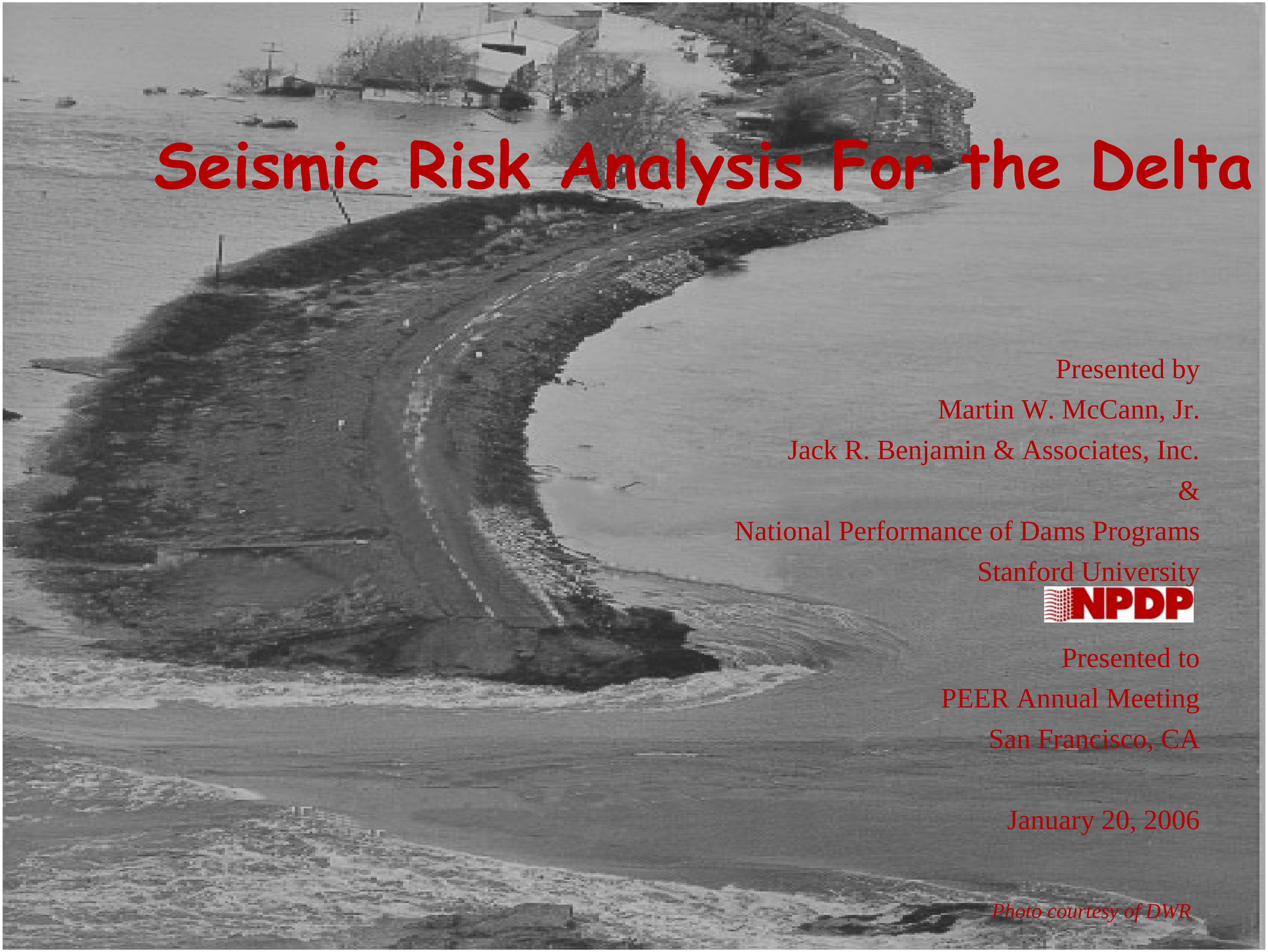

Seismic Risk Analysis For the Delta

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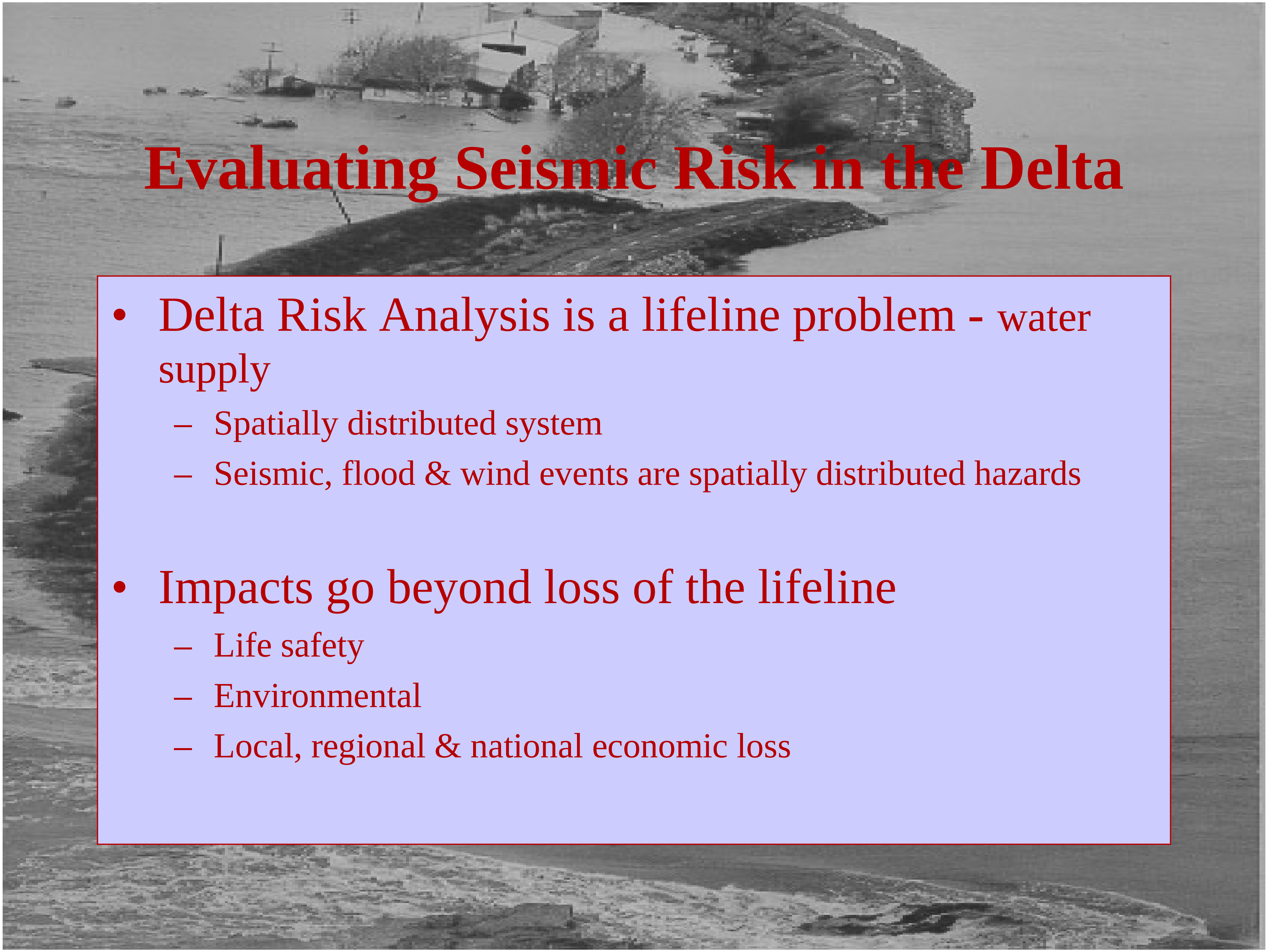
Photo courtesy of DWR

Topics

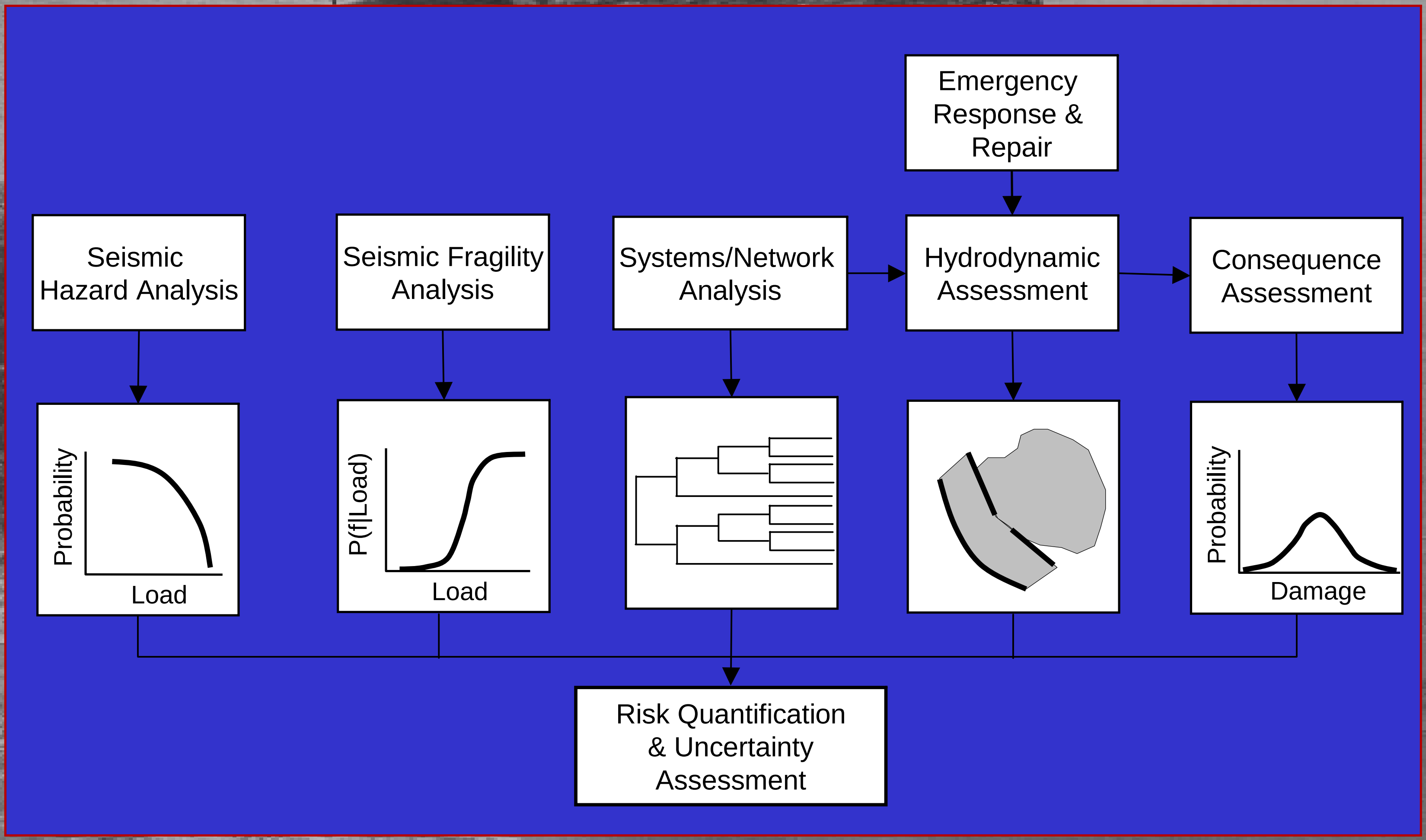
- Evaluating Seismic Risk in the Delta
- Preliminary Seismic Risk Analysis
- Delta Risk Management Strategy Analysis



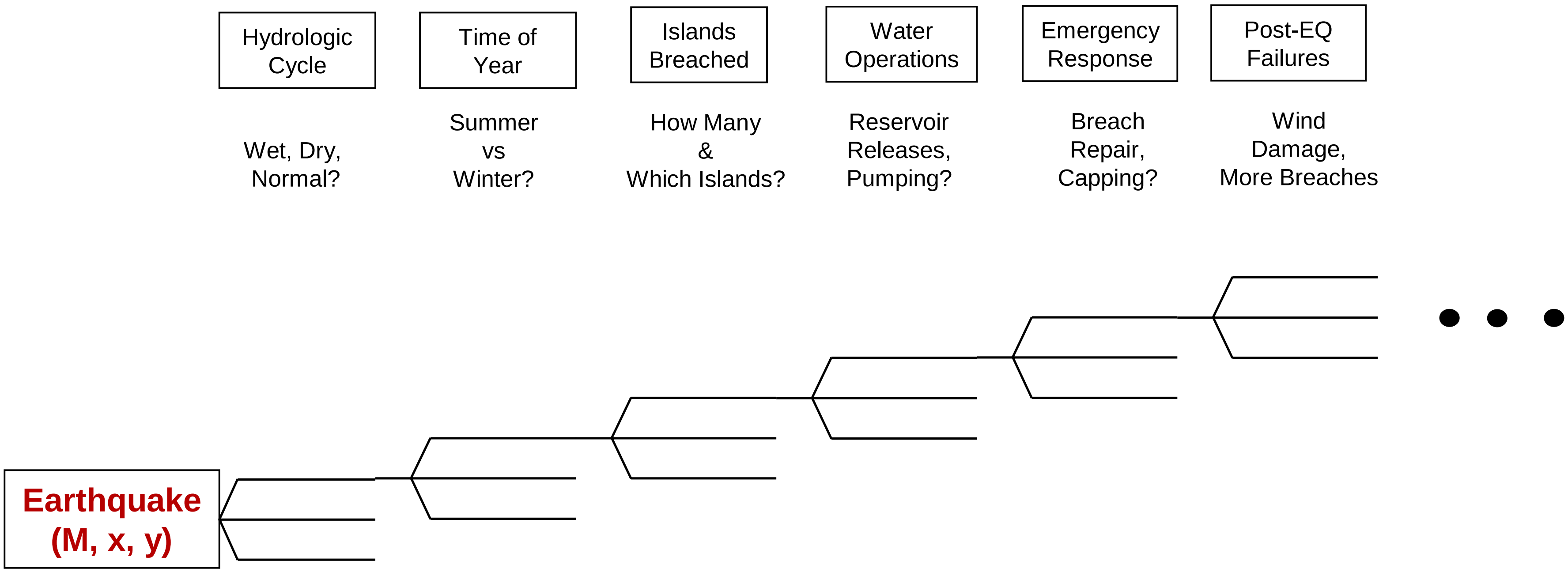
Evaluating Seismic Risk in the Delta

- Delta Risk Analysis is a lifeline problem - water supply
  - Spatially distributed system
  - Seismic, flood & wind events are spatially distributed hazards
- Impacts go beyond loss of the lifeline
  - Life safety
  - Environmental
  - Local, regional & national economic loss

Evaluating Seismic Risk in the Delta



When the Earthquake Occurs

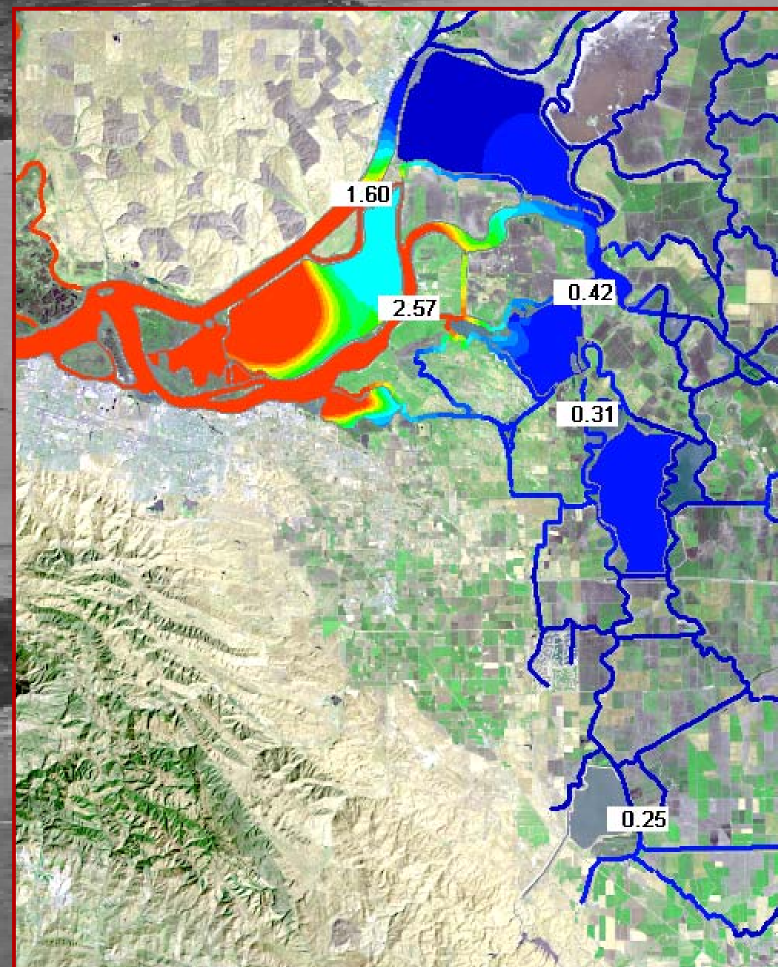


When the Earthquake Occurs

Hydrodynamic Response	Frequency	Life Safety	Export Disruption	In-Delta Impacts	State Impact	National Impact	Environmental
	ν_1	$F(L > l)_1$	$F(T_D > t)_1$	$F(\$ > c)_1$	$F(\$ > c)_1$	$F(\$ > c)_1$	$F(E > e)_1$
• • •	ν_i	$F(L > l)_i$	$F(T_D > t)_i$	$F(\$ > c)_i$	$F(\$ > c)_i$	$F(\$ > c)_i$	$F(E > c)_i$
	ν_n	$F(L > l)_n$	$F(T_D > t)_n$	$F(\$ > c)_n$	$F(\$ > c)_n$	$F(\$ > c)_n$	$F(E > e)_n$

When Levees Breach in the Delta

Salt Water Intrusion - Because islands are below sea level, salt water from San Pablo Bay fills the void that is created as the island(s) flood.



When Levees Breach in the Delta

Emergency Response – Efforts to repair the breaches, must cap the ends with rock to prevent further erosion; then breaches must be closed.

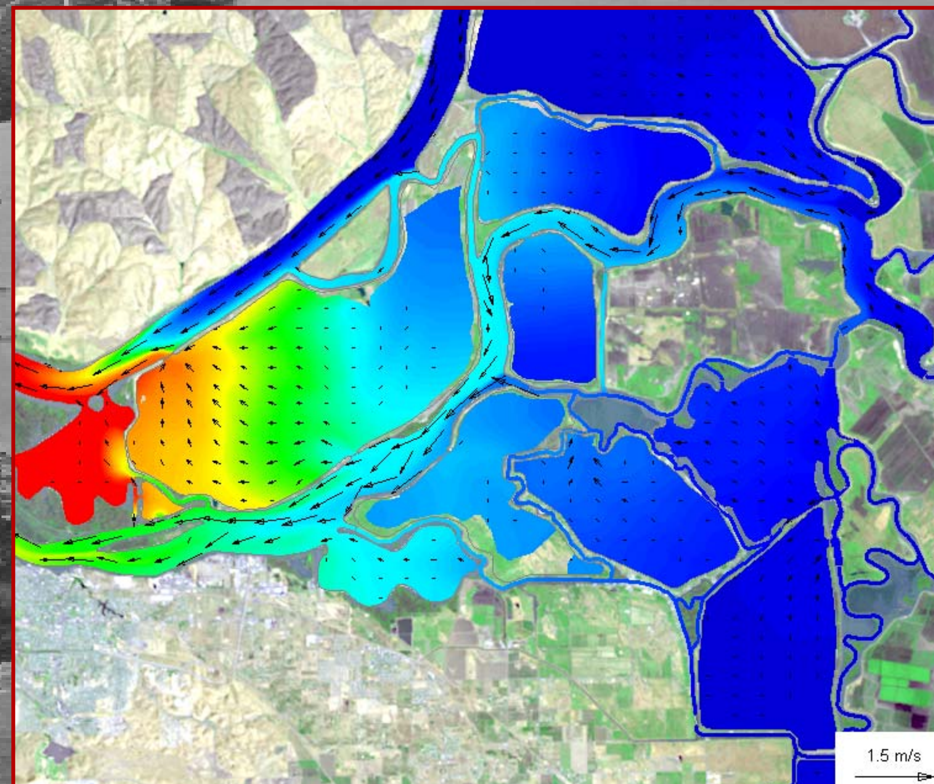
Close Breaches - Breaches are closed by dumping rock into the scour hole (50-90 feet deep).

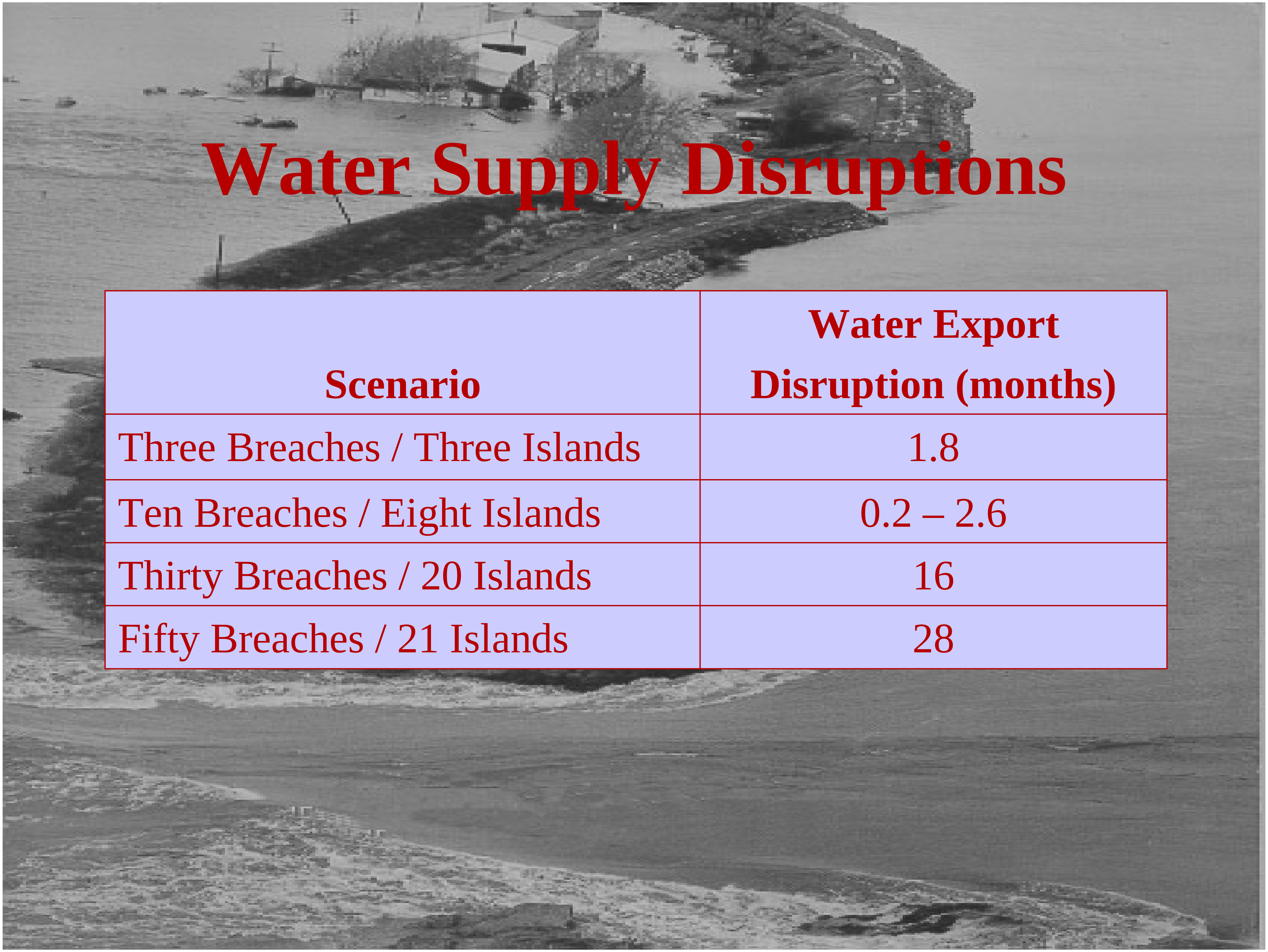
When Levees Breach in the Delta

Tidal Exchange – As the islands remain open, the tides contribute to continued mixing of salt water.

Trapping - Salt can be trapped in the middle and south Delta – flushing depends on breach repair sequence, releases, etc.

Wind Damage – The interior of islands can be damaged from wind waves generated on the flooded islands.



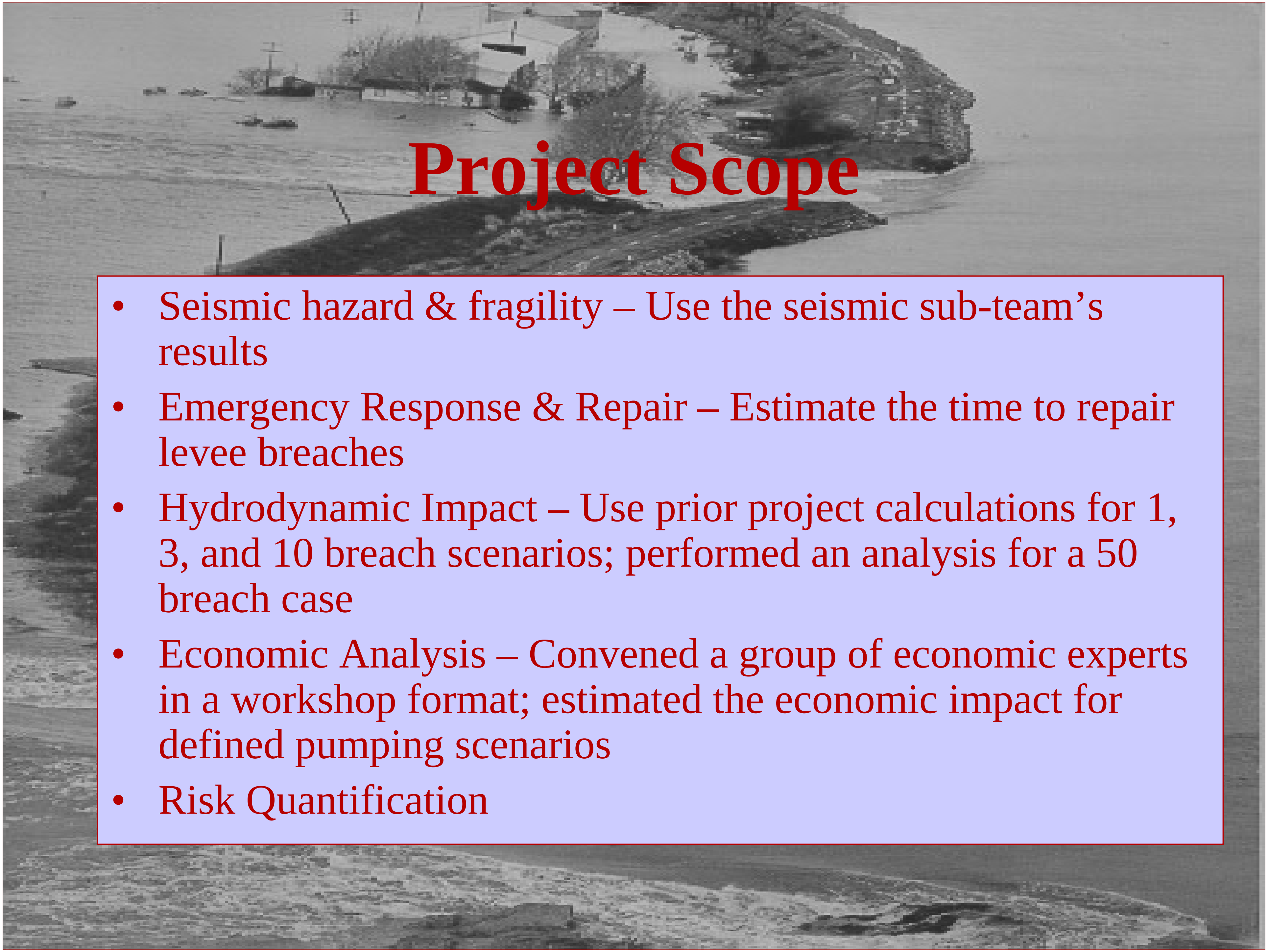


Water Supply Disruptions

Scenario	Water Export Disruption (months)
Three Breaches / Three Islands	1.8
Ten Breaches / Eight Islands	0.2 – 2.6
Thirty Breaches / 20 Islands	16
Fifty Breaches / 21 Islands	28

Preliminary Seismic Risk Analysis

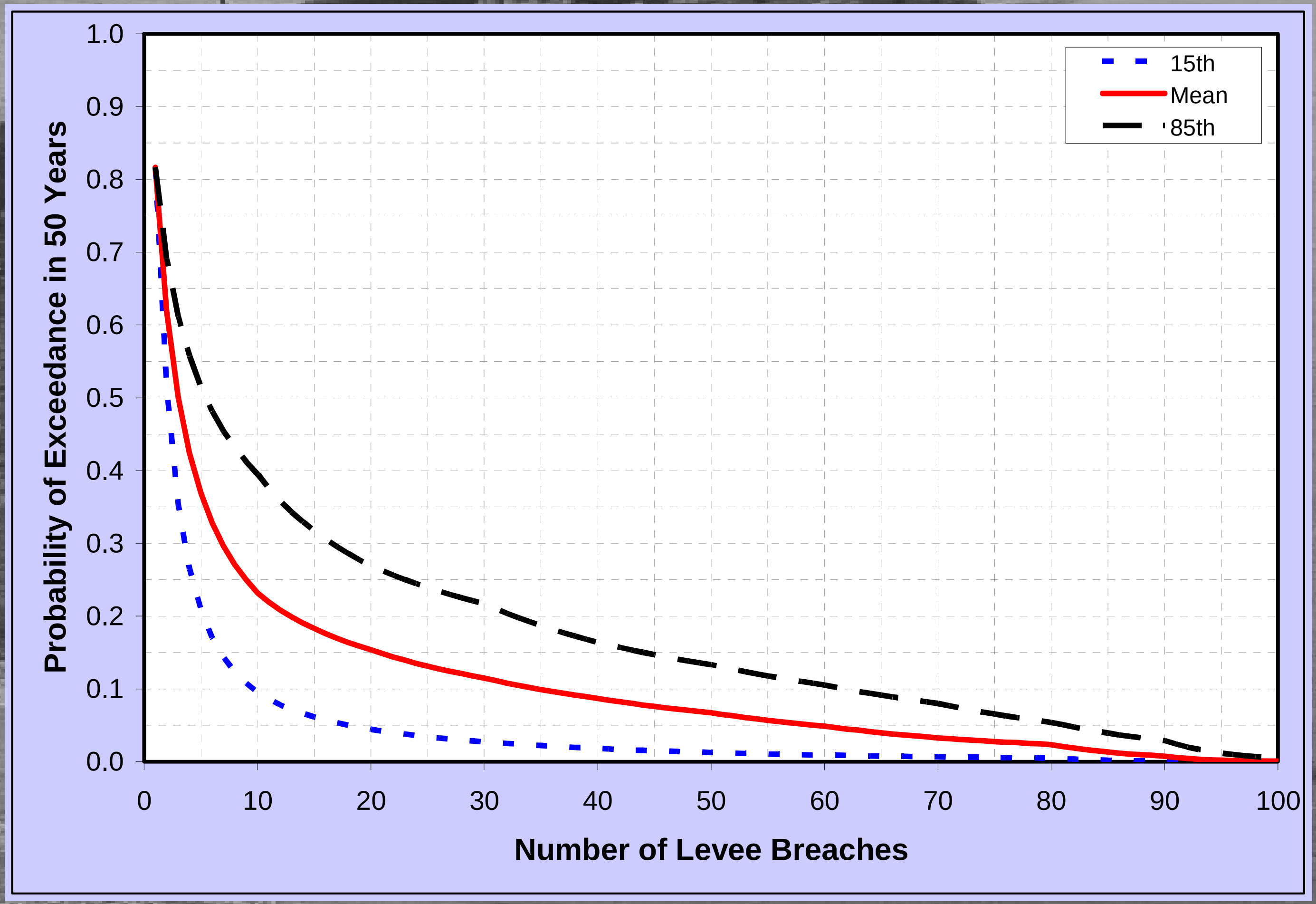
- Initial study conducted to get an initial assessment of the economic impact to the state
- Relied principally on existing information / studies
- Conducted a first-order expert elicitation to estimate the economic consequences



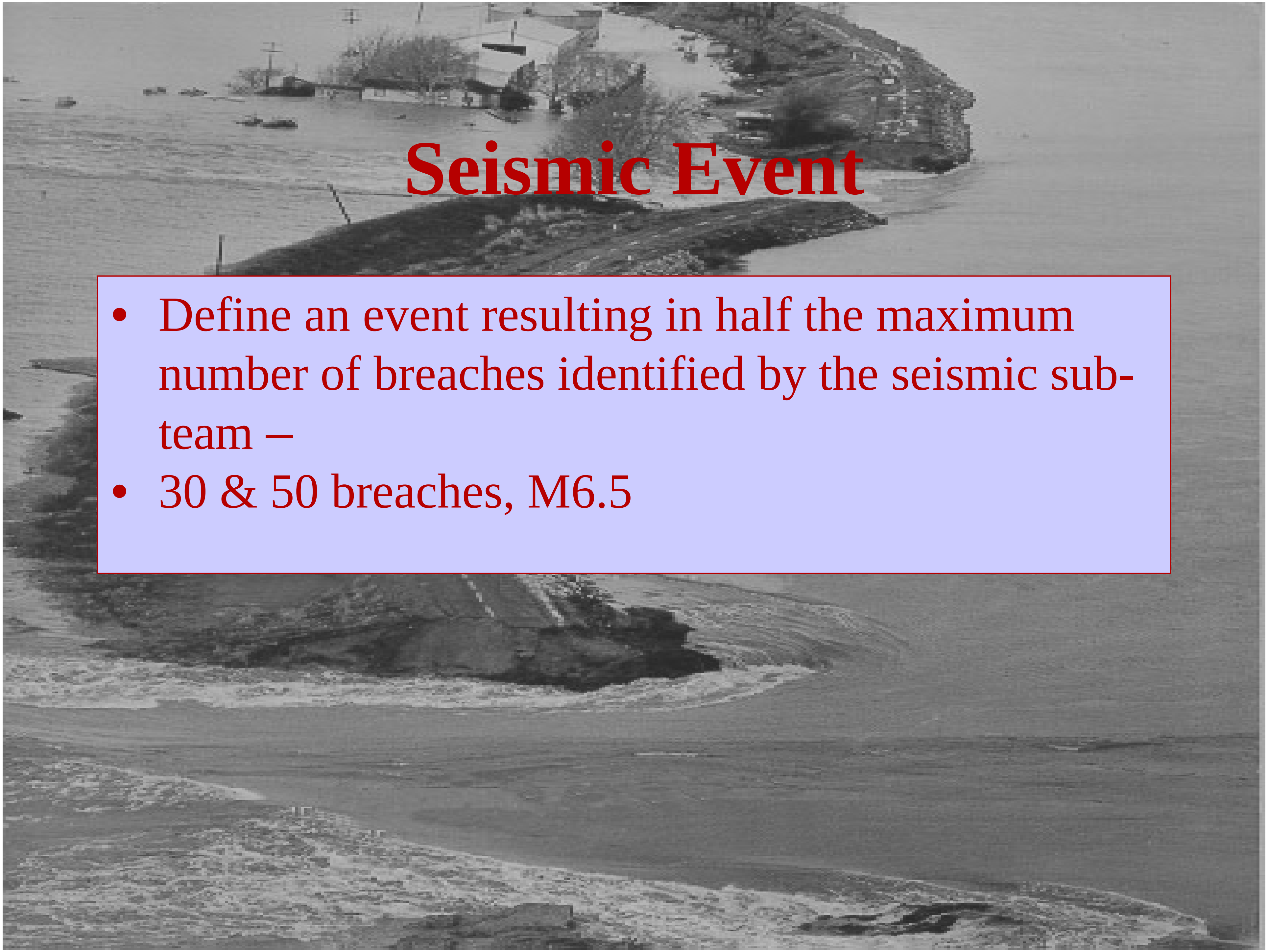
Project Scope

- Seismic hazard & fragility – Use the seismic sub-team's results
- Emergency Response & Repair – Estimate the time to repair levee breaches
- Hydrodynamic Impact – Use prior project calculations for 1, 3, and 10 breach scenarios; performed an analysis for a 50 breach case
- Economic Analysis – Convened a group of economic experts in a workshop format; estimated the economic impact for defined pumping scenarios
- Risk Quantification

Levee Seismic Risk

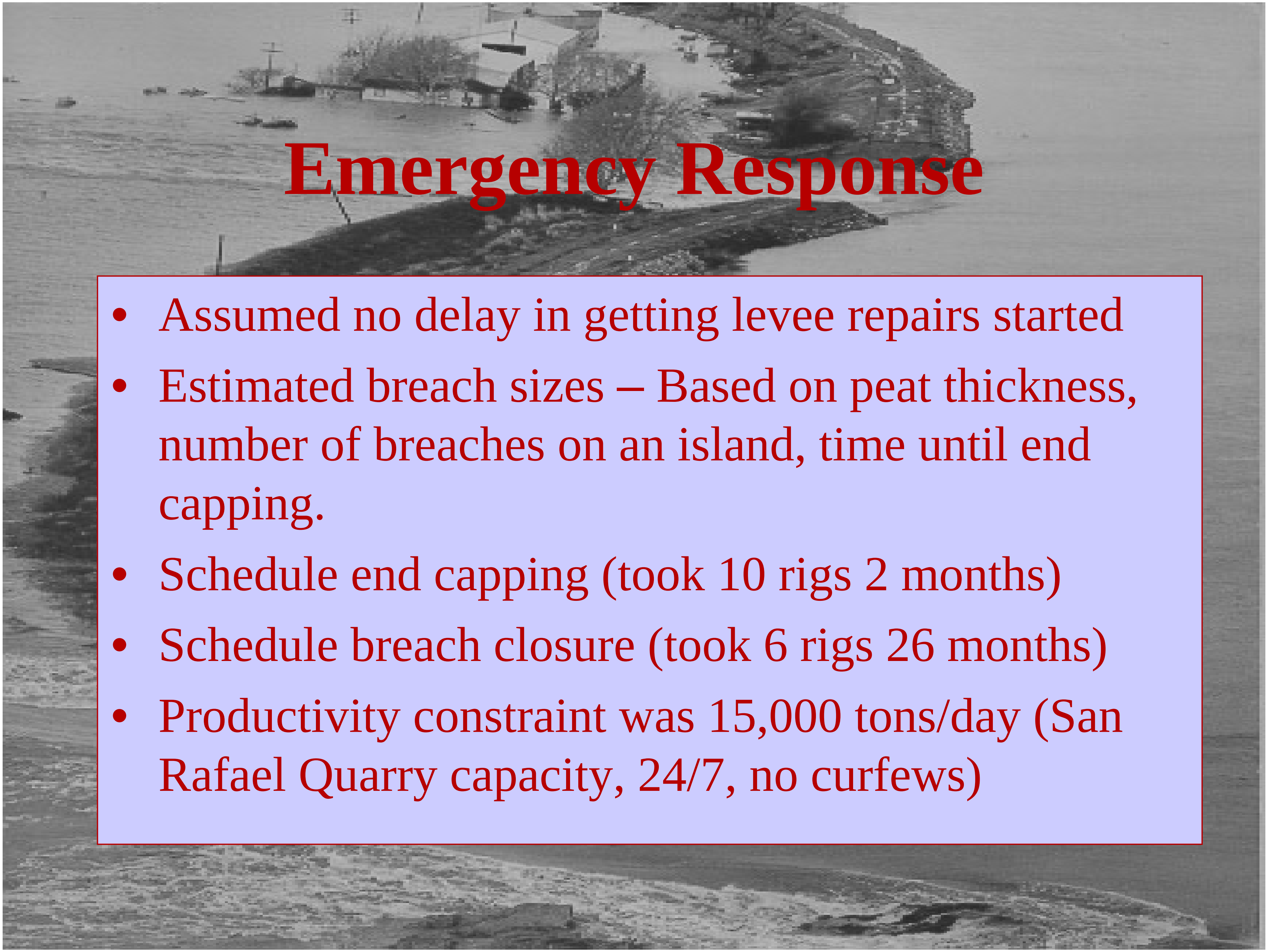


Ref. CALFED (2000)



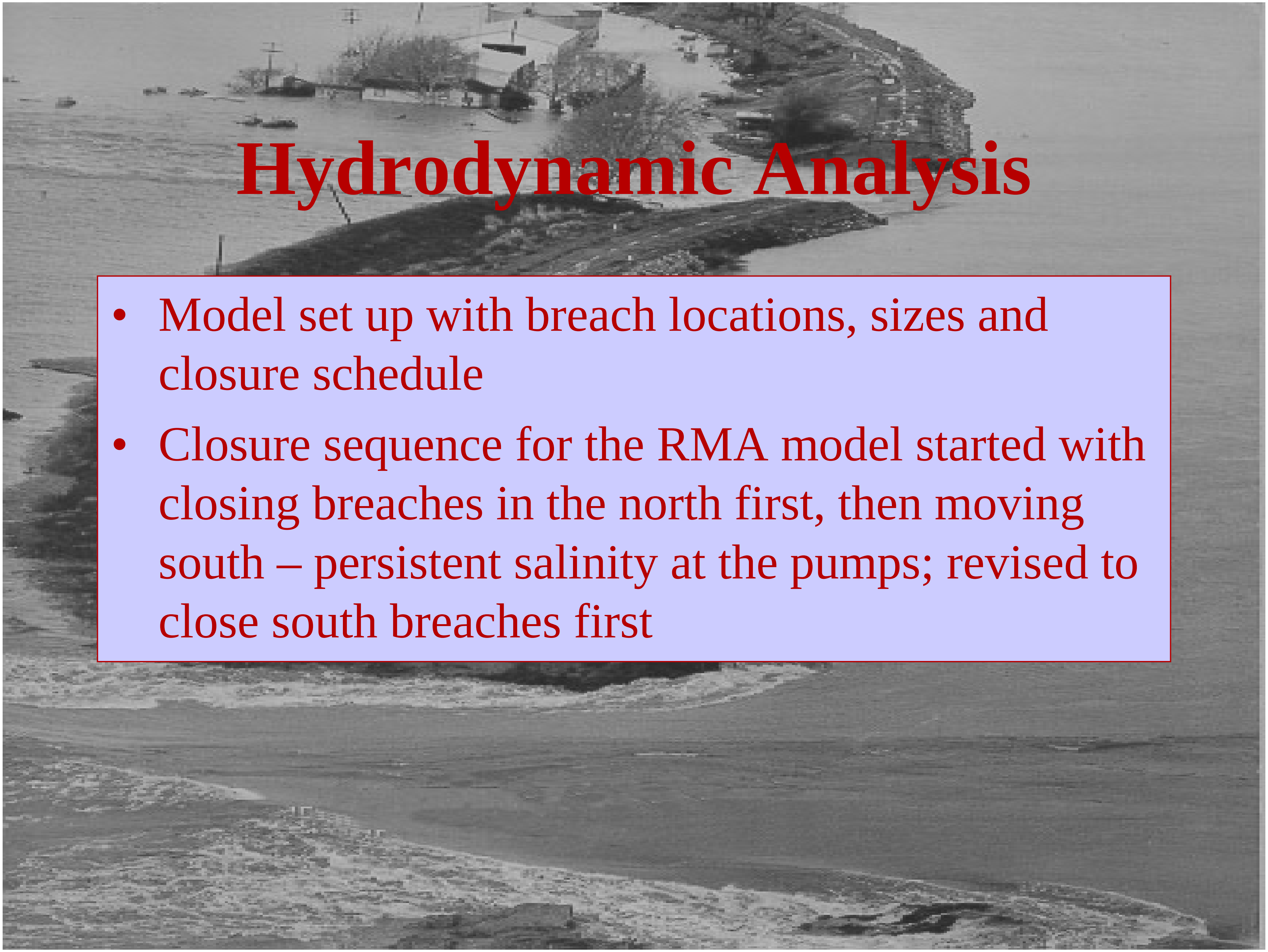
Seismic Event

- Define an event resulting in half the maximum number of breaches identified by the seismic sub-team –
- 30 & 50 breaches, M6.5



Emergency Response

- Assumed no delay in getting levee repairs started
- Estimated breach sizes – Based on peat thickness, number of breaches on an island, time until end capping.
- Schedule end capping (took 10 rigs 2 months)
- Schedule breach closure (took 6 rigs 26 months)
- Productivity constraint was 15,000 tons/day (San Rafael Quarry capacity, 24/7, no curfews)



Hydrodynamic Analysis

- Model set up with breach locations, sizes and closure schedule
- Closure sequence for the RMA model started with closing breaches in the north first, then moving south – persistent salinity at the pumps; revised to close south breaches first

Hydrodynamic Results

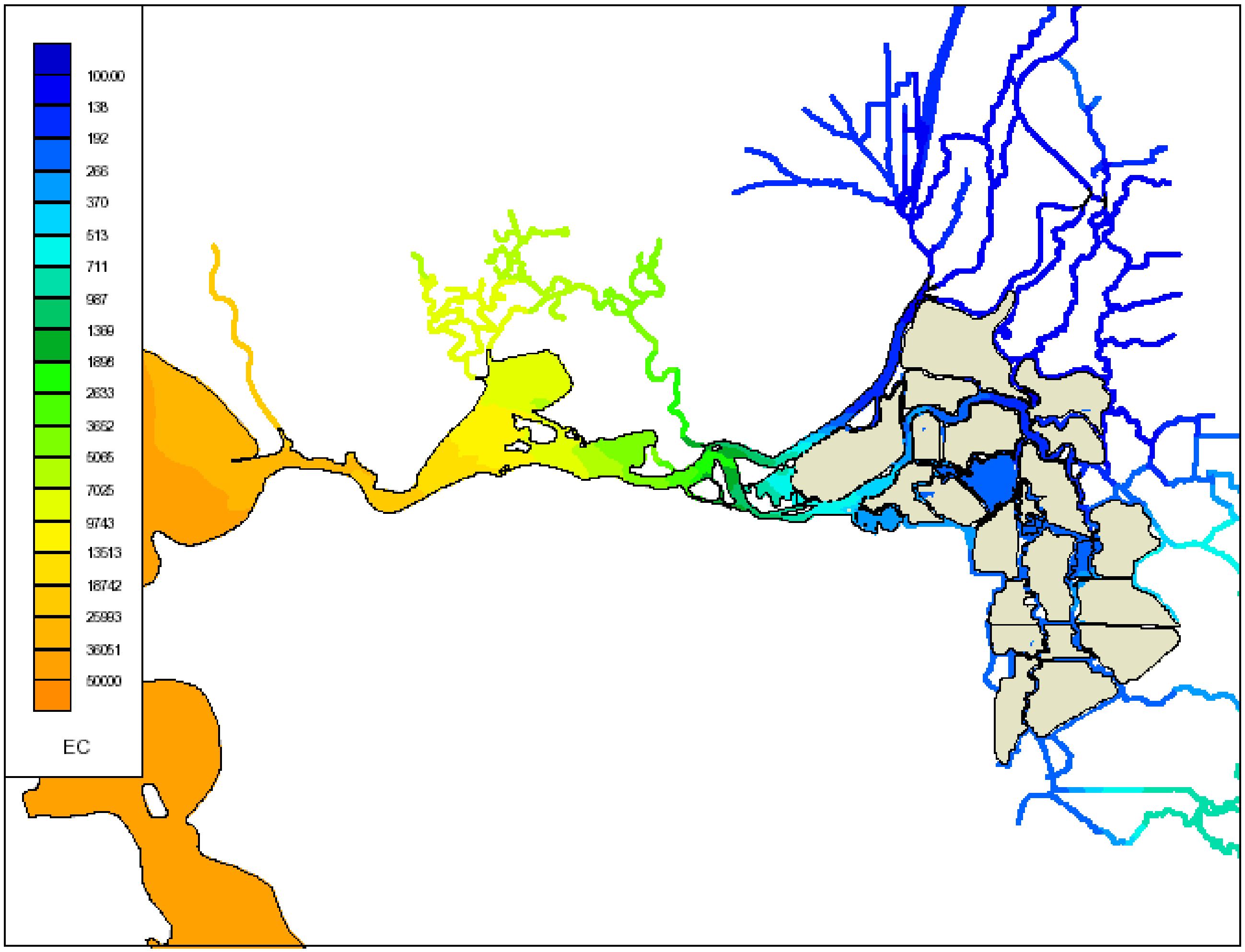


Figure 3-17 EC contour plot for 50 breach case on July 1, 2002, hour 0000 (just before breach event occurs).

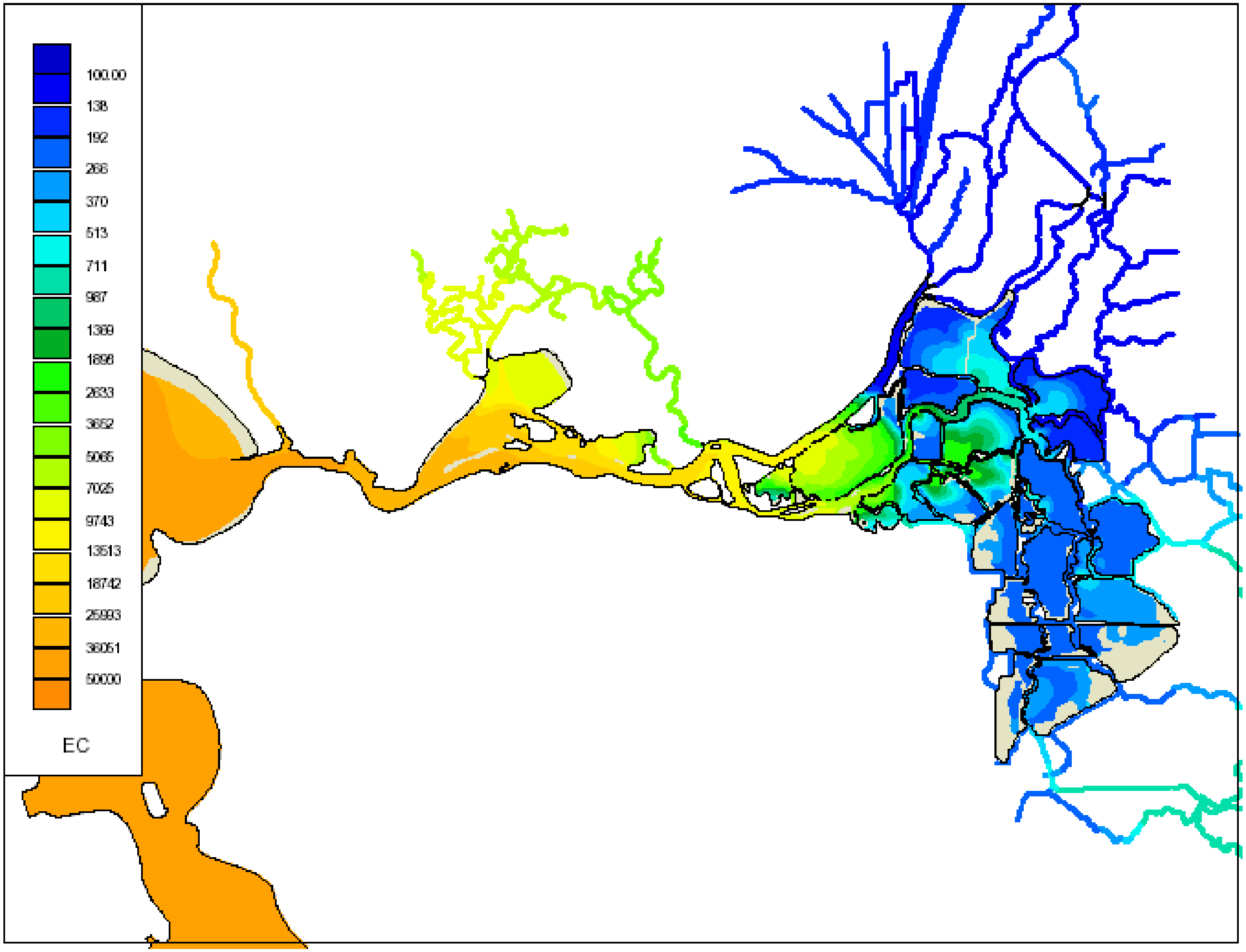


Figure 3-18 EC contour plot for 50 breach case on July 1, 2002, hour 1200.

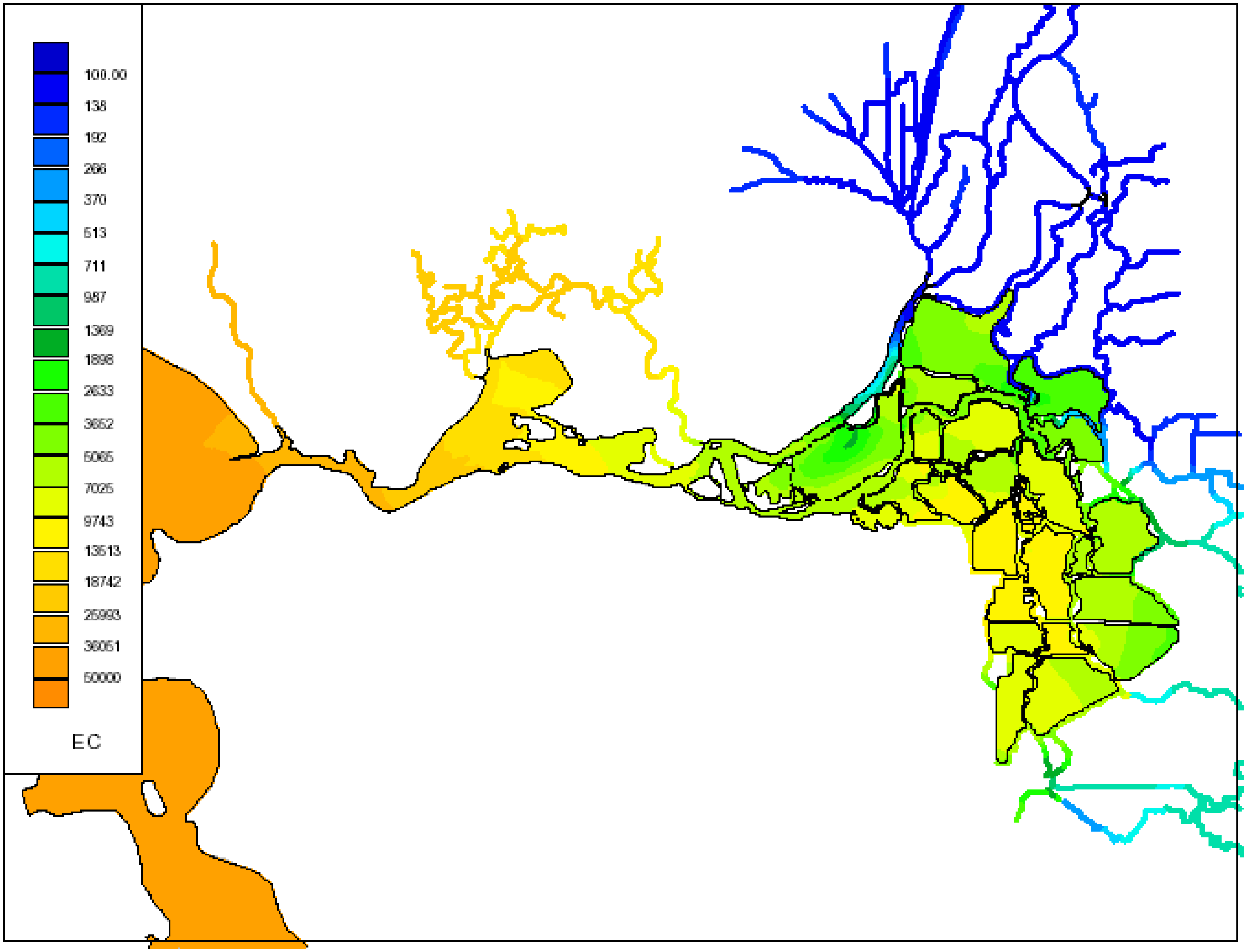


Figure 3-22 EC contours for 50 breach case on August 1, 2002, hour 0000.

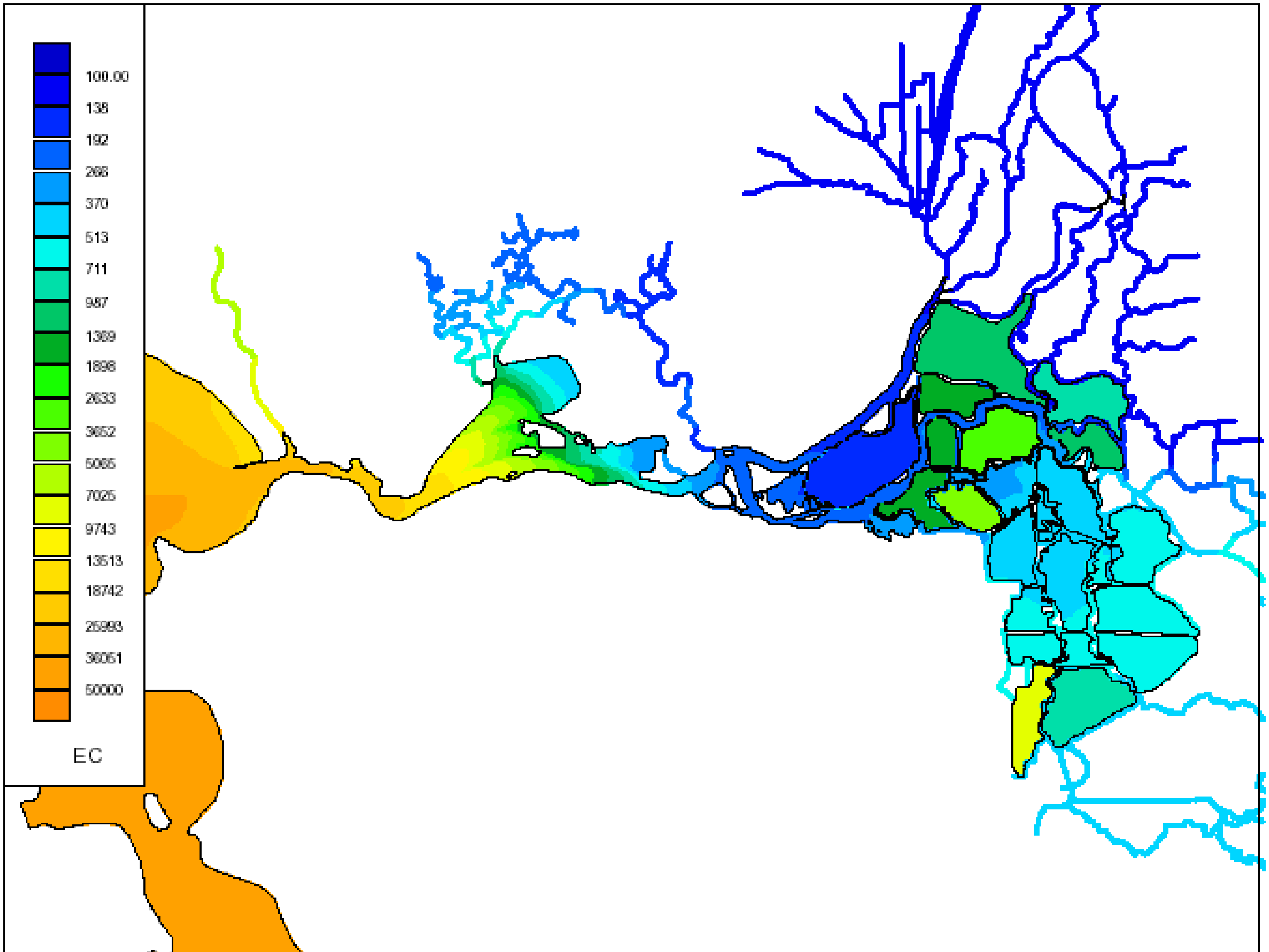
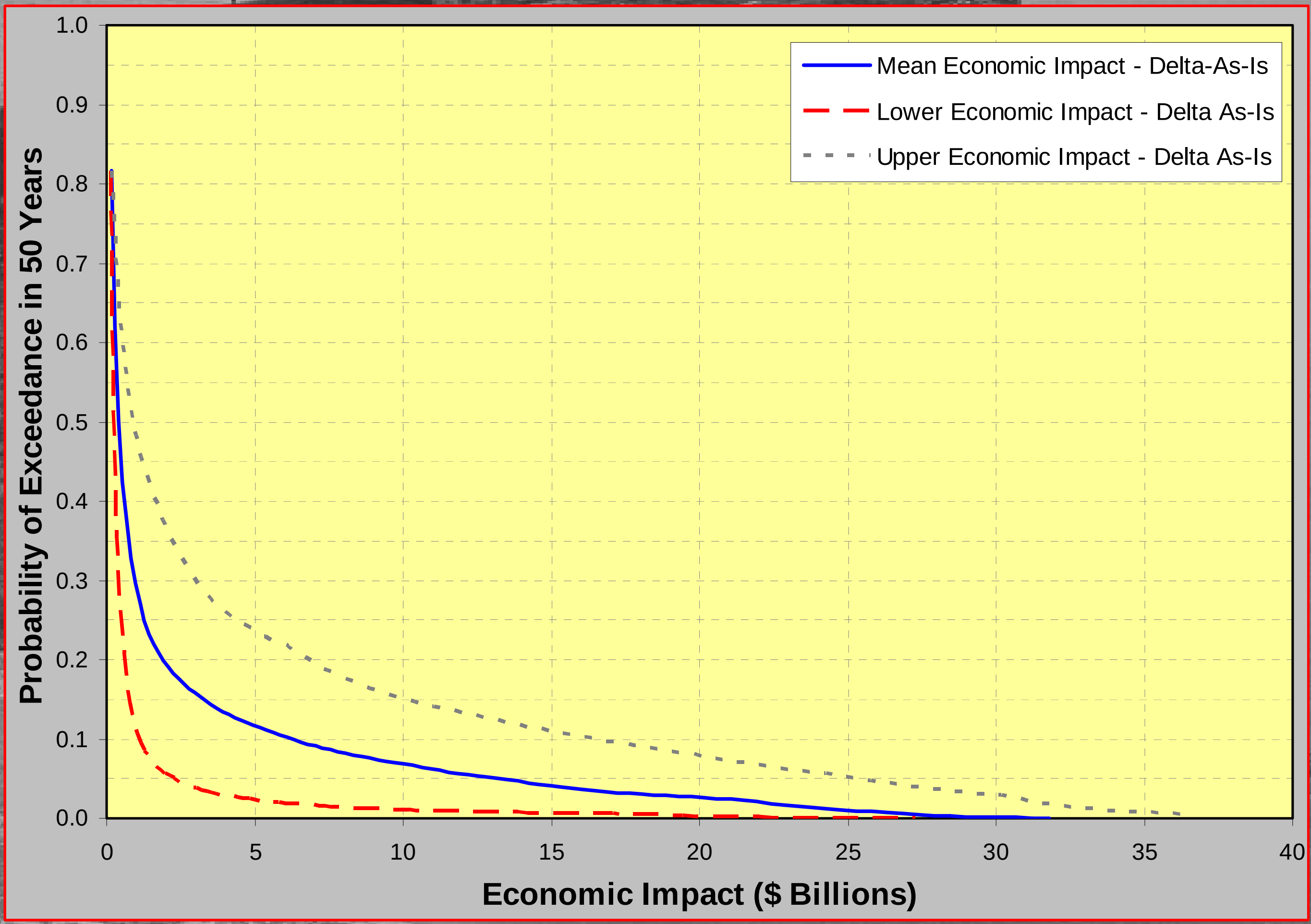


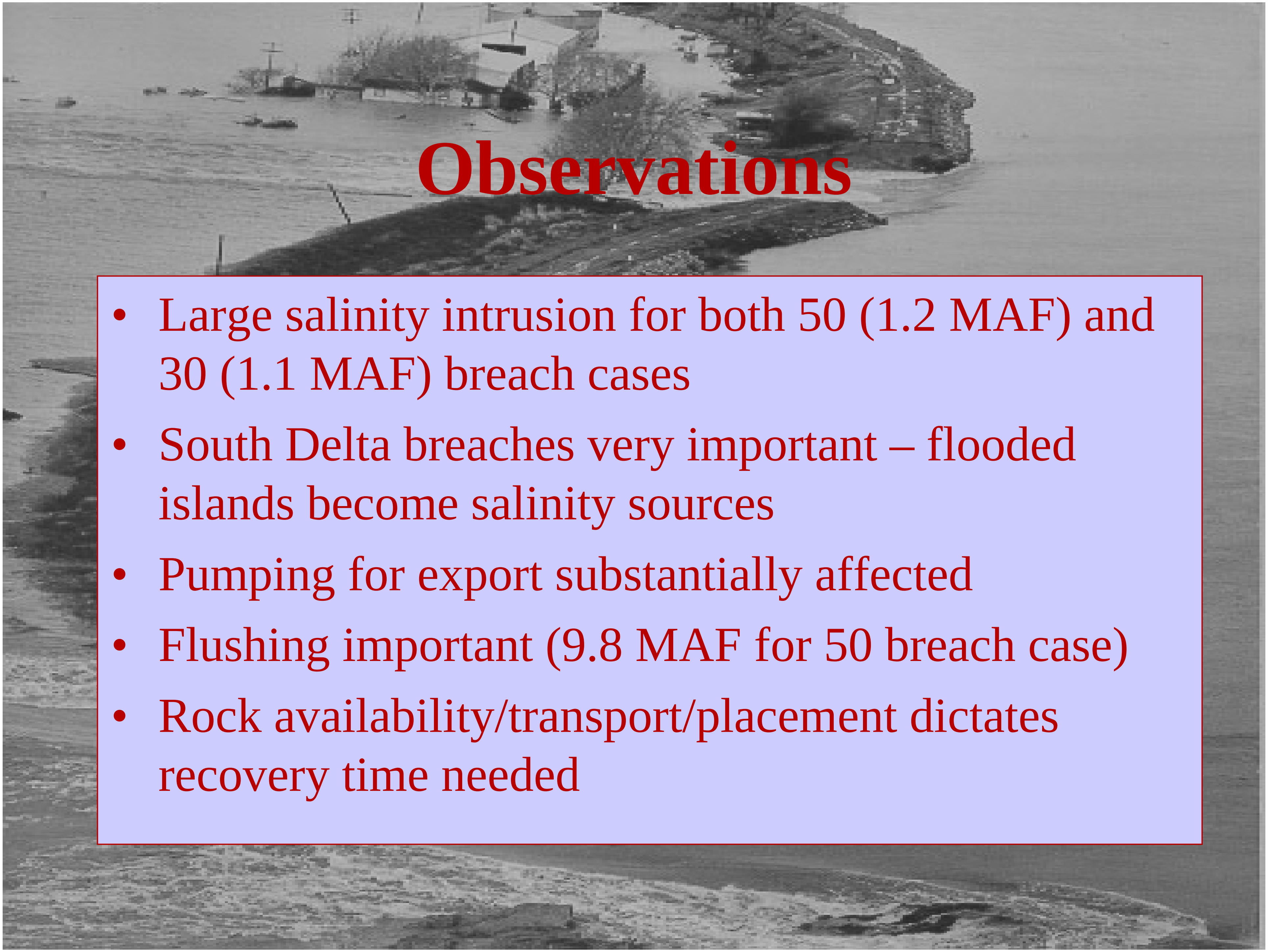
Figure 3-26 EC contours for 50 breach case on July 1, 2004, hour 0000.

Economic Analysis

- Four economists participated in a two-day workshop to estimate the impact and costs associated with the 30 and 50 breach scenarios.
- Analysis supported by input from water contractors and users.
- Evaluation involved economic analysis and expert assessment (seismic scenario went beyond modeling experience).

Economic Risk





Observations

- Large salinity intrusion for both 50 (1.2 MAF) and 30 (1.1 MAF) breach cases
- South Delta breaches very important – flooded islands become salinity sources
- Pumping for export substantially affected
- Flushing important (9.8 MAF for 50 breach case)
- Rock availability/transport/placement dictates recovery time needed

Observations (cont.)

- Economic impacts can vary significantly:
  - Among project contractors, depending on reserves on hand and other water supplies
  - Time of year of the earthquake can increase /decrease impacts
  - Dry water year in one or more of the three event/recovery years will substantially increase impacts
  - Analysis underestimates the economic impacts

Delta Risk Management Strategy

- URS/JBA team & 20± partners selected to conduct the DRMS
- Analysis of risks for seismic, flood, wind, other hazards
  - Economic, water supply, & environmental to be evaluated
- Technical (deterministic/probabilistic) modeling & expert elicitations
- Future time periods of 50 & 100 years to be evaluated
- Alternative risk-reduction/management strategies to be evaluated