San Francisco Bay Conservation and Development Commission
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March 7, 2017

TO: All Engineering Criteria Review Board Members

FROM: Rafael Montes, Senior (Staff) Engineer (415/352-3670; rafael.montes@bcdc.ca.gov)

SUBJECT: **Draft Minutes of March 30, 2016 BCDC Engineering Criteria Review Board Meeting**

1. **Call to Order.** The meeting was called to order by the Chair Dr. Roger Borcherdt at approximately 1:00 p.m., in the Monterey Conference Room at 455 Golden Gate Avenue in San Francisco, California.

The following Board Members were present: Dr. Roger Borcherdt, Board Chair, Professor Jack Moehle (UC Berkeley), Mr. Jim French, G.E., Mr. Frank Rollo, G.E., who was present only during the first discussion item, Mr. William Holmes, S.E. and Mr. Richard Dornhelm, who was only present during the second discussion item. The members of the staff present were Mr. Jhon Arbelais, Permit Analyst, Ms. Jaime Michaels, Chief of Permits, Mr. Marc Zepettelo, Chief Counsel, Ms. Hanna Miller, Permit Analyst and Mr. Rafael Montes, Staff Engineer and Board Secretary.

The audience included the following: Ms. Wen Lin, S.E. and Mr. James Conolly, S.E. of COWI, Mr. John Sumnicht, S.E. of SGH, Mr. John Gouchon, G.E. and Mr. Haze Rogers, G.E. of Langan Treadwell Rollo, Mr. Boris Dramov and Ms. Ivana Micic of ROMA, Mr. Jim Brady, S.E., Mr. Dilip Trivedi, P.E., Ms. Azadeh Bozargzadeh, S.E. and Ms. Ingrid Maloney, S.E. of Moffatt&Nichol, Mr. James Hurley, P.E., Mr. Kim von Bluhn, P.E. and Mr. Steve Reel, P.E. of the Port of San Francisco, Mr. Avinash Nafday, P.E. and Ms. Kendra Oliver, P.E. of the California State Lands Commission, Mr. Mike Gougherty of WETA, Mr. Justin Bajema of Anvil Corporation, Mr. Chris McDowell, Mr. Dominick Tagalog and Mr. Peter Carroll of Tesoro.

2. **Approval of the Meeting Minutes of October 22, 2015.** Chair Borcherdt solicited comments from the Board members regarding the last meeting minutes of October 22, 2015 with respect to the Brooklyn Basin project and the WETA SF Ferry Terminal. Mr. Holmes wanted to make a correction regarding his comments of the ferry terminal project on page 9, last sentence of the second paragraph. He noted that the sentence should be modified to delete the reference "regarding criteria for wharves" in connection with ASCE 41, for the latter does not include criteria for wharves. Mr. Rollo made a motion to approve the minutes. Mr. Holmes seconded the motion. The chair entertained a vote, and the minutes were approved unanimously.

3. **2nd Review of the WETA San Francisco Ferry Terminal Expansion.** At the request of the chair, the members of the audience introduced themselves. Mr. Gougherty gave a brief description of the project and let the Board know that the team had focused on the inquiries posed by the Board on its October 22, 2015 meeting and was back to present and discuss the engineering team's findings. He added that WETA had also been working closely with the Port of San Francisco to review the engineering as another peer evaluation of the project. Mr. Reel confirmed that the Port would be issuing a construction permit for the project pursuant to the classification as an "essential facility." Further, since the project would be highly significant to the region's infrastructure grid, the Port selected a peer review made up of prominent structural and geotechnical experts to help in the assessment of safety. The group would be retained to the completion of the project.

Mr. Holmes brought up the first issue regarding the incompatibility between two statements on the performance criteria for the structure in the "30% Engineering Design" report. The first statement on the report was sourced in Section 2 under "Methodology and Approach," which referenced the performance criteria as based on Immediate Occupancy (Level 1 earthquake) and Life Safety (Level 2 earthquake). The second statement was in reference to the "Project Structural Design Criteria," Appendix A where he noted that the design criteria of the Ferry Plaza was referred to as an "essential" structure that was to be designed for the risk-targeted Maximum Considered Earthquake (MCEr) pursuant to the 2013 California Building Code, with the goal of the structure to *remain operational after a strong earthquake*. Therefore, he argued, such description under Appendix A was not compatible with the Section 2 under the "Methodology and Approach" regarding performance criteria of levels 1 and 2 earthquake and ask the team to explain. Mr. Brady accepted Mr. Holmes' remarks and noted that the goal to remain operational was not correct.

After Mr. Brady's endorsement of Mr. Holmes' remark, Mr. Gouchon began his presentation of the new soil-structure interaction studies. He told the Board that the geotechnical report had been provided the last time without the Dynamic Soil Structure Interaction or FLAC analysis. He summarized the scope of the presentation in general and its geotechnical aspect more specifically. The scope of the presentation included the FLAC analysis results, the results of the pore pressure generation of the lower sands, discussing of the effects of boundary effects (boundary conditions) as requested by the ECRB in October 2015 and explanation of the kinematic loads as applied to the piles. The presentation would address the Board's comments with respect to the results of the evaluations of liquefaction and impacts of lateral spreading on the piles and performance of the entire structure if liquefaction occurs, what effects it would have on the lateral strength and displacement. One significant finding from FLAC analysis was the revelation of potential liquefaction of upper sand layers previously thought to be safe. As a result, the team had recommended a change of the pile design. A final note to be addressed would be with respect to explaining the strategy for the access aspect of the facility for when a strong motion occurs and in light of the structure's classification as an "essential" facility. He then requested that Mr. Rodgers present the results of the FLAC analysis.

Mr. Rodgers stated the purpose of this follow-up FLAC (fully non-linear) analysis of the seawall whose primary goal was to estimate seismic deformation of the seawall and impacts to the proposed structure, namely, to evaluate potential impacts of deformation of the soil mass, settlement behind and of the seawall, differential movement of the proposed structure and the loads that could possibly be induced onto the proposed piles of the structure due to this moving ground. The analysis consisted of a two-dimensional dynamic soil interaction analysis using a computer program named FLAC. Previously used in the Geotechnical report was a subsurface profile between Pier 1 and Ag Building. Based on comments from his team, a different subsurface profile was used that is somewhere between these two locations. The analysis extended the model to the top of the bedrock as part of the site-response analysis, developed scaled acceleration time-histories at rock, inputting those directly by manipulating those directly into the model and allows it to shake from the rock up. The analysis considered the proposed and existing improvements.

Mr. Rodgers pointed out the differences between the new analysis (shown as SSI 'soil-structure interaction' Profile) and the one presented at the October 22, 2015 meeting (profile A-A'). The former reflected features of the seawall and its underlying soils and piles, new plaza and Berth E whereas the latter projected the area of the section of the seawall underlain by a trench of granular fill, Ag Building and the Berths F and G. The new profile section was more representative of the project with the Plaza as the major public access feature but did not include the piles under the Ag Building. As a result, the characteristic of the seawall's profile as shown in SSI Profile was different from the previously discussed features in the A-A' profile.

Given that the analysis goal was to work with the most representative model in relation to the seismic performance, the SSI profile reflected a more accurate representation to be used to model the higher-risk or worse-case scenario when it came to understanding the potential impacts on the slope deformation analysis. The physical features of the profile included the MUNI turnaround structure on piles, the original seawall built prior to the 1906 Earthquake, the Embarcadero (pile-supported relieving platform) area timber piles, the new seawall on piles as well and the new structure. Mr. Rodgers expounded on the components of the new SSI model analysis criteria that included the properties of the structural elements: seawall and piles, Embarcadero deck and piles, MUNI Tunnel walls, roof, mat and piles and proposed facilities' deck, first and second rows of piles. In addition, he described the soil properties underlying the site in the SSI analyses. He described the ground motions selected for the site: Risk-targeted Maximum Credible Earthquake Risk or MCER and the Designed Earthquake of El Centro, PS-10 and TCU 102, which resulted in the largest deformations in the model, compared displacements and response spectra at mudline between structure and edge of model. He explained a the use of PM4SAND Calibration Model originating in UC Davis to model the effects of pore pressure increase during an earthquake for the liquefiable areas. During the analyses, the design team determined to keep the capacity of the steel piles as originally proposed and for yield moment, meaning that as stresses are induced to the piles they can only resist forces up to their yield capacity, and after that the capacity would not continue to increase like it would on a linear elastic material. Further, the mass of the proposed deck was neglected during this analysis although modeling was done as a pin connection between the deck and pile with no moment transfer. There was some discussion about this decision. Finally, the model was extended 240 feet beyond the easternmost proposed pile of the main ferry plaza to make sure the model went well away from any potential sliding mass at the seawall or any other potential mass displacement. Again, there was some discussion about this item as the Board questioned the shallow depth (bathymetry) of the site. The design team showed drawings of the bathymetric elevations at the site as evidence of the shallow depths. Mr. Rollo asked if the model was vetted by the independent peer review.

Mr. Rodgers provided the results of the SSI Evaluation that confirmed that (1) liquefaction of the saturated granular soils was occurring, (2) lateral displacement of the seawall and shoreline slope was predicted, (3) failure surface was relatively shallow (55 feet below top of pile or 42 feet below the mudline, (4) on-shore failure surface was confined to between the old and new seawalls (bayward of MUNI turnaround), (5) displacing soil intersects the existing and proposed piles, (6) displacing soil was limited to limits of the proposed structure, and (7) displacement and spectra between structure and eastern edge of model were the same. There was some discussion about the results. For clarity in reference to the potential maximum ground displacement relative to the proposed facility's piles, Mr. Rodgers showed a slide of the lateral bending of the piles relative to displacement of the adjacent soils. The first, second and fourth rows of piles closest to the seawall would bend but retain its space and shape whereas the soils would be globally displacing much farther (did not represent soil failure). For the farthest piles from the seawall, the pile and the soil generally move together. Based on the graphs, Mr. French asked whether the piles would be able to deflect 5.5 feet laterally. Mr. Rodgers said the design team did not see the piles reaching the yield moments limits.

The results of the SSI evaluations indicated the following:

1. The additional lateral load due to displacing soil;
2. Used the calculated pile shear forces in the first 6 piles;
3. Calculated an equivalent fluid weight for the shear force at 56 feet below top of pile (42 feet below mudline);
4. Increased average of three ground motions by approximately 1/3; and
5. Good agreement to simpler method considering strength of the displacing soil (checked with peer review team).

Mr. Rodgers provided a summary of the SSI model results that showed:

1. Seawall and shoreline slope would be subject to lateral displacement during a MCE_R ground shaking (4 to 5.5 feet);
2. An additional lateral load due to displacing soil should be considered;
3. 25 pcf over the first 6-rows of piles;
4. Load applied over top 42-feet of proposed piles;
5. Differential displacement between pile supported sea wall and structure is small (approximately 2-inches); and
6. Potential for differential settlement of non-pile supported shoreline and pile supported structures (approximately 9 inches).

For the kinematic loads modeling the following was included:

1. Three of the time series developed as part of the site response study were used as input motions for FLAC.
2. The mass of the platform deck was not included and the top of the proposed piles were modeled as pin connections to the plaza deck.
3. Deflection profiles of the piles and adjacent soil as well as bending moments in the pile were developed at the end of shaking.
4. The soil adjacent to the piles displaced more than the pile in the upper 42 feet (bottom of potential failure surface). These soil displacements would impose additional lateral loads onto the proposed piles.
5. A recommended equivalent fluid weight of 25 pcf was developed based on the shear profiles of the first six rows of piles from the landside end of the deck.

The geotechnical studies concerning liquefaction concluded the following:

1. The FLAC results indicate the upper sand layer will liquefy and displace laterally.
2. Estimation of liquefaction induced settlements up to ½ foot, which could cause downdrag on the piles. We have included downdrag on the piles as discussed in the geotechnical report.
3. The estimated lateral movements of the soil and pile from FLAC include the upper sand layer liquefying and consequently a reduction in strength of the sand layer.
4. Potentially liquefiable soil was modeled using the PM4SAND advanced constitutive model calibrated to the measured shear wave velocity and relative density (SPT N-values).

Mr. Rodgers ended the geotechnical side of the presentation and fielded questions. Mr. Rollo raised the concerns of the many existing piles scheduled for demolition that could interfere with the location layout of the new piles and their potential to losing the lateral capacity. Therefore, he suggested to add to their drawing notes to make an effort to slurry any of the open holes in the mud due to the concerns of the loss of piles capacity to resist high lateral movements, especially on the rows closer to the seawall. Mr. French asked about the seeming discrepancy between the depth features of the piles in the LPile model at elevation -80 feet and the FLAC model that showed the piles at elevation -140 feet. Mr. Grouchon said that the LPile was not inclusive of soil movement to generate soil P-Y springs whereas the FLAC analysis showed the soil movement below 55 feet to model the lateral displacement of the soil and the pile resisting such movement. In addition, Mr. French inquired about the reason for using end-of-shaking deflections in the study report instead of maximum-transient deflections. The team response: transient values would become more constant in a matter of thousands of a second; therefore, the design team opted to using the end-of-shaking values. Chair Borcherdt asked whether the large deformations in the piles would then remain after the strong-motion events. Mr. Rodgers asserted such assertion that there would be significant permanent movement. And if so, Chair Borcherdt asked about the piles usability afterwards. Mr. Rodgers deferred the answer to the structural team. Mr. Holmes asked whether there would be a vertical capacity change. The skin friction in the bay mud would provide more than needed capacity to prevent uplift. Mr. French requested a response describing the conventional liquefaction analysis/evaluation done for the project. Mr. Rollo asked whether the design team discussed liquefaction in the original report and whether it was based on a simplified approach. The team responded that it had and that the liquefaction discussion was already provided in the original report. Mr. Rollo's suggestion was to summarize such discussion in a reference or a paragraph in the report's findings. His second request and suggestion were to look again to/revise the bathymetry values used in the model since these seem to be steeper as shown in the drawings.

Ms. Maloney presented the structural design component of the project. Partly due to the results of the FLAC evaluation, there had been key structural changes made to the original design as presented in October 2015 meeting. She mentioned that the pile layout had been improved and optimized from the original 24-inch pilings by incorporating 24-, 30- and 36-inch steel piles and 24-inch concrete piles. Accordingly, the location of the piles had also been improved by increasing the spans, incorporating cantilevering sections at the edges of the proposed plaza next to the seawall, the BART deck and the Agriculture Building, and more consistent overall pile utilization. The 36-inch piles would be those closest to the seawall and its rock dike embankment; therefore, the cantilever section of deck between these piles and the seawall, spanning 16 feet, would be at the toe of such embankment for the purpose of missing it for easier pile installation. The piles at the promenade were also increased to 30-inch diameter.

The deck structure had also been modified from a cast-in-place (CIP) pile cap and deck system to a flat slab system comprising of a 18-inch thick slab that would provide flexibility for shifting piles in the event of obstructions and ease of deck construction. There was some board discussion about the thickness of the slab, any resulting weight penalties, rebar congestions and potential placement conflicts and the available space for moving the location of the piles if moved from planned locations. Questions regarding the span capacity of the deck were discussed. Mr. Brady said that the deck as proposed had wide capacity flexibility in the order of 5 to 10 feet. Ms. Bozorgzadeh would continue the presentation regarding the response to the last ECRB meeting and provide details on the analysis.

She first addressed the ECRB comment regarding seeking an explanation and evaluation of the criteria with regard to the damage on the concrete piles and whether there would be moment resistance left after an MCE-type of earthquake. Further, the Board requested to explain the results of any kinematic effects on the structure. She explained the modeling done to determine the displacement demand and capacity that incorporated torsional and orthogonality effects, the kinematic analysis that included soil displacement imposed on pile through the PY springs, soil pressure applied to piles in zones of failure and kinematic and inertial effects combined in time-history manner.

She proceeded to provide the same values as originally exposed of the performance objectives criteria for the hazard levels of earthquake for MCEr and 2/3MCEr of 1,000 years (life safety) and 475 years (Immediate Occupancy). The strain limits changed based on the last discussions with the ECRB and sourced now on the Port of Long Beach guidelines. She showed the areas included for the push-over analysis and cover the new details of the pile-deck connections for the three-different diameter piles. Ms. Bozorgzadeh explained that of the three time history ground motions, El Centro had the higher kinematic load displacement.

The next ECRB comment regarding the structural criteria was to be addressed by Mr. Brady. The comment from the Board requested a detailed evaluation of the sliding joints with respect to design for horizontal and nominal vertical displacement. Mr. Brady noted that there was a minimum vertical displacement based on the models and that there was no longer a tie-in joint between the Ag Building and the project components; therefore, the measure only involved resolving to horizontal displacement joint at the Promenade (Plaza and Promenade models), a joint at the Seawall and a joint at the BART Platform that required a displacement of 13.3 (10.0 for the Promenade model), 13.2 and 13.2 inches, respectively. The new joints would have a displacement capacity of 24 (24 for Promenade model), 30 and 27 inches, respectively. He showed some details of the joints at the seawall and BART platforms in cross sections depicting incorporation of splash and wave deflectors with joints being able to move 30 and 27 inches, respectively, in both horizontal directions. He also showed the joint details at the Promenade/Plaza intersection. There would no longer be ajoint between the Promenade/Plaza/Ag Building as a result of the last October discussions. There would now be open waters between the Ag Building and the new structures.

Mr. Brady also touched on the Board's concerns about access in and out of the facilities during emergencies such as those arising during and after a strong earthquake in which the areas landward of the seawall could see settlements in the order of two feet. He pointed out that the new structure would touch down to the seawall via joint plates, which are not expected to move vertically. Further, he said that the Port had a plan to deal with access after a major event. In light of that statement, Mr. Rollo inquired from the BCDC staff about the limits of ECRB/BCDC jurisdiction. Mr. Montes stated that the project limit upland stopped at the seawall. Mr. Rollo asked rhetorically whether the Board would then turn a blind eye about the safe access from the ferry facilities to the land areas or the staff ask the applicant to provide the Board/BCDC with a plan to mitigate the effects of this seawall settlement/movement in the future. He suggested one more option that the Board request an emergency plan be reviewed and certified by it at later time. Mr. Reel proposed that the Port be ready to mitigate the access immediately after the quake's damage. Mr. Rollo's concern was that this plan be well-planned and vetted beforehand since the structure would be serving emergency personnel; its access in and out would be critical. His final recommendation was for BCDC to work closely with the applicants on an safety plan to deal with a major emergency with the intent that the structure would function as designed for access to and from the seawall and to land. Mr. Holmes requested that the plan included the separation at the joints if these are breached. Ms. Michael acknowledged the Board comments to work with the applicant in the conditions of the permit. Mr. Rollo insisted that if WETA is proposing this project as an emergency facility, the applicants should commit to unimpeded access, especially during an emergency situation. Mr. Gougherty stated that WETA was determined to work with the Port, the US Coast Guard and other emergency agencies to reestablish access to the essential facilities under its purview.

Mr. Trivedi was next to elaborate on the responses to the Board questions from the last October meeting. He had provided responses in writing ahead of the meeting; however, there were no Coastal Engineering Board members at the meeting to respond to Mr. Trivedi's responses. He then gave up his time to end the meeting. Mr. Montes asked Mr. Trivedi to provide his response to the Board's comments in public for the record. But prior to the continuation of Mr. Trivedi's public presentation, Professor Moehle requested assurances from the applicant's design team that there would be a design check on the pull-out capacity of the piles' rebar embedded in the deck as this detail could create another potential failure plane. Mr. Brady said there were similar comments provided by the peer review panel to provide additional reinforcement at the top of the pile and addressed the panel's comments. Mr. Rollo requested evidence of the applicant's addressing of the peer review comments regarding pile pull-outs to be provided to BCDC for inspection and confirmation and added to the public record. Mr. Reel said that the Port could provide a letter from the peer review panel of this 30 percent design. He added that the review panel would remain to make recommendations throughout the project. Mr. Rollo accepted such offer of a 30 percent design review by the panel.

Chair Borcherdt began the process of closing this project item with a request for final comments and recommendations. But before proceeding to the final comments, Mr. Montes asked the Chair whether the Board would hear Mr. Trivedi's response to the Board's comments regarding the Coastal Engineering aspect of the project. The Board resolved to include his written response as part the public record in lieu of a hearing.

Board's motion: Preamble with the understanding that:

The initial ECRB review of the engineering criteria for the WETA San Francisco Ferry Terminal Expansion project was conducted when the project was at about the 35 percent design stage. Subsequently, the Applicant's consultants (Langan, Moffat and Nichol and Simpson Gumpertz & Heger) provided additional information for ECRB comment on March 30, 2016 regarding the following:

a. Results of the FLAC analysis regarding geotechnical issues of the area landward of the seawall;

b. Results of the pore pressure generation in the lower sands;

c. Comments about the model's incorporation of any kinematic loading of the piles at the floats in relation to potential exceedance of boundary effects that could result in potential movement of some lower liquefiable and softening sands at the edge of the model;

d. Explanation of kinematic loads as applied to and moments at the tops of the piles of new structure and relation to the FLAC model;

e. Evaluation of liquefaction and lateral spreading and their effects on pile capacities;

f. Discussion and commitment to provide BCDC staff with a comprehensive emergency plan for access and egress during a strong-motion event in light of the project's classification as an "essential facility."

g. Coastal engineering comments had been addressed in writing in lieu of a presentation to be placed in the public record. Documentation of the coastal analysis and responses to the Board shall be available for the public record.

The Board consensus indicated that the applicant's presentation and submittals addressed the comments raised by the ECRB at the initial October 22, 2015 review of the project. Therefore, Mr. Rollo proposed a motion that:

a. The applicant be allowed to continue design of the project provided that the results of the simplified liquefaction and FLAC analysis be addressed for comparison and discussion;

b. The applicant, its consultant and peer reviewers respond to the concerns of effects of an outboard slope steeper than shown in the model would have on the results;

c. Since the project is deemed a substantial Bay fill development with significant safety implications, it should be kept in the public record that preparations had been or would be made to maximize access attributes of the project, especially during emergency events including large earthquakes;

d. The pull-out analysis of the piles be checked as verified by the project reviewers. A confirmation of this independent review and verification shall be provided in writing to BCDC for inspection and shall be kept in the public record;

e. Corrections of errors in the measuring units as shown in the pile section figures, bathymetry and slopes differences from models be made; and

f. In compliance with SF Bay Plan regarding safety of fills for major projects under the auspices of BCDC, the applicant is encouraged to develop a plan for installation and maintenance of strong-motion instrumentation at the WETA SF terminal in conjunction with the California Strong Motion Instrumentation Program.

Professor Moehle seconded the motion. After discussion Chair Borcherdt Indicated that the motion was approved by unanimous vote of the ECRB.

The business of the meeting took a brief recess.

4. **3rd Review of the Tesoro-Avon Marine Terminal Project (BCDC Permit No. 2014.006.00).** Chair Borcherdt reminded the Board and the audience that this project had returned to the ECRB for review of a very particular issue regarding the displacement analysis of its proposed engineering criteria. The Commission had issued Permit NO. 2014.006.00 on July 16, 2015 to perform upgrades of the Avon terminal in order to comply with the Marine Oil Terminal Engineering Maintenance Standards (MOTEMS) with the condition that the permittee resolve engineering criteria issues regarding the anchoring system of the pipeline with respect to the site ground motions.

Mr. Tagalog, the project engineer, the first applicant's speaker, outlined the content of this presentation consisting of four sections: introduction, recap of the last ECRB August 11, 2015 meeting that provided guidance on resolving the issues, responses to the Board's comments and questions. He presented his team with consultants from Anvil, Langan/Treadwell&Rollo and COWI. He also introduced members of the Tesoro staff.

The path forward from the August 11, 2015 included 4 items, (1) the use of existing data, (2) the total anchor point relative displacements would be updated to take into account the differential ground displacements, (3) the pipe stress analysis would be performed using the updated total anchor point relative displacement and (4) the team would reconvene with the ECRB with updated analysis prior to March 1, 2016. The responses had been submitted to BCDC on November 12, 2015.

He listed the comments raised by the Board that needed addressing at this meeting. The comments/recommendations had been raised at the first review meeting on June 10, 2014; further guidance towards achievement of the recommendations had been made on the August 11, 2015. The main thrust of the Board's comments were regarding the concerns about the variation of the earthquake ground motions along the length of the pipeway and associated lines due to the differences in soil thickness, seismic velocities at each anchor support of the pipeway and pipeline. Mr. Rodgers would elaborate on the responses to the comments/recommendations.

Such recommendations and corresponding responses included:

a. The request to develop site-specific earth ground motion maximum displacement estimates for the locations of the anchor supports.

b. Using such estimates to infer the maximum differential ground motion expected between the locations of the supports, Mr. Tagalog provided the following responses to the questions:

(1) Differential displacement were the result of temporal effects;

(2) Temporal effects --"time lag" was calculated using the shear wave velocity of the rock and horizontal distance between anchor stations;

(3) The results of DEEPSOIL ground response software was used to model displacement time series for Wharf and Trestle at depth of Pile Fixity at 71 feet below ground surface;

(4) The displacement time histories were off-set by the calculated time lag;

(5) Wharf profile below Anchor Station 1, and Trestle profile for Anchor Stations 2, 3 and 4; and

(6) Design team decision to use 95th percentile differential displacements between 5 and 20 seconds (difference of 0.29 seconds) when combining with maximum relative structural displacements based on sum of the resultant square roots (SRSS) combination. The resultant 95th percentile differential displacement would be 14.7 cm or 5.8 inches. Mr. French tried to clarify this information to say that if you had 100 displacement peaks sampling within the 0.29 seconds, 95 percent of these would be below 5.8 inches and 5 percent of them would be above 5.8 inches. Mr. Rodgers asserted such description. Discussions regarding the modeling of the earthquake wave velocity (horizontally, vertical, multidirectional or through the surface) as represented in the findings ensued. Mr. Rodgers finished his presentation allowing Mr. Bajema to expound on the last Board comments, 3 and 4.

c. Consider these differential ground motion displacements in the evaluation of pipe stresses and the resultant design of the pipeline.

Mr. Tagalog showed a diagram of the estimates of axial pipe displacements between anchor stations at 180 degree out of phase deformation, which showed that largest displacement due to deformation between anchor stations 1 and 2 of a little more than 20 inches with a displacement demand/capacity ratio exceeded by 4 percent (ration = 1.04).

However, he used the SRSS, taken the differential displacement at each anchor station and combining them, analysis for the axial (longitudinal) pipe displacements between anchor stations as recommended by the Board that resulted in a displacement of 16.5 inches and a demand-vs-capacity (D/C) ration of 0.86 of the maximum allowable or with 14 percent overcapacity. Mr. Holmes inquired whether there had been perpendicular (vertical) movement taken into account. Mr. Bajema told the Board that there were also loops that absorbed some of the displacement at each station. Mr. Dornhelm asked whether such maximum differential displacement was sourced from a mechanical piping code. Mr. Bajema confirmed the code. The SRSS did not take the absolute maximum into the piping displacement modeling. Mr. Lin would develop on the last ECRB comment.

Two more comments from the ECRB on its second review of August 2015 included:

d. The confirmation that the common response spectra generated for all anchor stations was appropriate application for Anchor Station No. 1;

Response: Anchor Station 1 was conservatively designed using the pipeline response spectra instead of the wharf spectra.

And final comment:

e. The confirmation that any "soil failure" or permanent shift of soil due to a seismic event had been accounted for, and if not negligible how it would be relevant to the evaluation of anchor displacements;

Response: the soil failure was considered in the seismic analysis and design of Anchor Station 1 by applying design soil lateral spreading loads on Anchor Station 1 piles in combinations with Level 2 design earthquake (L2EQ) on seismic loads and pipeline reactions. Soil lateral spreading loads alone (as a rough estimate of "permanent" shift of soil) produce negligible displacement at the top of Anchor Station 1 (approximately ¼ inches).

Mr. Holmes told the chair he had no further questions. Ms. Michaels requested that the Board take an action response in order to comply with the permit requirements. Professor Moehle put forward a motion to accept the revised displacement analysis as presented. Mr. Holmes seconded the motion. The chair asked the Board for any further discussions. Mr. French requested that the language in the permit be revised to say that the ECRB accepted the engineering criteria rather than the design. Chair Borcherdt entertained the motion for a vote. The motion passed with a unanimous consent.

5. **Adjournment.** There being no further old or new business, the meeting was adjourned at approximately 5:00 p.m.

Respectfully submitted,

RAFAEL MONTES, P.E.
Board Secretary