STATE OF CALIFORNIA
HAZARD MITIGATION PLAN

SEPTEMBER 2018
2018 State of California Hazard Mitigation Plan

Prepared by:
California Governor’s Office of Emergency Services
3650 Schriever Avenue
Mather, CA 95655
www.caloes.ca.gov

With Valuable Input From:
California State Hazard Mitigation Team Members

And with Support From:
California Polytechnic State University
City and Regional Planning Department
Faculty Advisors and Consultants
San Luis Obispo, CA 93407

September 2018
TEAM ACKNOWLEDGMENTS

CALIFORNIA STATE HAZARD MITIGATION TEAM

The Director of the California Governor’s Office of Emergency Services (Cal OES) wishes to thank the members of the State Hazard Mitigation Team (SHMT) for their guidance and support in the development of the 2018 State Hazard Mitigation Plan. Additionally, the contributions of representatives of federal, state, tribal, and local governments, non-governmental and community-based organizations, and the public and private sectors were invaluable. A list of all agency or organization SHMT members is included in Appendix A.

CAL OES EXECUTIVE STAFF

Mark Ghilarducci  Director
Grace Koch  Chief Deputy Director
Christina Curry  Deputy Director

CAL OES HAZARD MITIGATION MANAGEMENT

Julie Norris  Chief, Mitigation and Dam Safety Branch
Jennifer Hogan  State Hazard Mitigation Officer
  Chief, Hazard Mitigation Grants Division

CAL OES MITIGATION PLANNING DIVISION

Adam Sutkus  Chief, Mitigation Planning Division
Ken Worman  Program Manager II
Megan Walton  SHMP Lead Coordinator/
  Senior Emergency Services Coordinator
Victoria LaMar-Haas  LHMP Program Lead/
  Senior Emergency Services Coordinator
Drew Hammond  Emergency Services Coordinator
Carly Landry  Emergency Services Coordinator
Karen McCready-Hoover  Emergency Services Coordinator

CAL OES HAZARD MITIGATION ASSISTANCE BRANCH

Steven Larson  Program Manager I
Ron Miller  Staff Services Manager I
Jason Williams  Staff Services Manager I
Emily Winchell  Staff Services Manager I
CAL OES DAM SAFETY PLANNING DIVISION

Jose Lara

Program Manager I

A SPECIAL THANK YOU GOES TO ALL ADDITIONAL HAZARD MITIGATION STAFF, CAL OES DIRECTORIES, AND OTHER STAKEHOLDERS WHO CONTRIBUTED TO THE 2018 SHMP!

2018 SHMP CAL POLY STATE UNIVERSITY SUPPORT TEAM

PROJECT MANAGEMENT

Michael R. Boswell, Ph.D., AICP

Project Director
(March 2017-September 2018),
Project Advisor
(September 2016-March 2017),
CRP Department Chair
City and Regional Planning Department

W. David Conn, D.Phil

Project Director
(September 2016-March 2017), Professor
City and Regional Planning Department

Meg Henry

Project Manager
City and Regional Planning Department

FACULTY SUPPORT ADVISORS

William J. Siembieda, Ph.D., AICP

Project Advisor, Professor
City and Regional Planning Department

Adrienne I. Greve, Ph.D.

Project Advisor, Professor
City and Regional Planning Department

Kenneth C. Topping, FAICP

Senior Advisor
City and Regional Planning Department

Chris Dicus

Project Advisor, Professor
Natural Resources Management & Environmental Sciences Department

Robb Moss Ph.D., P.E.

Project Advisor, Professor
Civil and Environmental Engineering Department

CONSULTANTS

Paula Schulz

State Liaison Consultant
Natural Hazards Mitigation

Carol Schuldt

GIS Consultant
City and Regional Planning Department

Natalie Macris

Plan Editor
Urban & Environmental Planning

GRADUATE STUDENTS/RESEARCH ASSISTANTS

Soroush Aboutalebi

Jesse Carpenter
Kylie Hensley

John Holder
Caitlin Miller
Kaitlyn Marines

Yliana Ortega
Natalia Robles
Carol Ziesenhenne
## TABLE OF CONTENTS

### Chapter 1 – Introduction

1.1 *Purpose of the Plan* ................................................................................................................. 1
  1.1.1 Vision and Mission .............................................................................................................. 2
  1.1.2 California – What’s at Stake? ............................................................................................ 2
  1.1.3 What is Hazard Mitigation? ............................................................................................... 5
  1.1.4 FEMA Review Responsibilities ......................................................................................... 5
1.2 *Plan Overview: How to Use the 2018 SHMP* ........................................................................ 6
  1.2.1 Quick Access to the SHMP by Topic Grouping ............................................................... 6
  1.2.2 2018 SHMP Chapters .................................................................................................... 7
  1.2.3 Approach for Hazards Identification and Risk Assessment .......................................... 8
  1.2.4 What’s New in the 2018 SHMP? .................................................................................... 10
1.3 *Essential Terminology* ........................................................................................................... 14
  1.3.1 Hazard, Risk, Vulnerability, and Disaster ........................................................................ 14
  1.3.2 Hazard Mitigation, Preparedness, Response, and Recovery ........................................... 16
  1.3.3 Sustainability and Resilience ........................................................................................... 17
  1.3.4 Climate Change Mitigation and Climate Change Adaptation ........................................ 18
1.4 *Institutional and Legal Context* ............................................................................................. 19
  1.4.1 Federal Laws, Institutions, and Policies .......................................................................... 19
  1.4.2 California Laws, Institutions, and Policies ....................................................................... 20
  1.4.3 Local Government Laws, Institutions, and Policies ....................................................... 23
  1.4.4 Private Sector Emergency Management and Hazard Mitigation ................................. 23
1.5 *SHMP Adoption by the State* .............................................................................................. 27
1.6 *2018 SHMP Assurances* ........................................................................................................ 29

### Chapter 2 – The Planning Process

2.1 *Cal OES SHMP Coordination Role* ....................................................................................... 31
2.2 *Preparing the 2018 SHMP Update* ....................................................................................... 34
  2.2.1 2018 Plan Update Process .............................................................................................. 34
  2.2.2 Coordination Among Agencies and Departments ............................................................ 39
  2.2.3 Outreach to Stakeholders ............................................................................................... 46
2.3 *Integration and Coordination with Other Planning Efforts* .................................................... 51
  2.3.1 Hazard-Specific Mitigation Plans – Primary Hazards ...................................................... 51
  2.3.2 Related Mitigation Planning Efforts ............................................................................... 51
  2.3.3 General Plan Guidelines ................................................................................................. 52
  2.3.4 Local Hazard Mitigation Planning .................................................................................. 53
  2.3.5 SHMP Integration with Emergency Management .......................................................... 53
Chapter 3 – California’s Mitigation Framework: Goals, Objectives, Strategies, and Priorities

3.1 Creating a Strategic Framework for Mitigation

3.2 Vision and Mission

3.3 2018 SHMP Goals and Objectives

3.3.1 Reducing Life Loss and Injuries

3.3.2 Minimizing Physical Damage and Service Interruptions

3.3.3 Protecting the Environment

3.3.4 Promoting Integrated Mitigation Policy

3.4 Types of State Mitigation Strategies

3.4.1 Direct vs. Indirect Strategies

3.4.2 Mandatory vs. Voluntary Strategies

3.5 Overview of Strategies for Implementing State-Local Mitigation Capabilities

3.6 California State Strategy 1: Support Legislative Efforts that Formalize California’s Comprehensive Mitigation Program

3.7 California State Strategy 2: Strengthen Inter-Agency Coordination Actions, Including State, Regional, Tribal, and Local Linkages

3.8 California State Strategy 3: Broaden Public and Private Sector Mitigation Linkages

3.9 California State Strategy 4: Assist Local and Tribal Governments in Implementing Land Use Guidance and Best Practices for Reducing Vulnerability within High Hazard Zones

3.10 California State Strategy 5: Incorporate Climate Change into Local, Tribal, Regional, and Statewide Hazards Profiles, Risk Assessments, and Mitigation Plans

Chapter 4 – Profiling California’s Setting .............................................. 103

4.1 State Assets at Risk ........................................................................... 103
4.1.1 Population, Economy, and Infrastructure ......................................... 105
4.1.2 Growth Patterns and Trends ......................................................... 110
4.1.3 Natural Environment ..................................................................... 117

4.2 California’s Disaster History ............................................................ 122
4.2.1 Statewide Disaster Loss Findings .................................................. 122
4.2.2 Primary Sources of Disaster Losses .............................................. 125
4.2.3 Catastrophic Vulnerabilities .......................................................... 125

4.3 Risk Factor: Climate Change ................................................................ 128
4.3.1 What is Climate Change? ................................................................. 128
4.3.2 Projected Impacts ............................................................................ 129
4.3.3 California’s Climate Change Assessment Program ............................ 130
4.3.4 Climate Change and the 2018 SHMP ............................................. 133
4.3.5 Climate Change Mitigation Efforts .................................................. 133
4.3.6 Climate Change Adaptation Initiatives .......................................... 137

4.4 Environmental Justice, Equity, and Hazard Mitigation in California .... 158
4.4.1 Social Vulnerability ........................................................................ 158
4.4.2 Health Equity .................................................................................. 160
4.4.3 Hazard Events and Disproportionate Impacts on Environmental Justice Communities and Socially Vulnerable Populations ................................. 160
4.4.4 Statewide GIS Analysis of Vulnerability to Hazards ....................... 164
4.4.5 Planning, Policy, and Action Implications ...................................... 173
4.4.6 California’s Actions to Address Social Vulnerability and Equity Needs ........................................... 173
Chapter 5 – California Local Hazard Mitigation Planning ...................... 181

5.1 California’s Role in Implementing FEMA’s LHMP Program .......................................................... 181
5.1.1 Cal OES LHMP Technical Assistance and Training Program .................................................. 182
5.1.2 The LHMP Submittal and Review Process .............................................................................. 185
5.1.3 LHMP Maintenance: Implementation and Evaluation ............................................................. 187
5.1.4 Way Forward for the Cal OES LHMP Program ....................................................................... 189

5.2 Analysis of California LHMPs ...................................................................................................... 191
5.2.1 LHMP Preparation Trends .................................................................................................... 191
5.2.2 LHMP Identified Hazards and Risks ...................................................................................... 194
5.2.3 LHMP Planning and Mitigation Trends and Effectiveness ..................................................... 199

5.3 Hazard Mitigation Planning Resource Guide for Local Jurisdictions ........................................... 204
5.3.1 Integration of Local and State Mitigation Efforts ................................................................ 204
5.3.2 Local Mitigation Planning Resources ................................................................................... 205
5.3.3 Local Coordination and Mitigation Capabilities .................................................................... 218
5.3.4 Guide to Community Planning and Hazard Mitigation .......................................................... 232

Chapter 6 – Earthquakes and Geologic Hazards: Risks and Mitigation .......... 243

6.1 Earthquake Hazards, Vulnerability, and Risk Assessment ......................................................... 243
6.1.1 Identifying Earthquake Hazards ............................................................................................. 243
6.1.2 Profiling Earthquake Hazards ................................................................................................ 248
6.1.3 Assessment of State Earthquake Vulnerability and Potential Losses ................................ 253
6.1.4 Assessment of Local Earthquake Vulnerability and Potential Losses ................................. 274
6.1.5 Current Earthquake Hazard Mitigation Efforts ...................................................................... 296
6.1.6 Additional Earthquake Hazard Mitigation Opportunities ..................................................... 338

6.2 Landslide and Other Earth Movement Hazards, Vulnerability, and Risk Assessment ............ 341
6.2.1 Identifying Landslide Hazards ................................................................................................ 341
6.2.2 Profiling Landslide Hazards .................................................................................................. 342
6.2.3 Assessment of Landslide Vulnerability and Potential Losses ............................................... 350
6.2.4 Current Landslide Hazard Mitigation Efforts ......................................................................... 355

6.3 Volcano Hazards, Vulnerability, and Risk Assessment ............................................................... 362
6.3.1 Identifying and Profiling Volcano Hazards ............................................................................. 362
6.3.2 Assessment of Volcano Vulnerability and Potential Losses ................................................. 368
6.3.3 Current Volcano Hazard Mitigation Efforts ........................................................................... 372
6.3.4 Additional Volcano Hazard Mitigation Opportunities ............................................................ 374

Chapter 7 – Flood Hazards: Risks and Mitigation ............................................. 375

7.1 Riverine, Stream, and Alluvial Flood Hazards, Vulnerability and Risk Assessment ................ 376
7.1.1 Identifying Riverine, Stream, and Alluvial Flood Hazards ..................................................... 376
7.1.2 Profiling Riverine, Stream, and Alluvial Flood Hazards ........................................................ 377
Chapter 8 – Fire Hazards: Risks and Mitigation

8.1 Wildfire Hazards, Vulnerability, and Risk Assessment

8.1.1 Identifying Wildfire Hazards

8.1.2 Profiling Wildfire Hazards

8.1.3 Assessment of State Wildfire Vulnerability and Potential Losses

8.1.4 Assessment of Local Wildfire Vulnerability and Potential Losses

8.1.5 Current Wildfire Hazard Mitigation Efforts

8.1.6 Additional Wildfire Hazard Mitigation Opportunities

8.2 Urban Structural Fire Hazards, Vulnerability, and Risk Assessment
Chapter 9 – Other Hazards: Risks and Mitigation ........................................573

9.1 Other Climate and Weather-Influenced Hazards ........................................573
  9.1.1 Agricultural and Silvicultural Pests and Diseases .....................................575
  9.1.2 Air Pollution ..........................................................................................581
  9.1.3 Aquatic Invasive Species .......................................................................592
  9.1.4 Avalanches .............................................................................................595
  9.1.5 Droughts and Water Shortages .................................................................596
  9.1.6 Energy Shortage and Energy Resiliency ..................................................621
  9.1.7 Epidemic/Pandemic/Vector Borne Disease .............................................633
  9.1.8 Extreme Heat .........................................................................................643
  9.1.9 Freeze .....................................................................................................656
  9.1.10 Severe Weather and Storms .................................................................660
  9.1.11 Tree Mortality .......................................................................................665

9.2 Sociotechnical/Technological Hazards .........................................................676
  9.2.1 Hazardous Materials Release .................................................................676
  9.2.2 Oil Spills ................................................................................................686
  9.2.3 Natural Gas Pipeline Hazards .................................................................696
  9.2.4 Radiological Accidents ..........................................................................705
  9.2.5 Train Accidents Resulting in Explosions and/or Toxic Releases ............712
  9.2.6 Well Stimulation and Hydraulic Fracturing Hazards ............................723

9.3 Threat and Disturbance Hazards ................................................................726
  9.3.1 Terrorism ...............................................................................................726
  9.3.2 Cyber Threats .........................................................................................734
  9.3.3 Civil Disorder In California ....................................................................742

Chapter 10 – Grants Management Capabilities and Enhanced Planning Efforts .............................................743

10.1 Integration with Other Planning Initiatives ..............................................744
  10.1.1 Legislative and Policy Integration ............................................................744
  10.1.2 State Agency Integration .......................................................................745
  10.1.3 SHMP Integration with State and Regional Planning Initiatives ...........746
  10.1.4 Financial Integration .............................................................................749
  10.1.5 Integration with FEMA Programs .........................................................750

10.2 Commitment to a Comprehensive Mitigation Program ............................755

10.3 Effective Use of Available Mitigation Funding .........................................759

10.4 Overview of FEMA Hazard Mitigation Assistance Programs Administered By Cal OES ........................................763
  10.4.1 Hazard Mitigation Grant Program (HMGP) Overview ..........................765
  10.4.2 Pre-Disaster Mitigation (PDM) Grant Program Overview .....................766
  10.4.3 Flood Mitigation Assistance (FMA) Grant Program Overview ..............766
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.4.4 Cal OES HMA Program Priorities for HMA Grant Funding</td>
<td>766</td>
</tr>
<tr>
<td>10.5 Cal OES Hazard Mitigation Assistance Grant Programs: Project Implementation Capability</td>
<td>769</td>
</tr>
<tr>
<td>10.5.1 Cal OES Grant Proposal Process</td>
<td>771</td>
</tr>
<tr>
<td>10.5.2 Cal OES Grant Administration</td>
<td>782</td>
</tr>
<tr>
<td>10.5.3 Programmatic and Financial Monitoring</td>
<td>788</td>
</tr>
<tr>
<td>10.5.4 Way Forward for Cal OES Hazard Mitigation Assistance Grant Program</td>
<td>789</td>
</tr>
<tr>
<td>10.6 Assessment of Mitigation Actions</td>
<td>790</td>
</tr>
<tr>
<td>10.6.1 State Mitigation Assessment Review Team (SMART) System</td>
<td>790</td>
</tr>
<tr>
<td>10.6.2 Opportunities for Other Mitigation Assessments</td>
<td>801</td>
</tr>
<tr>
<td><strong>Annex 1– Guide to California Hazard Mitigation Laws, Policies and Institutions</strong></td>
<td></td>
</tr>
<tr>
<td>1.1. Introduction</td>
<td>Annex 1-1</td>
</tr>
<tr>
<td>1.2. National Flood Insurance Act</td>
<td>Annex 1-1</td>
</tr>
<tr>
<td>1.3. Stafford Act</td>
<td>Annex 1-2</td>
</tr>
<tr>
<td>1.4. Disaster Mitigation Act of 2000</td>
<td></td>
</tr>
<tr>
<td>1.4.1. Local Hazard Mitigation Plans</td>
<td>Annex 1-3</td>
</tr>
<tr>
<td>1.4.2. Hazard Mitigation Grant Program</td>
<td></td>
</tr>
<tr>
<td>1.4.3. Pre-Disaster Mitigation</td>
<td></td>
</tr>
<tr>
<td>1.5. Other Federal Disaster Laws</td>
<td>Annex 1-4</td>
</tr>
<tr>
<td>1.6. Federal Emergency Management Administrative Directives</td>
<td></td>
</tr>
<tr>
<td>1.6.1. National Incident Management System (NIMS)</td>
<td>Annex 1-5</td>
</tr>
<tr>
<td>1.6.2. National Response Framework (NRF)</td>
<td></td>
</tr>
<tr>
<td>1.6.3. National Preparedness System</td>
<td></td>
</tr>
<tr>
<td>1.6.4. Threat and Hazard Identification and Risk Assessment (THIRA)</td>
<td>Annex 1-6</td>
</tr>
<tr>
<td>1.6.5. National Mitigation Framework</td>
<td></td>
</tr>
<tr>
<td>1.6.6. Presidential Policy Directives</td>
<td></td>
</tr>
<tr>
<td>1.7. California Emergency Services Act</td>
<td>Annex 1-7</td>
</tr>
<tr>
<td>1.7.1. State Emergency Plan</td>
<td>Annex 1-8</td>
</tr>
<tr>
<td>1.7.2. Standardized Emergency Management System (SEMS)</td>
<td>Annex 1-9</td>
</tr>
<tr>
<td>1.7.3. Role of Cal OES and SEMS</td>
<td></td>
</tr>
<tr>
<td>1.7.4. Local Government Coordination</td>
<td>Annex 1-10</td>
</tr>
<tr>
<td>1.7.5. Cal OES Administrative Regions</td>
<td></td>
</tr>
<tr>
<td>1.8. Relationship of SHMP to Emergency Management</td>
<td>Annex 1-12</td>
</tr>
<tr>
<td>1.8.1. Special Note on Relationship of Mitigation and Emergency Plans</td>
<td>Annex 1-12</td>
</tr>
<tr>
<td>1.8.2. Vital Role of SHMP in Emergency Management</td>
<td>12</td>
</tr>
<tr>
<td>1.9. State Agency Responsibilities</td>
<td>Annex 1-14</td>
</tr>
<tr>
<td>1.10. State Emergency Management and Mitigation Laws</td>
<td>Annex 1-18</td>
</tr>
<tr>
<td>1.11. Local Emergency Management Responsibilities</td>
<td>Annex 1-19</td>
</tr>
</tbody>
</table>
# Table of Contents

1.12. Local Hazard Mitigation Responsibilities .................................................. Annex 1-19
  1.12.1. Building and Fire Codes ................................................................. Annex 1-19
  1.12.2. Planning and Zoning .................................................................. Annex 1-19
  1.12.3. Seismic Zonation ................................................................... Annex 1-21
  1.12.4. State Responsibility Areas ......................................................... Annex 1-21
  1.12.5. Hazard Mitigation Through Local Land Use Planning .......... Annex 1-21

1.13. Relationships of Local Planning Processes to LHMPs ...................... Annex 1-22


1.15. Business, Industry, and Community-Based Organizations ........ Annex 1-23

## Annex 2 – Public Sector Funding Sources ..............................................Annex 2-1

2.1. Introduction .................................................................................. Annex 2-1

2.2. Federal Funding Sources ................................................................. Annex 2-2
  2.2.1. Federal Emergency Management Agency (FEMA) ..................... Annex 2-2
  2.2.2. Environmental Protection Agency (EPA) .................................. Annex 2-5
  2.2.3. National Oceanic and Atmospheric Administration (NOAA) .... Annex 2-6
  2.2.4. U.S. Army Corps of Engineers (USACE) and U.S. Fish and Wildlife Service (FWS) ......Annex 2-8
  2.2.5. Department of Housing and Urban Development (HUD) .......... Annex 2-9
  2.2.6. Bureau of Land Management (BLM) ......................................... Annex 2-10
  2.2.7. U.S. Department of Agriculture (USDA) .................................. Annex 2-10
  2.2.8. Health and Economic Agencies .................................................. Annex 2-14
  2.2.9. Research Agencies .................................................................. Annex 2-14

2.3. State Funding Sources ................................................................... Annex 2-17
  2.3.1. Earthquake Hazard Mitigation Funding .................................. Annex 2-17
  2.3.2. Flood Hazard Mitigation Funding .............................................. Annex 2-19
  2.3.3. Wildfire Hazard Mitigation Funding ......................................... Annex 2-23
  2.3.4. Other State Hazard Mitigation Funding .................................. Annex 2-24

2.4. Examples of Local Funding Sources ...................................................Annex 2-28
  2.4.1. Napa County Flood Protection and Watershed Improvement Expenditure Plan ......Annex 2-28
  2.4.2. City of Roseville Floodplain Management .................................. 28
  2.4.3. San Francisco Public Utilities Commission Water System Improvement Program ....Annex 2-29
  2.4.4. City of Santa Barbara Land Purchase ......................................... Annex 2-29

2.5. Examples of Alternative Funding Sources ...........................................Annex 2-29
  2.5.1. Combined Funding Approaches ................................................. Annex 2-29
  2.5.2. California Financing Coordinating Committee (CFCC) ................. Annex 2-29
  2.5.3. Non-profit Government Partnerships ....................................... Annex 2-30
  2.5.4. Utility Companies .................................................................. Annex 2-30

2.6. Other Funding Sources and Funded Project Examples .....................Annex 2-31
## Annex 3 – Lifelines Infrastructure and Hazard Mitigation Planning ....Annex 3-1

3.1. **Introduction** .................................................................................................. Annex 3-1

3.1.1. Hazard Mitigation and California Lifeline Systems ......................................... Annex 3-3

3.1.2. Cascading Lifeline Failures ........................................................................ Annex 3-5

3.2. **Lifeline Failure Case Examples** ........................................................................ Annex 3-5

3.2.1. Loma Prieta Earthquake - Impact on Water and Transportation ................ Annex 3-5

3.2.2. La Conchita Landslide – Impact on Transportation ........................................ Annex 3-7

3.2.3. Naples, Italy, Garbage Strike, San Francisco Combined Sewer Overflow, and Post-Disaster Debris – Impact on Society ........................................................................................................... Annex 3-7

3.2.4. New Orleans Levee Failure – Impact on Life ................................................. Annex 3-8

3.2.5. Chile Earthquake – Impact on Power, Water, Communication, and Transportation .. Annex 3-8

3.2.6. Japan Earthquake and Tsunami - Nuclear Disaster ........................................... Annex 3-9

3.2.7. Hurricane Sandy - Gas Shortage ................................................................ Annex 3-10

3.2.8. Mississippi Bridge and Oroville Dam Failures .............................................. Annex 3-10

3.3. **Lifelines and Systems Concepts** ..................................................................... Annex 3-11

3.3.1. Types of Systems ........................................................................................ Annex 3-11

3.3.2. Additional Concepts .................................................................................. Annex 3-12

3.3.3. Using “Decision Trees”: A Fictional Example ........................................ Annex 3-14

3.4. **Path Forward for Lifeline Resilience** ............................................................... Annex 3-17

3.4.1. Assessing Lifeline System Risk ................................................................ Annex 3-17

3.4.2. Understanding Other Systems and Interdependencies .................................. Annex 3-18

3.4.3. Information Sharing and Coordination: Lifelines Council and Critical Lifelines Workgroup .......................................................................................................................................... Annex 3-21

3.4.4. Lifeline Mitigation ..................................................................................... Annex 3-21

3.5. **Summary** ...................................................................................................... Annex 3-24

3.6. **Resources** ................................................................................................... Annex 3-25

3.6.1. Information Sources ................................................................................ Annex 3-25

3.6.2. References Used in This Annex ................................................................ Annex 3-25
LIST OF APPENDICES

| APPENDIX A | 2018 State Hazard Mitigation Team Roster of Agencies and Stakeholder Organizations | A-1 |
| APPENDIX B | State Agency Functions: Agency Responsibility Matrix | B-1 |
| APPENDIX C | Multi-Agency Mitigation Action Matrix | C-1 |
| APPENDIX D | Progress Tracking Outreach Plan | D-1 |
| APPENDIX E | California Disaster History, 1950-2018 | E-1 |
| APPENDIX F | Hazard Mitigation Legislation Referenced in the 2018 SHMP | F-1 |
| APPENDIX G | Earthquake Hazard Mitigation Legislation, 1933-2017 | G-1 |
| APPENDIX H | Flood Hazard Mitigation Legislation, 1933-2017 | H-1 |
| APPENDIX I | Wildfire Hazard Mitigation Legislation, 1933-2017 | I-1 |
| APPENDIX J | Top 10 California Repetitive Loss Counties (by total payment) Summary For 2017 | J-1 |
| APPENDIX K | Top 10 California Severe Repetitive Loss Counties (by total payment) Summary for 2017 | K-1 |
| APPENDIX L | Mitigation Grants NOI and SubApplication Processes | L-1 |
| APPENDIX M | Mitigation Grants Management and Closeout Processes | M-1 |
| APPENDIX N | GIS Risk Exposure Analysis Methodology | N-1 |
| APPENDIX O | SHMP Acronym List | O-1 |
| APPENDIX P | 2018 SHMP References | P-1 |

LIST OF MAPS

Map 1.A: California’s Size Compared to Eastern States ................................................................. 3
Map 1.B: California’s Counties and Population Centers ............................................................... 4
Map 1.C: Cal OES Administrative Regions .................................................................................. 22
Map 1.D: California Fire Safe Council Interactive Local FSC Location Map ............................ 26
Map 2.A: MyPlan Example Mapping Screen .............................................................................. 49
Map 4.A: California Population by County .................................................................................. 104
Map 4.B: California Population Change by County ...................................................................... 111
Map 4.C: California Residential Units Authorized by Permits .................................................... 112
Map 4.D: California’s Projection of Development Based on Historical Factors .......................... 114
Map 4.E: California Terrain ........................................................................................................ 119
Map 4.F: California Public Lands ................................................................................................ 120
Map 4.I: Population Distribution and Density ............................................................................. 162
Map 7.K: Projects of Central Valley Flood Protection Plan .......................................................... 413
Map 7.L: State Plan of Flood Control Leves and Bypasses .......................................................... 417
Map 7.N: Projected ARkStorm Flooding in California (Based on Modeled Scenario) ................. 437
Map 7.O: Businesses Vulnerable to Sea-Level Rise in the San Francisco South Bay .................. 446
Map 7.P: Tsunami inundation Mapping Completed, 2009 ............................................................ 467
Map 7.Q: Tsunami Inundation Map – Crescent City ................................................................. 468
Map 7.R: Example Maritime Tsunami Playbook Current-Threshold Map for the Port of Long Beach 470
Map 7.S: Example Harbor Cleat Failure Potential Analysis in the Draft Harbor Improvement Report for Oceanside Harbor .......................................................... 474
Map 7.T: Draft PTHA Inundation Lines for a Portion of Huntington Beach ............................. 479
Map 7.U: Delta Elevations Relative to Mean Sea-Level .......................................................... 483
Map 7.V: California Levee System with 1 Percent Annual Chance Flood Zones .................... 488
MAP 8.B: Fire Frequency (Number of Times Burned), 1950-2017 ............................................ 514
Map 8.C: California’s Projection of Development Based on Historical Factors ...................... 516
MAP 8.E: Fire Hazard Severity Zones in State Responsibility Areas .................................... 522
Map 8.G: Wildfire Threat in the Los Angeles County Area ..................................................... 524
Map 8.I: Population/Social Vulnerability with Wildfire Hazard ............................................. 530
Map 8.J: Wildfire Hazard Ranking in Local Hazard Mitigation Plans .................................... 539
Map 8.L: State Responsibility Area Viewer Example—SRA in Northern California .............. 551
MAP 8.M: FEMA-Funded Wildfire Mitigation Projects and Population/Social Vulnerability .... 563
Map 9.B: Area Designation Map for PM_{2.5} ........................................................................ 584
Map 9.C: Area Designation Map for PM_{10} ........................................................................ 585
Map 9.D: Area Designation Map for Ozone ............................................................................ 586
Map 9.E: Relative Particulate Matter Concentrations in California from CalEnviroScreen .... 588
Map 9.F: Relative Ozone Concentrations in California from CalEnviroScreen .................... 589
Map 9.H: Drought Indicators Map from U.S. Geologic Survey Showing Well Decline Along with Subsidence in the San Joaquin Valley .......................................................... 605
Map 9.I: Critically Overdrafted Groundwater Basins in the San Joaquin Valley .................... 606
Map 9.J: Subsidence Contours in the Central Valley ............................................................... 609
MAP 9.K: California’s Operating Power Plants ........................................................................ 622
Map 9.L: California’s Electric Transmission Grid ................................................................. 623
Map 9.M: West Nile Virus Activity in California Counties ...................................................... 635
Map 9.O: Valley Fever Average Annual Rates by California County ................................... 638
Map 9.Q: California Historical and Projected Temperature, 1961-2099 ............................... 648
Map 9.R: Social Vulnerability and Extreme Heat .................................................................. 651
Map 9.U: Tree Mortality (per acre) and High Hazard Zones .............................................. 668
Map 9.V: Screen Shot of Tree Mortality Viewer .................................................................. 672
Map 9.W: Tree Mortality Viewer Example of Map Export .................................................. 673
Map 9.Y: California Natural Gas Pipelines .............................................................................. 697
Table 6.O: Ground Lifelines Located in Volcano Hazard Zones
Table 6.N: Jurisdictions, Populations in Volcano Hazard Zones
Table 6.M: Notable Historic Landslides and Debris Flows in California
Table 6.K: Priority Recommendations of the 2016 Napa Earthquake Report
Table 6.I: 2016 Napa Earthquake Report Findings
Table 6.H: Seismic Gas Shutoff Valves Ordinances
Table 6.G: California Housing Units by Type, 2017
Table 6.F: Hospital Structural Performance as of December 2017
Table 6.E: Hazard Mitigation Grant Funded Seismic LAUSD Retrofit Projects
Table 6.C: Projected Earthquake Scenario Losses, Southern California
Table 6.B: Projected Earthquake Scenario Losses, Northern California
Table 6.A: Projected Earthquake Scenario Losses, Northern California
Table 6.9: Emergency Planning Zones (EPZs) for Diablo Canyon Power Plant
Table 6.8: Oil Train Routes and Potential High Hazard Sites
Table 6.7: High Hazard Designations for Oil by Rail
Table 6.6: FEMA-Funded Hazard Mitigation Grant Projects Obligated from 1994-2017, by Year
Table 6.5: FEMA-Funded Hazard Mitigation Grant Projects Obligated from 1994-2017, by Hazard
Table 6.4: FEMA-Funded Hazard Mitigation Grant Projects by Year – Bay Area and Greater Los Angeles Area
Table 6.3: Hazard Mitigation Grant Projects near 2014 South Napa Earthquake
Table 6.2: Mapping of HMA Grant Funded Projects Related to March 2018 Storm Event
Table 6.1: Declared or Proclaimed Disaster Incidents, Casualties, and Cost by Type, 1950
Table 5.L: State Agencies Involved in Community Planning
Table 5.J: Resources Supporting Local Hazard Mitigation Planning
Table 5.I: LHMP Components
Table 5.H: Types of Mitigation Measures in California LHMPs as of May 2017
Table 5.G: All Other Hazards Risks Identified in LHMPs as of May 2017
Table 5.F: Fire Risks Identified in LHMPs as of May 2017
Table 5.E: Flood Risks Identified in LHMPs as of May 2017
Table 5.D: Earthquake Risks Identified in LHMPs as of May 2017
Table 5.C: SHMT Public Review Draft Outreach Workshop Presentations
Table 5.B: SHMT and GIS TAWC Strategic Working Group Meetings 2014
Table 5.A: Recent Earthquake Losses

LIST OF TABLES

Table 2.A: 2018 SHMP Update Preparation Schedule
Table 2.B: SHMT and GIS TAWC Strategic Working Group Meetings 2014-2018
Table 2.C: SHMP Public Review Draft Outreach Workshop Presentations
Table 4.A: Population Change, 2012-2016, in 10 Largest Counties by Population
Table 4.B: Population Change, 2012-2016, in 10 Smallest Counties by Population
Table 4.C: 10 California Counties with Largest Number of Households with Disabled Residents, 2015
Table 4.D: Top 10 Counties in Population Growth, 2012-2016
Table 4.E: Declared or Proclaimed Disaster Incidents, Casualties, and Cost by Type, 1950
Table 4.F: Population and Disaster Deaths and Injuries by Time Phase, 1950
Table 4.G: Population and Disaster Deaths and Injuries by Time Phase, 1950
Table 4.H: Declared or Proclaimed Disaster Incidents, Casualties, and Cost by Type, 1950

California State Hazard Mitigation Plan | September 2018
Page xiii
Table 10.K: Grant Subapplicant Technical Training by Cal OES and FEMA
Table 10.H: Summary of PDM/FMA NOI Process
Table 10.E: Notices of Interest Submitted and Approved (obligations pending) for 2017, as of July 2018
Table 10.B: Distribution of Major FEMA Support Grant Programs in California, 2013
Table 9.X: Summary of Significant Civil Disorders in California
Table 9.V: Terrorist Events in California, 2006 to 2016
Table 9.U: Levels of Nuclear Power
Table 9.T: Gas Distribution and Local Transmission Line Incidents, 2013 to 2017
Table 9.S: Summary of California and Other Significant Oil Spills
Table 9.P: Tornado Losses, 1950
Table 9.O: Federally Declared Storm Disasters Since 1993 (as of February 2018)*
Table 9.N: Fujita Tornado Scale
Table 9.M: Freeze Disasters, 1950 to Present
Table 9.L: HeatRisk Categories by Color
Table 9.I: Drought Disaster Assistance Programs
Table 9.H: 2012 Drought Executive Orders
Table 9.G: Drought Response Funding Since 2014, by Category
Table 9.F: Summary of Impacts of 2015 California Drought
Table 9.E: Drought Incidents, 1972 to 2016
Table 9.C: Air Pollutant Emission Trends and Forecasts in California, 2000
Table 8.F: Reported Fire Loss in California by Property Type in 2014
Table 8.D: Potential Loss of State Facilities from Wildfire Hazards
Table 8.C: Top 20 Most Destructive California Wildland Urban Interface (WUI) Fires, by Structures Destroyed
Table 8.B: Largest California Wildfires, 125,000 Acres Burned or Greater
Table 7.K: San Francisco Bay-San Joaquin-Sacramento Delta Levee Failures, 1900-2017
Table 7.H: Projected Average Rate of Sea-Level Rise (millimeters/year) for San Francisco
Table 7.I: Sea-Level Rise Resources and Guidance
Table 7.J: Summary of Tsunami Damage Along the California Coast Since 1946
Table 7.G: Probability that Sea-Level Rise Will Meet or Exceed a Particular Height (in Feet) in San Francisco
Table 7.F: Projected Decadal-Sea-Level Rise (in Feet) for San Francisco
Table 7.E: Increases in Premium Savings Resulting from CRS Participation, Between 2011 and 2017
Table 7.D: Top 10 California Counties with NFIP Policies
Table 7.C: Flood Management Bond Expenditures by Program*
Table 7.B: Potential Loss of State Facilities from Flood Hazards
Table 7.A: Federally Declared Flood Disasters in California, 1992-February 2018*
Table 6.P: Airborne Volcanic Hazards Alert Levels

---

**CALIFORNIA STATE HAZARD MITIGATION PLAN | SEPTEMBER 2018**

---

**PAGE xiv**
LIST OF PROGRESS SUMMARIES

Progress Summary 3.A: Regional Flood Management Planning .......................................................... 77
Progress Summary 3.B: The Delta Stewardship Council and the Delta Levees Investment Strategy ........... 77
Progress Summary 3.C: Ongoing Progress on Integrated Climate Adaptation and Resiliency Program (ICARP) . 78
Progress Summary 3.D: SHMT Working Group Initiatives ..................................................................... 81
Progress Summary 3.E: AB 2140 Implementation ............................................................................... 86
Progress Summary 3.F: SB 1241 Implementation Resources ................................................................. 87
Progress Summary 3.G: MyPlan and GIS TAWC ............................................................................... 92
Progress Summary 3.H: SMART Post-Disaster Loss Avoidance Tracking ............................................. 94
Progress Summary 4.A: California Adaptation Planning Guide (APG) Updates ...................................... 153
Progress Summary 4.B: Additional Local Climate Adaptation Guidance Sources ................................. 153
Progress Summary 4.C: Creation of a Coastal Plan Alignment Compass: A Planning Tool for Coastal Communities .......................................................... 156
Progress Summary 5.A: Jurisdictions with Approved and Adopted LHMPs as of May 2017 ..................... 194
Progress Summary 6.A: HAZUS Earthquake Loss Estimation for California ........................................ 255
Progress Summary 6.B: Cal VIVA III and the Climate Adaptation Strategy Project 6A ......................... 274
Progress Summary 6.C: Earthquake Zones of Required Investigation (formerly called Seismic Hazards Mapping Projects) and Other Earthquake Data ................................................................. 297
Progress Summary 6.D: EQ Zapp: California Earthquake Hazards Zone Application .......................... 297
Progress Summary 6.E: University of California Retrofits .................................................................... 306
Progress Summary 6.G: California Residential Mitigation Program ..................................................... 317
Progress Summary 6.H: Seismic Evaluation of Single-Family Dwellings ............................................... 322
Progress Summary 6.I: Mobile Homes .................................................................................................. 323
Progress Summary 6.K: Highway Bridge Retrofits ............................................................................. 329
Progress Summary 6.L: Great California ShakeOut Earthquake Drill and Public Readiness Initiative ........ 333
Progress Summary 6.M: Landslide Hazard Mapping ............................................................................ 355
Progress Summary 7.A: Flood Laws .................................................................................................... 399
Progress Summary 7.B: California’s Flood Management Programs within the Flood Management System .... 401
Progress Summary 7.C: Central Valley Flood Management .................................................................... 404
Progress Summary 7.D: Regional Flood Management Planning......................................................... 404
Progress Summary 7.E: Statewide Flood Management ......................................................................... 405
Progress Summary 7.F: Water Plans and the Delta .............................................................................. 423
Progress Summary 7.G: Senate Bill 1278—200-Year Floodplain Maps and General Plan Amendments ........ 424
Progress Summary 7.H: California Coastal Commission Sea-Level Rise Policy Guidance ................. 456
Progress Summary 7.I: Local Coastal Resources Grant Program ......................................................... 457
Progress Summary 7.J: San Francisco Bay Conservation and Development Commission .................... 460
Progress Summary 7.K: Understanding Tsunami Probability ............................................................... 469
Progress Summary 7.L: Assessing Tsunami Hazards and Potential Losses ......................................... 472
Progress Summary 7.M: Probabilistic Tsunami Hazard Analysis Mapping Linkage to Mitigation Activities .... 478
Progress Summary 7.N: Earthquake, High Water, and Levee Failure: Cascading Hazards .................... 489
Progress Summary 7.O: Levee Hazard Mitigation: Evaluation and Repair .......................................... 491
Progress Summary 7.P: Delta Levees Program ..................................................................................... 493
Progress Summary 7.Q: Lower Elkhorn Basin Levee Setback Project .................................................... 497
Progress Summary 7.R: Dam Inundation Mapping and MyPlan ............................................................ 505
Progress Summary 8.A: Senate Bill 1241 (2012) and CAL FIRE’s Land Use Planning Program .......... 544
Progress Summary 8.B: Board of Forestry and Fire Protection Research Efforts .................................... 546
LIST OF BEST PRACTICES HIGHLIGHTS

Best Practices Highlight 3.A: Hermosa Beach—Integrating Coastal Protection with Land Use Planning .............. 89
Best Practices Highlight 4.A: Santa Cruz County Plan for Climate Action and Adaptation .......................................................... 157
Best Practices Highlight 6.A: Successful Update of Alquist-Priolo Map for Lake Tahoe Area Clarifies Fault Location .. 298
Best Practices Highlight 6.C University of California Seismic Mitigation .................................................................................... 307
Best Practices Highlight 6.D: URM Retrofit Program Success in San Luis Obispo ................................................................. 313
Best Practices Highlight 6.G: San Francisco Public Utilities Commission’s Water System Improvement Program ... 325
Best Practices Highlight 6.H: Devil’s Slide Tunnel Project ............................................................................................................. 361
Best Practices Highlight 7.A: San Mateo County’s Sea Change Program and Sea Level Rise Vulnerability Assessment .. 448
Best Practices Highlight 8.A: City of San Diego’s Campaign to Mitigate Wildfire Hazard and Protect Sensitive Resources .......................................................... 548
Best Practices Highlight 9.B: State Water Efficiency and Enhancement Program (SWEEP) ................................................................. 615
Best Practices Highlight 9.D: Kern County Cooling Centers ...................................................................................................... 653
LIST OF FIGURES

Figure 1.A: 2018 SHMP Statement of Plan Adoption Letter .......................................................... 28
Figure 4.A: California Population Projections .................................................................................. 113
Figure 4.B: California Growth Scenarios .......................................................................................... 115
Figure 4.C: Climate Change Impacts on Temperature Patterns. ....................................................... 129
Figure 4.D: 2018 Safeguarding California Climate Change Impact Sector Breakdown .................. 144
Figure 4.E: Impact of Climate Change on Human Health and Exacerbation of Existing Inequities 148
Figure 4.F: The Nine Steps in Adaptation Strategy Development .................................................... 152
Figure 6.A: FEMA HAZUS Modeling ............................................................................................... 259
Figure 6.B: Landfalling Atmospheric Rivers from October 2016 to March 2017 ............................ 347
Figure 6.C: Volcano Hazard Components ......................................................................................... 364
Figure 6.D: Hazard Information Flow from USGS Monitoring Networks to Civil Authorities and Stakeholders ................................................................. 374
Figure 7.A: Monthly Average Runoff of Sacramento River System ................................................... 384
Figure 7.B: Inter-Relationships Among California’s Flood Management Programs ......................... 400
Figure 7.C: Flood Risk Reduction Opportunities in California .......................................................... 407
Figure 7.D: Key Flood Infrastructure Components ........................................................................... 416
Figure 7.E: Flood Risk Reduction Opportunities in California .......................................................... 435
Figure 7.F: Global Upper Ocean Heat Content and Sea-Level Change Since 1900 ......................... 438
Figure 7.G: Locations of Tide Gauges Used as the Basis for Sea-Level Rise Projections ............. 440
Figure 7.H: Step-Wise Approach to Selecting Sea-Level Rise Projections ..................................... 444
Figure 7.I: Graphic from San Mateo County’s Sea Level Rise Vulnerability Assessment .................. 449
Figure 7.J: Sea-level Rise Planning Guidance ................................................................................... 459
Figure 7.K: Bay Conservation and Development Commission (BCDC) Adapting to Rising Tides Program – Resource Organization .......................................................... 460
Figure 7.L: Del Mar’s Process for Evaluating, Selecting, and Sea Level Rise Adaptation Options .......... 463
Figure 7.M: Hamilton City Flood Damage Reduction and Ecosystem Restoration Project Overview ............................................................ 496
Figure 9.A: Graphical Illustration of extreme Events for Temperature and Precipitation…………. 607
Figure 9.B: “Make Conservation a California Way of Life” Report Actions Summary .................... 620
Figure 9.C: Linking Climate Change, Extreme Heat, and Public Health ........................................ 649
Figure 9.D: Crude-by-Rail Imports into California, 2016 and 2017 .................................................. 713
Figure 9.E: Use of Height and Length in Describing Well Stimulation Treatment Fractures in California ....... 724
Figure 9.F: Cal OES Homeland Security Organizational Structure .................................................. 729
Figure 9.G: California Business Sectors Affected by Cyber Threats ................................................... 735
Figure 9.H: California Cyber Defense ............................................................................................... 737
Figure 9.I: California Cybersecurity Integration Center (Cal CSIC) Linkage to Other Agencies ........ 738
Figure 10.A: FEMA Public Assistance and Hazard Mitigation Assistance Programs .............. 763

LIST OF CHARTS

Chart 6.A: Multivariate El Nino Southern Oscillation Index ............................................................... 346
Chart 6.B: Schematic Comparison of Natural Hazard Timelines ....................................................... 368
Chart 8.A: Annual Acres Burned by Vegetation Type and Decade, 1960-2017 ............................ 511
Chart 8.B: Number of Structures Ignited During a Large Wildfire (Greater than 300 Acres), 1991-2017 . 520
Chart 8.C: Firefighter and civilian fatalities occurring during a large wildfire (>300 acres) from 1991 to 2017 .................................................................................................................. 521
Chart 8.D: Structures Destroyed by Wildfire 1989-2017 ................................................................. 537
Chart 9.B: Projected Increase in Extreme Heat, 2070-2099 ............................................................ 648
Chart 10.A: Cal OES HMGP Division Organization, as of March 2018 ...................................... 770
Chart 10.B: Cal OES Mitigation and Dam Safety Branch Organization, as of June 2018 ........................................771