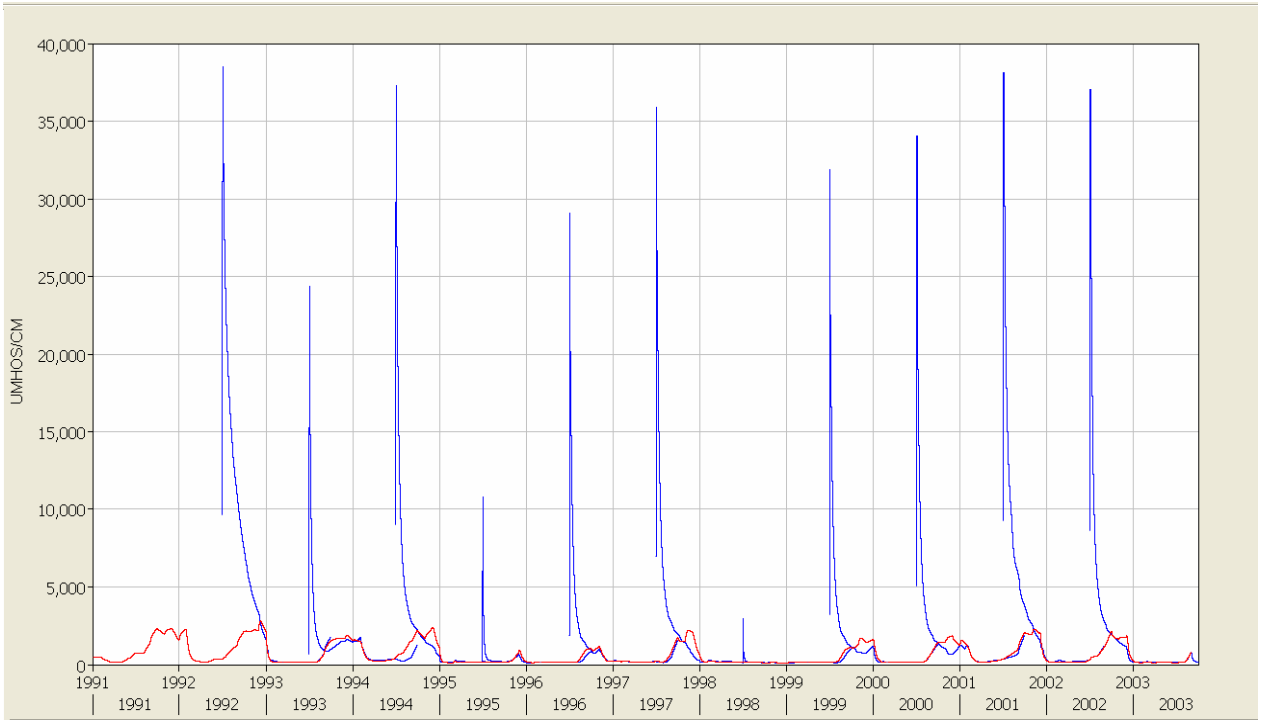
Delta Risk Management Strategy (DRMS) Phase 1
Response To Comments: Water Analysis Module

Comments	Responses
Reviewer: Roger Fujii, USGS, Steering Committee	
1. The WAM TM treats water quality as only salinity. This is a serious error. There are other water quality parameters that need thorough consideration ….	WAM addresses salinity first in developing a model of water quality impacts in the Delta from levee breaches and island flooding – especially from flooding of multiple islands. These impacts can be as severe as tens of thousands mg/l of dissolved solids making Delta water unfit for use either for municipal or agricultural uses. The unfit for use condition can last for months or years. The salinity impacts are relevant to the ecosystem as well as to water supply. The first question of importance is "How severe is the salinity impact?" and the second is "How long does unfit for use last?" WAM was specifically developed to answer those questions and does so successfully and efficiently for the many thousands of levee breach scenarios that are considered in the risk analysis and for approximately 1,000 different event start times based on historic hydrology. Development of this model was an essential first step. Because of limited schedule, it has not been possible yet to include other water quality parameters (such as organic carbon) into WAM. However, the project did perform preliminary analyses on organic carbon that have been added to the WAM TM as Appendix I. Organic carbon can be added to the WAM model when DWR can provide schedule and budget to do it. Other parameters can also be considered for addition.
2. Dissolved and particulate organic carbon form disinfection byproducts during water treatment with chlorine, some of which can have serious health effects. Use the data on organic carbon collected on Jones Tract.	The WAM modelers are aware of organic carbon contaminants interacting with chlorine and forming the mentioned disinfection byproducts. The preliminary analysis of organic carbon now provided in the recently added WAM TM Appendix I used the data collected on Jones Tract and extrapolated for several examples of multi-island breach scenarios. The scenarios did not include any

Comments	Responses
	particle tracking hydrodynamics or any effort to manage organic carbon discharges in island dewatering. Minor problems were found in the cases where ten islands or less were flooded. More substantial problems were found in the 20 and 30 island cases. With no specific hydrodynamic tracking of organic carbon loadings and no effort to manage organic carbon in dewatering, large multi-month spikes with more than 3 mg/l increases were estimated that result in total organic carbon concentrations assumed to be in excess of 6 mg/l. It may be possible, through more detailed modeling, better understanding of background organic carbon concentrations and management of dewatering locations and rates, to lessen the predicted magnitude and duration of spikes. Additional treatment costs for the preliminary calculation results presented were estimated at as much as $68 million. Although this is substantial, it is less than 0.15% of the overall disruption-of-water-supply impacts for the cases addressed. Of more importance is the question whether organic carbon concentrations over 6 mg/l are treatable to achieve potability. If not, municipal contractors may have to refuse delivery after salinity improves to the point that pumping can resume. Thus, they may experience an even longer disruption period. This highlights the importance of extending WAM when DWR's schedule allows.
3. Other water quality parameters of concern include nutrients, mercury, and selenium.	Other parameters can also be considered for addition to the WAM model, but it is less clear how they can be meaningfully addressed in a model that is used to calculate varied water quality impacts from tens of thousands of different levee breach scenarios. If they must be addressed in an overall, applicable-to-all-breach-scenarios way, or based on the gross number or area of islands flooded, familiarity with what WAM calculates for salinity and organic carbon will be an

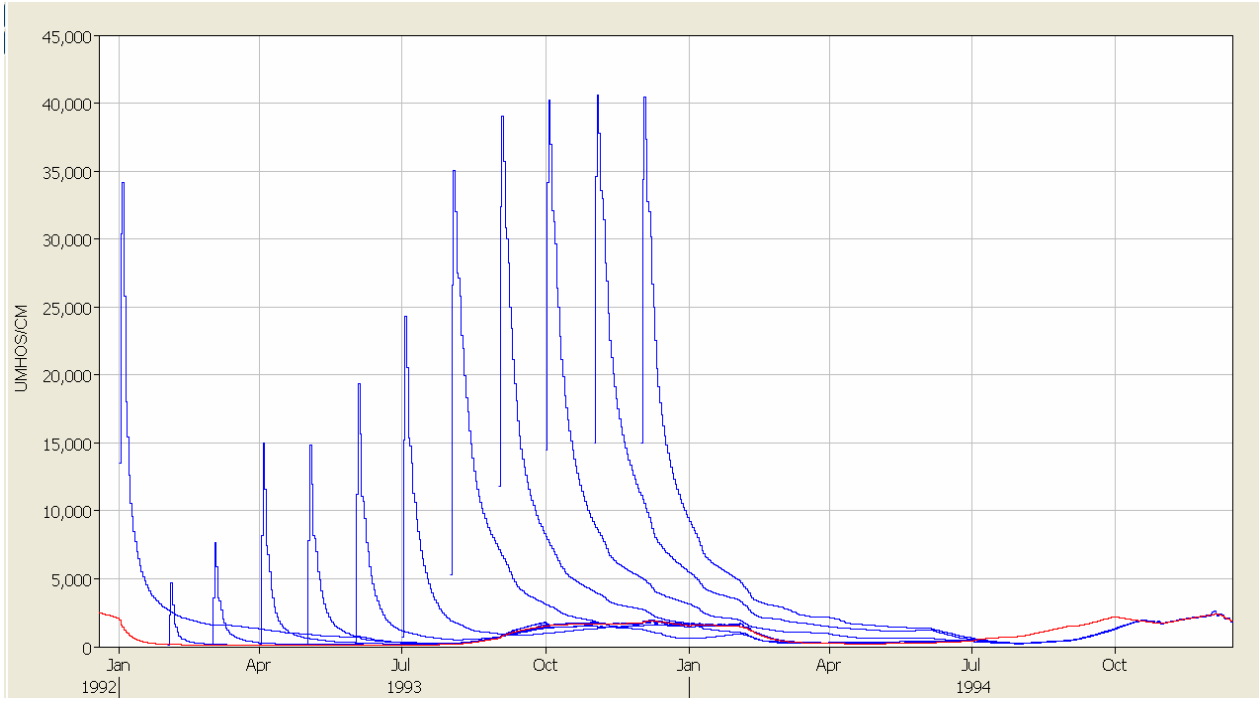
Comments	Responses
	important part of the input that is used to draw these generalized conclusions. A discussion of methylmercury is presented in Appendix E of the ecosystem impacts TM.
4. Conceptual models for processes affecting water quality during flooding.	As WAM is refined and extended to characterize a wider variety of water quality characteristics, Dr. Fujii's ideas on conceptual models for the water quality processes involved in island flooding will be an invaluable and welcome input.
5. Dr. Bill Glaze memo.	Dr. Glaze presents an admirable summary of numerous complex and important water quality concepts. To make discussions of these very sensitive, low concentration phenomena meaningful, one first needs to have a relatively stable, gross characterization of water quality. Normal operations of state and federal project exports from the Delta provide a somewhat stable reference. For Delta levee breach events, water quality in the Delta may be dramatically unstable. We have chosen to present a gross characterization of the Delta's unstable water quality by modeling salinity. The attached figures illustrate that, in a levee breach event, water quality, by any measure (even salinity), is dynamically variable. The very important fine points of water quality that Dr. Glaze summarizes must be discussed with specific reference to some portion of this progressive change in gross water quality throughout the levee breach event and prolonged recovery. Now that WAM characterizes this temporal progression of gross water quality variation, we look forward to future efforts to relate the temporal progression of event salinity to more subtle water quality phenomena.

Comments	Responses



WAM Hydrodynamic Calculation of the Jersey Point Salinity Response to a Multi-Island Levee Breach Event Occurring on July 1 in Various Years (red is base case with no levee breaches)

Comments	Responses



WAM Hydrodynamic Calculation of the Jersey Point Salinity Response to a Multi-Island Levee Breach Event Occurring (Alternatively) on the First of Each Month During 1993 (red is base case with no levee breaches)

Delta Risk Management Strategy (DRMS) Phase 1
Response To Comments: Water Analysis Module

Comments	Responses
Reviewer: Ralph Finch, DWR	
1. WAM Ability to Model Historic Conditions – "results at the interior and export locations do not support the above statements (reasonable results; fairly accurate). A Delta model that cannot explain half or more of the variability of salinity is neither reasonable nor fairly accurate."	Additional calibration has been performed, shared with the commenter, and incorporated in final calculations. Match between computed and observed daily averaged EC at the SWP and CVP export locations was improved by three adjustments to the model. First, the observed daily EC at Vernalis was used for the San Joaquin EC boundary condition in place of the CALSIM monthly-averaged Vernalis EC record. Second, the impact of the temporary barrier on Grant Line Canal was more accurately represented in establishing the net flow through Old River at Head. And third, the multiple linear regression relationship for estimating flow through Turner Cut was improved. These revisions will be discussed in the TM.
2. Ability of WAM to Reproduce Numerical Model Results – "and it is necessary to validate WAM output with the numerical model results using data not used for calibration. But this comparison is not provided in the Memorandum."	The relationship for net salt flux between channels and flooded islands used in the WAM was calibrated by comparing results to the RMA Bay Delta model for a 20 island levee failure scenario. The reviewer's comment is well taken and if additional time becomes available, follow-up comparisons to other breach cases would be valuable. There is a comparison to the historic Jones Tract breach case as a validation (which is updated with calibration adjustments noted for Comment 1 above). However, the Jones Tract event is only a single island failure with limited salinity impact. A modeling exercise is currently underway to compare results from DSM2 and the WAM HD for a CALSIM base run with no breaches. This comparison will be made available as soon as it is complete.

Delta Risk Management Strategy (DRMS) Phase 1
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Comments	Responses
3. Ability of Numerical Models to Model Historic Conditions – "A validation of the numerical models with observed data not used in their calibration is essential to evaluate the WAM process. But this comparison is not provided in the Memorandum."	The WAM HD was calibrated for salinity (EC) by manual adjustment considering the historic period of 1992 through 2003. 2004 has been simulated without adjustment of parameters and includes the Jones Tract breach event. With additional time, a further simulation of 2005 and 2006 could be made as validation tests. Ultimately, if the WAM HD is to receive wider use, implementation of an automated calibration process would be valuable. At that time, the historic period could be formally separated into calibration and validation sets.
4. Other Observations – "The fundamental approach of developing an experimental modeling system is not questioned nor systematically compared to other potentially valid and more traditional approaches."	A discussion of the rationale for developing WAM relative to using existing models was presented in the original Technical Framework document. Portions of that discussion will be brought forward into the TM. The fundamental reason for developing a new model is that there was no existing model that coupled coordinated system operation and Delta hydrodynamic/salinity response under levee breach scenarios in a manner <u>that meet the requirements of the Risk Analysis Framework</u>. Comments on the design of the Risk Analysis Framework are addressed elsewhere; but a fundamental requirement is for calculation of the water quality impacts of a large variety of levee breach events. This requires WAM calculations to be performed for a single event within a few minutes.

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Comments	Responses
Reviewer: Koger, Corps of Engineers (General)	
Note that comments 1 through 5, if they exist, were not submitted for response.	
6. The model is stated to be one dimensional, and does not consider a vertical profile or currents. The model will indicate when export pumping should resume. From a risk perspective, some considerations are whether the export pipes are below water surface, and if so is the model valid for that depth. If the model is for surface water, how robust is the assumption that the export sites are adequately represented by the model?	As explained in Section 2.5, the one dimensional, tidally averaged model considers the impacts of tidal and other currents and vertical stratification by relying on dispersion coefficients to calculate the mixing effects and then provides a cross-section average value of salinity. Thus, the model provides a depth-averaged, across-the-channel-averaged, and tidal-cycle-averaged flow, water surface elevation, and salinity concentration. Very low water surface elevations may occur during initial flooding of islands during the first hours or days following a breach event. The model assumes that pumps are not operated during the initial flooding. After the islands have filled, water surface elevations will fluctuate about mean sea level. The addition of newly flooded islands will generally decrease the tidal range and lower low water will tend to be higher than in the un-breached condition. So after the initial period of island flooding, water surface elevations are not expected to constrain pumping operation. Clarifying language has been added to Section 2.5 of the WAM TM.
7. Continuing with the model assumptions, it would be prudent to validate the model with localized field measurements prior to resuming pumping in areas that would be difficult to flush after salt water intrusion. An ad hoc network could be the municipalities or entities pumping the water	We presume such real time monitoring will occur in an actual levee breach event. It did not need explicit recognition in the WAM model.

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Comments	Responses
8. In the WAM, a basic assumption is water quality conditions are represented by salinity. Are there other potential contaminants of concern after levee breach, or is salinity the driving contaminant? Suggest providing justification for only evaluating salinity during a breach response.	Salinity is the driving contaminant and the one that is the first hurdle in developing a useful model for the risk analysis. Other contaminants, such as organic carbon are also important, but must be addressed later because of limited time for model development. Additional discussion is provided in the WAM TM.
9. Pumping may be allowed if the salinity in the south Delta channels is above standards, but allowable based on other criteria. What other criteria are being evaluated? Is the evaluation the responsibility of the entity pumping the water?	The entities pumping the water, their customers, and regulatory agencies would undoubtedly discuss whether pumping should begin when salinity was somewhat above the 500 mg/l normal standard for salinity. After a prolonged pumping shutdown, users may not want to wait several more months for salinity concentrations to decrease from 600 mg/l (or some similar number) down to 500 mg/l. WAM cannot model such a consultative process. Using a number, like 600 mg/l may be more sensible than using 500 as an absolute requirement. Additional language is provided in the TM.

Delta Risk Management Strategy (DRMS) Phase 1
Response To Comments: Water Analysis Module

Comments	Responses
Reviewer: Koger, Corps of Engineers (Specific)	
1. Page 3, Limited Pumping bullet, lines 5-6 – "fresh water because of the extra volume of tidal flow under a breach conditions and the resultant mixing." Please revise for clarity.	When islands are flooded, the volume of water flowing in and out of the Delta on each tidal cycle is increased because part of the flooded island becomes an active part of the tidal exchange. This causes extra tidal mixing. So a larger inflow of fresh water is needed to repulse salinity. Additional language is provided in the TM.
2. Page 9, Section 2.2, paragraph 4, lines 2-3 – "If an island is flooded, irrigation demand ceases, as does seepage, and return flow." Does return flow cease? Please revise for clarity.	When an island is flooded, many of that island's drainage/return flow pumps are under water and inoperative. Even those pumps above water will not operate, because any water discharged will just be replaced by water flowing into the island through the breach – a waste of pumping energy. More explanation is provided in the TM.

Delta Risk Management Strategy (DRMS) Phase 1
Response To Comments: Water Analysis Module

Comments	Responses
Reviewer: Keer, Corps of Engineers (General)	
1. Document doesn't read smoothly.	We have edited for smoothness as permitted by schedule.
2. Define the term "hydrodynamics" early in the text.	Done.
3. The topical areas covered in the Phase I Risk Analysis listed in the preamble needs to be consistent with the listing of documents provided in the website. There's no Global Warming ITF or TM, should be Climate Change; there doesn't seem to be a water quality topical area presented; there's no Water Management and Operation ITF of TM, it should be Water Analysis. Consistency.	Noted.
4. Many of the documents read that "this study relies solely on available data". There needs to be mention of the research that was done to discover "available data," an explanation of what was found, and a discussion of how it was utilized in this analysis or why it wasn't utilized.	In assembling our team, we selected modelers who were fully aware of available data. They have likely skipped the requested step, since (to them) it was common knowledge. We have inserted references where we identified omissions.
5. Knowing that the authors have an understanding of Corps processes, it would be a great benefit to have a chapter or possibly a separate document presenting an open discussion of how the authors intend this analysis to fit within the framework of the Corps process and possibly present their view of the analysis' shortcomings.	Though obviously useful, this is beyond the scope, schedule, and budget established for DRMS by DWR. We would be pleased to prepare such a document under Corps sponsorship.
6. Starting conditions and assumptions need to be outlined in a table, bulleted, brought out of the text so the reader doesn't have to fish for them.	WAM model inputs and outputs are carefully enumerated. Starting conditions vary. The model is designed to start for any combination of breaches/flooded islands with the initiating event occurring on the first day of any month in the CalSim historic record.
7. Are there any triggers within any of the hydrodynamic/water quality elements looking at whether or not engaging reservoirs to flush the system will directly or indirectly further exacerbate levee failure?	Reservoir flushing is limited by reservoir low-level outlet capacity and available water. Flushing flows implemented are generally less than 10,000 cfs total Delta inflow from the Sacramento River. It is assumed that these flows do not exacerbate levee failures.

Delta Risk Management Strategy (DRMS) Phase 1
Response To Comments: Water Analysis Module

Comments	Responses
Reviewer: Keer, Corps of Engineers (Specific)	
1. Page ii; Definitions and Assumptions, first paragraph; the phrase "some confidence" needs to be explained.	This phrase was inserted to avoid the interpretation that future conditions could be estimated with a "high degree" of confidence.
2. Page ii, Definitions and Assumptions, third paragraph; is this stating that there will be no without-project future conditions? If so, can we get through the Corps process without it?	No. This is stating that all of Phase 1 assumes "Business as Usual," even for future analysis dates. Thus, Phase 1 (BAU) is the "without project condition" or it is the foundation from which the Corps may derive a "without project condition" reflecting any without project change that the Corps wishes to forecast or assume.
3. Page 1, Section 1.1, last paragraph; the statement that the WAM tool needed to be "accurate enough" should be clarified.	Done.
4. Page 3, Section 1.2, first paragraph; what is the delay time between levee breaches and when upstream reservoirs adjust their outflows?	For Business as Usual, a delay of three days is assumed to allow for consultations with management and with regulatory and fish agencies. A shorter delay may be possible with development of specific emergency operating procedures (addressed in Phase 2).
5. Page 3, Section 1.2, first paragraph; does the statement that the *initial* versions of the models reflect input from operators and policy makers suggest that it's intended that this input be removed or that future models will exclude them?	The opposite. The DRMS schedule has not allowed for as much interaction with operators and policy makers as we would have liked and would have been appropriate. Thus, additional input and revisions are anticipated for future versions of the model. TM text has been revised to clarify this.
6. Page 3, Section 1.2, Island Flooding; what are the initial flow and salinity conditions?	Initial flow and salinity conditions are those provided in the CalSim base case for the date upon which the breach event occurs. The model is capable of starting on the first day of any month in the CalSim historic record, i.e., 12 months times 82 years = 984 start times.

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Comments	Responses
7. Page 3, Section 1.2, Flushing; what is the "normal" downstream location for the fresh water/saline water gradient? Is this computed on a daily time step? How does the flushing component dry the islands; in other words, does the model account for the out-pumping of saline water once the island's levees are repaired? If the computational interval is done on a daily time-step, how does the model account for the diurnal tidal fluctuations? If it ignores any fluctuations, does it use the daily max tide? Section 1.2 on page 4 mentions "tidal averaging simplifications…to achieve computational efficiency." This is unclear.	The normal downstream location of the salinity interface is as calculated by CalSim in response to Delta inflows and the requirements of SWRCB D-1641. In WAM it is computed daily and reported monthly with the target of achieving compliance as quickly as possible. When levee breaches are repaired, island pump out is included (water discharge rate and salinity). The model is a tidally averaged model; it works with average concentrations for the tidal cycle on a daily time step and includes the mixing effect of the tides by using dispersion coefficients. We have included language to provide additional explanation.
8. Page 4, Section 1.2, last paragraph; what is too much computer time for WAM? This analysis is of national significance…how much time is too much time, and why can't efforts be made to utilize more efficient processors that the UC systems might have?	Because of the vast number of scenarios to be calculated (tens of thousands) and the large number of other computer calculations in the risk analysis, a goal of having WAM run in about 10 seconds for a single start time was established. We achieved a run time for complex breach cases of about one minute. This compares with several days for a two dimensional model and a few weeks for a three dimensional model. If super computer access were available, it would be used to address other computational problems in the risk analysis; WAM would still be used as a simplified model of reservoir management and hydrodynamics, but might be enhanced in ways that doubled or tripled its run time.
9. Page 4, Section 1.3; what is the timing between request and observation of benefit?	The timing of flushing benefit depends on the flow time from the reservoir making the release, which is variable but generally between one-half and five days.

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Comments	Responses
10. Page 5, Figure 1-2; wouldn't the scheduling of any potential south of delta deliveries be computed *after* the module has determined that the system has recovered? Shouldn't some of the communication paths be bi-directional (i.e., communication between M3 and H5, M3 ↔ H5).	One criterion for making the model "simple" was to avoid feedback loops. There is some compromise of this rule by virtue of the daily time step used for calculation. South of Delta calculations for one day produce results that can be used to influence upstream submodels during the next time step (i.e., what that upstream submodel does on the next day). Since results are only reported monthly, this provides a manageable form of feedback that can be dampened.
11. Page 6, Section 1.3, first bullet; what hydrology is being used to describe the initial state of the Delta?	The CalSim historic record (82 years) and what it says the Delta conditions are at the specified breach event start time.
12. Page 6, Section 1.3, third bullet; shouldn't there be a delay in the model's response to new islands flooding? Might it be possible that as more levees are breached, flood-fighting response is quick, because resources are already staged locally and that as the number of breaches increases response timing decreases because it gets more difficult to disperse and allocate emergency response resources?	WAM responds as soon as a new breach occurs because, at that time, whatever effort has been made to prevent the breach has failed and the island is being flooded in an uncontrollable and accelerating way. WAM receives the time of the new breach from the Emergency Response and Repair Module, which considers flood fighting or other mitigating measures as well as allocation of emergency resources.
13. Page 6, Section 1.3, second to last paragraph; what marks a "recovered" system?	The system has recovered when the Delta is back to normal (as indicated by the CalSim base case) and when upstream and South of Delta storage is also back to normal as indicated by the CalSim base case.

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Comments	Responses
14. Page 7, Section 1.3, H2; the term "tidally averaged dispersive flux" needs to be explained. If the term is referring to the diurnal ebb and flow tides in and out of the Delta, wouldn't the fact that the model is computing on a daily time-step temper that tidally averaged dispersive flux?	Tidally averaged dispersive flux is a quantitative measure of how much salinity a tidal cycle carries upstream and leaves farther upstream than it was when the cycle started. WAM uses dispersion coefficients to calculate this quantity and thus avoid tempering the tidally averaged dispersive flux. In using a daily (tidally averaged) time step, the model must include the water movement due to a day of average flow to downstream plus the mixing that would be caused by the ebb and flow of tides. The mixing part is addressed by the dispersion coefficients that calculate the amount of dispersive salinity flux. The salinity movement caused by net downstream flow and the tidally averaged dispersive flux of salinity to the upstream tend to cancel each other out so that the location of the salinity interface moves only a little, if at all.
A15. Page 8, Section 2.1, third bullet; where and how is CalSim playing a role in this analysis all of a sudden? I believe the purpose of the CalSim model is to evaluate the water supply capability of the CVP and SWP…. In this application, CalSim has developed its own input hydrology; how is this hydrology different from that developed within the DRMS framework and how is this inconsistency documented and the uncertainty associated with using different sets of hydrology, within the same analysis, documented?	DRMS uses the CalSim hydrology (82 years of simulation based on historical hydrology and 2005 conditions – land development, water demand, and water system infrastructure). The main difference with DRMS is that CalSim assumes no levee breaches. DRMS therefore uses CalSim as the no-breach base case and models the breach scenario with the water that CalSim says is available during the incident. WAM is able to start the incident on the first day of any month in the CalSim hydrologic sequence.
16. Page 9, Section 2.1; how are the levee breach sequences determined? Is each breach determined by current conditions or are the breach scenarios dictated by the user, determining what levees breach, when they breach, and how the repair process is executed?	The breach sequence or scenario is determined by other modules based on earthquakes, floods, and levee fragility. These are inputs to the Emergency Response and Repair Module, which evaluates secondary breaching and establishes repair and pump out schedules and then forwards all that data to WAM. WAM could be used independently to evaluate any combination of breaching and schedule of repairs that one cared to define.

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17. Page 9, Section 2.2, second paragraph; what are the major Delta flow paths as defined by the hydrodynamics submodel and how are these flow paths different from those assumed in the Flood Hazard analysis?	The flood hazard analysis is oriented to conveyance of floods from tributaries (Yolo Bypass, Sacramento River, Mokelumne River, San Joaquin River, etc. to the mouth of the Delta. WAM is concerned with flow paths for Sacramento fresh water flow across the Delta to the various south Delta pumps. Figure 2-1 illustrates the flow paths incorporated into WAM. During floods, flow paths are not a big concern because the whole Delta is fresh.
18. Page 9, Section 2.2, fourth paragraph; "If an island is flooded, irrigation demand ceases…" is the assumption the cessation of processes is for the flooded island only?	Yes, for the flooded island only and only until the island is repaired and pumped out.
19. Page 10, Section 2.3, third and fourth paragraphs; the assumption here is that releases will be made according to D-1641 requirements regardless of the mechanism degrading water quality. Is it truly safe to assume that conditions resulting in increased salinity in the south Delta, such as a levee breach, are (or will be) treated as "standard project operating procedures?" Is the assumption that upstream CVP and SWP operators will <u>always</u> release water for flushing to sustain exports – regardless of the mechanism initiating the increase in salinity? "Upstream reservoirs" needs to be defined.	The water quality standards in D-1641 do not include exceptions for unusual circumstances such as multi-island flooding due to an earthquake. What the SWRCB staff said in our meeting with them is that the state and federal projects are on the hook to meet the water quality standards and would be expected to do everything reasonably possible to meet them. So the projects have two reasons to do what they can to help the Delta recover – water quality standards and resumption of pumping. The projects are assumed to release water as much as they can (responsibly) to accomplish this recovery. The upstream reservoirs are the project reservoirs – Shasta, Oroville, and Folsom. New Melones was not addressed because the CVP does not have control of a significant amount of stored water in New Melones; senior water rights have control.
20. Page 10, Section 2.4; emergency reservoir operating decisions are made to balance the amount of water released while emergency repairs progress…. What is the scope of the "emergency decisions" that are being made? Are they limited to non-flood scenarios?	Yes, they are limited to non-flood scenarios or time periods and are constrained by reservoir flood operation requirements. The balancing is to send as much flushing water as is really useful without depleting storage in an irresponsible way, given that the wetness or dryness of the next winter is not known.

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Comments	Responses
21. Page 14, Section 3; the input, output, and submodel modifications section is difficult to read. It's unclear what the inputs are, it's not explained how and why CalSim is used. This section really should be rewritten.	Revised.
22. Page 14, Section 3.1, second bullet; there's no explanation of how the breach locations and sizes are determined for each scenario.	This is an input from the earlier modules in the computational process; it is a consolidated input to WAM received from the Emergency Response and Repair Module.
23. Page 15, Section 3.1, first complete paragraph; how many different sets of hydrology are being used in the DRMS analysis – a set for CalSim, a set for the climate change analysis, a set for the flood hazard analysis…?	The 82-year, 2005 CalSim hydrology is used for the DRMS Phase 1, 2005 base case. For 2030, CalSim has a similar 82-year hydrology for their 2030 base case; we would use that for 2030 without climate change. We were unable (because of schedule and budget) to apply WAM for climate change. We would use a modified CalSim hydrology for future years reflecting forecast changes in annual runoff and the changed portions of runoff in the winter versus the spring. A special CalSim modification would be developed for each future year studied. We have (from global climate models) four different future scenarios, so we would ideally develop four different CalSim modifications for each future year to be studied.
24. Page 15, Section 3.1, Levee Breach Event Sequence Data; language states that the WAM module will not need to make specific allowances for the greater combined effects that sea level rise, seismic and flood hazards may have. The reasoning that the WAM has found it appropriate not to address this is unclear.	The important point is that these factors (though they are important) are reflected in WAM's inputs. They do not have to be accommodated through changes in WAM's structure or modeling relationships. Since changed hydrology will be accounted for by a modified CalSim run (a WAM input), the only future changes that WAM has to make internally are revised island volumes below sea level (flooding volume change due to subsidence and sea level rise) and revised dispersion coefficients to account for greater tidal mixing with sea level rise. The revised dispersion coefficients are addressed in WAM TM Appendix H3.

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Comments	Responses
25. Page 16, Section 3.3, Delta Water Operations; it is unclear why this section is included. Does the inclusion of the proposed south delta barriers incur a different operation in a levee breach emergency or not? Is it safe to include and assume the benefits in operation of a structure that's not in place yet?	The section is included because WAM must make specific assumptions on how Delta pumps and gates will be operated when there are levee breaches. Since the broad topic here is future conditions, the south Delta operable barriers are recognized as a real possibility. Since operation of these barriers has not yet been defined, they will be assumed (for now) to operate like the existing barriers if they are installed.
26. Page 16, Section 4.3; the intent of the paragraph is unclear. With the prospect of global warming and climate change altering the hydrometeorological conditions in the Central Valley, how is it that refinements to operating upstream reservoirs can be avoided? With less precipitation falling as snow and more of it falling as rain – these reservoirs will operate differently. Can it be expected that future conditions will really be a "business as usual" operation?	Business as Usual is not advocated as a reasonable picture of the future, but simply as a place to start in thinking about the future. Reservoir operation is a good example. Will the Corps demand and achieve larger flood control reservations to deal with more winter precipitation as rain rather than snow and the resultant increasing flood frequencies? Or will water supply interests demand and obtain more reservoir space for winter water storage to capture winter flows? We don't know. So assuming present operating rules is a reasonable place to start.
27. Appendix B, Page B-6, Table B-1; Table indicates that there are no (zero) releases from New Melones in support of sustaining or reestablishing water quality in the Delta; if true, why is it that this assumption seems to violate the criteria put-forth by D-1641? Question marks need to be replaced with descriptive text. How the "upstream reservoirs" are utilized in the analysis should get better explanation. Is the table indicating that the only upstream reservoirs assisting in the flushing efforts are Folsom, Oroville, and Shasta? Their limitations need to be presented in a clearer fashion.	Revised. New Melones is not used because senior water rights holders (not the CVP) control essentially all of the stored water.

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Comments	Responses
28. Appendix C, Page C-7, Figure C-2; the figure does not indicate boundary condition flows as stated within Section C4, Page C-6.	The figure indicates the locations of the boundary condition flows that are extracted from CalSim output. Since initiation of the levee breach event can be chosen to be any one of 984 start times, the boundary conditions themselves can take any of 984 values. The text has been clarified.
29. Appendix C, Page C-6, Section C4; how exactly is the Sacramento River index used in the Reservoir Management submodel? How does the "hydrologic year" dictate boundary conditions?	CalSim simulates management of the state and federal water projects. One of the indicators used within CalSim to make management decisions is the Sacramento River Index. Thus the index influences the reservoir management submodel in the fist instance though the CalSim base case. When an event start time is specified, it is specified in terms of a CalSim year and month. Thus, for example, it may be specified as June, 1977. The reservoir management model then extracts the CalSim output data for June 1, 1977 and those data become the boundary conditions with which WAM starts. The fact that 1977 was a Critically Dry year is used in managing the upstream and South of Delta reservoirs.
30. Appendix C, Page C-10, Section C6.2; second bullet; does statement indicate that the maximum upstream releases could be zero?	In the unusual situation when the factors indicated in the second bullet indicate that available water is less than would be needed for minimum releases, the minimum release is assumed. In the very rare instance when dead pool is reached, a deficit account is maintained. Allocation of deficits to downstream beneficial uses (north of Delta contractors and fish flows) has not yet been accomplished in the model. This is recognized as a loose end that needs to be addressed as soon as DWR authorizes further work.
31. Appendix E, All Figures; there's no map to reference any of the station locations.	Added.

Comments	Responses
32. Appendix F, Page F-4, Section F1.4; paragraph is a bit unclear. Is the word "adjusting" indicating that the base condition CalSim inflows are adjusted to represent inflow hydrology representative of climate change, or are the inflows substituted? It's still unclear how the location and extent of the levee breaches are dictated.	Levee breach locations and extent are established outside of WAM and are received by WAM as an input. They come principally from the Seismic Hazard Module and the Flood Hazard Module, via the Levee Fragility Module (which estimates which levees fail) and via the Emergency Response and Repair Module (which estimates secondary failures and establishes a repair schedule). WAM receives all this information as an input and the input may include a specification or restriction of breach event start times. For example, flood events can only occur in winter months. To model water quality for this event at a future time (say 2050) as influenced by climate change, WAM needs a 2050 CalSim run reflecting climate change and no levee breaches as a base case. This CalSim run must be created by adjusting each of the major CalSim monthly inflow streams (approximately 15) for all 82 years of record. This is done using the trend analyses described in Appendix F and includes indicated percentage increase or decrease in total annual inflow for each stream and changed proportion of total annual flow in each month. Then WAM uses the adjusted CalSim input to run CalSim and create a new base case as the source of input hydrologic data for modeling the breach event and recovery.
33. Appendix F, Page F-6, Section F2.4, first complete paragraph; shouldn't the description of CALVIN as a management model be that it shifts scarce supplies to higher value uses?	Clarified. The text was written from the opposite point of view, indicating that cutbacks are allocated to lower valued uses.
34. Appendix F, Page F-6, Sections F2.4 and F2.5; the a2 climate change scenario should be qualified with an explanation of the "mega drought" earlier…and in other TMs where the climate change analysis is	Noted. The information has been forwarded to the Climate Change Team.

Comments	Responses
influencing the analysis results.	
35. Appendix F, Page F-9, Section F3, Figures F-1a through F-4b; what are the trend lines used for? Some are trending upwards…some are trending downwards. How good a fit are these trends to the data?	The trend is used to adjust the 82-year monthly hydrologic record used as CalSim inflows. The adjustment is based on the trend value at the year of interest (e.g., 2050).