

OROVILLE COMPREHENSIVE NEEDS ASSESSMENT

Independent Review Board Memorandum

DATE: June 19, 2018

TO: Mr. Sergio Escobar, Project Manager
Oroville Comprehensive Needs Assessment
California Department of Water Resources

FROM: Independent Review Board for
Oroville Comprehensive Needs Assessment

SUBJECT: Memorandum No. 1

On Monday June 18, 2018, the Independent Review Board (IRB) met at the Department of Water Resources (DWR) Oroville Field Division Office at 9:00 am for a safety briefing followed by a tour of key features of the Oroville Project including the underground Edward Hyatt Powerplant, the main dam embankment, the Flood Control Outlet (FCO) Spillway and the Emergency Spillway.

Around 1:00 PM, the IRB returned to the Oroville Field Division Office to meet with representatives from the DWR Division of Engineering (DOE), DWR Division of Operations and Maintenance (DOM), the Federal Energy Regulatory Commission (FERC), and industry consultants working on the Comprehensive Needs Assessment (CNA) to discuss and be briefed on the following:

- The history of the Oroville Project,
- Project orientation and purpose,
- The Project Team, management, and organization,
- The role of the IRB, and
- The strategy for structuring the CNA approach

On Tuesday June 19, 2018 at 8:00 am, the IRB met at the Oroville Field Division Office for presentations made by the DWR and their consultants on the following project tasks:

- Task 1 - Alternatives Evaluation to Restore Spillway Design Capacity to Pass the Probable Maximum Flood
- Task 2 - Operations Needs Assessment to Support Development of Alternative Reservoir Outflow Enhancements
- Task 3 - FCO Enhanced Reliability

- Task 4 - Alternatives Evaluation for Low-level Outlet
- Task 5 - Oroville Dam Embankment Reliability and Improvements
- Task 6 - Instrumentation and Monitoring for the Oroville Dam Complex

Following the presentations, the IRB deliberated and prepared a draft of this report. Comments made on the individual presentations and the IRB's responses to DWR questions for the IRB are included in this report. A reading of the IRB's draft report was made to representatives from DWR DOE, DWR Division of Safety of Dams (DSOD), FERC, DWR DOM, and industry consultants working on the project at 3:00 pm. The meeting was adjourned following the reading of the report. IRB members present were (Elizabeth) Betty Andrews, Lelio Mejia, Bruce Muller and Paul Schweiger. A list of meeting participants for both days is attached.

QUESTIONS FOR THE IRB

- 1. Does the IRB have any recommendations or comments on the background and purpose of the Comprehensive Needs Assessment project?**

Response

The IRB is impressed with the importance of Oroville Dam and the considerable benefits it has provided over the past 50 years; providing enough power for a city the size of San Francisco, drinking water for 25 million residents, irrigation water for 750,000 acres of farmland, repeatedly saving lives and preventing damage through flood control, as well as numerous environmental and recreation benefits.

The IRB understands that in February 2017, the FCO spillway was unexpectedly damaged while making necessary releases. Flows were reduced to inspect the damage, but later resumed to control the rising reservoir. Following three days of monitoring inflows and regulating reservoir releases through the FCO Spillway, the Emergency Spillway passed flows for the first time because the reservoir inflows exceeded forecasted estimates. The releases over the Emergency Spillway resulted in erosion damage that was substantially greater than expected. At the end of the event, both spillways were severely compromised.

During the emergency operations it became evident that the Oroville Dam facilities are not capable of passing large reservoir outflows other than through the FCO Spillway. The River Valve Outlet System (RVOS) and Hyatt Powerplant have maximum outlet capacities that are adequate to make low-level releases under normal operating conditions, but are too small for reservoir regulation in

flood or emergency conditions. With the damage to the FCO Spillway and an inability to pass substantial flows in any other way during the February incident, the need to revisit reservoir release redundancy became apparent. The recent upward revision of the Probable Maximum Flood (PMF) inflow rate provides further impetus to explore opportunities to enhance reservoir release capabilities.

The IRB also understands that there is a need to re-evaluate the reservoir operation plan in relationship to potential reservoir outflow enhancements, the FCO Spillway structural reliability, embankment reliability, and the instrumentation monitoring plan.

Therefore, the purpose of the Comprehensive Needs Assessment (CNA) is to identify measures to restore and improve the safety and reliability of Oroville Dam and its appurtenant structures. The CNA will consist of the six tasks presented to the IRB, as previously noted.

A final report with recommendations for future next steps and future projects will be provided as the CNA project deliverable. The recommendations from the six tasks will be combined and prioritized at the project level. The project is scheduled to conclude by December 31, 2019.

The IRB appreciates the thoughtful tour of the Oroville facility and the expert presentations made by the CNA Project Team to explain the history and benefits of the Oroville Dam, and the purpose and goals of the project. The IRB was impressed with the depth of project knowledge demonstrated by members of the CNA Project Team, some who have been working on important aspects of Oroville Dam for decades.

The IRB considers the background and purpose of the CNA to be well conceived and the CNA to be an appropriate effort to provide assurance of the safety and reliability of a key facility for the management of California's water resources.

2. Does the IRB have any recommendations or comments on the DWR organization or role of the IRB?

Response

The IRB believes the proposed CNA project structure, which calls for the tasks to proceed in parallel while informing the integrated project whole, will serve the Project Management Team and support its delivery of a valuable comprehensive assessment of the safety and reliability needs for Oroville Dam. As a further step in support of a successful outcome, the IRB recommends that the CNA Project

Team develop an explicit plan for execution of project integration, perhaps under a Task 7. As part of this new task, we recommend that interdependencies between the tasks and between Tasks 1-6 and Task 7 (or project integration) be mapped out and reflected in the project schedules for all tasks.

The Project Management Team will oversee and coordinate the work of the task level teams, and interact with FERC, DSOD and the IRB. Each of the Tasks is assigned a Project Manager. Based on the quality of the presentations made by the Project Managers for their respective tasks, the IRB is confident that DWR has a well-qualified team with the right skills and resources to successfully complete the project.

The IRB understands that their role is to provide independent review, comments, and recommendations to DWR on the approach, content, and execution of CNA project tasks, and draft and final reports. We believe DWR selected IRB members with a diversity of technical and professional experience, with varied but complementary backgrounds and education that will work well together. The IRB will prepare for meetings by reviewing staff-provided materials, participate in staff presentations, and prepare verbal and written meeting reports during each meeting.

The IRB appreciates the proactive approach and planning of the CNA Project Team in tentatively scheduling most of the IRB and Community member meetings through the December 2019 completion of the project. The IRB was pleased to see active participation and interest in the project by DWR executives and senior representatives from FERC and DSOD. Active engagement of FERC and DSOD throughout the CNA project development is critical to ensuring a successful regulatory review upon completion of the draft and final CNA reports.

The IRB appreciates the opportunity to contribute to this important project, and work with DWR, their consultants, and FERC at future IRB and Community member meetings to identify measures to restore and improve the safety and reliability of Oroville Dam.

3. Does the IRB have any recommendations or comments on the strategy and structuring of the Comprehensive Needs Assessment approach?

Response:

DWR has presented a project strategy that is founded on a well-established model for conducting water resources planning studies. The IRB commends DWR for undertaking this project in the interest of assuring the safety and reliability of the dam and the safety of the public. The incident at the FCO Spillway in 2017 demonstrated the difficulty of accurately assessing the condition of a facility with sufficient time to address conditions that pose a risk to the dam and the public. The CNA approach creates an opportunity to take a fresh look at important questions and/or issues in a risk-based context at the nation's tallest dam.

Water resources planning studies typically take many years to implement specific actions. When planning includes consideration of dam safety issues, it is imperative that the dam safety issues be addressed in a timely manner. The IRB agrees with the current CNA approach for Task Managers to prioritize and submit recommendations for projects that provide significant interim public safety and risk reduction benefits to DWR Management for early implementation. The IRB also recommends:

1. The CNA Project Team broadly identify potential dam safety issues and concerns and conduct a screening level risk assessment to better understand the magnitude of risk associated with each issue or concern, including issues not specifically addressed in the six CNA Tasks. We note that the Team may already have done this informally, or in part, as evidenced by the intent to implement interim operations guidance, and the replacement of the valves of the RVOS. We recommend that a comprehensive risk assessment be outlined and fully documented for the project. If any of the issues or concerns indicate a need for expedited action, including data collection to reduce uncertainty, the IRB recommends that the CNA Project Team proceed to identify and implement actions necessary to reduce the risk either permanently or temporarily while the planning study proceeds.
2. The credibility of the final CNA report may be highly dependent on the order of completion of key activities. DWR must be careful to ensure that the order of activity scheduling and completion demonstrates integrity in the evaluation of alternatives. The IRB recommends that the CNA Project Team establish evaluation criteria for alternative selection prior to formulating alternatives.

This issue is elaborated more in the IRB's comments and recommendations for Question 4, Task 1 - Alternatives Evaluation to Restore Spillway Design Capacity to Pass the Probable Maximum Flood.

3. The IRB agrees with the proposed planning study steps of identifying problems, inventorying current and forecasting future conditions, and formulating, evaluating, and comparing alternative solutions to arrive at a selected solution. The planning process presented, however, has significant focus on identifying "problems". It is equally important (perhaps more important) to identify which aspects of the systems are performing well. The IRB recommends that in the initial phase of each task, the CNA Project Team explicitly state an objective of identifying what is working well to ensure that proposed alternatives do not unintentionally harm operations that are working well.
4. The plan evaluation activity of the CNA project tasks will consider the risk reduction attributable to the alternatives formulated for each task. In the evaluation of risk, consequences will be defined broadly to include public safety, employee safety, and other consequence categories. The IRB endorses the use of a risk framework for the evaluation of alternatives and recommends that the CNA Project Team include gain or loss of project benefits amongst the consequence categories to be considered in evaluating risk reduction.
5. In addition to the quantitative and qualitative risk-informed decision-making approaches currently outlined for evaluating problems and alternatives, the IRB recommends that the CNA Project Team also evaluate and document existing components and alternatives with respect to their robustness, redundancy, reliability, and resiliency, as is the current practice of the US Army Corps of Engineers (USACE) for evaluating, planning, and designing dam modifications. For convenience, abbreviated definitions from *USACE ER 1110-2-1156, Safety of Dams – Policy and Procedure* for these terms are provided below.

Robustness: Robustness is the ability of the component to continue to operate correctly across a wide range of operational conditions, with minimal damage, alteration, or loss of functionality, and to fail gracefully outside of that range.

Redundancy: Duplication of critical components of a system with the intention of increasing reliability of the system, usually in the case of a backup or fail-safe.

Reliability: Reliability is defined as the likelihood of successful performance. Mathematically, Reliability = 1 - Probability of unsatisfactory operation.

Resiliency: The ability to avoid, minimize, withstand, and recover from the effects of adversity, whether natural or manmade, under all circumstances of use.

The decision to provide a second or duplicate guard valve for the RVOS facility is an excellent example of modifying the facility to provide redundancy for a critical project feature.

6. The IRB recommends that the CNA Project Team consider adopting a “value planning” approach to the development of alternatives. Value planning uses the well-established process of value engineering to improve alternative formulation at the front end of a study/design to identify and incorporate good ideas earlier in the process. It is performed before a preferred alternative has been selected and usually concentrates on identifying project objectives and developing functional components and general approaches to meet project objectives. The well-documented process and tools of value engineering would be highly recommended for the phases of the identified tasks where objectives and alternatives are being formulated for consideration. Value planning was a critical element in the successful formulation of the Joint Federal Project at Folsom Dam, where two federally authorized projects (dam safety and flood control) with a combined cost of \$2.3 billion were integrated into a single project with an estimated cost of \$1.3 billion. A good description of the value planning process can be found at the following website:
<http://www.rsri.net/vp-approach.html>.
7. The IRB recommends that the CNA Project Team adopt the principle of “begin with the end in mind” which can be implemented by outlining the final reports as soon as possible. Beginning to define the content of the deliverables (initially an outline) will benefit the project by identifying many of the subtasks that will be necessary to complete the deliverables and will highlight needs for coordination throughout the team. Progressively expanding the content of the documents would provide a tool for

communication among team members, task leads, and with the project manager. It will also provide a visual indication of both progress and remaining needs for completing the project.

4. Does the IRB have any recommendations or comments for Tasks 1–6?

Response:

Given the broad scope of the CNA project and the urgency with which the project management plans are being developed, the CNA Project Team has done an exemplary job of defining the work to be performed. Likewise, there are many areas where the teams are still bringing various parts into alignment. Understanding that the Project Management Plans are still a work in progress, the IRB makes the following recommendations:

Comments and recommendations generally applicable to two or more tasks follow.

- 1) The IRB recommends that an effort be undertaken to define a common understanding of the terminology to be used across all tasks. Having common descriptors documented will facilitate more effective communication and reduce the possibility of misunderstandings.
- 2) The IRB recommends that quality management be viewed more holistically than just quality control and quality assurance. Quality products begin with assuring that the staff performing the work have the necessary training and resources (time and money) to properly carry out the work assigned.
- 3) As discussed during the IRB meeting, the reliability of mechanical, electrical and control systems is critical to the safety and reliable operation of the Oroville Dam facilities. The IRB understands that, in the development of Tasks 3 and 4, the CNA Project Team intends to evaluate the reliability of those systems that are needed for reliable operation of the FCO and the RVOS. The IRB recommends that the CNA Project Team consider a holistic approach to the evaluation of all mechanical, electrical, and control systems required for the safe operation of Oroville Dam, including those associated with operation of the Hyatt Powerplant.
- 4) The IRB understands that operation of the switchyard and the power transmission lines that link the Hyatt Powerplant to the state electrical grid are critical to the operation of the powerplant and its reliability in providing low-level outlet releases for the reservoir. Thus, the IRB recommends that the CNA Project Team consider evaluating plans for

providing redundancy in external systems that deliver power to the grid, as part of its evaluation of the low-level outlet facilities.

- 5) The IRB recommends that any risk assessment, whether at the task or project level, include an explicit statement of assumptions that form the contextual basis of that assessment. By explicitly acknowledging and justifying these assumptions, the CNA Project Team will provide the public with a more complete picture of what considerations were made related to factors that may be of potential concern.

Comments and recommendations related to specific tasks follow.

Task 1 - Alternatives Evaluation to Restore Spillway Design Capacity to

Pass the Probable Maximum Flood: The IRB recommends that the title of Task 1 be revised to: *“Alternatives Evaluation to Ensure Spillway Integrity to Safely Pass the PMF”*. As stated, a pre-determined conclusion is being made that the current spillway configuration is unable to adequately pass the PMF, and may not fully consider the substantial structural improvements that have recently been made to the spillway system.

As previously recommended, before the CNA Project Team assesses the comprehensive needs of the existing spillway system, the criteria that will be used to evaluate the spillway system needs to be clearly established. In particular, it is common practice for auxiliary spillways to be designed to allow limited damage during passage of the inflow design flood, provided it does not jeopardize the structural integrity of the dam or the function of the spillway. For example, the Natural Resources Conservation Service (NRCS) criteria for auxiliary spillways states: *“Earth and vegetated auxiliary spillways are designed on the basis that some erosion or scour will occur during passage of infrequent storms, but the spillway will not breach during passage of the freeboard storm” [NRCS TR-60]*.

If the evaluation criteria for this Task allows some damage to the spillway, one outcome may be that the existing spillway system can safely pass the PMF without breaching. The residual risks associated with damage to the spillway, such as excessive overburden material washing into the Feather River and related environmental consequences, however, may be unacceptable and need to be

mitigated. This is an area where the application of value planning can be very important and beneficial to the project.

The IRB recommends that the CNA Project Team question previous assumptions regarding downstream consequence thresholds and take advantage of the new incremental dam breach hydraulic analyses to develop accurate consequence information. This information may show that the downstream consequences are different than previously assumed, or have multiple thresholds that could impact the objectives or constraints for this and other tasks. The need for this information will be especially important for modifications that involve human intervention or operation, such as increasing the outlet works capacity or constructing an alternate emergency spillway configuration with gates.

Task 2 - Operations Needs Assessment to Support Development of

Alternative Reservoir Outflow Enhancements: The IRB appreciates the recognition that this task will require considerable coordination with Tasks 1, 3, and 4. While there are clearly drivers in place for updating the Water Control Manual, this task should begin with an understanding of those aspects of water management that are working well. DWR has a long history of working collaboratively with other water management agencies in the Sacramento River basin to manage water resources through both drought and floods. It is important to recognize what is working well to avoid unintentionally having adverse impacts on operations. Proposed modifications should also be no more complex than necessary as a means for maximizing reliability.

The issue of climate change has particular resonance with respect to the Operations Needs Assessment. As part of this Task or as a project-wide component, the IRB recommends the CNA Project Team either address how climate change has been accounted for in developing the operational plan for the facility, including potential changes in hydrograph shape, size, and seasonality, or explain why it is not a concern.

Task 3 - FCO Enhanced Reliability: The IRB endorses the proposed Semi-Quantitative Risk Assessment approach for this task to screen needs and alternatives, and agrees that the CNA Project Team has enough understanding of the project vulnerabilities and consequences to complete a meaningful assessment.

The current condition needs assessment for the FCO appears to focus exclusively on the structural integrity of the FCO gated control structure for earthquake and PMF loads. If not already completed, the IRB recommends that the assessment be expanded to include the hydraulic performance of the FCO Spillway as it relates to the operation of the FCO gates. For example, the unbalanced operation of the gates can create problematic flow conditions in the spillway chute that need to be avoided. The CNA Project Team may want to take advantage of the existing physical model of the FCO Spillway at the Utah State University Water Resources Laboratory to comprehensively assess FCO gate operating scenarios. The unbalanced operation of the gates may also have structural consequences that need to be considered.

Task 4 - Alternatives Evaluation for Low-level Outlet: DWR has previously studied the possibility of adding additional low-level outlet capacity to address reservoir evacuation capability. While the previous study concluded that the risk of constructing new capacity outweighed the dam safety risk reduction that could be gained, the 2017 spillway incident has caused DWR to reconsider the decision not to provide additional low-level release capacity. While the complexities of adding new low-level release capacity to the highest dam in the country would be extraordinarily challenging, the IRB believes the assessment of such alternatives is appropriate.

The IRB recommends that the information describing the reservoir evacuation deficiency be added to the scope of work for Task 4 to provide context.

The IRB recommends that the project summarize and document the analysis and/or assumptions relative to sedimentation in the reservoir at the dam.

The IRB recommends that the project also include an assessment of the benefits that could be derived from making the reservoir volume between elevations 350 feet and 640 feet available for active management.

Task 5 - Oroville Dam Embankment Reliability and Improvements: The IRB understands that the evaluation of embankment reliability and improvements will address recommendations of the Ninth FERC Part 12D Board of Consultants and consider potential failure modes (PFMs) associated with the Oroville Dam embankment, its interface with the FCO structure, and the Parish Camp and Bidwell Bar Canyon Saddle Dams. The IRB endorses the scope of the task as defined by the CNA Project Team and appreciates the Team's efforts to assess uncertainty in the subtasks that are planned to evaluate the reliability of the dam embankments and potential improvements. The IRB believes that the task also offers a good opportunity to define which aspects of the evaluations would benefit from collecting additional data on the embankment and material characteristics that may significantly reduce uncertainty in the evaluations. Thus, the IRB recommends that Task 5 include developing recommendations, as appropriate, for future collection of additional data on the embankment characteristics that would significantly reduce uncertainty for the evaluation of the dam embankment reliability.

Task 6 - Instrumentation and Monitoring for the Oroville Dam Complex: The scope of Task 6 is to evaluate dam safety instrumentation and monitoring needs for the Oroville Dam embankment, the saddle dam embankments, the FCO structure, the Emergency Spillway, and the Hyatt Powerplant and appurtenances. The IRB endorses the scope of Task 6 and the CNA Project Team's intent to align the evaluations considering the PFMs for the Oroville Dam facilities and to consider emerging technologies. The IRB endorses the Team's intent to review and gain a thorough understanding of the behavior of the dam facilities since construction, including behavior disclosed by instrumentation installed during construction, which is no longer operable.

5. Does the IRB have any other recommendations or comments?

Response:

The scope of a “comprehensive” project to assess the needs at Oroville Dam could be interpreted in many ways without appropriate definition of scope and context. DWR has presented a scope of the CNA project that clearly identifies a desire to understand potential dam safety issues and make recommendations to address those issues. Simultaneously, DWR has demonstrated a commitment to conducting the studies in a manner that is open and inclusive of stakeholders. The inclusion of an IRB in the process demonstrates a desire to seek independent input from individuals outside the DWR organization.

The IRB notes that the presentation provided on the background of the CNA did not describe the process used to identify the six component tasks of the project. The IRB recommends that future presentations to the public and the final project report provide a description of the rationale for the tasks included in the project. The description should be sufficiently detailed as to demonstrate that the process identified the appropriate tasks and that no necessary tasks have been overlooked.

The IRB believes the dam safety issues being addressed are not unique to Oroville Dam, and that the CNA will be of significant interest to dam owners worldwide. It is likely that the CNA Project and alternatives selected will become a model for evaluating and improving other dam projects.

IRB RECOMMENDATIONS SUMMARY

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| M1-1 | The IRB recommends that the CNA Project Team develop a plan for execution of project integration, perhaps under a Task 7. As part of this new task, interdependencies between the tasks and between Tasks 1-6 and Task 7 (or project integration) should be mapped out and reflected in the project schedules for all tasks. |
| M1-2 | The IRB recommends the CNA Project Team broadly identify potential dam safety issues and concerns, including issues not specifically addressed in the six CNA Tasks, and conduct a screening level risk assessment to better understand the magnitude of risk associated with each issue or concern. If any of the issues or concerns indicate a need for expedited action, proceed to identify |


and implement actions necessary to reduce the risk either permanently or temporarily while the planning study proceeds.

- M1-3 The IRB recommends the CNA Project Team establish evaluation criteria for alternative selection prior to formulating alternatives.
- M1-4 The IRB recommends that in the initial phase of each task, the CNA Project Team explicitly state an objective of identifying what is working well to ensure that proposed alternatives do not harm operations that are working well.
- M1-5 The IRB recommends that the CNA Project Team include gain or loss of project benefits amongst the consequence categories to be considered in evaluating risk reduction.
- M1-6 The IRB recommends that the CNA Project Team evaluate and document existing components and alternatives with respect to their robustness, redundancy, reliability, and resiliency.
- M1-7 The IRB recommends that the CNA Project Team consider adopting a “value planning” approach to the development of alternatives.
- M1-8 The IRB recommends that the CNA Project Team adopt the principle of “begin with the end in mind” which can be implemented by outlining the final reports as soon as possible.
- M1-9 The IRB recommends that an effort be undertaken to define a common understanding of the terminology to be used across all tasks.
- M1-10 The IRB recommends that quality management be viewed more holistically than just quality control and quality assurance.
- M1-11 The IRB recommends that the CNA Project Team consider a holistic approach to the evaluation of all mechanical, electrical, and control systems required for the safe operation of Oroville Dam, including those associated with operation of the Hyatt Powerplant.
- M1-12 The IRB recommends that the CNA Project Team consider evaluating plans for providing redundancy in external systems that

- deliver power to the grid, as part of its evaluation of the low-level outlet facilities.
- M1-13 The IRB recommends that any risk assessment, whether at the task or project level, include an explicit statement of assumptions that form the contextual basis of that assessment.
- M1-14 The IRB recommends that the title of Task 1 be revised to: “Alternatives Evaluation to Ensure Spillway Integrity to Safely Pass the PMF”.
- M1-15 The IRB recommends that the CNA Project Team question previous assumptions regarding downstream consequence thresholds and take advantage of the new incremental dam breach hydraulic analyses to develop accurate consequence information.
- M1-16 the IRB recommends the CNA Project Team either address how climate change has been accounted for in developing the operational plan for the facility, including potential changes in hydrograph shape, size, and seasonality, or explain why it is not a concern.
- M1-17 If not already completed, the IRB recommends that the Task 3 be expanded to include the hydraulic performance of the FCO Spillway as it relates to the operation of the FCO gates.
- M1-18 The IRB recommends that the information describing the reservoir evacuation deficiency be added to the scope of work for task 4 to provide context.
- M1-19 The IRB recommends that the project summarize and document the analysis and/or assumptions relative to sedimentation in the reservoir at the dam.
- M1-20 The IRB recommends that the project also include an assessment of the benefits that could be derived from making the reservoir volume between elevations 350 feet and 640 feet available for active management.

- M1-21 The IRB recommends that Task 5 include developing recommendations, as appropriate, for future collection of additional data on the embankment characteristics that would significantly reduce uncertainty for the evaluation of the dam embankment reliability.
- M1-22 The IRB recommends that future presentations to the public and the final project report provide a description of the rationale for the tasks included in the project.

Respectfully submitted,

Betty Andrews Lelio Mejia Bruce Muller Paul Schweiger