Anticipating Environmental and Environmental-Health Implications of Extreme Storms: ARkStorm Scenario

Geoffrey S. Plumlee, Ph.D.[1]; Charles N. Alpers, Ph.D.[2]; Suzette A. Morman[3]; and Carma San Juan[4]

Abstract: The ARkStorm Scenario predicts that a prolonged winter storm event across California would cause extreme precipitation, flooding, winds, physical damages, and economic impacts. This study uses a literature review and geographic information system-based analysis of national and state databases to infer how and where ARkStorm could cause environmental damages, release contamination from diverse natural and anthropogenic sources, affect ecosystem and human health, and cause economic impacts from environmental-remediation, liability, and health-care costs. Examples of plausible ARkStorm environmental and health concerns include complex mixtures of contaminants such as petroleum, mercury, asbestos, persistent organic pollutants, molds, and pathogens; adverse physical and contamination impacts on riverine and coastal marine ecosystems; and increased incidences of mold-related health concerns, some vector-borne diseases, and valley fever. Coastal cities, the San Francisco Bay area, the Sacramento-San Joaquin River Delta, parts of the Central Valley, and some mountainous areas would likely be most affected. This type of screening analysis, coupled with follow-up local assessments, can help stakeholders in California and disaster-prone areas elsewhere better plan for, mitigate, and respond to future environmental disasters. **DOI: 10.1061/(ASCE) NH.1527-6996.0000188.**

Introduction

In the winter of 1861–1862, a series of extreme winter storms pummeled California for 45 days, causing severe flooding and damages (Dettinger et al. 2012). The ARkStorm Scenario was developed by the U.S. Geological Survey (USGS) Multi-Hazards Demonstration Project (MHDP) to model the physical and economic impacts that such a series of storms would have on modern-day California (Porter et al. 2011). The MHDP and its successor, the Scientific Applications for Risk Reduction (SAFRR) Project, use disaster scenarios such as ARkStorm to engage emergency planners, businesses, universities, government agencies, and the public in preparing for major natural disasters.

The meteorological model developed for the ARkStorm Scenario (Dettinger et al. 2012) indicated that the series of storms would produce extreme precipitation across mountainous parts of California and high winds on the lee sides of mountain ranges (Fig. 1). Except over the highest elevations, most of this precipitation would be rainfall. Hydrologists concluded that the resulting runoff would likely overwhelm the state's flood-protection system, cause levee failures, and flood much of the Central Valley and portions of Orange County, Los Angeles County, San Diego, the San Francisco Bay area, and other coastal communities (Fig. 1). Storm-related flooding, coastal storm surges, high winds, runoff, erosion, and tens of thousands of landslides and debris flows triggered by the storms (Fig. 1) would cause extensive damage to homes, buildings, highways, and other infrastructure (Wills et al. 2014; Porter et al. 2011). Repairs to water, power, sewer, and road lifelines would likely take months. There could also be storm-caused fires ignited by wind-downed power lines or ignition of petroleum products released into floodwaters. The economic costs of the storm are estimated to include $350 billion in physical damages and $58–$290 billion in business interruption losses (Wing et al. 2015).

A review of the scientific literature and news media reports (e.g., Cozzani et al. 2010; Young et al. 2004; Gautam and van der Hoek 2003) provides significant insights into the types of environmental contamination that have resulted from past flood events and other disasters—results of this review are summarized in Table 1 and the Supplemental Data. There are also excellent summaries about the impacts of disasters on human health (e.g., Cook et al. 2008). However, there has not been a systematic assessment of the potential environmental damages, environmental contamination, and environmental-health threats to humans and ecosystems that could be caused by a geographically complex combination of extreme rainfall, flooding, landslides, winds, storm surges, and storm-caused fires.

The state of California and many of its counties and cities have developed hazard mitigation plans (Cal OES 2013b; URS Corp. 2005), emergency plans to help prepare for future disasters (Cal OES 2013a), and databases cataloging locations of environmentally significant facilities (e.g., Cal EPA CERS 2013). However, these efforts have not included a systematic assessment of potential environmental and environmental-health impacts of future extreme statewide disasters.

The ARkStorm Scenario thus provides a unique opportunity to assess for the first time the plausible environmental and environmental-health implications of a prolonged, catastrophic winter storm event across a large, geographically complex region such as California. This study uses knowledge gleaned from the literature review of disaster-related environmental contamination (Table 1) and a geographic information systems (GIS) analysis to

[1]Research Geochemist, U.S. Geological Survey, Denver, CO 80225 (corresponding author). E-mail: gplumlee@usgs.gov

[2]Research Chemist, U.S. Geological Survey, Sacramento, CA 95819. E-mail: cnalpers@usgs.gov

[3]Research Physical Scientist, U.S. Geological Survey, Denver, CO 80225. E-mail: smorman@usgs.gov

[4]Physical Scientist, U.S. Geological Survey, Denver, CO 80225. E-mail: csanjuan@usgs.gov

Note. This manuscript was submitted on May 4, 2013; approved on April 10, 2015; published online on July 22, 2015. Discussion period open until December 22, 2015; separate discussions must be submitted for individual papers. This paper is part of the ***Natural Hazards Review***, © ASCE, ISSN 1527-6988/04015015(11)/$25.00.