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Lidar Acquisition and Processing

LiDAR data were provided by the California Department of Water Resources (CADWR) following an information request on June 30th, 2017. The raw data is provided below with CADWR permission granted 10/19/2017.

November 10th and 11th LiDAR Acquisition: The LiDAR survey was accomplished using an Optech Orion M300 LiDAR system operating from a fixed wing aircraft (Cessna 310 Tail # N7516Q). The mission was completed over two days (November 10 and 11, 2015). A Trimble R8-3 GPS receiver was set up and operating at the Oroville Municipal Airport for the duration of the mission, recording data at 2 Hz.

The March 23rd merged LiDAR dataset provided by the California Department of Water Resources consists of the following datasets. From the metadata associated with the files and information provided by the CADWR, the main spillway damage area surveyed on February 27th and 28th.

- Towill, Inc. 2/24/2017 LiDAR (Additional metadata in file included in .zip file folder)

Oroville_Spillway_02
-24-2017_Project_Me

- CADWR 2/27/2017 Drone Point Cloud (Gated Spillway with no water)
- Towill Inc. 2/28/2017 LiDAR (Additional metadata in file included in .zip file folder)

Oroville_Spillway_02
-28-2017_Project_Me

- CADWR 3/13/2017 Drone Point Cloud (DF1223 upper spillway)
- CADWR 3/19/2017 Drone Point Cloud (DF1300 spoils near Hyatt Powerplant)
- CADWR 3/19/2017 Drone Point Cloud (DF1151 spoils on hillside near auxiliary spillway)

The surveys were conducted with horizontal control in California Coordinate System (CCS) State Plan Zone II (US Feet) and vertical control in North American Vertical Datum (NAVD) 1988 (US Feet).

The raw data is available file included in .zip file folder:

20170323_Oroville_LiDAR.TXT

20151111_Oroville_LiDAR.txt

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In this data, the first column is the easting, the second column is the northing, and the third column is vertical elevation (all in US feet). To create a difference map, a triangle irregular network (TIN) was created from each point dataset. Using nearest neighbor interpolation, a 1-meter resolution digital elevation model (DEM) was created. A difference raster dataset was created by subtracting the 2015 DEM from the 2017 DEM, and converting the result to meters. The volume change in the main spillway damage zone is the sum of each cell's volume (cell area x vertical change). All processing was completed in ArcMap 10.4 (ESRI).

Polarization Attributes

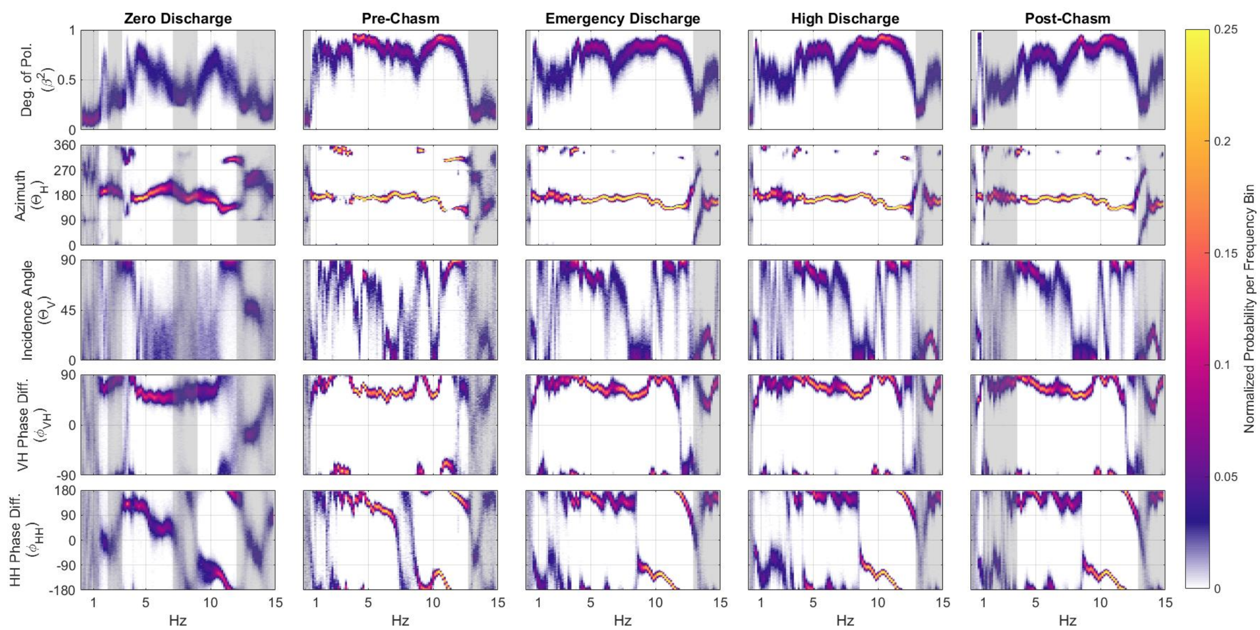

Figure S1- The four polarization attributes and degree of polarization (β^2) for the five time periods of interest. Grey shading indicates frequencies at which the polarization attributes are not interpretable ($\beta^2 < 0.5$). The Azimuth (θ_H) and vertical-horizontal phase difference (ϕ_{vh}) are shown in Figure 7 of the main text.

Scaling of Dominant Eigenvector Power and Discharge

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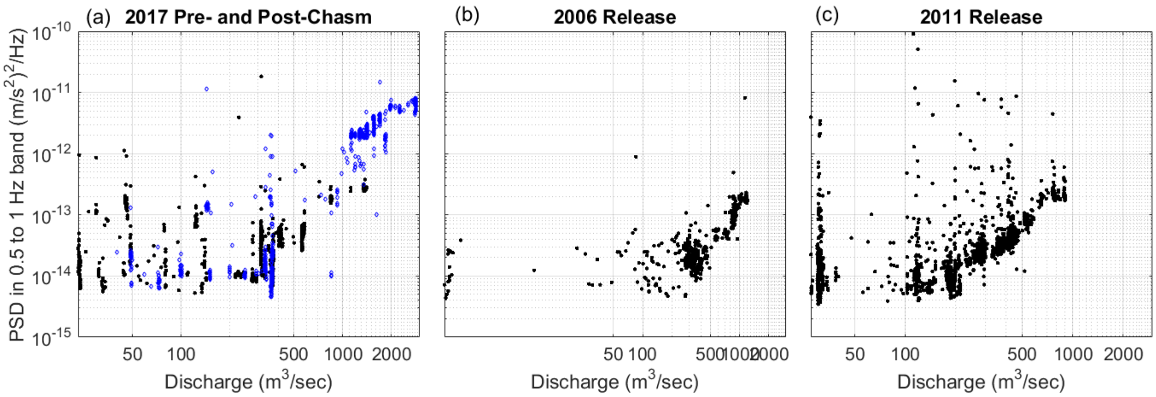

Figure S2- The hourly relationship between dominant eigenvector power and discharge has an apparent break in slope at approximately 200 cubic meters per second of discharge. We interpret this to be the threshold for which the seismometer is sensitive to flood control spillway discharge, and complete the scaling analysis in the main text only for hours with discharge greater than 200 cubic meters per second.

SPECFEM2D Simulation

Topographic model domain for the SPECFEM2D simulation was created by extracting the elevation profile along a transect extending through the BK ORV seismometer and the center of the Oroville Dam Spillway. To create the model domain, 1000 meters were added to the lowest elevation, so that the model boundary did not interfere with the topography.

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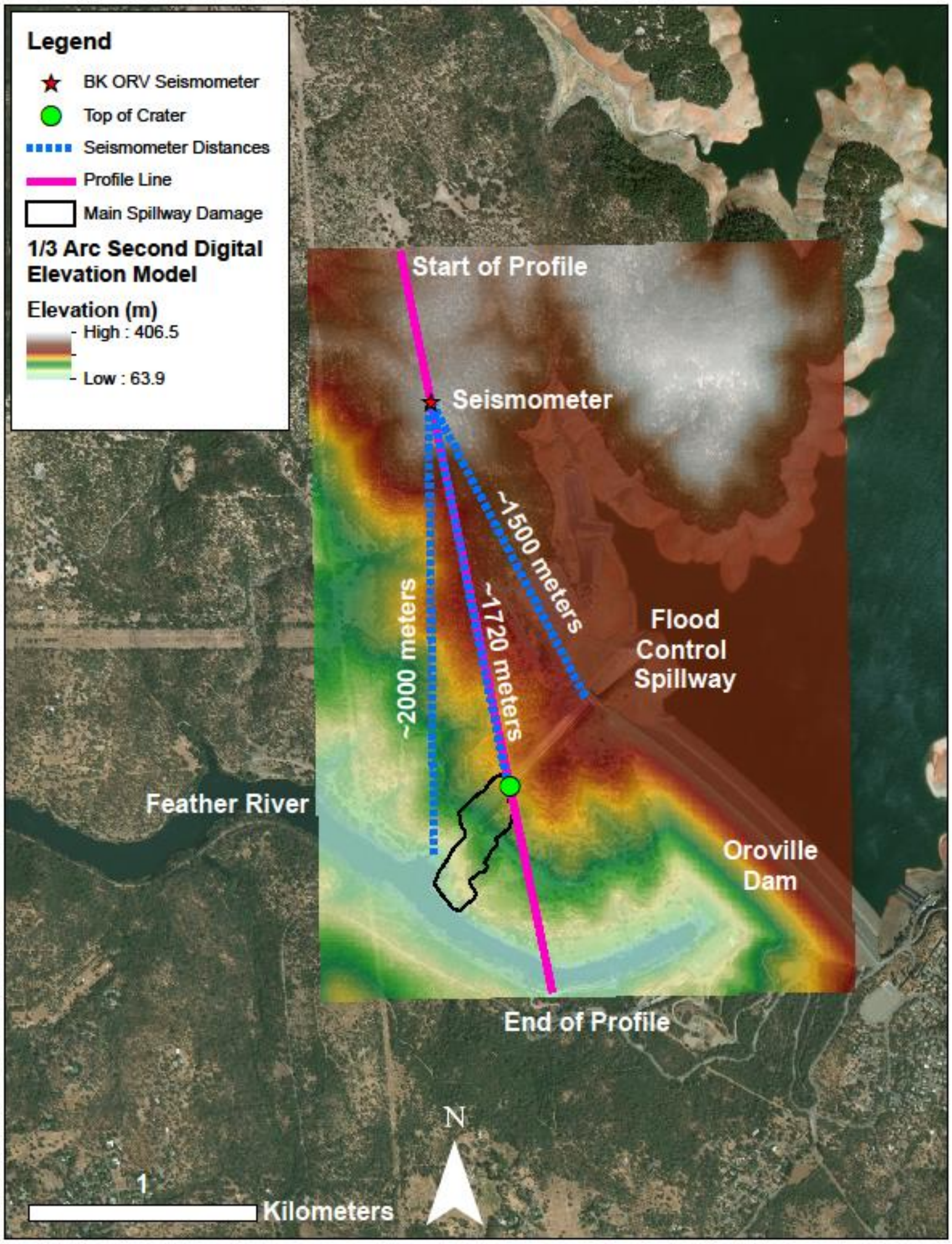

Figure S3- The hillside topography extracted for the SPECFEM2D simulation. If the entire length of the flood control spillway is considered an ambient seismic source, then the seismic waves travel a range of approximately 500 meters to the seismometer. In our simulation, we simplify this by simulating five sources spaced 100 meter apart along a profile line to the middle of the flood control spillway.

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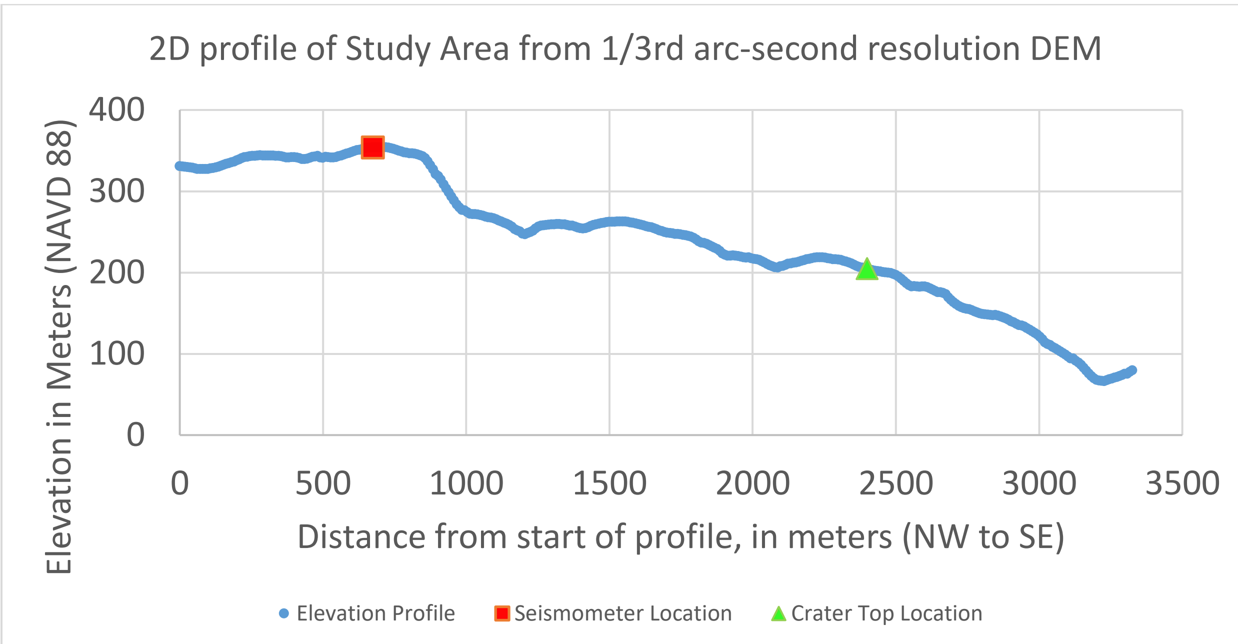

Figure S4- The elevation profile extracted for the SPECFEM2D simulation.

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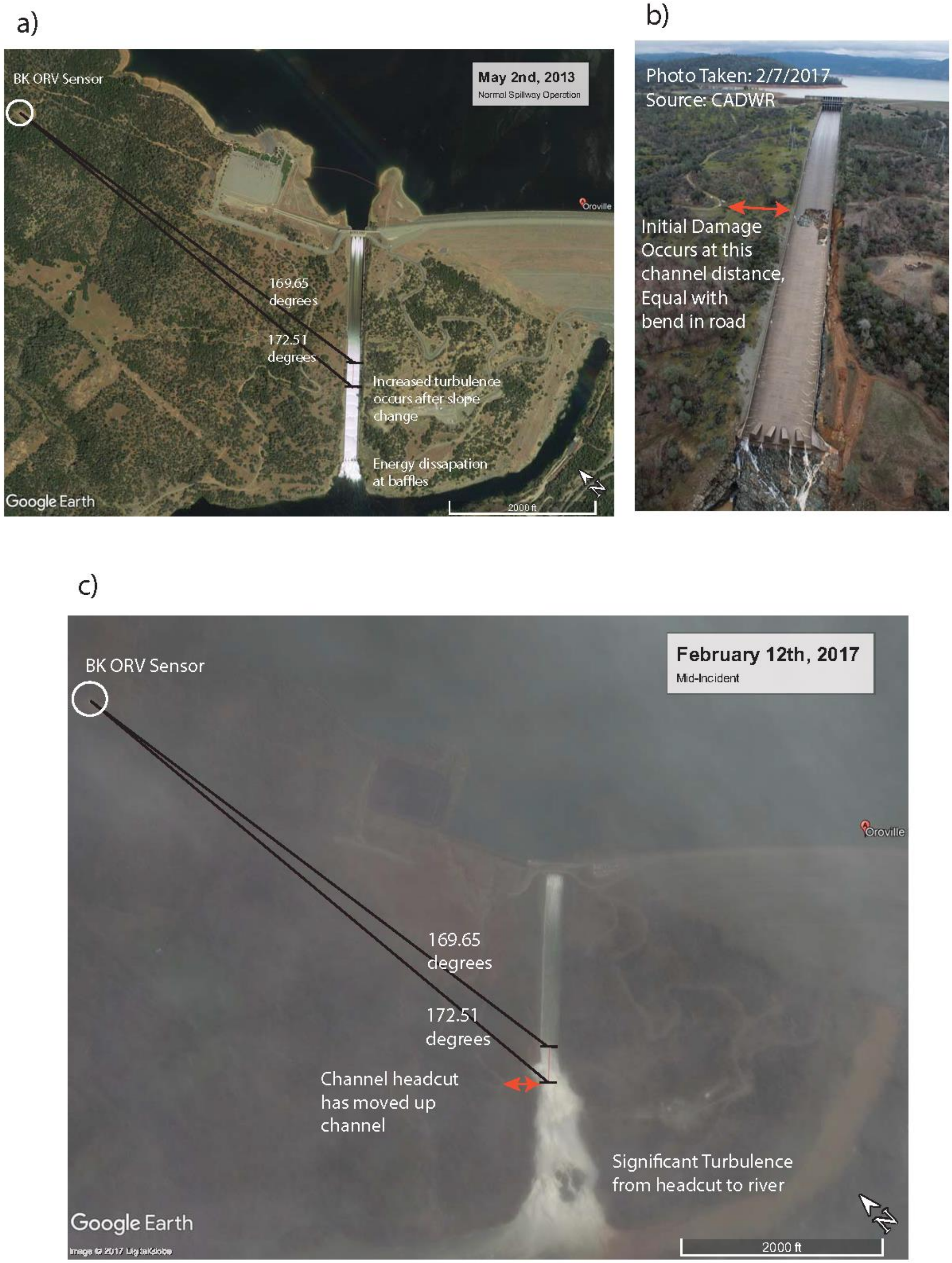

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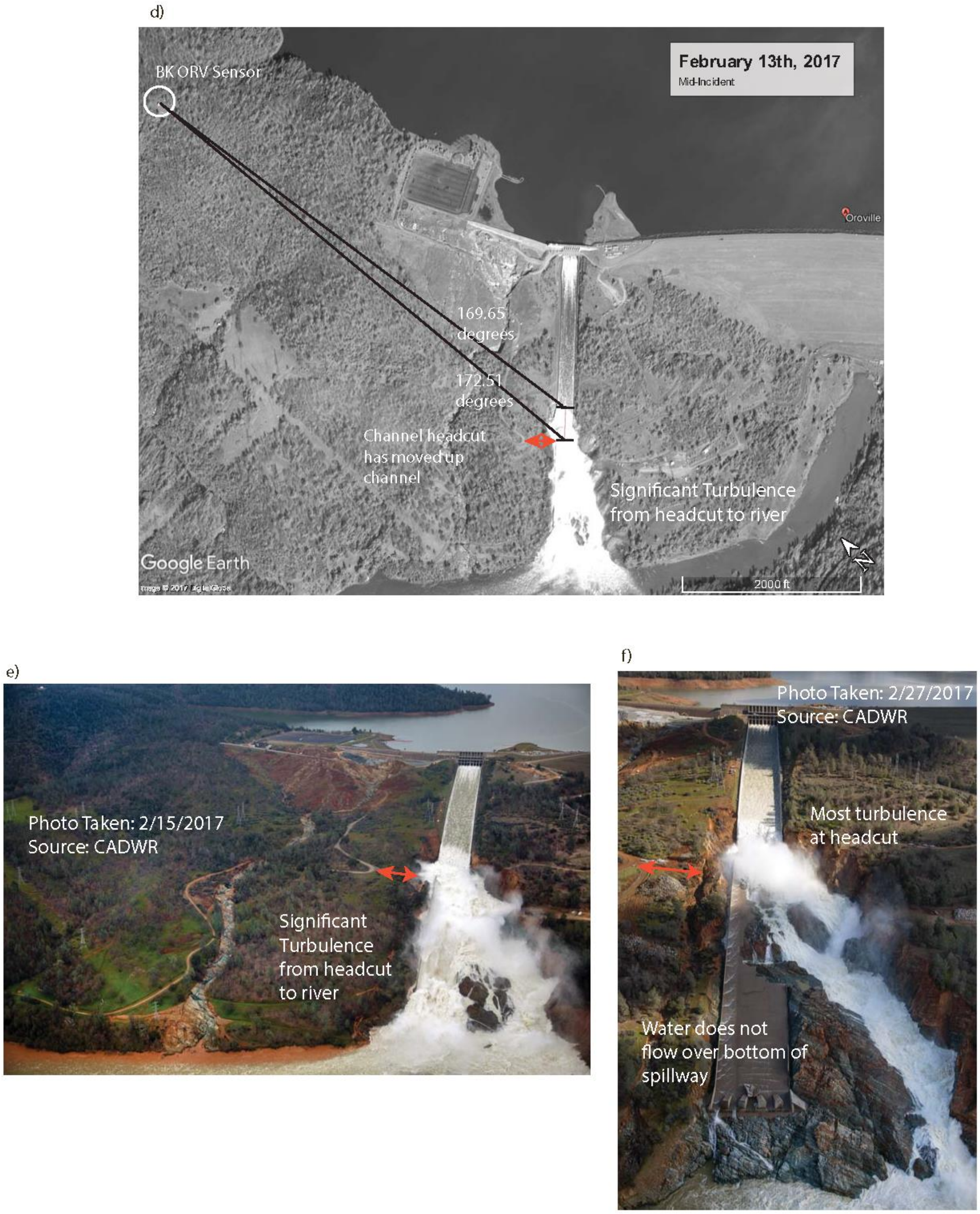

Figure S5 (a-f)- Aerial photographs collected during the time period of interest showing the evolution of the spillway erosion damage.

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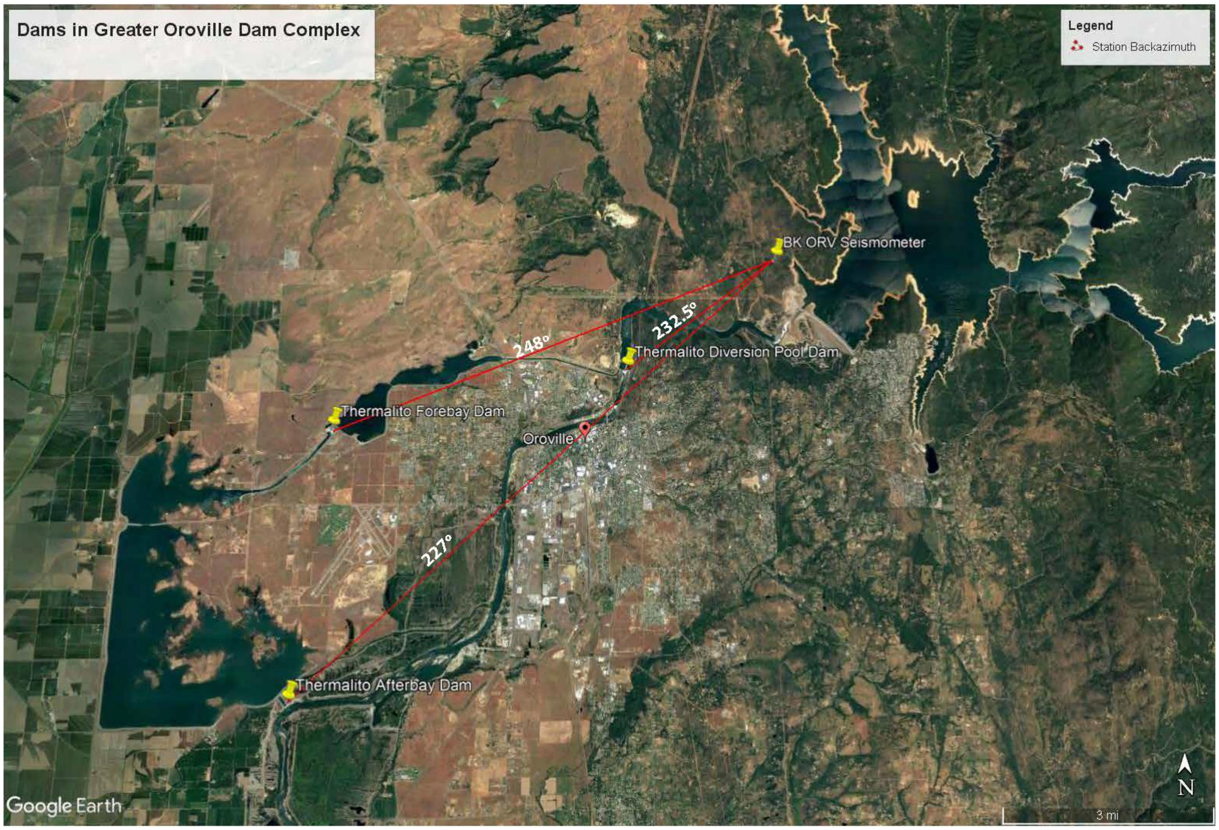

Figure S6- Three other dams- Thermalito Forebay Dam, Thermalito Diversion Pool Dam, and Thermalito Afterbay Dam- are a part of the Oroville Dam Complex and are at backazimuths of 248°, 232.5°, and 227°, respectively. The town of Oroville, California is located between station backazimuths of approximately 248° and 217°.