



DHI CASE STORY

FLOOD RISK – PROTECTING COASTAL COMMUNITIES

Using 2D modelling to improve San Francisco Bay's floodplain maps

For areas located near the coast, flooding can have a long-term impact on homes and businesses. For the counties around the San Francisco Bay, detailed information about which areas are prone to flooding is vital. Unfortunately, the available information to identify flood prone areas was non-existent or outdated. As such, the United States Federal Emergency Management Agency (FEMA) asked us to examine the flood risks for the entire Bay Area. Using MIKE 21, we developed two-dimensional (2D) regional scale coastal models of the San Francisco Bay shoreline. The data from our models provided more robust and reliable region-wide information for flood risk analysis. This enabled local governments to improve their flood management practices. It also gave the people living and working around the Bay the information they need to protect themselves better against floods.

DETERMINING SAN FRANCISCO BAY FLOOD RISKS

Located on the West Coast of the United States, the shores of the San Francisco Bay are home to more than seven million people. The scenic but low-lying bay front areas are home to the corporate headquarters of Google, Facebook, Cisco, Yahoo! and Apple. With billions of dollars of infrastructure located adjacent to the hundreds of miles of shoreline, an accurate assessment of the flood risk is vital. Extreme water levels caused by storms and other factors can have serious implications for the people and businesses that call the Bay Area home.



The Golden Gate Bridge crosses the opening of the San Francisco Bay where it meets the Pacific Ocean. ©Dale Kerper

SUMMARY

CLIENT

- U.S. Federal Emergency Management Agency (FEMA), Region IX

CHALLENGE

- Lack of knowledge about how flood risk has changed in San Francisco Bay since the last regional study performed in 1983

SOLUTION

Two dimensional (2D) modelling to examine flood risks for the entire San Francisco Bay Area

VALUE

- Increased confidence in the knowledge of flood prone areas for coastal communities around San Francisco Bay
- Ability to improve floodplain management practices for counties in the Bay Area

LOCATION / COUNTRY

San Francisco Bay, California, USA

The Bay Area has not had a comprehensive region-wide study since the early 1980s. Although innovative for its time, the previous study had several shortcomings. It relied on a limited number of tide gages that did not take measurements for a long enough period of time (with the exception of the Golden Gate Bridge tide gage). It also did not take into account the effect of waves. In addition, the study was inaccessible as the paper records had been archived.

To obtain a better idea of coastal flood hazards for the entire San Francisco Bay, FEMA asked us to perform a regional Flood Insurance Study (FIS). The FIS – a report that examines the flood risks of a specific area – is based on data collected from:

- statistical analyses of past river flow, storm tides
- consultations with potentially affected communities
- hydrographic bathymetric surveys
- floodplain topographic surveys (LiDAR for example)
- wave height measurements
- wind measurements
- hydrologic and hydraulic analyses

MODELLING THE BAY AREA

We utilised 2D modelling to improve upon the methods that were available in the previous study. Using MIKE 21, we developed a system of regional scale coastal models in order to predict the following for the entire San Francisco Bay:

- extreme tide (astronomical tide plus storm surge)
- swell entering from the Pacific Ocean
- sea waves generated from local winds in the Bay

Normally, we would apply a highly detailed study to a focused study area. This project, however, required the same level of detail for the entire 250 mile-long Bay Area shoreline. Several factors contribute to the variability and complexity of the Bay shoreline geography, including:

- orientation of the shoreline
- exposure to wind and waves (sheltering for example)
- water depths
- regional/climactic variation in wind and wave conditions (micro-climates)

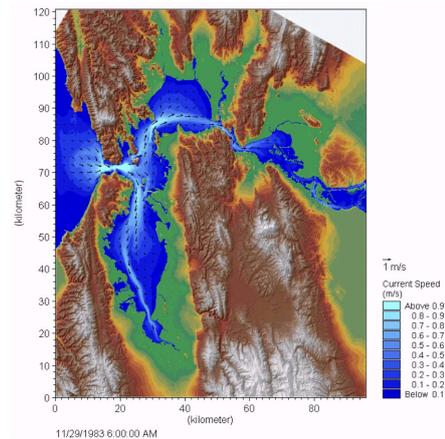
Because of these factors, it was very difficult to identify singular storm events that would apply equally across the entire Bay Area. To allow us to identify the storms in advance, we operated the models in hindcast mode to produce continuous results of water levels and waves covering:

- 31 years in the North and Central Bay
- 54 years in the South Bay

Following this, we used the regional model results to establish maximum 1% (100-year) and 0.2% (500-year) Still Water Levels (SWLs) – the maximum water level that will occur – and wave height conditions. We then utilised this information to drive local response-based models of:

- water level
- wave setup
- wave run-up
- overland waves

We calibrated and validated the models using National Oceanic and Atmospheric Administration (NOAA) tide gage measurements from around the bay, as well as various wave measurements from inside and outside the bay.



A time snapshot of the MIKE 21 regional model result, showing contours and vectors of currents for a flood tide condition during the historical storm event of 1983. © DHI

UPDATING FLOODPLAIN MAPS

The results of the regional modelling study were key components for the development of FIS floodplain maps for the entire Bay Area. FEMA and its study contractors are using the regional model results as boundary conditions for further detailed coastal hazard analysis. This will also be the basis for most future studies.

The detailed coastal hazard analysis could have far reaching implications for the businesses and people who live and work around the Bay. The results could lead to a modification in flood risk designations for coastal communities, which could in turn lead to changes in:

- flood insurance rates
- land-use planning around the Bay
- floodplain management practices

By having a clearer idea of where flooding is most likely to occur, communities surrounding San Francisco Bay can take the appropriate measures to ensure their safety.

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