Pit Lake Geochemistry Model Update Plan

As Required By: Mitigation Measure FS-GW-04

October 2018

Prepared by:

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HUDBAY

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Monitoring and Reporting Schedule

Task Schedule	*Purpose/Description/Timing*	*Active Mining Phase*[1]	*Closure Phase*[3]
		AN	*AN*
Collect geochemical data from waste rock characterization programs	Data to be used to update Pit Lake Geochemistry Model	X	
Collect rainfall and evaporation data from Rosemont hydrologic and meteorological stations	Data to be used to update Pit Lake Geochemistry Model	X	
Update Pit Lake Geochemistry Model	Update and revise, if necessary, predictions of post-closure pit lake water quality. Every 5-years in the Active Mining Phase and once in the Closure Phase.	X[2]	X
Reporting (updated model report)	To Forest Service. Every 5-years in the Active Mining Phase and once in the Closure Phase.	X[2]	X
Develop wildlife protection management plan, if needed	Based on “best and final pit lake model” prediction of post closure water quality		X

AN = As Needed; [1] = First update would begin five years into Active Mining Phase; [2] = 5-year increments; [3] = Once in Closure Phase

Revision Log

Revision Number	*Revision Lead*	*Purpose of Revision*	*Revision Date*
1	Rosemont	Based on Forest Service review of June 2017 MPO submittal.	March 2018
2	Rosemont	Based on Forest Service review of March 2018 MPO submittal.	June 2018
3	Rosemont	Added Data Management Language per FS	October 2018

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1.0 PLAN OBJECTIVE AND DESCRIPTION

This *Pit Lake Geochemistry Model Update Plan* (Plan) was developed by Rosemont Copper Company (Rosemont) in response to a mitigation and monitoring measure (Mitigation Measure) requirement of the U.S. Forest Service's (USFS, Forest Service) Coronado National Forest (Coronado) Final Environmental Impact Statement (FEIS; USFS, 2013) for the Rosemont Copper Project (Project). The Mitigation Measure requirement is specified as "FS-GW-04: Periodic update and rerunning of the pit lake geochemistry model throughout life of mine" on pages B-21 and B-22 in Appendix B of the FEIS. Corrections to any of the mitigation measures listed in Appendix B are provided in an Errata to the FEIS (USFS, 2017a). The Record of Decision (ROD; USFS, 2017b) for the Rosemont Project also lists the required mitigation measures.

Mitigation Measure FS-GW-04 requires updates to the 2010 pit lake geochemical model in the report by Tetra Tech titled *Geochemical Pit Lake Predictive Model – Revision 1* (2010a). Model updates will begin five (5) years after the start of the Active Mining Phase, continue through the Active Mining Phase, and end with one update in the Final Reclamation and Closure Phase (Closure Phase). Updates to the pit lake geochemical model will be coincident with updates to the regional groundwater model under Mitigation Measure FS-BR-27.

Data used in support of the pit lake geochemical model updates are provided under other mitigation measures and/or permits/requirements/certifications.

1.1 PLAN OBJECTIVE

The objective of Mitigation Measure FS-GW-04 is to:

- Ensure that the most accurate prediction of mine pit lake water quality is available at closure. At the time of closure, the modeling results would be assessed and would be used to develop a management plan for wildlife protection, if needed.

Other Forest Service mitigation measures and/or permits/requirements/certifications associated with gathering data that may be used in the pit lake modeling updates include:

- FS-BR-27: Periodic validation and rerunning of the regional groundwater flow model throughout life of mine. This mitigation measure also requires water level monitoring at select well locations located on the Project site and in surrounding areas. The installation of a new monitoring well is also required (see pages B-53 through B-55 in Appendix B of the FEIS);

- FS-GW-02: Water quality monitoring beyond point-of-compliance wells. This mitigation measure proposes groundwater level and water quality monitoring at up to 16 wells (15 existing and 1 new) and flow conditions and water quality monitoring at up to 10 springs (see pages B-17 through B-19 in Appendix B of the FEIS);

- FS-GW-03: Additional operational waste rock and tailings characterization. This mitigation measure includes the testing of waste rock and tailings to provide data on the long-term behaviour of the waste rock and tailings with respect to acid generation and metals leaching (see pages B-19 through B-21 in Appendix B of the FEIS);

- OA-SW-01: Detention and testing of stormwater. This mitigation measure is tied to Rosemont's Multi-Sector General Stormwater Permit No. AZMSG-74939 (industrial stormwater) with regard to monitoring stormwater quality at the Sediment Control Structures located down-gradient of the Project facilities (see pages B-88 and B-89 in Appendix B of the FEIS);

- FS-BR-22: Constructing and maintaining an on-site weather station plus automated stormwater/surface water/groundwater monitoring stations in washes downstream of the Project for the purpose of determining impacts from pit dewatering and changes to surface water features. This mitigation measure proposes monitoring of shallow and deep wells at

select locations, such as in Barrel and Davidson Canyon washes. Automated stormwater sampling is also part of this mitigation measures along with the monitoring of geomorphic changes (see pages B-48 through B-50 in Appendix B of the FEIS);

- FS-SSR-02: Spring, seep, and constructed/enhanced waters monitoring. This mitigation measure requires spring and seep flow/quantity monitoring at select springs located on and near the Project site to measure the effects of groundwater drawdown and to determine if decreased water levels are due to mine activities (see pages B-26 and B-27 in Appendix B of the FEIS);

- OA-GW-02: Reduction in potential for acid rock drainage per Rosemont's aquifer protection permit (APP) No. P-106100. This mitigation measure requires monitoring of waste rock placement and segregation of potentially acid generating (PAG) materials. Limited geochemical characterization is also part of this measure (see page B-84 in Appendix B of the FEIS); and

- OA-GW-06: Groundwater quality and aquifer level monitoring required under Rosemont's APP. This mitigation measure refers to monitoring requirements associated with point-of-compliance (POC) wells (see pages B-87 and B-88 in Appendix B of the FEIS).

1.2 PLAN DESCRIPTION

The remainder of this Plan includes the following sections:

- Section 2.0: Data Collection;
- Section 3.0: Update of Pit Lake Conceptual Model;
- Section 4.0: Numerical Model Update;
- Section 5.0: Monitoring and Reporting;
- Section 6.0: Closure and Bond Release;
- Section 7.0: Data Management; and
- Section 8.0: References.

2.0 DATA COLLECTION

The site data collection activities described below will provide for a continual improvement in understanding of the fundamental processes and parameters that influence the water quality of the ultimate pit lake, and which are incorporated in the conceptual and numerical geochemical predictive models. The following sub-sections are covered:

- Section 2.1: Pit filling and steady-state lake elevation;
- Section 2.2: Groundwater chemical quality;
- Section 2.3: Pit wall rock lithology and geochemistry;
- Section 2.4: Rainfall and evaporation estimates;
- Section 2.5: Stormwater inflow estimates; and
- Section 2.6: Opportunistic field geochemical measurements.

2.1 PIT FILLING AND STEADY- STATE LAKE ELEVATION

The rate at which the pit refills strongly influences the quality of the water in the pit lake at the time when the steady-state, or near steady-state, water level is established. In the pit lake numerical model, this filling rate is taken from the regional groundwater model. Pursuant to Mitigation Measure FS-BR-27, Rosemont is required to validate the regional groundwater flow model (Tetra Tech, 2010b; and any updates to that model) as described in the *Groundwater Model Update Plan* (MPO Volume II-m).

2.2 GROUNDWATER CHEMICAL QUALITY

The initial pit lake geochemical model (Tetra Tech, 2010a) and associated water quality estimates indicate that the majority of the chemical mass reporting to the pit lake will be derived from infilling groundwater. Updating the pit lake geochemical model includes updating the chemical quality of the groundwater infilling the pit.

Groundwater quality data in the vicinity of the mine pit will be gathered on an on-going basis per several of the mitigation measures and/or permits/requirements/certifications listed in Section 1.1. These groundwater quality analytical data will be compiled and used as an input to the model.

2.3 PIT WALL ROCK LITHOLOGY AND GEOCHEMISTRY

Rainfall or surface runoff that contacts exposed rock and reports to the developing pit lake will carry with it a range of dissolved chemical constituents. The chemical quality of these flows, as attributed to a specific rock type, is currently estimated using laboratory leach test data (i.e. Synthetic Precipitation Leaching Procedure [SPLP].) The total chemical load from any rock type is proportional to the exposed area of that material on the pit walls or other areas reporting to the pit lake. Therefore, updates to the pit lake geochemical model include updates to the exposed pit wall rock types along with updates to the chemical quality of the runoff associated with those rock types as informed by laboratory geochemical testing.

Mapping of geologic outcroppings occurring in the pit wall will be performed during pit development. Principal lithologies and alteration effects will be tracked and described using the same geologic descriptions used to log blast hole cuttings to insure integration across all geologic activities, past and present. Relevant data obtained from the mapping activities will be included in the pit lake model updates.

Geochemical data from waste rock characterization testing, as needed, will be incorporated into the updated pit lake geochemical model (see Mitigation Measures OA-GW-02 and FS-GS-03).

2.4 RAINFALL AND EVAPORATION ESTIMATES

Rainfall on the footprint of the pit (incident on both pit walls and directly on the surface of a forming lake) contributes to the formation of the pit lake. Relative to groundwater, rainfall makes only a very small contribution to filling, but can deliver some chemical mass to the lake when incident on pit walls and results in runoff to the lake. Alternatively, evaporation plays a very significant role in the evolution of the pit lake by removing water. Through evaporation, the rate of filling is restricted and chemical concentrations in the lake are increased over time.

Rainfall data is currently collected from a number of on-site monitoring stations and evaporation data is collected at the meteorological station. In 2015, Rosemont installed eighteen (18) hydrologic monitoring stations and one (1) meteorological station located on and in the near vicinity of the Project. The hydrologic monitoring stations, as well as two (2) automated surface monitoring stations, are located over seven (7) watersheds, including Davidson Canyon, Barrel Canyon, McCleary Canyon, Wasp Canyon, Scholefield Canyon, Trail Creek, and Box Canyon. Precipitation data from these 20 stations provide rainfall for use in the hydrologic modeling effort. The meteorological station, which is currently located at the Hidden Valley Ranch site, collects wind speed and direction, temperature, precipitation, relative humidity, and pan evaporation data. It is proposed to move this station to the Project administration area during the Construction Phase. Data from the hydrologic monitoring stations and the meteorological station are transmitted via a satellite and stored in a database.

Precipitation and storm flows are also recorded at a USGS stream gaging station located at the Barrel Canyon Wash Bridge on State Route (SR) 83.

It is anticipated that data collected from the hydrologic monitoring stations located near the pit will provide rainfall that can be used for estimating pit wall runoff reporting to the pit lake. Site rainfall and evaporation measurements will be used, as needed, to update the groundwater model, and therefore the pit-filling curve used in the pit lake geochemical model.

2.5 STORMWATER INFLOW ESTIMATES

Stormwater runoff from the ground surface upstream of the pit may, depending on engineering design and deployment, sporadically report to the forming pit lake. This flow may contact several areas, dissolve chemical constituents from the exposed rock, and deliver this chemical mass to the forming pit lake. These areas include: exposed pit walls, natural/undisturbed areas, and the waste rock shell used to buttress the Dry Stack Tailings Facility, and waste rock in the Waste Rock Storage Area.

Stormwater volume contributions to the pit will be updated/verified as part of the groundwater model update. The pit lake numerical model will be updated to reflect any updates to the engineering design for handling storm runoff as well as improved estimates of runoff quantity (i.e. runoff coefficients).

2.6 OPPORTUNISTIC FIELD GEOCHEMICAL MEASUREMENTS

To the extent they are available and can safely be collected, upstream stormwater quality samples will be collected. In addition, stormwater quality samples will be taken in nearby un-impacted drainages that may be substituted for upstream stormwater samples. Details of sampling locations will be determined once construction is complete. The volume of water from sources and the resultant quality information contributing to the formation of the pit lake will be estimated and updated in the model.

3.0 UPDATE OF PIT LAKE CONCEPTUAL MODEL

The conceptual geochemical pit lake model will be reviewed and revised. The conceptual model, as opposed to the numerical model (calculator) described in Section 4.0, considers those parameters and processes that significantly contribute to the rate of lake formation and the chemical quality of the lake water. Depending on the ongoing data collection and the resulting understanding, the pit wall configuration, geochemical test data, and pit lake water balance, model components will be updated, included, or deleted depending on their contribution to an improved model. The conceptual model also considers the magnitudes of various parameters and processes and provides for the inclusion of those that influence the ultimate prediction of pit lake water quality.

3.1 HYDROLOGIC CONCEPTUAL UPDATE

The conceptual model will be modified as necessary to reflect additional sources, or sinks, of water in the lake. The assessment will also address the status of the pit lake as a terminal sink for water.

3.2 GEOCHEMICAL CONCEPTUAL UPDATE

With improvement in understanding the hydrologic conditions of the mine pit, growing geochemical characterization, and wall rock mapping, updating the geochemical conceptual model of the pit lake will be necessary. Updates to the geochemical conceptual model may include components such as interaction between lake water and pit walls and modification of element attenuation within the water column due to saturation.

4.0 NUMERICAL MODEL UPDATE

Following a review of geochemical, hydrogeological and engineering data, the numerical model will be updated to reflect changes to the conceptual model. The input parameters will be assessed and updated, and the pit lake numerical model will be re-run. Post-processing of the pit lake numerical geochemical model will be completed using PHREEQC (or equivalent). Modeling will account for the chemical reactions potentially occurring within the pit lake water itself or on the pit walls. As with the initial pit lake geochemical modeling (Tetra Tech, 2010a), the pit lake water quality will be estimated at a point 200-years into the Post-Closure Period.

5.0 MONITORING AND REPORTING

Monitoring and reporting components for Mitigation Measure FS-GW-04 are listed below.

5.1 MONITORING

There are no specific monitoring requirements associated with Mitigation Measure FS-GW-04. Monitoring data from other mitigation measures will be used to update the pit lake geochemical model. Monitoring schedules are provided in other plans.

5.2 REPORTING

Reporting on Mitigation Measure FS-GW-04 to the Forest Service will be done every five (5) years during the Active Mining Phase beginning five (5) years after the start of active mining with a final report in the Closure Phase. Updates will also be coincident with the reporting/modeling schedule for the *Groundwater Model Update Plan* (MPO Volume II-m). Reporting will include the following information:

- Updated estimated pit lake water quality prediction; and
- Summary of updated data used in the model based upon review of previous five years' geochemical testing results, updates to the pit wall geologic outcroppings, updates to site groundwater model and rate of pit filling, and updates to the chemical quality of groundwater proximal to the pit. Common professional methods, professional experience, project-related needs, and ASTM guidance documents will be used, as needed, to guide the reporting of model results and analysis.

Pursuant to Mitigation Measure FS-GW-04, at closure, Rosemont will prepare a "best and final" pit lake geochemical model report and will coordinate with the Forest Service to develop "management plans to protect wildlife, if impacts from pit lake water quality are likely to occur."

6.0 CLOSURE AND BOND RELEASE

This section addresses closure activities associated with this Plan as well as the approach for funding of those activities and bond release of those funds. If bonding is set for one year or less (i.e., simply completing testwork or finalizing reporting) no bond release is proposed. For longer periods, the bonding terms and application for bond release, as well as the mechanism for that release, are included.

6.1 INTERIM CLOSURE

There are no interim closure activities associated with this measure.

6.2 FINAL CLOSURE

There are no final closure requirements associated with this measure. However, one modeling and reporting event will take place post-mining. The costs for this work have been estimated from previous work and are included in the *Reclamation and Closure Plan* (MPO Volume III-a). On-going, on site environmental monitoring/supervision costs are also included in the *Reclamation ad Closure Plan* (MPO Volume III-a) with regard to the general collection of monitoring data.

6.3 BOND RELEASE

There is no bonding associated with this measure.

7.0 DATA MANAGEMENT

Rosemont currently maintains data in various formats including logbooks, electronic logbooks, spreadsheets, hardcopy and database formats. Rosemont will collaborate with the Forest Service to ensure that the reporting format used will satisfy reporting requirements and that Forest Service concurs with the format prior to the first reporting deadline. It is Rosemont's intent that, ultimately, a robust database will be used to house all data collected for the various monitoring programs. Numeric data ultimately will be stored in a database and spatial data will be maintained in an ESRI database.

Depending upon the type of data to be reported, Rosemont will develop custom reports displaying required information in table or figure format. Electronic submittals will be provided in pdf format to provide a permanent record of the submittal and "raw" data will be maintained on-site for review by the Forest Service. If the Forest Service requests numeric data, it may include information such as cumulative results documenting the monitoring history and include baseline data for the resource.

Rosemont will make model files available to technical reviewers and/or third parties designated by the Forest Service for review upon request. No model files will be delivered to the Forest Service.

Electronic submittals will be made on the reporting period specified. Reports will be submitted every five (5) years in hardcopy form with a duplicate electronic pdf file. Delivery of the electronic files will depend upon the size of the file and will either be made via email, via a CD/DVD or thumb drive, or via a website set up and maintained for delivery of files to the Forest Service. Details regarding access will need to be worked out so transmittals can take place seamlessly.

8.0 REFERENCES

Tetra Tech, 2010a. *Geochemical Pit Lake Predictive Model Revision 1: Rosemont Copper Project*. Consultant report prepared for Rosemont Copper Company. November 2010.

2010b. *Regional Groundwater Flow Model – Rosemont Copper Project*. Consultant report prepared for Rosemont Copper Company. November 2010.

USFS, 2013. *Final Environmental Impact Statement for Rosemont Copper Project, Appendix B Mitigation and Monitoring Plan*. December 2013.

2017a. *Errata – Rosemont Copper Project Final Environmental Impact Statement*. April 26, 2017.

2017b. *Record of Decision – Rosemont Copper Project and Amendment of the Coronado Land and Resource Management Plan*. June 2017.