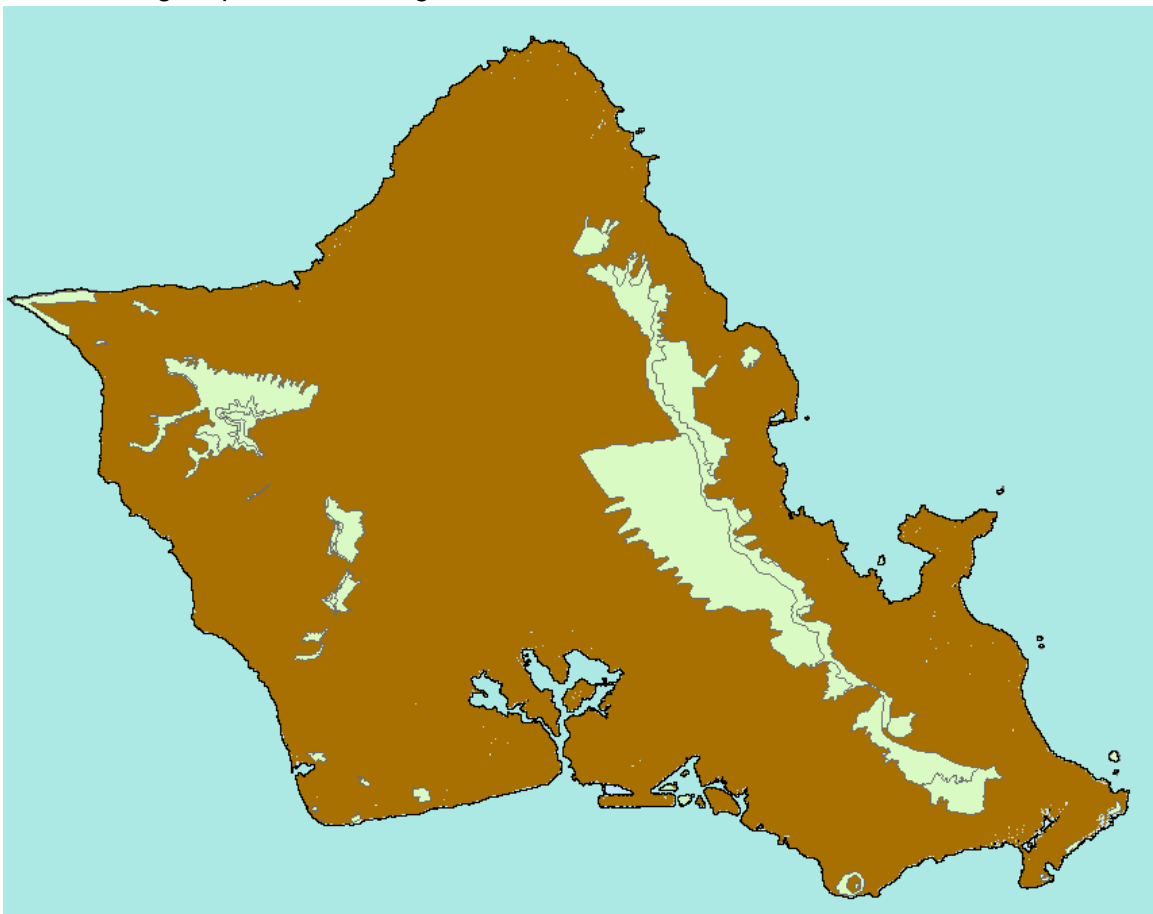


Figure 10: Critical Habitat Ecosystem Data

Map of Tsunami Effects on Community of Hawaii Kai on O'ahu Island, Hawaii

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1946 Tsunami



1952 Tsunami



1957 Tsunami

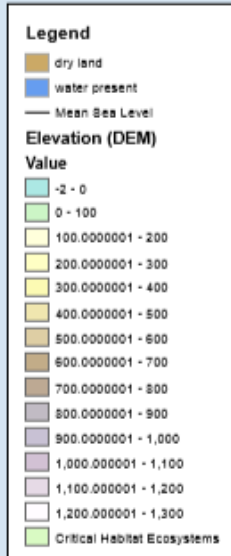


1960 Tsunami

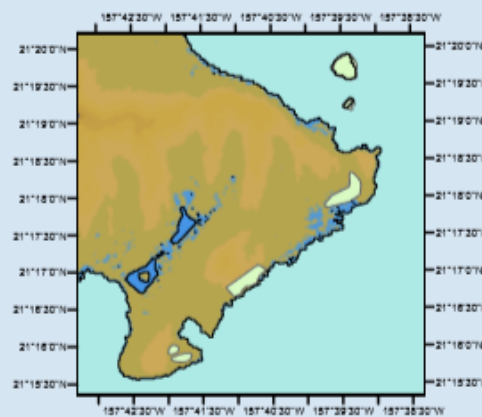


1964 Tsunami

0 500 1,000 2,000 3,000 4,000 Meters



Critical Habitat Ecosystems in 1946



Coordinate System: GCS WGS 1984
Datum: WGS 1984
Units: Degree

1 centimeter = 125,000 centimeters

Conclusions:

1946

The Tsunami originating from a magnitude 8.4 earthquake in Unimak Island, Alaska would have damaged 14 of the 62 critical environments associated with Oahu. Most of these ecosystems are located on the coast or on small islands off the coast of Oahu. Six people died due to this Tsunami whose wave heights reached 55ft, with an average of 18.5ft. Approximately 1% of the island flooded.

1952

The Tsunami originating from a magnitude 9 earthquake in Kamchatka, Russia would have affected the same number of critical ecosystems. Tsunami wave heights ranged from 1-20ft with an average of 7.6ft, and flooded 0.6% of the island. The tsunami would have affected 14 of the 62 critical ecosystem habitats.

1957

The Tsunami originating from a magnitude 8.6 earthquake in Andreanof Island, Alaska flooded 0.64% of the island. Tsunami wave heights ranged from 3-53ft, with a mean of 12.5ft. The tsunami would have affected 13 of the 62 critical ecosystem habitats.

1960

The Tsunami originating from a magnitude 9.5 earthquake in Southern Chile flooded .58% of Oahu, Hawaii. Tsunami wave heights ranged from 2-35ft, with a mean of 9.1ft. The tsunami would have affected 14 of the 62 critical habitats.

1964

The Tsunami originated in Prince William Sound, Alaska from a magnitude 9.2 earthquake. The tsunami flooded .58% of the island. Tsunami wave heights ranged from 2-16 ft, with a mean of 7.2ft. The 1964 tsunami would have affected 13 of the 62 critical habitats.