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Technical Memorandum

To:	Dale Ortman, P.E.	**Date:**	April 14, 2011
Copy to:	Tom Furgason, SWCA File, SRK	**From:**	Stephen Day, P.Geo. Corolla Hoag, P.G.
		Project #:	183101
Subject:	Technical Review of *Infiltration, Seepage, Fate and Transport Modeling Report – Revision 1*, Part 2 Geochemical Fate and Transport Modeling		

A technical review has been undertaken and this Technical Memorandum prepared at the request of SWCA and the Coronado National Forest, in accordance with a request for a Statement of Work dated December 2, 2010. Provided here are comments related to the review of *Infiltration Seepage, Fate and Transport Modeling Report–Revision 1* prepared for the Rosemont Copper Company by Tetra Tech (Tetra Tech, 2010c) and the Technical Memorandum *Rosemont Infiltration, Seepage, Fate and Transport Response to Comments*, (Tetra Tech, 2010h). Stephen Day and Corolla Hoag of SRK Consulting (SRK) prepared these comments, which address some of the discussion held in a teleconference with Tetra Tech and Coronado Forest Service personnel[1] on 10 March 2011. Editorial review was provided by Claudia Stone, also of SRK.

Previous reports related to geochemical characterization, seepage, fate and transport models were used for reference. These documents include:

- *Mine Plan of Operations* (WestLand Resources, 2007)
- *Geologic Report, Relogging Program at the Rosemont Porphyry Skarn Copper Deposit* (Augusta Resource Corporation, 2007)
- *Baseline Geochemical Characterization, Rosemont Copper* (Tetra Tech 2007b)
- *Geochemical Characterization, Addendum I, Rosemont Copper* (Tetra Tech 2007c)
- *Dry Stack Tailings Storage Facility Design Report* (AMEC, 2009, Appendix D)
- *Geochemistry Sample Update* (Tetra Tech, 2008)
- *Rosemont Tailings Geochemistry Sample Sources*, Technical Memorandum, August 30, 2010 (Tetra Tech, 2010d). These documents include:
  - A – *Rosemont 2006-2008 Tailings Material Sample Sources*, August 30, 2010 (Tetra Tech, 2010e)
    - Attachment 1 – *Tailings Geochemistry*, Technical Memorandum, March 24, 2009, 7p.
    - Attachment 2 – 2006-2008 *Tailings Material Sample Metallurgical Database Codes*, Excel table, August 2010, 3 p.
    - Attachment 3 – 2006-2007 *Tailings Material Sample Cores*, Excel table including rock type, borehole ID, code, depth and type of geochemistry test performed on three samples of Horquilla, August 2010, 1 p.

[1] Conference call with S. Day, C. Hoag, C. Stone, SRK; D. Ortman; S. Shafiquallah, M. Roth, CNF; M. Williamson, A. Hudson, Tetra Tech

    - o Attachment 4 – 2008 *Tailings 0-3 Year Composite Material Sample Cores*, Excel table containing date, type of sample, laboratory, sample material and rock type, composite name, data file code, and comments, August 2010, 5 p.
  - B – *Tailings Material Sample Metallurgical Database Codes*, Excel table including work date, type of sample, laboratory, material and rock type, composite name, data file code, and comments, August 2010, 2p.
  - C – *2010 Tailings Material Sample Cores*, Excel table containing sample rock type, borehole ID, sample type code, depth, and type of geochemistry test performed, August 2010, 24p.
  - D – *2010 Summary of Geochemical Data for Tailings Samples*, Excel table containing MWMP and SPLP results for 10 tailings samples, August 2010, 1p.
  - E – *SVL Analytical Data for the 2010 Tailings Samples*, Laboratory results for MWMP and SPLP results for 10 tailings samples, August 2010, 1p.
- *Rosemont Geochemical Sample Selection*, October 26, 2010 (Tetra Tech, 2010f)
- *Rosemont Preliminary Geochemistry Review*, *Response to Comments*, Technical Memorandum, November 23, 2010 (Tetra Tech, 2010i).

This memorandum is organized into two sections, corresponding to the two topics under review:

Part 1 - Infiltration and seepage modeling previously addressed (SRK, 2011), and

Part 2 - Fate and transport (geochemical) modeling addressed in this memorandum.

Some remaining comments and recommendations related to the seepage geochemical model and the model documentation are addressed below. The report comments are related to recommendations to improve clarity and model documentation.

1 FATE AND TRANSPORT (GEOCHEMICAL) MODELING

Tetra Tech (2010c) used standard industry methods to prepare conceptual models for the movement of precipitation, draindown process solutions, and entrained pore fluids through the proposed Waste Rock Storage Facility, Heap Leach Facility, and the Dry Stack Tailings Facility. They used CTRAN/W to perform the particle tracking model. The computer code PHREEQC (version 2.15.06) was used to model the resulting water quality in conjunction with the WATEQ4F database. WATEQ4F includes thermodynamic and kinetic parameters for minerals relevant to the rock types and mineralization expected at Rosemont. These methods and software codes conform to current industry standards for geochemical modeling.

Tetra Tech revised and improved the report illustrations and text in the revised report (2010c). SRK recommends the following additional revisions in the reporting of method, results, and table presentation to make the modeling approach clearer to the public and other technical reviewers and the document more complete as a "stand-alone" document. In particular, the report would benefit from:

- Compiled tables (or reference to existing compilation) showing which actual samples Tetra Tech used to calculate the starting solutions for each model and model rock type and the calculation method used to assign an average starting solution chemistry if more than one sample was used to derive the concentration. This would enable the reader to assess the reasonableness of the method used to calculate the average starting solution as well as the representativeness of the results.
- Additional citations in the text that reference or clarify the documents in which the geochemical data are presented and compiled.
- Documentation on PHREEQ inputs and outputs.

1.1 Brief Responses to Comments in Tetra Tech 2010h

The Tetra Tech memo *Rosemont Infiltration, Seepage, Fate and Transport Response to Comments* dated November 23, 2010 (Tetra Tech, 2010h) addressed a number of questions brought up in a SRK memo (2010c) dated April 30, 2010. Only a few items were not addressed or were not addressed in sufficient detail. The Tetra Tech (2010h) sections and item numbers are provided for reference.

Section 3.2.1.1 Item 1 Provide detailed site mineralogy to calibrate the ABA method results

Detailed mineralogy is not part of the physical sample descriptions in any of the geochemical characterization reports that have been made available to SRK; the information provided is of a general nature (host rock type only). SRK understands from a discussion with Tetra Tech on 10 March 2011 that Tetra Tech did have access to the Rosemont assay database to query the database and select relevant sample intervals based on rock type, grade, and location within the project area, but that detailed mineralogy descriptions for the samples tested is not present in the existing records. SRK requests that a table be included in the model report showing the assumptions for the mineralogical sources of the acid generation potential, acid neutralization capacity, and soluble sulfate.

Section 3.2.1.1 Item 2 Evaluate the soluble form of sulfur

Section 6.3 in the updated report does not provide the requested explanation of the mineralogical source of soluble sulfate expected at Rosemont. It is expected that jarosite is not present but this needs to be confirmed. This would be addressed by a mineralogy assumption table as mentioned above.

Section 3.2.1.1 Item 3 Evaluate the possible effect on neutralization potential of carbonates that have been converted to silicates (calcsilicates)

Tetra Tech's response is that calibration of ABA for site-specific conditions is not needed due to the dominance of acid consuming minerals. However, potentially ARD generating (APG) materials are present and the classification of ARD potential may be affected by over-estimating NP. It appears the data are not available to reach a conclusion on the issue, but it can be addressed by allowing for a conservative approach for PAG waste rock management. Appropriate analytical methods will need to be developed for operational testing and classification of PAG materials.

Section 3.2.1.1 Item 4 and Section 3.2.3.1 Nitrate from blasting residue

Blasting residue from ANFO or other products is expected and noted at some open pit mining operations. The starting solutions presented in Table 6.1 of Tetra Tech (2010c) consider only natural concentrations of nitrate, nitrite, and ammonia. There is extensive long-term evidence that leaching of explosives residues from waste rock at similar operations in wetter climates can result in elevated nitrate, nitrite, and ammonia concentrations in drainage from waste rock dumps and mines (eg Ferguson and Leask, 1988). A simple estimate of the effect can be made from explosives usage and anticipated explosives losses. An informal survey by C. Hoag in March 2011 of the water quality conditions at several large open pit copper mines in Arizona and of the Apache Nitrogen product test facility in Arizona indicates that anthropogenic nitrate+nitrite is not typically noted above the relevant numeric groundwater standards. The possible explanation is that mine rock is typically very dry and the residues volatilize resulting in this not being an important source in Arizona. Elevated anthropogenic nitrate+nitrite has been noted in historic tailings facilities where sewage disposal was incorporated in the tailings slurry, but this is not planned at the proposed Rosemont operation. No further action is required though Tetra Tech should acknowledge their predictions did not consider explosives residual leaching.

Section 3.2.1.1. Items 7 and 8; Section 3.2.3.1 Item 1

SRK has reviewed the conceptual plan for testing waste characteristics and segregating waste according to acid-generating or non-acid generating capacity as described in (Tetra Tech, 2009; 2010h) . Rosemont plans to place non-acid generating and potentially acid generating (PAG) waste materials in a manner that segregates or co-mingles them as required to minimize impacts to groundwater. PAG materials will not be placed on the perimeter surfaces used to buttress the tailings storage facility, in the starter dams, drains, or in channel-grading fills. PAG materials will be placed in the waste rock facility and isolated to the greatest extent possible. On a daily or weekly basis, some acid-generating materials may be exposed on the outer face of the Waste Storage Facility, but will be covered in the succeeding day or week by non-acid generating materials depending on the short-term mine plan for any particular day or week. Total sulfur analyses (with potential carbon content analysis) by an onsite laboratory were proposed for periodic sampling and waste classification (Tetra Tech, 2009, p. 166).

The conceptual planned identification and segregation methods look reasonable, but SRK recommends Rosemont provide additional engineering detail (or provide references to the details in another document) on implementation of the concepts, how the proposed approach will limit water contact with the PAG materials, what the potential for upsets might be, and benchmarking the planned procedures against procedures used at similar operations (i.e. Robinson Mine) to address this issue. Some items to clarify in Tetra Tech (2010c) related to waste management include:

- Has Rosemont or others prepared a conceptual dump plan to address waste segregation of PAG materials using the life-of-mine plan and known proportions of PAG rock types through the mine life?
- SRK assumes the bulk of the materials placed initially will be gravel and Willow Canyon Arkose and that pit-internal sulfide waste will dominate the waste materials at the end of the mine life. Will stockpiled inert waste materials or local inert borrow materials be needed to ensure that the acid-generating materials (if any) mined in the later part of the mine life are encapsulated by inert waste?
- SRK recommends that that a citation be added to Tetra Tech (2010c) text to refer the reader to the relevant supplementary document that describes the waste-rock identification protocols (for PAG and acid-neutralizing characteristics), proposed laboratory analyses to be done to assess waste classification, and the segregation techniques.

1.2 Waste Storage Facility Model, Tetra Tech (2010c)

The comments and questions below pertain to model set up, source terms, and model results as they relate to the geochemical model for the Waste Storage Facility.

1.2.1 Source of Waste Rock Sample Results, Tetra Tech (2010c)

SRK previously commented (2010a, 2010b) that descriptive mineralogy and some bulk materials characterization details are missing from the relevant Tetra Tech reports (Tetra Tech, 2007b; 2007c, 2010c, 2010d). The omitted information includes the copper grade analyses to demonstrate what materials were tested (waste, oxide or sulfide ore) and the mineralogical descriptions of the specific samples tested. Tetra Tech (2010f) has addressed the general sample collection method satisfactorily in *Rosemont Geochemical Sample Selection*. The lack of specific mineralogy or oxidation data available in the Rosemont database was discussed in the teleconference discussions on 10 March 2011.

Tetra Tech (2010h) responded to SRK (2010b) that the bulk characterization information for waste rock characterization was presented in previous Tetra Tech reports (2007b, 2007c) but that they added additional citations in Section 6.3.1 Waste Rock Storage Area (Tetra Tech, 2010c). Tetra Tech response item 7 (2010h, p. 8) lists the sources of waste rock characterization data as Tetra Tech's *Baseline Geochemical Characterization* report (2007b) and the *Geochemical Characterization, Addendum 1* (2007c). Section 6.3.1 on waste rock in the revised report (2010c), however, describes a different source of information for waste rock samples so a typographic error may exist in this section. Section 6.3.1 refers to SPLP and MWMP data generated by testing drill core as documented in *Rosemont Tailings Geochemistry Sample Sources* (Tetra Tech, 2010d); these samples are focused on tailings samples, however, rather than waste rock samples.

- SRK recommends clarifying the source of the waste rock samples in Section 6.3.1.
- SRK recommends adding a statement in the description of the source of waste rock samples that all waste samples tested were below the relevant cutoff grades for oxide and sulfide ore with citation to the relevant technical memoranda describing waste sample selection method.

1.2.2 Model Starting Solutions – Waste Storage Facility

Tetra Tech did not respond to SRK's concern about using dilute leachates from laboratory tests directly without scaling for arid conditions at the site except to acknowledge: "There is much debate about the proper scale up methods applied to this type of data, and there is currently not enough information to implement any type of adjustment." SRK agrees there is a debate but notes that analog site data provides a basis for determining whether small scale tests are providing relevant source terms. SRK provided a reference that can serve as a basis for the comparison. During the call on March 10, 2011, Tetra Tech indicated additional analysis had been done on the topic and this would be provided to SRK for review.

The source of data to calculate the model starting solutions is unclear. Section 6.3.1 of Tetra Tech (2010c, p. 71-72) indicates that average SPLP[2] or MWMP[3] results for each waste rock type were used to represent leachates derived from the rock under climatic conditions. The text in Section 6.3.1 further states that Table 6.1 presents the compiled average results and starting solutions used for each rock type. According to the explanation in Section 6.3.1, the SPLP and MWMP results are derived from tailings test work as documented in the technical memorandum *Rosemont Tailings Geochemistry Sample Sources* (Tetra Tech, 2010d).

- SRK assumes there is a reference citation error in Section 6.3.1. Could Tetra Tech confirm that the leachate chemistry from the results of waste rock characterization (Tetra Tech 2007b, 2007c, and 2008) were used as inputs to the fate and transport model for the Waste Rock Storage Facility rather than the chemistry results from tailings characterization work?

It is difficult to correlate the model starting chemistry shown for each constituent by waste rock type listed in Table 6.1 (Tetra Tech, 2010c) with analyses tabulated in a number of supplementary tables in other supporting documents. For completeness, SRK recommends adding tables (appendix) to the report listing the following information:

- The specific samples and results that were used to calculate the starting chemistry based on the planned proportions of each waste rock type (listed in separate tables by rock type if necessary). Listing the actual values would provide the minimum and maximum values measured and would help the reader verify that the chosen value is representative for each waste type.
- The report or data source, the type of analysis used (SPLP or MWMP), and the calculated average (and standard deviations if calculated) for each rock type.

Note 1 below Table 6.1 (Tetra Tech, 2010c) (p. 73) states: "NA = Metal is not part of the rock's composition and therefore was not included in the model's starting solution." SRK previously recommended a clarification on this footnote. The footnote may mislead the reader that the analyses are referring to whole rock analyses. Please clarify that the footnote is referring to SPLP or MWMP leachate results. For example, Table 6.1 lists the aluminum starting solution for a number of rock types as "NA" with an inference from the footnote that aluminum is not part of the rock composition. The whole rock analyses for these rock types, as documented by Tetra Tech (2007b and 2007c), confirm that aluminum is important part of the rock composition for these rock types. This comment applies to a number of other constituents where the solids analyses document the metals are present above detection or are in sufficient concentrations to be considered rock-forming components

[2] Synthetic Precipitation Leaching Procedure
[3] Meteoric Water Mobility Procedure

- SRK recommends modifying Note 1 to clarify that "NA" is listed for metals that were not detected in SPLP or MWMP leachate chemistry and therefore will not be included in the model's starting solution.
- SRK recommends adding footnote to indicate that the starting chemistry for nitrite + nitrate as N reflects the original rock composition and does not include an additional expected component related to residues from blasting slurry.

1.2.3 Model Source Terms – Reference to Standards

Tetra Tech has accurately commented that there are no mandated regulatory criteria against which the SPLP, MWMP, (and humidity cell leachate) results should be compared (Tetra Tech, 2010d, p. 5). Leachate test results for operations that are applying for an Aquifer Protection Permit can be compared with the Arizona Aquifer Water Quality Standards (AWQS). This is for reference purposes only but provides an indication of potential impacts resulting from seepage from a discharging facility. Additional comparisons can be made against relevant surface water quality standards or wildlife water quality standards as relevant.

SRK recommends that the analytical results tables for geochemical test work and model source terms should provide the analytical data for all AWQS constituents routinely used by ADEQ for groundwater monitoring related to copper mining and processing facilities because these constituents have numeric standards that may be applied in the baseline or compliance monitoring of the proposed facility. If the leachate results indicate an AWQS constituent is not present above detection, that may be sufficient reason to eliminate it from the model starting solutions or from further discussion, but the approach should be explained. A conservative approach, however, would be to assign an average concentration equal to one-half of the reporting limit for each AWQS constituent that was measured below detection. Additionally, an explanation is expected (such as an explanation of the source of the soluble constituent) when one or more constituents show concentrations that exceed an AWQS.

With these comments in mind, please consider the following:

- AWQS parameters antimony (Sb), beryllium (Be), chromium, Pb, mercury, thallium (Tl), and gross alpha, radium, etc. are missing from the list of parameters included in the model starting solutions and results presented in Table 6.1 and Table 6.7, respectively . SRK recommends adding all AWQS constituents for completeness (with non-detect noted as one-half the reporting limit) or adding a note to explain why an AWQS constituent is omitted.

- SRK recommends revising Tables 6.1 and 6.7 to provide consistency between the numbers and names of constituents recorded in the starting solution chemistry and model results. For example, nickel is listed as "NA" for all rock types in Table 6.1 but is omitted from Table 6.7. Total alkalinity, total dissolved solids, carbon (total inorganic carbon?), and Pb are listed in Table 6.7 results but are not listed in the starting solutions. Elemental fluorine (Fl_2) and chlorine (Cl_2) are reported on Tables 6.1 and 6.7 instead of the fluoride (F^-) and chloride (Cl^-), which are the results that were reported in the laboratory analyses. Table 6.1 lists a solution starting chemistry for "sulfate" while Table 6.7 lists modeled results for "sulfur" and Table 6.8 lists model results for combined "sulfate + sulfide."

- The laboratory reporting limits for some constituents used in the models are above the AWQS. For example, the SPLP and MWMP results for Sb and Tl reported in Tetra Tech (2010c, Attachment D) and the SPLP results in of Tetra Tech (2007c, Table A.4) are above the AWQS of 0.006 mg/L and 0.002 mg/L, respectively. SRK recommends adding any subsequent analyses for waste rock samples with reporting limit below the AWQS for these two constituents if they are available.

- The selenium starting solution concentrations for both arkose (0.0135 mg/L) and Horquilla (0.0196 mg/L) exceed the 0.006 mg/L AWQS for selenium. This should be noted or referenced in Section 6.3.1 and/or Table 6.1 (Tetra Tech, 2010c) with some indication of the source of this selenium because arkose comprises more than 44 percent of the waste materials.

- The arsenic starting solution concentrations by rock type do not exceed the AWQS of 0.05 mg/L. The starting concentrations in arkose, andesite, Horquilla and the overburden/gravel, however, would exceed the proposed arsenic AWQS of 0.01 mg/L if this numeric standard is approved. This should be noted in Section 6.3.1 and/or Table 6.1 of Tetra Tech 2010c. Arkose and the overburden comprise approximately 56 percent of the waste materials and will therefore have a dominant impact on generation of any metals in leachate associated with this rock type.

- SRK recommends including geochemical model support documentation in an appendix to itemize model input data, minerals used for modeling, and the model output; this could be similar to what was done for the infiltration model.

1.2.4 Model Results – Seepage Quality

The test work and modeling completed to date show that some individually tested waste materials have the potential to generate acid and metal-bearing leachate based on a comparison with reference standards. When the waste materials are blended in the expected life-of-mine proportions, however, the Waste Rock Storage Facility is expected to generate near-neutral seepage with a modeled pH of 7.73. The quantity of impacted seepage in gallons per minute (gpm) is forecast to be *de minimus* as shown by the results of the infiltration model.

The seepage water quality for the majority of constituents analyzed and modeled to date will not exceed the relevant AWQS. A conclusive opinion is not possible on the constituents where the laboratory method reporting limit exceeds the AWQS (primarily Sb and Tl) or where the analyses were not performed (radiochemicals).

- SRK recommends confirmatory analyses on a small set of representative samples, if they haven't been done already, to eliminate possible questions about whether these constituents, when compared with the reference AWQS, indicate there is the potential to contribute to groundwater impacts.

The seepage from the Waste Rock Storage Facility is not modeled to generate acid rock drainage or exceed current AWQSs. It may, however, have an arsenic concentration that exceeds the proposed AWQS for arsenic of 0.01 mg/L. Arsenic-bearing minerals have been noted in Rosemont mineralization and are commonly present in arsenopyrite and other trace gangue and ore minerals associated with skarn, carbonate-hosted replacement deposits, and porphyry deposits. As noted by Tetra Tech (2010c) naturally occurring arsenic elevated above 0.01 mg/L has been documented in the groundwater wells and seeps at the project site, which is consistent with this background mineral occurrence.

Data and model results presented in Tetra Tech (2010c) indicate that additional aquifer loading attributable to seepage from the Waste Rock Storage Facility is not anticipated to increase significantly the overall concentration of arsenic, other metals, or sulfate in the local groundwater.

1.3 Heap Leach Facility Model, Tetra Tech (2010c)

The revised report includes additional characterization comments and description about the model starting solutions and results. Some additional clarification is recommended relative to documentation of source terms and results.

1.3.1 Source of Heap Sample Results, Tetra Tech (2010c)

The model is constructed to use sample geochemistry in the relative proportions of ore material expected to be placed on the Heap Leach Facility. The Heap ore consists of 63 percent arkose, 21 percent quartz monzonite porphyry, and 16 percent andesite. According to documents provided online by Rosemont (WLR Consulting, 2006; M-3, 2009), material placed on the Heap for copper extraction will contain greater than 0.1% TCu copper grade. Section 6.3.2 indicates that the model was constructed by contacting spent ore with water mixed with 0.5% sulfuric acid solution.

SRK recommends adding the following information for clarification and completeness:

- A summary of expected mineralogy for the spent Heap Leach materials (based on column leach residues or materials from similar operations);
- A table of the minerals and soluble salts that were incorporated into the PHREEQC model for the spent Heap materials; and
- A table providing the sample IDs/laboratory IDs and relevant analytical data for the samples that were used as the basis for Heap draindown chemistry prior to mixing the draindown with precipitation or seepage from overlying waste rock. Of particular interest, what samples were used to represent leached arkose materials?

1.3.2 Model Starting Solutions – Heap Leach Facility

The model uses the analytical results from test work on column leach residues for the expected Heap rock types. The starting solutions shown in Table 6.3 for leached andesite and quartz monzonite porphyry were traced back to MWMP results presented in Tetra Tech (2007c, Appendix A *Laboratory Results* Table A.6). It was not clear from the text or Table 6.3, however, which results were used to support the starting solutions for arkose. There are two other leach residue samples listed in Table A.6 (Leach-1 and Composite-1) but they appear to be composites rather than leached arkose samples.

- SRK recommends amending Table 6.3 to indicate how many samples were used, the range of values measured (max, min, standard deviation), and how the calculation was performed on the solutions for each of the three rock types.

- Please clarify in the text why the starting solution for spent arkose leach ore in the Heap Leach Facility (Table 6.3) is identical to the starting solution chemistry shown for waste rock in Table 6.1 (except for sodium, nitrite+nitrate, and zinc). Different rock/mineral chemistry is expected in leached, acid-equilibrated spent arkose ore materials than is found in the barren, non-leached arkose waste materials so is expected to generate a different leachate quality.

- Please confirm the Heap starting chemistry in Table 6.3 for sodium, nitrite + nitrate, and zinc. The starting chemistry for “Arkose” listed in Table 6.1 appears to contain some typographical errors. Should the starting values be: sodium = 14.1 mg/L, nitrite+nitrate = 0.027, and zinc = NA? Is this a table error or were these the values used in the model?

- The pH of solutions derived from contact with leached arkose would be expected to have a lower pH than the 7.8 value used. The post-leach rock materials will be acid equilibrated and would be expected to generate additional acidity relative to non-leached materials in contact with water or dilute sulfuric acid. Is there column leach test work that indicates post-leach residues for arkose will generate near-neutral to slightly alkaline leachates?

- The rock types in Tables 6.3 and 6.4 appear to include “Arkose”, “Andesite”, and “Quartz Monzonite Porphyry.” Footnote 2 to Table 6.3 indicates the three starting solutions were for “Abrigo”, “Arkose”, and “Quartz Monzonite.” Footnote 2 should be clarified.

1.3.3 Model Source Terms – Reference to Standards

As expected for process solution, the Heap starting solutions have elevated concentrations of metals and are forecast to exceed a number of AWQSs including Be, cadmium (Cd), nickel (Ni), Pb, and selenium and the proposed AWQS for arsenic. For the reader’s convenience and understanding, the tables listing the model starting solutions and results should be amended for consistency and clarity.

- Tables 6.3 and 6.8 should have consistent parameters (number of constituents, names) even if some constituents are non-detect in the starting solutions or model results. A note should be added to explain the absence of AWQS constituents such as Sb, Pb, Se, Tl, and gross alpha, radium etc. from the Heap starting solutions in Table 6.3. Chloride and fluoride are incorrectly designated as chlorine and fluorine in Table 6.3. The modeled results in Table 6.8 are missing results for Sb, Be, fluoride, Pb, mercury, Tl, and gross alpha, radium, etc. A note should be added to explain their absence.
- For consistency of presentation, the starting solution chemistry in Table 6.3 should include total alkalinity, total dissolved solids (TDS), and any other relevant non-AWQS constituents reported as results in Table 6.8.

1.3.4 Model Results – Particle Tracking and Seepage Quality

A starting chemistry of 7.8 used for 63 percent of the spent Heap materials seems higher than expected and requires more explanation. The modeled seepage pH result of 3.23 as shown in Table 6.8, however, looks reasonable for the no-treatment case. Model results for some constituents such as arsenic, TDS, and sulfate appear low for the untreated seepage and for both treatment steps/options. The copper concentration in arkose for both starting and ending solution concentrations appears to be low – likely owing to the use of barren arkose to represent this material.

The Heap draindown is estimated to be about 10 gpm for 3 years post-leaching. The draindown would generate approximately 14,400 gallons per day during this expected timeframe, which will collect in the double-lined PLS Pond outfitted with a leak collection and recovery system. Tetra Tech's memorandum *Prescriptive BADCT Closure for the Heap Leach Facility Ponds*, (Tetra Tech, 2010a, p. 2) indicates that "contained solutions will be allowed to evaporate (in the pond or on top of the spent ore) or pumped to the SW-EW (sic) Plant for processing or possible treatment and/or incorporation into the sulfide ore circuit." The PLS Pond was designed to contain routine 8-hr operational flows of 2,500-3,000 gpm and temporary 24-hr draindown flows as described the leaching facility design criteria (Tetra Tech (2007a), so it appears to have adequate capacity to handle the draindown flow at the post-closure rate.

The Heap closure plan (Tetra Tech 2010a) proposes to manage the residual draindown by a one- or two-stage treatment process using the existing double-lined ponds. The modeled results for the two treatment options shown in Table 6.8 (Tetra Tech, 2010c) show three constituents (Cd, Ni, and Se) will remain above their respective AWQS after treatment. Ultimately, the treated draindown is proposed to be disposed of through evaporation (natural or by wobblers or other devices), processing in a SX-EW Plant, or by incorporation into the sulfide process circuit. Other remediation methods to treat acidic, metal-bearing drainage are also locally in use[4]. All of the methods Rosemont proposed for treatment and disposal are reasonable handling methods for the Heap draindown solution. As commented previously, SRK cautions the draindown may take longer than 3 years.

1.4 Dry Stack Tailings Facility Model, Tetra Tech (2010c)

The comments below address additional comments and questions related to the geochemical model set up, source terms, and model results for the Dry Stack Tailings Storage Facility.

1.4.1 Source of Dry Stack Tailings Samples and Model Construction

Tetra Tech (2010d; 2010e) provided extensive documentation of the drillhole names/footage intervals and coarse reject materials composited for tailings test work. The samples were prepared and tested by Mountain States to simulate the milling, flotation, and concentration procedures used in sulfide processing operations. The residual tailings materials were analyzed by Arizona-certified laboratories although the reporting or method detection limits used for some parameters were too

[4] The BioteQ plant treating the drainage from a low-grade heap stockpile in Bisbee is an example.

high to confirm their concentration relative to AWQS. The nine[5] samples, although limited in nature, appear to be representative of the tailings to be generated during the first 7 years of operation.

The procedures used to set up the conceptual model and to model the particle flow path and expected geochemical characterization follow standard industry procedures. Some additions or clarifications in the support documentation, input descriptions, and table presentations, as described below, would improve model documentation and reader understanding.

1.4.2 Model Starting Solutions – Dry Stack Tailings Facility

The starting solutions for the Dry Stack Tailings Storage Facility listed in Table 6.5 match the MWMP values presented in Attachment D (Tetra Tech, 2010d) so can be easily traced back to the original sample results. The only exception is the model starting solution of pH 7.82 for the 2010 Horquilla sample in Table 6.5 versus the reported result of 8.2 in Tetra Tech (2010d, Attachment D). To improve model documentation, SRK recommends the following changes:

- Add a footnote to Table 6.5 indicating the results are based on the MWMP results tabulated in the relevant Tetra Tech report (2010d, Attachment D).
- Use consistent numbers of parameters and parameter names in Tables 6.5 and 6.9.

1.4.3 Model Source Terms – Reference to Standards

Section 6.3.3 provides a good summary of the nine tailings samples. The text explains that a number of parameters were not included in the starting solutions listed in Table 6.5 owing to lack of detection in the samples. This is sufficient reason to eliminate them from further modeling or discussion as long as the reporting limits are below the AWQS numeric value.

The presence or absence of two parameters is not known because the laboratory reporting limit exceeded the AWQS numeric value for all of the Sb analyses and the majority of Tl analyses.

- SRK recommends adding a footnote to Table 6.5 to reiterate the omission of the parameters specified in Section 6.3.3 as well as other AWQS parameters such as nitrite+nitrate as N, gross alpha, and radium.

1.4.4 Model Results – Particle Tracking and Seepage Quality

The particle tracking approach and seepage quality results appear reasonable.

Seepage from the Dry Stack Tailings Facility is expected to occur over a long period as the residual pore water drains down and will vary seasonally. The average quantity of seepage is expected to be minimal at approximately 8.4 gallons per minute (gpm) or 0.0074gpm/acre.

The information reviewed to date indicates the tailings seepage quality results, when compared with AWQS for reference purposes only, will not to exceed AWQSs. The only exception to this statement is that sufficient analytical data are not available for Sb, Tl, and radionuclides to make a determination for these parameters. The seepage is expected to be elevated in sulfate with a slightly acidic pH of 5.87.

2 RECOMMENDATIONS

For the fate and transport components of the model report, SRK has the following recommendations:

- Clarify the source citations for the samples used for the three geochemical models.
- For models consisting of calculated starting solutions based on a number of analyses, include tables or an appendix (or reference to such tables) showing the samples used including type

[5] The 2006 sample was discarded as the reporting limits were higher than the respective AWQS values.

(SPLP or MWMP) so that the range of values can be reviewed and the basis for the starting calculations verified.

- Standardize the names and numbers of parameters listed on all starting solution and model results tables. Include all relevant AWQS regulated constituents even if the inputs are below detection in the starting solutions or model results. Correct the minor typographical errors in the tables and add footnotes to clarify definitions and source data.
- Provide model input/run documentation for each model.
- Explain the basis for using chemical analyses from arkose waste rock to model the leachate expected from acid-equilibrated spent arkose leach ore.

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4 REVIEWER QUALIFICATIONS

The Senior Reviewer for Geochemistry, Stephen Day, P. Geo., is a Principal Geochemist with SRK Consulting in Vancouver, Canada. Mr. Day has more than 30 years of experience in geochemistry; in particular, he has more than 10 years of experience in the development of waste management plans to address acid rock drainage and leaching of mine wastes in general, as related to hard rock mining. One area of Mr. Day's expertise relevant to the present review is in the development of prediction methods for mine planning and modeling of leachate chemistry.

The reviewer for geochemistry, Corolla K Hoag, R.G., is a Principal Geologist with SRK Consulting in Tucson. Ms. Hoag has 24 years of experience in mining and environmental geology including 10 years of experience in site characterization (geological, hydrogeological, geochemical) of operating and closed copper mining and processing facilities. Relevant experience for similar operations is the collection of geochemical sample data, and compilation and review of leachate chemistry associated with waste rock and tailings storage facilities, in-situ leaching operations, and heap leach operations. Her experience has focused on using site geochemical data for groundwater permitting applications, compliance monitoring, and assessment of engineering controls to demonstrate compliance with Arizona's water quality standards and best available demonstrated control technology (BADCT) requirements to minimize and mitigate impacts to groundwater.