Pacific Gas and Electric Company

Kevin M. Sullivan
Director, Chromium Remediation

77 Beale Street, B28P,
San Francisco, CA 94105
(925) 818-9069 (cell)
kmsu@pge.com

September 30, 2015

Via Electronic Mail

California Regional Water Quality Control Board Lahontan Region
2501 Lake Tahoe Blvd.
South Lake Tahoe, CA 96150
Attn: Sue Genera
Executive Assistant and Water Board Clerk
RB6enfproceed@waterboards.ca.gov

Re: Draft Cleanup and Abatement Order No. R6V-2015-DRAFT; WDID No. 6B369107001 Requiring Pacific Gas and Electric Company to Clean Up and Abate Waste Discharges of Total and Hexavalent Chromium to the Groundwaters of the Mojave Hydrologic Unit

PG&E appreciates the opportunity to submit these comments on the Draft CAO and supports a thorough and collaborative process to draft a cleanup and abatement order that facilitates our commitment to remediate groundwater in Hinkley. The release of the Draft CAO is an important step in continuing the significant progress made to date in cleaning up the chromium plume.

The Draft CAO contains several key improvements from the Proposed CAO, including recognition of the importance and value of the USGS background study, changes to the clean-up timeframes, provisions for transparent and accountable remedial system operation, clarified replacement water requirements, and provisions for a performance based and adaptable monitoring program. These changes will provide a better basis for efficient, expeditious, and scientifically and technically supported remediation under the CAO.

As our attached comments address, we have additional recommendations in areas where the advisory team made edits in the Draft CAO and which were discussed at the Public Workshop on September 16, 2015, and comments to clarify our previous comments. This cover letter highlights our recommendations and more detailed analyses along with suggested edits are in the attached comments, where needed.

1) Lower Aquifer Remediation

Some commenters at the Public Workshop asserted that based on the size and mass of the lower aquifer plume, remediation should be completed within a few years. This assertion that the remediation timeframe should be short does not reflect the challenges of remediation in this area. The hexavalent chromium plume that is currently referred to as the lower aquifer plume resides within a complex geological environment at the edge of the blue clay where the upper aquifer and lower aquifer are in hydraulic communication. PG&E will address this portion of the plume as quickly as possible, but in this complex hydrogeologic setting, aggressive remedial activity could inadvertently increase Cr(VI) concentrations in the lower aquifer by drawing higher Cr(VI) concentrations from the upper aquifer into the lower aquifer. Successful remediation of this transitional area at the edge of the blue clay will likely require that the upper aquifer and lower aquifer chromium levels be reduced concurrently, which therefore may lead to similar timeframes for complete remediation. To reflect these considerations, and to address the concerns voiced at the Public Workshop that the Draft CAO does not provide tangible requirements for remedial operations to address the lower aquifer, we are providing recommended language edits (in the attached comments) to add requirements for remedial action implementation and additional analysis of background values and the feasibility of treating to those values.

2) Plume Mapping

PG&E appreciates the changes that were made to allow for a combination of prescriptive and performance based requirements for plume mapping, allowing the use of best professional judgment. PG&E considers the change to be appropriate, with the understanding that the change was made to be consistent with other orders in the region. PG&E agrees with the use of best professional judgment, because it allows the use of all relevant data (e.g. groundwater flow direction) and site specific considerations and avoids interpretations that are arbitrary and artificial.

In the past, we have submitted maps based on best professional judgment. Water Board staff agreed with some interpretations presented on these maps and disagreed with others, (such as PG&E's judgment that there is considerable uncertainty concerning whether the chromium in the north is from the compressor station release). Once Water Board staff determinations have been made, PG&E has drawn the plume maps according to Water Board staff direction without extensive quarterly re-evaluation and will continue to do so, i.e. the northern plume will continue to be drawn. PG&E believes that this process works for resolving differences in best professional judgment. PG&E believes that depicting the data either on two different maps, or by using inserts, is useful for showing the public areas of agreement and disagreement in best professional judgment.

3) Representation of Uncertainty of Chromium Source and Background Values

PG&E agrees with the changes in terminology that were made in the draft CAO, recognizing that the plumes in the north are "uncertain" and that the background values listed in the order are "interim". The term "uncertain" is appropriate for the chromium in groundwater in the north, given that it is not certain what the background concentration is, what the source of chromium in the north is, nor whether chromium from the compressor station flowed to the north, as detailed in previous technical documents (Stantec 2015). The term "interim" appropriately reflects the current, discredited background values and the purpose of the ongoing USGS study to evaluate background.

PG&E is committed to addressing the groundwater impacts caused by our historical operations in Hinkley in a manner that is open and transparent, and that is protective of public health and the environment. We appreciate the dialogue with the Water Board and interested parties during the collaborative revision process that lead to the Draft CAO and look forward to the adoption of the order.

Sincerely,

Kevin Sullivan
Director, Chromium Remediation Program, PG&E

Attachments

A PG&E Comments on Draft Cleanup and Abatement Order
B Key Elements of Revised Conceptual Site Model for the Western Portion of the Lower Aquifer, Hinkley, California

References

Stantec. 2015. Comments on Proposed Cleanup and Abatement Order with Regards to Background Chromium Levels. Pacific Gas and Electric Company. Hinkley Chromium Remediation Project. March 13.

Attachment A PG&E Comments on Draft Cleanup and Abatement Order

The following comments on the Draft Cleanup and Abatement Order (CAO) are organized into two sections: one regarding the lower aquifer remediation requirements and other providing comments on various findings or requirements in Draft CAO.

1. Lower Aquifer Requirements

The hexavalent chromium [Cr(VI)] plume that is currently referred to as the lower aquifer plume resides within a complex geological environment at the edge of the blue clay where the upper aquifer and lower aquifer are in hydraulic communication. Pacific Gas and Electric Company (PG&E) will address this portion of the plume as quickly as possible, but in this complex hydrogeologic setting, aggressive remedial activity that does not consider the interaction of the lower aquifer with the upper aquifer could inadvertently increase Cr(VI) concentrations in the lower aquifer by drawing higher concentrations of Cr(VI) present in the upper aquifer downwards into the lower aquifer.

Recommendations for CAO Revisions

Based on several technical considerations that are described in detail below and in the attached Technical Memorandum (TM), PG&E recommends remedial goals for the lower aquifer be developed to acknowledge a revision to the conceptual site model (CSM) for the western limits of the lower aquifer where the blue clay aquitard transitions from being a confining layer to a thin, sandy and intermittently present clay layer (transition zone). The revised CSM should be used to determine which monitoring wells truly represent the lower aquifer versus the transition zone for use in assessing performance of the lower aquifer remedy. Finally, a technical assessment should be conducted to determine background chromium concentrations for the lower aquifer and the transition zone separately and to evaluate the timeframe of remediation to potentially very low background concentrations. PG&E suggests that if additional requirements for tangible lower aquifer remediation are desired, the requirement to remediate in accordance with the current workplans be re-inserted and a requirement to conduct technical assessments to update the CSM, define background, and evaluate the timeframe for remediation and to submit the findings be added.

To implement these recommendations, the text should be edited as follows (red text indicates edits already in the Draft CAO, comments in black are additional proposed edits):

"b) Lower Aquifer

PG&E shall clean up and abate chromium concentrations ~~greater than non-detect levels~~ in the lower aquifer that are linked to PG&E's historical discharge or remedial actions. ~~During 2014, greater than non-detect concentrations exist at: MW-23C, MW-28C, MW-31C, MW-42C, MW-92C, and MW-100C.~~

i. Continue implementing on-going groundwater extraction east of Mountain View Road to remediate chromium in lower aquifer groundwater, as proposed in PG&E's November 7, 2014 "Plan for Enhancement of Lower Aquifer Remedy" ~~and in accordance with the Water Board's conditional acceptance dated December 22, 2014..~~

> *ii. Submit a technical report within 180 days of this order presenting an evaluation of the updated conceptual site model and background concentrations for the lower aquifer and transition zone at the western edge of the lower aquifer.*
>
> *iii. Submit a feasibility assessment for remediation and cleanup to background concentrations in the lower aquifer and the transition zone at the western edge of the lower aquifer within 90 days of Water Board approval of the conceptual site model and background report required under item ii."*

Note the requirement to conduct lower aquifer remediation in accordance with the Water Board's conditional acceptance letter dated December 22, 2014 is recommended for removal from the original Proposed CAO workplan implementation requirement b.i above in an effort to streamline the number of active orders at the site. The conditional acceptance letter 1) approved the November 7, 2014 workplan and 2) required an assessment of the effectiveness of the remedy in March 2016. These requirements can be replaced with the CAO which 1) provides approval of the workplan in b.i. as written above and 2) requires annual performance reviews in Attachment 8.

Conceptual Site Model for the Lower Aquifer and Transition Zone

The attached TM provides a brief summary of technical considerations for remediation and understanding background values in what is currently referred to as the lower aquifer, which will be more fully developed with an updated CSM document. The key concepts presented in the TM are summarized here to provide context for the recommended changes to the CAO requirements. It should be acknowledged that near the margins of the blue clay that acts as an aquitard that separates the upper aquifer from the lower aquifer there is a transitional area where there is significant hydraulic communication between the two aquifers. This is particularly evident in the area of monitoring wells MW-28C, MW-92C, and MW-100C where chromium above the interim background levels has been reported. This is conceptually illustrated in cross-section on Figure 1 and in plan view on Figure 2 in the attached TM. As displayed with green well dots on Figure 2, the blue clay was either absent, logged as a sandy clay, or less than 3-feet thick at four monitoring wells (MW-28C, MW-92C, MW-98C, and MW-100C) located on the western portion of the lower aquifer. Included on Figure 2 in the attached TM is a blue shaded transitional area where the upper and lower aquifers are interpreted to be in hydraulic communication based on hydraulic testing data. The presence of the blue clay was interpreted during drilling at some wells and test borings in this area during previous investigation, but the blue clay in this area was logged to have an increasing sand content, and subsequent hydraulic testing (see below) has demonstrated that in this transitional zone the intermittent blue clay does not act as a competent aquitard in this general area.

Figure 3 in the attached memo shows hydrographs for upper aquifer/lower aquifer well pairs MW-23B/MW-23C and PZ-08/MW-92C, respectively. The blue clay acts as an aquitard at MW-23C, as demonstrated by the consistently 1-foot higher groundwater elevation at MW-23C than the upper aquifer well MW-23B, demonstrating an upward hydraulic gradient (top panel of Figure 3). On the other hand, the hydrograph for the PZ-08/MW-92C well pair shows comparable groundwater levels at both the upper and lower aquifer wells without a significant vertical gradient like the MW-23B/23C hydrograph (bottom panel Figure 3). The hydrograph for PZ-08/MW-92C is corroborated by the observation of thin and sandy blue clay in this area and suggests that the blue clay does not act as an aquitard in this area. Figure 4 shows hydrographs for upper aquifer/lower aquifer well pairs MW-42B2/MW-42C and PZ-09/MW-100C, respectively. Like the MW-23B/MW-23C hydrograph, lower aquifer well MW-42C shows a consistently higher groundwater level (more than 1.5 feet) than upper aquifer well MW-42B2, indicating that the blue clay acts as an aquitard in this area. While an upward gradient is shown in the hydrograph for PZ-09/MW-100C (blue line above orange line), both wells respond equally to changes in upper aquifer groundwater extraction at upper aquifer extraction well EX-26, indicating that the blue clay does not act as an aquitard in this area.

Geochemical Conditions in the Transition Zone and Lower Aquifer and Implications for Background Chromium

In Finding 7 of the Draft CAO and in comments at the Public Workshop on September 16, 2015, it was observed that several monitoring wells within the lower aquifer yield non-detect concentrations. To understand whether these non-detect values represent background conditions throughout the lower aquifer and the transition zone where the upper and lower aquifer are in hydraulic communication, it is important to also consider the geochemical conditions within these portions of the aquifer. Most of the lower aquifer monitoring wells with non-detect chromium concentrations contain low dissolved oxygen and relatively low oxidation-reduction potential (ORP) which indicate conditions that could promote natural reduction of chromium and relatively lower background Cr(VI) concentrations. Near the western limits of the lower aquifer in the transition zone where monitoring wells such as MW-100C and MW-92C are present, there is generally elevated dissolved oxygen and relatively elevated ORP, which indicate conditions that could be associated with relatively more oxidation of chromium and relatively higher background Cr(VI) concentrations. Elevated dissolved oxygen and ORP conditions are also prevalent throughout the upper aquifer, and chromium is present above non-detect levels at the majority of these wells. These observations indicate that background chromium levels may vary across the aquifer that historically been designated as “lower aquifer” and that careful analysis is needed to determine the background concentrations throughout this portion of the aquifer.

Implications for Remediation

The current remedy for Cr(VI) in both the upper and lower aquifer north of Highway 58 is groundwater extraction and treatment via agricultural application. However, treating the Cr(VI) concentrations at monitoring wells MW-92C and MW-100C within the transition zone and lower aquifer monitoring wells MW-23C and MW-42C with additional lower aquifer extraction to expedite remediation in this area could result in drawing groundwater with higher concentrations Cr(VI) from the upper aquifer downwards into the lower aquifer. If this occurred, this could adversely affect the currently stable to decreasing Cr(VI) trends at these and other lower aquifer wells that have been achieved with current lower aquifer remedial actions. Consequently, additional extraction may not expedite Cr(VI) treatment in what is currently referred to as the lower aquifer until the upper aquifer is remediated.

The hydraulic communication between the upper and lower aquifer in the transition zone at the edge of the blue clay discussed above dictates that cleanup of both the upper and lower aquifers in these areas must proceed in concert and on the same timeline. The solute transport modeling conducted as part of the Remedial Timeframe Assessment (ARCADIS 2014) was utilized to evaluate time for Cr(VI) concentrations within the upper aquifer in the vicinity of the lower aquifer transition zone to decrease to less than 3.1 parts per billion (ppb). In one of the modeling runs conducted in that study, the upper portion of the upper aquifer (model layer 1) is predicted to decrease below 3.1 ppb Cr(VI) after a period of 7 years, while the lower portion of the upper aquifer (model layer 3) is predicted decrease below 3.1 ppb Cr(VI) after a period of 20 years. Cr(VI) concentrations below 3.1 ppb were not discretely simulated with the solute transport model. Extended timeframe analyses to reach non-detect or an alternate lower Cr(VI) concentration target were therefore not assessed, but timeframes would be significantly longer than 20 years. As such, setting a cleanup goal for the lower aquifer that is sooner than the upper aquifer in this area or that is only a few years long is technically infeasible.

Further, remediating groundwater in select monitoring wells located within the transition zone such as MW-92C and MW-100C and lower aquifer monitoring wells MW-23C and MW-42C (with an effective blue clay aquitard present) to non-detect values may not be feasible with an extraction approach. Monitoring wells MW-92C and MW-100C in the transition zone are in hydraulic communication with the upper aquifer and likely to have background Cr(VI) values consistent with the upper aquifer. Because relatively elevated dissolved oxygen and ORP are observed at lower aquifer wells MW-23C and MW-42C, it may also be impossible to reduce Cr(VI) concentrations to non-detect levels with extraction at these wells where background Cr(VI) may be relatively higher than in lower aquifer locations with more strongly reducing conditions. PG&E recommends continuing to use the 3.1/3.2 ppb interim background numbers to contour Cr(VI)/Cr(T) in the lower aquifer until a new background number for the lower aquifer is determined and approved by the Water Board.

2. Additional comments

Finding 21, Page 6. PG&E previously suggested edits to this finding that were not implemented in the Draft CAO. The following edits were proposed to clarify the results of the Remedial Timeframe Assessment, to properly describe the geographic applicability of the results and the level of certainty of the results:

> *"The updated estimates range from six to 23 years to remediate 99 percent of the 50 ppb southern plume east of Serra Road; and 11 to 50 years to remediate 99 percent of the 10 ppb southern plume east of Serra Road. The ranges reflect remediation times for different modeled hydrologic layers of the upper aquifer (finer-grained versus coarser-grained model layers) and different assumptions of in-situ remediation modeling. These estimates inform the basis for the cleanup ~~requirement~~*

> *~~deadlines~~ goals in this Order. The timeframe estimates are uncertain given underlying simplifying assumptions in the modeling, uncertainty in conditions throughout the modeled aquifer, operational and construction uncertainties, and assumptions made on the timing and continuation of permitting for the project. "*

Ordering Requirement V.C., Page 18. PG&E previously suggested edits to this ordering requirement that were not implemented in the Draft CAO. The comment is repeated here to re-iterate the recommendations. PG&E acknowledges the importance of timely identification of lapses in hydraulic containment and requirements to quickly submit and implement contingency plans for correction in Ordering Requirements V.D, V.E, and V.F. The timeline for submittal of a contingency plan in V.E. and the requirement to re-establish capture as soon as possible will ensure PG&E is taking all possible measures to regain capture. PG&E requests a clarification that compliance with the CAO is ensured if PG&E complies with the requirements to: operate, monitor, identify when capture is not achieved, submit contingency plans with schedules by the required deadlines, and implement the contingency plan on schedule. This will allow for the time that may be required to regain capture as corrective actions are implemented. For example, in the case where specific hydraulic metrics indicated outward gradients from February to August 2013, corrective actions were implemented and resulted in immediate improvements in metric measurements; however, it took several months for the metrics to return to inward gradients. This example can be used to define the time that may be needed to implement corrective actions, during which PG&E should not be exposed to possible violation of the CAO requirements as onsite experience has demonstrated no threat to water quality during the time period required for the metrics to show inward gradients. To implement this change to the proposed CAO, the following edits to language are suggested in requirement V.D, consistent with the current requirements in CAO No. R6V-2008-0002A3:

> *"~~PG&E is in violation of~~ The Water Board may find PG&E out of compliance with this Requirement if at any time any of the following conditions occurs:"*

Ordering Requirements VI.C.1.a.i and XVIII on pages 20 and 30 and Attachment 1. Two opposite edits were made in the Draft CAO. In Requirement XVIII and Attachment 1, Water Board Investigative Order R6V-2013-0087 and the Water Board directive letter, dated February 25, 2014, regarding implementation of the western action plans dated September 24, 2013 and January 10, 2014 were replaced by the Draft CAO. Text added in Requirement VI.C.1.a.i on western area remediation required implementation of the western action plans in accordance with R6V-2013-0087 and the Water Board letter dated February 25, 2014. To resolve the inconsistency in these edits and to streamline the number of active orders at the site, PG&E recommends inserting the relevant requirements from R6V-2013-0087 and the Water Board letter dated February 25, 2014 into the Draft CAO.

Ordering Requirement VIII, Page 27. PG&E is committed to informing and educating the community about our programs and will continue to support the Independent Review Panel ("IRP") Manager. PG&E underscores that this aspect of the Proposed CAO is a critical component to the success of the cleanup of the chromium impacted groundwater. However, the level of effort of the IRP that is needed may evolve over time. PG&E recommends that the Executive Officer re-evaluate the line item requirements for the IRP every four years.

This change could be implemented with the following text revisions to requirement VIII.C:

> *"The annual workplan is subject to Water Board Executive Officer approval. Every four years, the Executive Officer will review and may revise the annual requirements listed above under item B."*

Attachment 8, Section II, Page Since the issuance of the Proposed CAO, a draft Issuance of New Notice of Applicability (NOA) of General Waste Discharge Requirements for In-Situ Remediation Zones and the Northwest Freshwater Injection system was issued on July 13, 2014. The draft NOA set reporting dates for the NOA quarterly report on January 30, April 30, July 30, and October 30, the same days the quarterly groundwater monitoring reports would be required under the Draft CAO. PG&E requests that the reporting dates be staggered by moving the groundwater monitoring report deadlines to February 10, May 10, August 10, and November 10.

Attachment 8, Section III.B, Page 9. In the draft CAO, edits were made to remove the premature finding that the background concentration for the plume in what is currently referred to as the lower aquifer is non-detect. PG&E recommends the following edit to the plume mapping requirements in Attachment 8 for consistency,

> "*Using data from the monitoring wells, quarterly reports shall define the full lateral and vertical extent of chromium in groundwater, based on the monitoring information gathered pursuant to the MRP, for hexavalent and total chromium to at least the interim maximum background levels of 3.1 ppb and 3.2 ppb, respectively, in the upper aquifer~~,~~ and ~~to non-detect concentrations in~~ the lower aquifer, and determine the direction of groundwater flow*."

Attachment 8, Section III.B.1.a/b/c, Pages 9 and 10. In the draft CAO, appropriate edits were made in requirement III.B.1.a to allow the presentation of saturated alluvium on maps where needed for data interpretation. Edits were not made to be consistent with this change throughout the section. PG&E recommends the following edits for consistency:

> In Section III.B.1.b, delete: "~~*These maps are not to show the approximate limit of saturated alluvium in upper aquifer or flow directional arrows."*~~

> In Section Section III.B.1.c delete: "~~*"Include the approximate limit of saturated alluvium in upper aquifer."*~~

References

ARCADIS. 2014. Remedial Timeframe Assessment. Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley, California. June 30.

Key Elements of Revised Conceptual Site Model for the Western Portion of the Lower Aquifer, Hinkley, California

PREPARED FOR: California Regional Water Quality Control Board, Lahonton Region, and Pacific Gas and Electric Company

PREPARED BY: Isaac Wood, P.G., C.HG

DATE: September 29, 2015

Introduction

As presented in this technical memorandum (TM), the hexavalent chromium (Cr[VI]) plume that is currently referred to as the Lower Aquifer chromium plume on the western portion of the Lower Aquifer at Hinkley, California, resides within a complex geological environment at the edge of the blue clay, where the Upper and Lower Aquifers are in hydraulic communication. Pacific Gas and Electric Company (PG&E) will address this portion of the Cr(VI) plume as quickly as possible. However, in this complex hydrogeologic setting, aggressive remedial activity that does not consider the interaction of the Lower Aquifer with the Upper Aquifer could increase Cr(VI) concentrations in the Lower Aquifer rather than reduce them, by drawing higher Cr(IV) concentrations in the Upper Aquifer downward into the Lower Aquifer.

PG&E recommends that remedial goals for the Lower Aquifer are developed while acknowledging that a revision to the conceptual site model (CSM) for the western limits of the Lower Aquifer where the blue clay aquitard transitions from being a confining layer to a thin, sandy and intermittently present clay layer (hereafter called the transition zone) is needed. The key components that need to be developed in a revised CSM for the Lower Aquifer are presented in this TM. PG&E proposes to submit a technical report that evaluates these components in greater detail after the Cleanup and Abatement Order (CAO) is issued. The revised CSM presented in this forthcoming technical report should be used to determine which monitoring wells truly represent the Lower Aquifer versus the transition zone for use in assessing performance of the Lower Aquifer remedy. In addition, a technical assessment should be conducted to determine background chromium concentrations for both the Lower Aquifer and the transition zone area near the Lower Aquifer edge to evaluate the timeframe of remedial actions to reduce concentrations to potentially very low background concentrations.

Conceptual Site Model for the Lower Aquifer and Transition Zone to Upper Aquifer

Recent aquifer testing data show that near the margins of the blue clay that acts as an aquitard separating the Upper Aquifer from the Lower Aquifer, there is a transitional area where there is significant hydraulic communication between the two aquifers. This is particularly evident in the area of monitoring wells MW-28C, MW-92C, and MW-100C, where chromium above the interim background levels has been reported. This is conceptually illustrated in cross-section on Figure 1 and in plan view on Figure 2. As displayed with green well dots on Figure 2, the blue clay was either absent, logged as a sandy clay, or less than 3-feet thick at four monitoring wells (MW-28C, MW-92C, MW-98C, and MW-100C) located on the western portion of the Lower Aquifer (Stantec, 2011a-c). Included on Figure 2 is a blue-shaded transitional area where the Upper and Lower Aquifers are interpreted to be in hydraulic communication based on hydraulic testing data. The blue clay was interpreted to be present during drilling at some wells and test borings in this area during previous investigation, but the blue clay in this area was logged to have an increasing sand content (Stantec, 2011a-c), and subsequent hydraulic testing (see below) has demonstrated that in this transitional zone the intermittent blue clay does not act as a competent aquitard in this general area.

Figure 3 shows hydrographs for Upper and Lower Aquifer well pairs MW-23B/MW-23C and PZ-08/MW-92C, respectively. The blue clay acts as an aquitard at MW-23C, as demonstrated by the consistently 1-foot higher groundwater elevation at MW-23C than the Upper Aquifer well MW-23B, demonstrating an upward hydraulic gradient (top panel of Figure 3). On the other hand, the hydrograph for the PZ-08/MW-92C well pair shows comparable groundwater levels at both the Upper and Lower Aquifer wells without a significant vertical gradient like the MW-23B/23C hydrograph (bottom panel Figure 3). The hydrograph for PZ-08/MW-92C is corroborated by the observation of thin and sandy blue clay in this area and suggests that the blue clay does not act as an aquitard in this area. Figure 4 shows hydrographs for Upper and Lower Aquifer well pairs MW-42B2/MW-42C and PZ-09/MW-100C, respectively. Like the MW-23B/MW-23C hydrograph, Lower Aquifer well MW-42C shows a consistently higher groundwater level (more than 1.5 feet) than Upper Aquifer well MW-42B2, indicating that the blue clay acts as an aquitard in this area. While an upward gradient is shown in the hydrograph for PZ-09/MW-100C (blue line above orange line), both wells respond equally to changes in Upper Aquifer groundwater extraction at Upper Aquifer extraction well EX-26, again indicating that the blue clay does not act as an aquitard in this area.

Geochemical Conditions in the Lower Aquifer, the Transition Zone, and Implications for Background Chromium

Several monitoring wells within the Lower Aquifer yield nondetect concentrations. However, to understand whether these nondetect values represent background chromium conditions throughout the Lower Aquifer and also the transition zone where the Upper and Lower Aquifers are in hydraulic communication, the geochemical conditions within these portions of the aquifer should also be considered. Most Lower Aquifer monitoring wells with nondetect chromium concentrations contain low dissolved oxygen and relatively low oxidation-reduction potential (ORP), which indicate conditions that could promote the natural reduction of chromium to result in relatively lower background Cr(VI) concentrations (CH2M HILL, 2015). Near the western limits of the Lower Aquifer in the transition zone where monitoring wells such as MW-100C and MW-92C are present, there is generally elevated dissolved oxygen and relatively elevated ORP, which indicate conditions that could be associated with relatively more oxidation of chromium and relatively higher background Cr(VI) concentrations. Elevated dissolved oxygen and ORP conditions are also prevalent throughout the Upper Aquifer, and Cr(VI) is present above nondetect levels at most of these wells. These observations indicate that background chromium levels may vary across the aquifer that historically been designated as “Lower Aquifer” and that careful analysis is needed to determine the background concentrations throughout this portion of the aquifer.

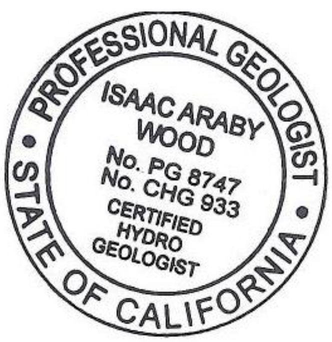
Implications for Remediation

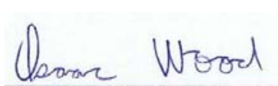
The current remedy for Cr(VI) in both the Upper and Lower Aquifers north of Highway 58 is groundwater extraction and treatment via agricultural fodder crops. However, addressing the Cr(VI) concentrations at monitoring wells MW-92C and MW-100C within the transition zone, and Lower Aquifer monitoring wells MW-23C and MW-42C, with additional Lower Aquifer extraction to expedite remediation in this area, could result in the drawing of Cr(VI) with higher concentrations from the Upper Aquifer downward into the Lower Aquifer. If this occurred, then it could adversely affect the currently stable-to-decreasing Cr(VI) trends at these and other Lower Aquifer wells that have been achieved with current Lower Aquifer remedial actions (CH2M HILL and ARCADIS, 2015). Consequently, additional extraction may not expedite Cr(VI) treatment in what is currently referred to as the Lower Aquifer until the Upper Aquifer is remediated.

The hydraulic communication between the Upper and Lower Aquifers in the transition zone at the edge of the blue clay discussed above dictates that cleanup of both the Upper and Lower Aquifers in these areas must proceed in concert and on the same timeline. The solute transport modeling conducted as part of the *Remedial Timeframe Assessment* (ARCADIS, 2014) was utilized to evaluate time for Cr(VI) concentrations within the Upper Aquifer near the Lower Aquifer transition zone to decrease to less than 3.1 parts per billion (ppb). In one of the modeling runs conducted in that study, the upper portion of the Upper Aquifer (model layer 1) is predicted to decrease below 3.1 ppb Cr(VI) after a period of 7 years, while the lower portion of the Upper Aquifer (model layer 3) is predicted decrease below 3.1 ppb Cr(VI) after a period of 20 years. Cr(VI) concentrations below 3.1 ppb were not discretely simulated with the solute transport model. Extended timeframe analyses to reach nondetect or an alternate lower Cr(VI) concentration target were, therefore, not assessed, but timeframes would be significantly longer than 20 years. As such, setting a cleanup goal for the Lower Aquifer that is sooner than the Upper Aquifer in this area or that is only a few years long is technically infeasible.

Further, remediating groundwater in monitoring wells located within the transition zone such as MW-92C and MW-100C and Lower Aquifer monitoring wells such as MW-23C and MW-42C (with an effective blue clay aquitard present), which are located near the transition area where hydraulic communication with the Upper Aquifer is present, to nondetect values may be infeasible with an extraction approach. Monitoring wells MW-92C and MW-100C in the transition zone are in hydraulic communication with the Upper Aquifer and likely to have background Cr(VI) values consistent with the Upper Aquifer. Because relatively elevated dissolved oxygen and ORP are also observed at Lower Aquifer wells MW-23C and MW-42C, reducing Cr(VI) concentrations to nondetect levels at these wells where background Cr(VI) may be relatively higher than in Lower Aquifer locations with more strongly reducing conditions may be impossible. PG&E recommends continuing to use the 3.1/3.2 ppb interim background numbers to contour Cr(VI)/Cr(T) in the Lower Aquifer until a new background number for the Lower Aquifer is developed and approved by the Water Board.

This TM was prepared on behalf of PG&E by the following California Registered Professional:





Isaac Wood, P.G., C.HG

CH2M HILL, Inc.
155 Grand Avenue, Suite 800
Oakland, California 94612

References

ARCADIS. 2014. *Remedial Timeframe Assessment*. Prepared for Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley California. June 30.

CH2M HILL. 2015. *Second Quarter 2015 Groundwater Monitoring Report and Domestic Wells Sampling Results Site-wide Groundwater Monitoring Program.* Prepared for Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley California. July 30.

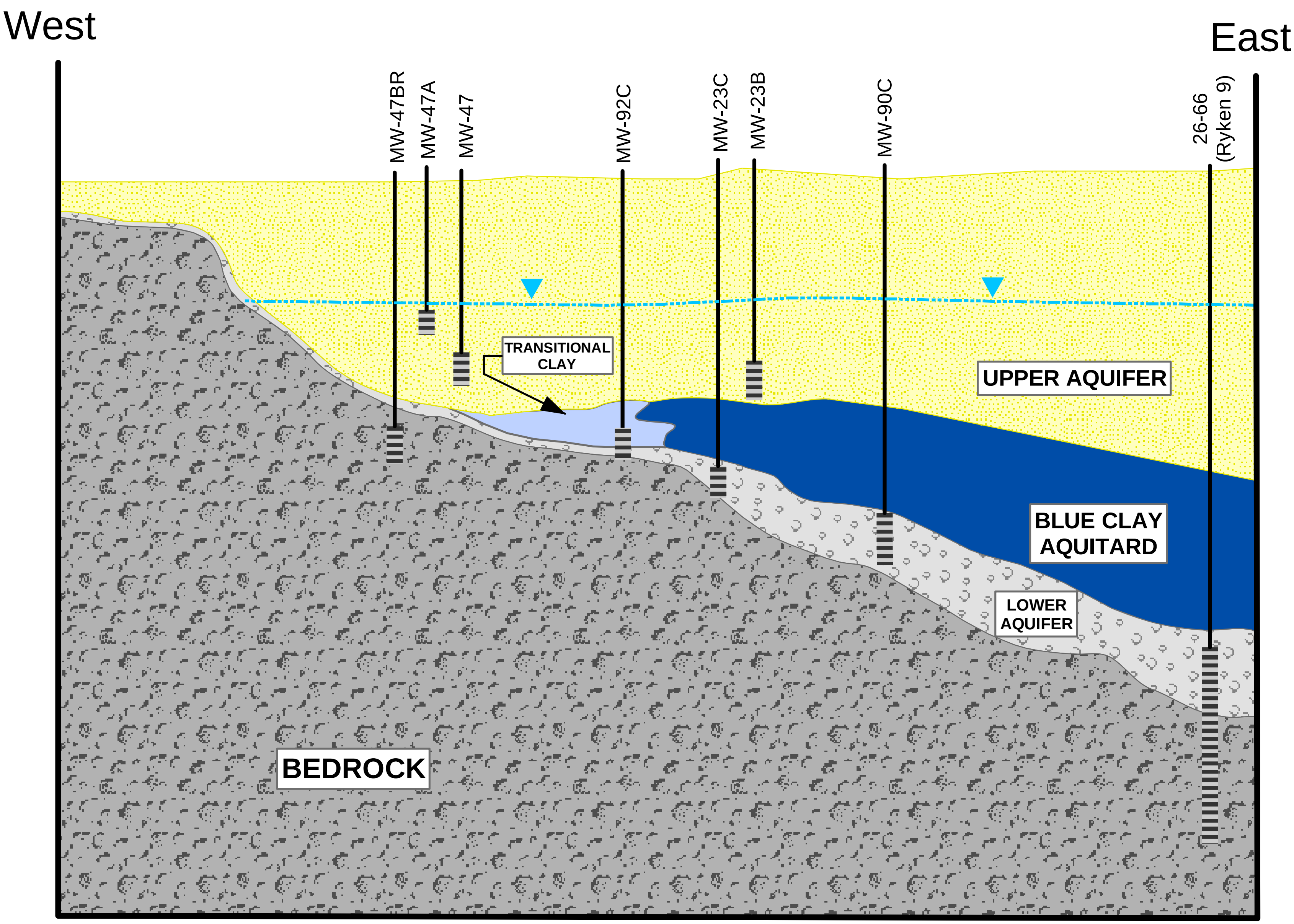
CH2M HILL and ARCADIS. 2015. *Semiannual Remediation Status and Final Cleanup Effectiveness Report (January through June 2015) for the Pacific Gas and Electric Company Groundwater Remediation Program, Hinkley, California*. Prepared for Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley California. September 30.

Stantec. 2011a. *Technical Memorandum of Geologic Conditions at the Western Edge of the Lower Aquifer - Response to Investigation Order R6V-2010-0055, Pacific Gas and Electric Company, Hinkley California*. Prepared for Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley California. January 31.

Stantec. 2011b. *Technical Memorandum Report in Response to Investigation Order R6V-2010-0055-Delineation of Chromium in the Lower Aquifer Pacific Gas and Electric Company, Hinkley California*. Prepared for Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley California. March 31.

Stantec. 2011c. *Technical Report – Response to Investigation Order R6V-2011-0043 – Delineation of Chromium in the Lower Aquifer, Pacific Gas and Electric Company, Hinkley California*. Prepared for Pacific Gas and Electric Company, Hinkley Compressor Station, Hinkley California. August 1.

Figures



Stantec
57 LAFAYETTE CIRCLE, 2ND FLOOR
LAFAYETTE, CALIFORNIA
PHONE: (925) 299-9300 FAX: (925) 299-9302

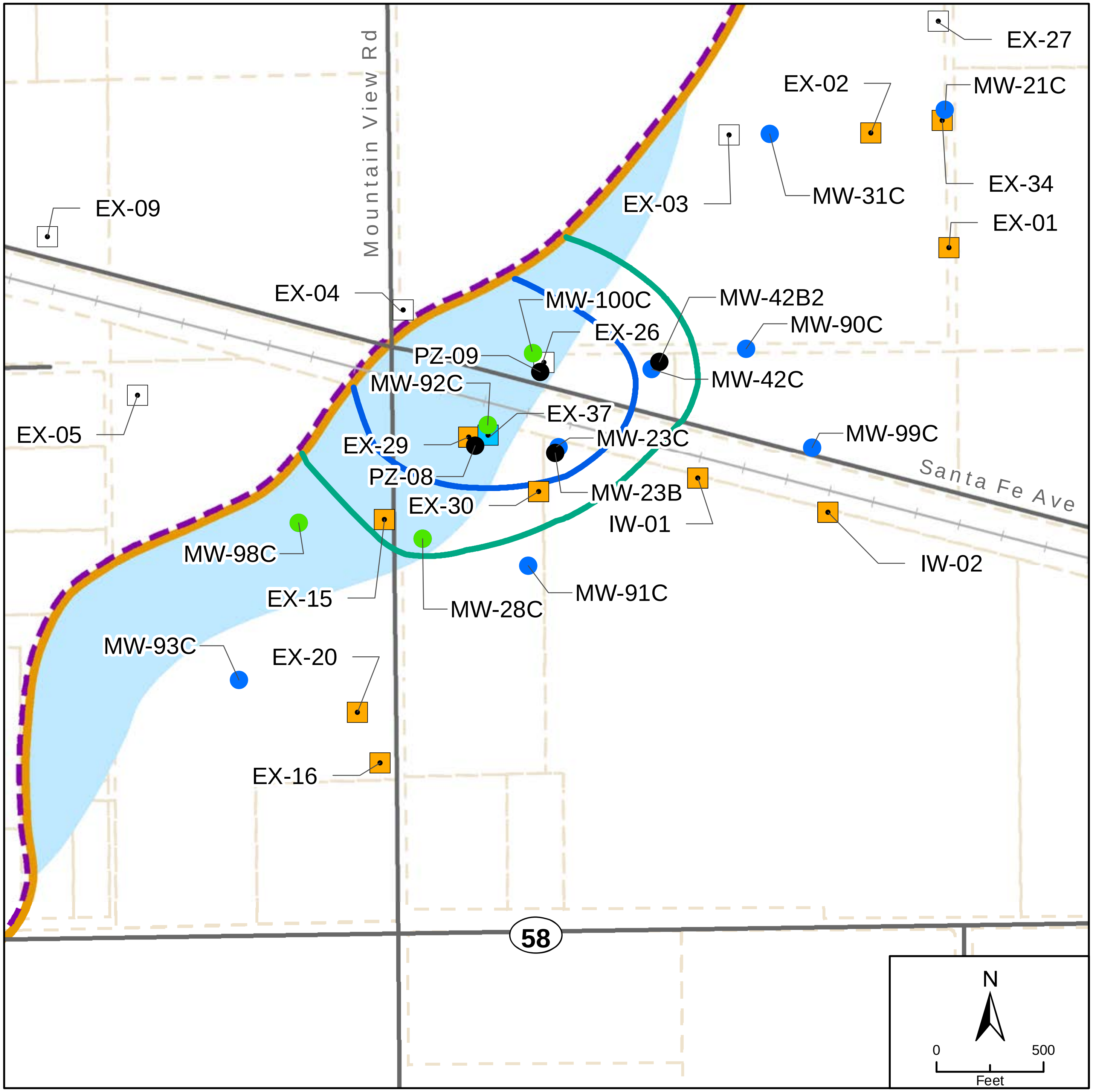
FOR:
Pacific Gas & Electric
Groundwater Remediation Project
Hinkley, California

GENERALIZED SITE STRATIGRAPHY

FIGURE: 1

JOB NUMBER:	DRAWN BY:	CHECKED BY:	APPROVED BY:	DATE:
185702221	TF	BD	CM	11/23/10

Z:\PG&E\MXD_Files\November 2010\Figure 2 (Site Stratigraphy (2010-11-22).mxd



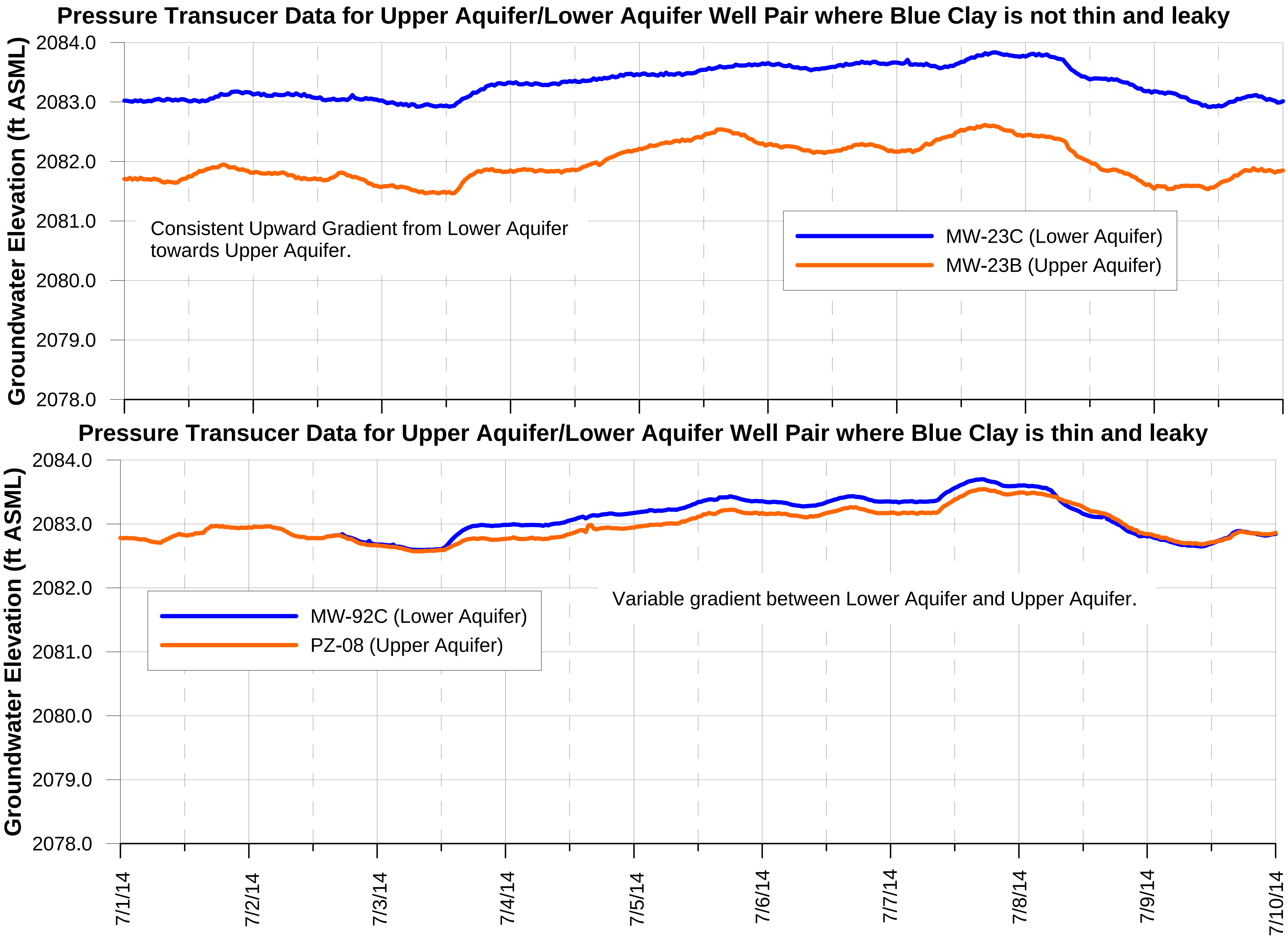
LEGEND:

- Upper Aquifer Monitoring Well
- Lower Aquifer Monitoring Well
- Blue Clay either absent or less than 3-feet thick in boring log.
- Groundwater extraction well
- Upper Aquifer Extraction Well
- Upper and Lower Aquifer Extraction Well
- Approximate limits of blue clay layer forming Lower Aquifer from boring logs. The blue clay layer is absent, thin and leaky in portions of its western extent.
- Approximate transition zone area where the Upper Aquifer and Lower Aquifer are in hydraulic communication. Reducing chromium concentrations in this area will be dependent on reducing Upper and Lower Aquifer concentrations in concert.
- Approximate outline of Cr(VI) or Cr(T) in Lower Aquifer exceeding values of 3.1 and 3.2 µg/L, respectively, Second Quarter 2015
- Approximate 10-µg/L outline of Cr(VI) or Cr(T) concentrations in Lower Aquifer, Second Quarter 2015

FIGURE 2
APPROXIMATE TRANSITION ZONE AREA FOR BLUE CLAY AQUITARD FORMING LOWER AQUIFER
PACIFIC GAS AND ELECTRIC COMPANY
HINKLEY COMPRESSOR STATION
HINKLEY, CALIFORNIA

\\MNUSTRICTGFS01\PROJECTS\PGEHINKLEY20000353\MAPFILES\2015\HYDRO_SUPPORT\METRIC\SEPTEMBER\FIG2_APPROXTRANSITIONZONEAREABLUECLAYAQUITARDFORMINGLA_2Q15.MXD MCLAY 9/23/2015

CH2MHILL



Notes
1) ft. ASML: Feet Above Mean Sea-Level

Figure 3
Pressure Transducer Data for
Upper Aquifer/Lower Aquifer Well Pairs at MW-23C and MW-92C
Pacific Gas & Electric Co. Hinkley Compressor Station

CH2MHILL

\\zinfandel\proj\PacificGasElectricCo\HinkleyRemediationProject\HydroSupport\Background-CSM\2013-2014\Deliverables\EX-36_Western_Action_Plan_Report

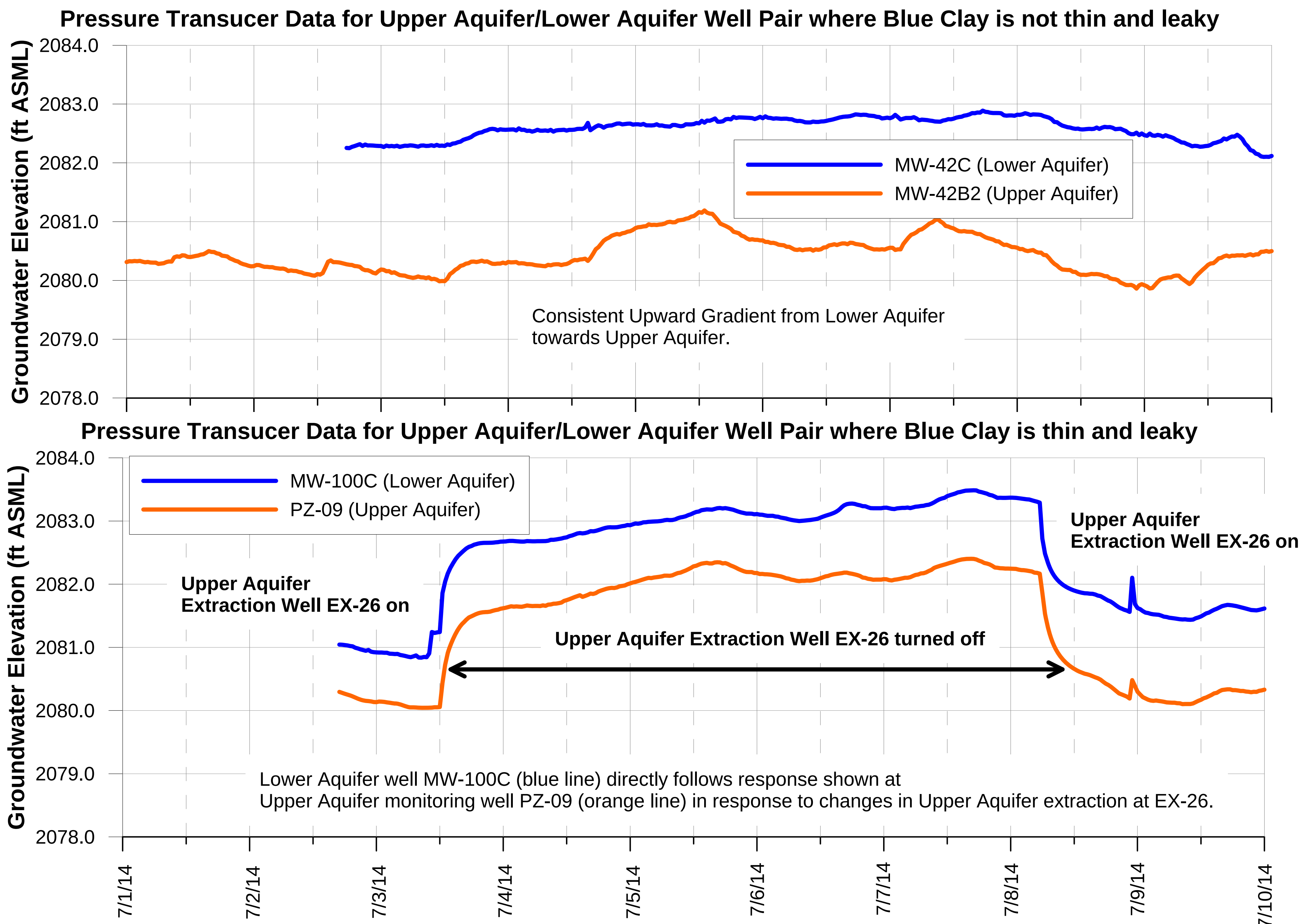


Figure 4
Pressure Transducer Data for
Upper Aquifer/Lower Aquifer Well Pairs at MW-42C and MW-100C
Pacific Gas & Electric Co. Hinkley Compressor Station

Notes
1) ft. ASML: Feet Above Mean Sea-Level

CH2MHILL