Potential Impacts of Large-Scale Delta Levee Failure on BDCP Restoration and Intake Investments

RMA Model Analysis
Modeling Summary

Two sets of analyses were performed:

- Breach event – short-term (4-month) simulation with simultaneous breaching of all affected islands to determine peak salinity intrusion
- Long-term (two-year) simulation starting with islands already breached to evaluate long term effects on salinity and tidal range

Simulations performed with no sea level rise and with extreme sea level rise of 140 cm (note that ROA geometry was originally developed for up to 45 cm SLR and other model geometry was not extended to represent the shoreline change with SLR)
Navigating Sea Level Rise Uncertainty

BCDC 2009
USACE 2009
Delta Vision/CALFED ISB 2009
DWR/CAT 2009
OCAP BA 2008/BOs 2008-09
DRMS 2009
IPCC 2007

45 cm (18 inches)
15 cm (6 inches)

Sea Level Change (cm)

1900  1950  2000  2050  2100
Short-Term Breach Event Model Assumptions

-Simulations were run September – December 1990
-Initial conditions taken from long-term “no breach” simulations
-Breach event occurs on October 1, 1990 at 1:00 AM
-Two failure scenarios are considered, all include LLT restoration:
  • 3 Island failure scenario (plus Grizzly Island failures)
  • Hayward failure scenario (plus Grizzly Island failures)
-Two tidal boundaries are considered
  • Historical Golden Gate tide (no sea level rise)
  • Historical Golden Gate tide plus 140 cm sea level rise
-South Delta Exports turned off for one week following breach event, then ramped back up for one week
Base Scenario – LLT
Restoration Only

3 Island Scenario

Hayward Scenario

Red areas are not flooded
Sep 30, 1990 @ 24:00
Pre-Breach Event

No Sea Level Rise

140 cm Sea Level Rise
Oct 7, 1990 @ 19:00
Three Island Event

No Sea Level Rise

140 cm Sea Level Rise
Oct 7, 1990 @ 19:00
Hayward Event

No Sea Level Rise

140 cm Sea Level Rise
Export Flows, Sep 1 to Dec 31, 1990
Levee Breach Event vs. No Breach

Export Flows (cfs)

Breach Event, Exports OFF
Transition Exports ON
Resume Full Exports

CVP, No Break
CVP, With Break
SWP No Break
SWP, With Break
Isolated Facility, No Break
Isolated Facility, With Break

Sep1990
Oct1990
Nov1990
Dec1990
Tidally Averaged EC, Sep 1 to Dec 31, 1990
Base, 3 Is Event, Hayward Event
Isolated Facility

Tidally Averaged EC, UMHOS/CM

- BASE_PP-LLT
- BASE_PP-LLT+SLR140CM
- 3ISEVENT_PP-LLT
- 3ISEVENT_PP-LLT+SLR140CM
- HAYWARDEVENT_PP-LLT
- HAYWARDEVENT_PP-LLT+SLR140CM

Isolated Facility

Graph showing EC values from Sep 1 to Dec 31, 1990 for different scenarios related to the Isolated Facility.
Tidally Averaged EC, Sep 1 to Dec 31, 1990
Base, 3 Is Event, Hayward Event
RSAN018 – Jersey Point
Tidally Averaged EC, Sep 1 to Dec 31, 1990
Base, 3 Is Event, Hayward Event

SWP
Tidally Averaged EC, Sep 1 to Dec 31, 1990
No Breach, 3 Is Event, Hayward Event
CVP
Long-Term Levee Failure Analysis
Model Assumptions

-Simulations were run January 1989 – December 1990 plus a three month spin-up

-Breach event is not simulated – simulations start with breaches open

-Three failure scenarios are considered, all include LLT restoration:
  • No levee failure (all breaches closed)
  • 3 Island failure scenario (plus Grizzly Island failures)
  • Hayward failure scenario (plus Grizzly Island failures)

-Three tidal boundaries are considered
  • Historical Golden Gate tide (no sea level rise)
  • Historical Golden Gate tide plus 140 cm sea level rise
  • Historical Golden Gate tide plus 140 cm sea level rise with 5% amplitude increase (this case not yet complete)
Long-Term Levee Failure Analysis
Model Assumptions (cont.)

- First iteration simulations use all PP-LLT inflow and export boundary conditions with no modifications

- Second iteration simulations:
  • SWP and CVP exports turned off when EC at RMID015 or ROLD024 > 1090 umhos/cm
  • These export flows are transferred to the Isolated Facility up to its potential capacity
  • All scenarios reach the 1090 limit, requiring the second iteration, except the Hayward scenario with no SLR
• With 140 cm SLR, EC frequently exceeds 1090 umhos/cm, thus export adjustments are significant
• Without SLR, periods of export adjustment are brief for Base and 3 Island cases
• No export adjustments are made for the Hayward case with no SLR
2nd Iteration Export Adjustments
3 Island Failure + 140 cm SLR

Daily Average Flow (cfs)

ROLD024
EC = 1090

Daily Average EC (UMHOS/CM)

2nd Iteration
Export
Adjustments

Island Failure
+ 140 cm SLR
Clifton Court Intake Channel, SWP, 3 Island simulation:
• Export adjustment reduces south Delta EC for SLR 140 cm case.
North Bay Aqueduct, 3 Island simulation:
• Export adjustment tends to increase EC in the Cache Slough area for SLR 140 cm case.
Levee Failure Analysis
EC Results Summary

**Isolated facility**
- EC is not impacted by open breaches, 140 cm sea level rise or export adjustments

**Cache Slough area**
- EC is significantly increased by 140 cm sea level rise
- Open breaches results in decreased EC or minor EC increases in this area
- Export adjustments increase EC in this area

**South Delta**
- EC is significantly increased by 140 cm sea level rise
- Open breaches result in decreased EC or minor EC increases in this area
- Reduction of south Delta exports reduces EC for sea level rise cases
- Due to small changes in exports for the cases without SLR, EC changes are small
- With SLR, export reduction is less effective in reducing EC in Old and Middle River for the Hayward case

**Montezuma Slough**
- EC is significantly increased by 140 cm sea level rise
- EC is significantly increased by both failure scenarios
- Grizzly Island failures are the same for both scenarios, thus results are similar
Isolated Facility:

• No significant impacts from SLR or Levee Failure.
RSAN018 – Jersey Point:

• 140cm SLR increases EC significantly at times.
• Differences between EC results with and without SLR are reduced due to export adjustments.
• With and without SLR, impacts of both breach cases vary seasonally.
• With SLR, the impacts of both failure cases vary seasonally.
• With SLR, the Hayward case is slightly less responsive to export reductions.
ROLDO24 – Old River at Rock Slough:
• 140cm SLR tends to increase EC.
• With no SLR, the Hayward case tends to decrease EC. Impacts of the 3 Island case vary seasonally.
• With SLR, both failure cases tend to decrease EC.
• With SLR, the Hayward case is less responsive to export reductions.
Clifton Court Intake Channel, SWP:
• 140cm SLR tends to increase EC.
• With no SLR, the Hayward case tends to decrease EC. Impacts of the 3 Island case vary seasonally.
• With SLR, both failure cases tend to decrease EC. Hayward case results in greatest decreases.
CVP:
• 140cm SLR tends to increase EC.
• With no SLR, the impact of both failure scenarios varies seasonally.
• With SLR, both failure cases tend to decrease EC. Hayward case results in greatest decreases.
• Export adjustments reduce SLR EC below no SLR EC at times.
Levee Failure Analysis

Tidal Marsh Impacts Summary

• Both breach cases reduce tidal range

• The Hayward case tends to have the greatest impact on tidal range

• In Suisun Marsh, the Grizzly Island breaches have the most important impact, thus results for both breach cases are similar

• Sea level rise shifts most of the ROA area to Below MLLW and leaves minimal area Above EHW

• With no sea level rise, breach cases reduce MHHW-EHW and MLLW-MHHW areas for all ROAs due to reduction in tidal range

• With 140 cm SLR, MLLW-MHHW areas for all ROAs are either reduced or show very little change

• Change in area between MLLW and EHW due to SLR depends on topography

• In some cases, the model boundaries limit the area above MHHW
Cache Slough Tidal Datum areas in Acres

<table>
<thead>
<tr>
<th></th>
<th>No SLR</th>
<th>140 cm SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>3 Island</td>
</tr>
<tr>
<td>Above EWH</td>
<td>12,275</td>
<td>12,899</td>
</tr>
<tr>
<td>MHHW-EHW</td>
<td>1,128</td>
<td>987</td>
</tr>
<tr>
<td>MLLW-MHHW</td>
<td>6,613</td>
<td>5,716</td>
</tr>
<tr>
<td>Below MLLW</td>
<td>6,397</td>
<td>6,811</td>
</tr>
</tbody>
</table>

Cache Slough:
- Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW
- Both breach cases reduce tidal range in Cache Slough
- The Hayward cases has slightly more impact on tidal range
Cache Slough ROA
No SLR

Above EHW
MHHW to EHW
MLLW to MHHW
Below MLLW
Cache Slough ROA
With 140 cm SLR

Above EHW
MHHW to EHW
MLLW to MHHW
Below MLLW
### Suisun Marsh Tidal Datum areas in Acres

<table>
<thead>
<tr>
<th></th>
<th>No SLR</th>
<th>140 cm SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>3 Island</td>
</tr>
<tr>
<td>Above EWH</td>
<td>1,449</td>
<td>2,608</td>
</tr>
<tr>
<td>MHHW-EHW</td>
<td>909</td>
<td>544</td>
</tr>
<tr>
<td>MLLW-MHHW</td>
<td>4,647</td>
<td>2,516</td>
</tr>
<tr>
<td>Below MLLW</td>
<td>9,088</td>
<td>10,423</td>
</tr>
</tbody>
</table>

Suisun Marsh:

• Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW

• Grizzly Island breaches significantly reduce the tidal range

• Delta breaches have minimal impact in Suisun Marsh in these cases
Suisun Marsh ROA
No SLR

Base

Above EHW
MHHW to EHW
MLLW to MHHW
Below MLLW

Hayward Failure
3 Island Failure
### West Delta Tidal Datum areas in Acres

<table>
<thead>
<tr>
<th></th>
<th>No SLR</th>
<th>140 cm SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>3 Island</td>
</tr>
<tr>
<td>Above EWH</td>
<td>322</td>
<td>344</td>
</tr>
<tr>
<td>MHHW-EHW</td>
<td>26</td>
<td>22</td>
</tr>
<tr>
<td>MLLW-MHHW</td>
<td>3,006</td>
<td>2,956</td>
</tr>
<tr>
<td>Below MLLW</td>
<td>880</td>
<td>907</td>
</tr>
</tbody>
</table>

West Delta:
- Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW
- Both breach cases slightly reduce tidal range in the West Delta ROA
- The Hayward cases has slightly more impact on tidal range
### Mokelumne-Cosumnes Tidal Datum areas in Acres

<table>
<thead>
<tr>
<th></th>
<th>No SLR</th>
<th>140 cm SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>3 Island</td>
</tr>
<tr>
<td>Above EWH</td>
<td>1,997</td>
<td>2,093</td>
</tr>
<tr>
<td>MHHW-EHW</td>
<td>235</td>
<td>233</td>
</tr>
<tr>
<td>MLLW-MHHW</td>
<td>1,382</td>
<td>1,241</td>
</tr>
<tr>
<td>Below MLLW</td>
<td>1,405</td>
<td>1,451</td>
</tr>
</tbody>
</table>

**Mokelumne-Cosumnes:**
- **Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW**

- **Both breach cases slightly reduce tidal range in the Mokelumne-Cosumnes ROA**

- **The Hayward cases has slightly more impact on tidal range**

![Graph showing tidal stage over time for Snodgrass Sl North of McCormack Williamson Tract]
East Delta Tidal Datum areas in Acres

<table>
<thead>
<tr>
<th></th>
<th>No SLR</th>
<th>140 cm SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>3 Island</td>
</tr>
<tr>
<td>Above EWH</td>
<td>1,221</td>
<td>1,254</td>
</tr>
<tr>
<td>MHHW-EHW</td>
<td>105</td>
<td>90</td>
</tr>
<tr>
<td>MLLW-MHHW</td>
<td>171</td>
<td>154</td>
</tr>
<tr>
<td>Below MLLW</td>
<td>841</td>
<td>841</td>
</tr>
</tbody>
</table>

East Delta:
• Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW

• Both breach cases slightly reduce tidal range in the East Delta ROA

• The Hayward cases has slightly more impact on tidal range
South Delta Tidal Datum areas in Acres

<table>
<thead>
<tr>
<th></th>
<th>No SLR</th>
<th>140 cm SLR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Base</td>
<td>3 Island</td>
</tr>
<tr>
<td>Above EWH</td>
<td>10,207</td>
<td>10,332</td>
</tr>
<tr>
<td>MHHW-EHW</td>
<td>666</td>
<td>662</td>
</tr>
<tr>
<td>MLLW-MHHW</td>
<td>2,547</td>
<td>2,188</td>
</tr>
<tr>
<td>Below MLLW</td>
<td>9,065</td>
<td>9,303</td>
</tr>
</tbody>
</table>

South Delta:
• Small tidal range results in minimal area between MLLW and EHW with no SLR

• Sea level rise inundates much of the ROA shifting most of the area to Below MLLW

• Both breach cases reduce tidal range in the South Delta ROA

• The Hayward case has more impact on tidal range with extreme damping in Middle River

RMID023
Questions?