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

RMA Model Analysis

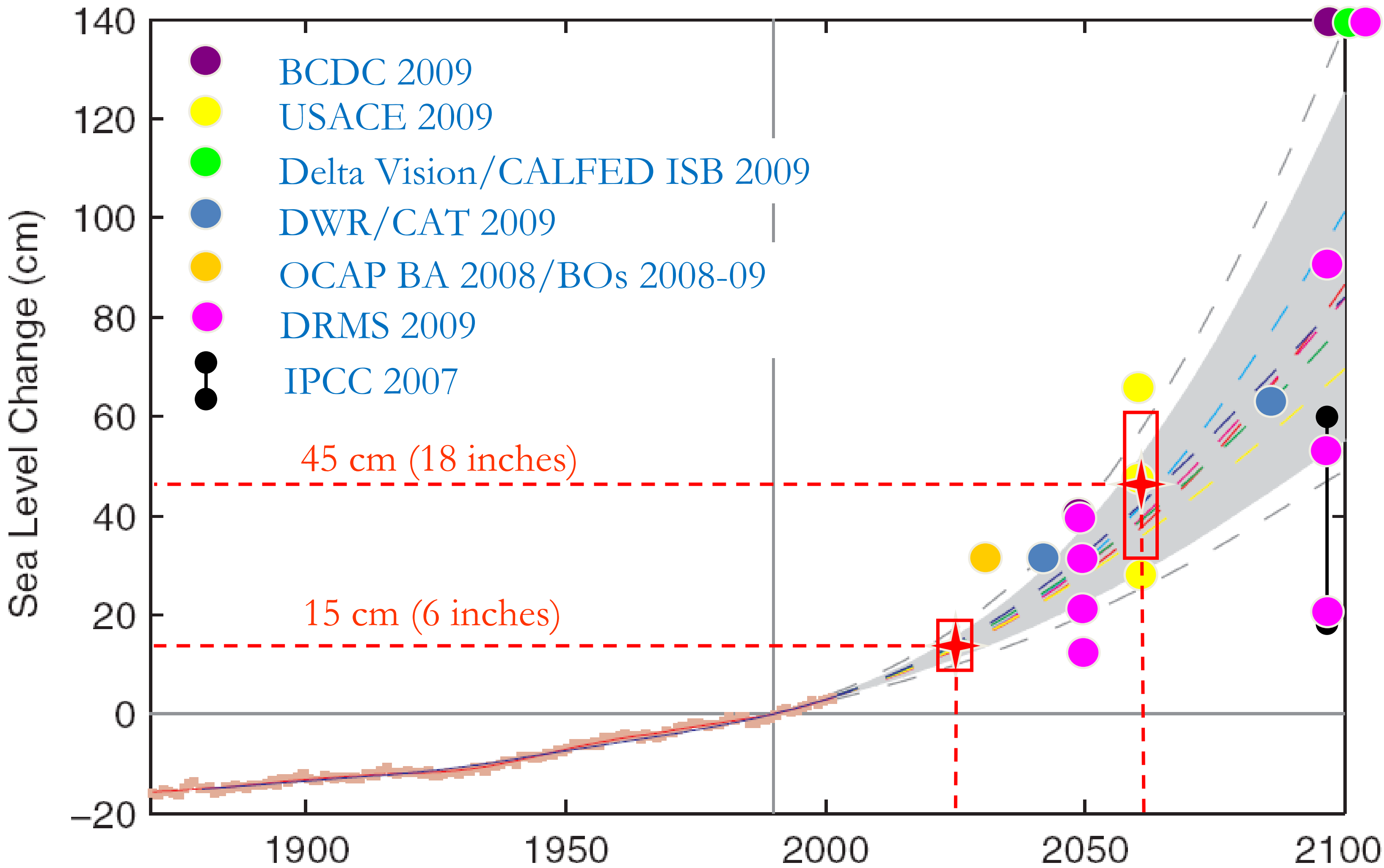
Modeling Summary

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



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:

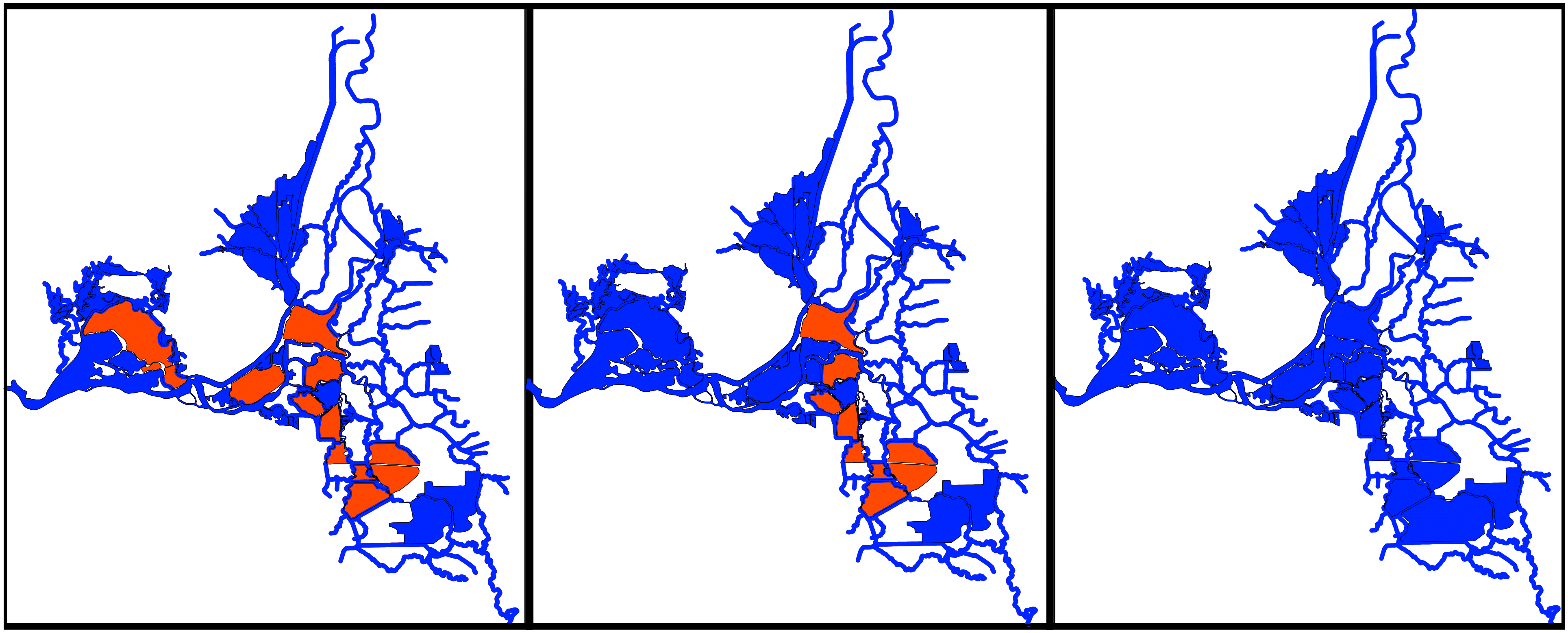
- 3 Island failure scenario (plus Grizzly Island failures)
- Hayward failure scenario (plus Grizzly Island failures)

-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

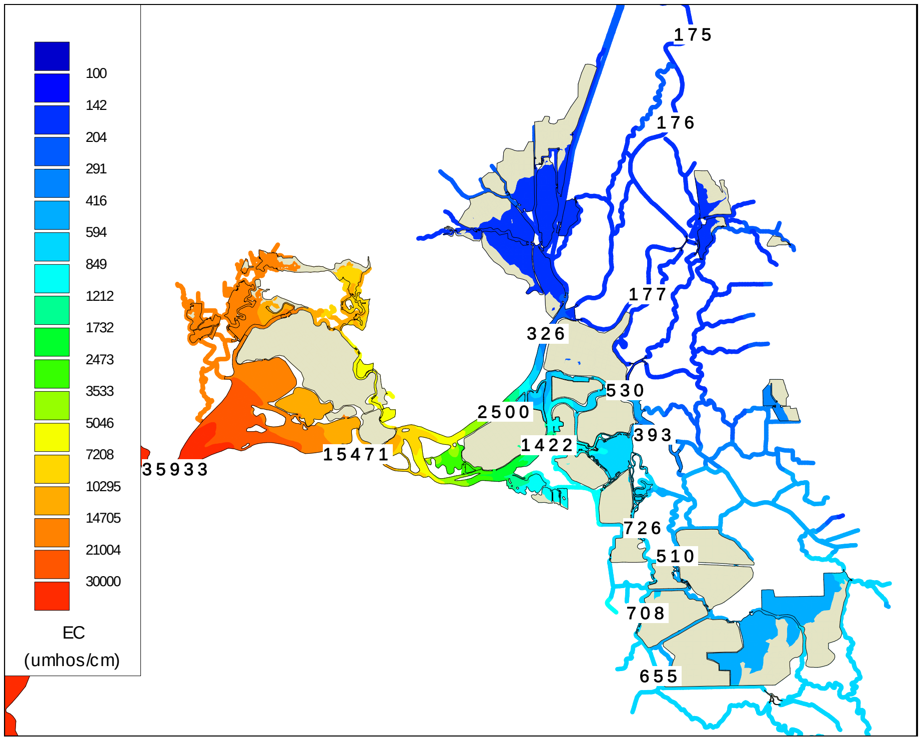
Base Scenario – LLT Restoration Only | **3 Island Scenario** | **Hayward Scenario**



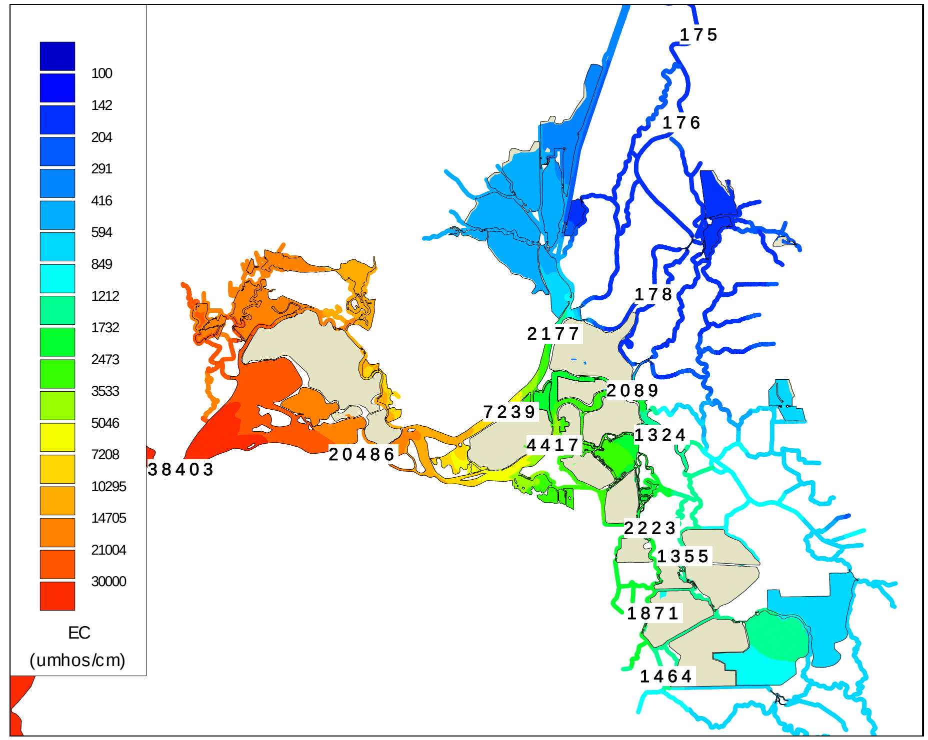
Red areas are not flooded

Sep 30, 1990 @ 24:00
Pre-Breach Event

No Sea Level Rise

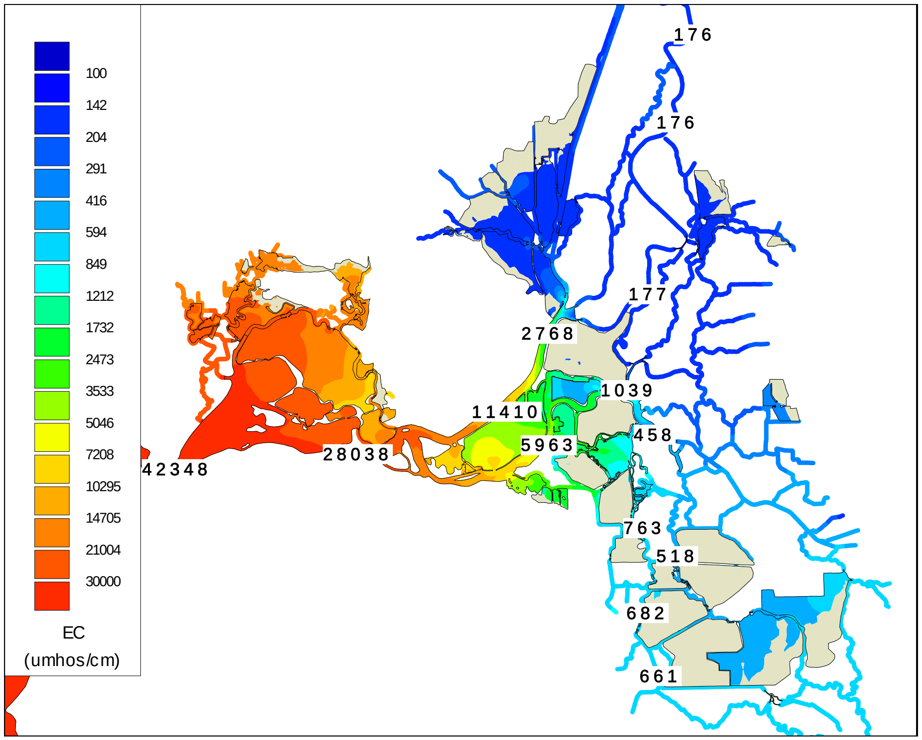


140 cm Sea Level Rise

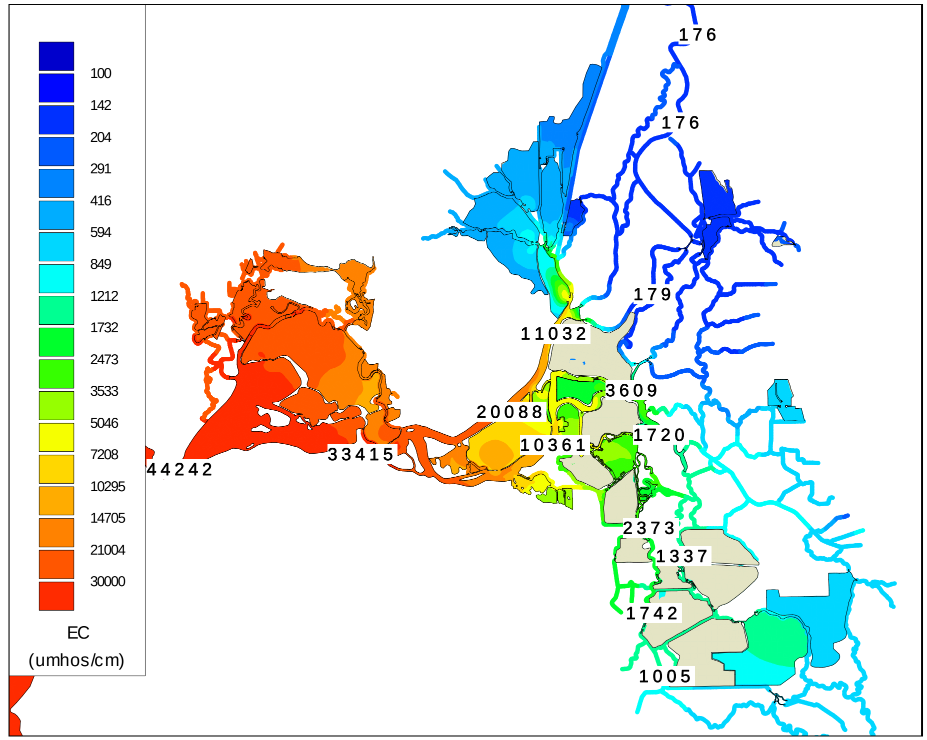


Oct 7, 1990 @ 19:00
Three Island Event

No Sea Level Rise

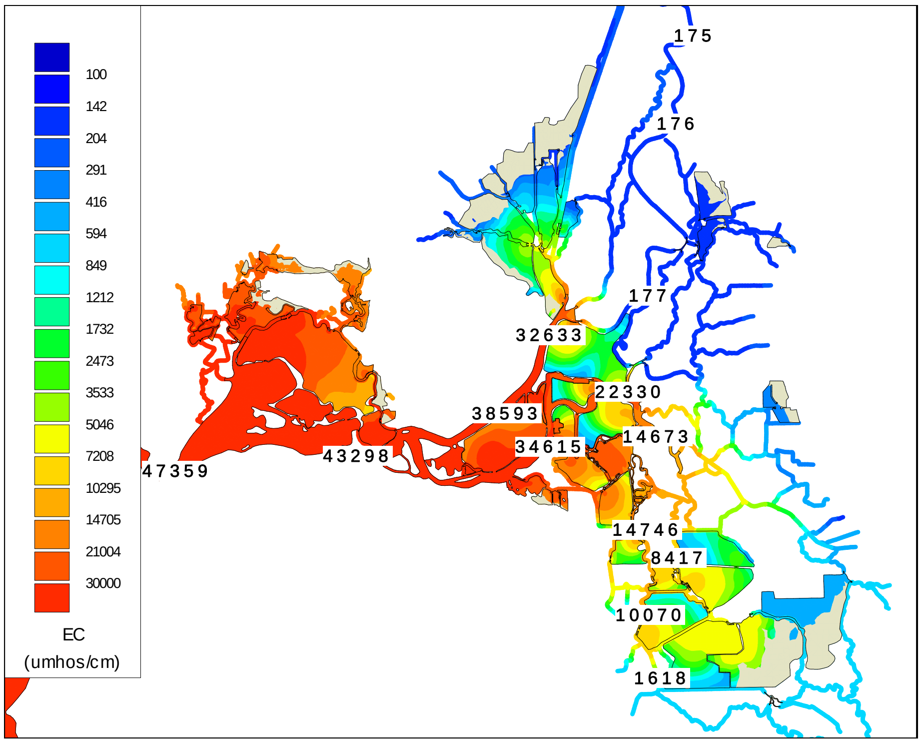


140 cm Sea Level Rise

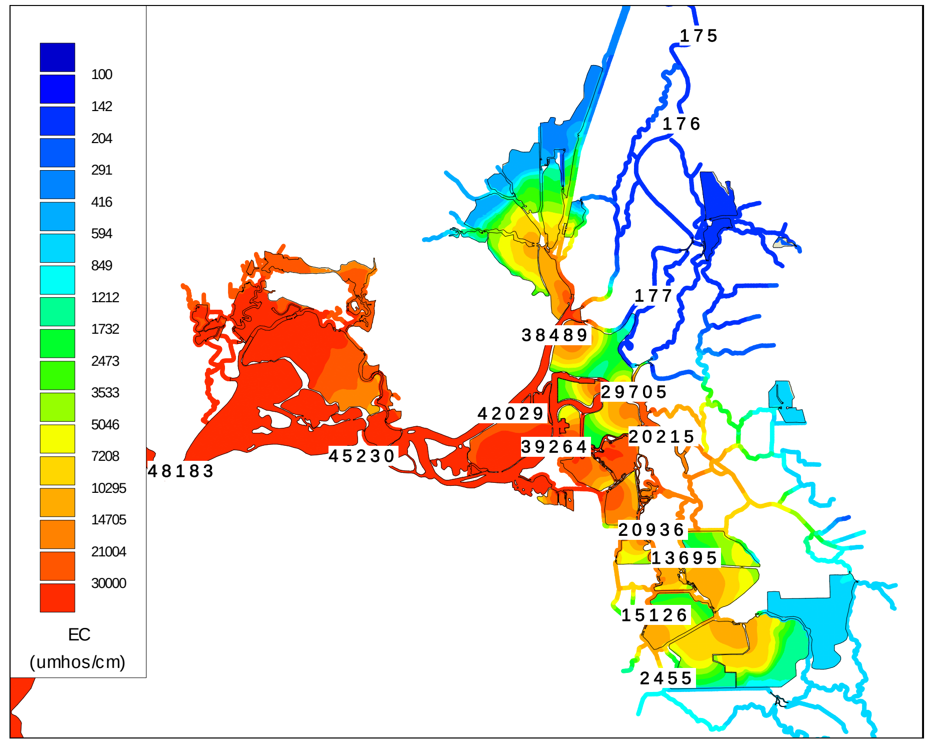


Oct 7, 1990 @ 19:00
Hayward Event

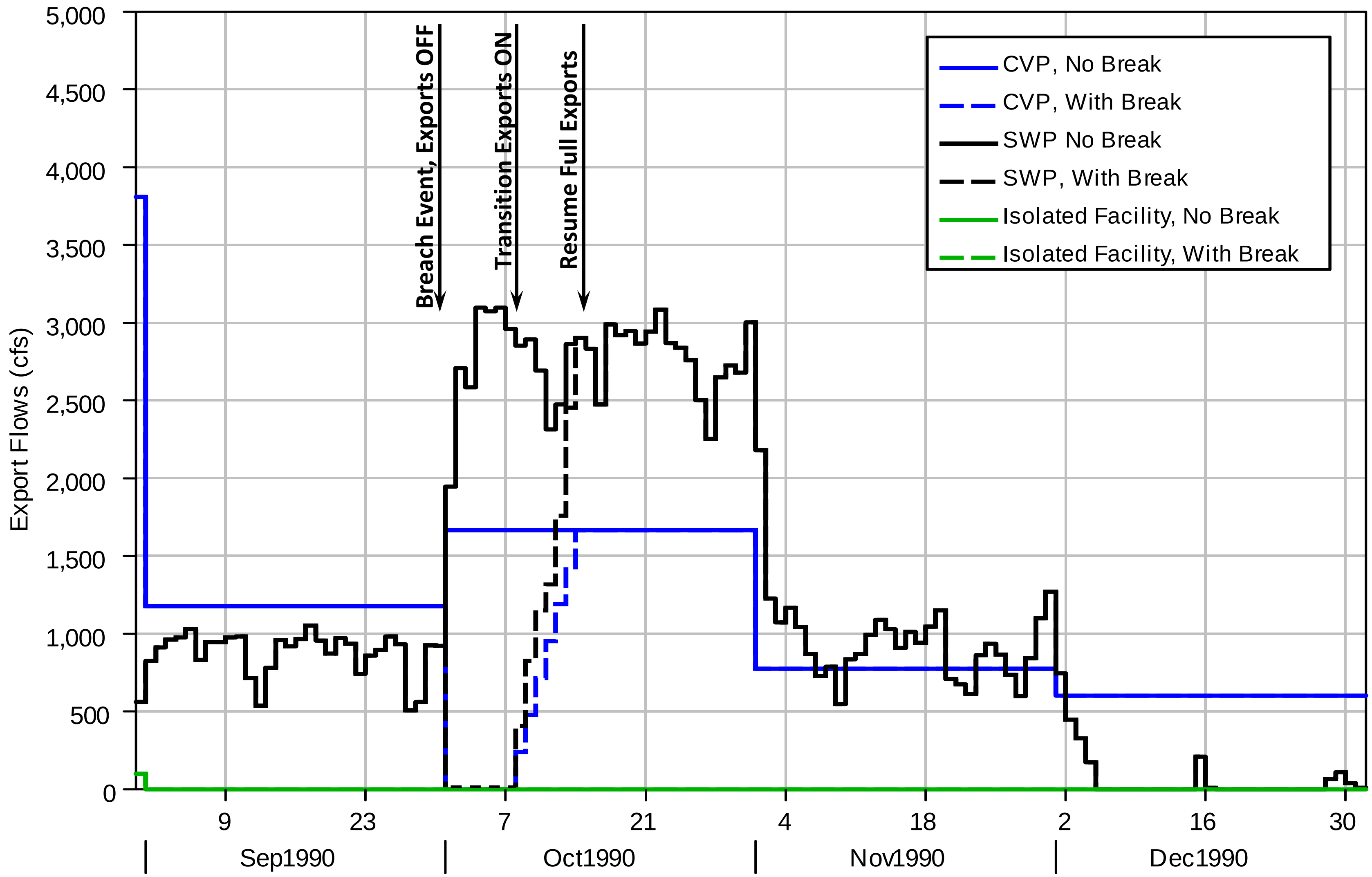
No Sea Level Rise



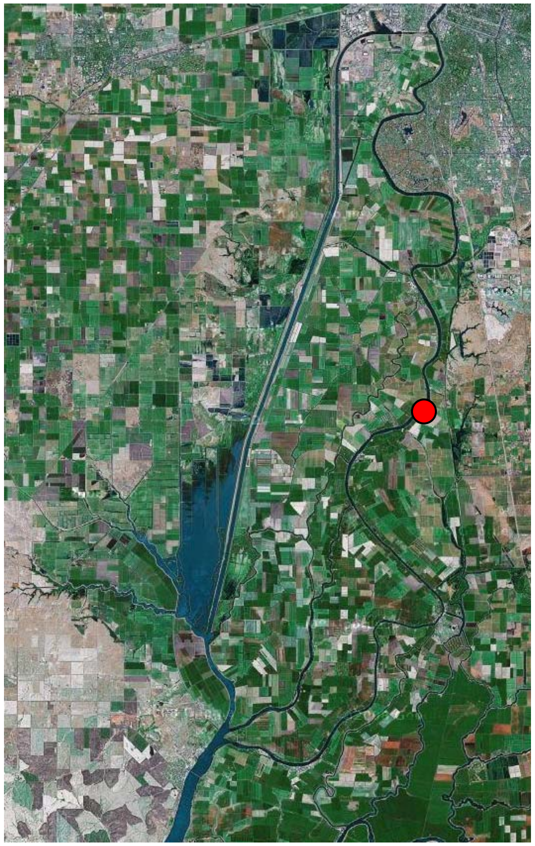
140 cm Sea Level Rise

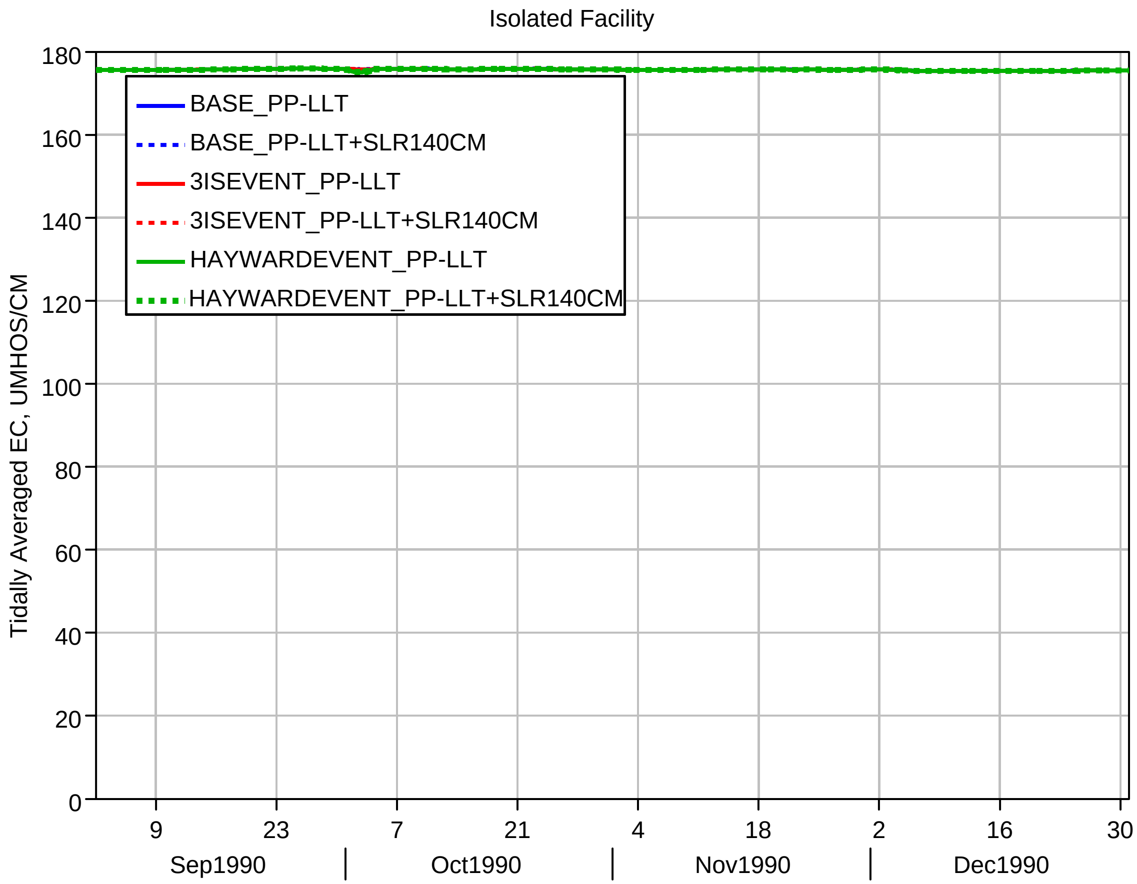


Export Flows, Sep 1 to Dec 31, 1990
Levee Breach Event vs. No Breach

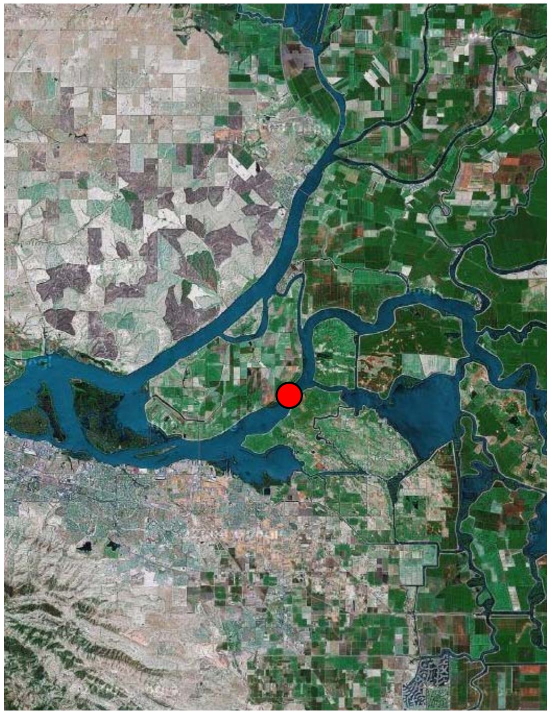


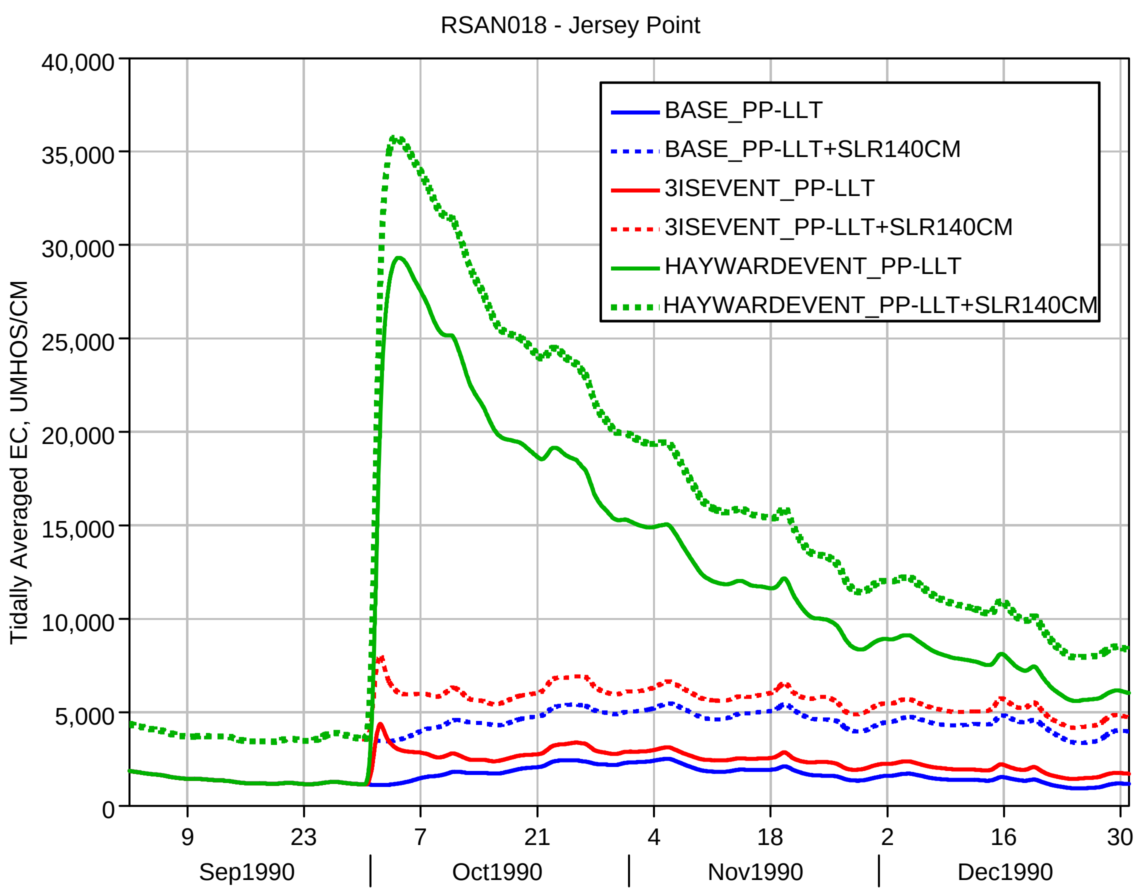
Tidally Averaged EC, Sep 1 to Dec 31, 1990
Base, 3 Is Event, Hayward Event
Isolated Facility



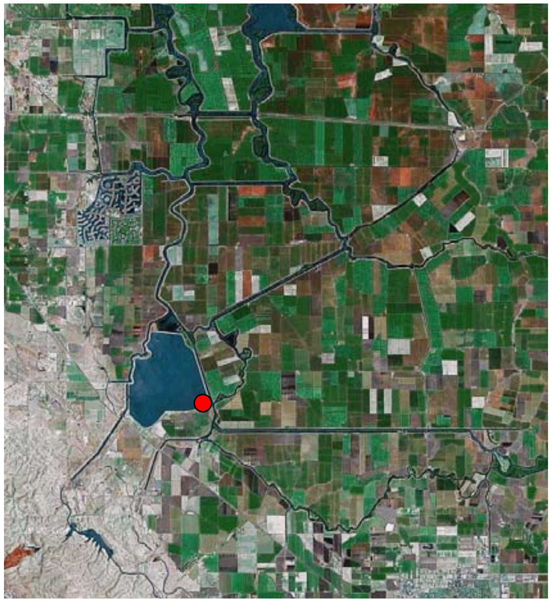


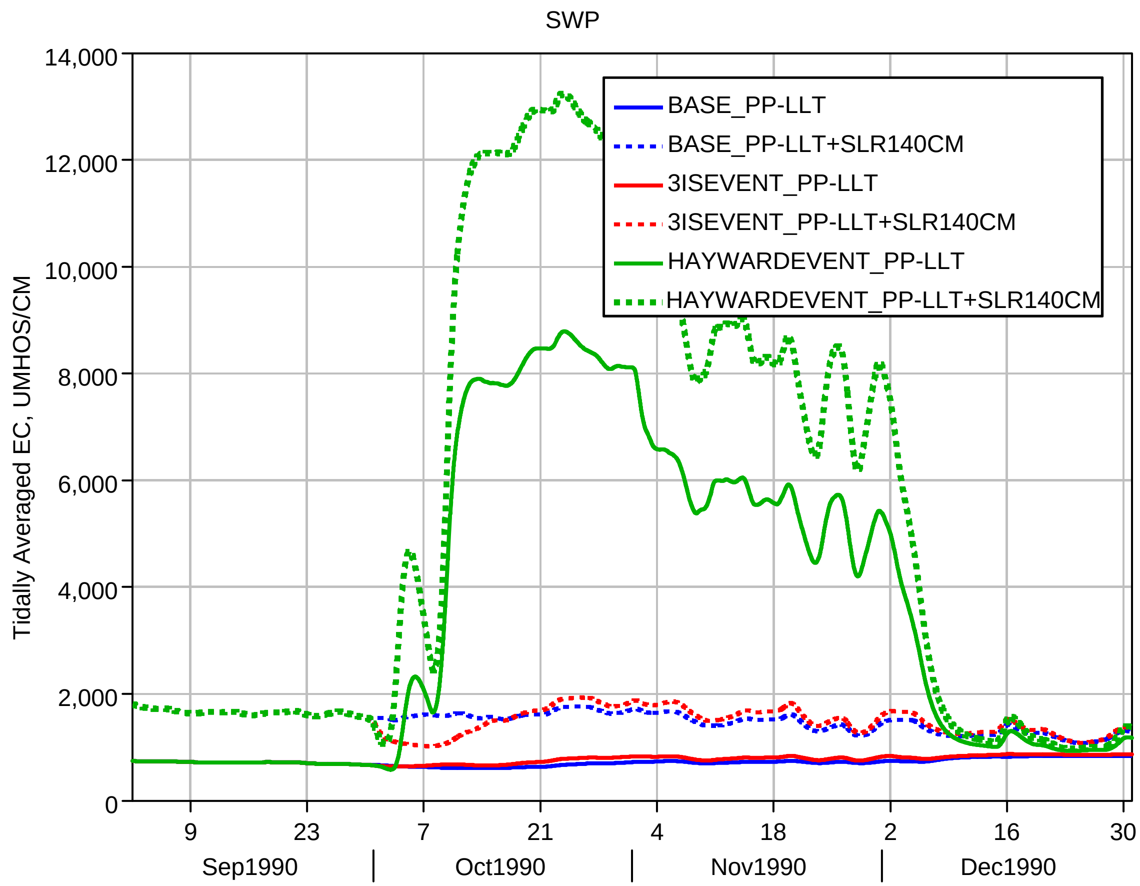
Tidally Averaged EC, Sep 1 to Dec 31, 1990
Base, 3 Is Event, Hayward Event
RSAN018 – Jersey Point



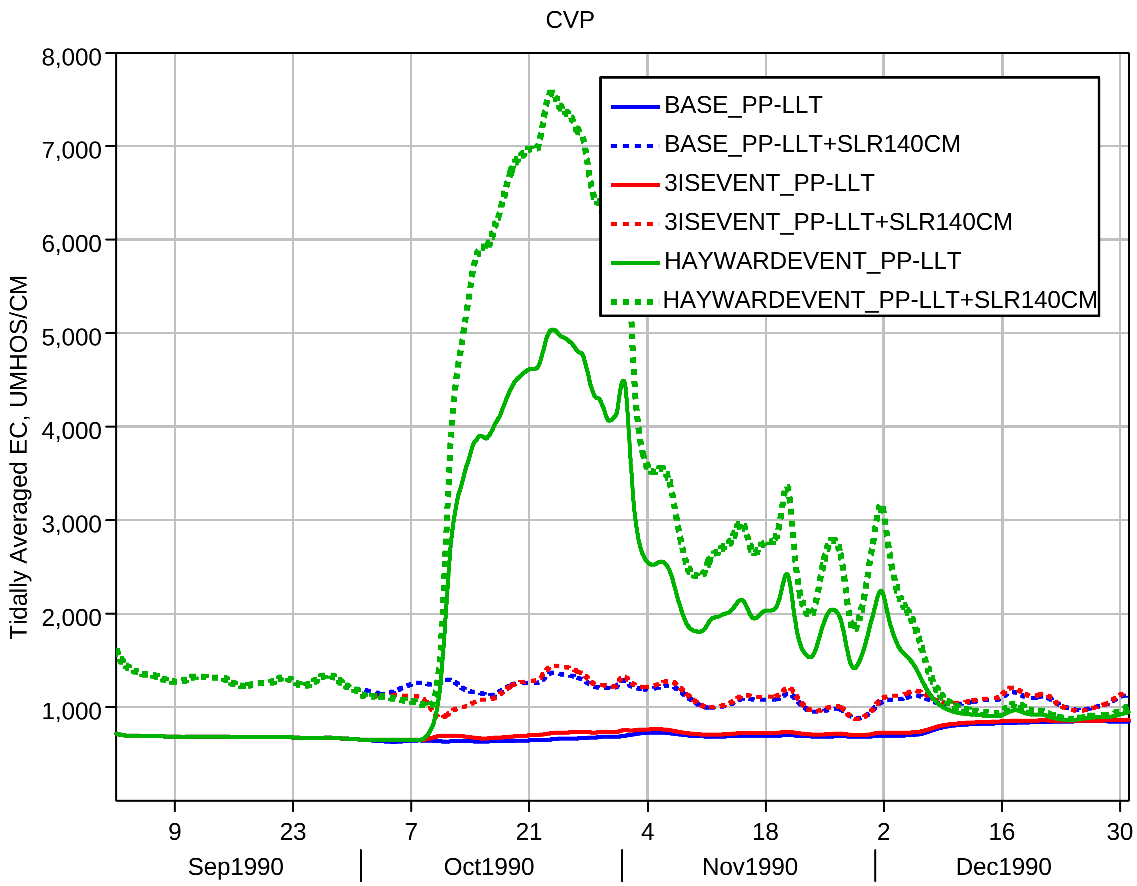


Tidally Averaged EC, Sep 1 to Dec 31, 1990
Base, 3 Is Event, Hayward Event
SWP





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)

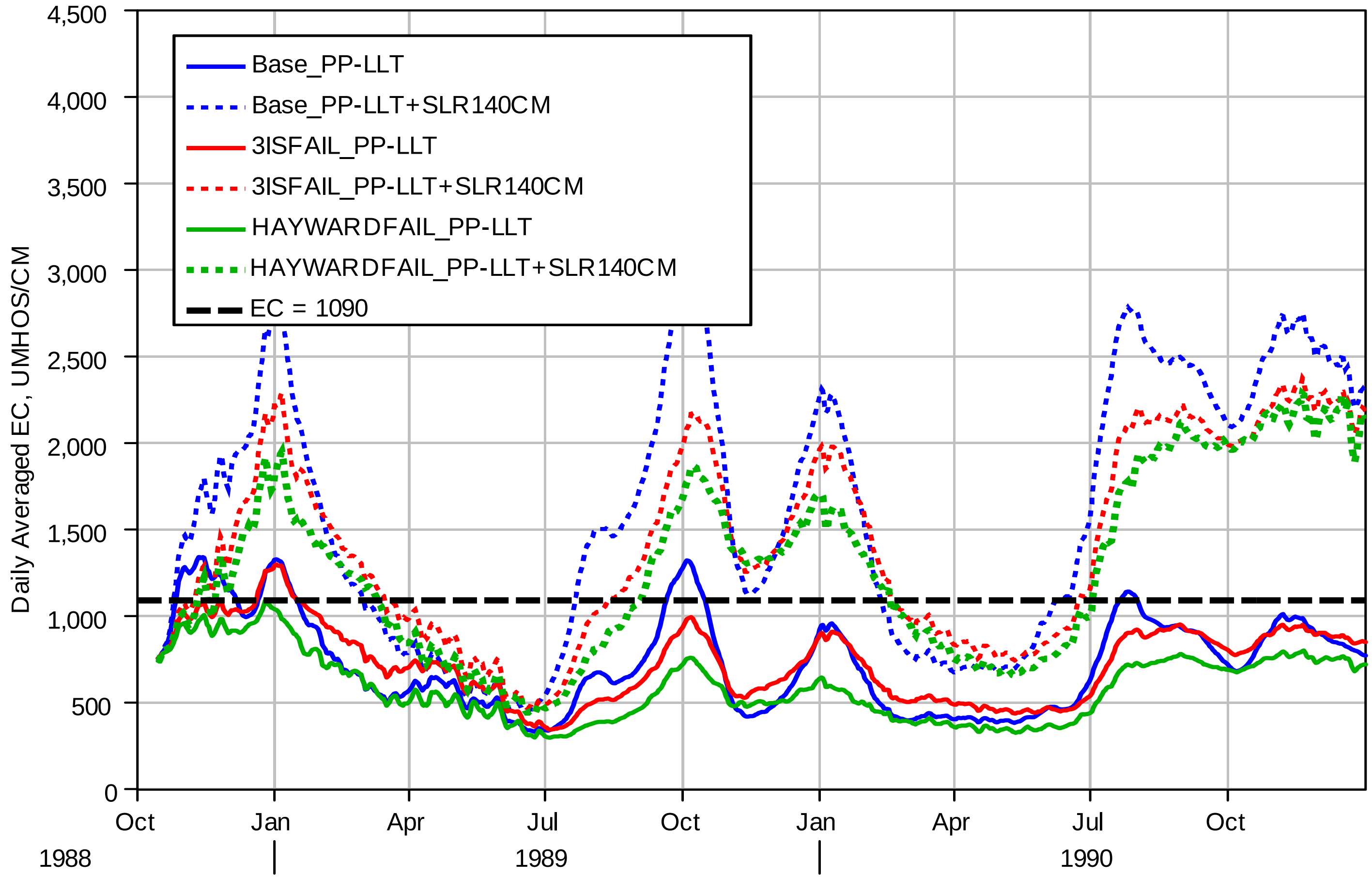
Long-Term Levee Failure Analysis Model Assumptions (cont.)

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

-Second iteration simulations:

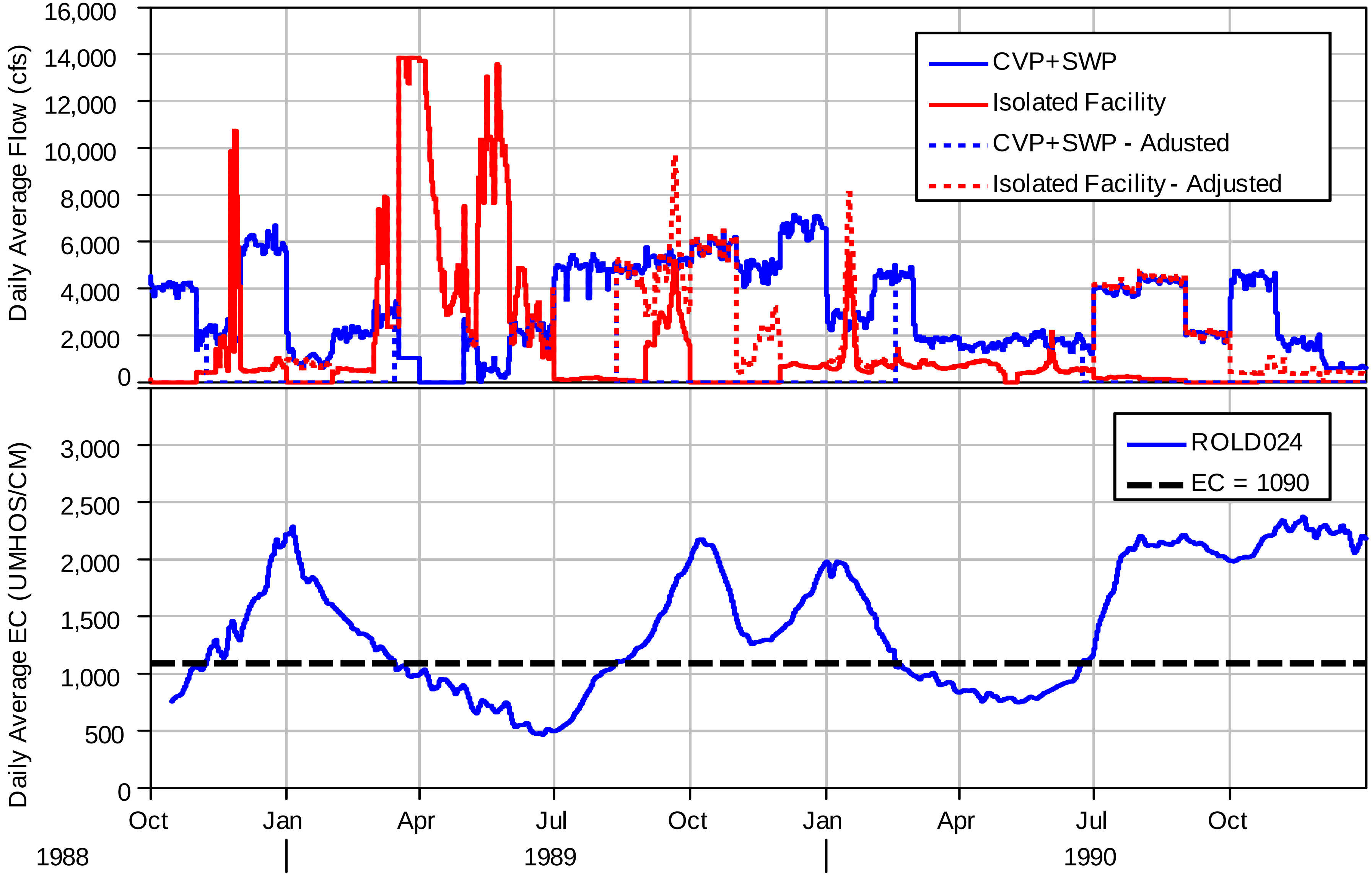
- SWP and CVP exports turned off when EC at RMID015 or ROLD024 > 1090 umhos/cm
- These export flows are transferred to the Isolated Facility up to its potential capacity
- All scenarios reach the 1090 limit, requiring the second iteration, except the Hayward scenario with no SLR

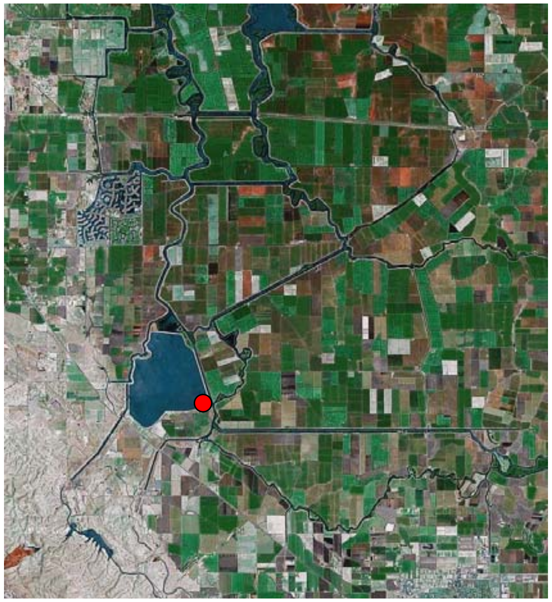
Daily Averaged EC at ROLD024

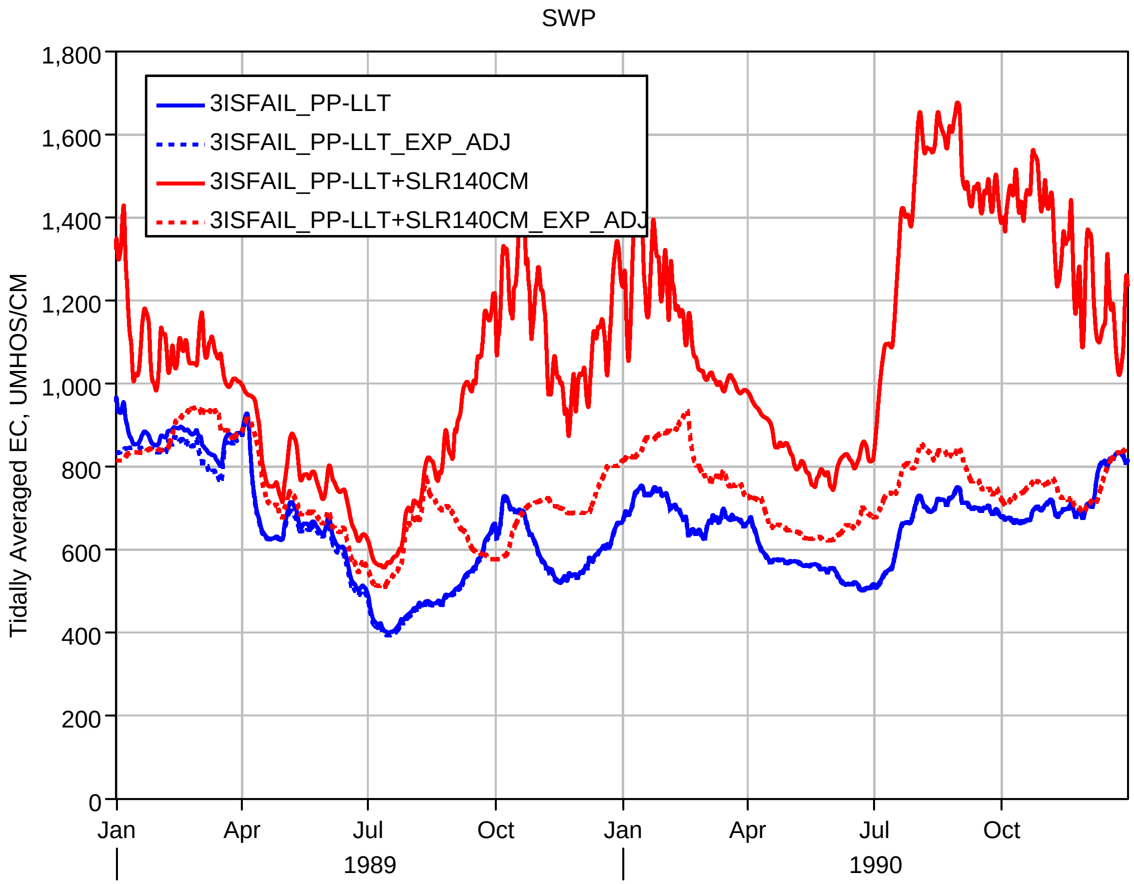


- With 140 cm SLR, EC frequently exceeds 1090 umhos/cm, thus export adjustments are significant
- Without SLR, periods of export adjustment are brief for Base and 3 Island cases
- No export adjustments are made for the Hayward case with no SLR

2^{nd} Iteration Export Adjustments
3 Island Failure + 140 cm SLR

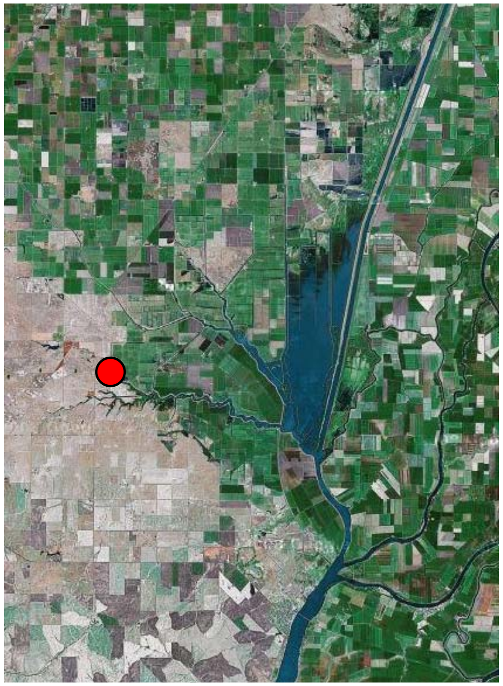


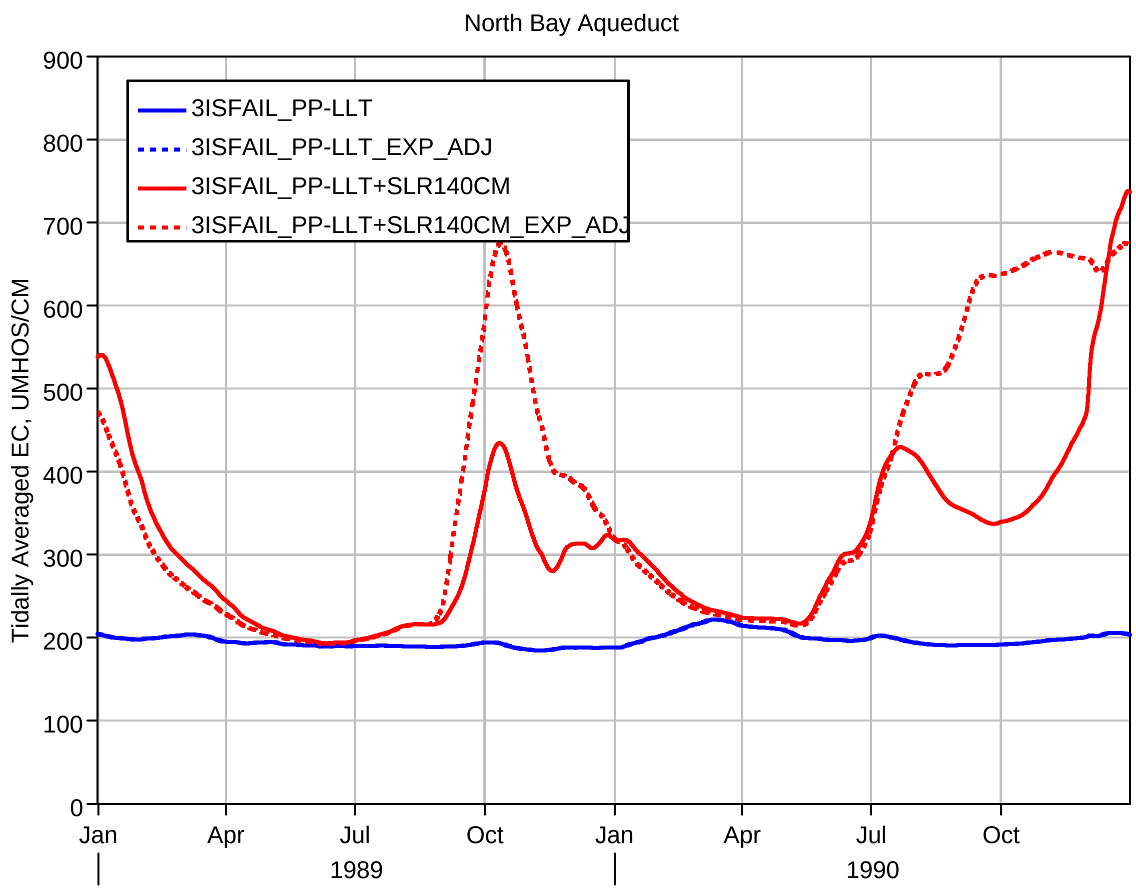




Clifton Court Intake Channel, SWP , 3 Island simulation :

•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

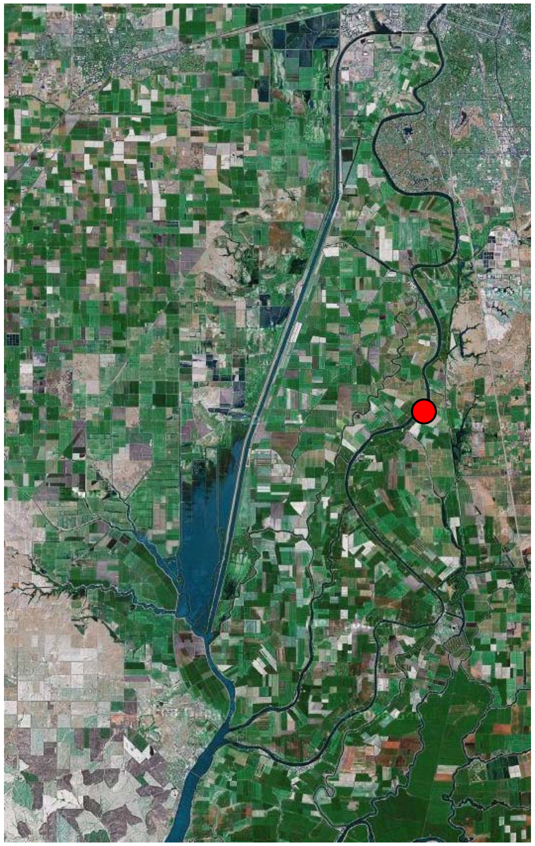
- EC is significantly increased by 140 cm sea level rise
- Open breaches results in decreased EC or minor EC increases in this area
- Export adjustments increase EC in this area

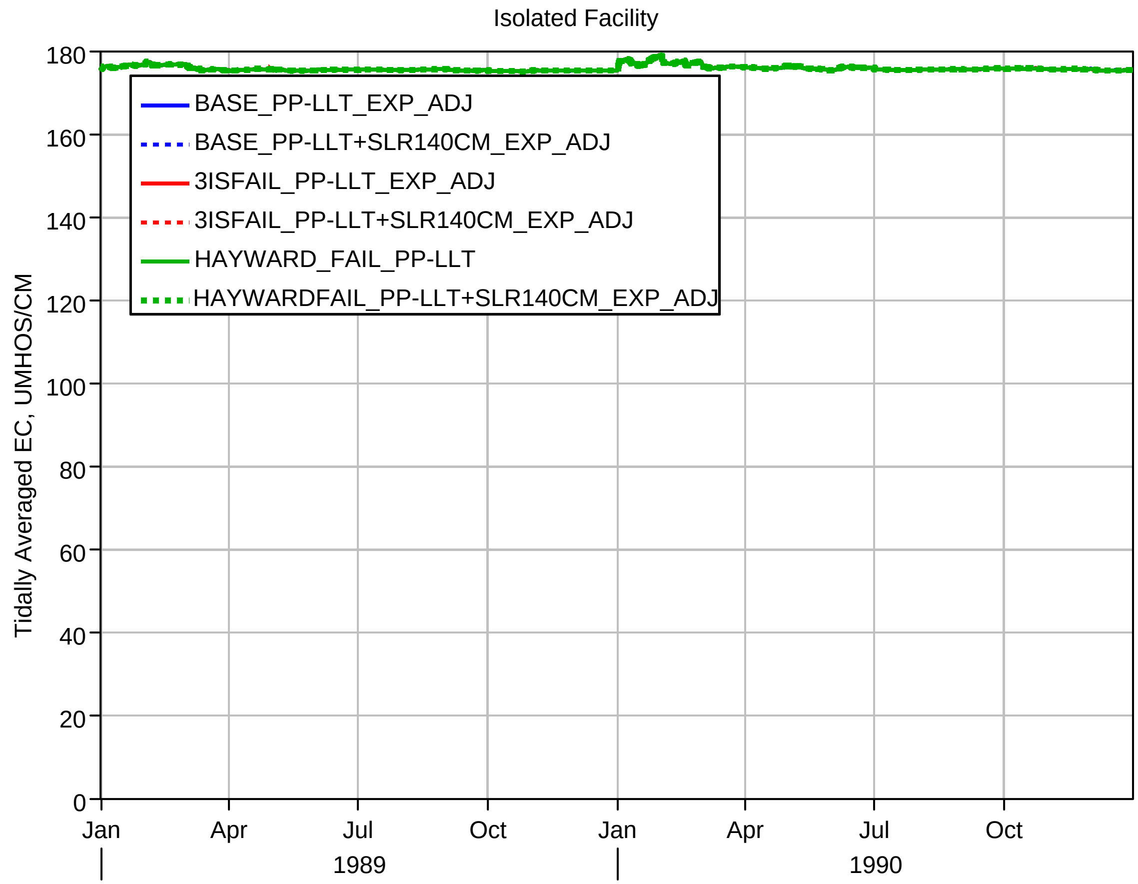
South Delta

- 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

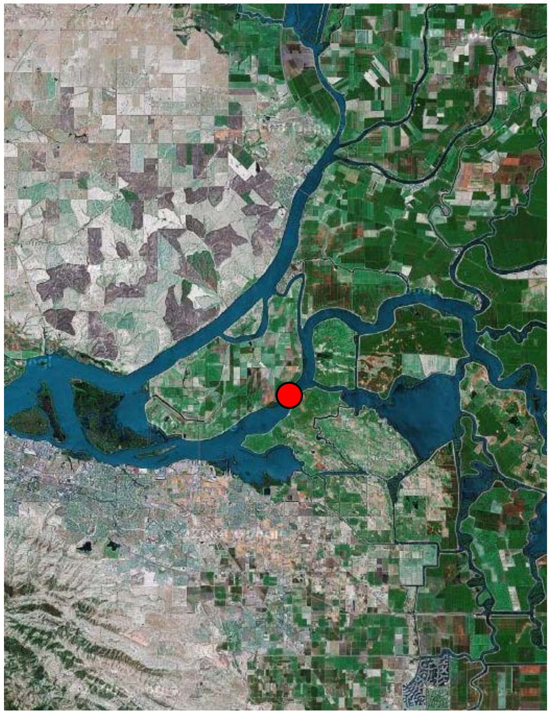
- EC is significantly increased by 140 cm sea level rise
- EC is significantly increased by both failure scenarios
- Grizzly Island failures are the same for both scenarios, thus results are similar

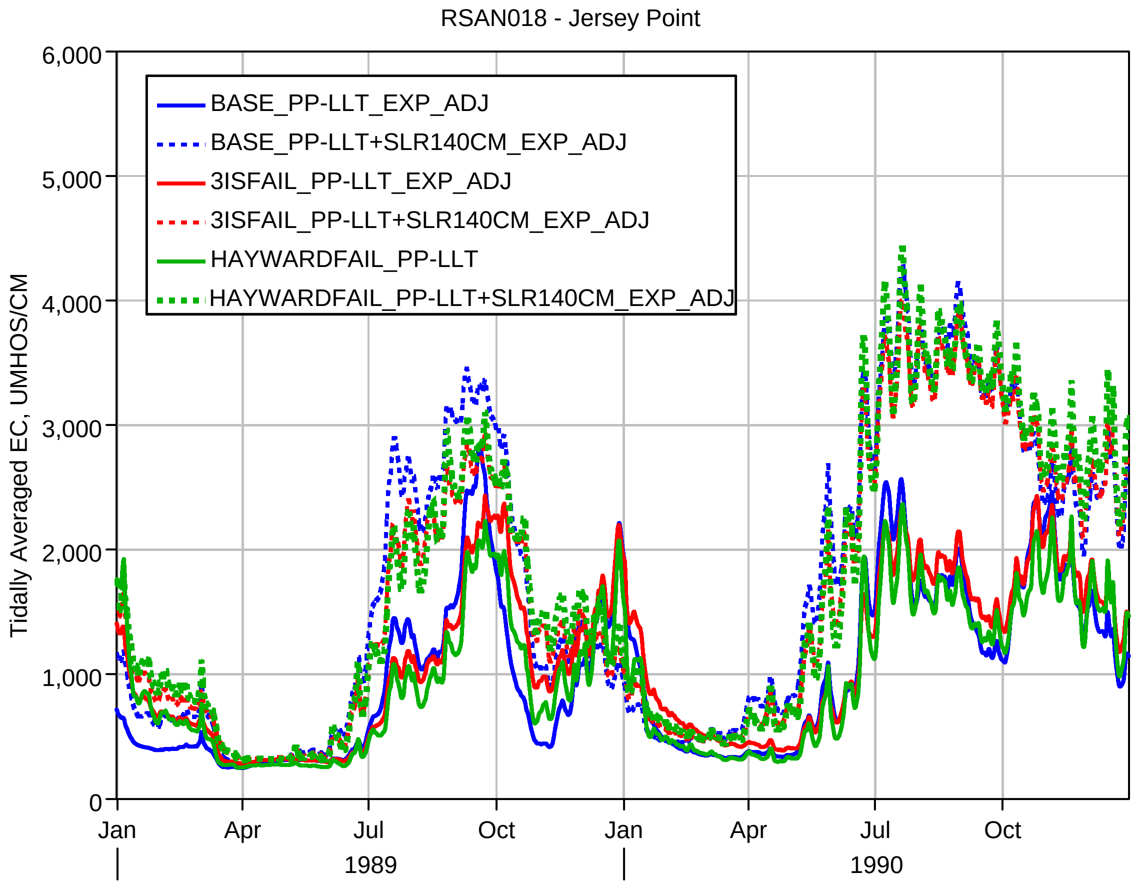




Isolated Facility:

•No significant impacts from SLR or Levee Failure.





RSAN018 – Jersey Point:

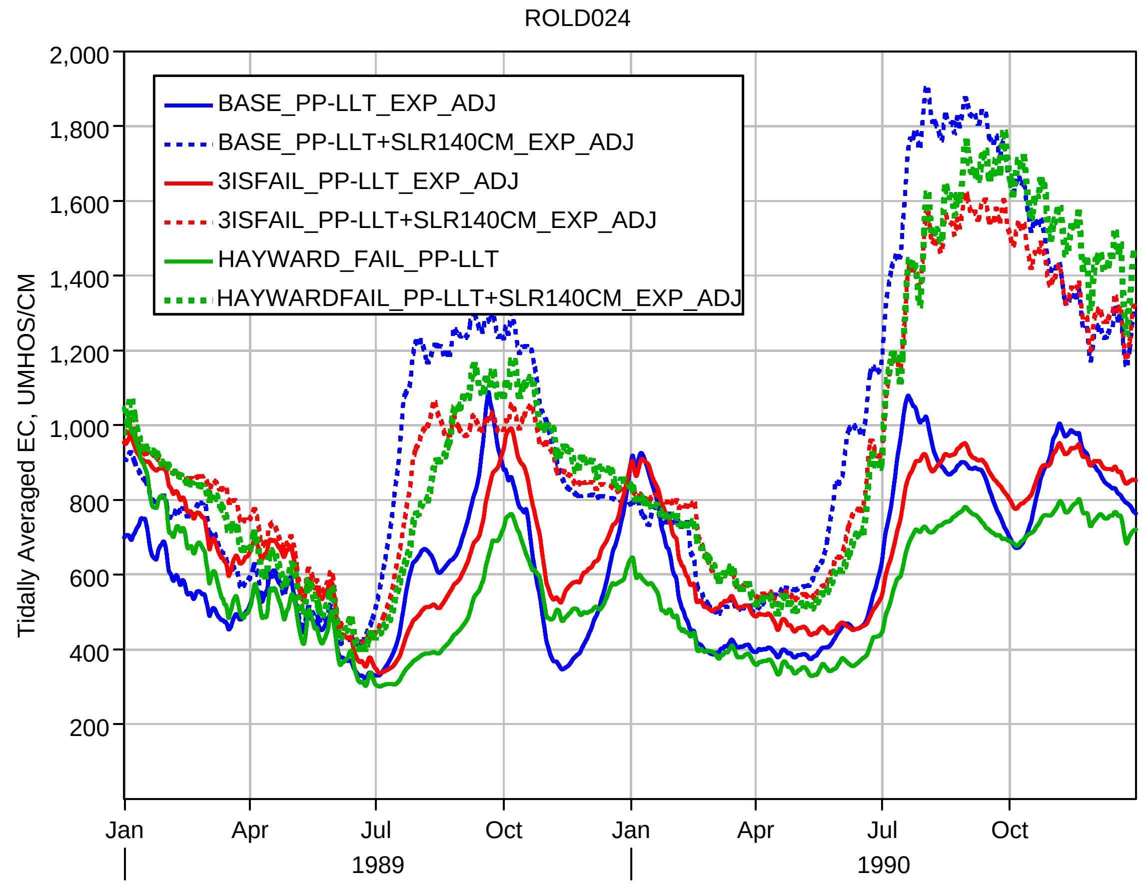
•140cm SLR increases EC significantly at times.

•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.

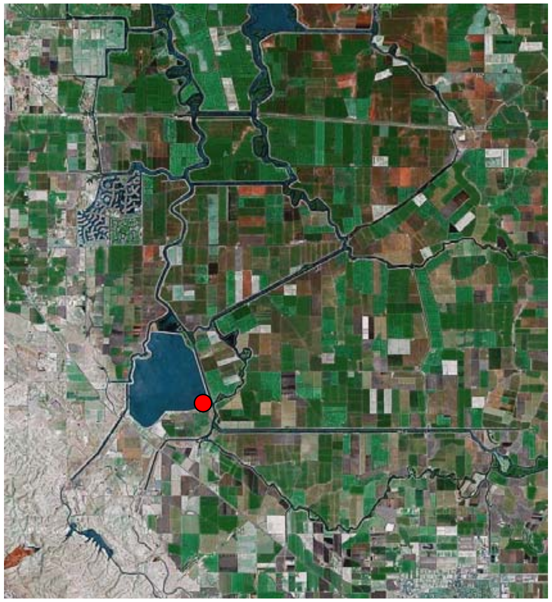
•With SLR, the impacts of both failure cases vary seasonally.

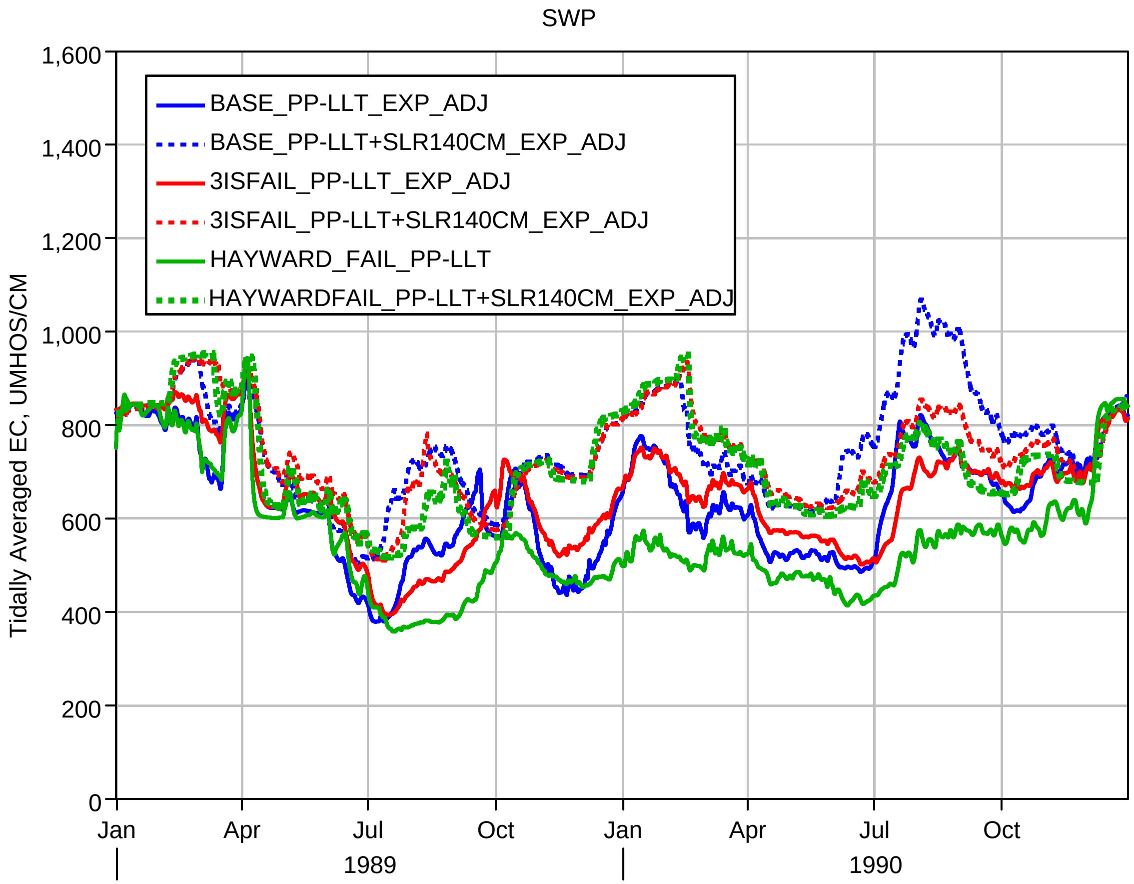
•With SLR , the Hayward case is slightly less responsive to export reductions.



ROLD024 – Old River at Rock Slough:

- 140cm SLR tends to increase EC.
- With <u>no</u> 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.



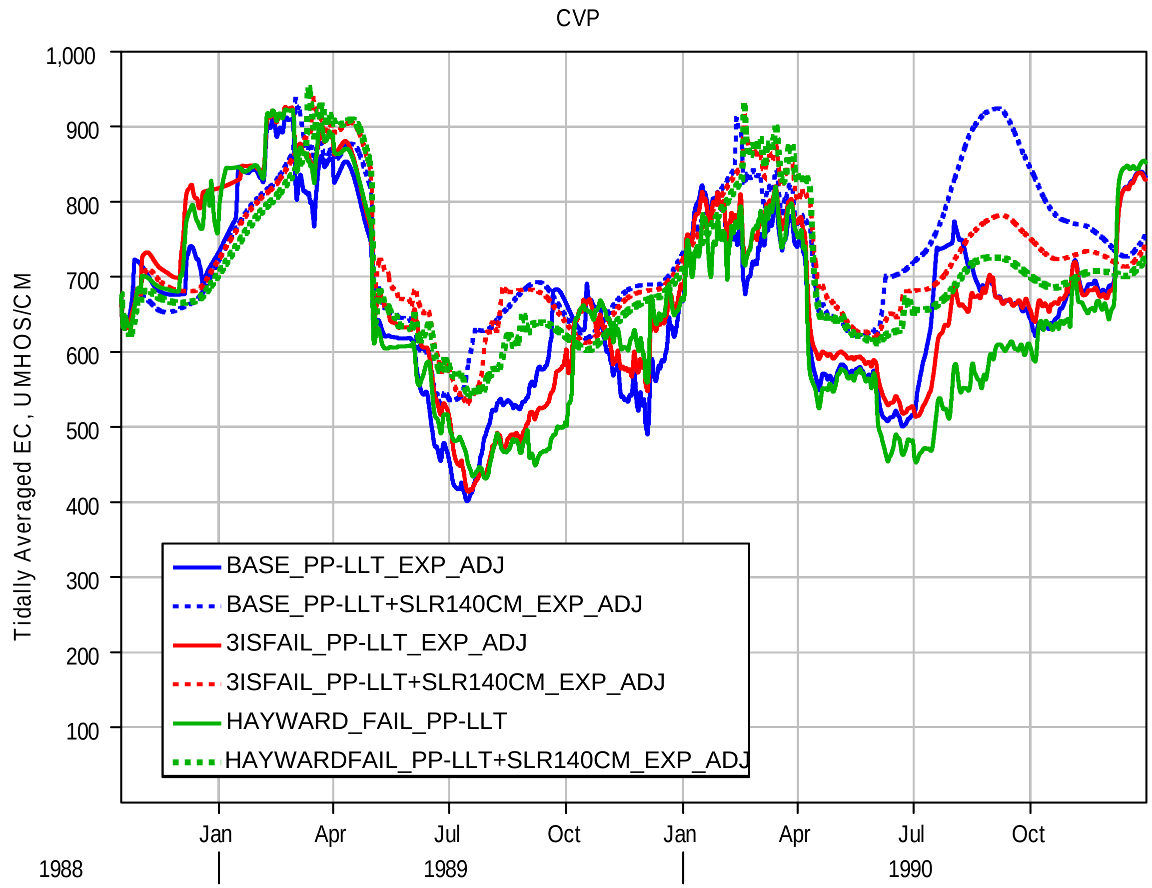


Clifton Court Intake Channel, SWP:

•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 <u>no</u> 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

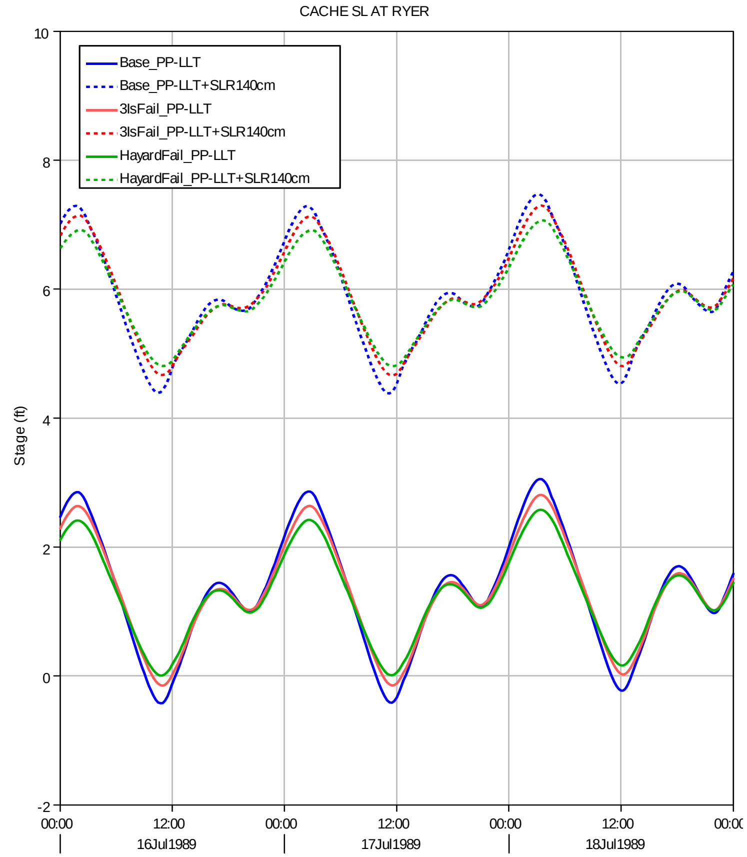
	Cache Slough Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	12,275	12,899	13,369	8	8	102
MHHW-EHW	1,128	987	863	184	545	703
MLLW-MHHW	6,613	5,716	5,162	4,850	4,274	3,940
Below MLLW	6,397	6,811	7,019	21,371	21,586	21,668

Cache Slough:

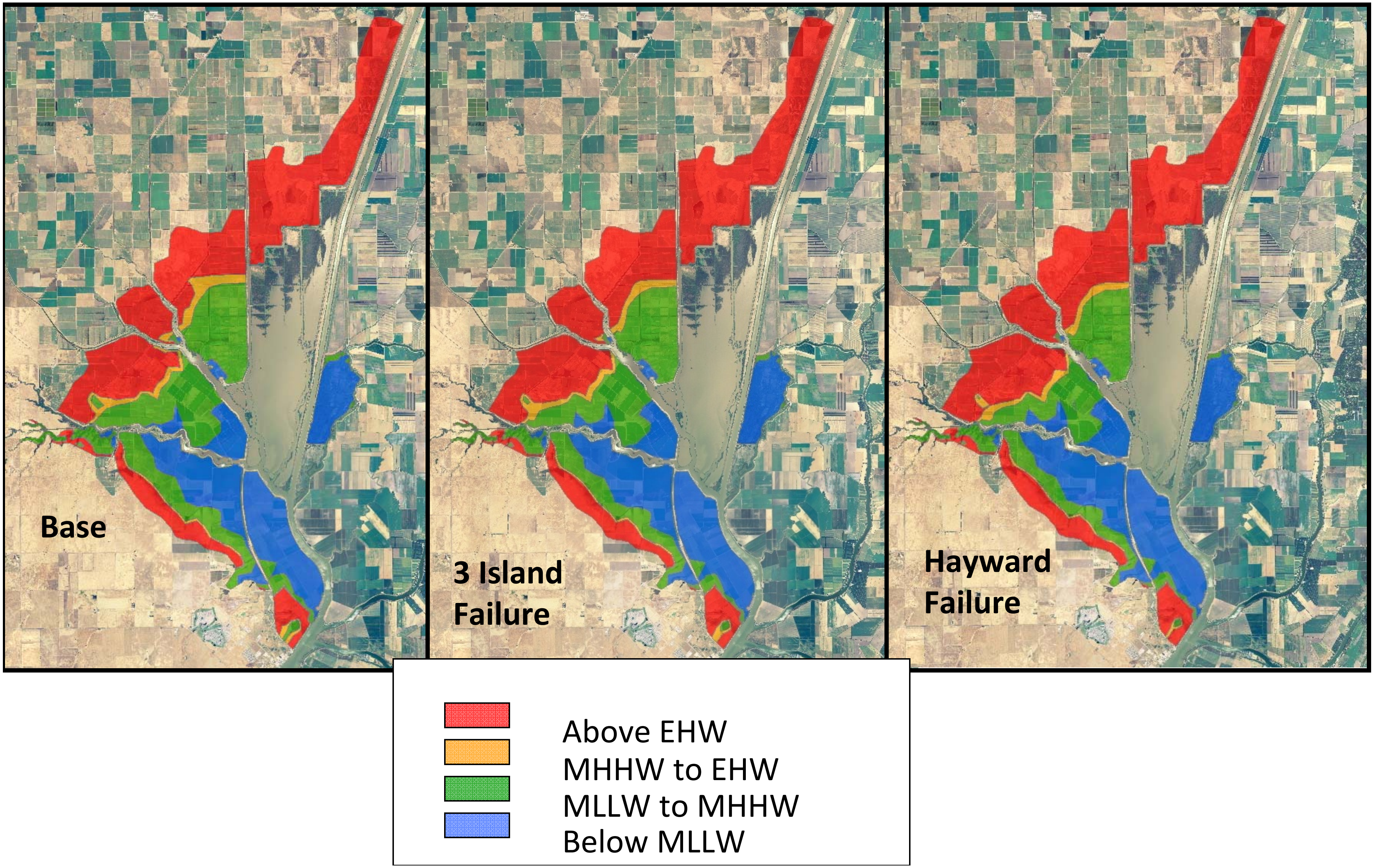
•Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW

•Both breach cases reduce tidal range in Cache Slough

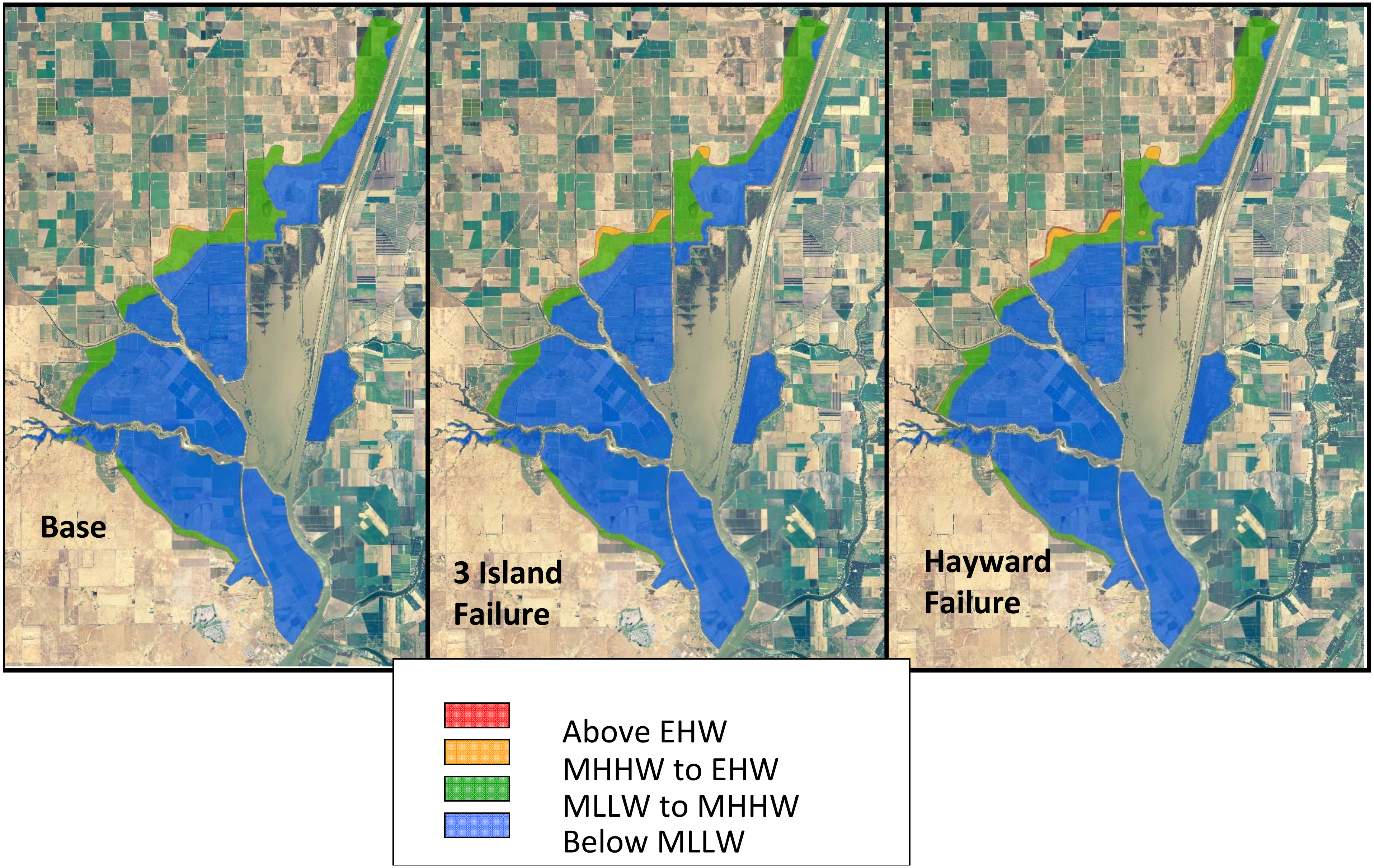
•The Hayward cases has slightly more impact on tidal range



Cache Slough ROA
No SLR



Cache Slough ROA
With 140 cm SLR



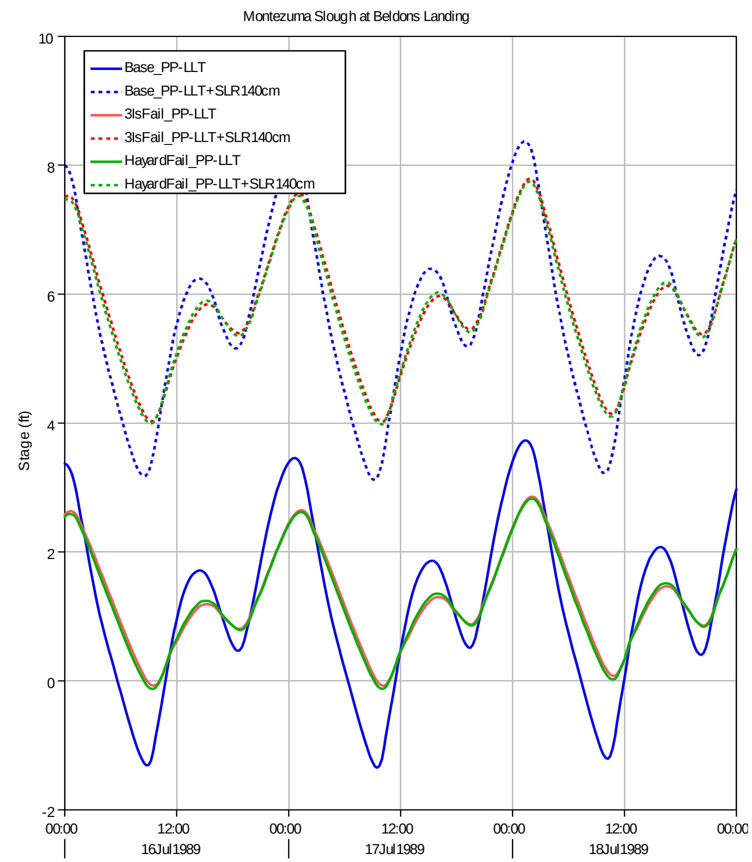
	Suisun Marsh Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	1,449	2,608	2,623	-	23	32
MHHW-EHW	909	544	522	16	171	168
MLLW-MHHW	4,647	2,516	2,557	1,562	904	921
Below MLLW	9,088	10,423	10,390	14,513	14,993	14,970

Suisun Marsh:

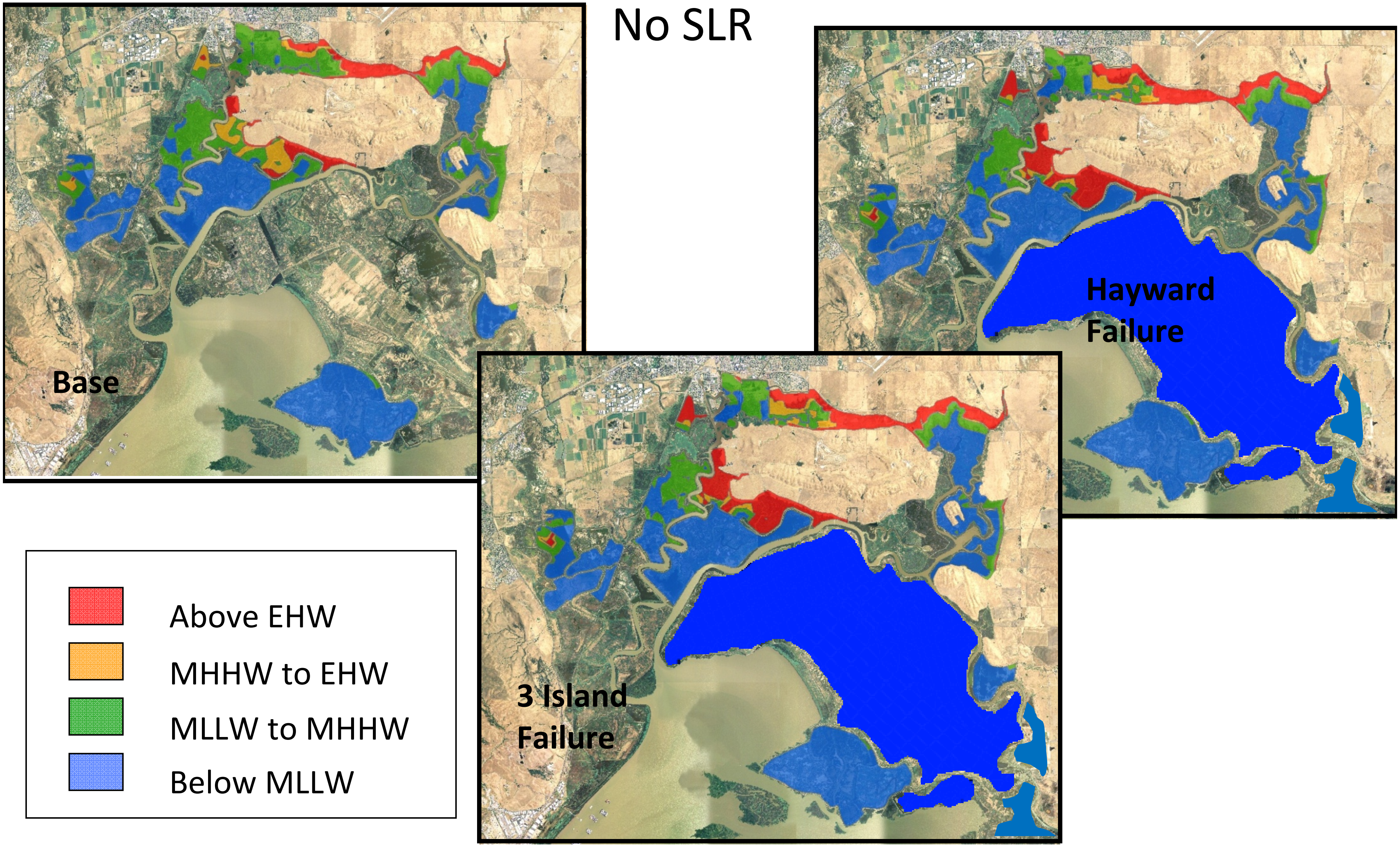
•Sea level rise inundates much of the ROA shifting the majority of the area to Below MLLW

•Grizzly Island breaches significantly reduce the tidal range

•Delta breaches have minimal impact in Suisun Marsh in these cases



Suisun Marsh ROA
No SLR



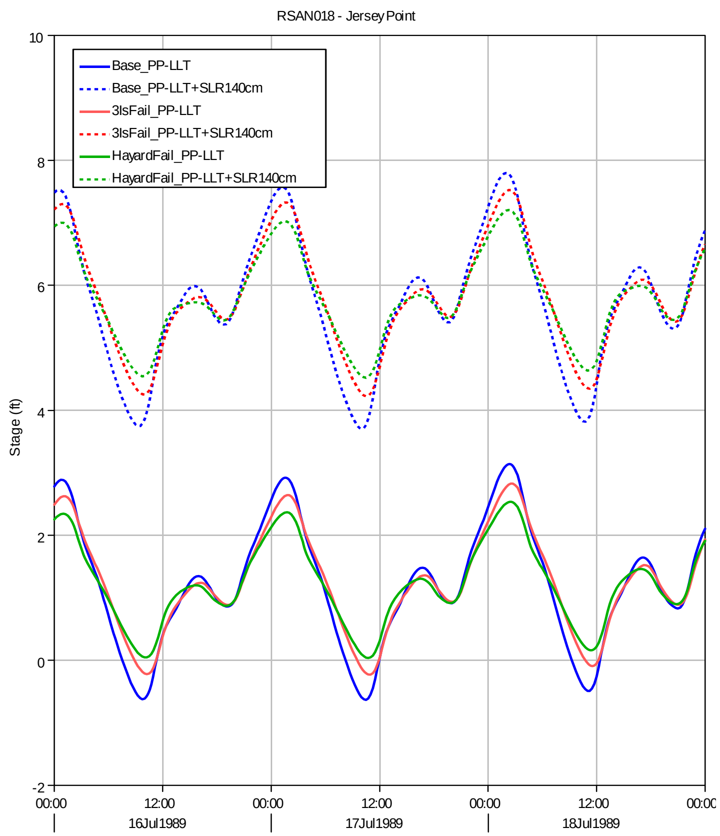
	West Delta Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	322	344	363	-	-	-
MHHW-EHW	26	22	12	-	-	-
MLLW-MHHW	3,006	2,956	2,904	280	214	196
Below MLLW	880	907	949	3,953	4,014	4,031

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



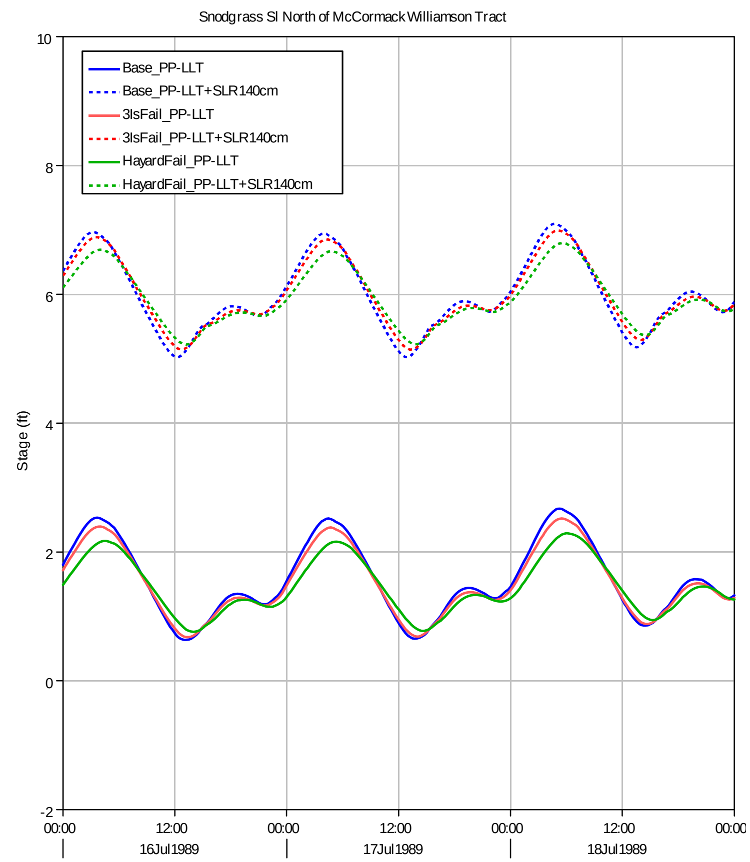
	Mokelumne-Cosumnes Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	1,997	2,093	2,230	164	194	222
MHHW-EHW	235	233	233	72	62	62
MLLW-MHHW	1,382	1,241	965	396	371	329
Below MLLW	1,405	1,451	1,591	4,386	4,392	4,406

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



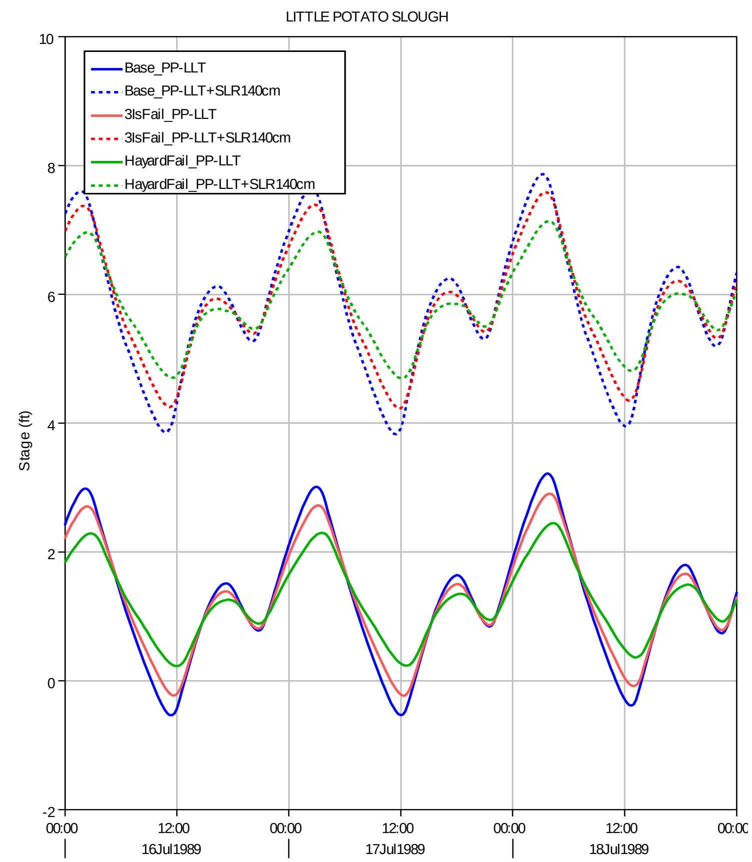
	East Delta Tidal Datum areas in Acres					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	1,221	1,254	1,325	-	47	47
MHHW-EHW	105	90	31	47	1	-
MLLW-MHHW	171	154	130	205	205	197
Below MLLW	841	841	852	2,086	2,086	2,093

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					
	No SLR			140 cm SLR		
	Base	3 Island	Hayward	Base	3 Island	Hayward
Above EWH	10,207	10,332	10,799	-	-	-
MHHW-EHW	666	662	518	-	-	-
MLLW-MHHW	2,547	2,188	840	-	-	-
Below MLLW	9,065	9,303	10,330	22,485	22,485	22,485

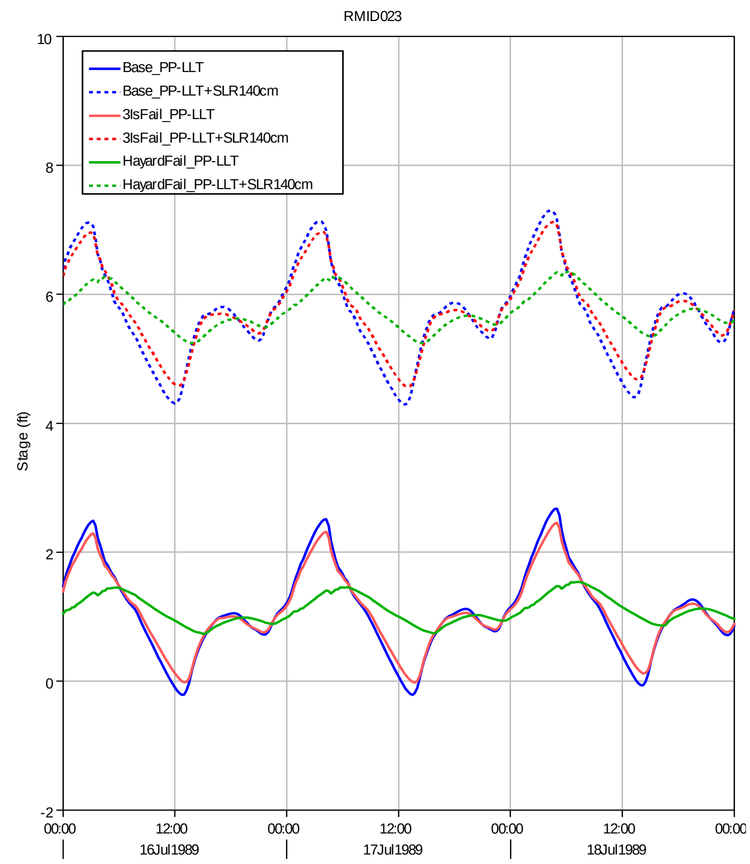
South Delta:

•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



Questions?