



## Animal Burrowing

### Introduction

The California Department of Water Resources' (DWR) Division of Flood Management conducted a levee evaluation program to assess the existing conditions of levees in California's Central Valley from 2008 to 2015. The Urban Levee Evaluations (ULE) Project addressed approximately 350 miles of Project<sup>1</sup> and non-Project<sup>2</sup> levees protecting populations of 10,000 people or more. Additionally, there are 1,200 miles of Project levees and 275 miles of non-Project levees protecting populations of fewer than 10,000 people.

The primary purpose of ULE/NULE is to evaluate state-federal Project levees and appurtenant non-Project levees to determine whether they meet defined geotechnical criteria and, if appropriate, identify remedial alternative(s) to meet those criteria.

### Background

Animal burrowing in levees can cause or contribute to a levee breach by amplifying one or more of the following common failure modes:

- Through-seepage
- Under-seepage
- Landside and/or Waterside Slope Instability

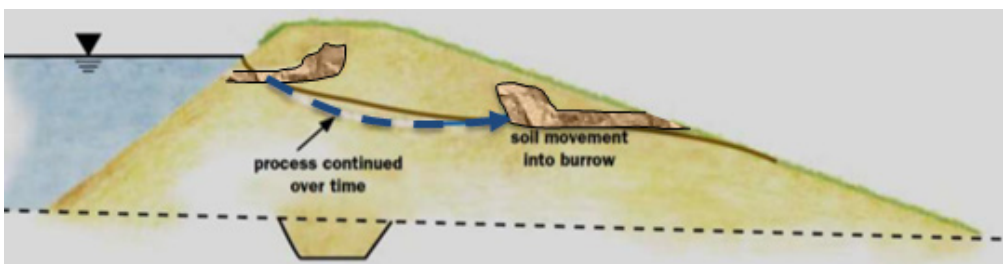
Animal burrowing activity contributes to these failure modes by creating extensive void systems which significantly reduce both seepage paths, and weaken levee embankments. These potential failure mechanisms are illustrated in Figure 1 below.



Common species of burrowing animals within the Central Valley include:

- |                               |              |
|-------------------------------|--------------|
| • California ground squirrels | • muskrats   |
| • Botta's pocket gophers      | • coyotes    |
| • California voles            | • gray foxes |
| • striped skunks              | • red foxes  |
| • beavers                     | • raccoons   |

The most commonly observed burrowing animals are gophers and squirrels in California's Central Valley (DWR, 2011).



**Figure 1. Illustration showing seepage-related failure mechanism due to burrowing animals.**

#### Footnotes:

1 Project Levee – A levee or flood wall that is a facility of the State Plan of Flood Control as defined in *Public Resources Code Section 5096.805*.

2 As defined in the *Urban Levee Design Criteria* (DWR, 2012), frequently loaded levees are defined as levees that experience a WSE of 1 foot or higher above the elevation of the landside toe at least once a day for more than 36 days per year on average. Levees not meeting the definition of frequently loaded levees are defined as intermittently loaded levees.

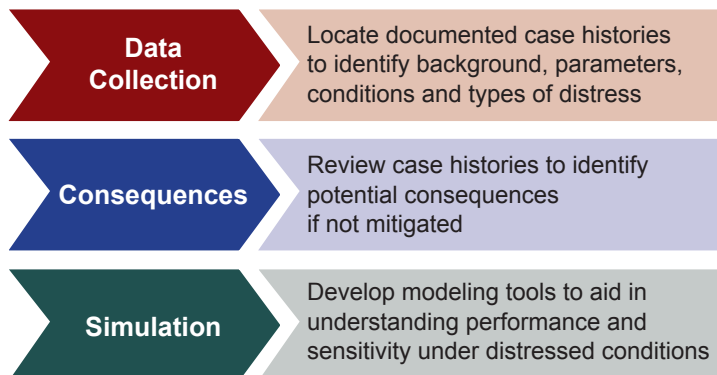
## Study Approach

The current study was performed in three phases:

Phase 1 of the study involved collection of case histories of levee distress due to burrowing animal activity. The collection process involved searching historical documents and corresponding with experts working on levee-related research projects. The case histories were divided into two groups: burrowing animal activity that resulted in a significant breach or failure and burrowing animal activity that affected levee performance but did not result in a breach or failure. In addition to the selected ten case histories, numerous performance records related to animal burrowing activity were identified during the review of historical documents.

During Phase 2 of the study, each case history was reviewed and a summary developed of potential consequences due to burrowing animal activity on the levees. Parameters such as levee geometry, embankment and foundation material, land use on the landside and waterside, type of distress observed, prior animal activity, types and geometry of burrows were identified from each case history and tabulated.

During Phase 3 of the study a conceptual mathematical model of the levee was developed to analyze for seepage and stability failure modes with and without animal burrows in the levee. Analysis results with and without animal burrowing activity were compared to understand the impact of animal burrowing on levee performance. A sensitivity analysis was performed by varying the location of animal burrows on both sides of the embankment at different water surface elevations (WSEs) to understand the performance of the levee.



The following conclusions were made based on review of the data collection and analysis results:

## CONCLUSIONS

- Solid physical evidence is available to indicate that animal burrowing has had a contributory role in the examined levee breach case histories.
- Mathematically modeling the effects of animal burrowing demonstrates a significant increase in the likelihood distress of levee embankment (increased exit gradients and lowered factors of safety for landside stability).
- Continued observation and maintenance in areas with identified animal burrow activities as well as backfilling and sealing of burrows in the levee embankments is recommended to minimize the risk of sudden levee failures.

### References:

*Technical Manual for Dam Owners, Impacts of Animals on Earthen Dams, FEMA 473.* Federal Emergency Management Agency (FEMA), September 2005.

*California Levee Vegetation Research Program: Habitat Associations of Burrowing Mammals along Levees in the Sacramento Valley, California.* DWR, September 2011.

*Risk Analyses of Burrowing Mammal Activities in State Plan of Flood Control Systems, Technical Memorandum submitted to California Department of Water Resources, Division of Flood Management.* URS, June 2014.

*Guidance Document for Geotechnical Analyses.* URS, April 2015.

Reference sources for this document are available at <http://www.dwr-lep.com/auth>  
For further general DWR information or to obtain copies of DWR publications,  
please contact DWR Public Affairs (916) 651-7512 or <http://www.water.ca.gov/publicaffairs.cfm/>

