January 31, 2013

Mr. Ken Ruzich
General Manager
West Sacramento Area Flood Control Agency (WSAFCA)
1110 W. Capitol Ave.
Sacramento, CA 95691

Subject: BOSC Special Report on Hydraulic and Scour Related Topics, West Sacramento Levee Improvement Program (WSLIP), Southport

Dear Mr. Ruzich:

This BOSC report presents the comments and recommendations by the WSLIP's Board of Senior Consultants (BOSC) regarding Hydraulic and Scour related activities by the WSLIP consultants since the April 10, 2012 BOSC meeting report.

The following are the comments and recommendations of the BOSC on documents produced by the WSLIP consultants. For emphasis, BOSC comments and recommendations are highlighted in Bold and Underlined.

1. **Memorandum by cbec:** Recommendations for continued analysis based on preliminary sediment transport model, (Mike 21c) results, Dated 6/21/2012

This memo documented the possible scour and deposition for the offset condition (CMA2), as compared to the existing condition, for the 200 year flood event using the MIKE 21c model.

The results for the existing conditions showed that there is slight degradation at the area adjacent to the northern offset inlet while the outlet has slight aggradation. For the offset condition, less degradation occurred in the inlet location and less aggradation at the outlet location, about 0.5 to 1.5 meters at both locations. Similarly, for the south offset location under existing conditions, the inlet had slight degradation, the middle had slight aggradation (as can be expected on the inside of a bend), and the outlet had slight aggradation. For the offset condition, the inlet had less degradation, the middle portion had less aggradation, and the outlet had slight degradation. It is noted that there were no significant bed elevation changes both upstream and downstream areas of the northern and southern offset location.

Long term analyzes are recommended by cbec in their memo to expand on these results. **The BOSC notes that the result show low sediment impacts for the offset conditions and these results are for the 200 year flood, which occurs very infrequently (note that the chance of a 200 year flood happening in a 100 year period is about 39%). Because of this, the BOSC does not see a need to perform long term sedimentation simulations.** It should be noted that the BOSC provided some suggestion on the implementation of long term simulations as documented in a cbec memo in the next section of this report but these suggestions were made only for if long term simulations were deemed necessary.

2. **Memorandum by cbec:** Southport EIP TO4: David Williams' Recommendations for Geomorphic Modeling, dated 8/21/2012

In this memo, cbec documented a telephone dialog with Dr. David Williams, a member of the BOSC, who made comments and suggestions on the long term (geomorphic) MIKE 21c modeling. NHC (Hall et al, 2010) performed an existing condition long term simulation of the area using a1D sediment transport model and showed similar results of the MIKE 21c modeling conducted by cbec for their short term simulations for floods up to the 200 year event. This was encouraging and gave more credence to the cbec result for existing conditions. However, the proposed levee offset conditions requires a 2D simulation and thus the requirement to use a model such as MIKE 21c. **As noted in the above BOSC comments for the cbec memo dated 6/21/2012, the BOSC did not see a necessity for long term simulation for the existing and levee offset conditions.**

In the memo, the BOSC suggested that a detailed memo be produced on the roughness factors used in the model for vegetated and non-vegetated conditions, particularly in the overbank areas near and in the offset areas – this was produced in a subsequent memo and is detailed further in this report. **The BOSC also recommended comparing the MIKE 21c velocities to the MBK RMA2 velocities near the offset areas.**

3. **Memorandum by cbec:** Southport EIP – Roughness Value Development for the Offset Area under Interim and Mature Vegetative Conditions (DRAFT), dated 8/28/2012

It is important to determine Manning's n values for the offset areas for initial conditions (minimal vegetation at year 0), interim (year 10) and mature (ultimate vegetation) conditions because the floods can occur at any time. Also, the n values significantly affect the velocities and the 2D flow distributions and therefore the aggradation and degradation trends. **The BOSC agrees with the methodology used and the results.**

4. **Memorandum by MBK:** WSAFCA Southport EIP Hydraulic Impact Analysis Procedure, dated 8/31/2012

In this memo, MBK Engineers (MBK) outlined a procedure for performing hydraulic analysis to determine regional impacts to water surface elevations and flows for various alternatives. The modeling results would also determine water surface elevations and velocities along the Southport area for each alternative to assist in their evaluation and design. The memo described an interaction procedure between HEC-RAS (a 1D model) and RMA2 (a 2D horizontal model). In essence, for without and with alternatives, the HEC-RAs model would provide "far field" hydraulic input (boundary conditions) to RMA2 so that the RMA2 model could provide hydraulic impacts for each alternative in 2D. **The BOSC concurs with the proposed procedures.**

5. **Memorandum by cbec:** North Offset Outlet Configuration Evaluation (Draft), dated 9/05/2012

The MIKE 21c model was used by cbec to evaluate 4 alternatives to the north levee offset just upstream of the Sacramento Yacht Club. The concern was, for flood conditions, a potential for the overbank flows affecting the Yacht Club as they return to the main flow area.

Alternative 1 – Partial Degrade of the Levee Spur

This alternative has the 100 and 200 year floods overtopping the levee spur, go through the offset area, and over and across the degraded levee. The cited potential issues were that the levee spur would erode and that debris could collect in the offset area and be transported toward the Yacht Club when the degraded levee is overtopped. **Given that the maximum velocity over the levee is 2.5 fps at the relatively short peak duration (5 days) of the 200 year flood (and a lower maximum velocity for the**

100 year flood), the BOSC does not believe significant erosion would occur to the point that the spur levee would completely erode away during a flood event.

Alternative 2 – No Degrade of the Levee Spur

For this alternative, the flows will not overtop the existing levee for both the 100 and 200 year floods although the offset areas would be inundated with minor recirculation (eddies). The result is that there would be no overtopping waters that would go to the Yacht Club but due to the offset area essentially being a pool situation, it could collect debris and have an increased sediment deposition rate. **The BOSC believes that since the area is infrequently inundated, the long term debris issue is negligible as well as the sediment deposition issue; however, under flood conditions, there may be a short term problem but would not affect the integrity of the levee.**

Alternative 3 – Complete Degrade of the Levee Spur

The results for this alternative showed that, as expected, the velocities in the offset area are higher than the first 2 alternatives. The issue with this alternative is that velocities up to 3 fps occur adjacent to the Yacht Club as the offset flow returns to the main channel with a potential for erosion and dynamic hydraulic forces affecting the Yacht Club. **The BOSC feels that these two issues are insignificant given the low velocities. The structures associated with Yacht Club have been historically subjected to flow velocities from the main channel much higher than 3 fps with no significant adverse effects.**

Alternative 4 – Levee Realignment

This alternative involves realignment of an offset tie-in levee, located just upstream of the Yacht Club, that would be high enough to contain the 200 year flood. The MIKE 21c modeling showed that the "guiding" levee would return the right overbank waters to the main channel with negligible hydraulic effects on the Yacht Club. **The BOSC agrees that for this alternative 4, there would be negligible, if any, effects on the Yacht**

Discussion by cbec:

The most severe consequences of the outlet alternatives identified by cbec are increased sediment and debris transported to and through the Yacht Club. To eliminate this, cbec recommended alternative 4, as described above. However, this alternative eliminates approximately 9 acres of floodplain that could be of beneficial use.

The second ranked alternative recommended by cbec is alternative 2, which calls for no degrade of the existing spur levee. The levee would not be overtopped up to the 200 year flood and allow flooding of the floodplain at the landside of the spur levee. Again, the concern for this alternative was that there would be accelerated sediment deposition and collection of debris. However, in memo item 2 above, cbec provided an example using "hand calculations" to determine an overbank deposition rate which resulted in a rate of approximately 1.5 mm per year or 150 mm over a 100 year period (0.49 feet). **Given a 200 year flood flow depth of up to 10 feet in the overbanks, the deposition is not a concern to the BOSC for any of the alternatives. Accumulation of debris is also not a concern to the BOSC in respect to the levee safety and hydraulic impacts because overbank flows occurs only a few times a year and can be easily managed.**

Another issue that was pointed out by cbec was the long term geotechnical stability of the spur levee. **As pointed out by cbec, the BOSC does not envision this as a problem if the spur levee is not allowed to deteriorate over time.**

Recommendation by the BOSC

Given that the potential adverse effects of all the alternatives are very small, all the alternatives are acceptable to the BOSC and none would pose a safety problem with the project.

6. Hydraulics Workshop of 9/10-11/2012 and Sacramento River Reconnaissance of 9/11/12

On 9/10-11/2012, a hydraulics/scour/sedimentation workshop was held at the MBK and cbec offices. In attendance were David Williams (BOSC member), Michael Vecchio (HDR), Derek Larsen (MBK) and Chris Bowles, representing his staff at cbec. In attendance via phone was F. Douglas Shields (self-employed), who is under contract to cbec. The meeting was conducted in conjunction with a boat trip on the morning of 9/11/12. Numerous topics were discussed and the BOSC made several comments and suggestions and are documented by cbec (Appendix I) and HDR (Appendix II). **The BOSC requests that HDR and cbec consolidate the meeting notes and the appropriate person address each numbered item in the meeting notes, as appropriate, and provide the results to the BOSC as soon as possible.**

7. Bees Lake Breaching Scenarios

Bees Lake is located on the right side of the river (looking in the downstream direction) and is between the marina and the Yacht Club. The proposed levee would be on the landside of the Lake and the existing levee is on the river side of the Lake, which essentially makes the Lake surrounded by a ring levee system. The issues related to this location, as stated in Appendix III, are:

1. To simulate potential failure mechanisms of proposed levee features around Bees Lake and subsequent flow structure within Bees Lake Area.

2. To predict potential flow structures and shear forces around vicinity of Bees Lake, including Yacht Club, Sherwood Marina and Sacramento River, as a result of potential levee breaches. What hazard, if any, would such breaches create for the integrity of the new setback levee?"

Three breach scenarios were proposed by cbec: 1) breach at downstream end of the Bees Lake reach, 2) at the access embankment of the Yacht club, and 3) simultaneous breach at the 2 locations in scenarios 1 and 2. Note that the Bees Lake area is "hydraulically connected" to the Sacramento River, mostly through underseepage, and there is almost instantaneous water level response between the two.

The BOSC endorses the 3 scenarios and the overall methodology but has a few comments. It is anticipated that the breach be performed using HEC-RAS. Since the existing levee is earthen and there would be a "pool" condition within the Bees Lake for the flood events area due to the hydraulic connection, the breach progression should be rather slow (i.e., no sudden failure) and large surges are not expected. The breach modeling should reflect this. Geotechnical information on the existing levee should be used to estimate the breach progression as well as the shape of the progression. Although hand calculations can be made to determine the hydraulic impact of surges, the BOSC does not see a need to model this phenomenon.

8. Inlet Location to the Southern Offset Area

The BOSC was asked by MBK if moving the southern offset inlet (downstream of Bees Lake) upstream from its current design location would give the BOSC any concerns. The reason for the current location of the offset inlet (downstream of the 90 degree bend) was concern that if it was placed further upstream into the curve, the increased shear stress and possible impinging flow near the maximum radius of curvature could have an adverse impact on the new levee. To evaluate the impact of moving the offset inlet upstream, the BOSC examined the 200 year flood velocity contours and vectors at the area of concern for the conditions of 1) proposed inlet location, 2) existing levee not degraded, and 3) existing levee degraded. These results, shown in Appendices IV - V, were developed by RMA2 and MIKE 21c, both 2D depth averaged models. Note that the MIKE 21c results are in meters/second and the RMA2 results are in feet/second. These results do show some flow vectors perpendicular to the main channel flow as it enters the overbank area (see Appendix VI) and directed toward the outside of the bend (an indication of potential impinging flow). However, the momentum and resulting erosive force on the levee is related to impingement angle and the velocity. **Because the velocities are so small in the outside of the bend (less than about 1.5 feet/second) for all displayed cases, the BOSC has no concerns on the integrity of the new levee should the offset inlet be moved upstream. The BOSC notes that 2D vertically averaged models cannot simulate vertical vortices that occur at bends. However, this is not a concern because these vertical vortices are primarily in the main channel and become very weak as a portion of that flow goes into the overbank area. This means that the hydraulic forces in the overbanks are almost exclusively associated with the horizontal flows. Again, since these horizontal velocities are so small, the additional forces not captured in the 2D models are not of concern to the BOSC.**

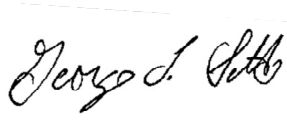
References:

Hall, B., A. Shvidchenko, R. Leeler, L. Adams, and R. Copeland. 2010. Comprehensive Geomorphic and Sedimentation Analyses of Lower Sacramento River for Flood Management, Erosion Mitigation and Habitat Enhancement Design. 2nd Join Federal Interagency Conference, Las Vegas, NV, June 27 – July 1, 2010.

Very truly yours,

West Sacramento Levee Improvement Program
Board of Senior Consultants

Dr. David T. Williams, P.E. CFM.



Mr. George L. Sills, P.E.

Dr. Ray E. Martin, P.E.

Appendix I - Hydraulic meeting notes by cbec
Appendix II - Hydraulic meeting notes by HDR

Appendix III – Bees Lake Breaching Scenarios (by cbec)
Appendix IV - RMA2 Velocity Contours (by MBK), Proposed Inlet
Appendix V – MIKE 21c Velocity Contours (by cbec), Existing Levee Not Degraded
Appendix VI – MIKE 21c Velocity Vectors (by cbec), Existing Levee Degraded

Appendix I - Hydraulic meeting notes by cbec

CBEC Notes from BOSC - 9/10/11

1. We need to have a discussion of how our bank erosion assessment compares with others (NHC, Ayres, etc.). (SAM/SHIELDS)

2. Template analysis has shown only segment A and part of segment B are deficient. This is because Segment G will be strengthened by addition of an adjacent new embankment.

3. Application of ULDC to template analysis was done in segment A in a way that "honors" or leaves in place existing landward infrastructure. See email, pdf document, and other notes from Michael Vecchio's explanation.

4. Our bank erosion decision tree should use the expression "non setback segments" rather than "adjacent levee" because of difference in meaning for the expression "adjacent levee." "Strengthen in place" involves treatments that require no movement of the landside toe. (SAM/SHIELDS)

5. We could support our decision tree branch based on location within river planform (inside of bend, outside of bend, straight reach) by examining Mike 21c bank shear stress outputs for 2yr Q. (JOHN)

6. We need to provide input to the table of contents for the next major design document (65%??) very shortly (Michael Vecchio will request). The document itself must be done by mid-October (?). (JOHN/BOWLES)

7. We need to provide an exhibit for each bank erosion site explaining why it was categorized as high, medium or low priority for bank protection work. The consequences of additional erosion/bank failure should be considered. Include 11x17 figure of each, showing an aerial photo of site with photos of typical erosion condition and a description of the mechanism and severity, scoring on the numerical ranking scheme (below), summary table.

THIS WILL BE INCORPORATED WITH THE NUMERICAL RANKING SCHEME DISCUSSED ON 9/11/12.

8. We need to provide information that can be used for rough quantity and cost estimates.....for example, the no. of feet of bank to be treated with bank treatments by type and typical drawings of each treatment type. Consider assigning ranges for dimensions (e.g., A=x' from sta. 1 to sta. 2) that may vary over the length of the repair, in order to address applicability of a typ. Sect. to the whole repair. This information is needed within a week or so. (SAM/SHIELDS)

9. I need to check with Specialty Devices to find out what types of ground truth they have obtained for previous work so that if they can map the rock under sediment, the conclusions will be defensible. (SHIELDS)

10. Look at Federal Highway (HEC series) for erosion design criteria for erosion treatment within adjacent levee sections. (SAM)

11. Maybe add HDR's "Type 1 Deficiency" locations to our repair list. HDR will make design decision on shape of rock template at toe on Sections A/B.

12. Need to define what is "adequate" toe protection in decision tree. We're assuming if we find toe stone, it's good enough, but is it remnants of a launched toe and possibly not thick enough?

13. Look at SacBank projects to see if historical solutions are consistent with our current project decisions.

14. Send MV a quote for sub-bottom sediment profiling work. (BOWLES)

15. Establish a rationale for repair of levees in non-setback reaches (e.g., if we find this, we'll do this)

BOSC 9/11/11

1. Need to develop a decision ranking / numerical prioritization of the erosion sites already identified using the existing decision matrix. Ranking system will be applied uniformly across both setback and non setback areas. Parameters at a minimum should include severity of erosion (sub-categorize – visible erosion, erosion at toe), proximity to existing levee template and presence of existing protection. Other parameters may include other erosion mechanism and apparent bank retreat rate, consequence of continued erosion/bank failure, other infrastructure, and cost (add columns to the summary table), etc. The erosion classification matrix will still hold for areas that fail the template analysis (must repair) or areas that lack toe protection (repair if on the outside of a bend). We may provide a cutoff number/score that indicates the urgency for repair of a given site. We may integrate the need for toe repair and template analysis results into the numerical ranking scheme. Add numerical rank to summary table.(SAM/SHIELDS)
    a. Any site that fails the template analysis automatically receives highest mark for severity of erosion category as well (MV) – one way of weighting the criteria.
2. Need to take a look at pg. 22 in the ULDC that provides definition on the erosion sites that are in need of immediate repair due to high probability of failure during low or high water conditions. Site G3 seems like an obvious site that would fall into this category. Highlight and describe factors that play into it. Numerical prioritization should identify these high priority sites—make sure it does. Numerical prioritization should produce results in agreement with the severity estimation language of severity on pg. 22. (SAM/SHIELDS)
3. David suggested using the stream-power/bed shear analysis we used for Yuba Goldfields to examine erosion potential at the identified sites. This would only account for fluvial erosion and would not consider potential impacts associated with wave erosion, which is the dominate erosion mechanism within the reach. This seems like a significant limitation.
4. HDR needs to rerun template analysis using Morrow's land survey data with special consideration for segment G. We'll need this info soon if we are to incorporate into 65% design deliverable. Incorporate into summary table and numerical ranking. (SAM)
5. Need to produce erosion design typical for each erosion site (red-green) and associated length of treatment. HDR needs this before (soon) Oct 18 deadline for 65% deliverable. (SAM/SHIELDS)
6. Need to check with Agency folks on use of sub-bottom profiling to see if they think it's a proven/appropriate technology. CBB suggest that this is much more advanced than anything that has been done in the past. (BOWLES)
7. Need to rewrite alternative analysis (levee spur) and completely remove 'risk' from the discussion. Just present the hydraulic/geomorphic changes each alternative presents compared to the existing condition. Consider vector differencing? We may summarize by saying "alt 1 has more hydraulic changes than any of the other alts" etc. (JOHN)

8. Need to include max differencing analysis for bed level change for the 200-year event to quantify the change/impact in max scour/deposition over the course of the entire hydrograph. Use this method to identify areas that may be susceptible to slope instability (banks) or an increase in underseepage potential – although many existing banks are already near vertical and using this for underseepage potential is pretty iffy. This would be more appropriate exercise for bridge scour analysis. (JOHN)
9. The concept of adding a structure that could be used to manage flows within the low-flow channel within the offset area was discussed. Should discuss with ecologist at ICF. This will be looked at in more detail in the 65-90% design.
10. Need to produce frequency of inundation mapping for the offset area. This information was included in the Offset Sustainability report, but needs to be done in planform/graphically. (JOHN)
11. Discussion on what to do with in the bend downstream of Sherwood Marina. Shields says "can of worms". Ideal area for sub-bottom profiling and this where we would likely do initial testing at. Michael to provide actual revetment design sections for this area from the early 1960's – USACE Sac Bank Protection Program. (SAM/SHIELDS)
12. Does mild erosion have a severe consequence? Can we just monitor our remnant levees and not spend money on repairs now? Run a few "what if's" using model simulations. Look at removing section of remnant levee in C1/C2 repair location to see what happens. Incorporate sub-bottom profile data to identify toe of rip-rap after 65%. For 65%, if SSS indicates rock down to toe, then it has sufficient coverage.
13. Refine "Treatment of Existing Levee" column in summary spreadsheet for treatments of adjacent levees.
14. Consider a shear analysis to determine whether in a high flow event the sacrificial material (outside levee template) on an eroding section is eroded to within the levee template.

Appendix II - Hydraulic meeting notes by HDR

WSAFCA
Southport EIP
Hydraulics and Geomorphology Workshop / HDR Meeting Notes
Day 1: 9/10/2

1.) USACE to review MBK modification of USACE HEC-RAS model in conjunction with review of the 65% design DDR.
2.) MBK to provide appropriate revisions to the 65% Design Documentation Report table of contents (TOC) to allow for thorough USACE model review.
3.) CBEC presented the technical memorandum (TM) developed jointly by MBK and CBEC to assign roughness coefficients for differing vegetative cover conditions. See Attachment A for a copy of the TM. This topic is of particular importance as regards the interim, post-construction setting when roughness coefficients will likely be lower than the fully vegetated condition. Such conditions might generate water surface elevations along the offset area that are lower than the existing condition. Such lowering could increase the hydraulic gradient between the American River confluence with the Sacramento River and the site, causing an increase in the portion of American River inflow directed downstream relative to that which flows upstream to the Sacramento Bypass weir.
4.) MBK presented their methodology for determining whether the Southport project, when built, might affect changes to the flow split at the Sacramento/American River confluence and potentially generate regional hydraulic effects. See TM in Attachment A for a full discussion of the methodology – WSAFCA Southport EIP Hydraulic Impact Analysis Procedure, MBK 31 August 2012.
5.) David Williams suggested completing evaluations with respect to storm centering to determine whether they may have an effect on the utility of the method developed by MBK.
6.) David Williams noted that detailed documentation of all changes made to the USACE HEC-RAS should be kept and provided to USACE when their review is requested.
7.) The group then reviewed the CBEC decision-making matrix for identifying sites that require erosion control measures to be implemented. See Attachment A.
8.) Because a part of the matrix relies on whether the location of interest falls 'inside' of a bend (point bar) or outside of bend (cut bank) to return an answer, it was suggested that historical placement of rip rap be reviewed to evaluate consistency with this implied relationship between what side of the bend a site falls on and likelihood of erosion.
9.) David Williams suggested that modeled shear stresses should be reviewed for areas assigned as 'high', 'medium', and 'low' erosion risks to see whether there is a correlation between shear stress magnitude and risk level.
10.) David Williams noted that O&M requirements should be defined for each risk level.
11.) CBEC to provide more information about technology that can be used to evaluate the down-slope extent of rip rap, including calibration efforts.
12.) HDR to define for the Southport EIP project the difference between an in-place and adjacent levee repair.

Day 2: 9/11/12

1) There was discussion of CBEC potentially completing long-term simulations to evaluate effects of changes in sedimentation dynamics due to project construction. Other long-term simulations might entertain what effect meander bend migration could have by building a 'with-meander' model containing a channel shifted into the offset area.
2) David Williams noted that the maximum bed change occurring at any time throughout a long-term simulation was of more relevance to evaluating the potential for the geotechnical destabilization of a levee than was the difference between the (simulation) beginning and ending bed elevations.
3) Much attention was focused on the area just downstream of Sherwood Marina, where the river's alignment shifts sharply to an east/west bearing, creating a high angle of attack on the river bank, and where there is a deep whole located in the river bottom. Discussion centered on evaluating a) what difference river migration into the offset might have, b) whether the river bank needed to be strengthen/reinforced in this area, and c) whether a structure should be incorporated into the river bank upstream of this site to prevent upstream migration (into Sherwood Marina) of bank erosion that may occur in this area.
4) A discussion followed that addressed whether inline weirs installed at the inlet/outlets might be a good idea to provide operational flexibility in the offset area. Positive aspects of this idea include being able to better manage annual inundation and associated benefits. Negatives include the increased responsibility operators have for the functionality of the offset area.
5) The CBEC TM addressing the existing levee spurs was discussed. See Attachment A for a copy of the TM. The group directed CBEC to revise the TM to focus on how modifications to the existing levee spur modify hydraulic parameters in and around the marinas, rather than on the amount of risk any given configuration presents.
6) David Williams suggested that CBEC develop an erosion site ranking system that could be used to prioritize erosion repairs and, possibly, to differentiate between sites that would be upgraded in conjunction with project construction and those that would be the responsibility of another maintaining authority.

Appendix III – Bees Lake Breaching Scenarios

Bees Lake Levee Breaching Scenarios

GOALS

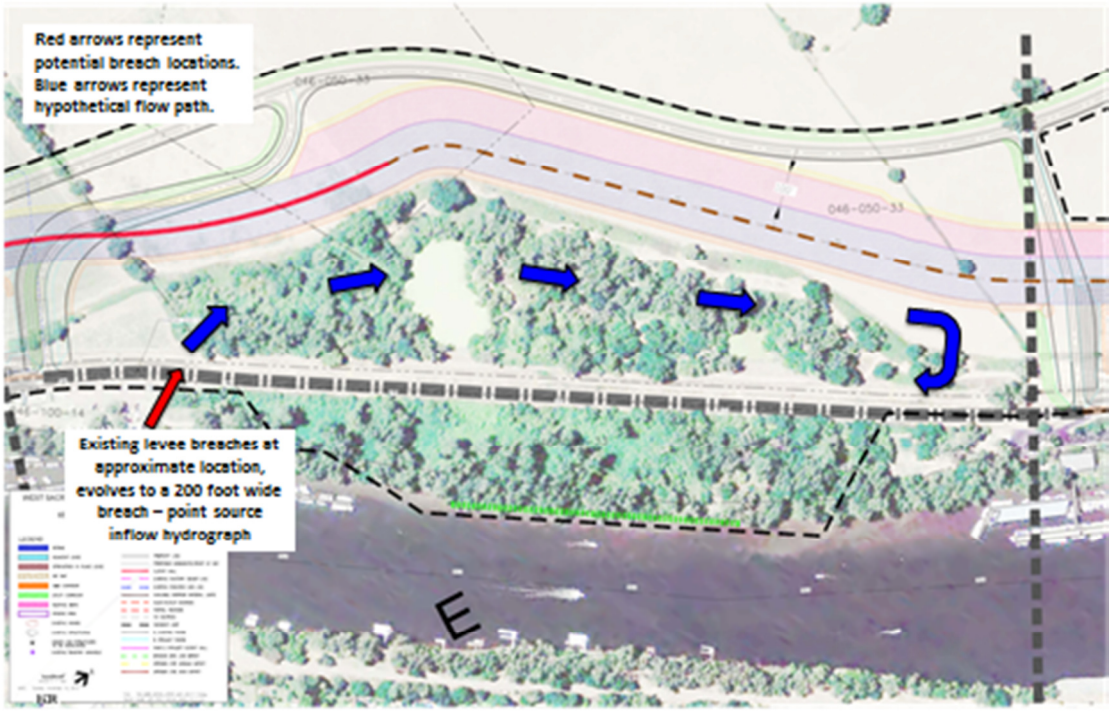
1. To simulate potential failure mechanisms of proposed levee features around Bees Lake and subsequent flow structure within Bees Lake Area.
2. To predict potential flow structures and shear forces around vicinity of Bees Lake, including Yacht Club, Sherwood Marina and Sacramento River, as a result of potential levee breaches. What hazard, if any, would such breaches create for the integrity of the new setback levee?

PROPOSED SCENARIOS

1. For an initial analysis, we propose simplified representation of a limited number of worst case scenarios.
2. Development of breach hydrographs - represent the inflow to the region inside the Bees Lake levee ring as a storage area within existing HEC-RAS model of the project reach. The river water surface profile at the outset of the breach events will be set equal to the peak of the 200-year discharge (determined from MIKE 21C simulations) + 1 ft and held steady at that level.
3. HEC RAS allows selection of the speed of breach development and final breach geometry. Again, since the worst case is of interest, we will assume rapid breaching to an ultimate width of 200 ft. This boundary condition should promote the most rapid breach development and the highest velocities and turbulence inside the levee ring.
4. Flow patterns and boundary shears inside the levee ring will be simulated using the HEC-RAS output hydrographs as a point source input to MIKE 21C Curvilinear 2D model already constructed as part of ongoing studies).
5. Scenario 1 – apply one point source inflow breach in existing levee, at location shown on sketch.
6. Scenario 2 - apply one point source inflow breach hydrograph to simulate breach in the access embankment to Sacramento Yacht Club, at location shown on sketch.
7. Scenario 3 –apply point source inflow breaches in existing levee and in access embankment with breach initiation occurring simultaneously. Direction of flow at downstream breach will be a function of water level inside levee ring.
8. Based on the outcome of these exercises, additional scenarios may be simulated or appropriate design modifications can be prepared.

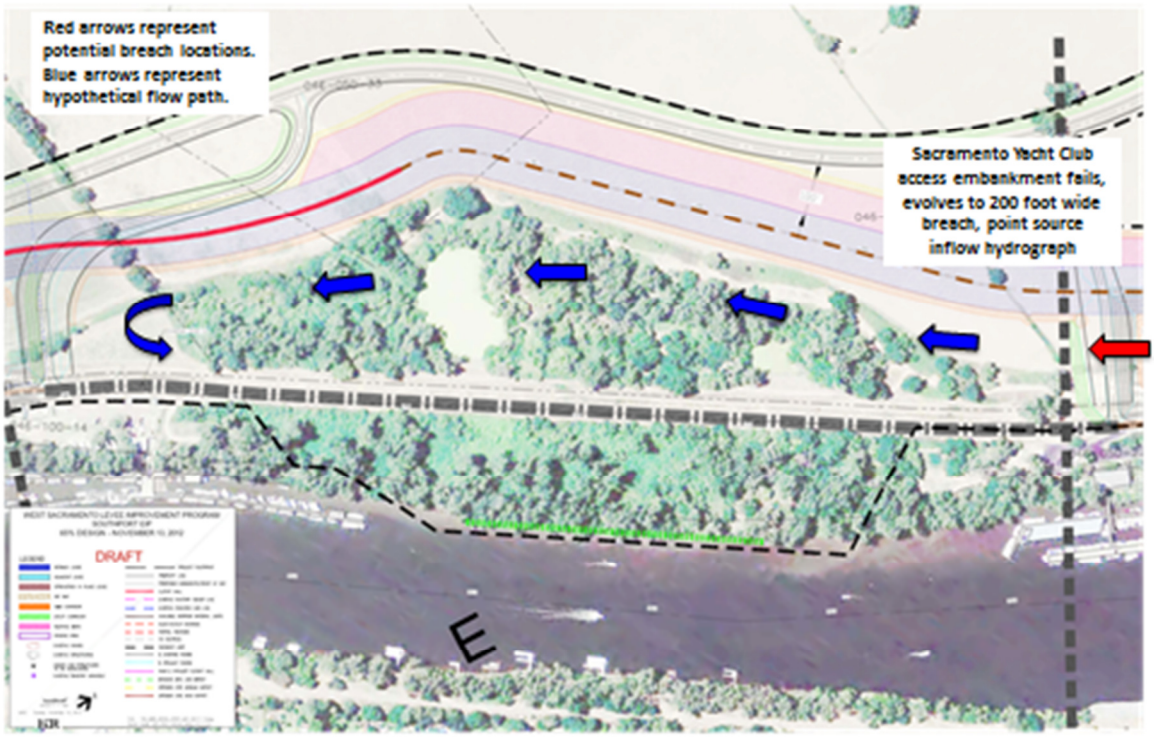
Levee Breach Scenario 1

One upstream inflow breach



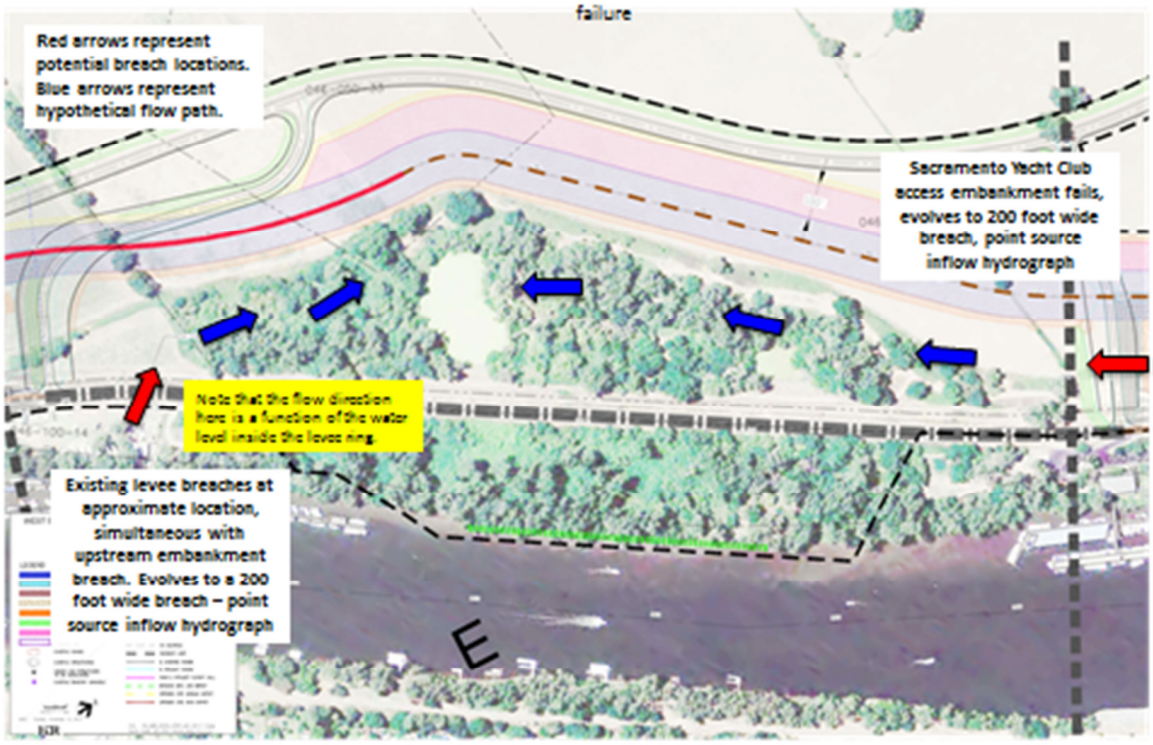
Levee Breach Scenario 2

Sacramento Yacht Club embankment failure

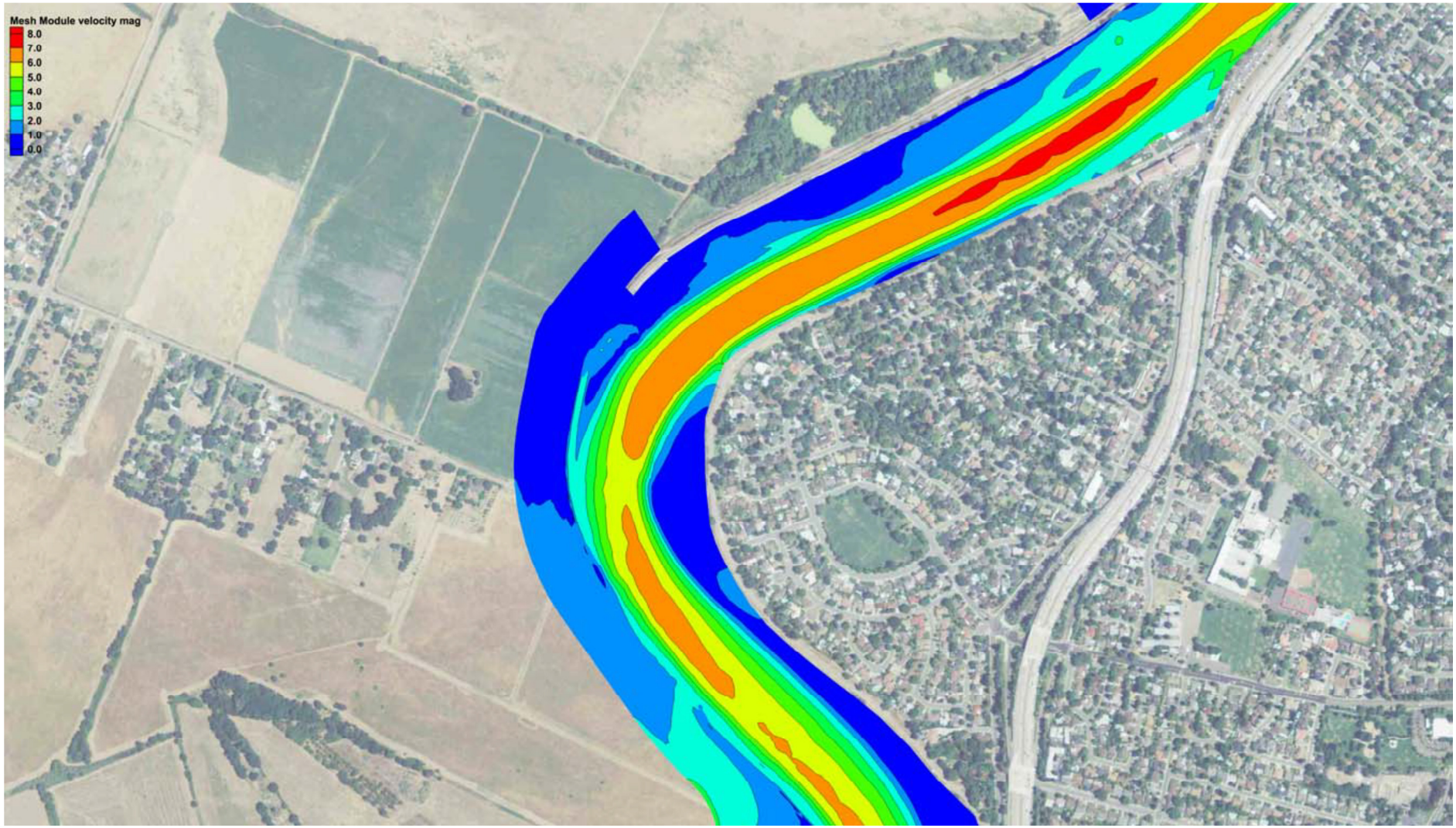


Levee Breach Scenario 3

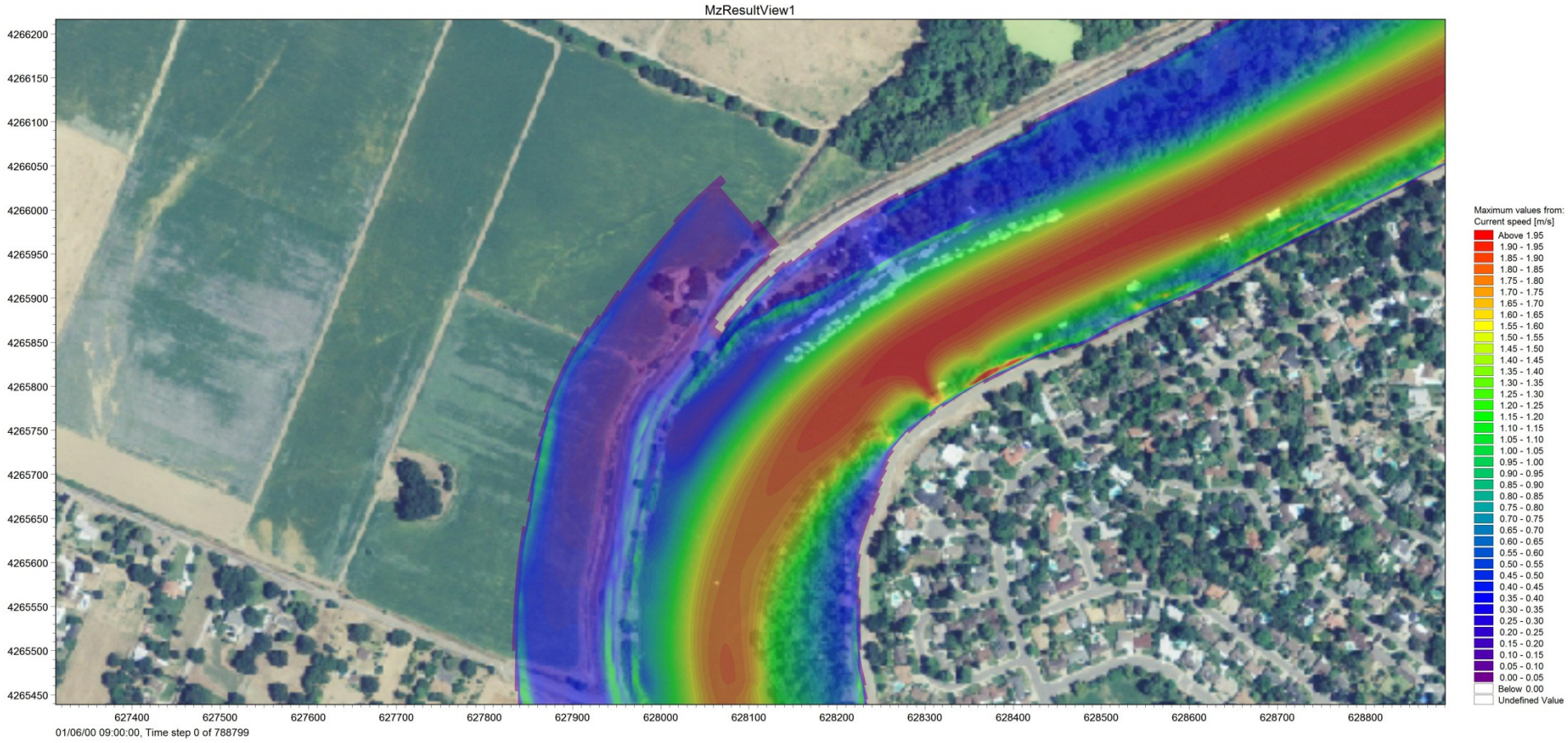
Sacramento Yacht Club embankment failure with simultaneous downstream existing levee failure



Appendix IV - RMA2 Velocity Contours (by MBK), Proposed Inlet



Appendix V – MIKE 21c Velocity Contours (by cbec), Existing Levee Not Degraded



Appendix VI – MIKE 21c Velocity Vectors (by cbec), Existing Levee Degraded