DRISI
Caltrans Division of Research, Innovation and System Information

# Research Notes

Planning, Policy and Programming

JULY 2022

Project Title:
Projecting Risk of Highway Flooding Due to Sea Level Rise

Task Number: 3335

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Project is 90% complete and the final report is being prepared

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## Projecting Risk of Highway Flooding Due to Sea Level Rise

Observing water levels to calculate short-term and long-term flood risk at specific sites.

### WHAT IS THE NEED?

Inundation of low-lying coastal lands threatens the sustainability of coastal communities, infrastructure, and ecosystems. Climate change and local environmental change exert multiple influences on the probability of inundation of these lands. The interaction of storm surge, tides, river flows, atmospheric pressure, local wind/wave effects, and sea level rise represent a knowledge gap. Small-scale differences are expected in extreme water levels that are not well represented in regional models. These small-scale differences are likely to change from one potential flooding event to the next, depending on local conditions.

Highways represent critical infrastructure that are vulnerable to flooding events when adjacent to the coast. A high-profile example is Highway 37, which crosses low-lying land on the north shore of San Francisco Bay, which has flooded twice in recent years, representing a severe disruption to traffic. By focusing on what controls water level extremes in specific locations, the research team aim to provide short-term and long-term forecasts in high-risk locations.

Short-term forecasts look ahead a few days, similar to weather forecasts, which can provide improved early warning of flood events. Paired with planning tools, these projections will help guide behavior during floods and reduce the negative impact of the events as they occur. Long-term forecasts look ahead across the years and provide an assessment of increased flood risk associated with the slow rise in sea level. These projections will help guide policy and investments.

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## WHAT ARE WE DOING?

The researchers' approach is to develop forecasts based entirely on data (field observations) and without any use of models and the assumptions inherent in the models. Combining long-term tide gage and weather station data from the region with new observations at multiple sites adjacent to high-risk locations, they expect to be able to separate the effects of storm surge, tides, river flows, atmospheric pressure, local wind/wave effects, and sea level rise on observed water levels at the location of concern. For short-term forecasts, each of the drivers of these contributing factors can be forecast and thus the combined effect can be forecast a few days in advance (with given uncertainty). Also, by providing real-time data at the high-risk site, these forecasts can be continuously updated. For long-term forecasts, climate-change predictions of changes in sea level, precipitation and local wind can be combined to produce decadal predictions of changes in water level at the focal sites.

The project will focus on Novato Creek and Petaluma River where they cross Highway-37. The researchers are deploying pressure sensors at multiple sites in each channel, as well as in adjacent Bay waters. The pressure signal is corrected for changes in atmospheric pressure and water density to obtain a record of water level at each site. Deploying at several sites will allow resolution of small-scale differences and site-to-site gradients in the study area, which is necessary for separating correlated signals due to offshore surge, local wind, waves, and rain/runoff. The research team will also deploy high-frequency pressure gages to quantify waves automated cameras to track changes. These data will be combined with publicly available data on tides, winds, rain and runoff. After phase-one analyses, real-time water level recorders will be deployed.

The research analysts will test whether low-frequency signals such as sea level rise, interannual variability, and seasonal fluctuations are coherent at the scale of the San Francisco Bay and whether intermediate-frequency signals show some coherence with lags, offsets or amplifications. They will also test if high-frequency signals are well correlated with local forcing due to winds, waves and river flow. They will then construct a risk assessment tool and an operational forecast tool for projecting future water levels. If this new methodology works well, it can easily be deployed at other high-risk sites across the State – and the site-specific data will be used to improve existing model predictions.

## WHAT IS OUR GOAL?

This project will provide proof-of-concept for a new methodology based on site-specific water-level monitoring. In doing so, it will provide improved forecasts of risk associated with sea-level rise (long-term forecasts) and improved short-term operational forecasts for flooding of Highway-37 adjacent to Novato Creek and Petaluma River.

## WHAT IS THE BENEFIT?

Shoreline infrastructure such as state highways are increasingly affected by sea level rise and extreme storms. By combining multiple contributing factors related to shoreline flooding, predicted water levels can be provided that can be used directly by shoreline infrastructure managers and emergency response agencies. Present response plans depend on generalized flood prediction models. Having a more accurate site-specific assessment of risk will allow transport corridors to be made more resilient to climate change impacts including more frequent flooding and erosion of shoreline infrastructure.

## WHAT IS THE PROGRESS TO DATE?

The researchers have deployed pressure sensors at selected study sites in Novato Creek and Petaluma River and about two years of data have been collected at selected sites. The researchers have merged data from Novato Creek with data available from County of Marin, California, allowing analysis of years prior to 2020 (e.g., 2019 wet year). The research team has completed analysis of tidal fluctuations at sites in Novato Creek and Petaluma River and correlation of tidal residual signals at these sites with data on winds, river flow, atmospheric pressure, and ocean state. This analysis is the basis for model forecasts. By including data on forcing factors, like wind, rain, and river flow, the precision and confidence of high-water predictions are improved beyond that obtained with tidal predition alone.

The researchers have developed a website to display real-time observations as well as short-term forecasts of water level at field sites. And the researchers continue data collection, including field servicing and re-deployments.

The primary activities for summer of 2022 were:
1) Maintaining the field water level stations and continuing collection of water data; 2) Updating the water-level/flooding model with new data; 3) Development of short-term and long-term forecast models, with output displayed on website; and
4) Drafting a final technical report describing the methods and findings. The researchers are now working on finalizing the model and technical report.

## IMAGE

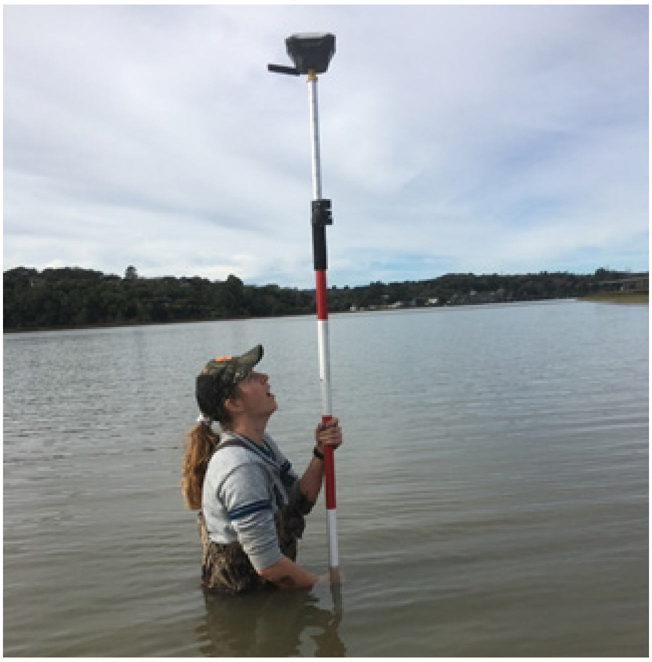

Image 1: Determining precise elevation of pressure sensors deployed.