ARIZONA DEPARTMENT
OF
ENVIRONMENTAL QUALITY

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March 11, 2010

Mike Jaworski, Site Manager
Freeport McMoran Gold & Copper Inc.
Copper Queen Branch
36 W Highway 92
Bisbee, Arizona 85603

Re: Comments to Aquifer Characterization Report
Dated April 29, 2009

Dear Mr. Jaworski:

The Arizona Department of Environmental Quality (ADEQ) has completed its review of the Aquifer Characterization Report (ACR) submitted by Freeport McMoran Bisbee (FMI Bisbee) on April 29, 2009. The ACR was completed pursuant to the requirements of the Mitigation Order on Consent between FMI Bisbee and ADEQ, which requires FMI Bisbee to investigate and mitigate the impacts of the sulfate plume on drinking water sources in the underlying aquifer emanating from the Phelps Dodge Concentrator Tailings Storage Area (PDCTSA). The Mitigation Order requires that FMI Bisbee present detailed findings pertaining to sulfate concentrations down gradient of PDCTSA in excess of 250 mg/L. According to Section III(C) of the Mitigation Order, FMI Bisbee was required to address the following in the ACR:

1. Current sulfate plume delineation;
2. Sulfate plume fate and transport; and
3. Identification of all existing registered private drinking water wells and public drinking water system wells identified by the well inventory.

Based on the findings submitted by FMI Bisbee, the existing sulfate plume appears to extend through areas of basin fill to the south and west of the PDCTSA, as well as bedrock complex to the south and east of the PDCTSA. ADEQ has prepared the following detailed comments which track the sections of the ACR. However, the most significant deficiency of the ACR appears to be the lack of horizontal and vertical delineation of the sulfate plume in the bedrock complex and the resulting inability of FMI Bisbee's numerical model of groundwater flow and sulfate transport to evaluate mitigation alternatives for the drinking water sources present in the bedrock complex. This has been an issue that ADEQ has discussed with representatives of FMI Bisbee for many months and remains an unresolved issue. FMI Bisbee has suggested that it would be very difficult to fully characterize the portion of the sulfate plume within the bedrock complex, and would likely fail to yield any additional benefits in the development of mitigation actions.

FMI Bisbee has suggested that the sulfate plume in the area of the bedrock complex might be better addressed by "engineering controls" instead of active mitigation actions. Although the ACR does not attempt to fully explore the options available to address the sulfate plume in the bedrock complex, this is an issue which needs to be better defined and addressed. As part of the following evaluation of the ACR, ADEQ will reserve requests for further investigation and characterization of the southeastern portion of the plume in the bedrock complex at this time. However, ADEQ may request additional investigation if FMI Bisbee is unable to provide sufficient mitigation measures to address the southeast portion of the sulfate plume, including the groundwater which is currently or may be in the future a source of drinking water.

The following represents ADEQ's detailed comments to the ACR:

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.
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.
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 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.
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.

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.
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.
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.
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.

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.
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.
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.
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.
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.
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.

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

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.
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.
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.
26. The report should include stiff diagrams along with piper diagrams for 1996 and 2008 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.
28. Figure 43 Groundwater Level Target Locations should include water levels in wells near and east of Bisbee Municipal Airport.
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.
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.
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.
32. Hydrographs should be included for all wells in Appendix F Historic Groundwater Levels.

33. Sulfate concentration graphs should be included for all wells in Appendix G Historic Groundwater Quality.
34. Appendix N Hydraulic Testing of BMO-2008 Wells (Task 2.3) and Existing Wells (Task 2.4) should include a table with all hand level measurements conducted during step-drawdown and constant rate discharge testing.
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.
36. The report should define and describe the Dupuit corrections that were used to improve the fit of observed and simulated curves.
37. Plate 2 and 3 Cross-Sections A-A' Through C-C', and H-H' Bisbee – Naco and Cross-Sections D-D' Through G-G' Bisbee-Naco should include additional interior contours rather than just providing an 250 mg/l boundary contour.
38. On Plate 2 Cross-Sections A-A' Through C-C', and H-H' Bisbee – Naco 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.
39. On Plate 3 Cross-Sections D-D' Through G-G' Bisbee-Naco 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.

ADEQ looks forward to discussing these comments to the ACR, as well as revisions and a timetable for submission of a feasibility study. If you have any questions or concerns, please contact me at (602) 771-2209.

Sincerely,

Marcia Caldwell

for Cynthia S. Campbell, Manager
Water Quality Compliance Section

Cc: Stuart M. Brown, FMI
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