**ATTACHMENT 2**

## Natomas Levee Improvement Program

## Board of Senior Consultants

# Board Report No. 1

## Initial Recommendations Following First Meeting Of the Board of Senior Consultants on March 4-5, 2008


**Report Prepared by:**

**Board of Senior Consultants:**

**Dr. Leslie F. Harder, Jr.**
**George L. Sills**
**Dr. David T. Williams**


**May 9, 2008**

May 9, 2008

Mr. Stein Buer
Executive Director
Sacramento Area Flood Control Agency
1007 7th Street, 7th Floor
Sacramento, CA 95814

Dear Mr. Buer:

## 1. Introduction

This report presents the initial comments and recommendations for the Natomas Levee Improvement Program by the Program's Board of Senior Consultants (Board). The Board has been retained by the Sacramento Area Flood Control Agency to provide expert review of the investigations, problem identification reports, alternatives analyses, and the design documents for levee improvements proposed as part of the effort for providing 200-year flood protection to the Natomas Basin. The initial comments and recommendations that are contained in this report were developed following the first meeting of the Board in Sacramento on March 4-5, 2008.

During this initial meeting, several high-level presentations were made to the Board regarding river hydraulics, channel erosion, geotechnical issues, and levee design approaches, together with a tour by van of the Natomas levees (see attached meeting agenda). These briefings provided a good introduction with regard to the Natomas Levee Improvement Program and the numerous challenges that must be overcome in order to successfully complete the project over the next few years. A copy of the notes from this meeting detailing the topics covered is attached.

## 2. General Comment

The Board appreciates the intense desire to achieve first 100-year level of flood protection and then 200-year flood protection over the next few years. This is a remarkable challenge and a major, sustained effort will be necessary to be successful. During the briefings, the Board gained an understanding that the levee improvements will be led by different consultants for different portions of the basin, and that multiple phases and construction contracts will be needed over approximately the next five years. The Board understands and appreciates the pressures that are being placed for rapid completion of the work, but wishes to caution that going too fast on a large, complicated project can potentially result

in substantial additional costs and delays due to selection of non-optimum alternatives, inconsistent construction schedules, or incomplete designs and construction documents. The Board strongly recommends that each phase and element of the project have adequate, detailed reviews completed before the beginning of any construction work.

## 3. Lessons from Hurricane Katrina

The catastrophic destruction and loss of life in New Orleans following Hurricane Katrina in August 2005 vividly demonstrated the countless personal tragedies that result when an urban area is subjected to deep flooding. Following this event, evaluations of the flood protection system for New Orleans showed that it was not actually a system at all, but a series of separate projects linked together, with little or no integration of the individual elements. Many levee failures actually occurred at the intersections of different elements, and there were also problems with completing improvements using the wrong vertical datum. The potential for inconsistent and inadequately linked project elements is an issue that needs to be addressed in the Natomas Levee Improvement Program.

The Natomas Basin can actually flood to depths twice as much as those in New Orleans (e.g. up to 20-28 feet in Natomas versus up to 12-14 feet in New Orleans). Consequently, it is imperative that we learn from Katrina and assure that the specific inadequacies identified in the New Orleans system are not repeated in Natomas. Accordingly, the Board recommends that specific attention be placed in the following areas:

A. **Vertical Datum** – The Board understands that two different vertical datums are in use in the surveys, investigations, and designs of the Natomas levee improvements: NGVD29 and NAVD88. Much of the initial work was apparently conducted using NGVD29 and is being converted into NAVD88 for producing construction drawings. The Board recommends that a technical memorandum be developed that describes the datums in use, the processes for converting from one to another, and the quality control measures that are in use to assure that datum errors are not affecting the project designs. Any issues or differences in levee stationing should also be addressed in this document. This technical memorandum should be signed by the survey, hydraulics, geotechnical, and civil design team members, and the conversions should be concurred with by the Sacramento District of the United States Army Corps of Engineers (Corps).

B. **Intersections/Connections of Different Levee Improvements** – The Board understands that different levee improvements are being designed for different reaches of levees (e.g., slurry cut-off walls vs. seepage berms vs. pressure relief wells). The Board recommends that the design team

produce a technical memorandum detailing the assumptions and procedures that will be used for connecting/overlapping different levee improvements and for connecting/overlapping different levee improvements to areas where no improvement is provided. This should be achieved in order to prevent one type of improvement from adversely impacting an adjacent reach, and that the connection between elements should represent the strongest area of flood protection rather than its weakest. This technical memorandum should also identify procedures for assuring that, when a levee improvement is left only partially completed before the flood season, no adverse impacts are created (i.e., the levee is not left with a reduced flood protection that is lower than what it was prior to construction – see recommendation on Interim Emergency Action Plans). This technical memorandum should also be concurred with by the Sacramento District of the Corps.

## 4. Seismic Stability

In the past, levees have generally not been designed for concurrent earthquake loadings because it was understood that floods are rare events and that major earthquakes are rare events, and that it would be overly conservative to design for both types of events occurring simultaneously. However, in recent years, we have increased evidence that many levee embankments and foundations are liquefiable and that levees may sustain significant deformations and slumping during major earthquakes, most likely under "fair weather" conditions. Accordingly, both the State and the Corps are trying to develop earthquake engineering design criteria and/or considerations. The Board recommends that the design team develop a seismic mitigation design approach, and that such measures be implemented as part of the Natomas improvements.

The Board is ***not*** recommending that the design team develop measures to eliminate liquefaction potential in the levee embankments or their foundations as the Board believes that this will be prohibitively costly and infeasible. Rather, the Board recommends that the design team evaluate the general level of deformations and damage that 100-year to 500-year earthquake loadings might induce in the levee system, develop an emergency response plan that would lead to rapid repair of the damaged levee system (perhaps up to a 25-year level of protection) over a period of a few weeks, and implement the measures necessary for the response plan to be in place. This is particularly imperative since large deformations could occur during, or just prior to, the flood season. Such measures could include identification and purchase of borrow materials, strategic placement of equipment during, or just before, the flood season, and establishment of haul routes necessary for rapidly rebuilding the levee system.

The Board also recommends that seismic stability be explicitly considered in the selection of levee improvement alternatives. For example, under seismic

loadings, a seepage berm is probably more resilient than a slurry cutoff wall, a SB wall is probably more resilient than a CB wall, and an adjacent setback levee provides a wider, more resilient levee than a fix-in-place levee improvement. Excess material in seepage berms could also be a source of material for rebuilding distressed levees.

The Board recommends that the design team formally put together a seismic mitigation design plan that incorporates the measures that will be adopted and to submit it for review and comment to the State, the Sacramento District of the Corps, and the Board.

## 5. Hydrology and Hydraulic Design Approach

As presented during the briefings, the hydraulic design stage for the 200-year flood event is being determined using traditional deterministic approaches. In these approaches, an expected, or median, water surface for the 200-year flood event is calculated and employed as the design water surface. Freeboard, typically three feet, is then added to this water surface to establish the crown elevation of the levee and tapered up another one foot at structures.

The Federal Emergency Management Agency (FEMA) has traditionally employed and/or accepted this approach for a 100-year level of flood protection. For the Natomas Basin, the 200-year water surface is based on 2002 hydrology developed by the Sacramento-San Joaquin River Basins Comprehensive Study, with recent modifications in the hydraulic model made by MBK Engineers. However, there were significant conservative assumptions employed in the hydraulic model, including the assumption that all of the rural levees upstream of Natomas have had their design freeboard deficiencies remedied, that rural levees can be overtopped and act like weirs without failing, and that no urban levees upstream of Natomas can either overtop or fail. The assumption of overtopping without failure is a significant conservatism, partly because many rural levees could not sustain any significant overtopping, but also because there are structural deficiencies in many of these levees.

The Board believes that these are appropriate assumptions for design purposes, considering the consequences of failure of the Natomas levees, and that the flood protection of different basins should not rely upon the failure of other levees and the flooding of other basins to achieve a minimum level of flood protection. However, the Board wishes to note that there is a significant amount of conservatism in these assumptions and that additional conservative assumptions should not be cumulative.

The Board also understands that the Corps has abandoned this type of deterministic approach and now requires that risk and uncertainty be explicitly incorporated in determining the design water surface profile for the

establishment of the top of levee profile, and for analyzing slope stability and seepage issues. In fact, the Corps and FEMA have been urged to sign a memorandum of agreement to phase in risk and uncertainty analyses over a 10 year period. The Corps has been unclear on how it performs geotechnical analyses with different water surfaces but seems to be using conventional deterministic geotechnical analysis techniques based upon a risk-based water surface (90% or 95% probability of non-exceedance) and/or by setting the design water surface at the top of the levee, whichever is the higher water surface. One of the issues that must be addressed when using a risk-based hydrology/hydraulic approach is what assumptions should be made with regard to upstream levee failures – many are concerned that going to high probabilities of non-exceedance without allowing for levee failures at high levels of overtopping will be unrealistic and lead to excessively conservative designs.

Preliminary analysis results using the risk and uncertainty approach and incorporating levee failures when overtopping conditions developed were presented to the Board for the Natomas Basin levees and are as follows:

90% probability of non-exceedance for 100-year flood ~ 1.4 feet above 200-year deterministic stage
95% probability of non-exceedance for 100-year flood ~ 1.8 feet above 200-year deterministic stage

90% probability of non-exceedance for 200-year flood ~ 1.7 feet above 200-year deterministic stage
95% probability of non-exceedance for 200-year flood ~ 2.2 feet above 200-year deterministic stage

The implications of the above preliminary results suggest that the Corps' risk and uncertainty approach may give about 1½ to 2 feet higher stages for 90 and 95% probability of non-exceedance over the 200-year deterministic approach, assuming that upstream levee failures are incorporated into the risk analyses. With the addition of 3 feet of freeboard to the deterministic design water surface, it may turn out that a 90-95% probability of non-exceedance water stage would thus not necessarily require additional levee height over the 3 feet of freeboard that is currently being incorporated into the designs. However, both the 100-year and the 200-year R&U design water surface might end up being a couple of feet higher than the 200-year deterministic stage, and the risk and uncertainty approach could possibly lead to requiring more extensive levee improvements.

The Board believes that the proposed deterministic approach using conservative assumptions about upstream levee failures is an adequate design approach for a 200-year design flood given the current point in time with respect to changing criteria by different agencies. However, the Board also recommends the following:

- Current Corps levee design criteria require that an underseepage exit gradient at the toe of the levee be less than 0.5 for the design water surface elevation. It is our understanding that this 0.5 exit gradient criterion is being used in the Natomas designs with the 200-year deterministic water surface (i.e. not the top of the levee which is set 3 feet higher). The Board concurs that this is an adequate approach, but also recommends that the underseepage exit gradient at the toe of the levee be less than 0.6 for a water surface set at the top of the levee. This latter recommendation is intended to ensure that the levee is structurally adequate for water surfaces rising all the way up to the top of the levee. It is our understanding that the State may require this additional underseepage criterion as well.

- While not clear at the current time, the Corps' risk and uncertainty approach will undoubtedly lead to higher design water surfaces (perhaps a foot or two above the current 200-year deterministic water surface). Further, some interpretations of Corps policy indicate that the design water surface should be at the top of the levee based upon a specific probability level. The implications of this is that the Corps will probably not recognize a 200-year level of protection based on designs employing the 200-year deterministic water surface only, nor might they recognize or certify a 100-year level of protection since seepage/stability evaluations were not performed to the higher probabilistic water levels. While other engineers are likely to be able to certify that the designs provide the 100-year level of flood protection for the purposes of FEMA accreditation ***using current FEMA criteria***, the Corps may not fully credit the Natomas improvements for use in funding future phases of work unless a full risk and uncertainty analysis (Corps of Engineers style) is performed and design water surface elevations determined accordingly.

  ***The Board recommends that the design team evaluate the additional costs and consider using the top of the levee as the design water surface (i.e., the 200-year deterministic stage plus 3 feet would be used with a maximum exit gradient of 0.5 at the toe of the levee). This is not as much a recommendation for additional safety as much as it represents a business decision that would weigh additional current costs versus potential future credits. In addition, the design team should consider lowering the current design elevation for the top of levee by approximately 1 foot to be consistent with the 200-year 95 percent non-exceedance value (Corps' R&U approach), and then using this as the design water surface with no extra freeboard. This analysis would take into consideration the conservative assumptions of upstream levee scenarios (non-overtopping urban levees and non-failures when overtopping occurs) previously pointed out. The addition of the 3-foot freeboard on top of the 200 year deterministic water surface elevations could be considered adding conservatism on***

***top of already conservative assumptions. Any extra cost for seepage mitigation would possibly be offset by a decreased quantity of material for raising and widening the existing levees. This latter approach should still meet the traditional FEMA requirements for 100-year protection (100-year deterministic water surface plus three feet) as well as satisfy Corps of Engineers' requirements.***

## 6. Approach for Phased 100-year and 200-year Levee Improvements

The Board understands that the Natomas improvements will be phased to first achieve a 100-year level of flood protection over the next 3-4 years, and then to achieve a 200-year level of flood protection within the next 5 years. However, the design approach is understood to be that, for any improvements necessary to achieve the 100-year level of flood protection, the improvements will be designed to a 200-year standard. That is, if freeboard has to be increased, it is increased not to the 100-year plus 3 feet level, but to the 200-year plus 3 feet level. If underseepage mitigation is required, then it is designed to the 200-year deterministic water surface. Presumably, this is to achieve both various economies and to reach higher levels of protection as quickly as possible. The Board strongly agrees with this approach.

## 7. Interim Emergency Action Plans

The Board understands that an Emergency Action Plan is being developed for the Natomas Basin. The Board recommends that interim plans be developed that define the actions necessary to respond to flood emergencies while the levee improvements are underway. This is particularly important since the system as a whole will have different levels of protection until the project is finalized. This, in turn, means that under similar catastrophic flooding conditions, overtopping locations and possible failure modes could change, depending on what phase the project is in. The interim plans would consider the potential modes for distress and failure, and account for changes in conditions and locations as the improvements progress. We expect that these would differ considerably between the present time and after the 200-year level of protection is in place.

## 8. Recommendations on Specific Design Issues

The Board to date has not had the opportunity to review detailed analyses, evaluations, or designs. However, during the initial meeting, the Board discussed several specific issues with the design team. Our recommendations on these selected items are as follows:

a. **Slurry Cut-off Walls** – There was extensive discussion regarding the potential use of cement-bentonite (CB) slurry cutoff walls instead of the planned soil-bentonite (SB) slurry cutoff walls. While the discussion was quite beneficial, there was no resolution. The Board believes that there are potential benefits associated with a CB wall, and it recommends that this issue be further researched, perhaps with a special meeting/session that would involve industry experts.

b. **Levee Embankment Zoning and Borrow Area Analyses** – The Board was briefed on the plan to zone the embankment to allow incorporation of higher plasticity clays within the center of the levee. The purpose of this was to make use of available plastic clay material within the borrow area and avoid excessive overexcavation and expensive rehandling of the materials in the borrow area. There was significant discussion regarding the difficulty of separating out Type 1 soils with a liquid limit of less than 45 from Type 2 soils with a liquid limit of less than 55 – it is very likely that such determinations will be very difficult to do in the field. The Board shares the concerns of the design team that zoning of the embankment will lead to higher costs, and that more work needs to be done in developing a borrow plan. The Board recommends that more attention be given to this issue and that this issue be subject to a constructability review process.

c. **Levee Impervious Zone** -The preliminary plans for the levee improvements which incorporate a slurry cutoff wall include the placement of an impervious zone in the upper 10 feet or so of the levee above the cutoff wall. The Board does not understand the need for such an impervious zone as the borrow material is essentially composed of silty and fat clays. Thus, the entire new levee fill that would be placed above the cutoff wall would be essentially impervious and would not need a special “impervious” zone. The Board believes that this zone is probably unnecessary and that its elimination may reduce costs.

d. **Piezometers Between Pressure Relief Wells** – In one reach of the proposed levee improvements, a new adjacent setback levee is proposed to be constructed with a 5:1 landside slope. Due to underseepage concerns, a 300-foot-wide seepage berm will also be constructed. To reduce the underseepage exit gradient to a value below 0.8 at the toe of the levee, approximately 60 pressure relief wells are also planned to be installed. It is the Board’s understanding that the Sacramento District of the Corps is recommending that a piezometer be placed in the middle of the lengths between each relief well to assure that the exit gradient that develops during flood stages will be less than 0.8. The Board believes that the placement of 60 or so piezometers is excessive and is not required by Corps design procedures. In fact, current published Corps criteria does not even require relief wells at the end of berms more than 300 feet in width (see ETL 1110-2-569). The Board recommends that an appropriate number of piezometers

should be between 3 and 5 for this reach. The wells themselves can serve as piezometers during pumping of the wells. A written request should probably be sent to the Sacramento District to receive their approval for reducing the number of required piezometers in this area.

e. **Pritchard Lake Area** – During the briefing and the tour, the Board was briefed on the Pritchard Lake area, the previous site of a pump station and recent underseepage distress. While much of the pump pit and intake canal have been filled in, there was what appeared to be a boil in the canal about 300 feet landward of the levee at the time of the tour (see photographs below). This boil was remarkable because it was not only far from the levee, but it was also occurring with very little river head at the time (in fact, the Board was informed that the boil was actually at a higher elevation than the river, and that the boil may have been associated with a buried pipe connected either to a ditch or to the remnant Pritchard Lake). The Board believes that this area has a complicated geology and has been distressed by past seepage events and by the numerous pipe penetrations in the levee and foundation. In light of the ongoing distress, the Board recommends that a second line of defense be considered at this location. This would be in addition to the adjacent setback levee, 300-foot-wide seepage berm, and pressure relief wells that are currently planned. Such a second line of defense might consist of something such as a slurry cutoff wall 80 feet deep running along the crown of the levee for a distance of up to 1,500 feet, centered on the sump. However, such a second line of defense should be designed based on additional investigations of the site and its performance.

Photograph No. 1: Boil in Pritchard Lake Intake Canal (03-04-08)

Photograph No. 2: Close-up of Boil in Pritchard Lake Intake Canal (03-04-08)

## 9. Closing Remarks

The Board very much appreciates the opportunity to participate in this extremely important and interesting project, and extends its appreciation to all of the design team and agency personnel who gave the very informative briefings and who participated in the very valuable discussions.

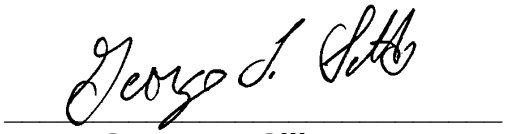
Some of the questions that were asked during the meeting could not be readily answered at that time (e.g., for the calculation of wave setup, was the velocity of the water taken into account in determining the representative wind velocity over water?) Consequently, the Board anticipates that these questions will be formally answered in the coming weeks and provided to the Board in written form.

The Board looks forward to future meetings, briefings, and discussions on this project.

Very truly yours,

**Natomas Levee Improvement Program**
**Board of Senior Consultants**

**Dr. Leslie F. Harder, Jr., P.E., G.E.**



**George L. Sills, P.E.**

**Dr. David T. Williams, P.E., PH, CFM, DWRE**

**Attachments**

MBK ENGINEERS
Water Resources ◆ Flood Control ◆ Water Rights

JOSEPH D. COUNTRYMAN, P.E.
GILBERT COSIO, JR., P.E.
MARC VAN CAMP, P.E.

ANGUS NORMAN MURRAY
1913-1985

CONSULTANTS:
JOSEPH I. BURNS, P.E.
DONALD E. KIENLEN, P.E.

February 25, 2008

To: Les Harder, PhD, PE, GE – HDR Engineering (Folsom, CA)
George Sills, PE – George Sills Geotechnical Engineering Consultant, LLC (Vicksburg, MS)
David Williams, PhD, PE, PH, DWRE – PBS&J (Denver, CO)

**RE: Natomas Levee Improvement Program (NLIP) – Board of Senior Consultants Session**

As previously coordinated via email, the Board of Senior Consultants (BOSC) meeting is scheduled for March 4 and 5, 2008 at the United States Army Corps of Engineers (USACE) in Sacramento, CA. The purpose of the meeting is to review the critical elements of the Natomas Levee Improvement Program (NLIP) to assure that the improvements achieve the intended objective.

The BOSC will meet with members of agency staff from USACE, California Department of Water Resources, Reclamation District 1000 and Sacramento Area Flood Control Agency, as well as the consultants responsible for the design, environmental, and management aspects of the NLIP.

**Location**: United States Army Corps of Engineers
1325 J Street: Room 814
Sacramento, CA 95814

**Time**: March 4 and March 5, 2008, 8:00 a.m. to 5:00 p.m.

**Agenda**: <u>Tuesday, March 4, 2008: Project Briefing and Field Trip</u>

| | |
|---|---|
| 8:00 a.m. – 11:00 a.m.: | Project briefing and current status of NLIP |
| 11:00 p.m. – 12:00 p.m.: | Lunch (not provided) |
| 12:00 p.m. – 5:00 p.m.: | Natomas Basin Field trip |

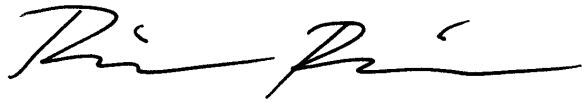
<u>Wednesday, March 5, 2008: Technical Sessions</u>

| | |
|---|---|
| 8:00 a.m. – 10:00 p.m.: | Hydraulics Analysis |
| 10:00 a.m. – 11:00 a.m.: | Erosion Control |
| 11:00 a.m. – 12:00 p.m.: | Analysis and review of project connections |
| 12:00 p.m. – 1:00 p.m.: | Lunch (not provided) |
| 1:00 p.m. – 3:00 p.m.: | Slurry Wall design, Seepage criteria |
| 3:00 p.m. – 5:00 p.m.: | Integrating past performance with design analysis |

The attached scope of work outlines the roles and responsibilities of the BOSC.

Please do not hesitate to contact me at 916-812-9497 or Pro Mitra at 916-456-4400 if you have any questions.

Sincerely,



Ric Reinhardt, PE
Principal
MBK Engineers

Cc: Mary Perlea, USACE
Ethan Thompson, USACE
Dan Tibbitts, USACE
Ed Ketchum, USACE
John Hess, USACE
Rick Poeppelman, USACE
Kevin Knuuti, USACE
Greg Kukas, USACE
Mark Boedtker, USACE
Rick Torbik, USACE
John Bassett, SAFCA
Tim Washburn, SAFCA
Peter Buck, SAFCA
Stein Buer, SAFCA
Jay Punia, California Valley Flood Protection Board
Eric Butler, DWR
Rod Mayer, DWR
George Qualley, DWR
Eric Koch, DWR
Gary Hester, DWR
Tim Kerr, DWR
Steve Mahnke, DWR
Anna Hegedus, DWR
Constantin Mercea, DWR
Paul Devereux, Reclamation District 1000
Mike Nolan, City of Sacramento
Bill Busath, City of Sacramento
Chris Krivanec, HDR
Blake Johnson, HDR
Barry Meyer, HDR
Jonathan Kors, Wood Rodgers
Ray Costa, Kleinfelder
Lynn O'Leary, Kleinfelder
Roberta Childers, EDAW
Ken Rood, Northwest Hydraulic Consultants
Steve Sullivan, Mead & Hunt
Tim Busch, Mead & Hunt
Bob Morrison, Bender Rosenthal
Joe Countryman, MBK
Mike Archer, MBK

HDR | ONE COMPANY *Many Solutions*℠

# Meeting Notes

| | | | | |
|---|---|---|---|---|
| Subject: | NLIP – Board of Senior Consultants Briefing & Field Trip | | | |
| Client: | Sacramento Area Flood Control Agency | | | |
| Project: | Natomas Levee Improvement Program – Sacramento River Levee Design | Project No: | 07886-63040-141 | |
| Meeting Date: | March 4-5, 2008 | Meeting Location: | USACE-Sacramento District Office | |
| Attendees: (See sign up sheet for detailed list) | SAFCA<br>George Sills<br>WR<br>CVFPB | USACE<br>David Williams<br>NHC | DWR<br>HDR<br>City of Sacremanto | Les Harder<br>KA<br>Mead & Hunt |

***Note –*** *Please see slide presentations for each overview or technical discussion below for main content. Notes are intended to supplement information presented on the slides. (Notes were requested on the Day 2, so they may be more complete than those from Day 1. Please contact the presenters for more specific information.)*

# Day 1 – Project Briefing

## I. Introduction & NLIP Overview

A. Speakers – Stein Buer, Ric Reinhardt, John Bassett (SAFCA & MBK)
B. Overview of basin location and features presented.
C. Hydraulics considered: SRFCP Design Flow – 430,000 cfs
D. Bassett walked through issues & constraints considered during alternatives analysis.
E. Design slides presented with conceptual layouts of adjacent levee, seepage berms and cutoff walls.
F. Mitigation plan discussed – oak woodlands and grasslands.
G. Real estate needed for project to be acquired in fee.
H. Environmental status
    1. EIR completed last fall for 2008 work. EIS to be completed at the end of March '08.
I. Questions/Issues
    1. Les Harder – What levee improvements are to be accomplished by 2010?
        - Bassett – should have 200-year freeboard/100-year for underseepage
        - Board would like table summarizing improvements (from EIS)

## II. Hydraulic Analysis

A. Speaker – Joe Countryman (MBK)
B. Hydrology from USACE 2002 Comp study.
C. Considered 3 Storm centerings.
    1. Not the 50 percentile event.
    2. Used a conservative, deterministic approach
    3. Unregulated flow frequency considered. Adjusted to get to 200-year flow.

D. John Hess – Need to check NGVD29 to NAV88 conversion. It may not be straight mathematic conversion.
E. 1997 flood is estimated to be an 80 year flood. 1986 flood is estimated to be a 60 year flood.
F. Assumptions :
    1. All levees to design height
    2. No levee failures upstream
    3. 200-year flow volume
    4. 3 ft freeboard is required for wind/wave
    5. Assumed rural levees overtopped but did not fail, and urban levees will not overtop
G. David Williams – should we consider the need for 3' feet of freeboard on top of wind/wave?

## III. Erosion Control

A. Speaker – Ken Rood (NHC)
B. David Williams – Was a scour analysis performed? Did preliminary scour analysis using 200-year – regime analysis.
C. No sediment transport analyses were conducted.
D. Design keeps revegetation outside 3:1 slope (as projected from existing levee).
E. Compared to the Ayers evaluation –one major site was added.

## IV. Geotechnical Investigation

A. Speaker – Lynn O'Leary (Kleinfelder)
B. Reports
    1. Problem Identification Report, Alternatives Analysis, Data Report, Basis of Design Report
C. Areas of Investigation
    1. Sacramento River – 380 borings completed
    2. Reach 4B – 20 additional borings
    3. Pump Station #2 – 10 borings
    4. Reach 5-11 – 41 additional borings (by 4/4).
    5. Reach 12-20 – 46 additional borings (by 5/3).
    6. American River – 50 borings done, 7 to go
D. David Williams – why no waterside borings in some areas? Access issues, and generally not needed.
E. Ray Costa – Described main levee repair features.
    1. At Main drain outlet – jet grouting needed to complete wall.
F. The Elkhorn pumping plant is at an old breech area.

## V. Water infrastructure, wind/wave analysis

A. Speaker – Steve Sullivan (Mead and Hunt)
B. Summarized basin pumps & canal system.
C. David Williams – Was interior drainage considered? No, not evaluating as part of this project. The basin has a 100-year capacity.
D. Wind/Wave – USACE program (CEDAS) evaluated at 32 locations
    1. 8 locations < 1'; 13 locations 1-2'; 10 locations 2-2.6'; 1 location @ 2.67'

## VI. Sacramento River and American River Levees

A. No additional notes taken for HDR portion while presenting overview.

# Day 2 Technical Discussions

## VII. Hydraulic Analyses (Hydraulic Simulation Walk Through)

A. Speaker – Mike Archer (MBK)
B. Hydrology from USACE Comp. Study
C. Natomas basin is controlled by 2 storm centerings (Sacramento River & Feather River)
D. Design Criteria
    1. 200-year urban levees do not overtop
    2. Non-urban levee overtop but do not fail
    3. All SRFCP levees have design freeboard
    4. Folsom release is 160,000 cfs
    5. TRLIA improvements are in place
E. Hydrology is "best estimate" – not 90$^{th}$ percentile
F. Question – Were sensitivity analysis done?
G. Compliant freeboard raises were discussed.
H. Results – overtopping locations (39) assumed 500' weirs, typical flow over weirs, 100's of cfs vs. 100,000 total
I. Question (USACE) – how much does WSE change if no levees overtop?
    1. Don't know but at 500-year, water surface elevation (WSE) up 5' at Natomas
    2. Does 200-year design WSE satisfy 100-year @ 90$^{th}$ percentile (R&V)? Within 0.01'
    3. Joe Countryman – for 100-year, the 95$^{th}$ confidence WSE is 2.2' above mean 100-year WSE.
J. 200-year Design WSE ~ 1' above 100-year from model on Sacramento River (same assumptions)
K. Reviewed charts with WSE comparison curves – model vs. high water marks.
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M. DWR & USACE revising models for entire system. Discussed need for conservative model in interim.

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A. Speaker – Steve Sullivan (Mead & Hunt)
B. Analysis – USACE method – Coast Engineering Design and Analysis System (CEDAS)
    1. 32 locations – Sacramento River, American River, NCC
C. Findings – most below 2.5' – only one at 2.6' on American River at confluence
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C. Figure – Bank materials profile (from crown borings)

D. Projected thalwag used to identify likely bank materials – loose sand vs. resistant clays
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    1. Primary mud rotary borings – 1,000 ft spacing through levee crown, at/near landside toe, and 100 to 300 ft from landside toe
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        c) John Hess – how do berms function?
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    2. CPTs (for seismic liquefaction assessment)
        a) Seismic – no critical areas in Reach 1 to 4B.
        b) What WSE used?
            (1) Simmer mean.
    3. Piezometers
    4. Relief Wells – designed for gradient mid-span at 0.65
F. Laboratory testing
    1. Undisturbed strength/consolidation
    2. Grain size distribution
    3. Plasticity determinations
    4. Remolded strength
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    1. Seepage (SEEP/W) – no blanket theory confirmation to date; permeability from Kozeny-Carman, published values (NAVFAC, Terzaghi and Peck, Freeze and Cherry, and Cedergren), field slug/pump tests, piezometer calibration. Boundary conditions.
    2. Seepage run with 200-year WSE. Looked at top of levee – relief well spacing would be closer. George Sills – need to look at WSE at top of levee and use a 0.5 criteria. New EM will require top of levee WSE and may keep 0.5. Bassett – may consider a lower factor of safety (not 1.6, say 1.3).
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the economics make sense. (Note - Hold TOL at 200-year WSE plus 3 feet, and there is more freeboard in some areas).

4. Stability
    a) Steady state (SLOPE/W) – uses SEEP/W input
    b) Rapid Drawdown (UTEXAS4)

H. Design Criteria –
1. USACE Levee Design Material
2. USACE Seepage ETL
3. USACE Sac District SOP
4. DWR Guidance Document
5. MBK 100 and 200 yr WSE
6. Underseepage (100 yr, 200 yr, and 200 yr + 3 ft WSE)
    a) Avg gradient <0.5 at levee toe
    b) Minimum berm – 4 times levee height or 100 ft, whichever greater
    c) Maximum berm – 300 to 400 ft, check gradient at berm toe
    d) Ditches (empty) <0.5 at levee toe; <0.8 at 150 ft from toe
    e) Berms, undrained; impermeable
7. Stability
    a) Case I End of Construction FOS >1.3
    b) Case II Rapid Drawdown FOS >1.2
    c) Case III Steady Sate Seepage >1.4
    d) Case IV Seismic – check for liquefaction – used 200 year return frequency event
8. Relief Wells
    a) Average gradient mid-spacing <0.65 (allows for 80% efficiency between maintenance intervals)
9. Transition between mitigations
    a) 200 ft for cutoff walls Reaches 1 and 2
    b) 300 ft for seepage berms Reaches 4A and 4B

I. Construction Materials
1. Levee embankment
    a) Type 1 soils: LL<45; 8<PI<30; -200 >30%; org content <4%
    b) Type 2 soils: LL<55; 8<PL<35; -200 >30%; org content <4%; 5 ft minimum cover
    c) Clay Cap. Type 1 (CL)
    d) 90% relative compaction (ASTM D1557)
        (1) Discussed Type 1&2, zoned embankment (Note – Type 2 – LL<55, 8<PL<35)
        (2) George – you might consider all Type 2 material in the embankment.
        (3) Have there been shallow slumps? Yes – in high plasticity (CH) slopes
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2. Berm
    a) Type 2 soils; min 105 pcf
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3. Cutoff wall
    a) Perm for design 1x10E-6 cms; construction 5x10E-7 cms
    b) SCB 28 day comp strength 40 psi min and 300 psi max; 3ft min width
    c) SB 3 ft min width (1 ft width for every 10 ft differential head); Allow 4 weeks settlement period; Estimated settlement is 1 ft. Require 30 to 50% fines content.

d) George – should also consider CB walls during design.

J. Borrow source issues
   a) Non-spec materials present
   b) Shallow groundwater
      (1) Profiles – discussed groundwater recharge
      (2) Discuss piezos between RWs – Mary P wants between each well
      (3) CB walls no need to core for QC

## XI. Sacramento River and American River Levees

A. No additional notes taken for HDR portion while presenting technical issues.
B. Technical issues discussed (see presentation for details):
   1. Design Layouts
   2. Levee Prism and Waterside Encroachments
   3. Vegetation and Root Zones
   4. Utility Poles
   5. Drainage/Intake Pipes
   6. Borrow Available – Levee Zonation
   7. Soil Bentonite Wall Construction

## XII. NCC, PGCC, and NEMDC

A. Speaker – Jonathan Kors (Wood Rogers)
B. Selection of cutoff wall
   1. Slurry wall contractors not comfortable with coring requirements in '07 SW spec
   2. Rich Millet – Last year – 2 SCB wall failures when cored. Used recent Sacramento District SCB wall spec. Crew worked continuously. In 30' wall, had 2-4' of poor wall material at bottom (~10%).
C. SCB Cutoff Walls
   1. Typical QC Requirements
   2. Typical Mixing Method
   3. Seismic Performance
D. SB Cutoff Walls
   1. CB walls typically get $10^{-6}$cm/s – more uniform wall, fewer cave-ins (denser fluid), less filter cake, 10-50psi (can be 300 psi)
   2. CB would flow into soil pipes & set up
   3. Degrade CB wall – 1/3 levee height. Cost ~ SB wall plus n2/SF
   4. Settlement Time
   5. Typical QC Requirements
   6. Fines Limits
      a) Fines limit 20-40& - for ease of mixing
   7. DSM Method (32-inch Effective Width)
   8. Box Mixing vs. Levee Top (Ground) Mixing
      a) SB – mixing in box less desirable – better mixing on ground, can observe more easily.
         (1) Need more careful observation of box
   9. Seismic Performance
   10. Specify % Bentonite

E. CB Cutoff Walls
    1. Depth Limitations
    2. Strength Limits for Seismic Performance
    3. QC Requirements
    4. Setup Time
    5. Typical Cost/SF
F. Other items

MBK ENGINEERS
Water Resources ◆ Flood Control ◆ Water Rights

JOSEPH D. COUNTRYMAN, P.E.
GILBERT COSIO, JR., P.E.
MARC VAN CAMP, P.E.

ANGUS NORMAN MURRAY
1913-1985

CONSULTANTS:
JOSEPH I. BURNS, P.E.
DONALD E. KIENLEN, P.E.

February 25, 2008

To: Les Harder, PhD, PE, GE – HDR Engineering (Folsom, CA)
George Sills, PE – George Sills Geotechnical Engineering Consultant, LLC (Vicksburg, MS)
David Williams, PhD, PE, PH, DWRE – PBS&J (Denver, CO)

**RE: Natomas Levee Improvement Program (NLIP) – Board of Senior Consultants Session**

As previously coordinated via email, the Board of Senior Consultants (BOSC) meeting is scheduled for March 4 and 5, 2008 at the United States Army Corps of Engineers (USACE) in Sacramento, CA. The purpose of the meeting is to review the critical elements of the Natomas Levee Improvement Program (NLIP) to assure that the improvements achieve the intended objective.

The BOSC will meet with members of agency staff from USACE, California Department of Water Resources, Reclamation District 1000 and Sacramento Area Flood Control Agency, as well as the consultants responsible for the design, environmental, and management aspects of the NLIP.

**Location**: United States Army Corps of Engineers
1325 J Street: Room 814
Sacramento, CA 95814

**Time**: March 4 and March 5, 2008, 8:00 a.m. to 5:00 p.m.

**Agenda**: <u>Tuesday, March 4, 2008: Project Briefing and Field Trip</u>

| | |
|---|---|
| 8:00 a.m. – 11:00 a.m.: | Project briefing and current status of NLIP |
| 11:00 p.m. – 12:00 p.m.: | Lunch (not provided) |
| 12:00 p.m. – 5:00 p.m.: | Natomas Basin Field trip |

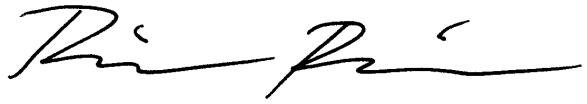
<u>Wednesday, March 5, 2008: Technical Sessions</u>

| | |
|---|---|
| 8:00 a.m. – 10:00 p.m.: | Hydraulics Analysis |
| 10:00 a.m. – 11:00 a.m.: | Erosion Control |
| 11:00 a.m. – 12:00 p.m.: | Analysis and review of project connections |
| 12:00 p.m. – 1:00 p.m.: | Lunch (not provided) |
| 1:00 p.m. – 3:00 p.m.: | Slurry Wall design, Seepage criteria |
| 3:00 p.m. – 5:00 p.m.: | Integrating past performance with design analysis |

The attached scope of work outlines the roles and responsibilities of the BOSC.

Please do not hesitate to contact me at 916-812-9497 or Pro Mitra at 916-456-4400 if you have any questions.

Sincerely,



Ric Reinhardt, PE
Principal
MBK Engineers

Cc: Mary Perlea, USACE
Ethan Thompson, USACE
Dan Tibbitts, USACE
Ed Ketchum, USACE
John Hess, USACE
Rick Poeppelman, USACE
Kevin Knuuti, USACE
Greg Kukas, USACE
Mark Boedtker, USACE
Rick Torbik, USACE
John Bassett, SAFCA
Tim Washburn, SAFCA
Peter Buck, SAFCA
Stein Buer, SAFCA
Jay Punia, California Valley Flood Protection Board
Eric Butler, DWR
Rod Mayer, DWR
George Qualley, DWR
Eric Koch, DWR
Gary Hester, DWR
Tim Kerr, DWR
Steve Mahnke, DWR
Anna Hegedus, DWR
Constantin Mercea, DWR
Paul Devereux, Reclamation District 1000
Mike Nolan, City of Sacramento
Bill Busath, City of Sacramento
Chris Krivanec, HDR
Blake Johnson, HDR
Barry Meyer, HDR
Jonathan Kors, Wood Rodgers
Ray Costa, Kleinfelder
Lynn O'Leary, Kleinfelder
Roberta Childers, EDAW
Ken Rood, Northwest Hydraulic Consultants
Steve Sullivan, Mead & Hunt
Tim Busch, Mead & Hunt
Bob Morrison, Bender Rosenthal
Joe Countryman, MBK
Mike Archer, MBK

HDR | ONE COMPANY *Many Solutions*℠

# Meeting Notes

| | | | | |
|---|---|---|---|---|
| Subject: | NLIP – Board of Senior Consultants Briefing & Field Trip | | | |
| Client: | Sacramento Area Flood Control Agency | | | |
| Project: | Natomas Levee Improvement Program – Sacramento River Levee Design | Project No: | 07886-63040-141 | |
| Meeting Date: | March 4-5, 2008 | Meeting Location: | USACE-Sacramento District Office | |
| Attendees: (See sign up sheet for detailed list) | SAFCA<br>George Sills<br>WR<br>CVFPB | USACE<br>David Williams<br>NHC | DWR<br>HDR<br>City of Sacremanto | Les Harder<br>KA<br>Mead & Hunt |

***Note –*** *Please see slide presentations for each overview or technical discussion below for main content. Notes are intended to supplement information presented on the slides. (Notes were requested on the Day 2, so they may be more complete than those from Day 1. Please contact the presenters for more specific information.)*

# Day 1 – Project Briefing

## I. Introduction & NLIP Overview

A. Speakers – Stein Buer, Ric Reinhardt, John Bassett (SAFCA & MBK)
B. Overview of basin location and features presented.
C. Hydraulics considered: SRFCP Design Flow – 430,000 cfs
D. Bassett walked through issues & constraints considered during alternatives analysis.
E. Design slides presented with conceptual layouts of adjacent levee, seepage berms and cutoff walls.
F. Mitigation plan discussed – oak woodlands and grasslands.
G. Real estate needed for project to be acquired in fee.
H. Environmental status
    1. EIR completed last fall for 2008 work. EIS to be completed at the end of March '08.
I. Questions/Issues
    1. Les Harder – What levee improvements are to be accomplished by 2010?
        - Bassett – should have 200-year freeboard/100-year for underseepage
        - Board would like table summarizing improvements (from EIS)

## II. Hydraulic Analysis

A. Speaker – Joe Countryman (MBK)
B. Hydrology from USACE 2002 Comp study.
C. Considered 3 Storm centerings.
    1. Not the 50 percentile event.
    2. Used a conservative, deterministic approach
    3. Unregulated flow frequency considered. Adjusted to get to 200-year flow.

D. John Hess – Need to check NGVD29 to NAV88 conversion. It may not be straight mathematic conversion.
E. 1997 flood is estimated to be an 80 year flood. 1986 flood is estimated to be a 60 year flood.
F. Assumptions :
    1. All levees to design height
    2. No levee failures upstream
    3. 200-year flow volume
    4. 3 ft freeboard is required for wind/wave
    5. Assumed rural levees overtopped but did not fail, and urban levees will not overtop
G. David Williams – should we consider the need for 3' feet of freeboard on top of wind/wave?

## III. Erosion Control

A. Speaker – Ken Rood (NHC)
B. David Williams – Was a scour analysis performed? Did preliminary scour analysis using 200-year – regime analysis.
C. No sediment transport analyses were conducted.
D. Design keeps revegetation outside 3:1 slope (as projected from existing levee).
E. Compared to the Ayers evaluation –one major site was added.

## IV. Geotechnical Investigation

A. Speaker – Lynn O'Leary (Kleinfelder)
B. Reports
    1. Problem Identification Report, Alternatives Analysis, Data Report, Basis of Design Report
C. Areas of Investigation
    1. Sacramento River – 380 borings completed
    2. Reach 4B – 20 additional borings
    3. Pump Station #2 – 10 borings
    4. Reach 5-11 – 41 additional borings (by 4/4).
    5. Reach 12-20 – 46 additional borings (by 5/3).
    6. American River – 50 borings done, 7 to go
D. David Williams – why no waterside borings in some areas? Access issues, and generally not needed.
E. Ray Costa – Described main levee repair features.
    1. At Main drain outlet – jet grouting needed to complete wall.
F. The Elkhorn pumping plant is at an old breech area.

## V. Water infrastructure, wind/wave analysis

A. Speaker – Steve Sullivan (Mead and Hunt)
B. Summarized basin pumps & canal system.
C. David Williams – Was interior drainage considered? No, not evaluating as part of this project. The basin has a 100-year capacity.
D. Wind/Wave – USACE program (CEDAS) evaluated at 32 locations
    1. 8 locations < 1'; 13 locations 1-2'; 10 locations 2-2.6'; 1 location @ 2.67'

## VI. Sacramento River and American River Levees

A. No additional notes taken for HDR portion while presenting overview.

# Day 2 Technical Discussions

## VII. Hydraulic Analyses (Hydraulic Simulation Walk Through)

A. Speaker – Mike Archer (MBK)
B. Hydrology from USACE Comp. Study
C. Natomas basin is controlled by 2 storm centerings (Sacramento River & Feather River)
D. Design Criteria
    1. 200-year urban levees do not overtop
    2. Non-urban levee overtop but do not fail
    3. All SRFCP levees have design freeboard
    4. Folsom release is 160,000 cfs
    5. TRLIA improvements are in place
E. Hydrology is "best estimate" – not 90$^{th}$ percentile
F. Question – Were sensitivity analysis done?
G. Compliant freeboard raises were discussed.
H. Results – overtopping locations (39) assumed 500' weirs, typical flow over weirs, 100's of cfs vs. 100,000 total
I. Question (USACE) – how much does WSE change if no levees overtop?
    1. Don't know but at 500-year, water surface elevation (WSE) up 5' at Natomas
    2. Does 200-year design WSE satisfy 100-year @ 90$^{th}$ percentile (R&V)? Within 0.01'
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