FREEPORT-McMoRAN COPPER & GOLD

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36 West Highway 92
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May 18, 2010

Cynthia S. Campbell, Manager
Water Quality Compliance Section
Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, AZ 85007

Re: Response to ADEQ Comments on Aquifer Characterization Report Mitigation Order on Consent Docket No. P-121-07

Dear Ms. Campbell:

Thank you for your comments, dated March 11, 2010, regarding the Aquifer Characterization Report (ACR) submitted to Arizona Department of Environmental Quality (ADEQ) on April 29, 2009 by Freeport-McMoRan Copper Queen Branch (CQB). CQB reviewed ADEQ's comments and prepared this comment response letter.

ADEQ's comments begin with a general statement regarding the adequacy of hydrologic characterization in the bedrock aquifer east of the Black Gap fault and then provide detailed comments to specific portions of the ACR. The matter of the bedrock aquifer east of the Black Gap fault and CQB's proposal for additional characterization are discussed in this letter. ADEQ's detailed comments are primarily requests for additional information on various aspects of the report. CQB's responses to ADEQ's detailed comments are provided in Attachment 1. Most of ADEQ's comments will be addressed by including the requested information into an updated ACR report. However, two of ADEQ's detailed comments request installation of wells at sites BMO-2008-10 and BMO-2008-13. The matter of new wells at BMO-2008-10 and BMO-2008-13 is also discussed in this letter.

BEDROCK CHARACTERIZATION AND UPDATED ACR

CQB and ADEQ have previously discussed the level of characterization of the bedrock aquifer east of the Black Gap fault. The bedrock aquifer east of the Black Gap fault exhibits a high degree of heterogeneity as evidenced by widely varying groundwater elevations over short lateral distances which indicates an apparent lack of hydraulic connectivity between all portions of the bedrock. High degrees of heterogeneity and anisotropy are characteristic of bedrock aquifers in which groundwater flow occurs predominantly along poorly connected secondary structures, such as fractures and bedding planes, rather than an extensive network of interconnected fractures approximating a porous medium.

CQB's opinion is that the bedrock aquifer has been adequately characterized. However, although CQB believes that the conceptual and numerical models for the bedrock aquifer are adequate for evaluating potential mitigation alternatives, in acknowledgement of ADEQ's comments, CQB proposes conducting additional characterization of the bedrock aquifer east of the Black Gap fault and additional evaluation of geologic and hydrogeologic information for this area to determine if the conceptual and numerical models can be improved.

The outcome of the additional investigation may or may not result in a significant improvement of the conceptual and numerical models. However, CQB believes it is important to undertake the additional characterization and complete the investigative phase of the aquifer characterization task prior to completing the Feasibility Study rather than having ADEQ determine at a later time that additional characterization is needed. CQB proposes a focused investigation in the bedrock east of the Black Gap fault consisting of:

1. Installation and testing of a new groundwater monitoring well in the portion of the bedrock aquifer north of Bisbee Junction. The objectives of the well would be to determine the depth of the sulfate plume, to obtain additional water quality and water level data, and to allow additional hydraulic testing in the bedrock in this area.

2. Aquifer testing at existing monitor wells TM-16 and TM-42. CQB will also seek access to the recently installed FLEMING well northwest of NWC-04 for the purpose of conducting an aquifer test. The results of aquifer testing will provide additional hydraulic properties estimates for bedrock and qualitative information on the degree of fracture control of groundwater flow.

3. Reevaluation of historical resistivity and induced polarization geophysical data covering this portion of the bedrock aquifer. The data will be reevaluated to identify bedrock structures that may control groundwater flow.

4. Detailed evaluation of water quality data in the bedrock east of the Black Gap fault. The major element chemistry of wells east of the Black Gap fault will be evaluated to discern if there are different water types that can be used to infer groundwater flow directions or aquifer units.

The conceptual and numerical models for the bedrock east of the Black Gap fault may be revised based on the results of the focused investigation. A work plan and schedule for the additional bedrock characterization will be submitted to ADEQ by June 15, 2010.

CQB will also be installing and testing (aquifer testing and water quality sampling) two new monitoring wells in basin fill and bedrock along Greenbush Draw between the front of the sulfate plume and the Arizona Water Company wellfield. The wells will be installed to provide additional geologic and water quality information in this part of the basin fill and bedrock aquifers. Installation of the Greenbush Draw wells is expected to start in June 2010. The data generated by these wells would be a useful addition to the ACR. Additionally, there have been five quarters of groundwater monitoring results since the ACR was submitted. CQB proposes that the ACR be updated to include the results of the focused investigation, the installation and testing of the Greenbush Draw wells, and groundwater monitoring data collected since 2008. The schedule for submittal of the updated ACR will need to be discussed with ADEQ and considered in the context of the focused bedrock characterization work and the Greenbush Draw well installations.

ADDITIONAL WELLS AT BMO-2008-10 and BMO-2008-13

ADEQ's comments indicate that additional monitoring wells should be installed at sites BMO-2008-10 and BMO-2008-13 because the vertical extent of sulfate was not completely determined. Well BMO-2008-10GL is 810 feet deep and screened in bedrock from 700 feet to 800 feet below land surface (ft bls). Well BMO-2008-13M is 1,030 feet deep and screened in bedrock from 920 feet to 1,020 ft bls. As described in detail in Attachment A, both of these wells were installed following the methods outlined in the Work Plan[1] which relied on reconnaissance groundwater samples to determine the depth of the sulfate plume and monitoring well screened intervals. While reconnaissance sampling can be a useful guide, it does have limitations, as discussed in Section 3.4.2.2 of the ACR.

At BMO-2008-10GL and BMO-2008-13M, the reconnaissance samples led to the false positive identification of the base of the plume. In the case of BMO-2008-10GL, reconnaissance samples indicated that sulfate concentrations in groundwater from 780 to 820 ft bls were below 250 milligrams per liter (mg/L). Subsequent sampling from the completed well indicated that this was not the case as sulfate concentrations exceeded 250 mg/L. In the case of BMO-2008-13M, testing conducted at temporary wells indicated a tendency for leakage around temporary well seals. Well BMO-2008-13M was ultimately constructed as it was because a temporary well screened from 920 to 940 ft bls initially produced samples with sulfate concentrations below 250 mg/L for two hours. Subsequent samples from BMO-2008-13M have had sulfate concentrations ranging from 217 mg/L on April 29, 2009 to 494 mg/L on December 2008. Thus, while the majority of samples indicate that BMO-2008-13M is in the plume, we interpret the occurrence of

[1] Hydro Geo Chem, Inc. 2008. Revision 1, Work Plan to Characterize and Mitigate Sulfate with Respect to Drinking Water Supplies in the Vicinity of the Concentrator Tailing Storage Area, Cochise County, Arizona. July 3, 2008.

a sulfate concentration less than 250 mg/L to indicate that the screen is near the base of the plume.

CQB agrees with ADEQ that, strictly speaking, the vertical extent of the plume has not been determined at the locations of BMO-2008-10GL and BMO-2008-13M. However, CQB believes that the vertical extent of the plume has been adequately characterized for purposes of identifying and evaluating potential mitigation actions. The vertical extent of the sulfate plume is adequately defined by numerous wells in the footprint of the plume (e.g., BMO-2008-4B, BMO-2008-7M, BMO-2008-8M, BMO-2008-9M, GARNER635, TM02A, TM-19A). These wells provide sufficient information on the vertical extent of the plume for model development and evaluation of mitigation actions. Installing deeper wells to define the vertical extent of the sulfate plume at BMO-2008-10GL and BMO-2008-13M would not substantially improve our knowledge of the overall extent of the plume and would not provide data needed for model development or analysis of mitigation actions. Thus, CQB does not propose to install additional monitoring wells near BMO-2008-10GL and BMO-2008-13M as requested by ADEQ.

Thank you for the comments on the ACR and for this opportunity to respond. Unless CQB hears otherwise from ADEQ, a work plan for the focused bedrock investigation east of the Black Gap fault will be submitted by June 15, 2010. CQB will contact ADEQ to discuss a schedule for submittal of an updated ACR.

Sincerely,

Rebecca A. Sawyer
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Freeport-McMoRan Copper Queen Branch

cc: Michael Jaworski, Freeport-McMoRan Copper Queen Branch
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ATTACHMENT 1

RESPONSE TO ADEQ DETAILED COMMENTS

In the following response to detailed comments by the Arizona Department of Environmental Quality (ADEQ), ADEQ's numbered comment is reproduced in its entirety in italics followed by the Copper Queen Branch (CQB) response in bold font.

1. *The first full paragraph on page 43 in Section 3.2.4 Historical Groundwater Levels indicates that many of the wells that were re-surveyed had different measuring point elevations than were previously reported. The measuring point elevation differences ranged from approximately 0.02 feet to approximately 20 feet. The report should indicate in Appendix F which wells had measuring point elevation changes, when the elevation change was noted and from that point on the calculated groundwater elevations should be with the new elevation. Any hydrographs should also use the old elevations and then indicate on the hydrograph when the new measuring point elevations were used. For example, if the new elevation was determined in 2007, all data to 2007 would use the old elevation, then after 2007 the new elevation would be used. The hydrograph should also put a line which indicates when the new elevation was determined.*

CQB RESPONSE

The measuring points were resurveyed in 2008. All water level data in Appendix F pre-date this re-survey. Therefore, these data are calculated using the old measuring point elevation data. Appendix F will be revised to include more recent water level data. Notations regarding the measuring point elevation changes will be added, and levels will be calculated from the correct measuring point elevation. The time of the re-survey will be depicted with a line on the hydrographs.

2. *Section 3.2.7.2 Artificial Recharge Sources – North and South Tailing Impoundments states that water percolation rates through the CTSA is expected to be low due to the low hydraulic conductivity of the tailings and high evaporation rates. The report also states that there is no recharge from the CTSA except when the tailings were being deposited. The report should provide documentation that the CTSA is not a source of recharge to the aquifer since unlined tailings impoundments are common long-term sources of recharge as the tailings drain.*

CQB RESPONSE

Several lines of evidence indicate that current water percolation rates through the CTSA are low, due to low hydraulic conductivity and high evaporation rates. These lines of evidence, particularly when considered together, strongly support the statement that percolation rates from the CTSA are low:

a. **The Aquifer Characterization Report relies largely on a study conducted by Savci Environmental Technologies, LLC (1998a)[2] which predicted net infiltration rates using the HELP and SOILCOVER models. Hydraulic conductivities (K) of tailings were evaluated by in situ methods at seven locations and by laboratory testing of five samples. Net infiltration from the CTSA was modeled using these K values and climate data. The study concluded that "*The arid climate of the CTSA, combined with the unique hydrologic properties of the North and South Tailing Impoundments, result in a low net infiltration ranging from 3.6 x 10^{-7} cm/s to less than 2.4 x 10^{-10} cm/s. These site factors combine to provide a level of containment comparable to a clay underliner system having a saturated hydraulic conductivity of 10^{-7} cm/s.*"**

b. **Groundwater levels in monitor wells GL-03, BMO-2008-11G, BF-01, TM-02A, TM-03, COB-WL, BIMA, and SUNBELT do not indicate the presence of a groundwater mound under the CTSA. Dry and dusty drill cuttings were observed at during drilling at BMO-2008-11G to a depth of 340 ft bls, 1100 feet west of the south Tailing Impoundment.**

c. **Tailings have not been pumped to the CTSA since 1974. Thirty-five years of drain-down can be sufficient time to allow a reduction of the head within the tailings to significantly reduce percolation to the aquifer.**

d. **Sulfate concentrations are less than 110 mg/L at GL-03, BMO-2008-11G TM-03, and COBWL in the vicinity of the impoundments, indicating that the tailings impoundments are not currently significant sources of sulfate to the aquifer in the vicinity of the tailings impoundments.**

3. *Section 3.4.4.1 Site BMO-2008-1 briefly discusses analytical results and geology from monitoring well BMO-2008-1. The report should include analytical results from the depth specific sampling conducted during drilling. Additionally, the report states that during drilling, moisture was first noted at 70 feet below ground surface (ft bgs), depth specific samples were collected between 210 to 320 ft bgs, and once the monitoring well was*

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[2] Savci Environmental Technologies, LLC. 1998a. Hydrologic Assessment of Tailing Impoundments, CTSA APP Project Area, Bisbee, Arizona. May 12, 1998.

installed, groundwater levels rose to approximately 61 ft bgs and have persisted at that level. The report should discuss the need to monitor groundwater in the Morita Formation and discuss whether the water levels are reflective of a potentiometric surface rather than a water table surface.

CQB RESPONSE

The report does include analytical results from the depth specific sampling. These data are provided in Appendix K. The data will be added to the main text for ease of reference.

To address the second part of this comment, we propose that a discussion of multiple aquifers (confined and unconfined) and whether the water levels are reflective of potentiometric surfaces or water table surfaces be included in the Conceptual Model section (Section 6). This is an issue that applies to the entire study area, not only Site BMO-2008-1; thus Section 6 is a more suitable location to place this discussion in the text.

4. *Section 3.4.4.2 Site BMO-2008-3 briefly discusses analytical results and geology from monitoring well BMO-2008-3. The report should include analytical results from the depth specific sampling conducted during drilling. The report should provide a discussion as to why water levels rose 20 feet between groundwater first encountered during drilling and final depth to groundwater in the monitoring well. The report should provide a discussion on potential reasons why sulfate was detected at 300 milligrams per liter (mg/l) at 220 ft bgs and were at lower concentrations from the rest of the depth specific samples collected.*

CQB RESPONSE

The report does include analytical results from the depth specific sampling. These data are provided in Appendix K. The data will be added to the main text for ease of reference.

The 20-foot difference between the first encounter with groundwater and the final water level in the well is likely due to the interaction between the capillary fringe and air injection for cuttings removal. It is not uncommon for the capillary fringe to contribute little water to the boreholes when first penetrated. The high air injection rates for drilling can mask the presence of groundwater inflow when the inflow rate is low. The difference between the initial and final water levels in inconsequential.

A discussion of potential reasons why sulfate was detected at 300 mg/L at 220 ft bgs and lower at other depths will be provided. This discussion could be applied to most of the borings that were drilled for the ACR, as the sulfate concentrations were

never consistent throughout any of the borings. During drilling of the BMO borings, it was common to see the highest sulfate concentration at some depth below the water table; lower sulfate concentrations were detected above and below this depth. Changes in sulfate concentrations with depth were not always consistently up or down with increasing depth. Aquifer heterogeneities, including hydraulic properties and aquifer lithology and chemistry, can explain such variations.

5. *Sections 3.4.4.3 through 3.4.4.11 discuss analytical results and geology from monitoring wells BMO-2008-4 through BMO-2008-13. The report should include analytical results from the depth specific sampling conducted during drilling for each well.*

CQB RESPONSE

Results are provided in Appendix K. We will add the results to sections 3.4.4.3 through 3.4.4.11 for ease of reference and provide additional discussion regarding the range of sulfate concentrations.

6. *In Section 3.4.4.7 Site BMO-2008-8, the report states that temporary wells installed from 530 to 1,030 ft bgs contained sulfate concentrations greater than 250 mg/l and it was probably due to fractures allowing borehole water from the basin fill to by-pass the temporary well seal. The bedrock well was installed with a screen interval of 1,100 to 1,200 ft bgs. The report should discuss whether drilling indicated that numerous fractures were encountered during drilling and discuss the results of the video logging and limited borehole geophysics. The report should also discuss whether production rates in the temporary well constructed from 1,030 to 1,050 ft bgs contained similar electrical conductivity (EC) and total dissolved solids (TDS) results as samples collected higher in the water column. The report should hypothesize the vertical extent of sulfate contamination in the Morita Formation. The report should also discuss whether an additional shallower Morita Formation monitoring well should be installed.*

CQB RESPONSE

The requested discussion will be included in the report. Regarding the vertical extent of sulfate in the Morita Formation, Section 3.4.47 discusses the results of temporary well samples and lines of evidence suggesting possible cross-contamination by drilling water. The depth of sulfate in the Morita Formation is depicted on Plates 2 and 3 based on temporary well data. The temporary well data indicate a maximum potential depth of the sulfate plume if cross-contamination was limited. The bottom of the plume could be shallower than depicted if cross-contamination was extensive. Inasmuch as the current depiction of the plume on Plates 2 and 3 may overestimate plume depth, the interpretation is conservative in

that it does not underestimate depth. Another well higher in the Morita Formation is not needed because the depth of the plume is constrained by the existing data.

7. *In Section 3.4.4.8 Site BMO-2008-9 the report states in the third paragraph that "Reconnaissance samples collected during drilling in the upper portion of the bedrock were suspected of being unrepresentative of groundwater in the aquifer. A sulfate concentration of 347 mg/L obtained from sampling the return water produced from a depth of 740 feet the first thing in the morning was inconsistent with the 800 to 900 mg/L sulfate concentrations observed above and below this interval." It is not necessarily inconsistent for varying concentrations of sulfate be observed in a fractured system. Depending upon fracture orientation, source of water, and interconnectivity, it is highly likely that a significantly lower concentration would be observed between two higher concentrations.*

CQB RESPONSE

Comment noted.

8. *In Section 3.4.4.9 Site BMO-2008-10, the report states in the last paragraph: "The sulfate concentration of a groundwater grab sample collected after removing over 2,500 gallons of water during air lift development was 96 mg/L. In contrast to the reconnaissance sample results, initial sampling of the completed well conducted during hydraulic testing produced a sulfate concentration of 1,320 mg/L. The increase in sulfate may be the result of pulling high sulfate groundwater through the fracture system in the low permeability formation during drilling, well development, and hydraulic testing. The difference in static water level elevation between BMO-2008-10GU and BMO-2008-10GL indicates poor hydraulic connection between the water-bearing zones tapped by the wells." The above statement appears to be contradictory. The report states that the high concentrations observed in BMO-2008-10GL were from drilling, development and hydraulic testing. However, the report states in the next sentence that there is no hydraulic connection between wells BMO-2008-10GU and BMO-2008-10GL. If there is no hydraulic connection, then the well was properly installed and the sulfate contamination observed was a true reflection of the aquifer conditions. If a true observation, an additional monitoring well should be installed to vertically define sulfate contamination at this location.*

CQB RESPONSE

We agree that the vertical extent of the plume is not delineated at BMO-2008-10. These wells were installed in the source area in the footprint of the former evaporation ponds. While reconnaissance sampling can be a useful guide, it does have limitations, as discussed in Section 3.4.2.2 of the ACR. In the case of BMO-2008-10, reconnaissance samples indicated that sulfate concentrations in

groundwater from 780 to 820 feet bgs were below 250 mg/L. Subsequent sampling from the completed well indicated that this was not the case. Sulfate concentrations exceeded 250 mg/L in the completed well.

The well was installed according to Section 3.3.3.2.3 of the Work Plan (Hydro Geo Chem, Inc., 2008) which says, "*At sites in impacted bedrock (sites 2, 10, and possibly 8 and 9) drilling will proceed to at least 200 feet below the impacted zone as determined by reconnaissance sampling and a well screen will be installed no farther than 100 feet from the base of the impacted zone to monitor the unimpacted aquifer below it. . .*" In the case of BMO-2008-10, reconnaissance sampling results did not adequately predict what would be encountered in the completed well.

CQB appreciates ADEQ's note about the apparent contradiction of "pulling high sulfate groundwater through the fracture system" and a "poor hydraulic connection between the water bearing zones tapped by the wells" (meaning BMO-2008-10GU and MBO-2008-10GL). This section will be clarified by indicating that the source of high-sulfate groundwater pulled into BMO-2008-10GL was a fracture system other than the shallow fracture system penetrated by BMO-2008-10GU.

We disagree with the need for a deeper monitor well at this location to vertically define the sulfate plume because:

- **The additional data will not significantly change the conceptual and numerical models for the reason that BMO-2008-10 is in the footprint of the former source area and not representative of the generally prevailing conditions defined by other wells; and**

- **The additional data are unlikely to contribute information that would alter the evaluation of mitigation alternatives for drinking water sources because the site is distant from the downgradient portion of the plume where mitigation planning is needed.**

9. *In Section 3.4.4.11 Site BMO-2008-13, the report should discuss the rationale for the screen interval deviation of BMO-2008-13B, 200 feet versus the work plan approved 100 feet. In discussing temporary well concentrations and the rationale as to where to install the screen interval for BMO-2008-13M, ADEQ does not necessarily agree with the conclusions. Results from the monitoring well indicate that the concentrations observed from the temporary boring were correct. The sulfate observed in this well appears to be reflective of aquifer conditions and not as a result of cross-contamination. Based upon this information, the aquifer at this location has not been vertically characterized and an additional well should be installed.*

CQB RESPONSE

Well BMO-2008-13B was constructed with 200 feet of screen in accordance with the Work Plan. Specifically, on page 69 of the Work Plan, the third bullet is applicable to the construction of this well: "*Wells constructed in impacted (concentration of sulfate is above 250 mg/L) basin fill to monitor the impacted zone will have screened intervals up to 200 feet long, centered on the impacted zone to sample all, or as much of the zone as possible.*"

We agree that the vertical extent of the plume is not delineated at this location. Nevertheless, during testing of the temporary wells, there were several indications that water from shallower parts of the borehole was leaking around the temporary well seal and into the temporary screened interval. This evidence, discussed on pages 98 to 99 in Section 3.4.4.11 of the ACR, included unexpectedly high airlift pumping rates for the lithology, and numerous fractures and an irregular borehole wall (as reflected in the caliper and video logs provided in Appendix I). Also, when additional bentonite chips were added to increase the length of the seal, the flow rate declined, indicating that the thinner seal was allowing shallower water into the testing interval. The well was ultimately constructed as it was because a temporary well constructed with screen from 920 to 940 ft bls initially produced samples with sulfate concentrations below 250 mg/L for two hours.

Since construction of the well, sulfate concentrations at BMO-2008-13M have varied from 217 mg/L (on April 29, 2009) to 494 mg/L (on December 2008). Sulfate concentrations appear to be trending down at this location. During the most recent monitoring event (February 2010) sulfate was detected at 375 mg/L. While the screen appears to be in the plume, we interpret from the analytical data that the screen is near the base of the plume. Therefore, CQB does not believe that another well is needed.

10. *Section 4.1.2 Bedrock Structure primarily discusses the Abrigo Fault and the Black Gap Fault. However, there is one other fault in close proximity to the sulfate plume, Ninety-One Hills Fault Zone, and other structures, (i.e., an interpreted syncline in the central and western portion of the plume area that may impact groundwater flow and contaminant transport.) The report should provide a discussion of these other structures in this section.*

CQB RESPONSE

A discussion of these structures will be provided.

11. *Section 4.1.2 Bedrock Structure states that there may be an additional fault near monitoring wells BMO-2008-5 and BMO-2008-6 that is reflected in a bedrock rise that is observed at these wells. The geologic cross-sections do not reflect that interpretation.*

CQB RESPONSE

Although we theorized in Section 4.1.2 that a fault may be the cause of higher bedrock elevations observed in BMO-2008-5 and BMO-2008-6, we also stated that this observation might be due to an irregular erosional surface. The geologic cross-sections depict the latter scenario, which, given the absence of any other evidence of a fault, is the simpler and more conservative of the interpretations. We will add the following sentence to this section to clarify which interpretation is presented: "Cross Sections B-B' and C-C' on Plate 2 show this difference in elevation as a result of an irregular erosional surface."

12. *Section 4.2.3 Potentiometric Relationships, Section 4.2.3.1 Water Level Maps, and Section 4.2.3.2 2008 Water Elevations discuss general groundwater flow directions, a brief discussion and interpretation of groundwater elevation contour maps, and a discussion of interaction between groundwater flow in bedrock and basin fill. The following additional groundwater contour maps should be produced:*

   a. *The water table (both bedrock and basin fill);*

   b. *Deeper screened intervals;*

   c. *Basin Fill;*

   d. *Bisbee Group; and,*

   e. *Glance Conglomerate.*

   Specific comments to these sections will be presented during comments to the groundwater contour maps.

CQB RESPONSE

The additional groundwater contour maps will be produced. We caution that there may be insufficient data to produce some of these maps. If this is the case, it will be noted in the text.

13. *The third sentence in the third paragraph in Section 5.1.1.2 Temporal Trends states: "However, decreasing concentrations since 2005 at TM-16 and at NWC-04, located approximately 2500 feet south (and downgradient) of TM-16, indicates that the southeastern*

portion of the plume has contracted slightly." The report should indicate that NWC-04 has been reconstructed with a deeper screen interval and is pumping from a portion of the aquifer that has not been as impacted by sulfate contamination. It is probably not accurate to state that the sulfate plume is contracting; rather, it is likely more accurate to state that the sulfate plume is no longer being drawn into NWC-04 and is now following natural groundwater flow path.

CQB RESPONSE

The text will be revised and Figure 29 corrected to show NWC-04.

14. *The last sentence in Section 5.1.1.3 Vertical Distribution, in discussing elevated sulfate concentrations in BMO-2008-10GL, states: "The contradictory sulfate concentration indicated, by reconnaissance and monitoring well samples, suggests incursion of sulfate-bearing water to the well during development and aquifer testing." As previously noted, ADEQ does not necessarily agree with this interpretation. Depending upon fracture orientation, it is possible for a lower set of fractures to contain higher concentrations of sulfate than a higher set of fractures. The report should present all alternatives and provide a discussion of why one alternative is more likely than another.*

CQB RESPONSE

There is no disagreement over this point. The text will be clarified as discussed for comment 8.

15. *The report states in Section 6.2.1 Influence of Faults on Groundwater Flow and Sulfate Transport and shown on Figure 34 Sulfate Concentrations and Groundwater Elevations for Fourth Quarter 2008 that there are two areas of low water elevations as compared to nearby areas. The first is centered on the BIMA and Noteman wells immediately north of the Bisbee Municipal Airport and the second traces from GL-03 southwest across the Abrigo Fault to BMO-2008-11G and then runs due west to the Burke well and is shown to run approximately 1.5 miles further west. The report should discuss in detail these areas of low water elevations and provide hypotheses on why these five bedrock wells have low water elevations as compared to other bedrock screened wells.*

CQB RESPONSE

We will include a discussion in Section 6.2.1 of the areas of low groundwater elevations and provide possible reasons for the low groundwater levels.

16. *Section 7.1.5.2 Aquifer Recharge assumes the CTSA is a low, natural recharge source of water to the groundwater flow model. As stated in Comment #2, tailings typically are a*

source of recharge for years after the tailings impoundment has received the last tailings, as demonstrated by the FMI Sierrita Tailings Impoundment. The report should discuss FMI Bisbee's conclusion why the CTSA is different than other tailing impoundments.

CQB RESPONSE

Please refer to the response under comment 2 above.

17. *The report should include the model run logs as an appendix to the report.*

CQB RESPONSE

Model run logs were not maintained for this project, and therefore cannot be included as an appendix.

18. *The report should include a discussion of the water balance used to create the groundwater flow model and a discussion of the water balance the groundwater flow model generated.*

CQB RESPONSE

We will include a discussion of the water balance for the project area.

19. *Section 7.2.3 Calibration Results provides a discussion of results of calibration analysis conducted on the groundwater flow and fate and transport models. The report should provide the results of the mean residual analysis conducted during calibration. The report should also present the residual, absolute mean, root square mean, normalized mean and standard deviation error calculations and related calibration figures. The report should provide a detailed discussion of these results.*

CQB RESPONSE

As stated in comment 17, model run logs were not maintained and individual calibration results and figures are not available. The residual, absolute mean, root square mean, normalized mean and standard deviation error calculations will be provided for the final calibrated model run only.

20. *The report states in Section 7.2.4 Modifications Made During Calibration that the effective porosity was reduced in Zone 4 of Layer 1 to 23.5 percent, sulfate concentrations in the Warren Ranch irrigation area recharge to 250 mg/l from 1,500 mg/l, and recharge rates in the Warren Ranch irrigation area east of the Black Gap Fault were increased to match recharge rates west of the Black Gap Fault. The report should provide additional justification on reducing the sulfate concentration in recharge water from the Warren Ranch*

irrigation area. The volume of recharge should also be assessed as part of the calibration process.

CQB RESPONSE

Justification for reducing the sulfate concentration in recharge water from the Warren Ranch Irrigation area is presented in Section 7.2.4.2 of the report. Because the initial sulfate concentration in this area is uncertain, as discussed in Section 7.1.7, the sulfate concentration was adjusted to improve the model calibration. The volume of recharge is discussed in Section 7.2.4.3 of the ACR. Based on these points, the discussion of sulfate concentration modification and recharge volume in the Warren Ranch Irrigation Area appears to address comment 20.

21. *The report states in Section 7.3 Model Sensitivity that model sensitivity was in general only conducted on flow and transport parameters. The report should justify why a sensitivity analysis was not conducted on the groundwater flow model.*

CQB RESPONSE

The current groundwater model is an update of the groundwater flow and transport model developed by Savci Environmental Technologies, LLC (SET) (1998b)[3]. A complete sensitivity analysis was completed on the flow model, as reported in Section 6 of SET (1998). Calibration of the updated model is discussed in Section 7.2 of the Aquifer Characterization Report. Hydraulic conductivity and recharge were the only two parameters that indicated model sensitivity. Back-up for the sensitivity analysis will be included as an appendix in the updated ACR.

22. *Figures 17, 18, and 19 Groundwater Elevations for Second Quarter 2008, Third Quarter 2008 and Fourth Quarter 2008 show two areas of low water level elevations which were not contoured. The report should provide an explanation of why these areas have low water level elevations. The report should also provide a discussion on why these areas were not contoured.*

CQB RESPONSE

See comments 15 and 25. We will provide possible explanations for low groundwater levels at these locations and a discussion on why they were not contoured.

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[3] Savci Environmental Technologies, LLC. 1998b. Groundwater Flow and Transport Model Report, CTSA APP Project Area, Bisbee, Arizona. June 19, 1998.

23. *Figure 20 Saturated Thickness of Basin Fill (Based on Fourth Quarter 2008 Water Elevations) indicates that TM-42 has approximately 100 feet of saturated basin fill thickness. However, based upon cross-section line C-C' on Plate 2, well TM-42 is completed completely in the Morita Formation with basin fill being completely unsaturated. This figure should be revised.*

CQB RESPONSE

Review of the well driller's report indicates that cross section C-C' is correct. The driller's log indicates that the Morita Formation was encountered at 65 ft bls, as shown on cross section C-C'. The well is screened from 180 to 250 ft bls, entirely within the Morita Formation. Figure 20 will be revised to show zero (0) feet of saturated thickness of basin fill at TM-42.

24. *The following additional sulfate concentration contour maps should be produced:*

  a. *The water table (both bedrock and basin fill);*

  b. *Deeper screened intervals;*

  c. *Basin Fill;*

  d. *Bisbee Group; and,*

  e. *Glance Conglomerate.*

CQB RESPONSE

The requested additional sulfate concentration maps will be produced. We caution that there may be insufficient data to produce some of these maps. If this is the case, it will be noted in the text.

25. *Figure 34 Sulfate Concentrations and Groundwater Elevations for Fourth Quarter 2008 contours sulfate concentrations but not groundwater elevations from the area of low groundwater elevation areas centered around wells BIMA and Noteman. If the area can be contoured for sulfate concentrations, it can be contoured for groundwater elevation. Groundwater elevation for these two wells should be contoured.*

CQB RESPONSE

We will review the data and contour the groundwater levels at the BIMA and NOTEMAN wells, if appropriate. These wells are active water supply wells; they were not constructed for monitoring purposes. If the usage is sufficient and if the

wells intersect only a few fractures, recharge rates may be sufficiently low such that these wells rarely reach static levels. On the other hand, these wells may represent the static water level of a different aquifer.

26. *The report should include stiff diagrams along with piper diagrams for 1996 and 2008 data.*

CQB RESPONSE

Piper diagrams and Stiff diagrams are both used to graphically depict groundwater quality data, specifically concentrations of major cations and anions. In the ACR, Piper diagrams were used because data from many locations can be shown on one plot, allowing for evaluation of various groupings of water chemistry and direct comparison of water chemistry from well to well. Furthermore, because these data are plotted with different symbols to show different characteristics of the well (i.e. if it is completed in basin fill inside the plume, basin fill outside the plume, Bisbee Group inside the plume, Bisbee group outside the plume, etc.), Piper diagrams allow for an immediate comparison of water chemistries from wells that are screened in different zones.

In contrast, a Stiff diagram depicts the groundwater quality in only one well. These diagrams are most useful when plotted on a map to show the sample location. However, in this case, even if we were to plot Stiff diagrams on a map, we would not be able to compare and contrast chemistries in different screened intervals, as allowed with the Piper diagrams. Simply put, plotting the Stiff diagrams on the map would not convey all of the information we wished to convey. Therefore, Piper diagrams are the suitable format for presenting these data.

27. *Geologic structure should be overlain on Figure 36 RSET Model Discretization, Figure 37 Bedrock Surface Contours and Figure 40 Hydraulic Conductivity Zones – Layers 1 Through 4.*

CQB RESPONSE

We will add geologic structure as an underlay to Figures 36, 37, and 40.

28. *Figure 43 Groundwater Level Target Locations should include water levels in wells near and east of Bisbee Municipal Airport.*

CQB RESPONSE

We will add available water levels for wells east of the Bisbee Municipal Airport to Figure 43.

29. *Figures 45, 46, 47, and 48 Simulated Layer 1 Groundwater Levels with Measured Values for Fourth Quarter 2008, Simulated Layer 2 Groundwater Levels with Measured Values for Fourth Quarter 2008, Simulated Layer 3 Groundwater Levels with Measured Values for Fourth Quarter 2008, and Simulated Layer 4 Groundwater Levels with Measured Values for Fourth Quarter 2008 should include groundwater contouring for actual water elevations for each of the four model layers.*

CQB RESPONSE

We will add actual 2008 groundwater level contours to Figures 45, 46, 47, and 48.

30. *Figure 50 Simulated Versus Measured Groundwater Levels at Target Locations should provide labels to indicate which wells significantly deviate from a best case scenario.*

CQB RESPONSE

Table 27 contains the data depicted on Figure 50. Due to the large number of data pairs shown, it will be difficult to annotate Figure 50. Instead, a note will be placed on Figure 50 referencing Table 27. Residuals larger than one percent of the target value will be highlighted.

31. *Appendix E Results of Historical Hydraulic Testing provides the results for three events: 1) Appendix E.1 - Drawdown values and measured drawdown profile for AWC-05; 2) Appendix E.2 - Tables prepared by Errol L. Montgomery for aquifer tests conducted in 1989 and reported by Steffen, Robertson and Kirsten (SRK) in 1997; and, 3) Appendix E.3 - Aquifer properties reported by SRK. The appendix should include the analysis that was conducted for AWC-05 in determining aquifer parameters. The report should at a minimum provide the graphs and analysis that were utilized to calculate hydraulic parameters in Appendix E.2. The appendix should also include the analysis that was conducted in re-evaluating hydraulic parameters in Appendix E.3.*

CQB RESPONSE

We will include the requested data in Appendix E.

32. *Hydrographs should be included for all wells in Appendix F Historic Groundwater Levels.*

CQB RESPONSE

We will include the requested hydrographs in Appendix F.

33. *Sulfate concentration graphs should be included for all wells in Appendix G Historic Groundwater Quality.*

CQB RESPONSE

We will include the requested sulfate concentration graphs in Appendix G.

34. *Appendix N* <u>*Hydraulic Testing of BMO-2008 Wells (Task 2.3) and Existing Wells (Task 2.4)*</u> *should include a table with all hand level measurements conducted during step-drawdown and constant rate discharge testing.*

CQB RESPONSE

The requested data will be included in Appendix N.

35. *The report should provide the equations that were used in determining the hydraulic properties for the two solutions used, 1) homogeneous aquifer solution and 2) partial penetration solutions.*

CQB RESPONSE

The report will be revised to include the equations used for the homogeneous aquifer and partial penetration solutions.

36. *The report should define and describe the Dupuit corrections that were used to improve the fit of observed and simulated curves.*

CQB RESPONSE

The text will be revised to include the requested information.

37. *Plate 2 and 3* <u>*Cross-Sections A-A' Through C-C', and H-H' Bisbee – Naco and Cross-Sections D-D' Through G-G' Bisbee-Naco*</u> *should include additional interior contours rather than just providing an 250 mg/l boundary contour.*

CQB RESPONSE

We will revise the cross sections to include interior contours. We anticipate that the contours will be based on the data from the completed wells. Temporary well data, which appear on the cross sections, and reconnaissance testing data, which do not currently appear on the cross sections, are not as reliable and may not be consistent with the data from the completed wells.

38. *On Plate 2* <u>*Cross-Sections A-A' Through C-C', and H-H' Bisbee – Naco*</u> *cross-section H-H' shows the bottom sample collected during drilling BMO-2008-8M indicates a sulfate concentration of 550 mg/l. The 250 mg/l contour should be extended to include that sample*

even though the sulfate sample collected from BMO-2008-8M was 197 mg/l. The sample collected from BMO-2008-8M is a composite sample over a 100 foot screen interval while the sample collected during drilling was from a 20 foot screen.

CQB RESPONSE

We do not recommend that the plume be defined by a single sample collected from a temporary well. The data from the temporary well samples were collected only to aid in the design of the permanent wells. The plume should be defined by the samples from permanently-installed wells that were designed and constructed for this purpose. The data from temporary wells should not be used to define the plume for the following reasons:

a. **Temporary wells are not constructed and purged to provide defensible groundwater quality data as permanent monitor wells are constructed and sampled.**

b. **Temporary wells cannot be re-sampled for confirmation purposes.**

c. **In section 3.3.3.2.1 of the Work Plan, "General Considerations" for well design were presented. The first consideration was that "Wells must be screened over a significant portion of the aquifer such that the interval is long enough to represent the water quality of a portion of the aquifer that might be reasonably tapped by a drinking water supply well, but short enough so as not to overly generalize water quality in areas where vertical stratification of sulfate concentrations may exist." This statement indicates that it was always the intent to define the plume by monitor wells that are screened over a "significant portion of the aquifer".**

d. **The plume is defined at other locations based on data from permanent monitor wells. In fact, temporary well samples from smaller screened intervals were not collected from most monitor well locations. Therefore, for consistency, the plume should be defined by the concentrations of samples collected from the permanent monitor well.**

39. *On Plate 3 <u>Cross-Sections D-D' Through G-G' Bisbee-Naco</u> cross-section F-F' shows the 250 mg/l sulfate contour ending just below the screen interval for BMO-2008-13M. However, the last sample collected during drilling, approximately 60 feet below BMO-2008-13M's screen interval, shows a sulfate concentration of 410 mg/l. The 250 mg/l contour should be below this sample interval.*

CQB RESPONSE

The 250 mg/L contour will be revised as requested.