Seismic Review Comments and Responses on
Technical Memorandum
Delta Risk Management Strategy (DRMS) Phase 1 Draft 3
Topical Area: Levee Vulnerability

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General: Please provide responses to previous review comments submitted by the Seismic Review Panel both individually and in our joint letter. Please indicate what action was taken in response of the comment and what changes were made to the report.

The responses to comments on the individual letters have been submitted. Responses on more recent comments and the joint letter are being prepared.

General: The overall process used to evaluate the seismic levee vulnerability is confusing. I still do not see a clear explanation of the overall process and the implications of the numerous simplifying assumptions used in the study.

The topic is certainly very complex and involves complicated modeling and simulation of multiple and interdependent variables and processes. We have rewritten the TM and had it professionally edited.

We have prepared a document that goes through the fragility calculation step-by-step to further explain the process using an illustrative example. This document was submitted on April 11, 2008 to the seismic review group.

Introduction: correct spelling of my name and KY.

We apologize for the misspelling and we will make the corrections.

Section 2.5.1 – this section states that blowcounts greater than 20 were not enter into the database. This would appear to strongly bias any characterization of the levee materials to the lower blowcount materials. Since the corrected blowcount was used as a random variable in the evaluation of the levees it is difficult to see how the distributions assigned to this variable are valid if no blowcounts over 20 are included in the sample.

It was assumed that blowcounts over 20 represent soils that are not susceptible to liquefaction. In each boring we screened the values of the blowcounts. Borings with blowcounts over 20 were not added to the potentially liquefiable reaches. They represent levee reaches that are placed in non-liquefiable classes.

If blowcounts are found to vary within each boring, the blowcounts less than 20 will represent the stratum thickness that is susceptible to liquefaction. For example if sand substratum is 50 feet thick, but has blowcounts less 20 in the upper 10 feet, then the upper 10-foot stratum was considered as a potentially liquefiable layer (10 feet). The lower 40 feet represented a different and non-liquefiable layer.

Please refer to our previous response to your earlier comment on the Draft 2 of this TM on the discussion related the randomization of the blowcount along a boring versus across borings.

Section 2.9 – This section states that most of the borings were performed more than 25 years ago and may have used the most current techniques. If these borings were not performed for the specific purpose of seismic evaluation, drilling mud may not have been used and will likely produce much lower N-values in the saturated sands due to heave. This could significantly bias the results. How is this addressed in the study?

Please refer to our response to your similar comment on draft 2 of this TM.

Table 2-1 – This table include numerous examples of available borings that were not digitized. It is not clear if the blowcounts were not used as well. Also it is not clear why they were not used. This also has potential to bias the results.

An explanation on the reasons for why some borings were used and why others were not, is provided in our response to your comments on the draft 2 of this TM.

Figure 2-13 – Typical sections should be extended to at least the toe of both slopes. Also please show the normal water level that will be used for the seismic evaluation on these sections.
These figures were digital information provided to us by DWR. Displaying them was just an illustration of information made available to us. We will add a legend saying that these are original data provide by DWR.

All analysis cross-sections we developed were extended 100's of feet beyond either toe and the all show the water level used in the analysis (see Section 6). We have provided maps of levee crest elevations (Figure 2-11) and the mean higher high water (MHHW) elevations used for seismic analysis for the entire Delta and Suisun Marsh. Since there are thousands of reaches used in the simulations and risk model we could not possibly produce all of them in the report. However, using the two maps listed above one can readily find the exact crest elevation and water level used for each station for each island and at any point in the Delta and Suisun Marsh.

Chapter 2 – It would be valuable to show a detailed cross-sections of showing the actual geometry, stratigraphy, and blowcounts where you can have enough data. This would help the readers evaluate how well the approximated sections used in the vulnerability classes match the insitu sections.

In the step-by-step description of the fragility calculation, we show the real cross-section for the test case at Bacon Island. In the original TM we did perform stability analyses at specific locations (Sherman and Bradford Islands) for calibration and validation purpose.

The Appendices of the TM also provides multiple real cross-sections and boring logs plotted on the cross-sections developed during the original investigation.

6.2 - It is still not clear why there was a classification of N-values greater than or less than 20 and why this section states that it was assumed that for values less than 20 there is a potential for liquefaction. Does this mean that there was at least one blowcount in the embankment fill less than 20 or that all of the blowcounts in the embankment fill are less than 20. What distribution was assigned to these two groups.

In the TM we indicate that out of 207 $N_{1,60}$ collected across the levee fill, only 4 were greater then 20. The remaining 203 $N_{1,60}$ were below 20 and crossed potentially liquefiable sandy fill as shown in Figure 6-19. In other words, the great majority of blowcounts in the sandy levee fills were below 20 and are susceptible to liquefaction. The mean blowcount of those sandy fills was around 8.

For the foundation sand, there were 936 $N_{1,60}$ collected across the levee fill, 310 were greater then 20. The remaining 626 were below 20 as shown in Figure 6-18. Most of the $N_{1,60}$ below 20 were encountered in the upper 5 to 10 feet of the shallow sand deposit. The blowcounts increase greatly with depth.

6.2 (second bullet) – Thee probability of liquefaction does not depend on the post-liquefaction residual strength.

We agree, and the text will be corrected.

6.2 – It would be useful to present a cross-section for each vulnerability class. This section does not discuss some important aspects such as the embankment height, water elevations, assumed piezometric surface, and assumed stratigraphy.

We do show these typical cross-sections in the TM, for example Figures 6-65 through 6-69 and other figures in Section 6. If some are missing we will add them. For the same V-class the water level varies depending on whether V-class X is in area Y or area Z of the Delta. Each V-class in each specific location in the Delta has a specific MHHW level associated with it. Two cross-sections will be the same, but having two different $N_{1,60}$ they will belong to different classes.

6.4.2 – The discussion of the analysis method is still confusing. I would suggest that a consistent method be used for all of the idealized sections (vulnerability classes).

- Determine the probability of liquefaction (and no liquefaction) for the embankment and foundation sand layer.

- Estimate the deformation for each of the four cases using the most appropriate method.
    - Embankment liquefies- FLAC post-earthquake static.
    - Foundation liquefies – FLAC post-earthquake static.
    - Embankment and Foundation liquefies – FLAC post-earthquake static.
    - No liquefaction - Newmark
- Multiply the probability for each of the four cases times the deformations determined and sum to obtain the total deformation.
- Determine the probability of breach given deformation/freeboard.

We have described the procedure more clearly in the revised TM. It appears that more explanation is needed. We will do so.

Also, please refer to the Ste-By-Step procedure document we produced after our recent phone call with Professor Boulanger and Mr. Volpe on April 2, 2008.

6.4.2- It is not clear what water level and piezometric surface was used in the analysis.

See the response to comment above on Section 6.2.

6.4.2 – Throughout this chapter is not always clear which method of estimating deformation is being discussed. Also please describe what deformation is being calculated. Vertical, horizontal, maximum???

The deformations calculated in the "Displacmenet vs PGA" curves are all horizontal. The step-by-step illustrates how the horizontal deformations are converted.

6.4.3 – How does the decision to select 5% strain to determine the apparent strength of the peat influence the results?

The 5% strain was selected because the average strain at failure of the mineral soils appears to occur around 5%. Please see the laboratory test strain-strain test curves on peat and mineral soils in the Appendices of the TM.

6.4.4 – It is not clear how the results of the calibration analysis were used. Some statements indicate that back-calculated values were adopted. Were these parameters still treated as random or deterministic variables? Were c and phi treated as correlated or independent?

They were treated as random variables. The mean values of c and ϕ were adjusted to reflect the know failure cases used in the calibration. The distributions around the mean were maintained the same from the original data. The values of c and ϕ were assumed to be auto-correlated. The TM shows mean and distribution of these variables.

6.4.4- There was no discussion of the water levels and assumed piezometric levels in the calibration cases. This has significant influence on the analysis and should be discussed.

They were definitely considered in the analysis. In order for the calibration to make sense, the same conditions have to be represented in the model including of course water level and piezometric line through the embankment. This information will be added to the TM.

6.4.4- In the comparison with the Newmark and FLAC deformation analysis Figure 6-28 does not show solutions for comparisons to many of the cases for the Magnitudes and accelerations. Why are these not shown?

The analysts did not run FLAC for M-5.5 beyond 0.2g, and for M-6.5 beyond 0.3g because they do not believe that those magnitudes can produce higher PGA' in the Delta than those limits .

6.4.4- Please indicate what component of deformation is presented on Figures 6-27 and 6-28. Is it horizontal for both? Vertical for both? Horizontal for Newmark and vertical for FLAC?

The deformations are horizontal.

6.4.6- distributions used for the parameters should be shown in the report. In particular the N160 distributions for each VC type need to be shown.

The $N_{1\text{-}60} \leq 20$ distributions for the levee fill and foundation sands are shown in the TM, Figure 618 and 6-19. Each bin (0-5, 5-10, 10-20) is sampled for its representative class by the number of times each particular $N_{1\text{-}60}$ occurs within that bin. The number of occurrences across all bins, follows the normal distribution for all the $N_{1\text{-}60}$ less than 20 (see previous discussion regard regarding the $N_{1\text{-}60}$ $\leq$20. Each class was screened for $N_{1\text{-}6}$. If the lowest $N_{1\text{-}60}$ falls between 0 and 5 then that bin is associated with that class, if the lowest $N_{1\text{-}60}$ of another class is between 5 and 10, then that bin is associated with that class, etc.

We will show the values of $N_{1,60}$ in Table 6-3.

6.4.6- The lognormal distribution may not be the best for all parameters being modeled. For example, it may be better to use a uniform distribution for the N160 values for each bin: 0-5, 5-10, 10-20, >20

Please see the response above on the treatment of $N_{1\text{-}60}$ for each class.

6.4.6 – This section does not discuss other important variables. Pore pressures, unit weight, levee height, etc.

Pore pressure, unit weights, levee heights were not treated as random variables for the following reasons:

- Levee heights are known at each location since the entire LiDAR (2007) crest elevation was entered into the risk database. At each station the crest elevation is known within the accuracy of the survey. For each reach analyzed we use the minimal value from the 2000-foot running crest elevation average.
- The pore pressure was considered constant along with the piezometric line for each class given crest elevation and analysis water stage, since the analysis was conducted with the specified MHHW surface elevation.
- The unit weights used for the analyses were selected as the best estimate values for each unit. No randomization of this variable was considered.

6.4.6- The last section states that the properties have "no insignificant effects". Is this correct?

The two deposits whose properties were not treated randomly are the deep dense sand and the lower stiff clay. We did however test the effects of the variation of the shear modulus and damping ratio and found their effects to be secondary.

6.4.7- Why was the effective overburden stress not calculated for each Vulnerability class? Was the unit weight considered as a deterministic or random variable?

The ratio of the effective to total overburden stress was calculates for the levee fill and he foundation sand. It was found that for the levee fill, the ratio was close to one and it made a great deal of simplification in the calculation of the CRS by assuming it to be constant. However, the effective to total stress ratio was calculated for each class as shown in equation (2) of the TM.

6.4.7.1 – Deformation analysis. –What were the input parameters?

Each modeling method has its own set of input parameters that are discussed in the TM.

6.4.7.1- Liquefaction of levee fill- Given liquefaction of embankment materials, was the residual shear strength applied to the entire embankment or just the saturated materials below the phreatic surface?

It was applied to the saturated material.

6.6 – Page 27- In step six it says that the vertical displacement was assessed to be 50% of the horizontal displacement. It is my understanding that this only applied to the deformations estimated from the Newmark analysis. Please clarify.

Yes to the first part of the comment. Since the deformation curves had to have a uniform definition of axes, we used the horizontal deformation in all curves.

6.6 – Page 29- In step 9 it states that 28% variation was set to represent the epistemic uncertainty. It is not clear if this was only applied to the liquefaction probability. What about the uncertainty in the predicted site response and deformation estimates steps of this analysis.

The uncertainties associated with the site response and deformation are carried throughout as explained in the TM and further illustrated in the Step-By-Step document submitted recently. The epistemic uncertainties associated with the expert elicitation curve (conditional probability of failure give deformation) and the epistemic uncertainties associated with the different methods used to estimate the probability of liquefaction are both considered.

Figures 6-30 – 6- 33 – No water or piezometeric levels are shown on these sections. What was used in the evaluations?

Piezometric lines will be added.

Figure 6-64 – This figure indicates that the remaining crest elevation is much higher than the maximum vertical deformation. Was this considered in the analysis or in the development of the levee fragility curves?

NO, we used the maximum deformation, and hence that cross section would fail by overtopping..

Table 6-3 – Please enter the values for N160 for the foundation in the table.

We will add the $N_{1\text{-}60}$ *in Table 6-3.*

Table 6-5a- Please enter the values for c' and phi' in the table.

C' and phi' will be added to the table.

Table 6-5b- Please enter the values for C

They will be added to Table 6-5b.

Chapter 7- This section is very brief for the magnitude of analysis that was performed in this study.

We can certainly expand the discussion on the findings in that Chapter.