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6.1 INTRODUCTION

6.1.1 Background

Phase 2 of the Delta Risk Management Strategy (DRMS) considers approaches to reducing the risk of economic and environmental consequences associated with levee failure events in the Sacramento–San Joaquin River Delta (Delta) and Suisun Marsh. This building block considers the concept of pre-flooding islands as a means of reducing risk associated with levee failure events. Because the land surfaces of many Delta islands are below sea level, highly saline water may be pulled into the Delta from Suisun and San Pablo bays should the levees surrounding these islands fail. The risk analysis conducted in Phase 1 of DRMS indicated a significant probability that a multi-island failure event may occur; such an event could disrupt water exports from the Delta for months or even years due to salinity intrusion.

One approach to reducing the impact of accidental flooding is to reduce the potentially flooded volume in the system and thereby reduce the possibility that a large volume of saltwater will be drawn into the Delta during an emergency event. This volume reduction might be accomplished by hardening the levees surrounding islands or by filling islands with soil or water. Hardening the levees surrounding islands sufficiently to prevent failure is considered as a separate Phase 2 building block. Because of the very large volumes required, filling islands with soil or other solid material is difficult. For example, Upper and Lower Jones Tract contains approximately 120,000 acre-feet below mean sea level, and 20 of the principal islands in the western, central, and southern Delta cumulatively include approximately 1 million acre-feet of volume below sea level. Islands could readily be filled with water from surrounding channels, and if this action were taken in a controlled fashion during high run-off periods, little or no immediate salinity impact would occur.

Figure 6-1 shows the flash card for Building Block 1.4: Pre-Flooding of Selected Islands.

6.1.2 Purpose and Scope of Building Block

The purpose of pre-flooding selected islands is to reduce the risk of accidental flooding that may cause excessive salt intrusion. Possible options for pre-flooded islands might include the following:

1. After a controlled breach, allow surrounding levees to naturally degrade with wind-wave action, similar to what happened at Franks Tract.
2. Carefully design and construct breaches and armor levee interiors to preserve the levees and control tidal flow in and around the flooded islands.
3. Armor and preserve the surrounding levees and use the flooded islands as in-Delta reservoirs, similar to the proposed Delta Wetlands project.

In all three cases, the islands should be filled during periods of high run-off to minimize any salinity intrusion.

If the flooded islands are left open to tidal filling and draining, then the large-scale changes in tidal flows throughout the system must be considered. Most important, changes in the tidal flows in the western Delta may increase tidal dispersion of salt, which would necessitate an increase in

Net Delta Outflow (NDO) (carriage water) to meet water quality standards in the Delta. If many islands were to be pre-flooded and left open to tidal exchange, a significant reduction in overall tidal range would occur throughout the Delta.

The residence time of water in flooded islands may be quite long if the breaches are small relative to the size of the islands and no opportunity exists for flow through the island. The release or production of organic carbon, tri-halomethane precursors, or other constituents from soils within the islands may create issues for water exports intended for municipal water supply.

6.1.3 Objective and Approach

6.1.3.1 Objective

This building block is evaluated for salinity impacts only. If the risk reduction potential of this building block is promising, future work will be required to consider other important water quality issues, such as organic carbon production.

The two primary objectives of this evaluation are:

- To determine whether pre-flooded islands left open to tidal exchange significantly alter the salinity regime in the system, and
- To determine how much benefit is derived by pre-flooding islands with regard to recovery from a levee failure event.

6.1.3.2 Approach

Two tools are used to evaluate the salinity impact and risk reduction potential of pre-flooding islands. The first tool is the Research Management Associates (RMA) Bay Delta Model, which is used to evaluate the change in tidal dynamics and salinity intrusion associated with pre-flooded islands that are open to tidal action. The second tool is the DRMS Water Analysis Module (WAM), which is used to estimate the reduction of risk as measured by export disruption after a large-scale breach event. The modeling exercises discussed in this section are intended to illustrate the general characteristics of this building block.

The RMA Bay Delta Model configuration used in the preliminary Delta levee risk assessment (JBA 2005) to evaluate a 20-island/50-breach levee failure event is used to examine changes in tidal dynamics and salinity transport for several pre-flooded island cases. A base case simulation is performed for three consecutive years (2002–2004). Using the same flow boundary conditions and operations as the base case, simulations are also performed for four sets of flooded islands open to tidal exchange. The sets include five western Delta islands, five eastern Delta islands, six southern islands, and the entire group of 20 islands analyzed. Because the boundary conditions are the same for all runs, the differences observed between the resulting salinity distributions are a direct result of the change in tidal dynamics.

The WAM is run with a 20-island failure case at four event start dates with the western, eastern, and southern islands sets pre-flooded. Simulations are performed with and without the islands being open to tidal exchange. For the purpose of the WAM simulations, where the pre-flooded islands are not open to tidal exchange, there is no consideration for flushing the in-Delta reservoirs, so the simulations are equivalent to simply hardening the surrounding levees.

6.2 CONCEPTUAL DEVELOPMENT OF IMPROVEMENT

6.2.1 Analysis Criteria and Basis of Design

The analysis of this building block focuses on illustrating the salinity impacts of a representative set of potentially flooded islands. Because the tidal hydrodynamics of the San Francisco Bay–Delta system are complex, it is not possible to perform a small set of simulations and provide a conclusive and all-encompassing evaluation of all possible options for pre-flooding islands. The analysis presented here provides a starting point for more detailed analysis of specific pre-flooded island designs, if needed. The analysis focuses on:

- Change in tidal stage and flow
- Change in salinity distribution over time
- Potential required increase in NDO to meet salinity standards
- Variation in number of days to resume export pumping for a reference levee failure event
- Variation in export deficit at the time exports resume for a reference levee failure event

6.2.2 Geometric Description of Improvement

Three sets of potentially flooded islands are selected to illustrate the variation that may be expected by choosing islands in the western, eastern, or southern Delta. A fourth set of islands includes all 20 islands currently represented in the RMA Bay Delta Model. The island sets are shown in Figures 6-2 to 6-5. The islands included in each set are as follows.

- Set 1: Western Delta — Sherman, Jersey, Bradford, Twitchell, Brannan-Andrus
- Set 2: Eastern Delta — Venice, Mandeville, McDonald, Jones, Bouldin
- Set 3: Southern Islands — Palm-Orwood, Bacon, Woodward, Jones, Victoria, Byron
- Set 4: 20 Islands — Sherman, Jersey, Bradford, Twitchell, Brannan-Andrus, Venice, Mandeville, McDonald, Jones (Upper and Lower), Bouldin , Palm-Orwood, Bacon, Woodward, Victoria, Byron, Bethel, Webb, Holland, Quimby

Breach locations were taken from the original 20-island case simulated for the preliminary Delta levee risk assessment (JBA 2005). Other breach configurations may lead to different results, though general trends are expected to be similar for the western, eastern, and southern island sets.

6.2.3 Analysis Results

This section presents the analysis results from the RMA Bay Delta Model simulations of pre-flooded islands open to tidal exchange and the WAM simulations comparing the effectiveness of pre-flooding sets of islands to reduce impacts of a representative levee breach scenario.

6.2.3.1 RMA Bay Delta Model Simulation

The RMA Bay-Delta Model has previously been used to simulate the Jones Tract levee failure in 2004 and 1-, 3-, 10-, 30-, and 50-breach cases in the preliminary Delta levee risk assessment (JBA 2005). A description of the RMA Bay-Delta Model can be found in the recent calibration report prepared for the Flooded Islands Pre-Feasibility Study, which is available online at http://www.rmanet.com/zip/FloodedIslandsCalibrationFinalReport-2005-06-30.zip. The description of the modeling work performed for the preliminary Delta levee risk assessment is also relevant (JBA 2005).

Simulation results presented in this section include impacts on tidal flow and stage, evolution of the Delta salinity distribution over a 3-year simulation period, and estimation of the increased NDO required to meet salinity standards for the western island set of pre-flooded islands.

Model Geometry

The finite element model geometry with primary boundary condition locations is show in Figure 6-6. A more detailed view of the island geometry with levee breach lengths is show in Figure 6-7. The model configuration is such that individual levee breaches may be opened or closed for any given simulations. All simulation results presented here utilize the same model geometry. For each individual simulation, breach elements were set open or closed as appropriate for the islands set being modeled. For the base case simulation, all breach elements where closed. For Set 4, the 20 island case, all breach elements where open.

Simulation Period and Boundary Conditions

The simulation period used for this analysis was April 1, 2003, through December 31, 2004. Inflow and export boundary conditions for the simulations where taken from the Dayflow Database (http://iep.water.ca.gov/dayflow). DWR Delta Modeling Section’s monthly Delta Island Consumptive Use (DICU) estimates are used to determine agricultural channel diversions and returns within the Delta as well as the salt load associated with return flows. The base DICU estimates where used for all simulations. DICU was not adjusted to consider pre-flooding of islands because the intention of the simulations was to evaluate the salinity impact associated with changes in configuration of the Delta, not changes in DICU flows. Historical gate operations where used for the Delta Cross Channel, the temporary south Delta barriers, and the Montezuma Slough Salinity Control Gate.

Initial conditions where developed from the historical salinity distribution on April 1, 2002. For the pre-flooded islands, initial salinity was set equal to that of its neighboring channels.

Figure 6-8 shows the Total Delta Inflow, Total Exports, and NDO from the Dayflow Database. The NDO computed by the RMA Bay-Delta Model may be slightly different because of the use of the distributed monthly average DICU flows as opposed to the Dayflow Consumptive Use estimate.

The Dayflow estimate of NDO is negative on June 4, 5, and 6, 2004, due to the flooding of Jones Tract. In this modeling exercise it is not appropriate to include the historical Jones Tract flood event because pre-flooding of Jones Tract is one of the components of the analysis. Therefore, none of the simulations presented below, including the base case simulation, represent the dynamic breach and flooding of Jones Tract.

Comparisons of observed tidally averaged electrical conductivity (EC) with the base case simulation result are presented in Figure 6-9 (Delta monitoring stations for comparison of computed and observed EC) and Figures 6-10 to 6-14 (corresponding to the five Delta stations identified in Figure 6-9). EC is a quantity that is readily measured in the field and is commonly used as a surrogate for salinity. Observed data have been collected from the online Interagency Ecological Program (http://www.iep.ca.gov/data.html) and the California Data Exchange Center (http://cdec.water.ca.gov/) databases. Data collected at intervals less than one day was filtered using a two-pass, 24.75-hour running average to generate tidally averaged EC time series. The RMA Bay-Delta Model results are computed at a 7.5-minute interval and then filtered using a two-pass 24.75-hour running average to generate tidally averaged EC time series.

The period influenced by the Jones Tract event is shown in each figure. During that period, it is not expected that the computed and observed time series will match because the base case simulation did not include the breach event.

Hydrodynamic Impact

Pre-flooding islands and leaving them open to tidal exchange can have an important impact on stage and flow throughout the Delta. Because of the complex and restrictive channel geometry of the Delta, increasing the total area open to tidal inundation does not necessarily increase the total tidal flow in and out of the Delta. In general, tidal flow in the neighborhood of the newly breached island will increase while stage range decreases. Farther from the breach, the tidal flow may decrease.

Variation in stage in the system is illustrated by color contour plots of the primary semi-diurnal (M_2) and diurnal (K_1) tidal constituents shown in Figures 6-15 to 6-19. A comparison of M_2 and K_1 at selected locations is presented in Table 6-1. Both M_2 and K_1 decrease in the central Delta at Franks Tract from 20 percent to 50 percent with the pre-flooded island sets simulated. As expected, the largest reduction is for Set 4, the 20-island case. However, at Chipps Island Sets 1 and 4 increase M_2 by approximately 10 percent, while Sets 2 and 3 decrease M_2 by 10 percent to 15 percent. At Martinez the tidal amplitude is slightly decreased with Sets 1 and 4 and slightly increased with Sets 2 and 3.

Instantaneous flow and “tidal flow” at Martinez and Chipps Island are shown on Figures 6-20 and 6-21, respectively. The tidal flow is the average flood and ebb flow and is representative of the active tidal prism (tidal flow accumulated over 6 hours is an estimate of the tidal prism). Tidal flow is computed by averaging the absolute value of the mean flow, <Q>, subtracted from the instantaneous flow, Q(t),

Tidal flow = <|(Q(t) - <Q>)|>.

Averaging is accomplished by a two-pass 24.75-hour average. The tidal flow time series varies with the spring-neap cycle, with larger values during spring tides and lower values during neap tides.

Perhaps the most interesting result of this analysis is that tidal flow at Martinez decreases slightly for all the pre-flooded island sets simulated. The largest decrease occurs with Set 4, the 20-island case, where the tidal flow at Martinez is on the order of 5 percent less than the base simulation. This result is counter-intuitive, as one would expect that the tidal flow at Martinez to increase with such a significant increase in area open to tidal exchange.

At Chipps Island, Set 1 and Set 4 cause an increase in tidal flow of 10 percent and 12 percent, respectively, while Sets 2 and 3 cause a decrease in tidal flow of approximately 5 percent. This result suggests that breaching the western islands will generally increase dispersion of salt from Suisun Bay into the western Delta, whereas breaching southern or eastern islands will tend to decrease dispersion. This result is borne out by the salinity results shown in the next section.

Salinity Impact

For the locations indicated in Figure 6-22, instantaneous and tidally averaged EC results are shown on Figures 6-23 to 6-28. Color contours of EC are shown for each simulation on October 31, 2002, and May 31, 2003, in Figures 6-29 to 6-33. The general result is that when the western islands are breached, a tidal dispersion increase leads to an increase in EC along the San Joaquin River upstream of Jersey Point, which leads to an increase in EC to the south Delta export locations. However, when the southern or eastern islands are breached, a minor decrease in dispersion occurs and the EC in the interior of the Delta decreases slightly.

At RSAC075 (Chipps Island), a minor increase in the daily variation occurs when the western islands are breached, but little change occurs in the tidally averaged EC for any of the cases. The most important changes are evident at RSAN032, where EC increased substantially with pre-flooded island Sets 1 and 4. When the western islands are breached, tidal dispersion increased mixing of salt upstream of Jersey Point. In these simulations, Sherman Island has many breaches and there is a direct path between the lower Sacramento River and the San Joaquin bypassing Threemile Slough. Different breach configurations on Sherman Island are likely to impact the level of increased dispersion.

Over the 3 years of simulation, there is some evidence that the 20-island case may accumulate salt in the southern Delta; however, for these years the accumulation was not significant. Further investigation is required to determine whether any of the flooded islands would have a tendency to accumulate salt over a long period of time.

With Sets 1 and 4, late summer and fall EC at the State Water Project intakes ranged from 1,000 to over 1,400 umhos/cm. The following section considers how much additional NDO might be required to counterbalance the increased dispersion associated with opening the western islands to tidal exchange.

Carriage Water Requirement

Reservoir releases and Delta exports are carefully managed to meet water quality requirements. Current operations are based on balance of advective and dispersive fluxes present in the existing Delta configuration. NDO drives the downstream advective flux that balances the upstream salt flux from San Pablo and Suisun bays by tidal mixing. If the configuration of the Delta is changed such that the dispersive salt flux in the western Delta increases, as is the case for pre-flooded island Sets 1 and 4, the required NDO, or “carriage water,” would be increased to meet water quality standards.

To estimate the required increase in NDO, two additional simulations where performed with pre-flooded island Set 1 increasing the Sacramento River inflow, and thereby the NDO, for the period of June through December 2002. Set 1 was selected for these simulations because opening the western islands to tidal exchange resulted in the greatest increase in tidal dispersion among the cases evaluated. In simulation Set 1a, the Sacramento River inflow was increased by 1,500 cubic feet per second (cfs), and in simulation Set 1b the Sacramento River inflow was increased by 750 cfs. Over the period June 1 to December 31, these increases amounted to an additional release of 625,000 acre-feet and 312,000 acre-feet, respectively.

EC time series showing results from the base simulation as well as Sets 1, 1a, and 1b are shown in Figures 6-34 through 6-39. Increasing the NDO decreases the EC at RSAC075 to below the base level for the entire period. At RSAN018, increasing the NDO by 750 cfs with the western islands breached is sufficient to match the base level EC in the late fall. In the interior of the Delta, increasing the NDO by 750 cfs is sufficient to match the base EC during the early summer, but into the fall months the EC for the Set 1b simulation exceeds the base simulation. Increasing the NDO to 1,500 cfs for the period June through December results in lower EC than the base condition during the early summer, but matches the base condition in late fall.

This simple set of simulations is not a conclusive evaluation of increased carriage water requirement. But based on these results, it may be expected that should the western islands breach and remain open to tidal action, the additional water demand may be on the order of several hundred thousand acre-feet per year.

6.2.3.2 WAM Simulations

To evaluate the risk reduction potential of pre-flooding islands, the DRMS WAM was used to simulate a representative 20-island failure event with the base condition and pre-flooded island Sets 1, 2, and 3. Two runs were made for each pre-flooded island set—with and without the islands open to tidal exchange. Runs with islands closed to tidal exchange are equivalent to hardening the islands to prevent flooding in terms of the hydrodynamic and salinity response. When the WAM was used to simulate islands open to tidal exchange, a separate simulation was performed from the California Water Resources Simulation Model (CALSIM) flow record without additional island failures to establish the initial salinity conditions in the pre-flooded islands. These simulations used CALSIM run 2005A01A.

Four breach event starting times were simulated for each case.

- June 1, 1927
- October 31, 1930
- August 1, 1970
- September 1, 1984

Figure 6-40 shows the CALSIM NDO and total export for each starting time including 12 months before the event date and 3 years after the event date. The NDO preceding the event date is important in that it establishes the salinity distribution present at the time of the breach. If NDO is high prior to the breach, pre-flooded islands will contain lower salinity water and there will generally be less salt intrusion associated with the breach event. The balance of NDO and base exports after the breach event determines how long it will take to recover from the event and how large the export deficit will be.

For each simulation, the number of days to resume exports is shown in Figure 6-41 and the export deficit at the time export pumping is resumed is shown in Figure 6-42. The effectiveness of pre-flooded islands in reducing export disruption varies based on the hydrology before and after the breach event. This approach appears to be most effective when the system is relatively fresh at the time of the breach and there is significant outflow in the wet season following the breach event, as for the 1927 event. In that case, both the time of export disruption and the export deficit where reduced by as much as 75 percent to 80 percent. All of the pre-flooded island cases provide some risk-reduction benefit. The best result is achieved by pre-flooding the southern islands without leaving them open to tidal exchange, which on average over the four start times reduced the time of export disruption and the export deficit to just under 50 percent of the base condition. Pre-flooding the southern islands and leaving them open to tidal exchange was almost as effective, though when the breach event is followed by a prolonged period of low flow the islands can accumulate salt, which reduces their effectiveness at risk reduction.

6.2.4 Description of Values, Benefits, and Constraints

Pre-flooding islands reduces the potential volume of saltwater that may be drawn into the Delta during a levee failure event and thereby reduces the severity of the event and reduces the time to recover. If the pre-flooded islands are left open to tidal exchange, it is important to consider the change in Delta hydrodynamics. It is likely that allowing the western Delta islands to be open to tidal exchange will increase the required NDO to maintain water quality standards. Conversely, it may be possible to pre-flood eastern Delta islands and leave them open to tidal exchange without adversely impacting tidal dispersion in the system. The most effective pre-flooding option appears to be with the south Delta islands that are not left open to tidal exchange.

An important limitation of this initial analysis is that the impacts associated with residence time and water quality issues other than salinity are not considered.

6.3 COST ESTIMATE

Recommended for further study.

6.3.1 Capital Cost

Recommended for further study.

6.3.2 Operation Cost

Recommended for further study.

6.4 RISK REDUCTION ESTIMATE

The initial evaluation of a representative 20-island breach event indicated that pre-flooding a group of five Delta islands may reduce the disruption of Delta exports and the export deficit when exports are resumed by as much as 50 percent. Further analysis is required to extend this estimate to consider a wider range of breach scenarios, hydrology (event start time), and island groups.

6.5 FINDINGS AND CONCLUSIONS

6.5.1 Findings

Pre-flooding sets of Delta islands and leaving them open to tidal action affects overall Delta hydrodynamics, though the effects depend on the location of the flooded islands. Breaching islands in the western Delta increases tidal flows in the mixing zone of the estuary and tends to increase the dispersive flux of salt into the central Delta. Breaching islands in the interior of the Delta causes a minor reduction in the flux of salt into the central Delta. All of the breach cases considered cause a minor reduction in tidal flows at Martinez, which is a counter-intuitive result. If five western islands are pre-flooded and left open to tidal exchange, the managed NDO will need to be increased to counteract increased tidal dispersion and maintain Delta water quality standards. This preliminary analysis indicates that the increase in NDO will be on the order of several hundred thousand acre-feet annually.

Pre-flooding sets of Delta islands reduces the disruption of Delta exports and the export deficit associated with large-scale levee failure events when exports are resumed. The most promising option appears to be selecting sets of islands in the south Delta and leaving those islands closed to tidal exchange.

6.5.2 Conclusion and Recommendations

The western Delta islands should not be breached and left open to tidal exchange due to the resulting increase in dispersive salt flux into the central Delta.

Pre-flooding eastern Delta islands and leaving them open to tidal exchange does not appear to have a negative salinity impact. This result is likely true for northern Delta islands as well.

Hardening Delta islands against failure or pre-flooding islands and leaving them closed to tidal exchange may in general be a more robust solution because breached islands may accumulate salt if the period after a failure event is very dry.

This preliminary analysis has not considered the effects of residence time or water quality issues other than salinity. These important issues should be addressed in future analyses, and a wider array of pre-flooded island test cases should be considered.

Tables

Table 6-1 Comparison of Primary Semi-Diurnal (M_2) and Diurnal (K_1) Tidal Constituents

Location	Base	M2 (ft)				% Diff			
		Set 1	Set 2	Set 3	Set 4	Set 1	Set 2	Set 3	Set 4
Martinez	1.82	1.77	1.91	1.87	1.83	-3%	5%	3%	1%
Chipps Island	1.4	1.17	154	1.51	1.28	-16%	10%	8%	-9%
Rio Vista	1.04	0.76	1.11	1.14	0.82	-27%	7%	10%	-21%
Franks Tract	0.97	0.71	0.57	0.77	0.42	-27%	-41%	-21%	-57%
		K1 (ft)				**% Diff**			
Location	**Base**	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 1**	**Set 2**	**Set 3**	**Set 4**
Martinez	1.27	1.2	1.27	1.28	1.21	-6%	0%	1%	-5%
Chipps Island	1.05	0.87	1.01	1.05	0.87	-17%	-4%	0%	-17%
Rio Vista	0.9	0.7	0.8	0.86	0.6	-22%	-11%	-4%	-33%
Franks Tract	0.89	0.68	0.52	0.64	0.39	-24%	-42%	-28%	-56%

Figures

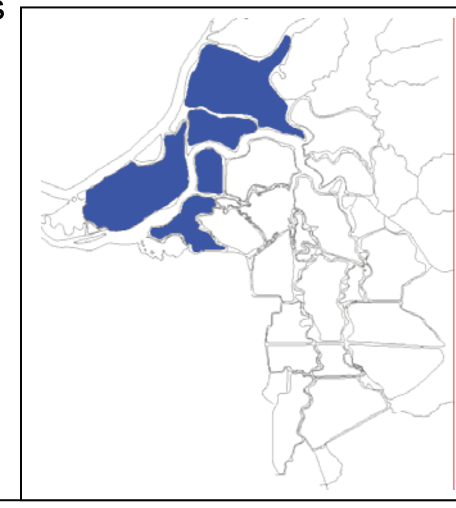
Analysis Approach

- RMA Bay-Delta Model -- examine salinity (EC) impact of pre-flooding groups of Delta Islands
- Simulation period is April 2002 through December 2004 with historic boundary conditions
- Islands are left open to tidal filling and draining
- Delta inflows and exports are kept the same as the base (no flooded islands) case.
- Initial flooding of the islands (and associated salinity intrusion) was not simulated – initial EC concentrations in islands were set equal to neighboring channels EC of April 1, 2002
- No breach event (e.g., earthquake) is simulated

Pre-flooded Island Groups

Set 1 – Western Islands

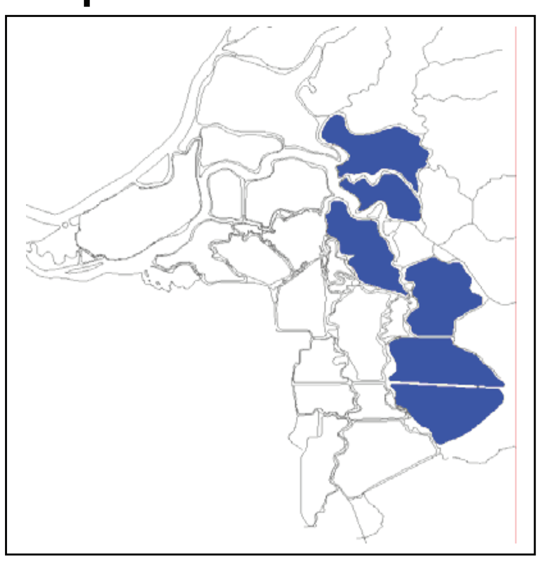
- Brannan-Andrus
- Sherman
- Jersey
- Bradford
- Twitchell



Pre-flooded Island Groups

Set 2 – Eastern Islands

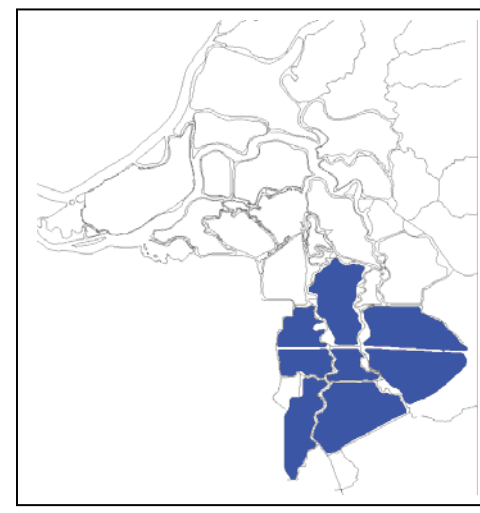
- Jones
- McDonald
- Mandeville
- Venice
- Bouldin



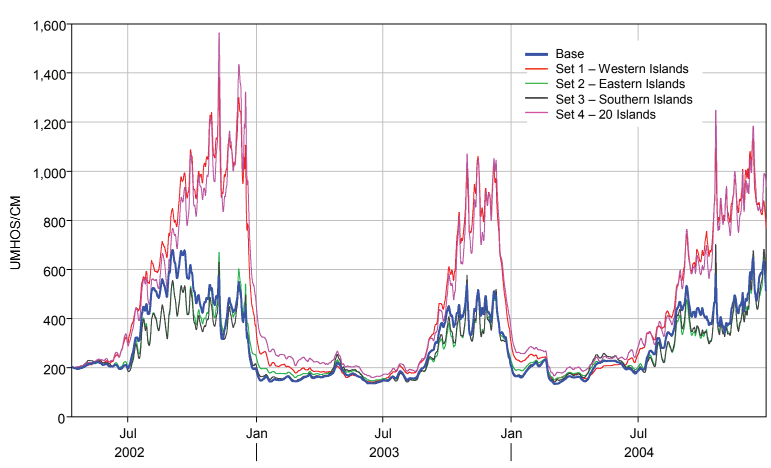
Pre-flooded Island Groups

Set 3 – Southern Islands

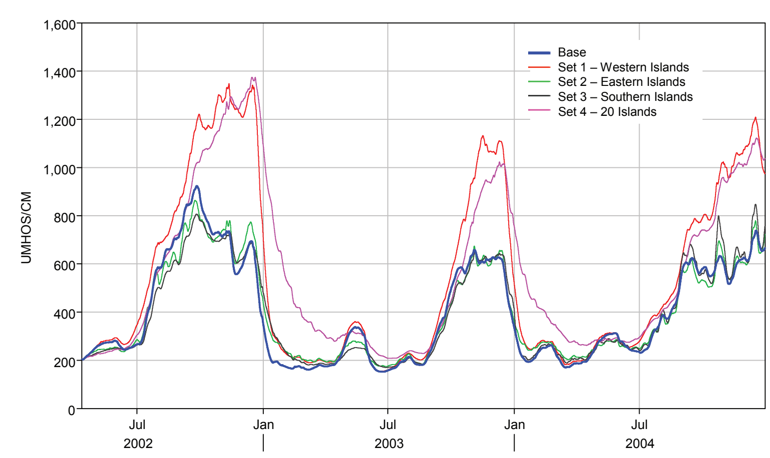
- Jones
- Victoria
- Byron
- Palm
- Orwood
- Woodward
- Bacon



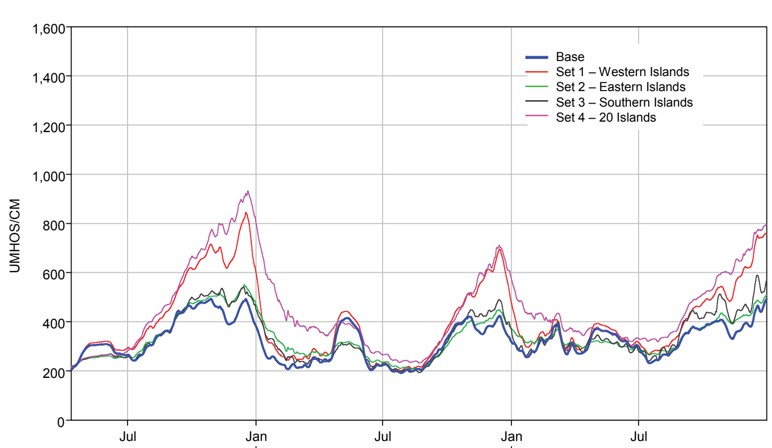
Tidally Ave EC at RSAN032 (San Joaquin River at Webb Tract)



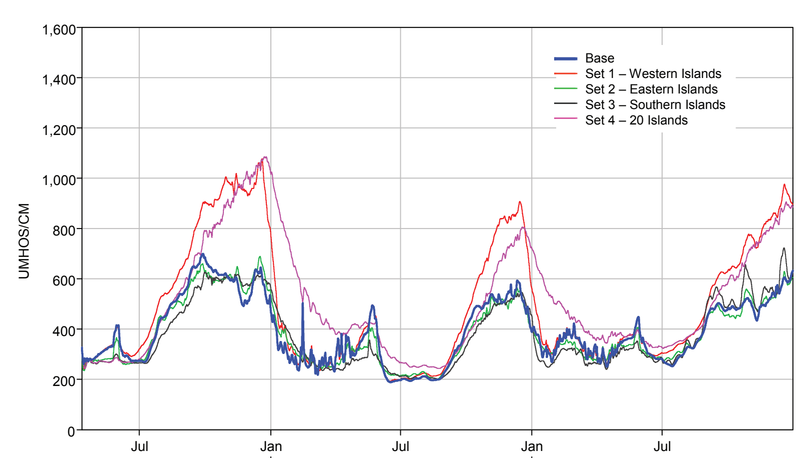
Tidally Averaged EC at ROLD024 (Old River at Bacon Island)



Tidally Averaged EC at RMID015 (Middle River at Jones Tract)



Tidally Averaged EC at SWP (Clifton Court)



Findings

- Pre-flooding western islands and allowing them to remain open to tidal action increases mixing of ocean salt into the Delta
- Pre-flooding selected islands in the southern or eastern Delta has minimal impact on mixing of ocean salt into the Delta
- For the period simulated, islands sets 1, 2, and 3 did not significantly accumulate salt over multiple years, while set 4 (20 Islands) does show signs of salt accumulation
- If 5 western islands are pre-flooded and left open to tidal exchange, the required increase in Net Delta Outflow will be on the order of several hundred thousand ac-ft annually to maintain water quality standards
- Pre-flooding sets of Delta islands will reduce the disruption of exports and the export deficit when exports are resumed associated with large scale failure events
- The most promising option appears to be selecting sets of islands in the south Delta for pre-flooding and leaving those islands closed to tidal exchange

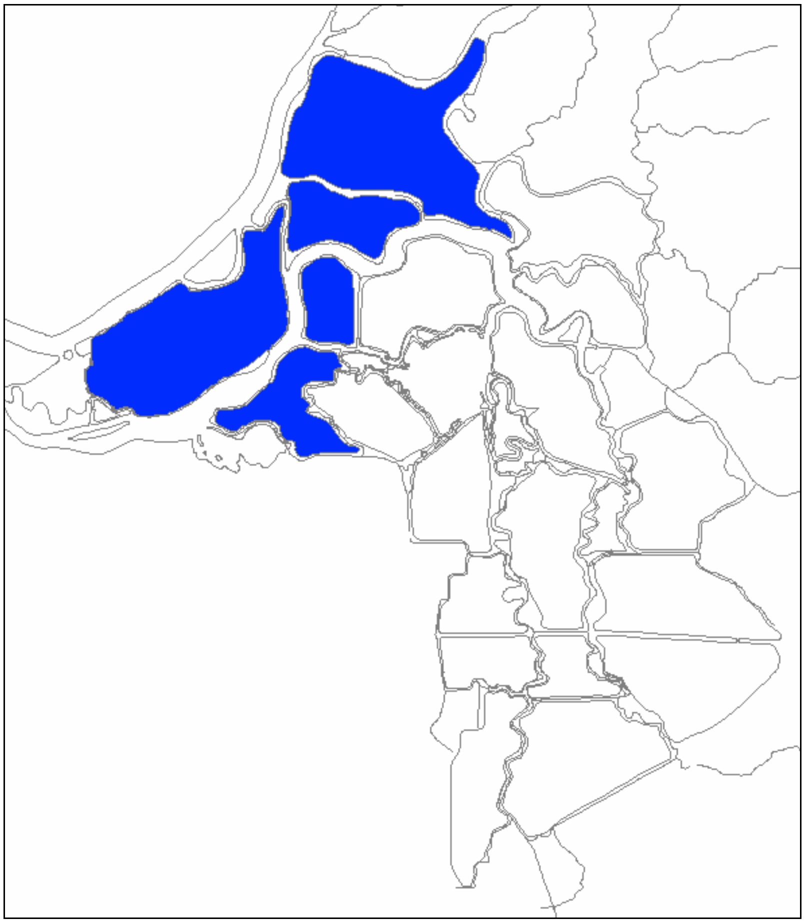


Figure 6-2 Set 1: Western islands – Sherman, Jersey, Bradford, Twitchell, Brannan-Andrus

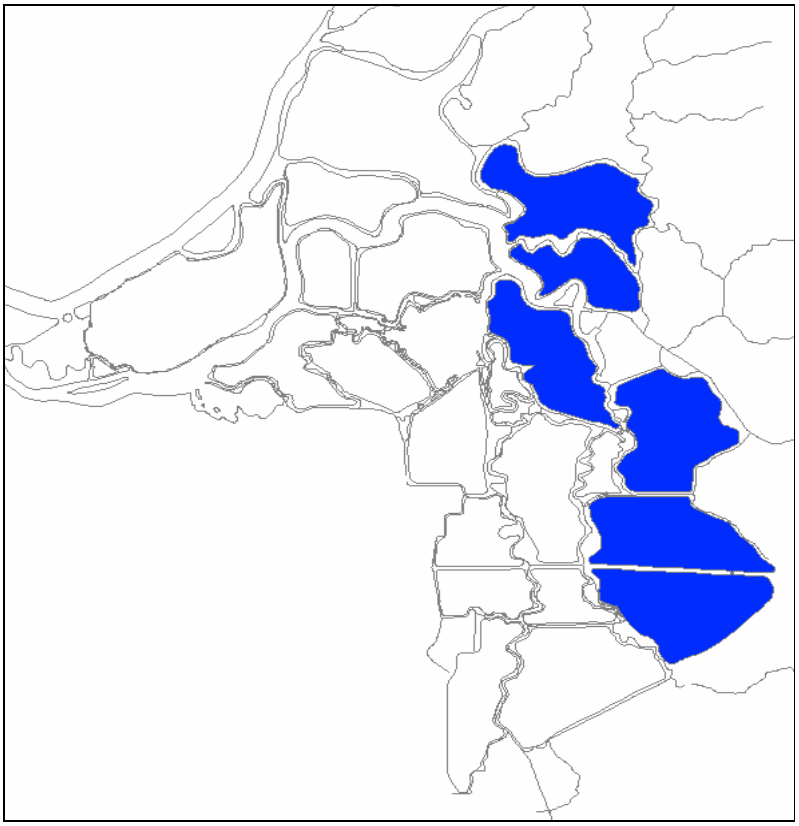


Figure 6-3 Set 2: Eastern Islands – Venice, Mandeville, McDonald, Jones, Bouldin

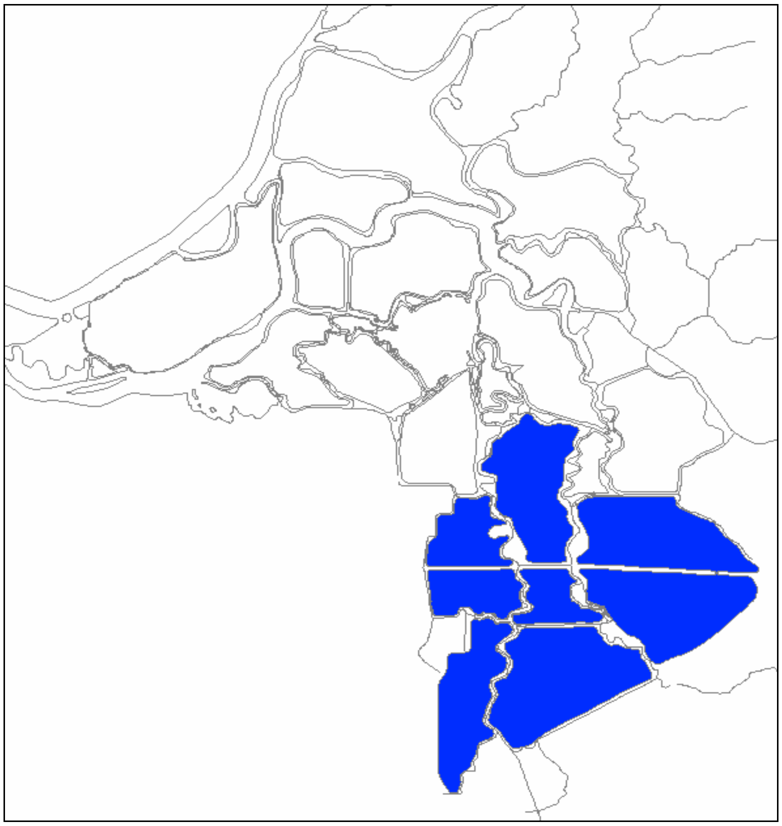


Figure 6-4 Set 3: Southern Islands – Palm-Orwood, Bacon, Woodward, Jones, Victoria, Byron

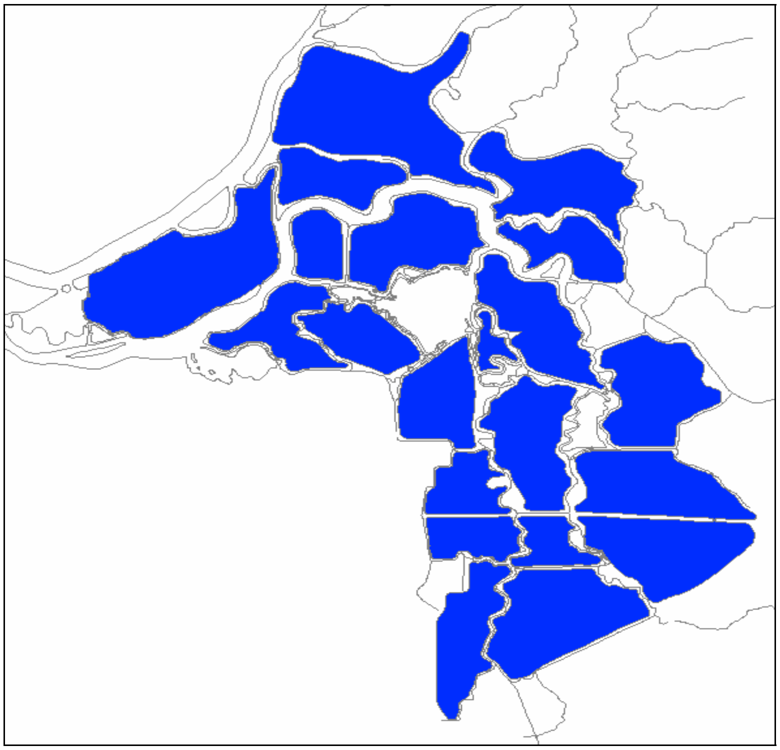


Figure 6-5 Set 4: 20 Islands

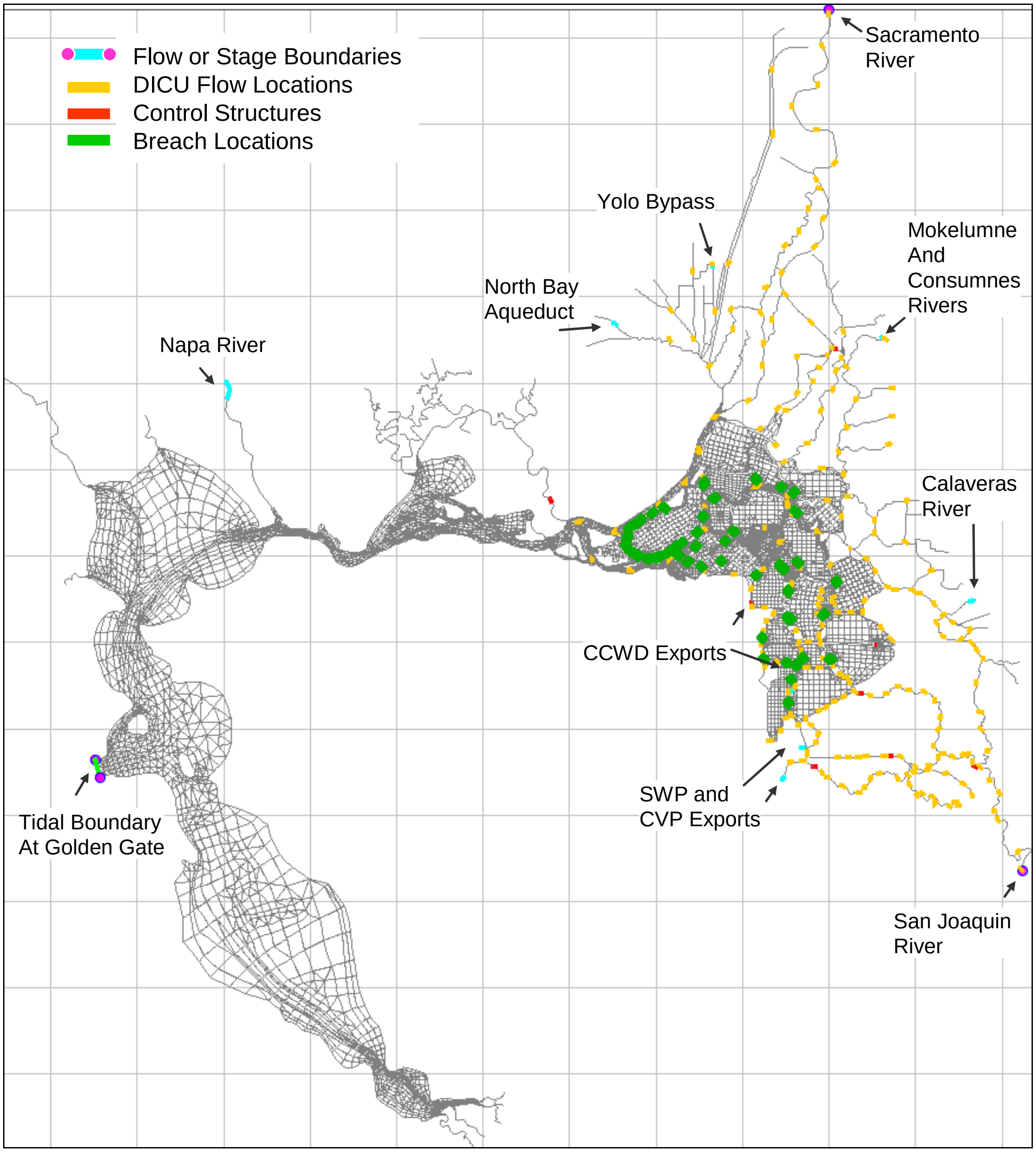


Figure 6-6 RMA Bay Delta Model Finite Element Geometry with 20 Delta Islands

Breach Lengths (ft)

Sherman Island #1	1300	Twitchell Island	1600
Sherman Island #2	1300	Brannan/Andrus Is. #1	1300
Sherman Island #3	1000	Brannan/Andrus Is. #2	1300
Sherman Island #4	1000	Webb Tract	1000
Sherman Island #5	1000	Bethel Tract #1	500
Sherman Island #6	700	Bethel Tract #2	500
Sherman Island #7	700	Holland Tract #1	1300
Sherman Island #8	1000	Holland Tract #2	700
Sherman Island #9	1000	Palm Tract #1	1300
Sherman Island #10	1000	Palm Tract #2	700
Sherman Island #11	1000	Orwood Tract #1	1000
Sherman Island #12	700	Orwood Tract #2	700
Sherman Island #13	1300	Bouldin Island	1300
Sherman Island #14	1300	Venice Island	1600
Sherman Island #15	700	Mandeville Island	1300
Sherman Island #16	700	Quimby Island	1300
Sherman Island #17	700	Bacon Island #1	1300
Sherman Island #18	700	Bacon Island #2	1300
Sherman Island #19	1000	Woodward Is. #1	1000
Sherman Island #20	1000	Woodward Is. #2	1000
Jersey Island #1	1000	McDonald Tract	1300
Jersey Island #2	1000	Lower Jones Tract	1300
Jersey Island #3	1000	Upper Jones Tract	1300
Jersey Island #4	700	Bryon Tract	500
Bradford Island	1300	Victoria Island	1000

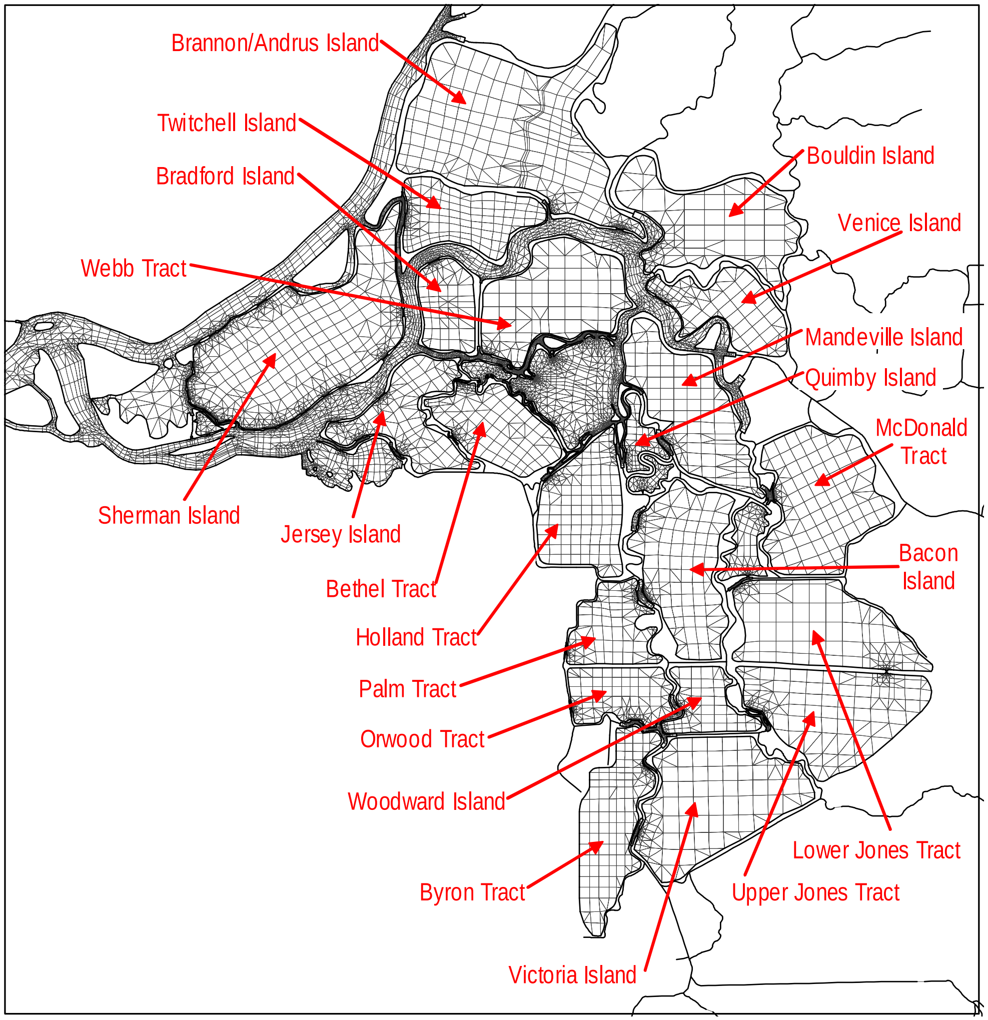


Figure 6-7 RMA Bay Delta Model Island Breach Locations and Lengths

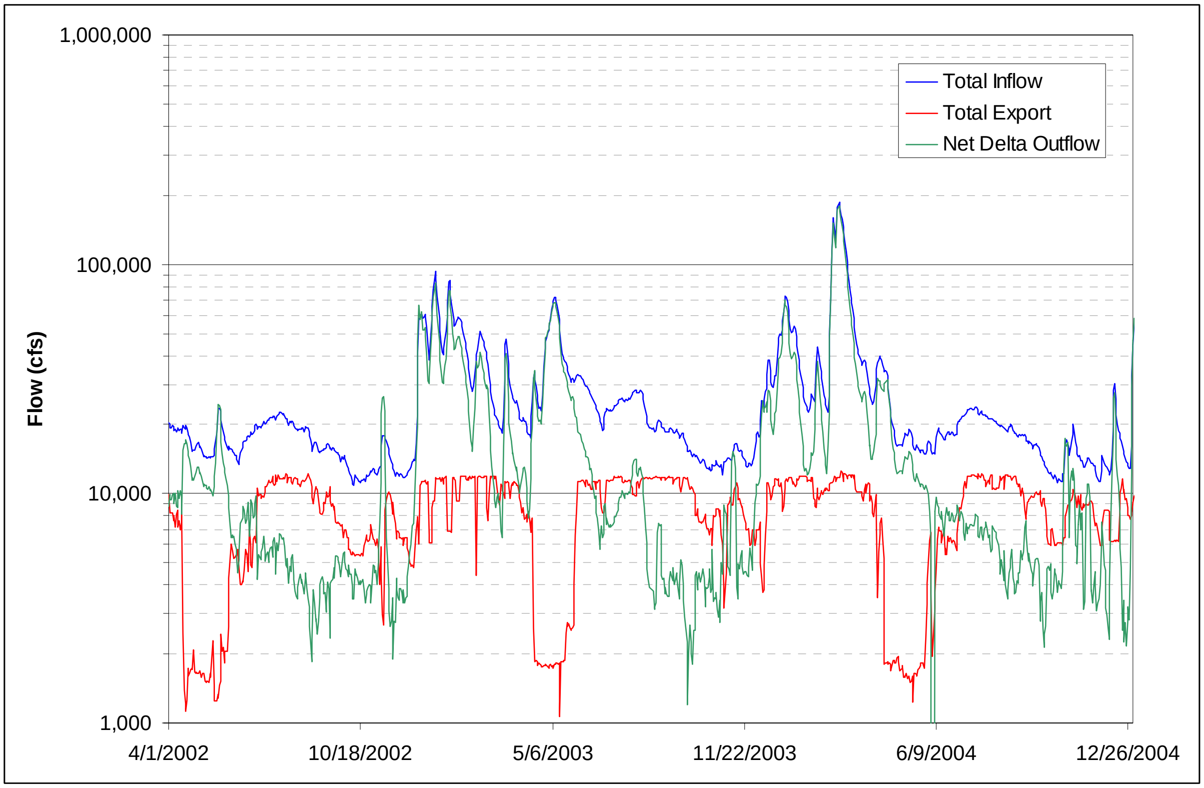


Figure 6-8 Total Inflow, Total Export, and Net Delta Outflow estimate from Dayflow

Figure 6-9 Delta Monitoring Stations for comparison of computed and observed EC

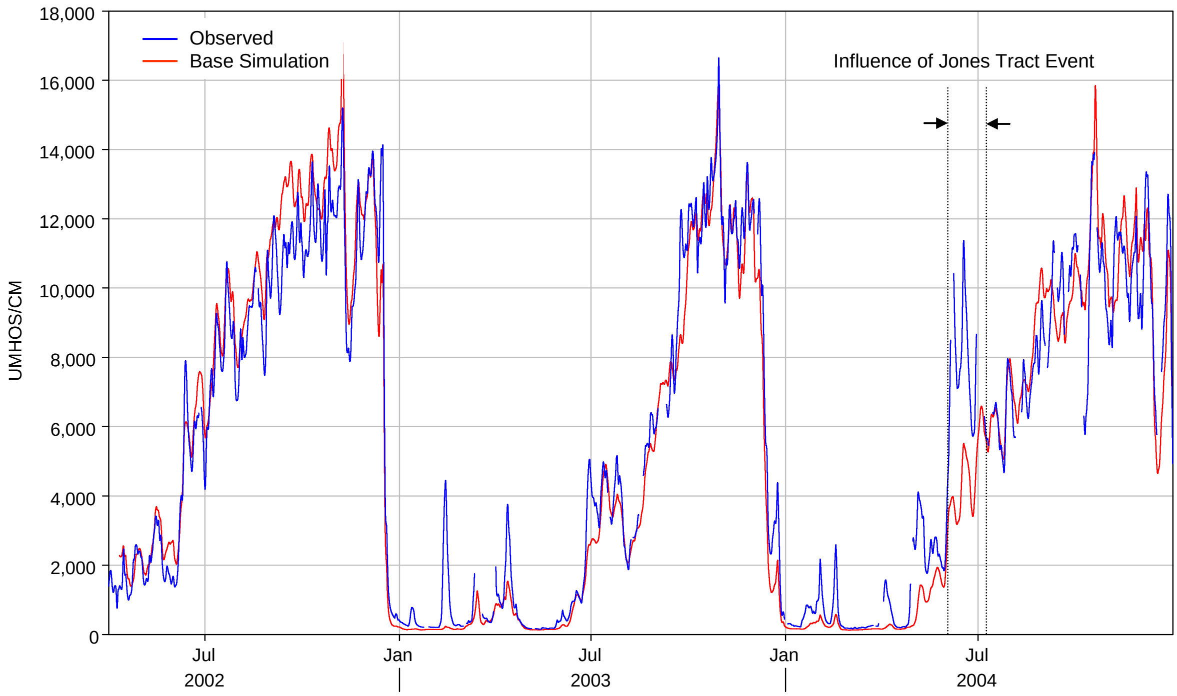


Figure 6-10 Comparison of Observed and Simulated Base Case tidally averaged EC at RSAC075 (Chipps Island)

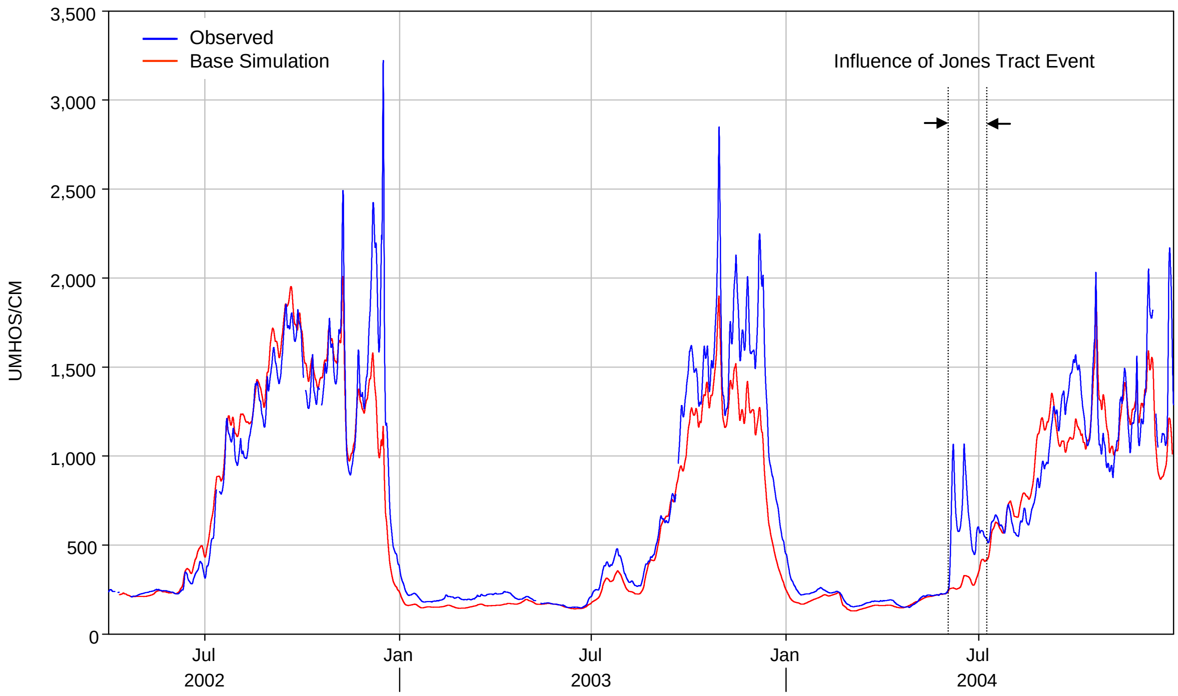


Figure 6-11 Comparison of Observed and Simulated Base Case tidally averaged EC at RSAN018 (Jersey Point)

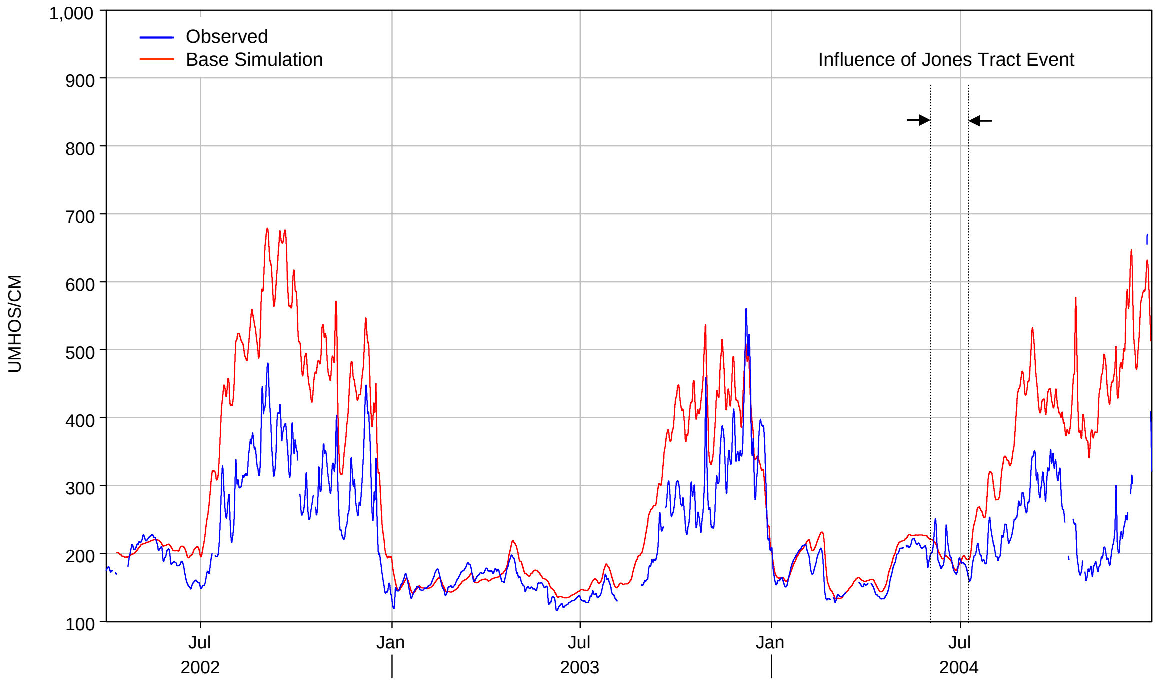


Figure 6-12 Comparison of Observed and Simulated Base Case tidally averaged EC at RSAN032

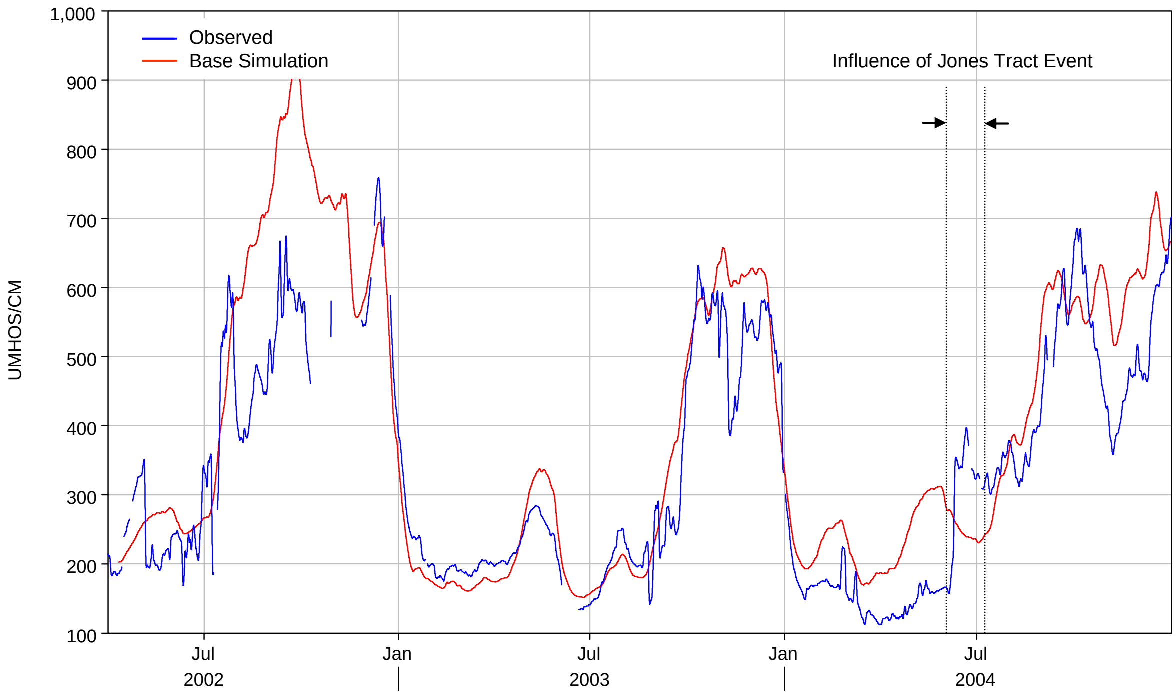


Figure 6-13 Comparison of Observed and Simulated Base Case tidally averaged EC at ROLD024

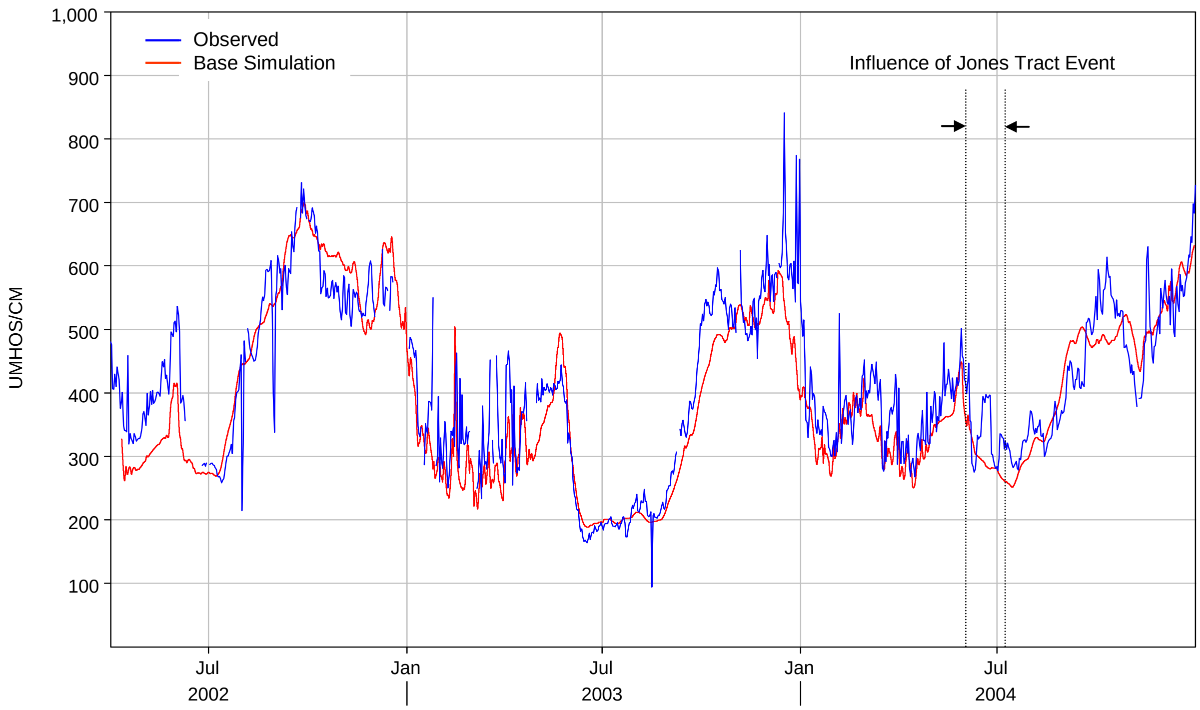


Figure 6-14 Comparison of Observed and Simulated Base Case tidally averaged EC at SWP Intake

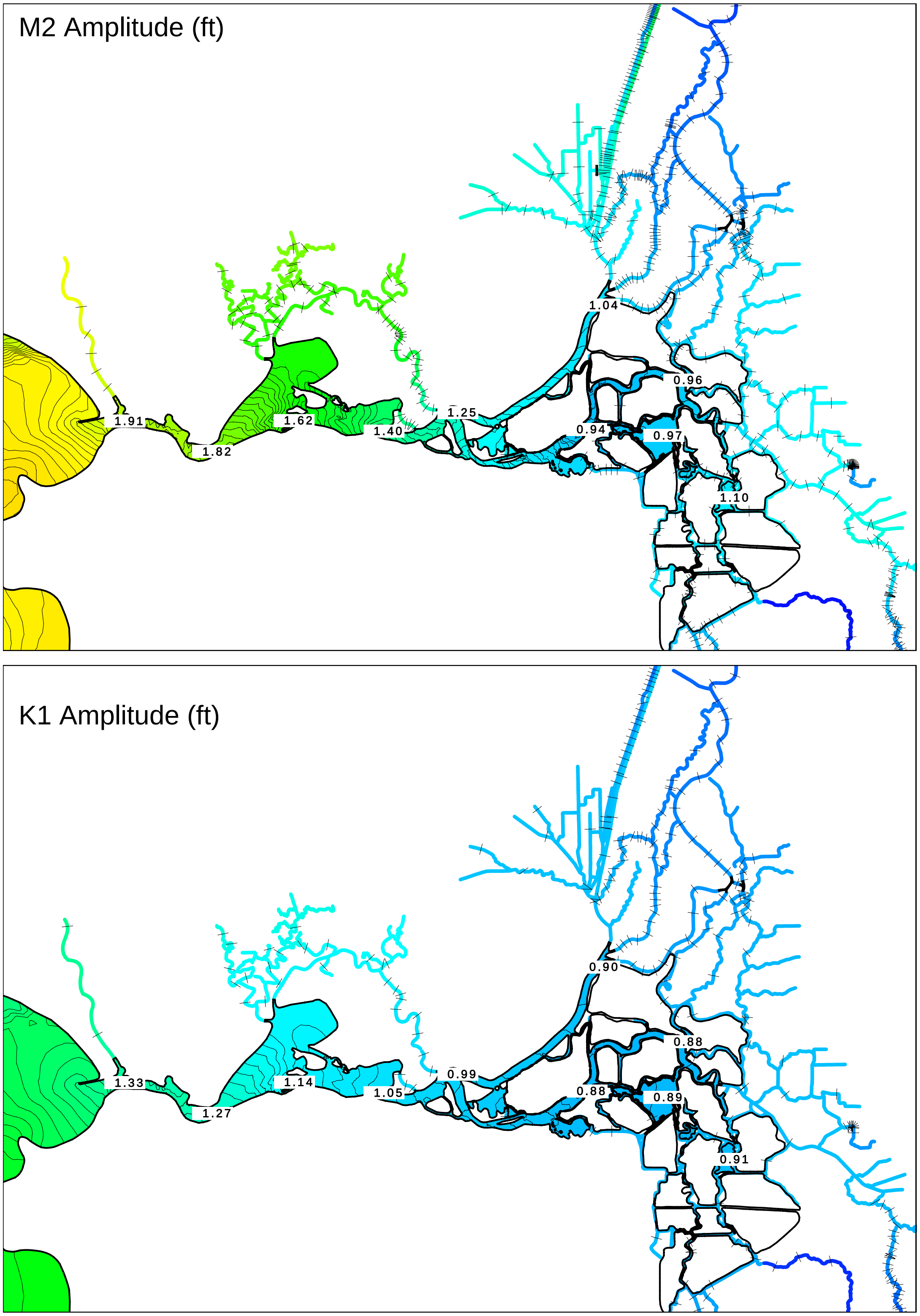


Figure 6-15 M2 and K1 Amplitude, Base Case

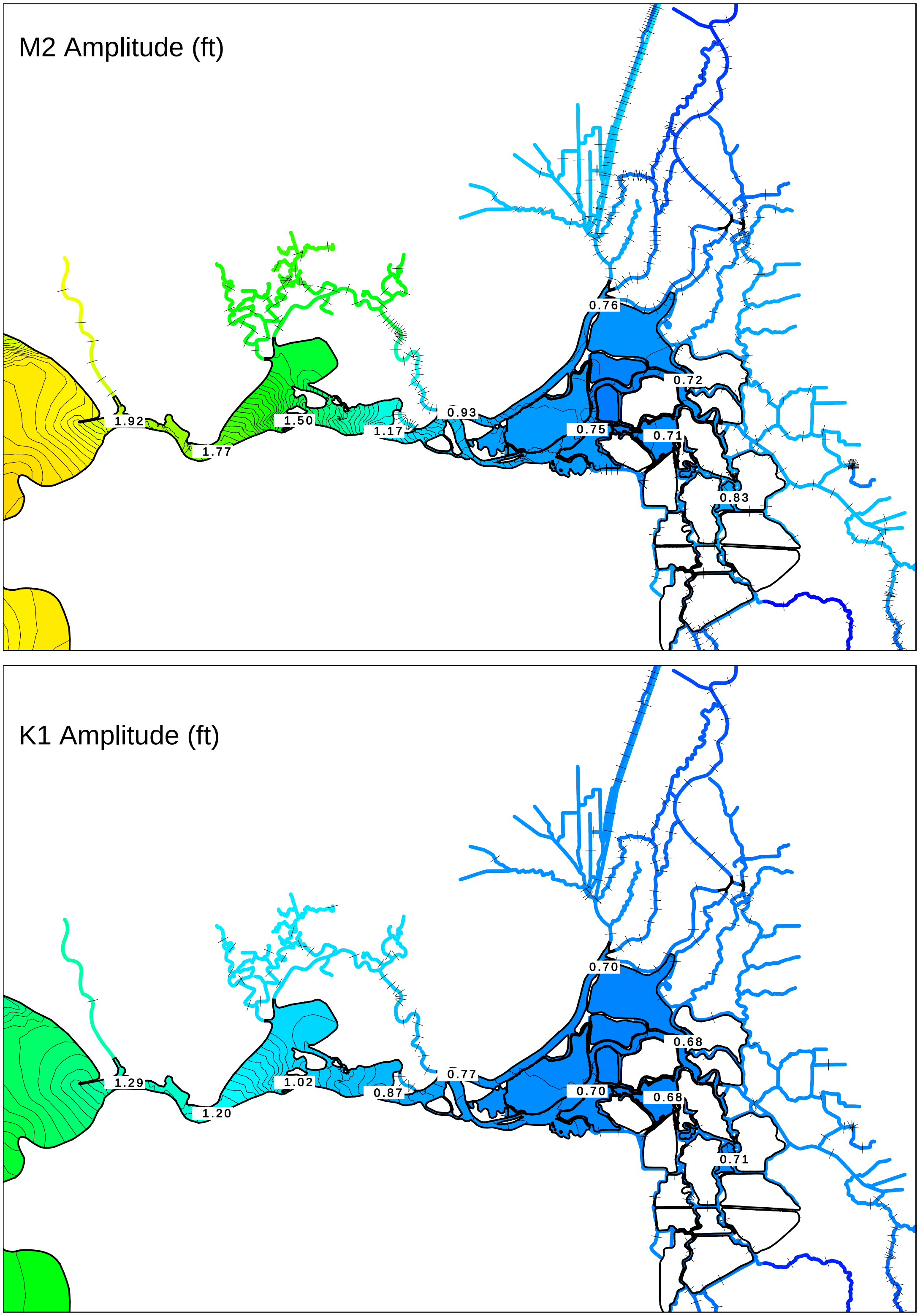


Figure 6-16 M2 and K1 Amplitude, Set 1: Western Islands

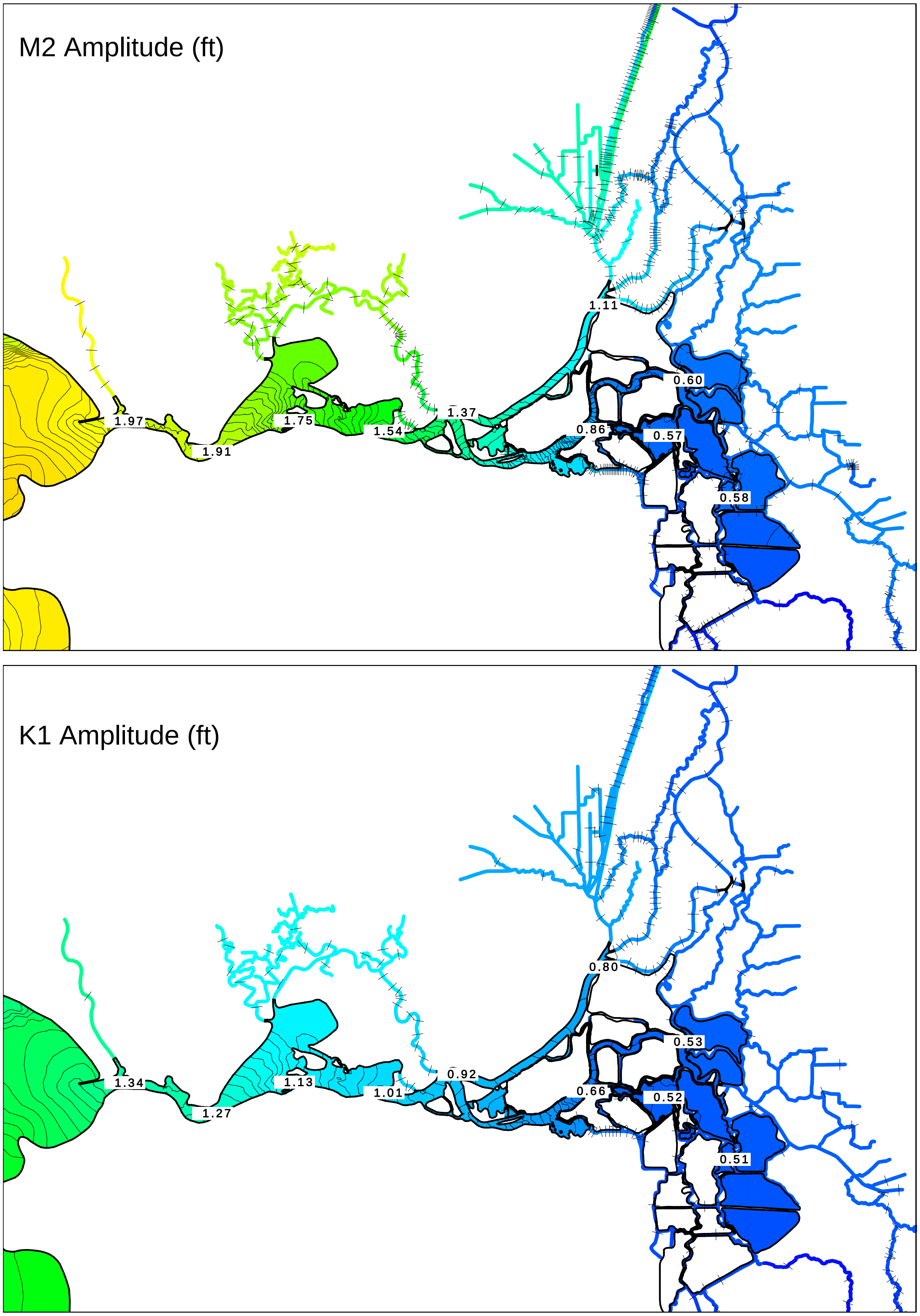


Figure 6-17 M2 and K1 Amplitude, Set 3: Eastern Islands

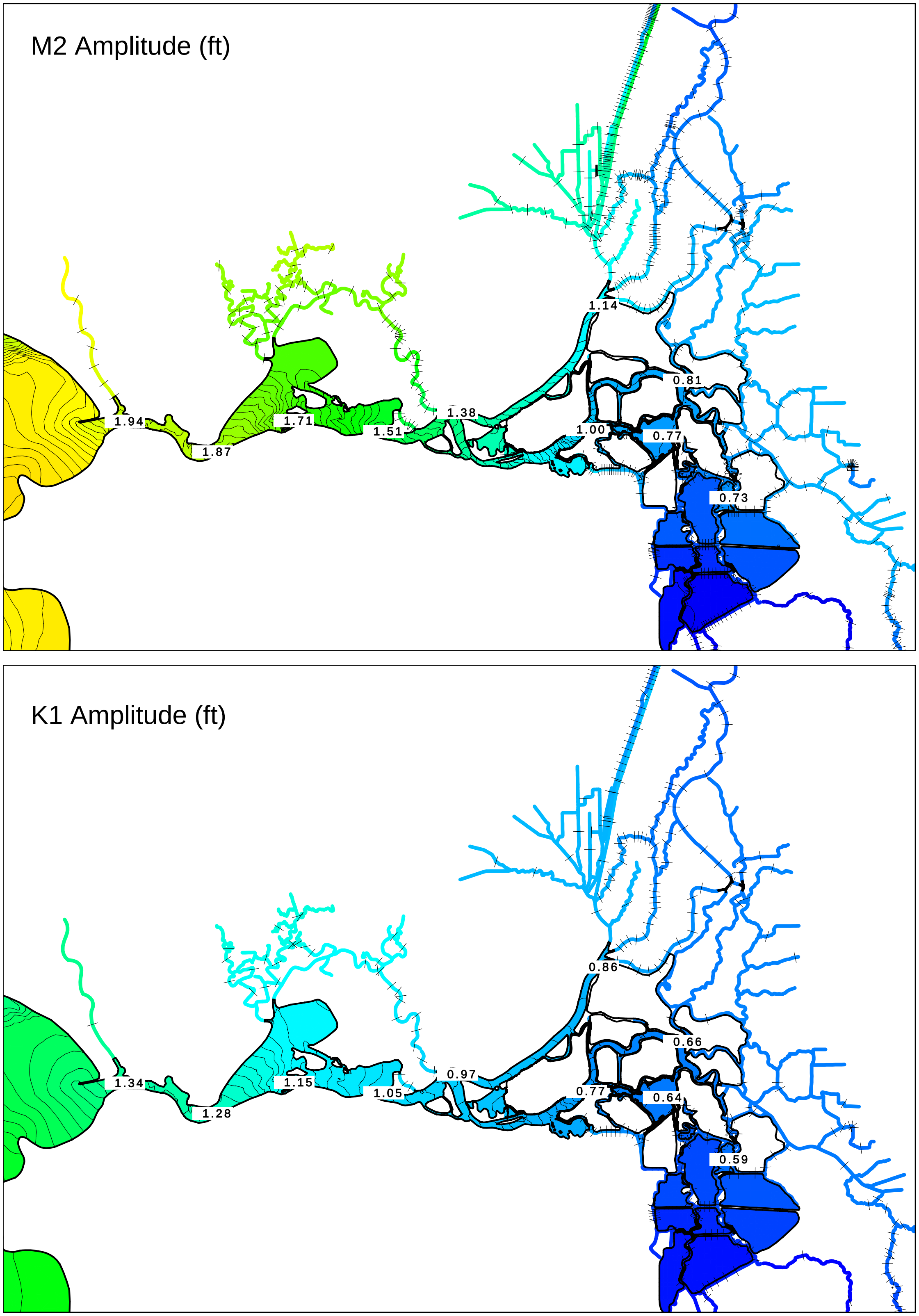
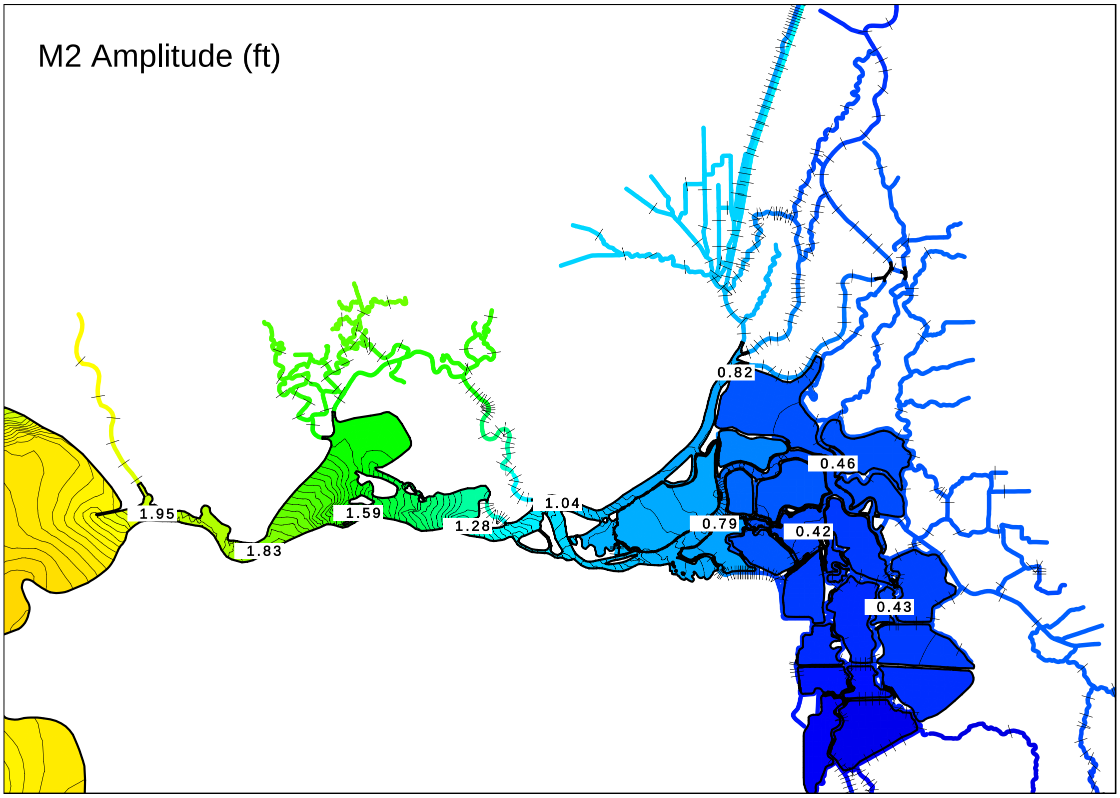


Figure 6-18 M2 and K1 Amplitude, Set 3: Southern Islands



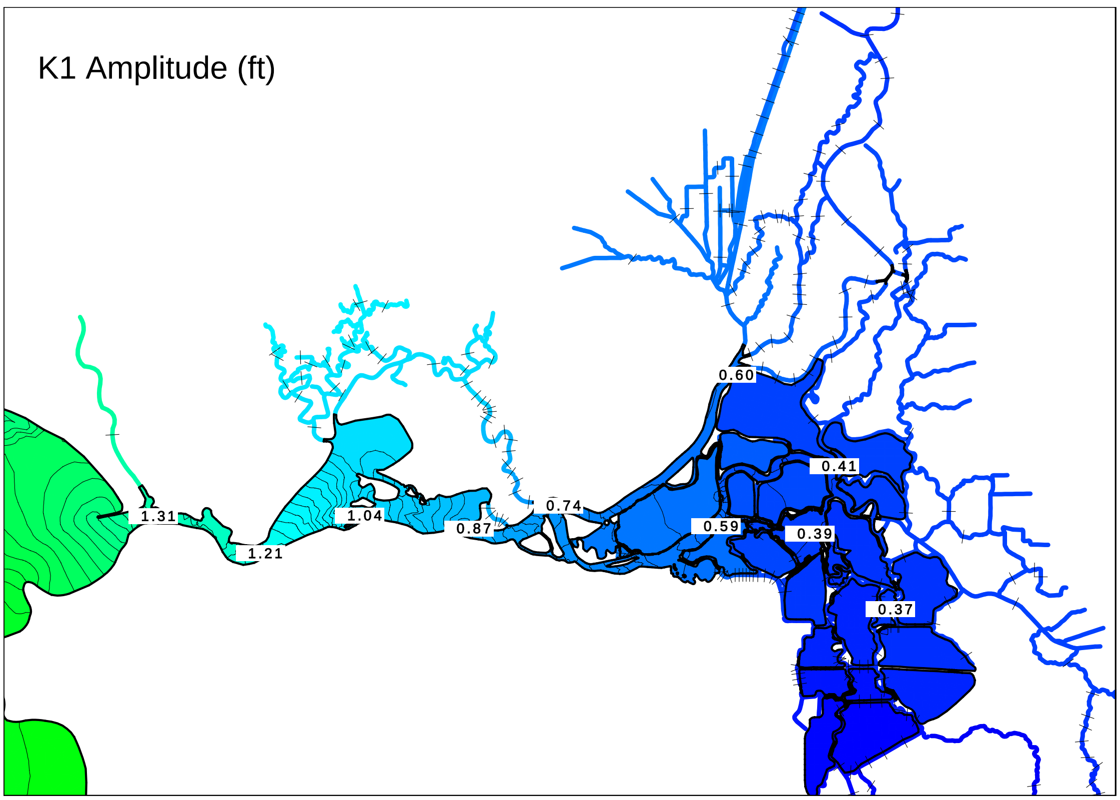


Figure 6-19 M2 and K1 Amplitude, Set 4: 20 Islands

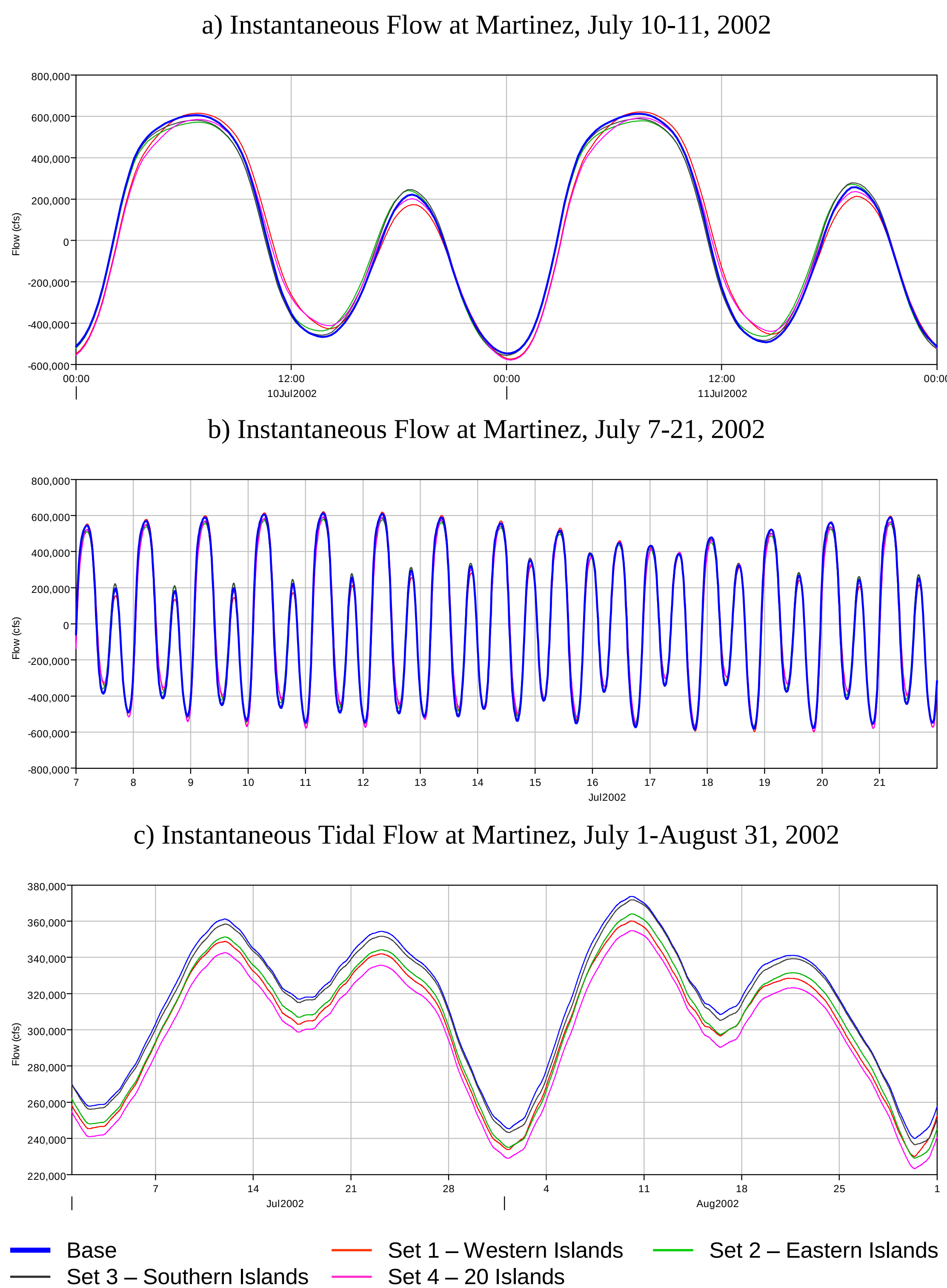


Figure 6-20 Tidal Flow at Martinez

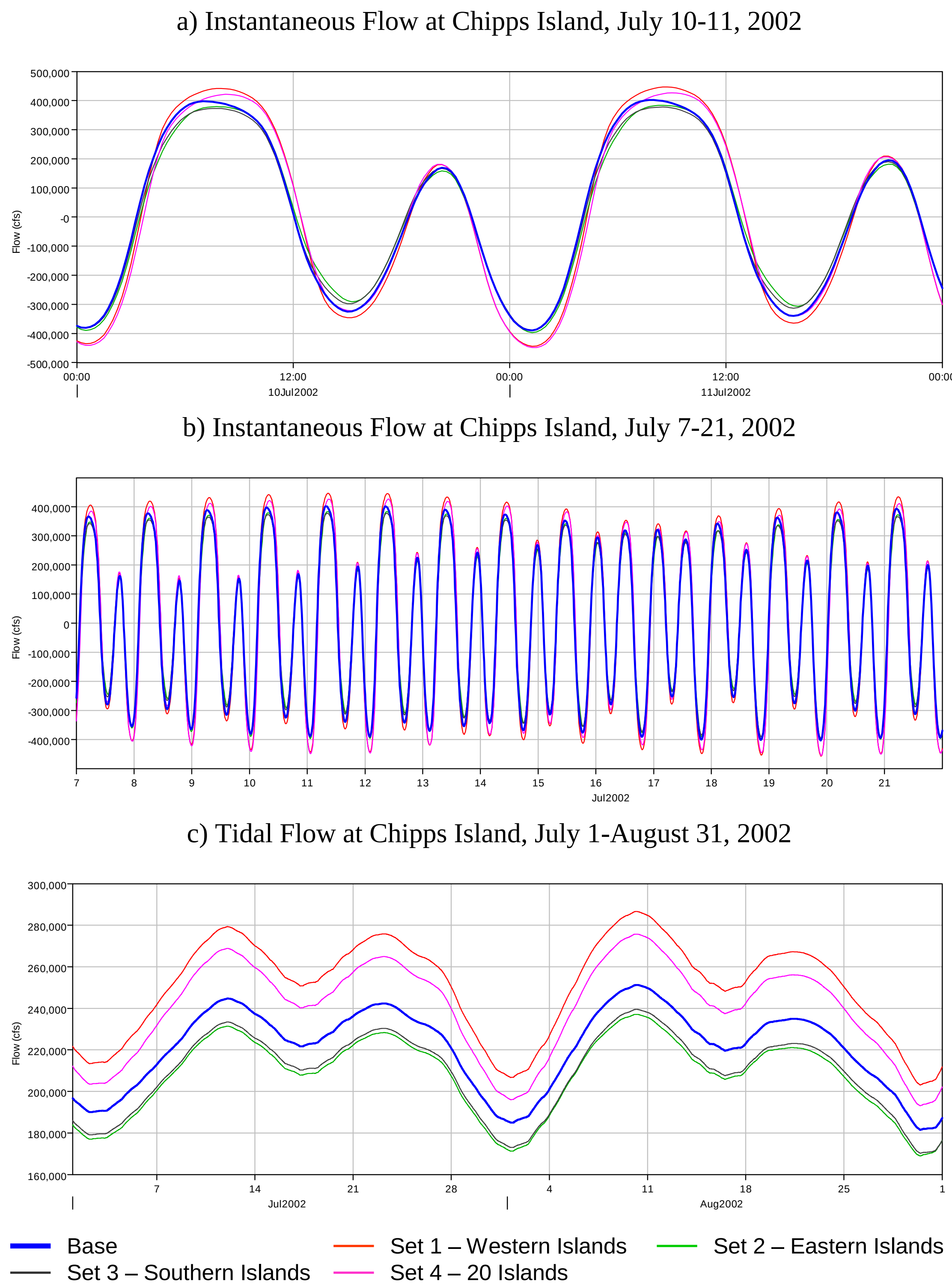


Figure 6-21 Tidal Flow at Chipps Island

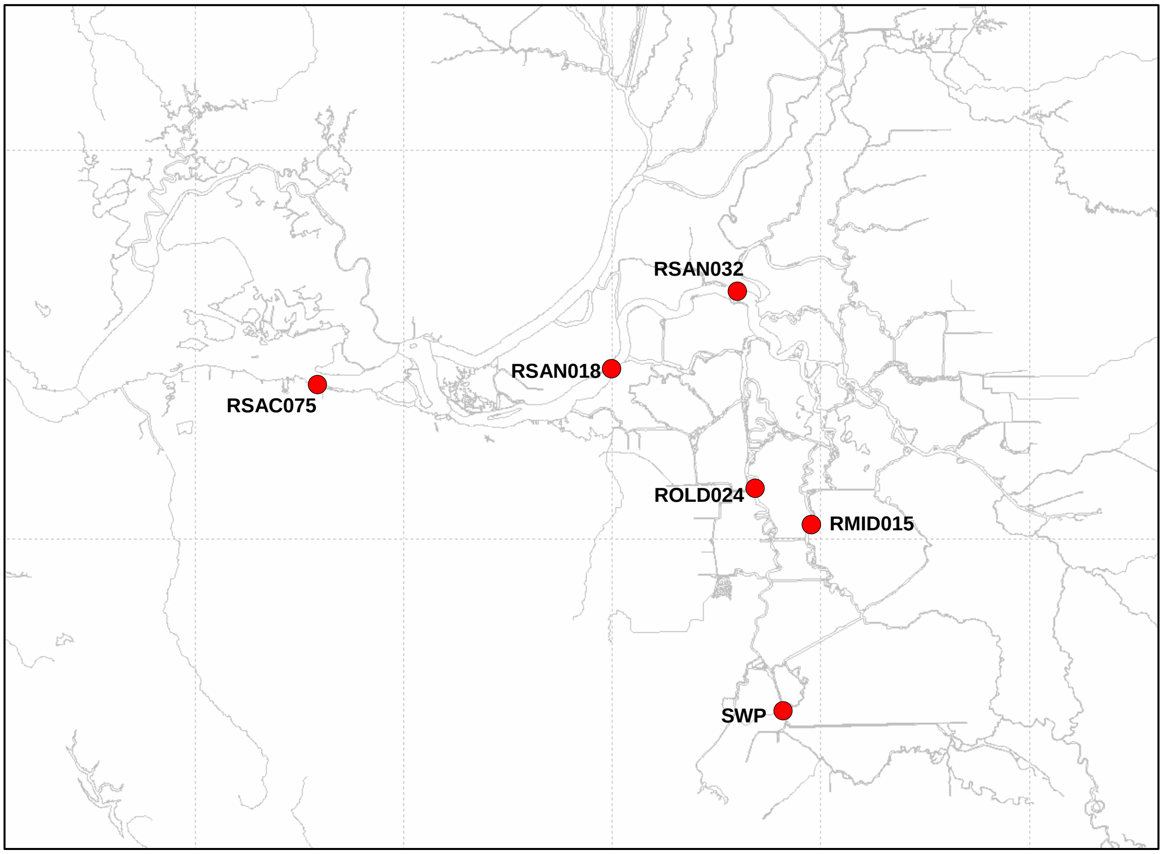
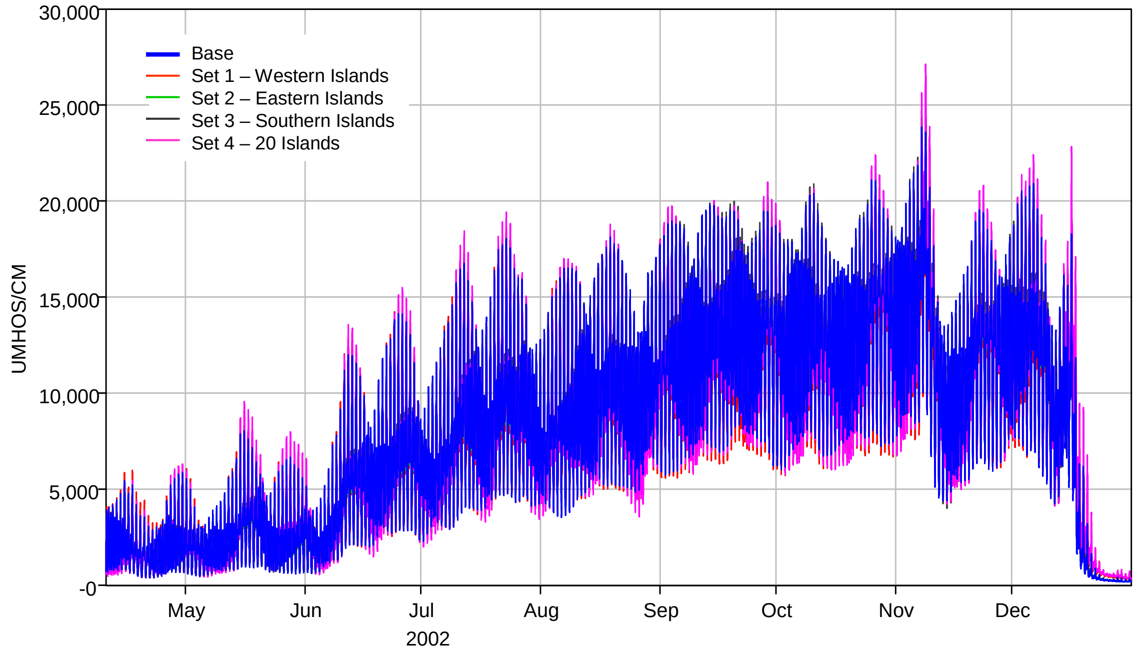


Figure 6-22 EC Time Series Locations for Comparison of Pre-Flooded Island Sets

a) Instantaneous EC at RSAC075, April 1 to December 31, 2002



b) Tidally Averaged EC at RSAC075, April 1, 2002, to December 31, 2004

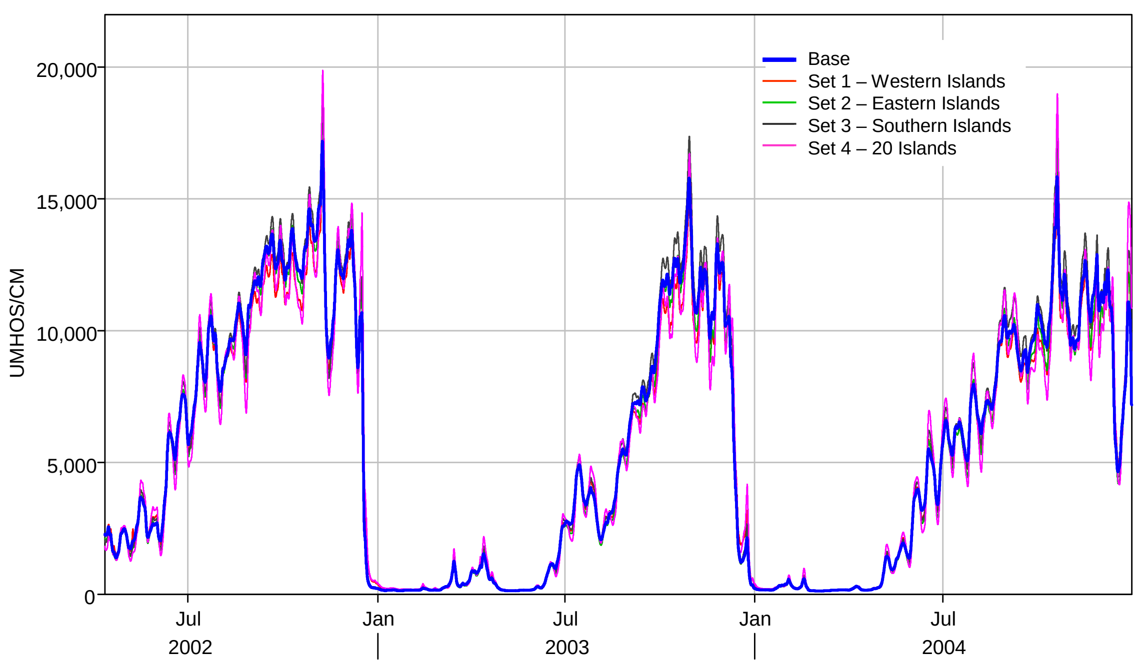
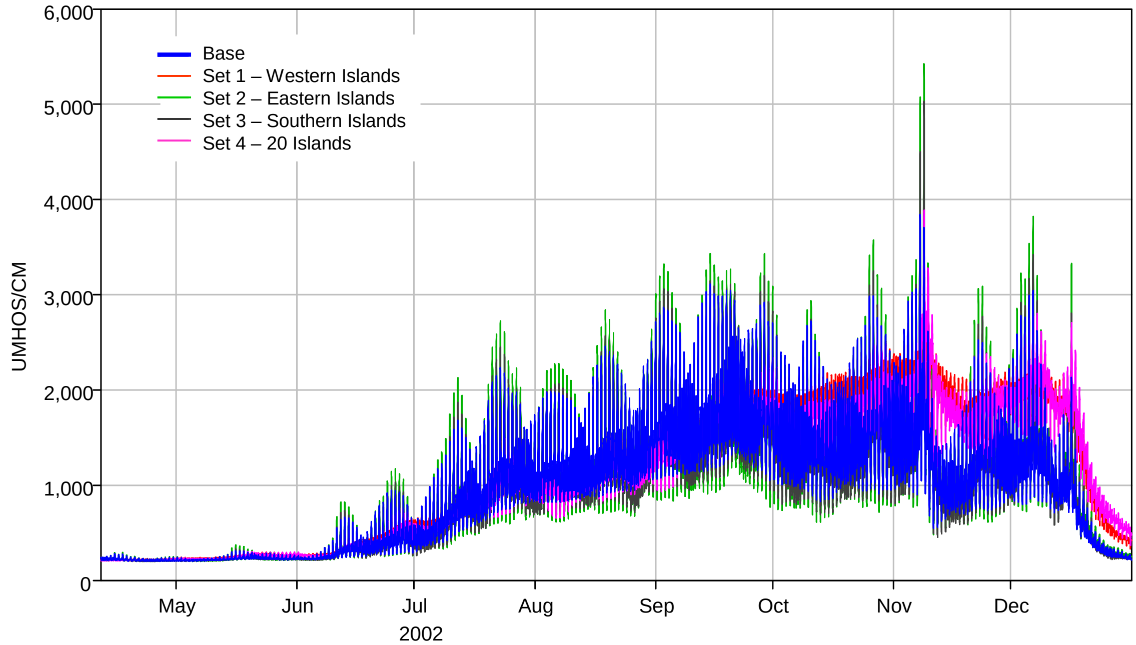


Figure 6-23 Comparison of Instantaneous and Tidally Averaged EC Time Series for Pre-Flooded Island Sets at RSAC075

a) Instantaneous EC at RSAN018, April 1 to December 31, 2002



b) Tidally Averaged EC at RSAN018, April 1, 2002, to December 31, 2004

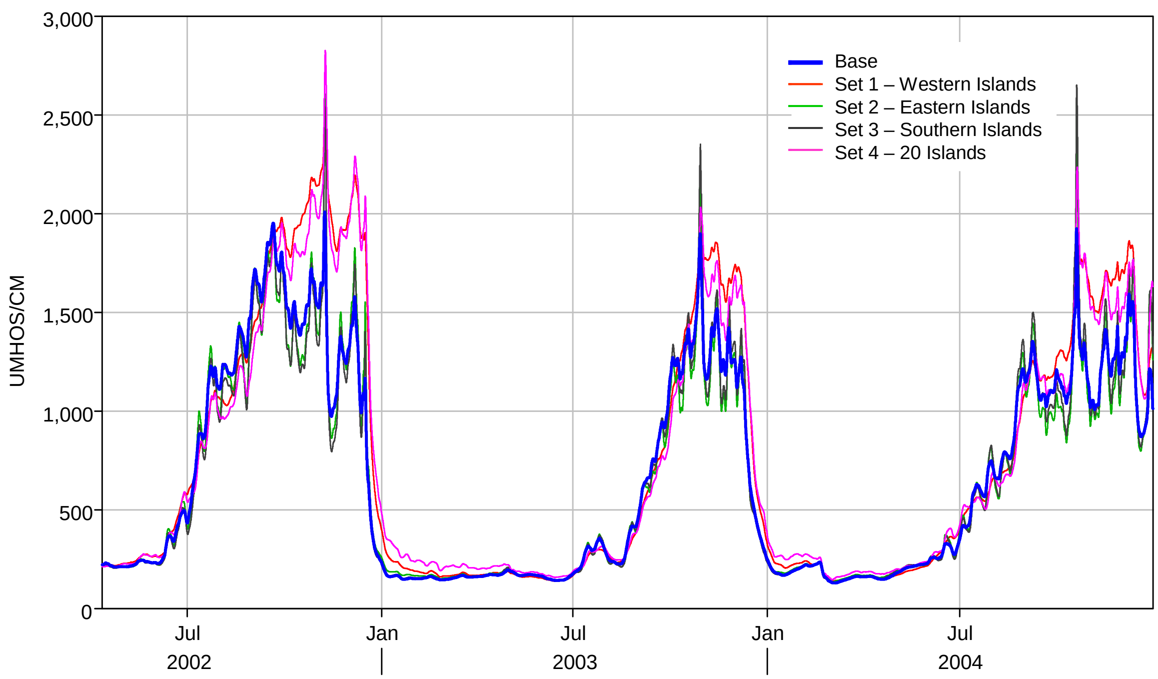
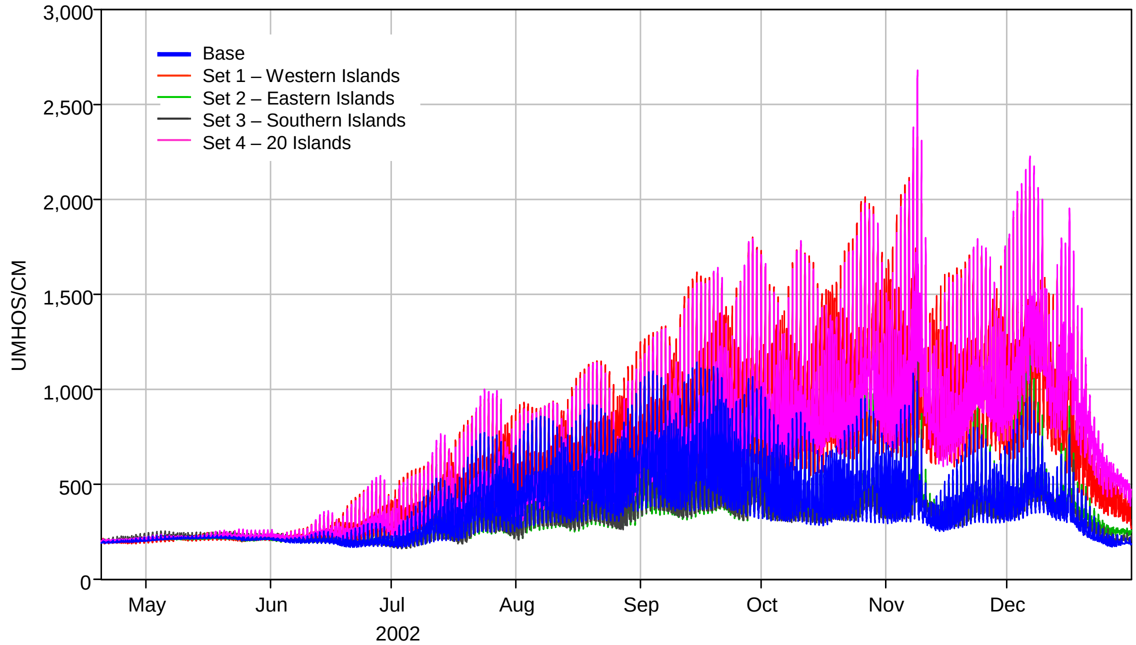


Figure 6-24 Comparison of Instantaneous and Tidally Averaged EC Time Series for Pre-Flooded Island Sets at RSAN018

a) Instantaneous EC at RSAN032, April 1 to December 31, 2002



b) Tidally Averaged EC at RSAN032, April 1, 2002, to December 31, 2004

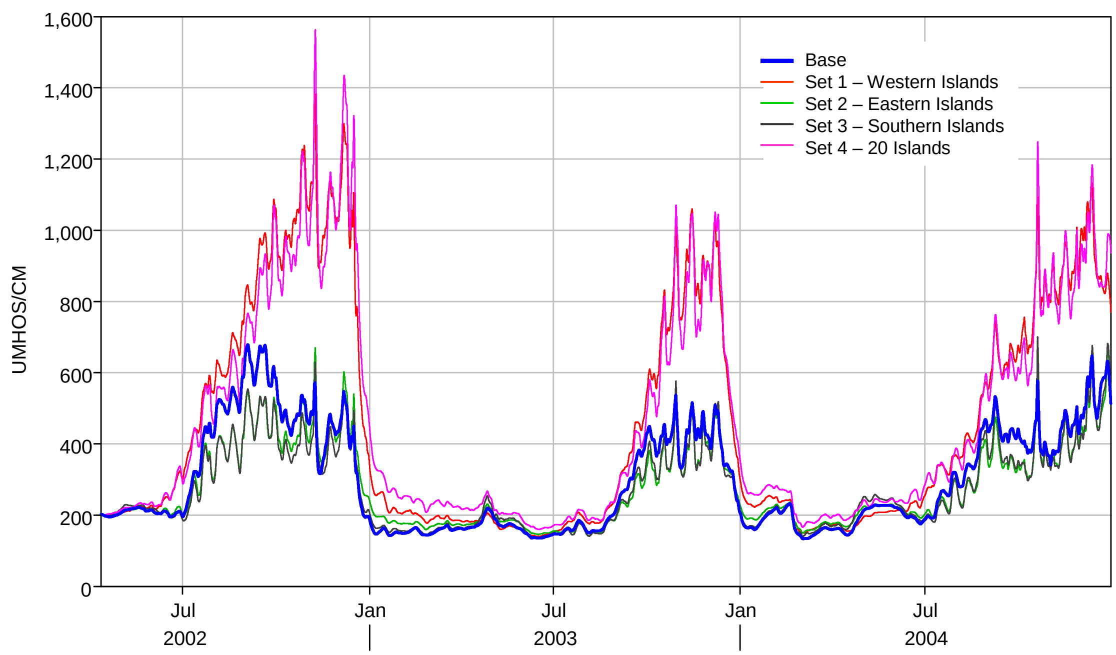
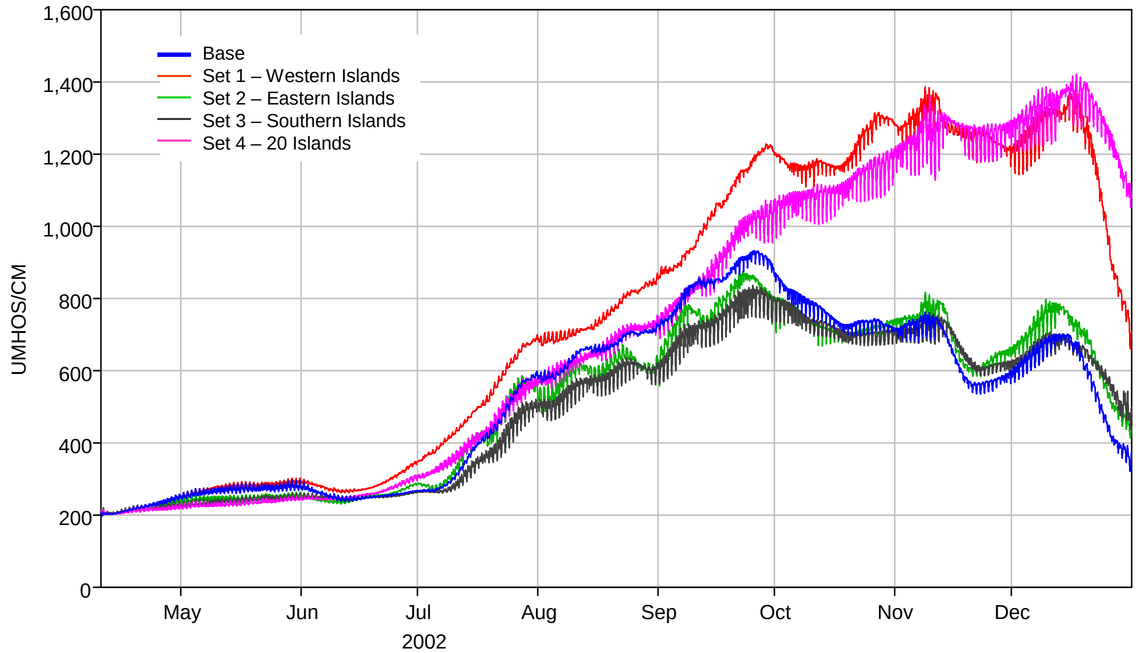


Figure 6-25 Comparison of Instantaneous and Tidally Averaged EC Time Series for Pre-Flooded Island Sets at RSAN032

a) Instantaneous EC at ROLD024, April 1 to December 31, 2002



b) Tidally Averaged EC at ROLD024, April 1, 2002, to December 31, 2004

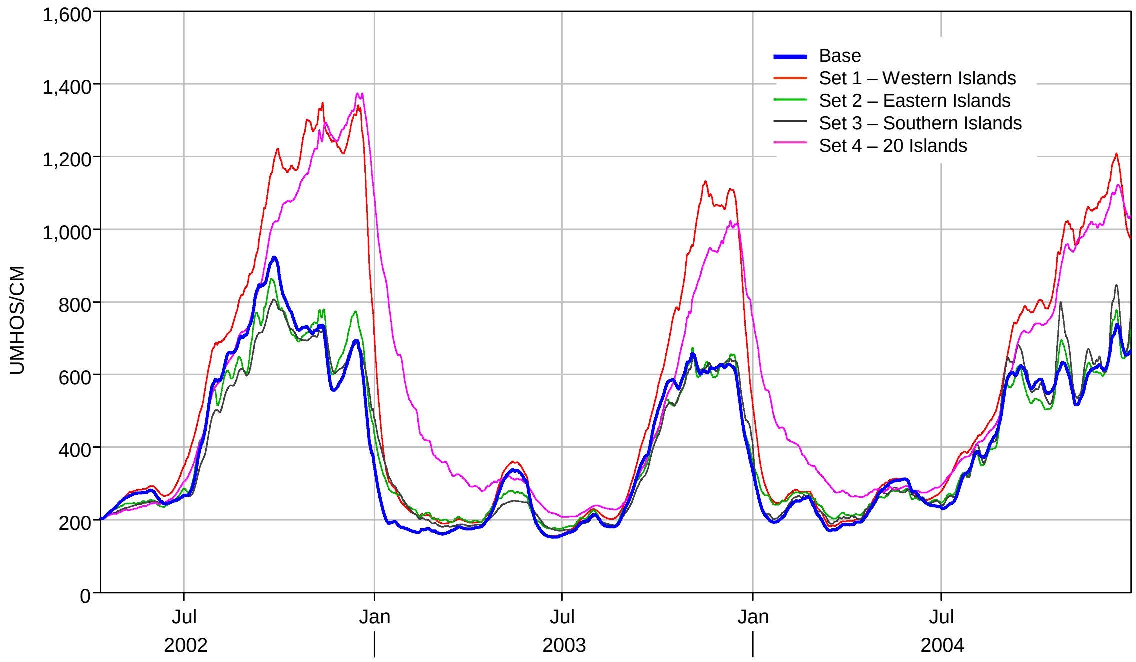
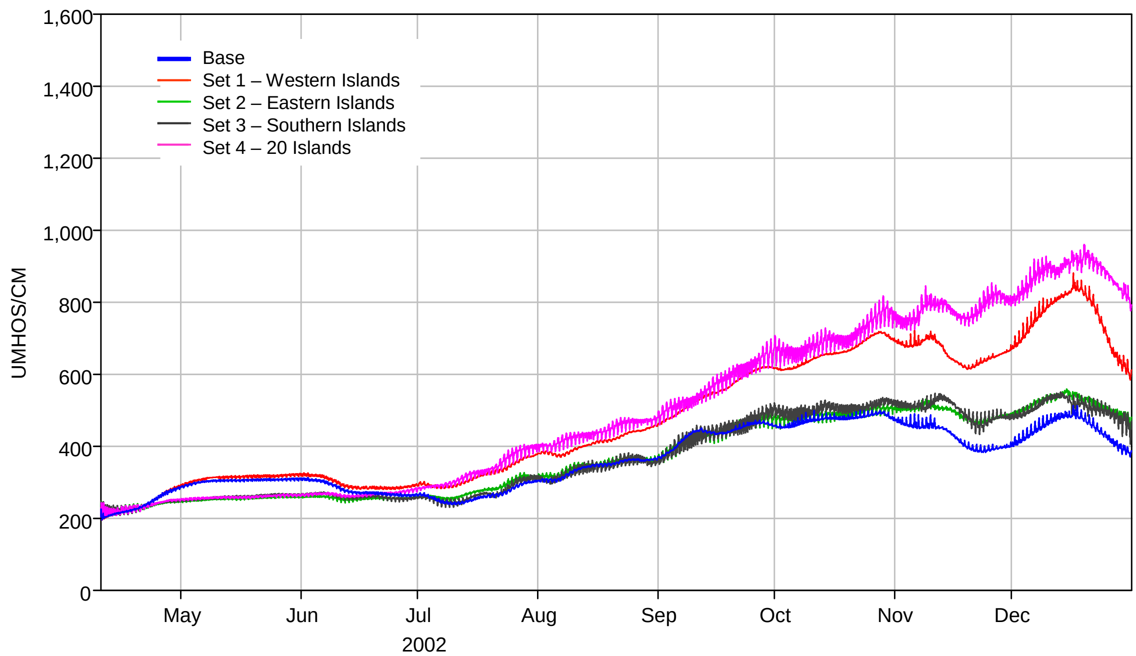


Figure 6-26 Comparison of Instantaneous and Tidally Averaged EC Time Series for Pre-Flooded Island Sets at ROLD024

a) Instantaneous EC at RMID015, April 1 to December 31, 2002



b) Tidally Averaged EC at RMID015, April 1, 2002, to December 31, 2004

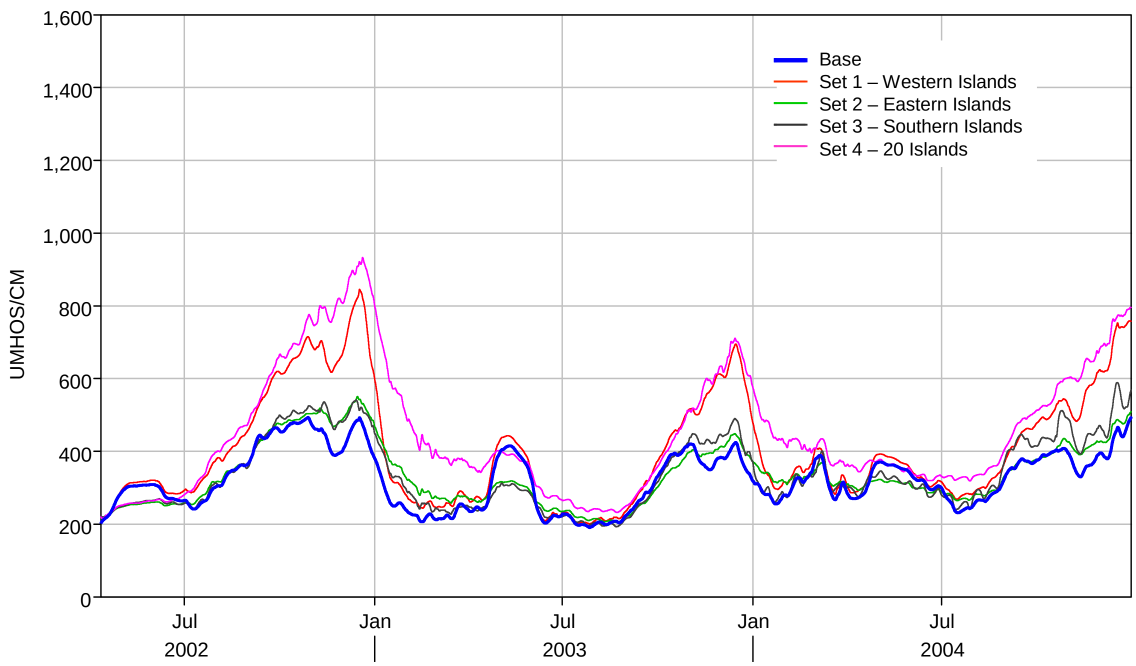
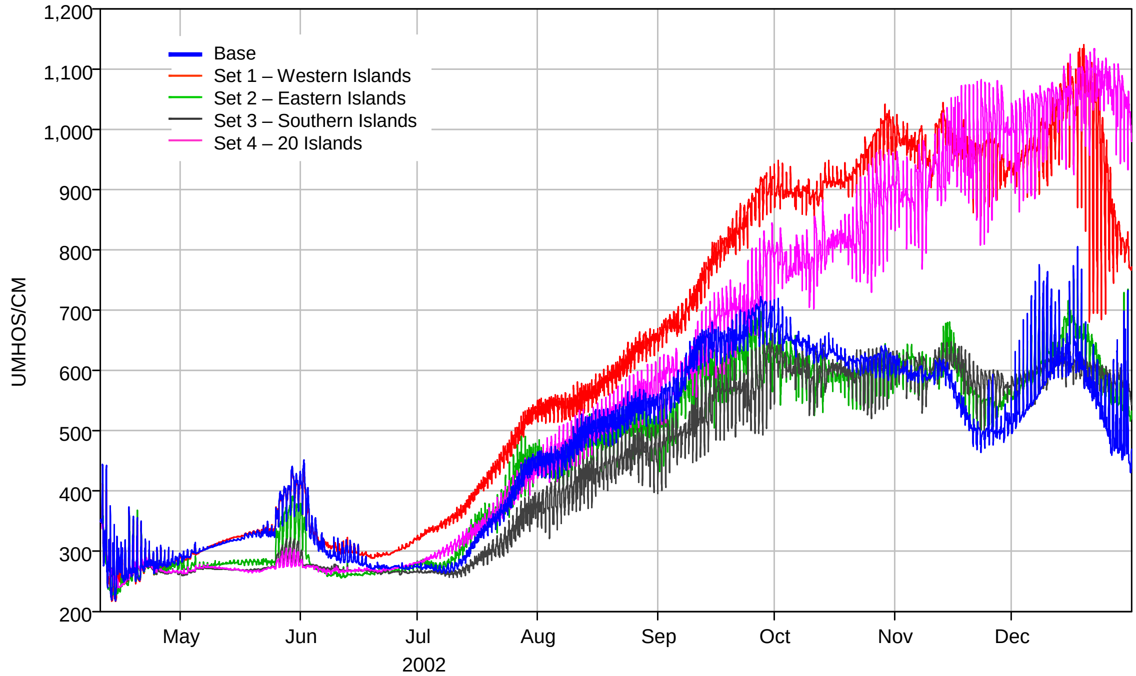


Figure 6-27 Comparison of Instantaneous and Tidally Averaged EC Time Series for Pre-Flooded Island Sets at RMID015

a) Instantaneous EC at SWP Intake, April 1 to December 31, 2002



b) Tidally Averaged EC at SWP Intake, April 1, 2002, to December 31, 2004

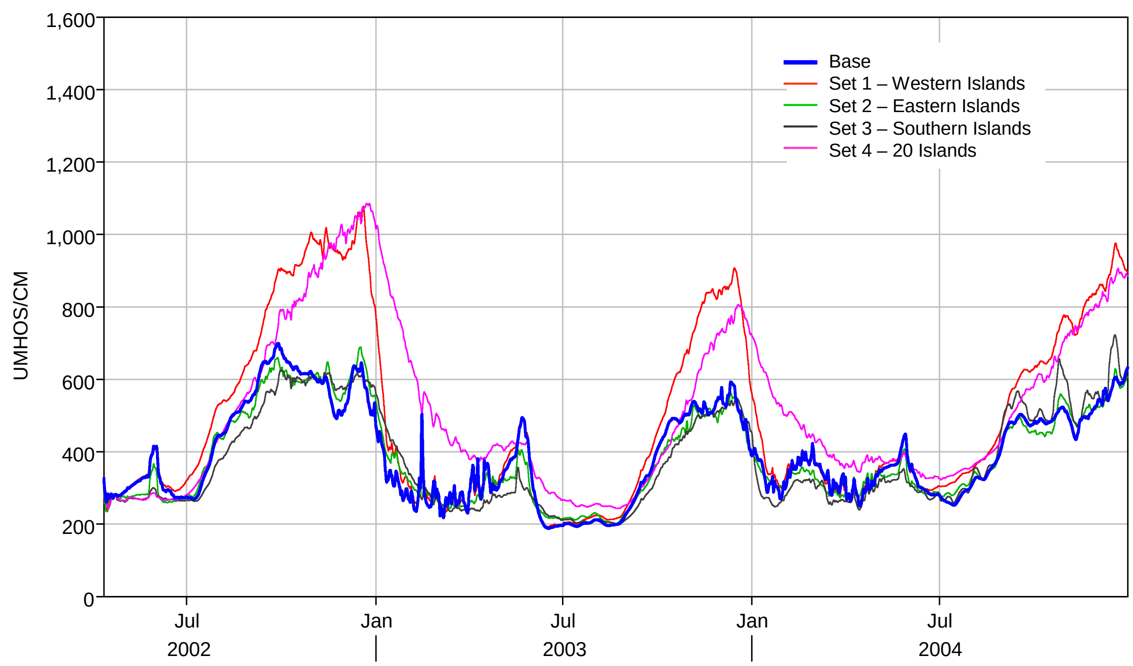
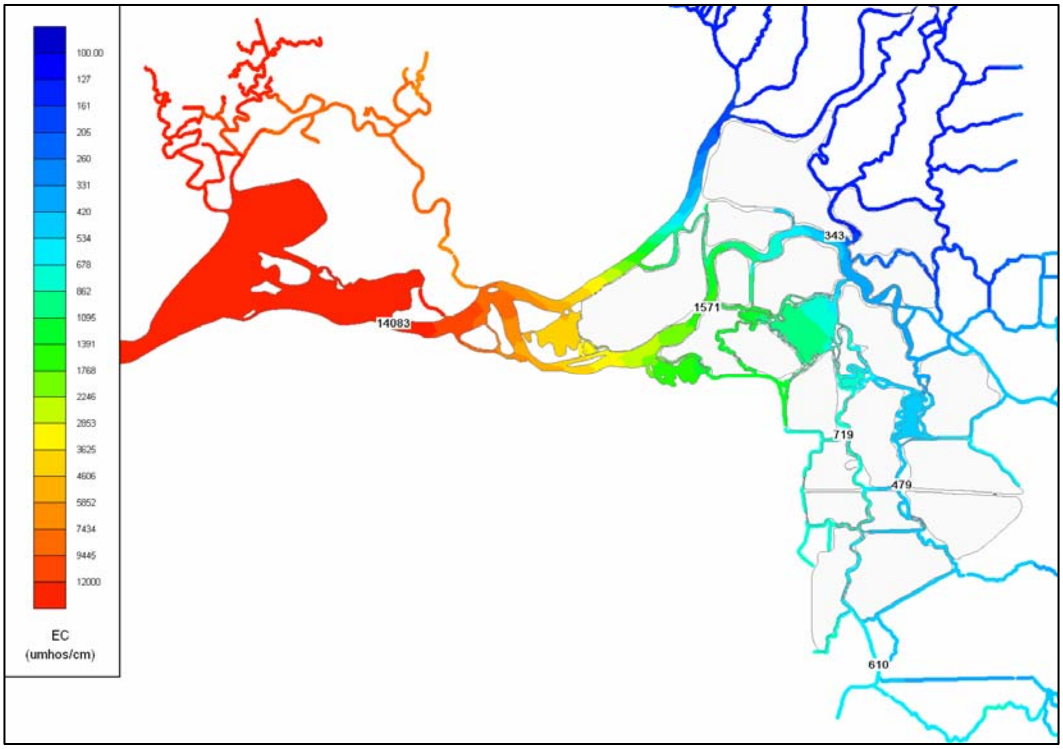


Figure 6-28 Comparison of Instantaneous and Tidally Averaged EC Time Series for Pre-Flooded Island Sets at State Water Project Intake

a) Base Simulation, October 31, 2002



b) Base Simulation, May 31, 2003

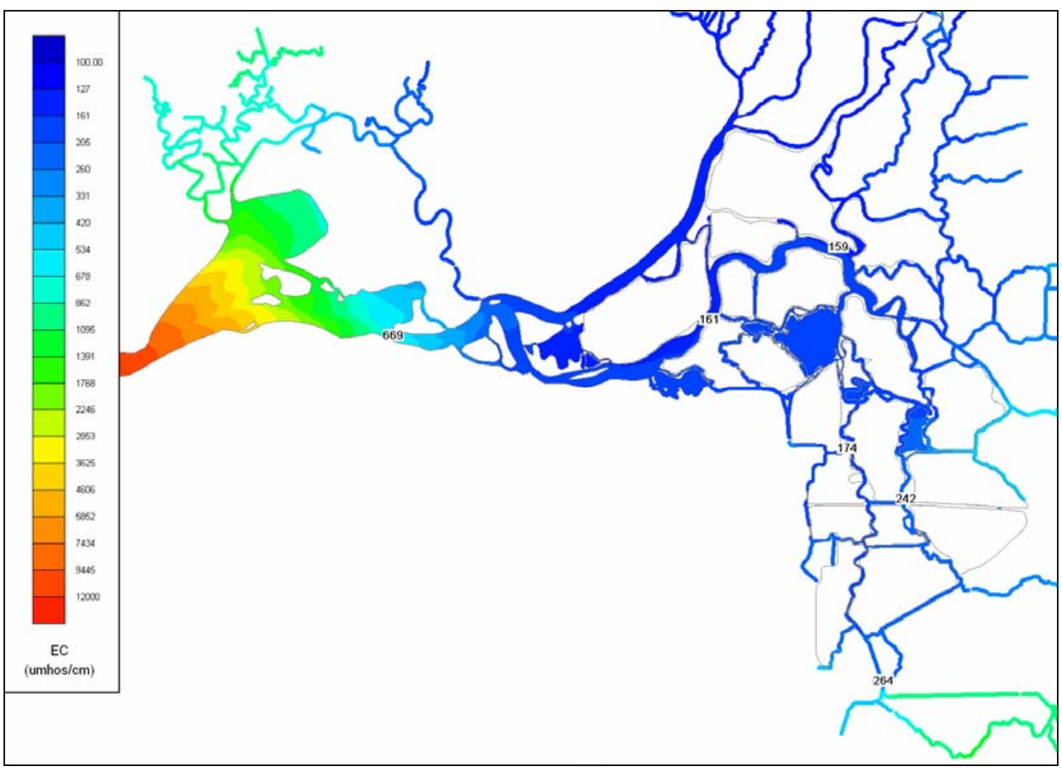
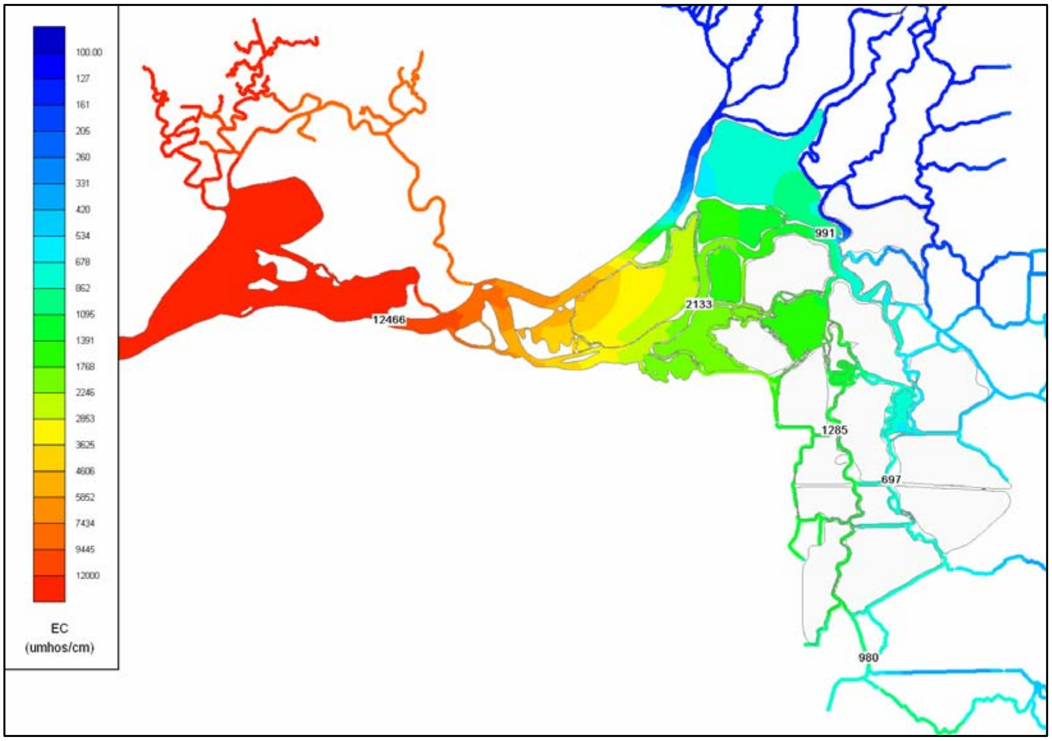


Figure 6-29 EC Contours on October 31, 2002 and May 31, 2003 – Base Simulation

a) Set 1, October 31, 2002



b) Set 1, May 31, 2003

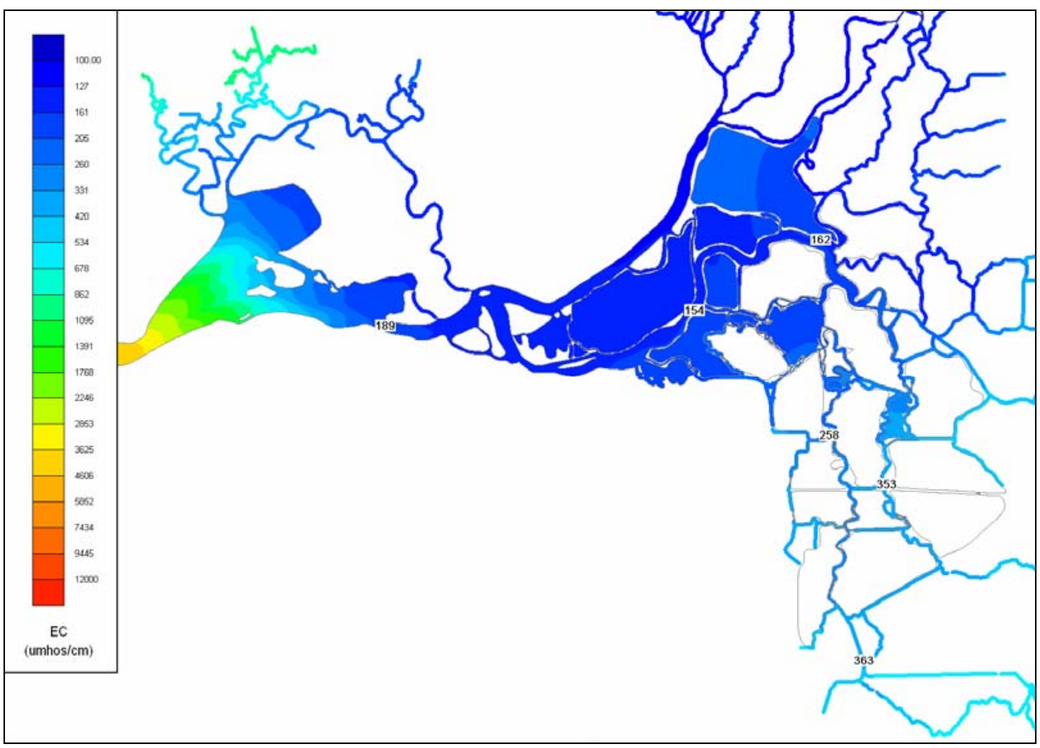
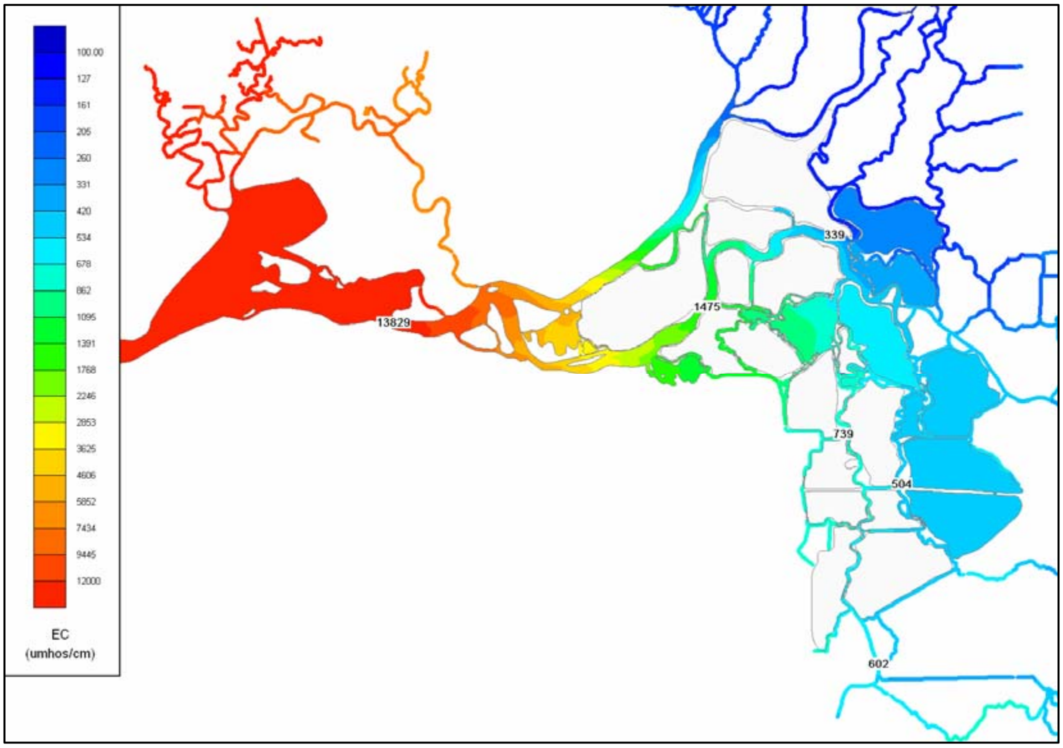


Figure 6-30 EC Contours on October 31, 2002 and May 31, 2003 – Set 1: Western Islands

a) Set 2, October 31, 2002



b) Set 2, May 31, 2003

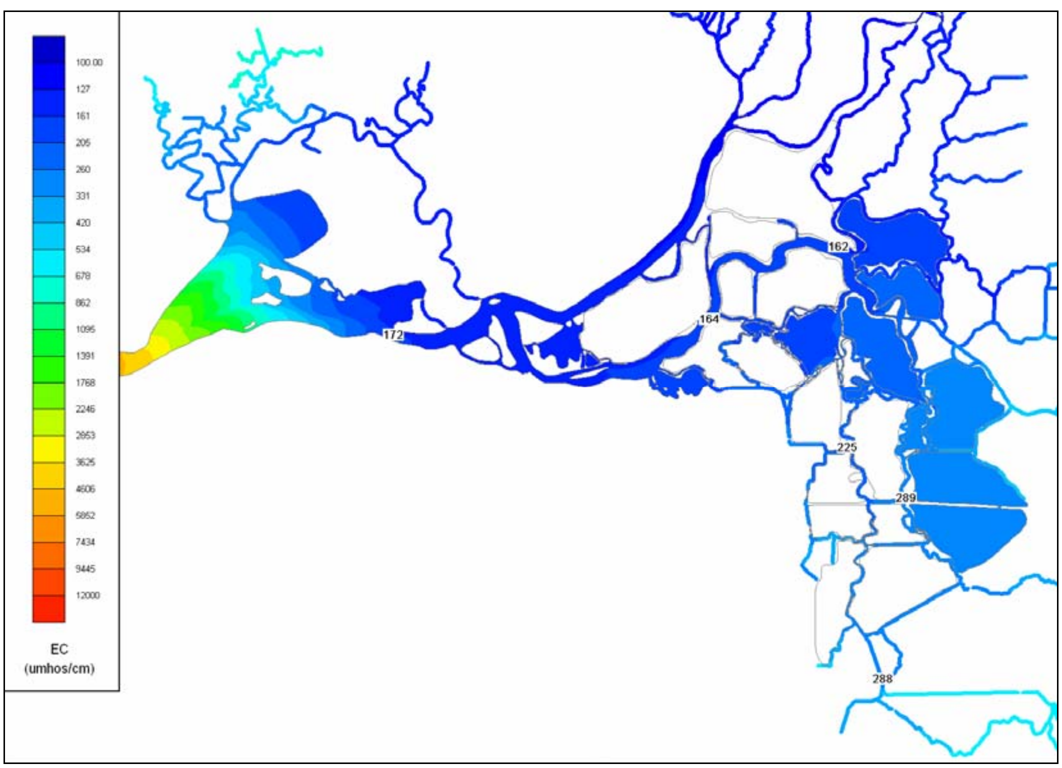
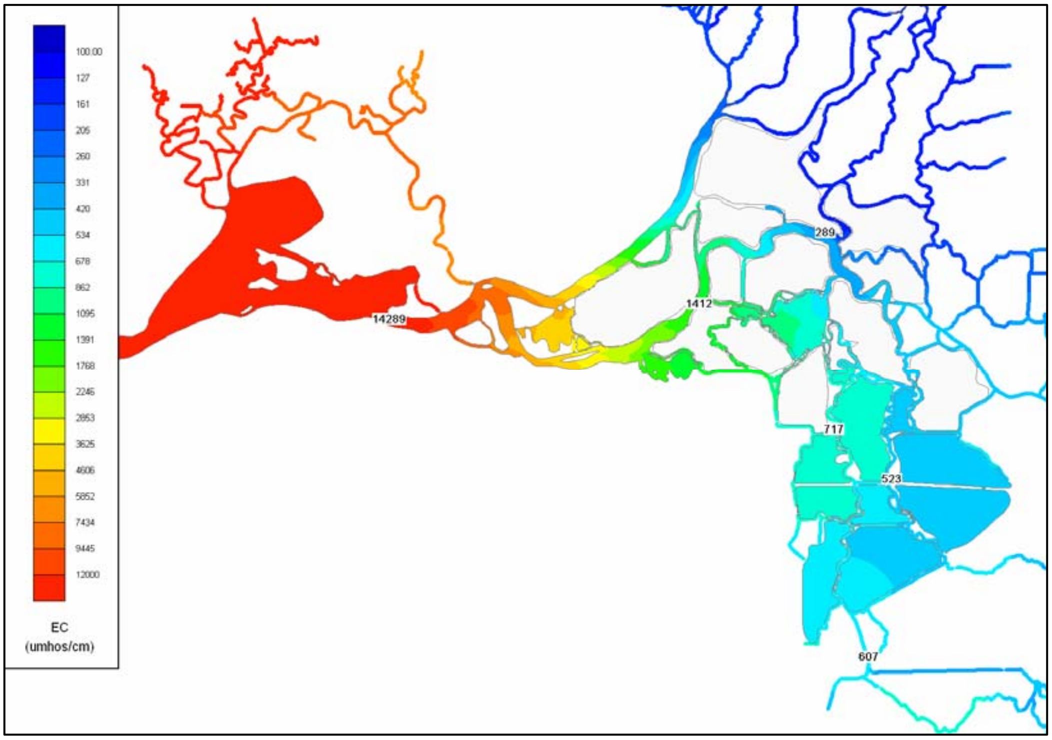


Figure 6-31 EC Contours on October 31, 2002 and May 31, 2003 – Set 2: Eastern Islands

a) Set 3, October 31, 2002



b) Set 3, May 31, 2003

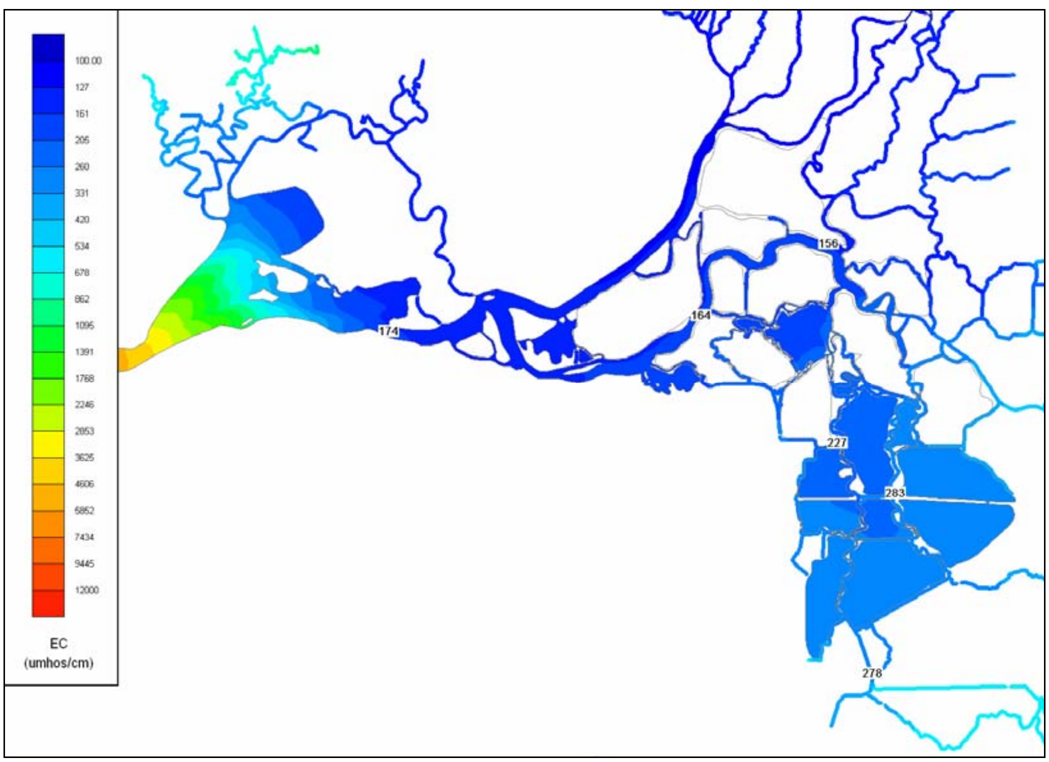
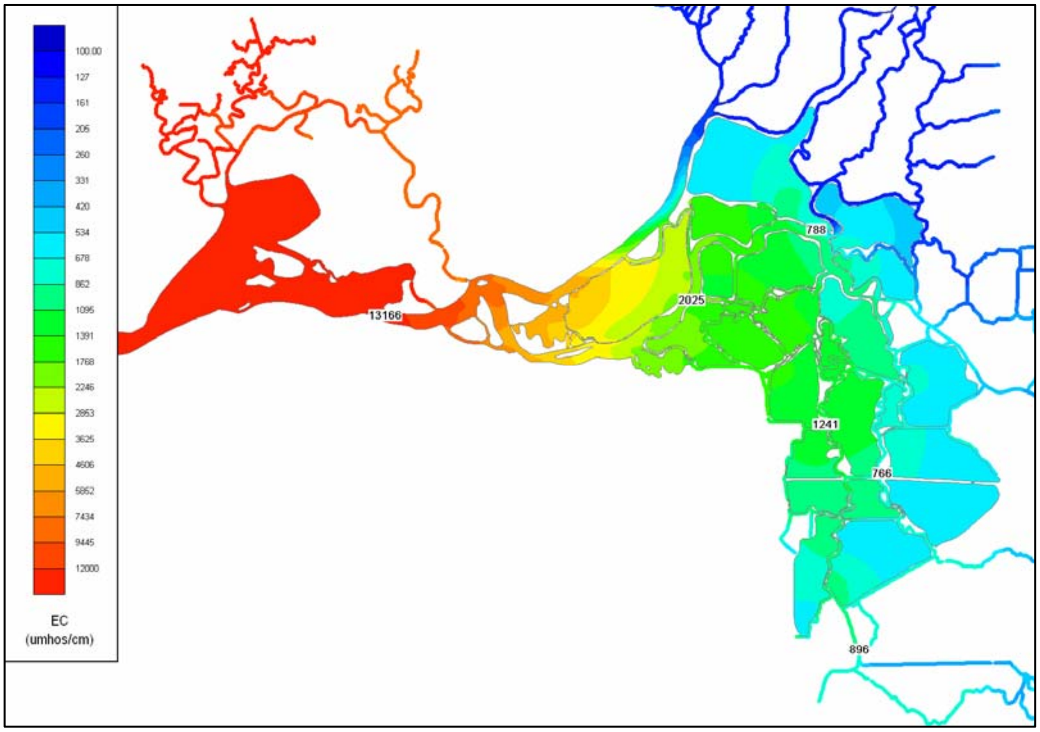


Figure 6-32 EC Contours on October 31, 2002 and May 31, 2003 – Set 3: Southern Islands

a) Set 4, October 31, 2002



b) Set 4, May 31, 2003

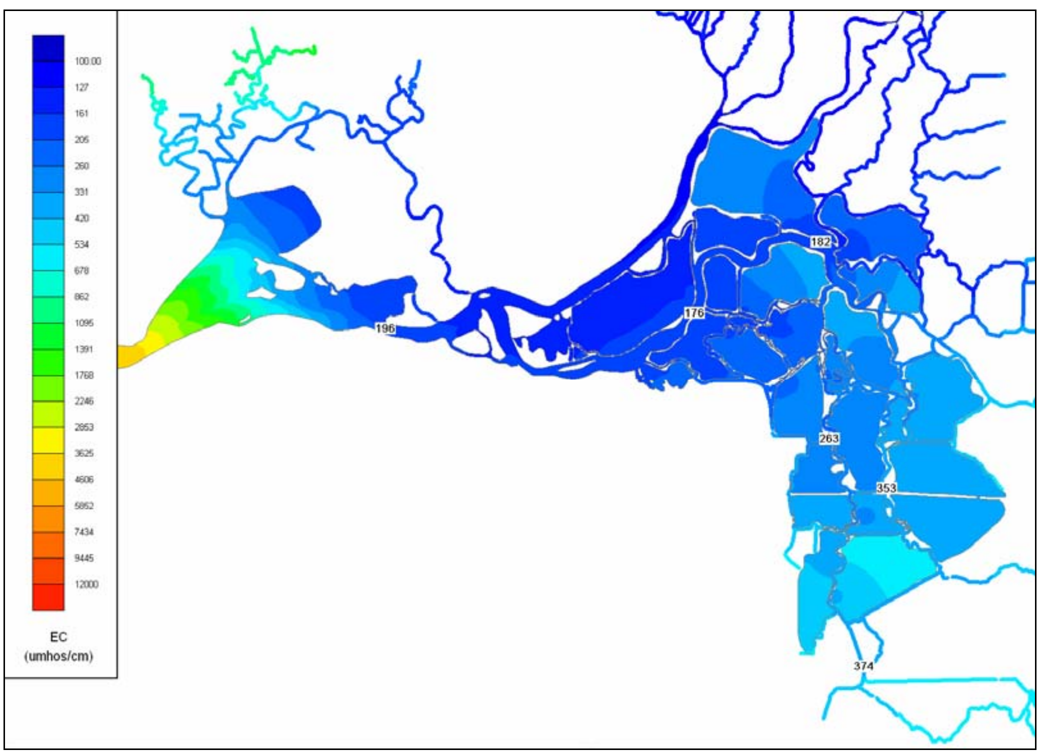


Figure 6-33 EC Contours on October 31, 2002 and May 31, 2003 – Set 4: 20 Islands

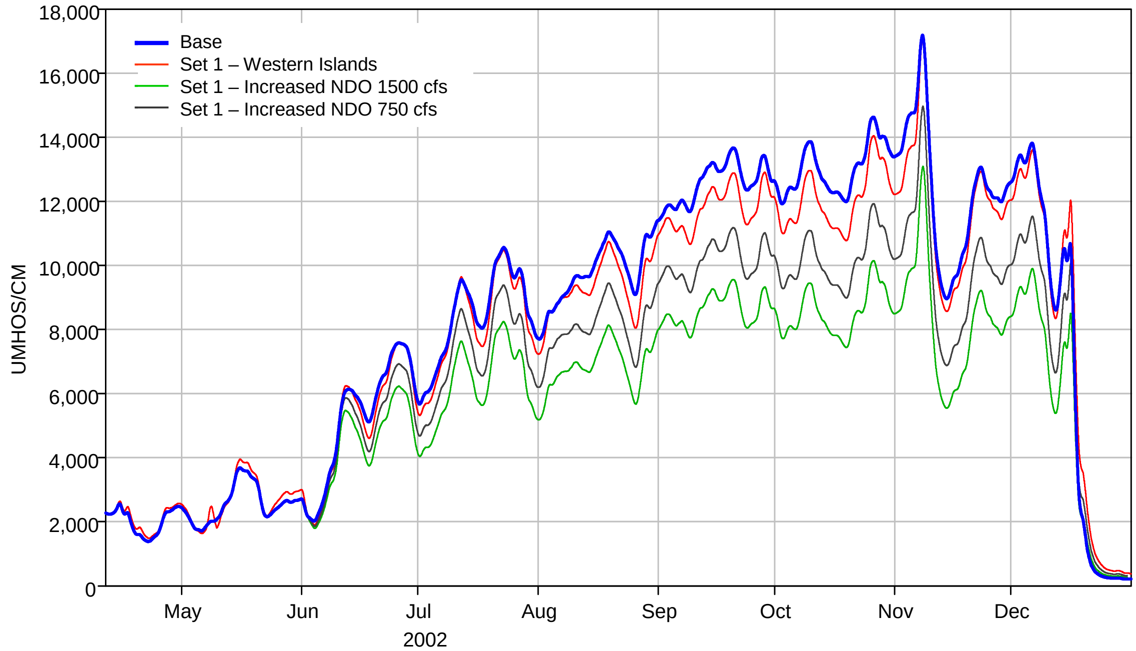


Figure 6-34 Comparison of Tidally Averaged EC for Pre-Flooded Island Set 1 with varying Net Delta Outflow at RSAC075

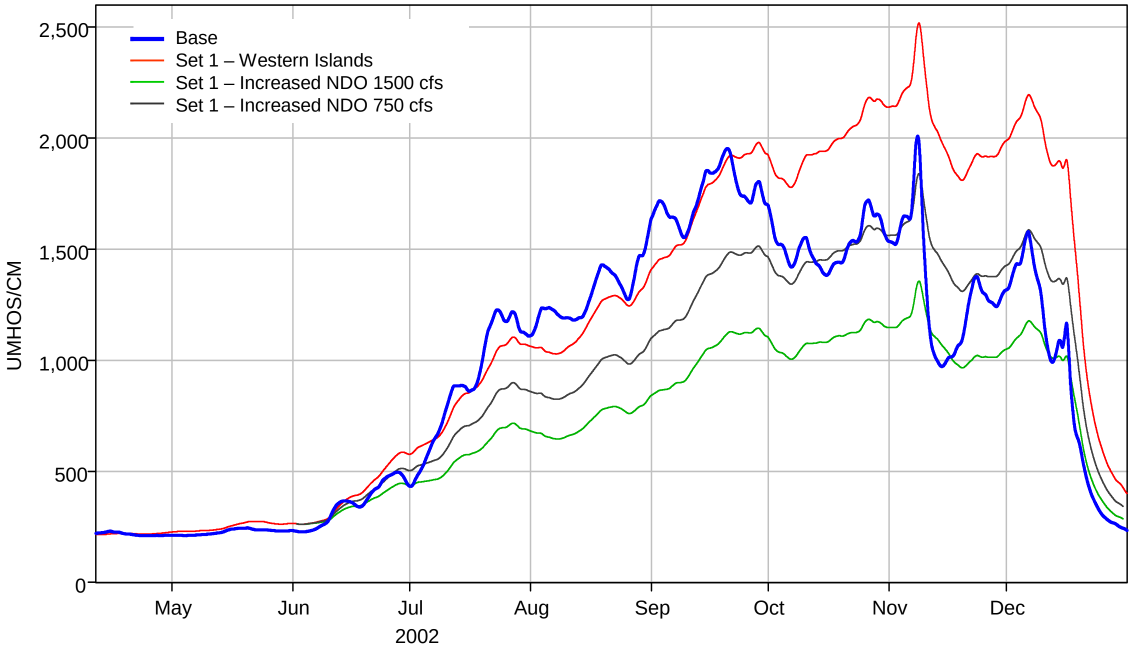


Figure 6-35 Comparison of Tidally Averaged EC for Pre-Flooded Island Set 1 with varying Net Delta Outflow at RSAN018

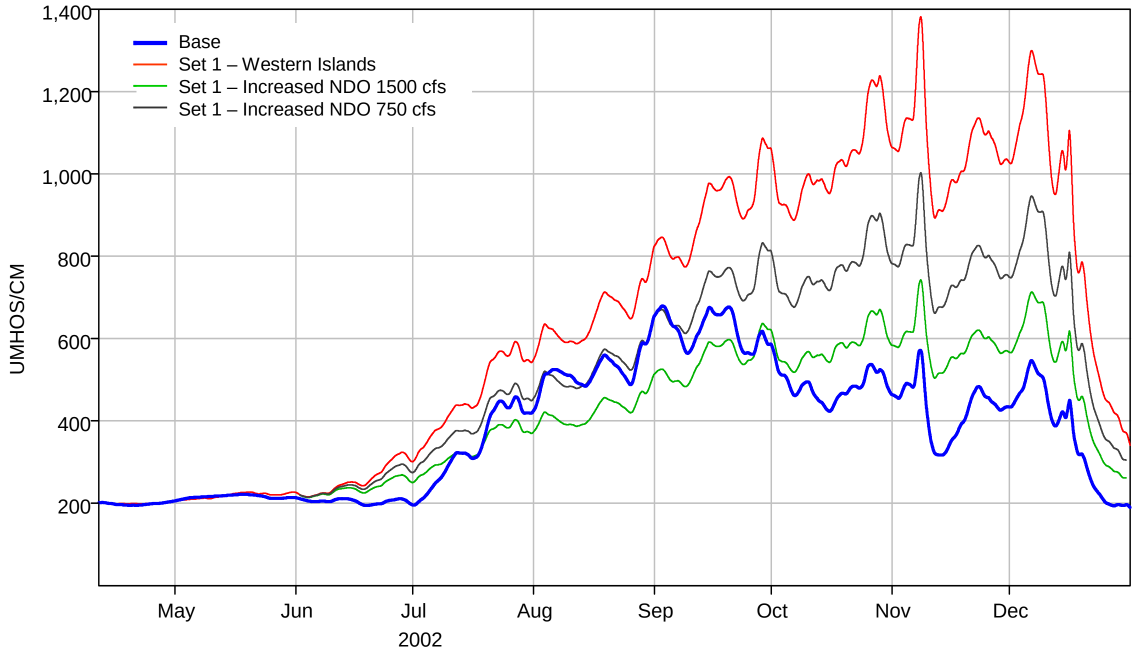


Figure 6-36 Comparison of Tidally Averaged EC for Pre-Flooded Island Set 1 with varying Net Delta Outflow at RSAN032

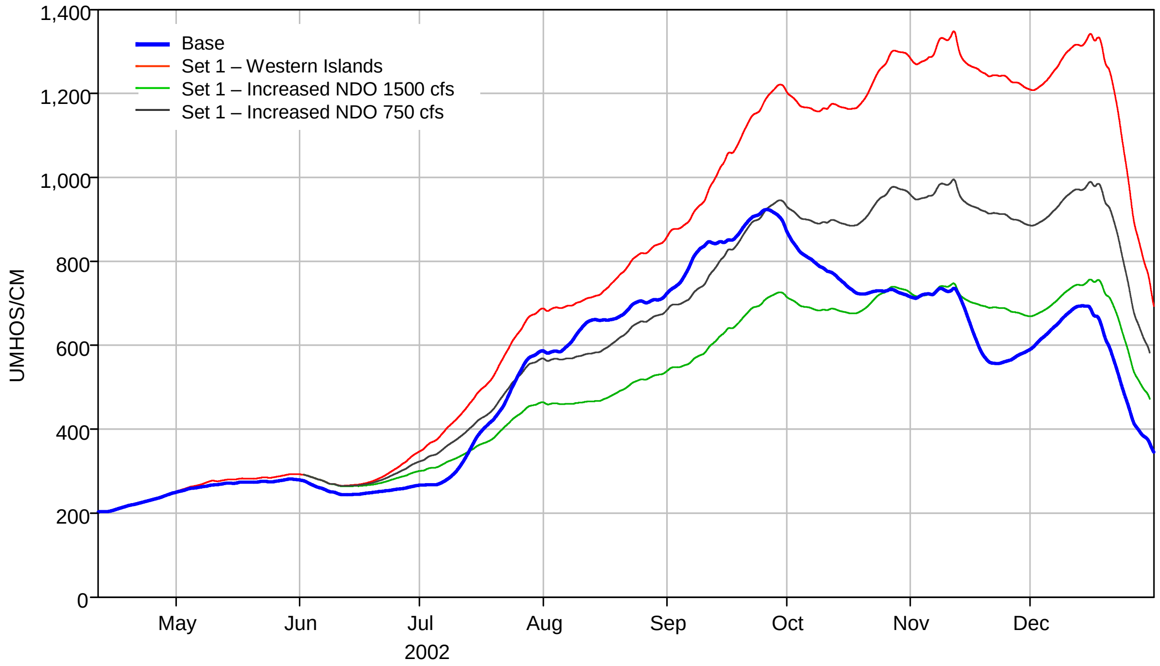


Figure 6-37 Comparison of Tidally Averaged EC for Pre-Flooded Island Set 1 with varying Net Delta Outflow at ROLD024

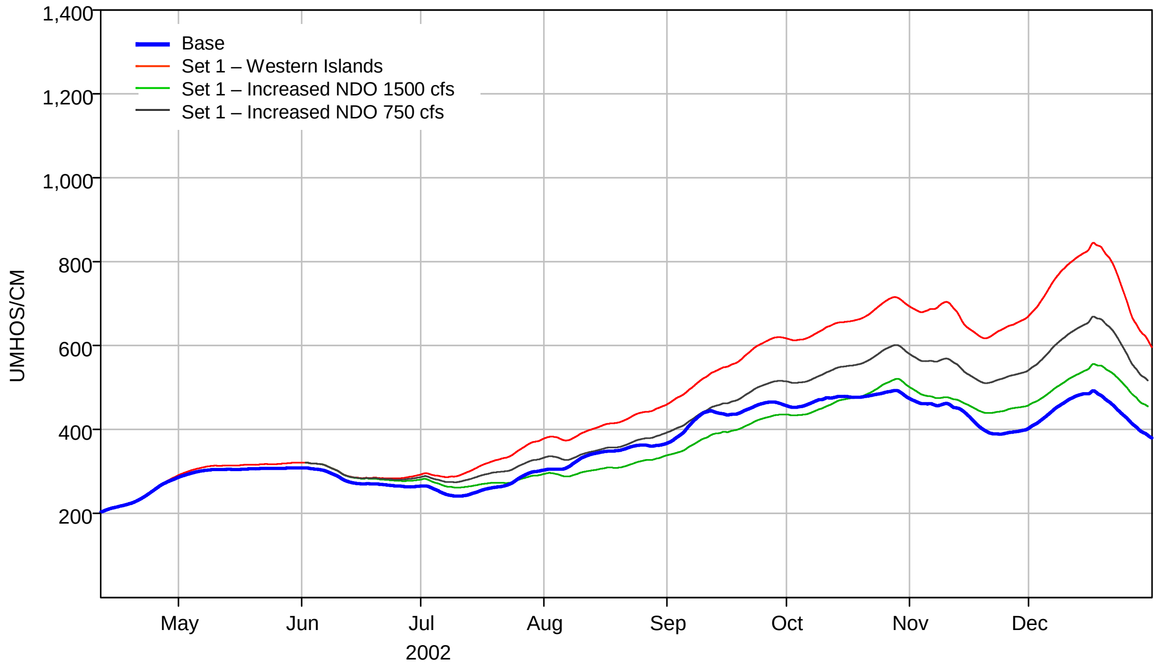


Figure 6-38 Comparison of Tidally Averaged EC for Pre-Flooded Island Set 1 with varying Net Delta Outflow at RMID015

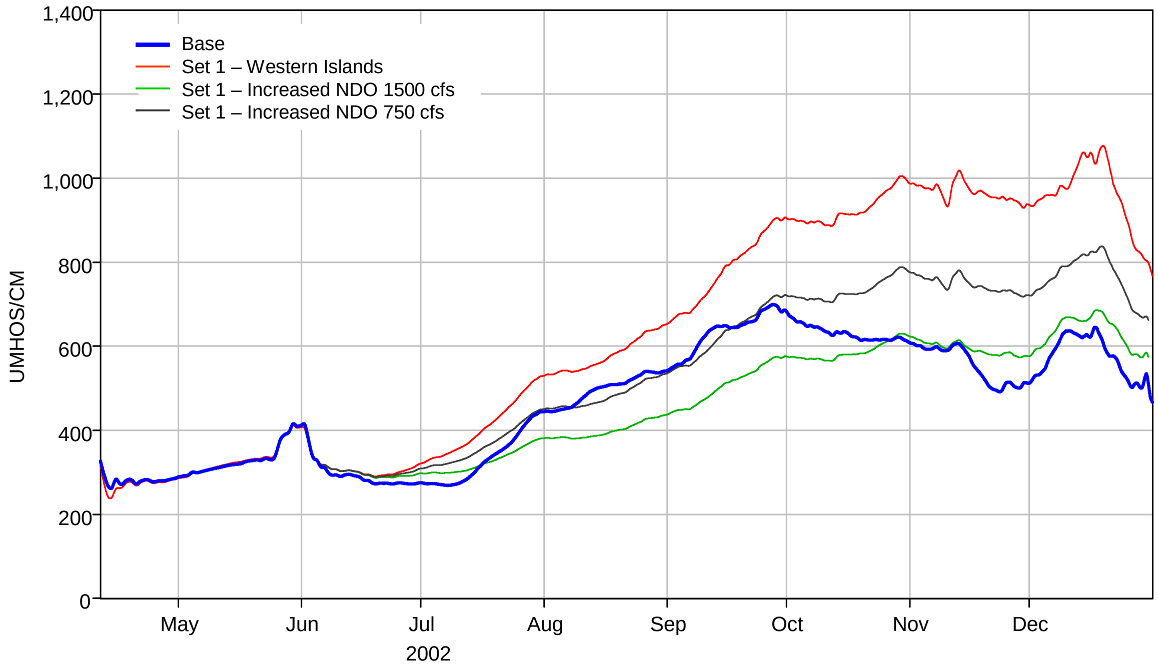


Figure 6-39 Comparison of Tidally Averaged EC for Pre-Flooded Island Set 1 with varying Net Delta Outflow at State Water Project Intake

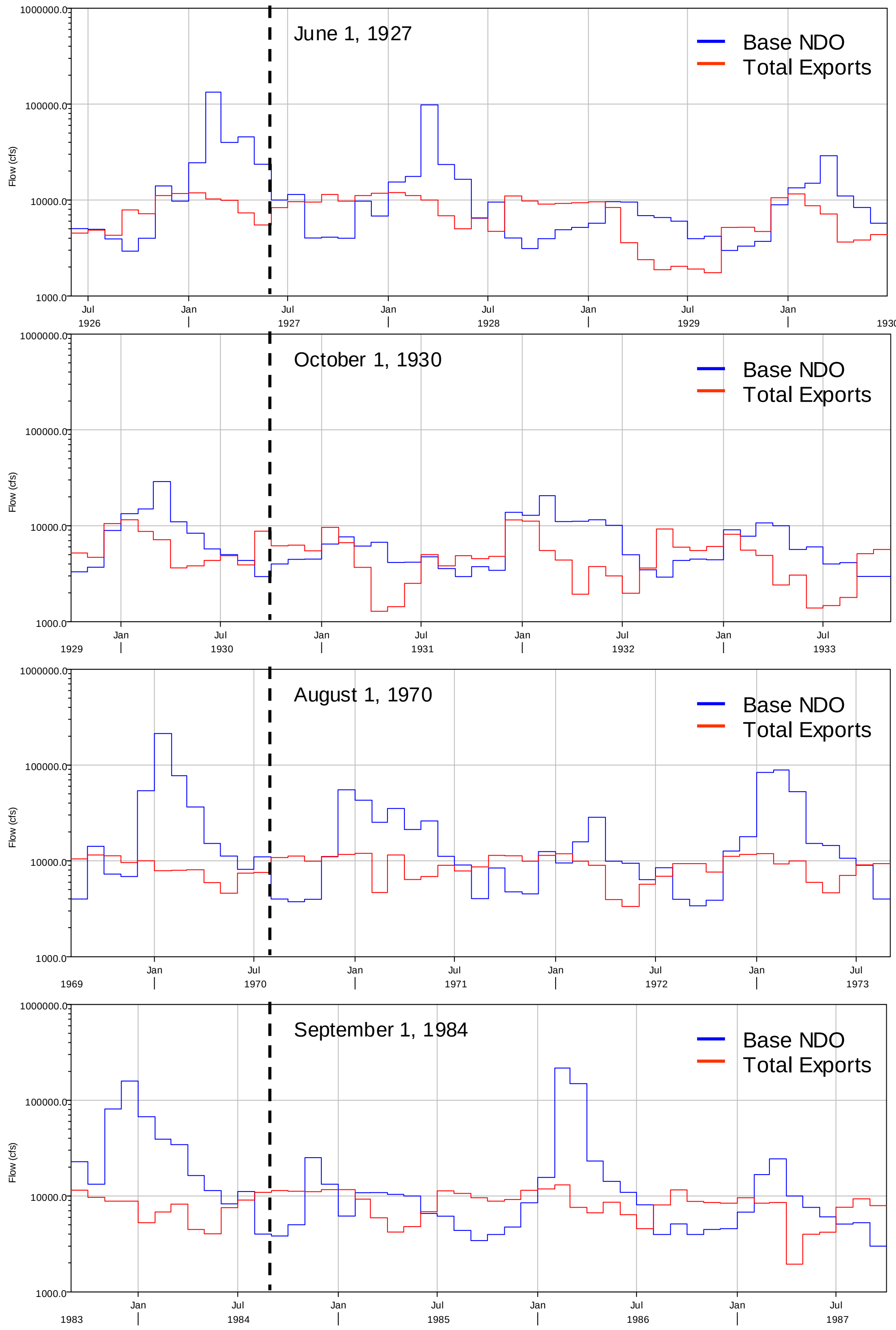


Figure 6-40 CALSIM Base Net Delta Outflow and Total Exports for Breach Event Start Times

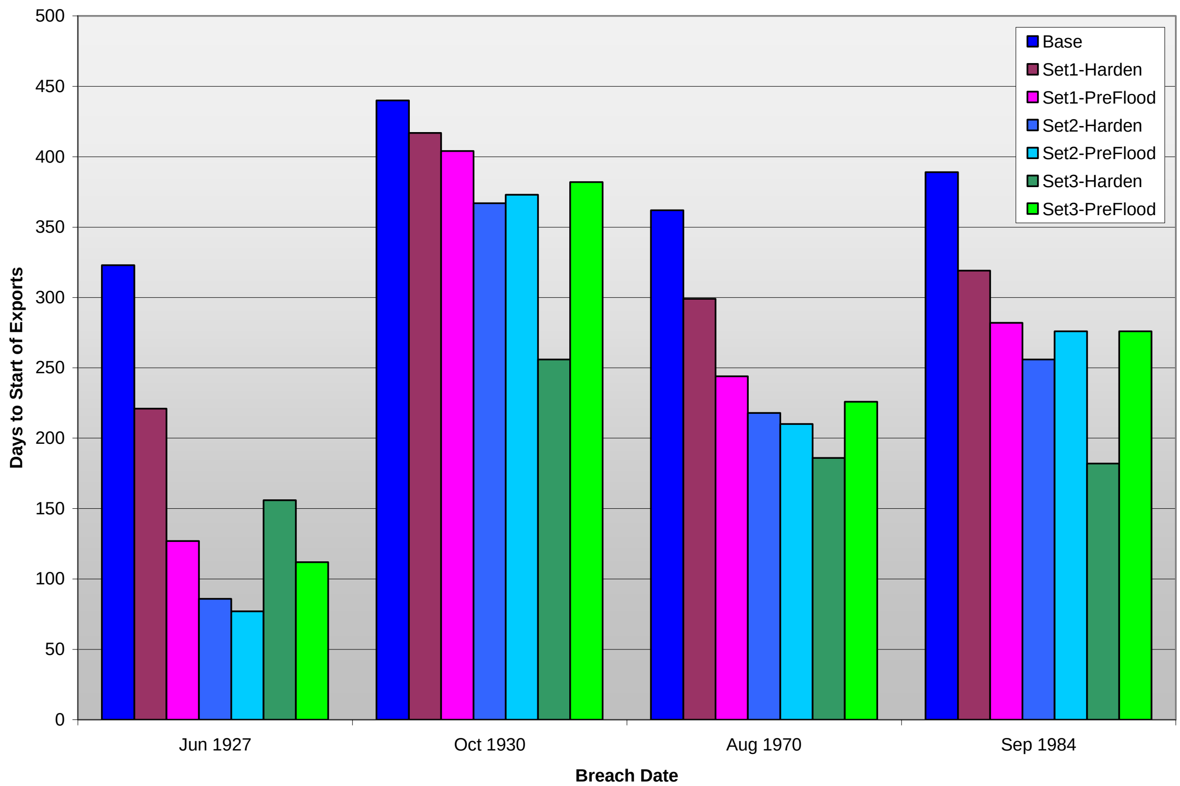


Figure 6-41 Number of Days to Resume Export Pumping, 20-Island Levee Failure Event

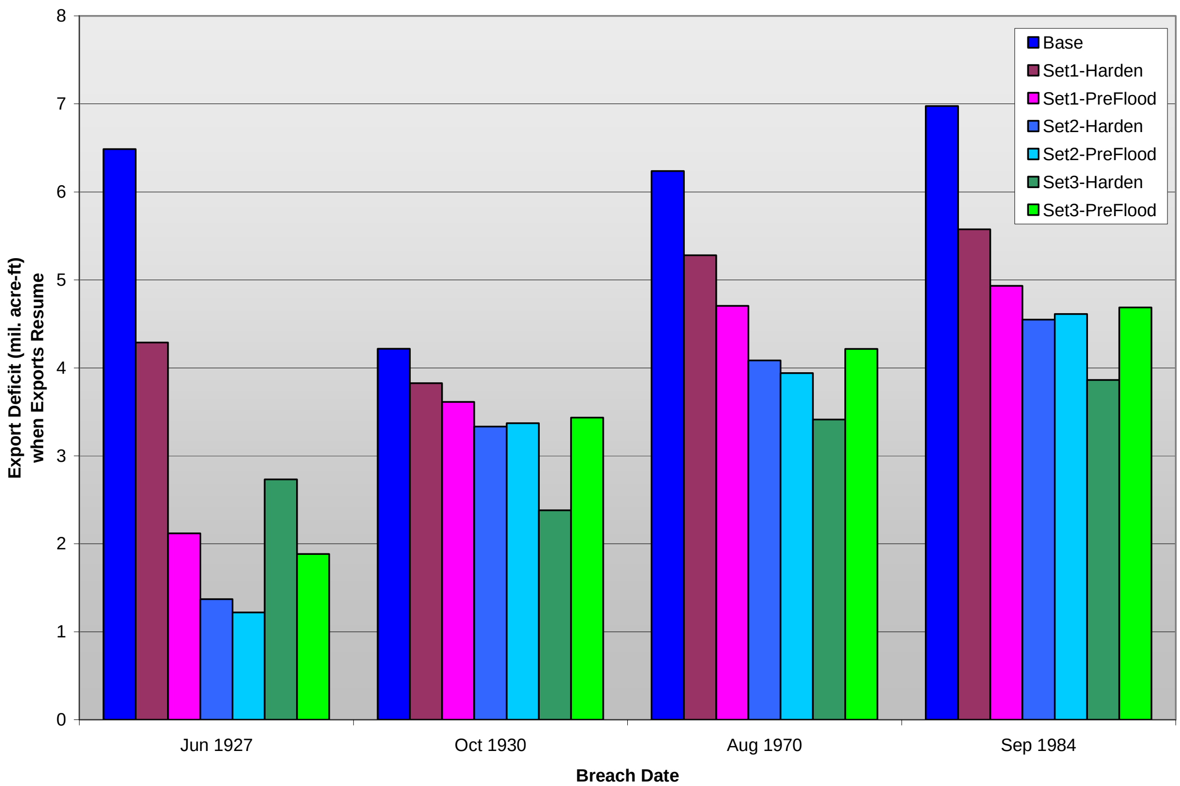


Figure 6-42 Export Deficit when Pumping is Resumed, 20-Island Levee Failure Event