United States Department of the Interior
California Department of Toxic Substances Control

ELECTRONIC SUBMISSION

October 13, 2017

Mr. Edgar Castillo
Topock Project Manager
Cocopah Indian Tribe

Ms. Jill McCormick, M.A.
Cultural Resources Manager
Cocopah Indian Tribe

Ms. Nora McDowell
Project Manager Topock Remediation
Fort Mojave Indian Tribe

Ms. Dawn Hubbs
Cultural Resources Director
Hualapai THPO
Hualapai Tribe

Subject: Response to Tribal Inquiries Regarding the Final Design Directives Specific to Groundwater Modeling Updates on Topock Groundwater Remediation Project

Dear Tribal Representatives,

The Department of Toxic Substances Control (DTSC) and the Department of the Interior (DOI) (the Agencies) received a joint letter from the Cocopah Indian Tribe, Fort Mojave Indian Tribe, and Hualapai Indian Tribe dated January 27, 2017 and from the Fort Mojave Indian Tribe date April 24, 2017, submitting comments regarding the January 2017 Arcadis Addendum to the Development of Groundwater Flow and Solute Transport Models. The letters are similar enough that we have elected to respond to those comments in one response letter.

Comment 1: *In offering comments at this time, we point out that this letter and its contents are NOT a review of the January 2017 Arcadis Addendum to the Development of Groundwater Flow*

and Solute Transport Models. However, we believe it is important to comment on some remaining issues that are still of concern.

Response: The Agencies have prepared responses to the comments received. These responses represent our current positions on the various topics.

Comment 2: *First, outside of the immediate plume area, we believe that both conceptual and numerical model uncertainty still remains high, especially beneath the Colorado River and immediately east of the river, in Arizona. Though Arcadis updated and re-calibrated the model, we believe the calibration to localized (plume area) steady-state groundwater levels produces a highly non-unique solution. As such, many alternate combinations of model input parameter values and model boundary conditions can produce equally well-calibrated results. This non-uniqueness produces high uncertainty in model predictions, particularly outside of the immediate plume area.*

Comment 2a (Fort Mojave Comment 1): *Additional calibration points added to the model as part of the addendum development, outside of the immediate plume area and in AZ, improve the overall reliability and usefulness of the model. This is especially relevant in the expanded area of the remedial infrastructure across the river within AZ and will be helpful to evaluate pumping influences on the AZ side, in order to substantiate the viability of a remedy injection water source. It is critical to the effective and timely progress of the remedy that the source of injection water is not interrupted or lessened. A timely and effective remediation is of key importance to the Fort Mojave Tribe.*

Response: The Agencies agree with the observation that both the conceptual and numerical model uncertainty is high beneath the Colorado River and east of the river. In fact, the Agencies believe that the conceptual and numerical model uncertainty are high all the way to the model boundaries. Please keep in mind that the steady-state model was not recalibrated, but simply checked to determine whether the model remained adequately calibrated once the parameter and boundary conditions were modified. We also agree that model predictions within these areas of the model domain will yield both non-unique and highly uncertain predictions.

An important distinction in our position, however, is that although the calibration to localized (plume area) steady-state groundwater levels produces a highly non-unique solution east of the river, the data within the plume area is of sufficient quantity and quality to provide an adequate calibration upon which to base the remedial design and meet the Remedial Action Objectives (RAOs). As described in the Remedial Design document, the RAO's that the modeling was designed to support are:

1. Prevent ingestion of groundwater as a potable water source having Cr(VI) in excess of the regional background concentration of 32 micrograms per liter (ug/L).

2. Prevent or minimize migration of total chromium (Cr[T]) and Cr(VI) in groundwater to ensure concentrations in surface water do not exceed water quality standards that support the designated beneficial uses of the Colorado River (11 ug/L Cr[VI]).

3. Reduce the mass of Cr(T) and Cr(VI) in groundwater at the site to achieve compliance with the applicable or relevant and appropriate requirements (ARARs) in groundwater. This RAO will be achieved through the cleanup goal of the regional background concentration of 32 ug/L of Cr(VI).

4. Ensure that the geographic location of the target remediation area does not permanently expand following completion of the remedial action.

The intent of the RAOs are to set the priorities in order to focus project resources. As indicated in the Agencies October 4, 2016 Modeling Directives (p. 2), Dr. Prucha noted that "an updated evaluation for siting MW-X/MW-Y is still missing." He did indicate, however, that his "major concerns would not significantly impact the remedial design and operation since the model predictions within the remedial design area are based on substantially more data." As further explained in the Agencies Directive, "the overall purpose of the groundwater model continues to be the evaluation of the subsurface flow conditions in support of remedy design and operation." Furthermore, the Agencies also believe that to reduce the model predictive uncertainties and non-uniqueness of the solution, additional water level elevation data would be needed from the area immediately east of the Colorado River in Arizona. Please note that any additional project related Arizona data, including water level data, would become available for incorporation into a model update. As indicated in Section 3.1.5 of the 100% Design document, the groundwater flow and solute transport model will be updated annually during remedy well installation and testing.

Comment 3: *Despite the high predictive uncertainties inherent in the model, we continue to believe that the model can and should be used to address several remaining concerns that the Tribes have raised for several years. In particular, we feel strongly that the model needs to be sufficiently accurate and robust to be able to address various conceivable scenarios and contingencies as have been expressed during the course of our technical discussions.*

Response: Comment 1 states that "…*outside of the immediate plume area, we believe that both conceptual and numerical model uncertainty still remains high…"* presumably, the reason that the reviewers believe that the conceptual and numerical model uncertainty is lower *inside* of the plume area is because there is substantially more data available to calibrate the model—thereby leading to a more unique solution. It is therefore, unclear to the Agencies how the high conceptual and numerical model uncertainties that exist east of the river can be reduced without collecting additional data. It is our position that uncertainty and sensitivity analysis alone are insufficient to build a robust model with the accuracy required to address the scenarios and contingencies outlined by the reviewers in later comments.

Comment 4 - *Potential for Arizona Groundwater Contamination. Given high model uncertainty outside the existing plume area, what is the potential for contamination of Arizona groundwater? What is the maximum possible magnitude and extent of contamination in Arizona? This is a sensitive cultural area for one or more Tribes and has been determined eligible as a Traditional Cultural Property (TCP) by BLM and Arizona SHPO, which are in the process of setting a boundary that includes this area (MW-X and MW-Y). We believe the updated model can easily be used to evaluate the potential for Arizona groundwater*

contamination.

Response: This comment emphasizes that the model has a high predictive uncertainty outside of the existing plume area, but also asserts that the updated model can easily be used to evaluate the potential for Arizona groundwater contamination. It is difficult for the Agencies to reconcile these contradictory claims in order to reach the same conclusion. It is the Agencies position that there is currently too much inherent uncertainty in the model predictions east of the river to draw reliable conclusions regarding contaminant transport over that same area.

Comment 5: *What are Agency plans if contamination occurs? Should Arizona groundwater become contaminated, it would be clear that the California remediation wells (i.e., riverbank extraction wells) will have failed to contain the plume under currently proposed operations, a key Remedial Action Objective (RAO).*

Response: Volume 3 of the Operations and Maintenance Manual (OMM) describes detailed contingency plans in the event unacceptable migration of chromium and/or by products (see Table 2.1-1) are encountered. Operational changes would be made to adjust extraction and/or injection rates as well as substrate dosing to rectify the issue and bring the remedial system back to expected operational parameters. In the unlikely event that these adjustments are ineffective, additional provisional or contingent extraction wells could also be installed as identified in the remedial design.

Comment 6: *We believe the model can also be used to evaluate mitigation of impacted Arizona groundwater, and to demonstrate the infeasibility of attempting to*

- ***6a)*** *draw back contaminated groundwater from Arizona to California, using for example, the existing California riverbank extraction wells.*

Response: The Agencies agree that the model can be (and has been) used to evaluate the remedial effectiveness on contaminated groundwater that may migrate east beyond the existing riverbank extraction wells. Current modeling runs indicate that it is feasible to contain the plume and/or byproducts via hydraulic capture to the east of the riverbank extraction wells. Monitoring wells will be in place to confirm capture and model predictions. To enhance this type of capture zone analysis, however, we believe that additional groundwater elevation data is required east of the riverbank extraction wells. Data will be collected as part of the remedy from the minimal number of wells planned in Arizona and can be used to refine the model.

- ***6b)*** *If Arizona groundwater becomes contaminated, we are concerned that another investigation and characterization, followed by remediation would then be required, resulting in further negative impacts to the TCP.*

Response: The Agencies understand this concern. In the event that the system is not working as intended, mitigation plans have been developed to rectify the unacceptable migration of chromium and/or by products. See Vol. 3 of the Remedial Design OMM. Also, drastic adverse impacts to water in Arizona is not anticipated since a robust groundwater monitoring program

will continue to be implemented throughout active remedy operations and even years after the active remedy is shut down.

- ***6c)*** *How many more wells than currently planned in the 100% Basis of Design Report could be required in the worst case in both Arizona and California?*

Response: The Agencies agree with previous Tribal comments regarding the high uncertainty associated with the model predictions east of the Colorado River. The Agencies also believe that without the model being calibrated to additional data collected east of the Colorado River, model predictions requiring the specificity desired by the comment will be unreliable and worst-case estimates would not be meaningful.

- ***6d)*** *What would be the anticipated locations of these wells? We are very concerned that, once constructed and operational, project-momentum will override the long-standing protocol not to place wells in our culturally-sensitive areas.*

- ***6d(2) (Fort Mojave Comment 4):*** *The Fort Mojave Tribe continues to have a strong preference for having NO additional construction or well installations as the remediation progresses. The impact of the remedial construction as currently designed -the November 2015 100% Basis of Design Report and the 2015 Errata, is huge, and any further elements (wells or other infrastructure -and especially the up to 25% increase in remedy infrastructure identified as part of the Draft SEIR Future Activities Allowance) added to this project are unacceptable. Proper use of the digital model, when augmented with the additional data which will be collected during the installation and initial operation of the remedy should provide a key, valuable tool to understanding the natural system, and ensuring efficient implementation of a remedial design that already has significant flexibility and expansion elements built in.*

Response: Based on our current understanding of where additional data should be collected in order to better understand and monitor the system, X and Y locations have been proposed. The Agencies believe that we have demonstrated, and are committed to continue considering culturally-sensitive areas as an integral component of decision making. In fact, the Agencies believe that it is very important to balance the model predictive capability against data requirements. As aptly pointed out by Dr. Prucha, the reason model predictions within the plume area are adequate to base a remedial design is because there is substantially more data in the plume area. In our opinion, it would take significantly more data east of the river to adequately calibrate the model to reliably address many of the concerns raised in the comments that follow. Nevertheless, the Agencies are not pursuing additional wells out of respect and concerns raised by the Tribes.

- ***6e)*** *<u>Maximum Project Duration</u>. If contamination occurs in Arizona, PG&E will likely reduce Arizona freshwater pumping and reduce IRL freshwater injection, thereby reducing the enhanced "flushing" gradient, intended to reduce overall treatment time. As a result, remedy duration would likely increase considerably beyond 30 years. Under these circumstances, how long would the system need to be operated to achieve remedy goals? The duration of remediation system operation has not been adequately considered, but should be using the*

updated model. Scenarios ranging from minimal reductions in Arizona pumping and IRL injection to the complete elimination of such should be considered.

Response: Prior to implementing mitigation measures, the cause for the failure would first have to be identified. It could be that no adjustments to pumping/injection rates are required and only refinements to the carbon dosing are necessary. The Agencies recognize that, ignoring hydrogeological and other uncertainties, there are conditions that, if left unmitigated, could lead to longer than estimated remediation times. After one or two years of system operation and monitoring there should be additional information to more reliably predict the fate and transport of the contaminants in order to more reliably estimate remediation times and undertake mitigation measures, if necessary. To best ensure contamination does not arrive in Arizona, the groundwater monitoring system will be assessed to ensure potential concerns are identified and appropriate actions are taken in a timely manner.

- ***6f)*** *Maximum Number and Location of Future Wells. Given the high uncertainty in model predictions:*

Response: Our position is that the model predictions are not sufficiently reliable to identify the maximum number or locations of future wells. While we believe the model could be improved in Arizona by installing many more wells, it is counter to Tribal concerns regarding cultural sensitivity of the area.

In light of these concerns, the Tribes recommend that the following actions be taken as the Topock Groundwater Remediation Project proceeds:

- ***Comment 7:*** *<u>Uncertainty Analysis</u>. We continue to believe an uncertainty analysis should be performed now to address our immediate concerns, particularly an analysis that evaluates conceptual parameter and boundary condition uncertainty in model predictions. At the June 2017 TWG meeting, the Tribes referenced the Santa Susana – Ventura County (Boeing, NASA, DoE) project in California, a similar high profile environmental site with DTSC oversight that is conducting such a predictive uncertainty analyses. Effects of major changes to model boundary conditions and hydraulic properties on predictions (and calibration), should be evaluated as described in ASTM D 5611 – 94 (2016).*

Response: It is unclear to the Agencies how an uncertainty analysis could be effective in addressing the Tribes concerns regarding very specific modeling objectives (e.g., number and location of wells, longest possible remediation times). With respect to the uncertainty analysis at Santa Susana, the analyses were designed to test competing hypotheses as to how a hydrologic feature or assignment of parameters would impact model forecasts. For example, at Santa Susana there were questions regarding assumptions pertaining to whether faults behaved as conduits or flow barriers and whether the fresh groundwater flow system was shallow or deep. Alternate conceptual models with a similar level of fit to the calibration of the base case model were considered plausible and included in the uncertainty analysis. These alternative conceptualizations were thought to result in important differences in Darcy fluxes and/or groundwater flow directions. It is also essential to recognize that the Santa Susana uncertainty

analysis was performed after a robust data set was amassed before testing the alternative conceptual models.

At Topock, the Agencies are unaware of alternative conceptual models of the conceptual parameter or boundary conditions that would potentially result in important differences in Darcy fluxes and/or groundwater flow directions from the existing calibrated model over those areas of significance. The Agencies recognize that the nature of the model boundaries and parameter distributions east of the river are uncertain, and that the few existing calibration points over that area could be equally matched with any number of combinations of hydraulic gradients, transmissivities and fluxes. In our opinion, however, these are not the types of alternative conceptualizations that can fundamentally alter our understanding of system behavior. Furthermore, with so few data calibration points the optimization solution used to test the alternative conceptual models would become intractable or open ended, which is one of the reasons why the conceptual model testing at Santa Susana will be performed after the RI. It is our position that uncertainty analysis performed without adequate calibration data leads to too many possible outcomes and will not adequately narrow down feasible alternative conceptual models. However, if for some reason the remedial system does not perform as expected, and the deficiency could be explained by alternative conceptualizations, the Agencies are open to further investigating the implications of conceptual model uncertainty.

Comment 8: *Model Calibration/Demonstrate Unique Solution. Though the model has been updated and now incorporates more appropriate boundary conditions (i.e., river cells, ET rates, ET locations, Sacramento or Warm Springs Wash inputs, etc.), we strongly feel that a unique calibration solution needs to be clearly demonstrated. In particular, the model needs to be calibrated to more regional data outside the plume area. Standard modeling protocol requires that modelers show how the final set of parameters and boundary conditions produce the best calibration over the entire model area. The recently observed lack of change in mean local calibration performance (mean residuals) only confirms that the solution is non-unique, and/or the riverbed conductance, which controls flux between river and aquifer, is set far too high, effectively isolating the remediation system performance from the rest of the model domain.*

Comment 8a (Fort Mojave Comment 2): *The project schedule now permits PG&E and Arcadis to further investigate the numerous regional calibration points that were rejected as part of the Addendum development. Possibly, some of these points could be used for future calibration, for example, by filling in data gaps on pumping rates, by verifying elevations, etc. Also, calibration statistics pertaining to the regional calibration alone have not been, but should be developed going forward.*

Comment 8b (Fort Mojave Comment 5): *The Fort Mojave Tribe encourages the Agencies, PG&E and the Arcadis modelers to recognize that the model and the project, along with its impacts, extend well beyond the site vicinity. Such recognition does not appear to presently exist, based on statements in the last paragraph of Addendum Section 2.2 (Directive 2).*

Response: The Agencies recognize that the Tribes believe that the area known as Topock, and specifically the immediate Project area, is part of a broader cultural landscape. It is the Agencies

position that a truly unique solution will never be demonstrated by this model largely due to the complex physical and chemical processes existing over large areas. The quality of the regional calibration data set outside of the plume area is very poor. The wells where regional water-level data is available were not constructed as monitoring wells. For most of these wells, the depths, screened intervals, top of casing elevations and pumping schedules are not well known. It is our opinion, that the current and any future calibration to these data would provide little more than a general understanding of flow directions. Calibration to water-level data alone without independently measured stresses (e.g., pumping) placed on the system will never yield a unique calibration. Only very general information on regional pumping is available. It is also the Agencies opinion that standard modeling protocol was followed and gave greater weight to the model calibration over the region of most interest (i.e., plume area). The Agencies believe that the model solution is non-unique, and that additional calibration data will become available at system start up and subsequent monitoring. We also understand that the riverbed conductance is one of the most important parameters with respect to how the remedial system will perform. The transient calibration was designed to narrow down the range of the riverbed conductance although it is still uncertain. It is difficult for us to conclude, however, that the conductance is set far too high based on the results of the recent changes to the boundary conditions, river cells etc. During model calibration, the optimizer (i.e., PEST) will attempt to minimize the errors over where there is measured data. Since the data is concentrated within the plume and west of the river, the model should always provide a good match in that area and not change very much from simulation to simulation. Therefore, it is not surprising that changes to the boundaries and stream/ET nodes east of river had little effect on the overall calibration. Once more data is available during system startup and from the eastern side of the river it will be easier to assess how well river leakance is being simulated. Finally, if the model was found to be overpredicting the leakance from the river it is also underpredicting the capture zone and the actual remedial system would perform better than predicted by the model.

Comment 9: *Model Calibration/Historical Plume Development. We strongly feel that the recently updated and re-calibrated model should have its performance and credibility demonstrated by reproducing historical plume development, exactly as done previously for earlier model versions by CH2M Hill. This would help confirm that the solution is indeed unique within the remediation area. If it cannot reproduce the historical plume like before, we would find it difficult to believe future fate and transport predictions during remedy operation. We also believe that calibration should include fate / transport calibration. Nearly 10 years of system performance data for IM-3 and total mass removal and concentration trends are available.*

Response: The Agencies do not believe that calibration to the historical plume data (circa 1950s through 1990s) would provide a sufficient basis upon which future plume behavior could be reliably predicted. The historical data calibration dataset is sparse and unreliable and the past factors controlling plume movement would be different than current and future conditions. There are so many assumptions that would need to be made to address the uncertainties regarding historical pumping rates, groundwater flow directions, and river stages, that any conclusions would be very subjective.

The IM-3 data was used to assist in the flow model calibration and to estimate effective porosities. The Agencies agree that it would be worthwhile to revisit additional transport calibration to the IM-3 data, however, the Agencies do not believe that additional transport calibration is necessary at this time to support remedial design. As noted in response to Comment 2, the fate and transport model will be recalibrated during the first year of startup and operation of the recovery system. It is the Agencies opinion, that this would also be the best time to perform a more comprehensive transport calibration to IM-3 data since there will be significantly more data available to calibrate both the flow and transport models.

Comment 10: *River-Aquifer Flow. Riverbed conductance is a critical calibration model parameter that we believe strongly governs existing flows between California and Arizona, beneath the river and more so during remedy operation. We are unaware of any field data to support assigning uniform values assigned to this parameter throughout the model, which makes the parameter highly uncertain. Although lower conductance values were assigned in lower velocity areas like Topock Marsh/Bay based on our recommendations, values throughout the model and especially within the River could easily be further reduced. We are concerned that over-specification of conductance values, which the non-unique calibration appears insensitive to, will under-predict future groundwater transport of contaminants from California to Arizona during remedy operation. We believe this requires further evaluation and efforts should be made to base model values on field measurements, for example using shallow piezometers in Colorado River and Topock Marsh areas.*

Response: The Agencies agree with this overall assessment that; the model predictions are very sensitive to river-conductance; river-conductance values are very uncertain and the values need to be further substantiated and/or refined with field measurements of water-level response east of the river during system startup and operation. We do not believe, however, that this is the time to perform additional field investigations to further evaluate this parameter. The calibration to transient conditions should have helped to narrow the range of the conductance. Additional aquifer response information, under greater pumping stresses, will become available once the remedial system is turned on. We also believe that if the remedial system does not perform as expected and a better understanding of riverbed conductance would assist in rectifying the problem, additional investigation may then be warranted.

Comment 11*. Independent Peer Review****.*** *The Agencies should consider conducting an external independent model peer review by a noted modeler with extensive expertise in calibration and uncertainty analyses. The TRC can provide names of experts external to the project who could provide unbiased industry-standard assessment of model calibration and predictions.*

Response: The Agencies position is that the modeling has followed industry standards, and that the independent review provided by TRC and DOI has resulted in a model that can reliably meet the RAO's as intended.

Comment 12*: We understand the interest in expediency to complete modeling and obtain Agency approval of the 100% Basis of Design Report. We do not believe that implementing our recommendations would hold up the approval, but we do request the following:*

- ***Comment 12a***. *Implement our above recommendations now. These actions can be addressed during the interim period and prior to construction and startup.*

Response: The Agencies believe that any additional substantive modeling work should not be conducted until additional information is available from the system startup and operation. Please see responses to individual comments for further clarification.

- ***Comment 12b***. *Continue the modeling sub-group meetings to permit sustained involvement of Tribes and Stakeholders towards addressing our concerns.*

Response: The Agencies are amenable to continuing to address the Tribes and Stakeholders questions and concerns within the context of the modeling that has already been performed. Once additional data become available at system startup and further modeling is performed, the Tribes and Stakeholders will have more opportunities to participate.

- ***Comment 12c****. Provide updated model input files upon request by interested Tribes and Stakeholders. This would permit us to fully understand how the system behaves and how it will be impacted by the remedy operations, rather than relying on overly-simplified graphics and tables that we do not believe adequately convey the complexity of the natural system or the planned remediation system.*

Response: As has been the case in the past, all modeling files created in the future will be made available for review to the Tribes and Stakeholders.

Comment 13. *We greatly appreciate the creation of the modeling sub-committee as a working forum. This forum provided an opportunity for technical interaction among the Tribes, Stakeholders, and the Agencies with PG&E and its consultants. This forum offered the chance to provide and receive feedback and input regarding the ongoing model revision effort in real time and to provide recommendations on how to best proceed with the modeling. This is the type of working relationship the Tribes have been asking for throughout the remedy design process, and we believe this serves as a model for and demonstration of the success that can be realized through such collaborative fora.*

Comment 13a (Fort Mojave 3): *Tribal involvement should be maintained in periodic updates and data additions to the model. Specifically, the Modeling Subgroup should be relied upon during periodic updates to discuss and review new data and potential ways in which the model might be used to maintain remedial progress, maximize the utilization of the infrastructure, and minimize the project duration. As noted in the report:*

> *"During installation and implementation of the remedial system, the additional hydrogeologic and groundwater quality data that will be generated can be utilized to update the groundwater flow and transport models and to further improve their effectiveness as tools for understanding site conditions and optimizing remedy*

performance."

The data generated during the remedy construction, and again following the initial phase of operation of the system, will be critical to refining a more detailed site conceptual model, and updating the digital groundwater model. Using the updated digital model to run predictive scenarios will be important to increase the likelihood that the remedy will continue to operate as effectively as possible, which should also result in keeping the active remediation time, and therefore the total remedy duration, to a minimum.

Response: The Agencies believe that the contributions from the Tribes, Stakeholders and consultants were important in advancing the model to more closely represent the conceptual model, and we are committed to ensuring that all interested parties are able to participate in future model reviews.

If you have any questions, please contact Pamela Innis at (602) 417-9578 or Aaron Yue at (714) 484-5439, at your convenience.

Sincerely,

Pamela S. Innis
DOI Topock Remedial Project Manager

Aaron Yue
Project Manager
Department of Toxic Substances Control

cc: PG&E Topock Consultative Workgroup Members – Via e-mail

PG&E Topock Geo/Hydro Technical Workgroup Members – Via e-mail

Tribal Representatives in PG&E Contact List – Via e-mail

Technical Review Committee – Via e-mail

Mr. Curt Russell
Pacific Gas and Electric Company