



U.S. Department  
of Transportation  
**Federal Highway  
Administration**

FHWA Climate Resilience Pilot Program:

# California Department of Transportation District 1

The Federal Highway Administration's (FHWA)'s Climate Resilience Pilot Program seeks to assist state Departments of Transportation (DOTs), Metropolitan Planning Organizations (MPOs), and Federal Land Management Agencies (FLMAs) in enhancing resilience of transportation systems to extreme weather events and climate change. In 2013-2015, nineteen pilot teams from across the country partnered with FHWA to assess transportation vulnerability to extreme weather events and climate change and evaluate options for improving resilience. For more information about the pilot programs, visit: [http://www.fhwa.dot.gov/environment/climate\\_change/adaptation/](http://www.fhwa.dot.gov/environment/climate_change/adaptation/).

The California Department of Transportation (Caltrans) road system is important for access, particularly in northern California where impacts to highways and limited availability of alternate routes have isolated populations during past extreme weather events. Caltrans District 1, in cooperation with the Humboldt County Association of Governments, assessed criticality of assets and potential impact to screen for vulnerability. The vulnerability assessment approach drew from methodologies developed by FHWA and the Washington State DOT 2010-2011 Climate Resilience Pilot Project. The pilot team then conducted an analysis of adaptation options at prototype locations. The team gathered input from Caltrans maintenance staff, project partners, and the public throughout the project.



## Scope

The vulnerability assessment covered the entire Caltrans District 1, which consists of the counties of Del Norte, Humboldt, Mendocino, and Lake. The project inventoried and analyzed over 16,000 Caltrans assets within the study area, including storm drains, culverts, bridges, buildings, and other assets. The vulnerability assessment focused on primary climate change effects including temperature, precipitation, and sea level rise, and projected the potential impacts of secondary effects such as erosion, flooding, and landslides.

The adaptation phase of work studied resilience to the secondary climate impacts to road segments in four prototype locations.

## Objectives

- Confirm the level of asset vulnerability throughout the District.
- Develop a methodology for addressing the impacts of climate change, including short- and long-term adaptation strategies, for prototype locations.



Gully erosion at Last Chance Grade, Del Norte County. Photo credit: Caltrans D1.



Flooding impacts to road. Photo credit: Aldaron Laird.



Hathaway Creek at Highway 1, looking downstream. Photo credit: Craig Bell, via krisweb.com.

# Approach

**Establish advisory groups.** The project team formed a technical advisory group (TAG) composed of experts from local transportation planning agencies. TAG members reviewed and critiqued project progress, contributed to vulnerability and adaptation rankings, and contributed ideas and knowledge to the overall process. The team also established a stakeholder group (SG) to confer with and seek input throughout the project from other regional land managers and jurisdictions that were not necessarily transportation experts.

**Inventory assets and services.** The project team conducted an inventory of Caltrans-owned transportation assets in District 1. Much of this data was available in Geographic Information Systems (GIS) format. The project team also reached out to maintenance staff to collect data on historical maintenance events, including miles per event, cost per mile, and total cost (see Figure 1).

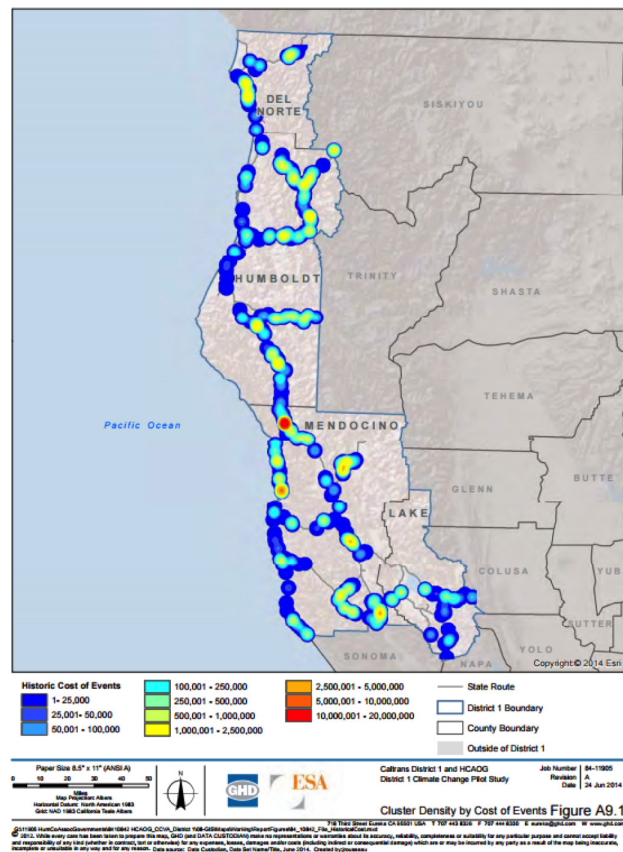


Figure 1. Cost of historical maintenance events. Red indicates relatively high cost and blue indicates relatively low cost.

The team analyzed the “services” provided by the assets (including average daily traffic, designated bus routes, designated bike routes, and other similar services) and “indicators of potential needs for services” (such as the population or number of commercially zoned parcels

within a given distance of the roadway). The team consulted TAG members to clarify and refine all the data.

**Gather climate data.** The team used existing downscaled Coupled Model Intercomparison Project Phase 3 (CMIP3) climate information from six climate models for emissions scenarios B1 and A1 for 2050 and 2100. The team also reviewed multiple sources for sea level rise estimates specific to Northern California. As recommended in California Coastal Commission’s published guidance on planning for sea level rise, the team adjusted the projections in the Humboldt Bay region to reflect tectonic conditions. The team also gathered existing information about fire risk, landslide risk, and dune and cliff erosion hazard areas.

**Score criticality and potential impact.** The study assessed the relative importance of a transportation facility as defined by local stakeholders. The team established 40 criticality factors related to socioeconomic functions, use and operational characteristics, health and safety functions, replacement costs, and degree of redundancy. The TAG and stakeholders helped rank the weighted criteria for each roadway segment on a scale of 0 to 10.

The team overlaid the climate change information for both mean and extreme conditions on the asset data in GIS. The maps and information from historical maintenance events helped the team evaluate the potential for impact, defined as the level of interruption of service of the asset. Potential impact factors were scored on a scale of 0 to 10 for each roadway segment.

**Calculate vulnerability.** The team multiplied the criticality and potential for impact scores to calculate the vulnerability of each segment for each of the two emissions scenarios and two timeframes. The team developed GIS maps for asset criticality, potential impact, and vulnerability.

**Identify adaptation options.** The team selected four prototype locations, one in each county, to test out a methodology to identify and evaluate adaptation options. The project team used their existing knowledge and information from local sources such as the Humboldt Bay Sea Level Rise Adaptation Planning Working Group to develop a preliminary list of short- and long-term measures to address climate change impacts at each location. The team then expanded this list through a literature review and consultations with stakeholders. The adaptation strategies focused on engineering-based solutions. In addition, they investigated opportunities to incorporate ecosystem-based adaptation and non-structural solutions.

**Evaluate adaptation options.** Adaptation evaluation criteria included cost, effectiveness, flexibility, benefits, and social and environmental factors. The team weighted these criteria based on input from stakeholders and public meetings to reflect local priorities and values. The team formalized the adaptation methodology into a tool to assist with the evaluation and prioritization of adaptation options. They further evaluated the highest priority option at each location in terms of potential planning and implementation costs and possible funding sources.

## Key Results & Findings

**Vulnerable assets.** Vulnerability scores throughout the district varied by geographic location (see Figure 2). Coastal segments were among the most vulnerable due to the high potential impact associated with rising sea levels and increased coastal erosion hazards. Vulnerability associated with significant historical slope instability, drainage, and erosion issues exists throughout the district. Routes with higher asset criticality such as lacking redundancy, high use, high route classification, and critical nodes were present throughout the district.

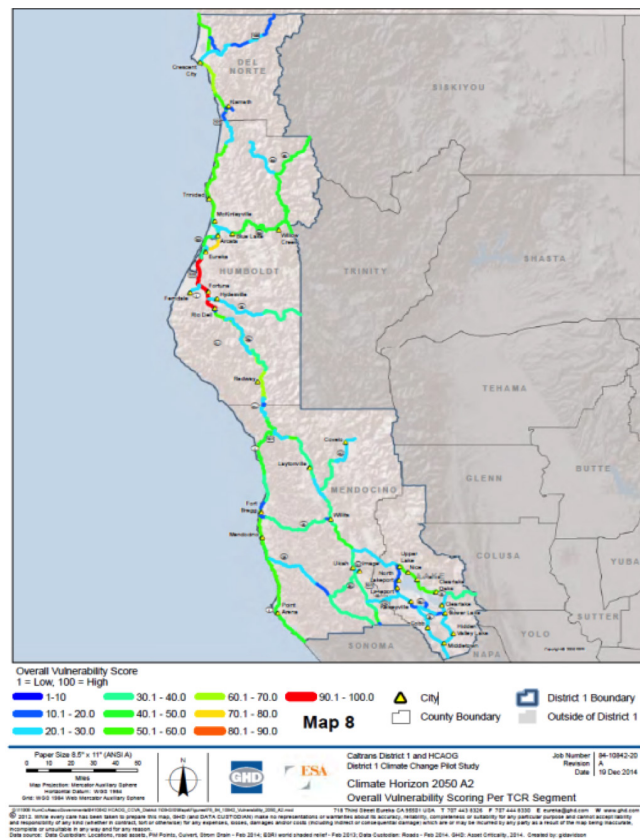


Figure 2. Vulnerability scores under the 2050 A2 scenario. Red indicates high vulnerability, shades of green indicate medium vulnerability, and shades of blue indicate low vulnerability.

“Findings from the project are informing existing projects and demonstrating opportunities to leverage resources.”

– Caltrans District 1 Pilot Team

However, the majority of the 93 segments ranked for vulnerability in the study received low vulnerability scores: 85% received a score lower than 50 out of 100, and 95% received a score lower than 60. This suggests that there are a relatively small number of assets that have both a high criticality and a high potential for impact and hence a high vulnerability.

**Adaptation options.** Proposed adaptation projects are expected to: prevent strandings and ensure a high level of service in an area in Mendocino County; maintain a lifeline to Crescent City in Del Norte County; reduce traffic diversions and disruptions of service in Humboldt Bay (see Figure 3); and minimize re-routing and delays in Lake County. Some adaptation options also present multiple benefits. For example, the adaptation options in Humboldt Bay can minimize flood risks to existing diked tidelands or help restore tidal processes and wetland habitats.

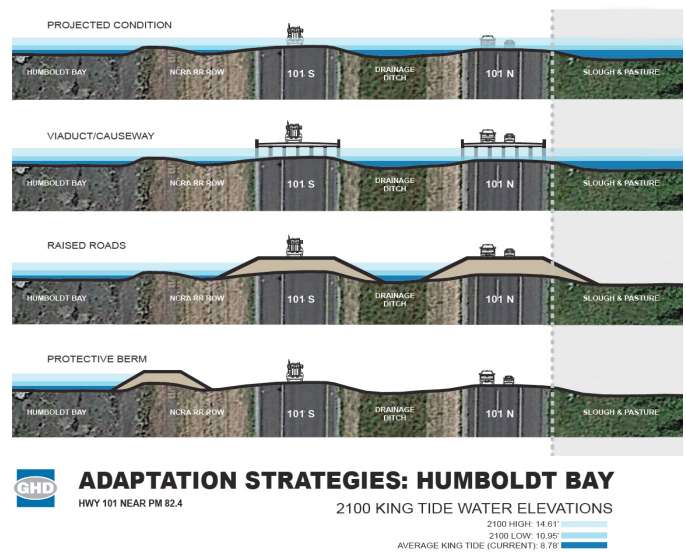


Figure 3. Adaptation options for Humboldt Bay for sea level rise projections for 2100. Options include a viaduct/causeway, raised roads, and a protective berm.

## Lessons Learned

**Leverage experts and tools to manage large volumes of data.** The data collection step resulted in large volumes of data that needed to be sorted and evaluated. The team gathered input from the technical experts such as Caltrans staff via the TAG and Stakeholder Group to help hone in on

data use and interpretation. It was also helpful to process the data in GIS models.

**Review and select climate projections best suited to analysis.** The team recognized that no one climate model was correct and that they should carefully interpret and select future climate projections for use in the analysis. There is considerable variability in precipitation projections for the region among the six climate models selected to represent California conditions. The averages of the six climate models under both emission scenarios project a decrease in total annual precipitation, but the individual model projections range from “dry” to “wet.” The team decided to use the “wet” conditions to guide assessments in order to consider the potential impacts of flooding that may result from increased heavy precipitation events. Extreme runoff projections also varied greatly across models and emission scenarios and the team used the greatest change in extreme daily runoff results from the “wet” model.

**Gather institutional knowledge from maintenance staff and stakeholders on vulnerabilities and adaptation solutions.** Maintenance staff have a good understanding of vulnerabilities from recent severe weather effects. Drawing on their knowledge can help simplify the analysis. The vulnerability screening validated existing vulnerabilities already understood by the managers of the assets. In regions where vulnerable assets are well understood, it may be more important to focus funding on site- or asset-specific assessments. The project included significant public engagement at the beginning, middle, and end of the project. In particular, identification of workable adaptation solutions requires the input from a range of stakeholders because there may be a multitude of interests affected by climate change in an area.

**Develop criteria to identify criticality and adaptation options, but recognize that assigning weights can be subjective.** The criticality assessment was challenging because it was based on a value judgment. To address this challenge, the team evaluated many criteria but found that it created a false sense of detail and overemphasized some factors. The pilot team also recognized that assigning weights and scores to the established adaptation evaluation criteria can be a highly subjective process. The team conducted technical research of the adaptation options and gathered opinions from relevant experts from the TAG, stakeholders, and public.

## Next Steps

Findings from this project are supporting local transportation planning. The assessment is informing studies on Highway 101 at Last Chance Grade in Del Norte County and informing dialogues about design on a planned interchange on Highway 101 in Humboldt Bay. The adaptation options explored in Mendocino County are providing information to assist the local transportation planning agency, Mendocino Council of Governments, in its assessment of routing options over the Garcia River. Findings for the Lake County road segment can be used by agencies working on Middle Creek/Rodman Slough restoration to inform their planning.

The study identified three prioritized actions for District 1 to build on the results of the study:

1. Coordinate with public agencies and private landowners on adaptation planning given the interdependencies between Caltrans assets and nearby public and private assets.
2. Consider updates to Caltrans planning and design policies to integrate climate, such as updating the maintenance and repair data collection and tracking systems to collect data related to extreme weather events.
3. Conduct detailed site-specific risk analyses at highly vulnerable locations.

## For More Information

**Final report available at:**

[www.fhwa.dot.gov/environment/climate/adaptation/2015pilots/](http://www.fhwa.dot.gov/environment/climate/adaptation/2015pilots/)

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