

# California Central Valley Levee Geotechnical Evaluations: Providing Protection For A Growing Population

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# California's Central Valley



Sacramento Valley

Delta

San Joaquin Valley

## Sacramento/San Joaquin/Delta levees now protect

- Communities with over 2 million people
- 200 thousand structures with estimated value over \$56 billion
- Public trust resources
- Water supply to 2/3 of California's population
- 1.5 million acres of cultivated land



# FLOOD SCENARIO: Flood in Sacramento

## Critical Infrastructure Impacted

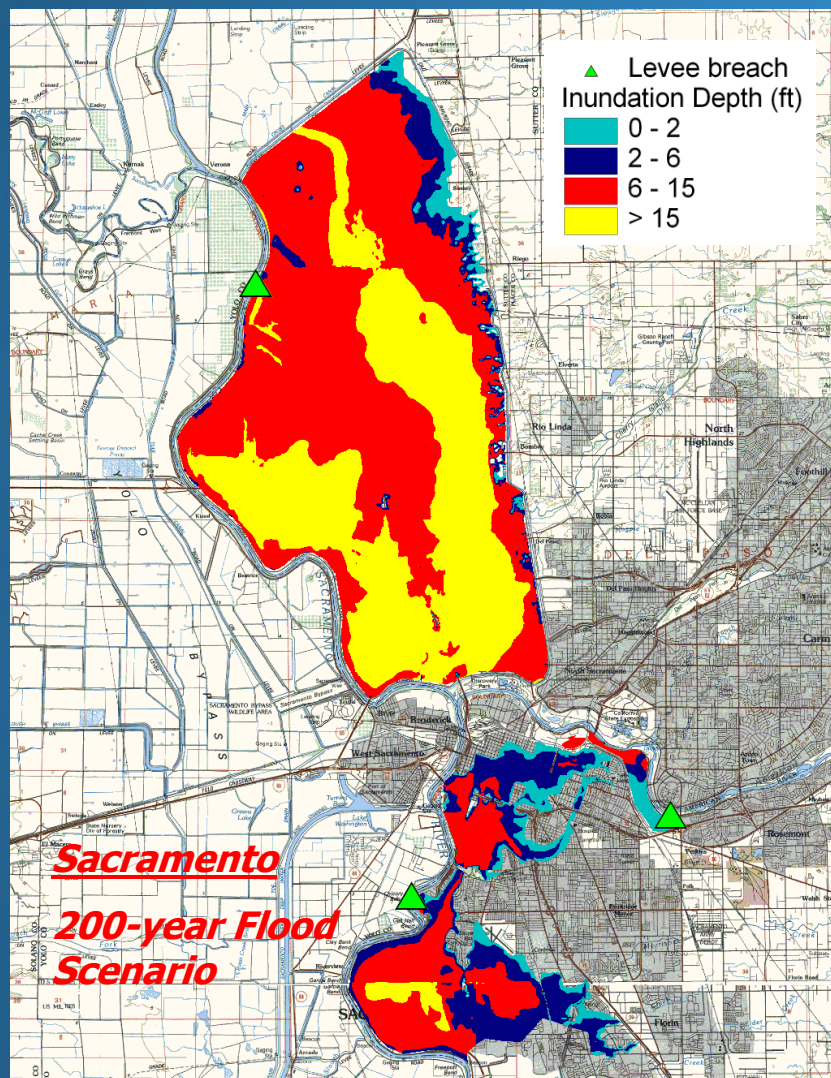
- 12 Fire stations, 9 have inundation depth of 4 ft or more
- 1 Police station, minor flooding
- 38 Power substations, including 3 high voltage substations
- 16 Wastewater pump stations; likely many pipe breakages
- 1 Water treatment plant; water not drinkable
- 2 Airports; including 13 ft flooding of Sac. Intl. Airport
  
- 4 Hospitals, 2 have 1 ft or more
- 26 Medical/health facilities, 19 have 1 ft or more
- 193 Licensed care facilities, 176 have 1 ft or more
- 65 Schools, 59 have 1 ft or more

## Cost items

## Cost

Property damage	\$ 11.2 billion
Displacement/temporary housing	\$ 1.5 billion
Lifeline utility repairs	\$ 24 million
Levee repair and pumping cost	\$ 58 million
Emergency response and recovery	\$ 16 million
	\$ 12.8 billion

Additional indirect fiscal impacts up to \$ 15 billion



# Continuing Development in Deep Floodplain





# Urbanized Deep Flood Plain



Natomas Fire Station



Arco Arena, Natomas



Projected Flooding of Natomas Fire Station



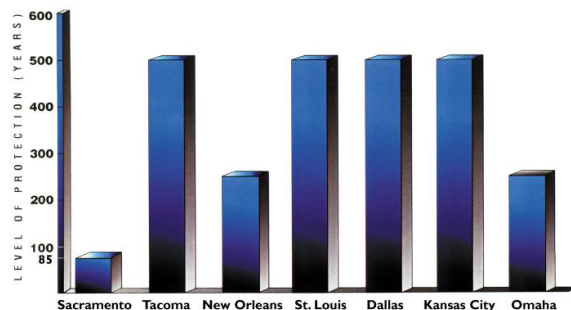
Projected Flooding of Arco Arena, Natomas

# Sacramento Valley

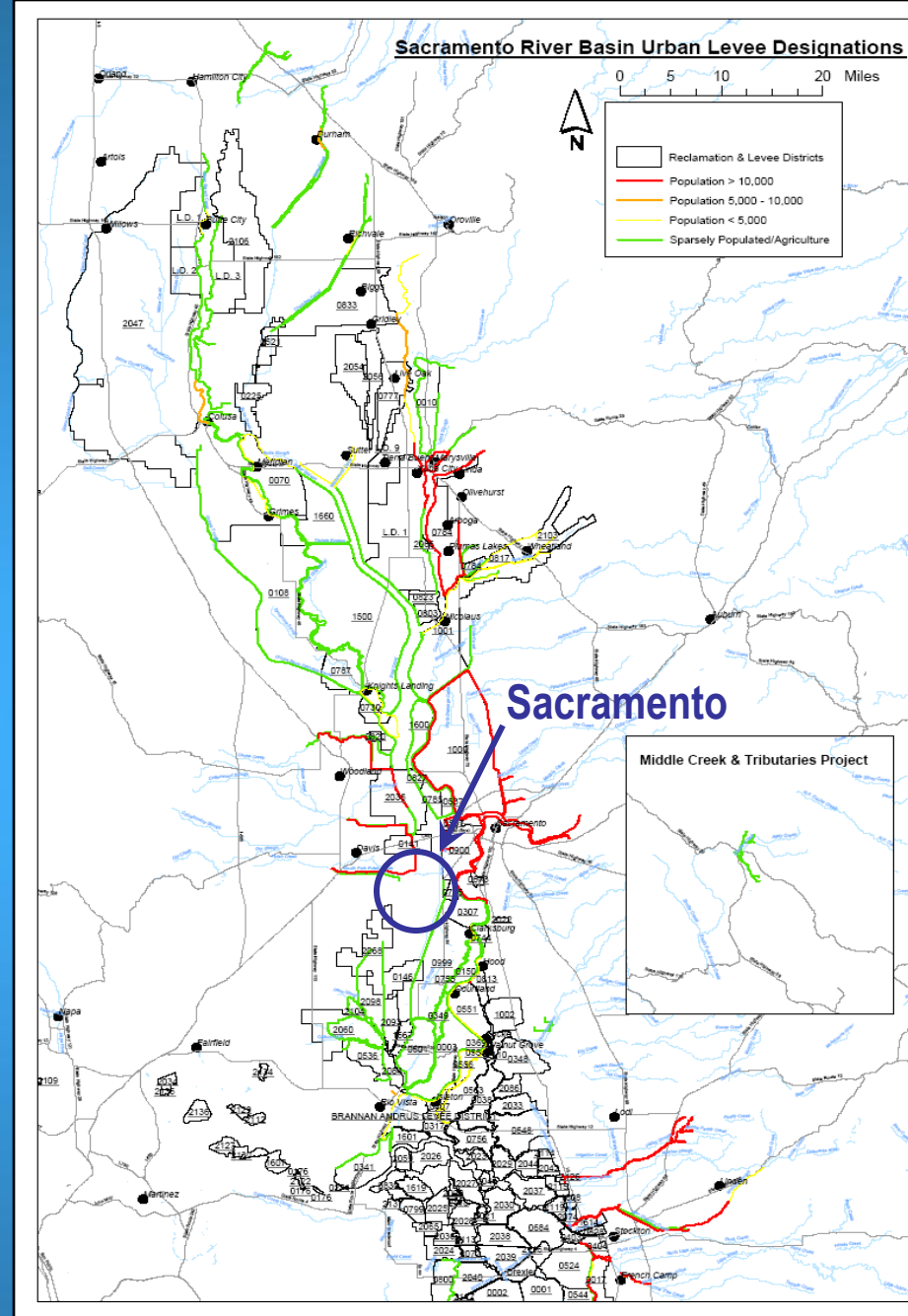
- Urban levees
- Rural levees



**Sacramento's Level of Flood Protection by Comparison to other River Cities**



SAFCA

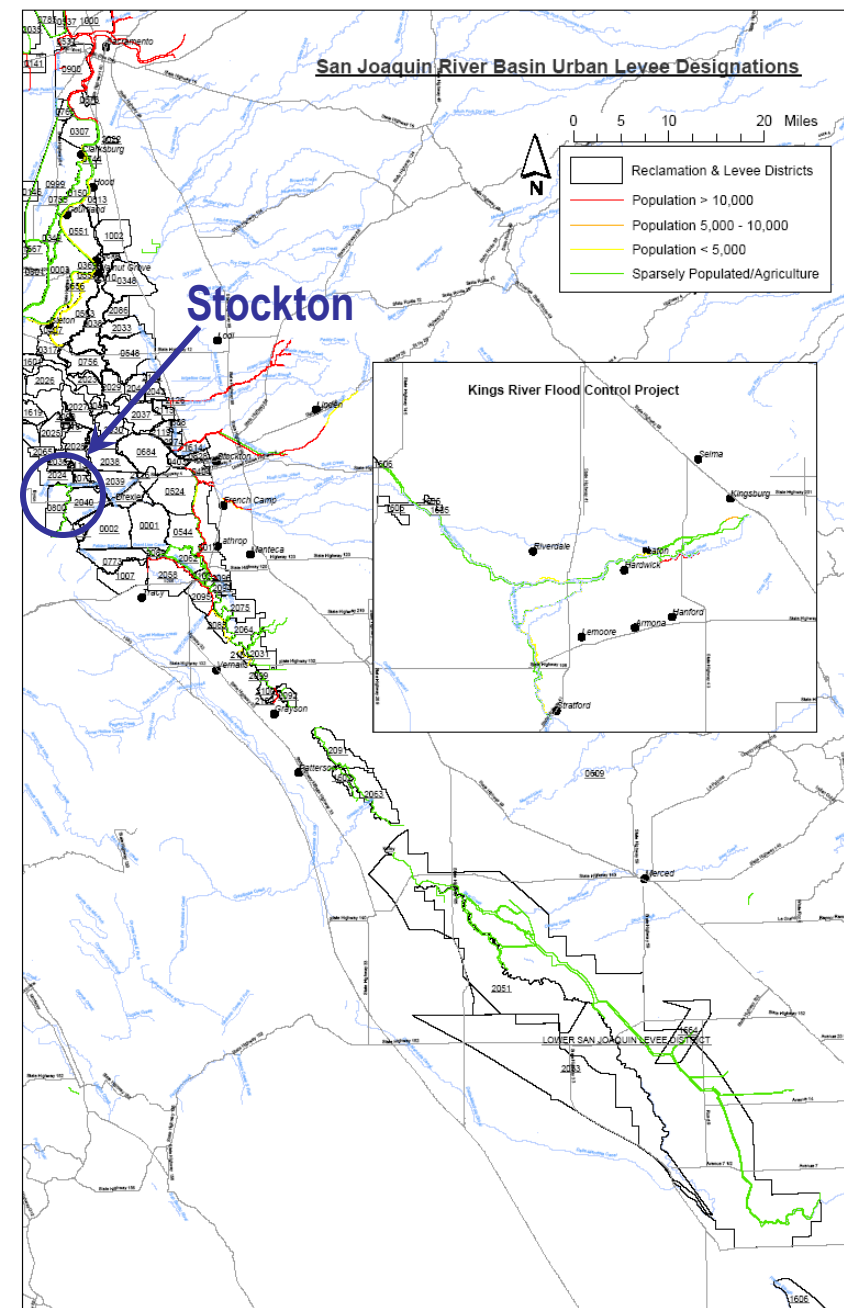


URS



# San Joaquin Valley

- Urban levees
- Rural levees





# Historic Levee Construction in California

- Originally built to protect fertile farmland
- Constructed of sand, silt, and peat



- Dredge from adjacent river or slough channel
- Excavate from nearby dry land
- Poor compaction, little segregation of suitable vs. unsuitable materials

# Historic Levee Construction in California

Results: Levees were often

- permeable
- easily eroded
- possibly not constructed to sufficient height
- susceptible to great settlement





# Land use has changed

The levees were never intended to protect

- Urban areas
- Water supply that is vital to Central and Southern California

# Central Valley Delta Region

Affected by unique geologic conditions that are generally not present in Sacramento or San Joaquin Valleys



# California's Central Valley



Sacramento Valley

Delta

San Joaquin Valley

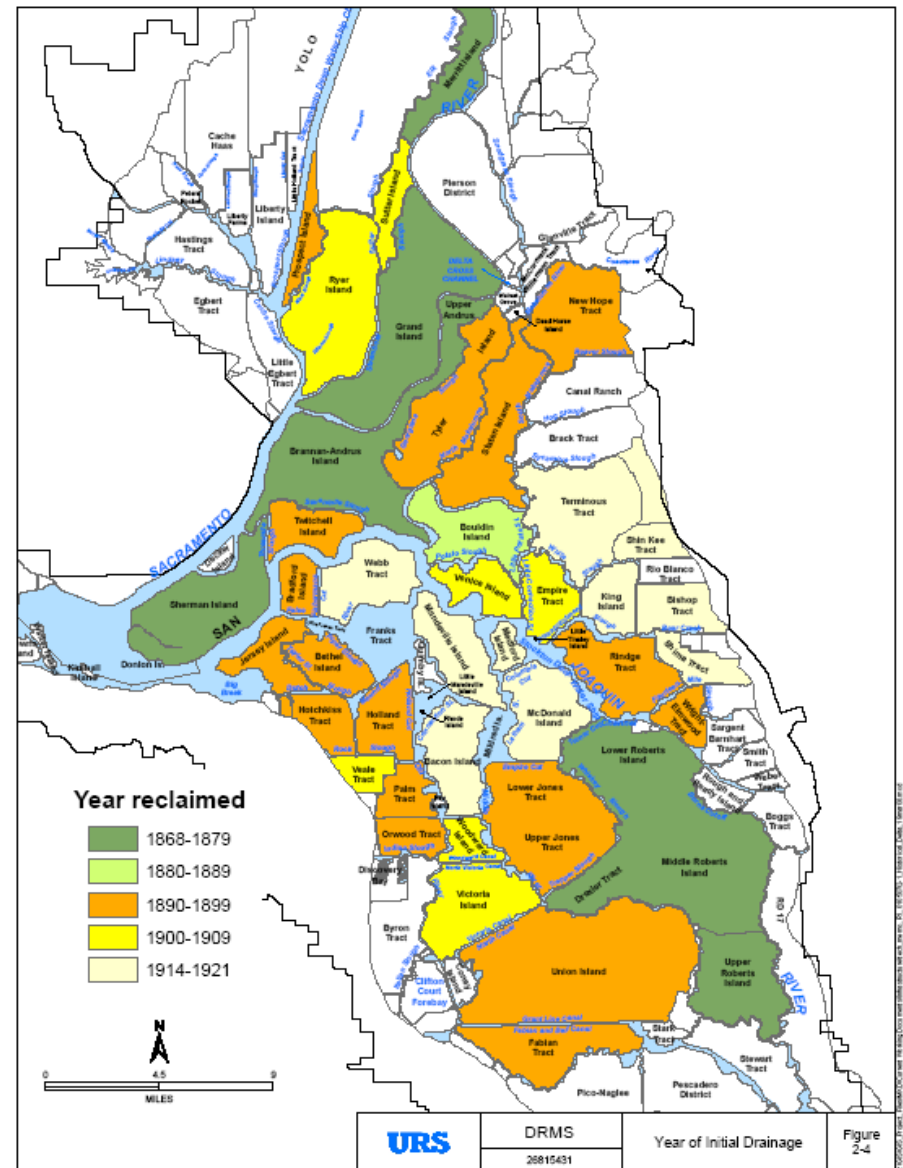
# Central Valley Delta Region

- Delta is affected by unique geologic conditions that are generally not present in Sacramento or San Joaquin Valleys
- Wide spread organic soils (peat) are very soft, compressible, and oxidize when exposed to air
- Levee mass compresses underlying peat and settle
- Landside area also settles as organic soils irreversibly oxidize. Many are below sea level.
- Susceptible to failure in earthquakes
- Overtopping and underseepage are big issues



# Delta Map

- Broad flat area composed of a series of more than 70 islands
- Islands are created by ring levees that enclose areas that are now often below sea level



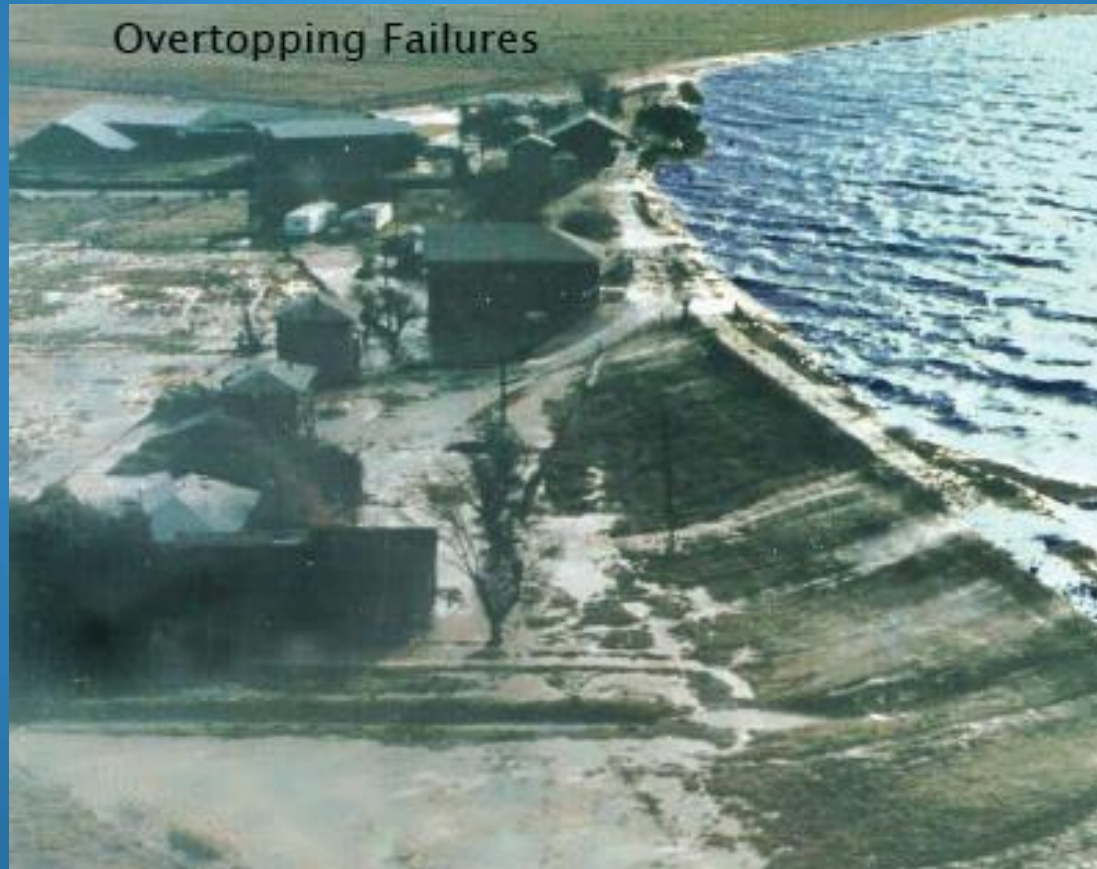
# Ways that Levees Fail

- Overtopping
- Through Seepage
- Under Seepage
- Slope Instability
- Erosion
- Seismically Induced Failure



# Ways that Levees Fail

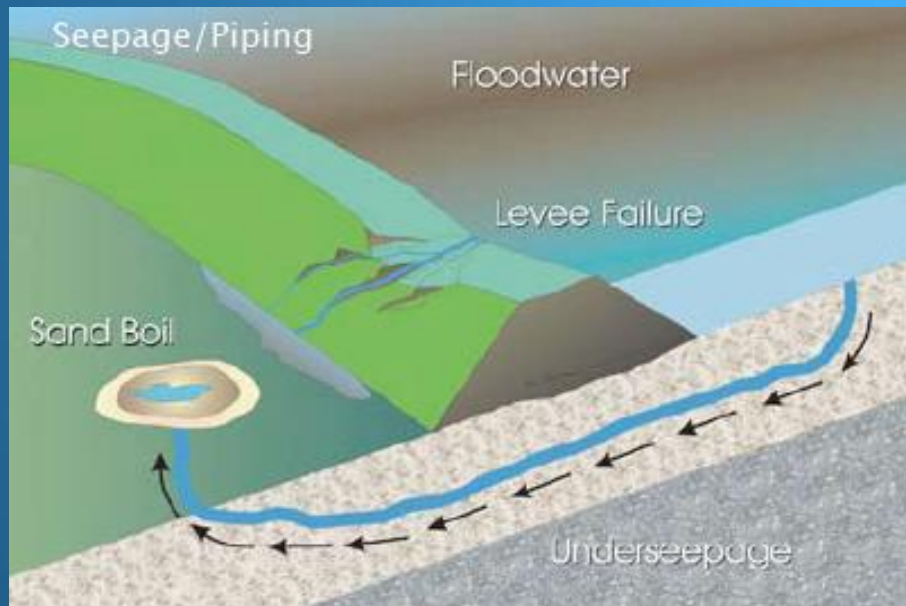
## Overtopping





# Ways that Levees Fail

## Through Seepage and Under Seepage

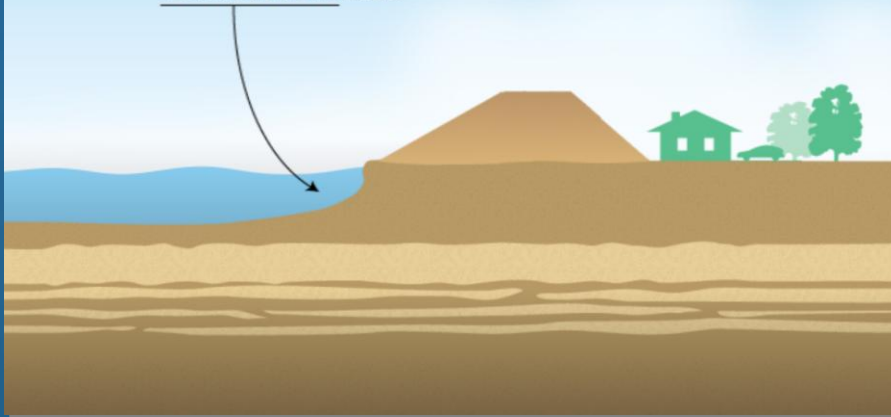


# Ways that Levees Fail

## Erosion and Slope Instability



Bank erosion has reached  
a critical condition

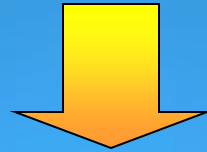


Flood level

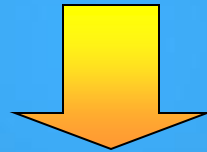


# Ways that Levees Fail

Seismic Shaking



Liquefaction and Settlement



Insufficient Freeboard and Overtopping



# Geotechnical Evaluation of Central Valley Levees

Evaluating more than 1750 miles of levees

- Review available historic information and aerial photos
- Perform geologic mapping
- Phased subsurface exploration program and soil testing
- Engineering analyses
- Reporting

# Review Available Historic Information and Aerial Photos

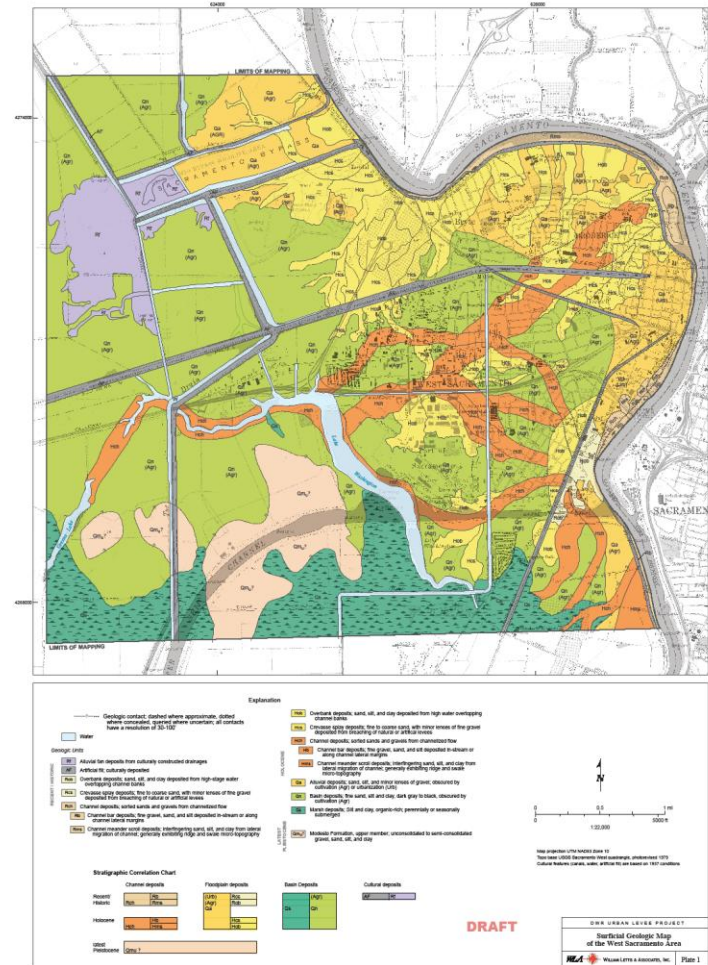
- Lots of information is available but is often difficult to locate.
- Meet with Levee District/Reclamation District owners to discuss past performance problems.
- Review historic construction photographs.
- Review aerial photographs.



# Geologic Mapping

# Map surficial sedimentary geologic units from high altitude aerial photographs

Confirm/refine mapping  
through field checking  
and subsurface  
exploration





# Geotechnical Evaluation of Central Valley Levees

- ✓ Review available historic information and aerial photos
- ✓ Perform geologic mapping
  - Phased subsurface exploration program and laboratory soil testing
  - Engineering analyses
  - Reporting

# Phased Approach to Subsurface Exploration

- Cost effective
- Involves up to three phases of soil borings
- Many sites may only get first or first and second phases
- Focuses resources on known problem areas immediately

# Subsurface Exploration: Primary Soil Borings

- Drilled on levee crest
- Drilled in known problem areas and on 5000-ft spacing





# Subsurface Exploration: Secondary Soil Borings

- Drilled in potential problem areas identified during first phase of exploration
- Drilled on landside toe and offset from toe



# Subsurface Exploration: Tertiary Soil Borings

- Drilled on waterside in problem areas



# Geotechnical Evaluation of Central Valley Levees

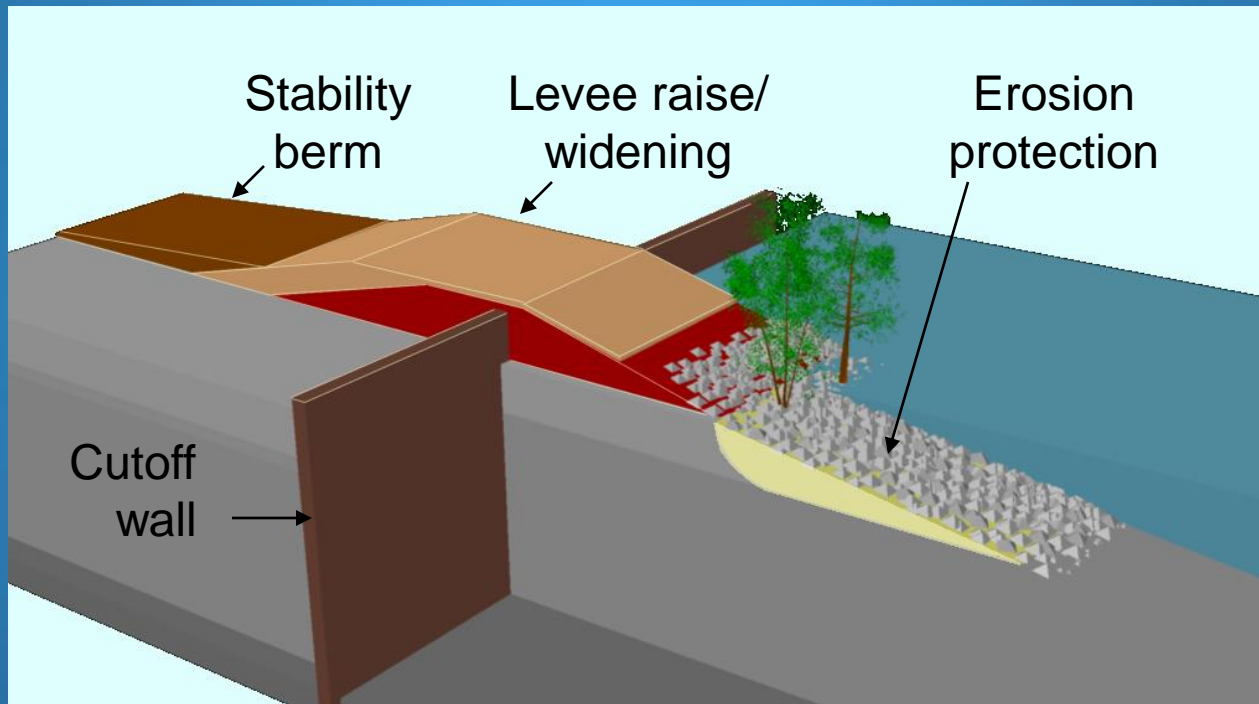
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  - Reporting



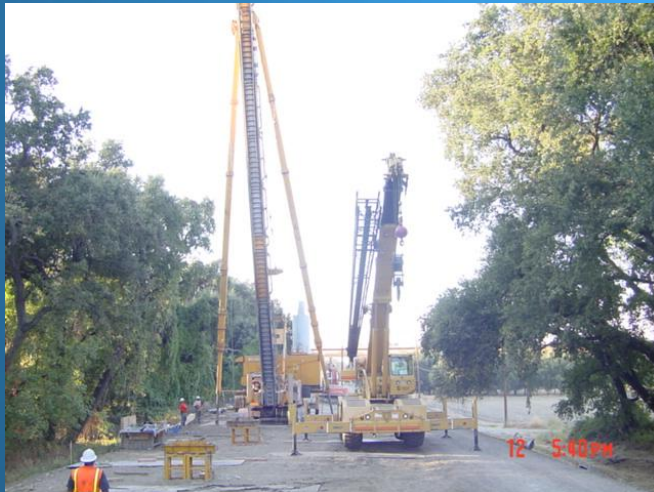
# Geotechnical Evaluation (continued)

- Engineering analyses
  - seepage
  - slope stability
  - seismic
  - settlement
- Geotechnical Report
  - Provide recommendations for areas needing repair and type of repair

# Examples of Levee Repairs



# Cutoff Wall Construction





# Issues with Cutoff Walls

- Expensive to construct
- Difficult to confirm that a positive continuous cutoff has been achieved
- Requires closing access along levee crest during construction

# Stability Berm

Stability berm for slope stability and/or seepage control



# Issues with Stability Berms

- Expensive to construct
- Requires purchasing land or easement parallel to levee
- Requires large volume of imported fill soil



# Erosion Protection



# Issues with Erosion Protection

- Expensive to construct
- Requires importing large boulders – expensive material
- Environmental issues related to working in riparian corridor



# Setback Levee





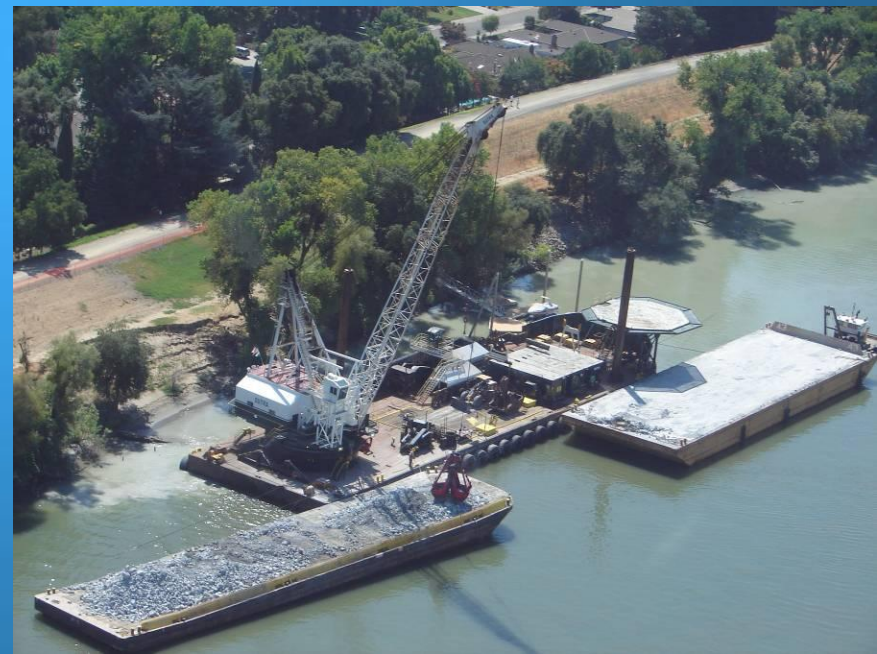
# Issues with Setback Levees

- Very expensive to construct
- Requires purchasing land for setback levee to be constructed on
- Requires very large volume of imported fill soil
- May also require removal of old levee

# Improving Flood Protection for California's Urban Areas is Expensive

- Current Estimates Show that it will cost almost **\$5 billion** to improve flood protection for just the following six communities:
  - Sacramento
  - West Sacramento
  - Stockton
  - Lathrop
  - Marysville/Plumas Lakes
  - Yuba City

\$400 million for West Sacramento alone!



- California State Bonds Provide an Initial \$4.89 Billion in Flood Control Funding
- California Submitted FY09 Federal Funding Requests
  - To the Army Corps of Engineers for 27 critical flood control projects
  - Two of these requests are for studies that are essential to engaging the Corps in developing a comprehensive plan to improve flood control in the Central Valley
    - Sacramento and San Joaquin River Basins Comprehensive Study
    - Sacramento River Flood Control System Evaluation
  - Until these two studies have been completed, the Central Valley's system-wide flood control improvements and the resulting total costs are uncertain



# What we want to avoid!



Any questions?