PITEAU ASSOCIATES
GEOTECHNICAL AND WATER MANAGEMENT CONSULTANTS
A TETRA TECH COMPANY

2500 N Tucson Blvd. Suite 100
Tucson, AZ 85716
TEL: +1.520.355.2559
www.piteau.com

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TECHNICAL MEMORANDUM

FINAL: April 5, 2024

TO: David Krizek, PE
Copper World Inc., Senior Manager, Environmental & Permitting

FROM: Dwaine Edington, Brian Giroux

RE: **Copper World Project – Numerical Fate and Transport Modeling of Tailings Seepage Sulfate**

INTRODUCTION

Piteau Associates (Piteau), at the request of Copper World, Inc. (CWI), undertook numerical fate and transport modeling of sulfate to predict how far downgradient sulfate from the Tailings Storage Facilities (TSF-1 and TFS-2) migrates before it “dilutes” to less than 250 mg/L. This concentration represents the USEPA Secondary Drinking Water Standard for sulfate.

FATE AND TRANSPORT MODEL SETUP

The Copper World Project (Project) groundwater model (Water Quantity Impacts Assessment. Appendix F.2 of the APP application, September 2022) was used to simulate tailings seepage sulfate transport from TSF-1 and TSF-2. The following changes were made to the Project model for this exercise:

- TSF-1 and TSF-2 were represented as sources of seepage with an elevated sulfate concentration. The source concentration was set to 808 mg/L based (Geochemical Impacts Assessment. Appendix G.1 of the APP application, September 2022) and was applied in conjunction with the seepage recharge term that was previously defined for these facilities.
- Initial concentration was set to 173 mg/L in all active model cells. This represents the background concentration and is based on an average of 28 observed sulfate concentrations measured from October 2021 and August 2022 from six monitoring locations near the TSFs.
- The background concentration of 173 mg/L was also added to all recharge zones other than the zones associated with TSF-1 and TSF-2, to maintain background conditions throughout the predictive model time and domain.
- Retardation (which slows transport by adsorbing and desorbing solute to and from the porous media) was set to 1 and the decay coefficient (which decreases solute mass by

transforming it to a different state of mass) was set to 0 day^{-1}; these are conservative assumptions.

In addition to the above, the transport model assumes that sulfate is primarily transported by advection (the average speed of groundwater). As it does so, it is affected by two types of processes that “dilute” the sulfate concentration. The first is diffusion which causes a solute to spread in response to concentration gradients. Diffusion was not simulated because diffusion is relatively small compared to the second process. This is a conservative assumption.

The second process is mechanical dispersion. Mechanical dispersion is the product of the groundwater flow velocity and dispersivity. Dispersivity is the amount of solute spreading longitudinally (in the direction of flow), transverse horizontally (perpendicular to the flow direction in the horizontal plane), and transverse vertically dispersivity (perpendicular to the flow direction in the vertical plane). A fourth term, longitudinal vertical dispersivity applies to dispersion in the direction of flow when that flow is vertical.

- Dispersivity is a property of the porous media and thus, unique values of dispersivity were assigned to two distinct rock types based on data published by Gelhar et al. (1992).
    - Alluvium longitudinal horizontal dispersivity (aLh) was set to 0.66 ft.
    - Bedrock longitudinal horizontal dispersivity (aLh) was set to 2.92 ft.
- Transverse horizontal dispersivity was set to 1/10th of the longitudinal dispersivity. Transverse vertical dispersivity was set to 1/100th of the of the longitudinal dispersivity. Longitudinal vertical dispersivity was set to 1/100th of the longitudinal dispersivity.

To evaluate the model results, the maximum concentration in every model grid cell and selected times were exported. These were used to make a series of concentration maps at the selected time snapshots, which were in turn used to construct a map of the maximum extents of the 250 mg/L sulfate concentration. In addition, a series of artificial monitoring wells were defined along a transect approximately aligned with the hydraulic gradient towards the northwest. This assisted in analyzing the vertical nature of the concentration migration through time.

SULFATE EXTENT PREDICTIVE RESULTS

The predicted maximum lateral extents of the 250 mg/L sulfate concentration are shown on Figure 1. The highest concentrations from all layers are projected onto the map.

Along the line of artificial monitoring locations towards the northwest, the maximum length of the 250 mg/L sulfate migration is about 9,000 ft from TSF-1. This condition occurs at about 300 years after the end of mining. Following 300 years after the end of mining, the area greater than 250 mg/L begins to shrink back towards the source areas because the sulfate continues to spread longitudinally, laterally, and vertically into a greater volume of the aquifer. In other words, the sulfate released from the TSF facilities (a finite mass) is spread into a greater volume of the aquifer over time and this results in a reduction of area with concentrations greater than 250 mg/L.

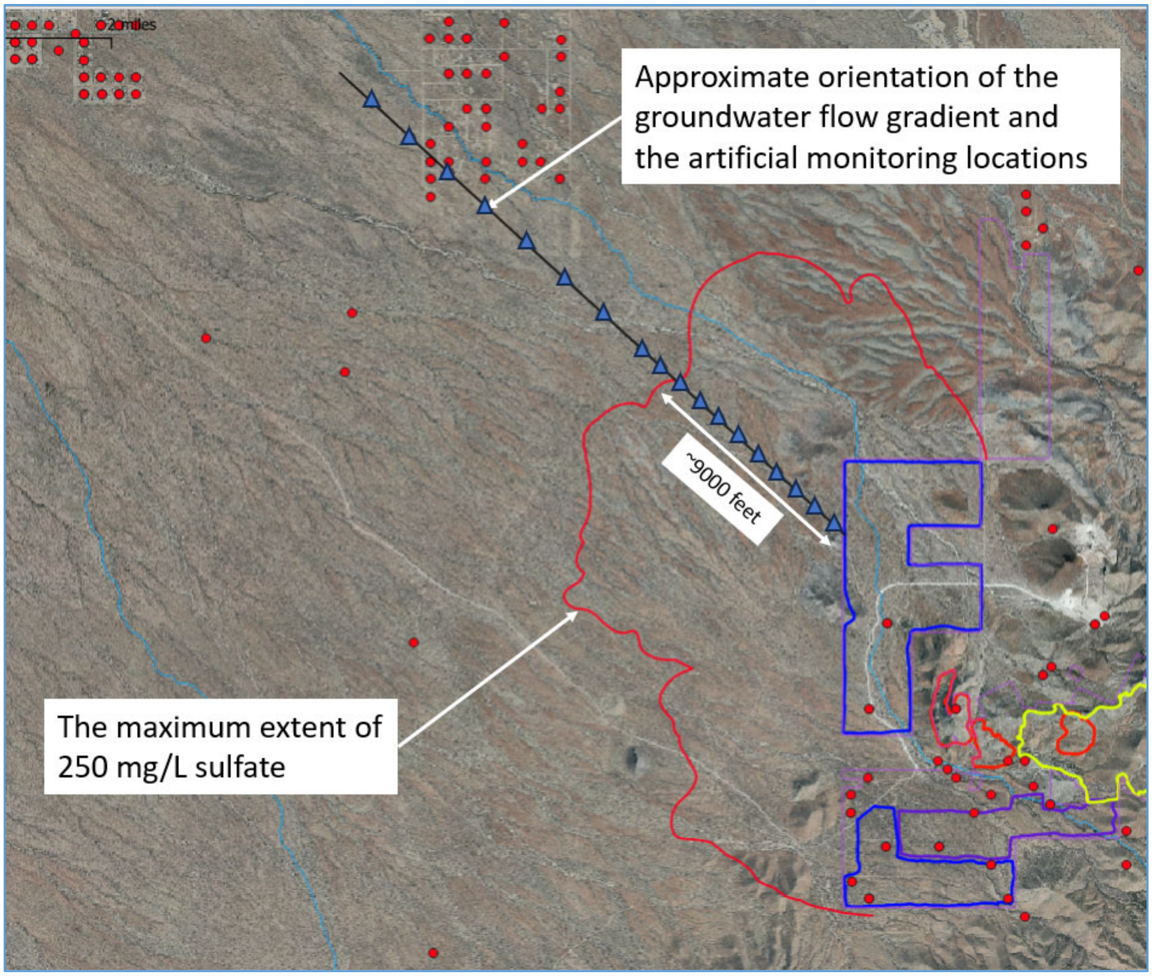

Figure 1. Blue triangle markers along NW line represent artificial monitoring locations for cross section data export. Red circle markers represent ADWR Wells55 database wells.

The model artificial monitoring locations provided the information used to prepare a depiction of the sulfate concentration in cross section (Figure 2). The maximum downgradient length of the extent of sulfate elevated above 250 mg/L is approximately 9,000 ft from TSF-1. This is consistent with the plan view analysis shown on Figure 1.

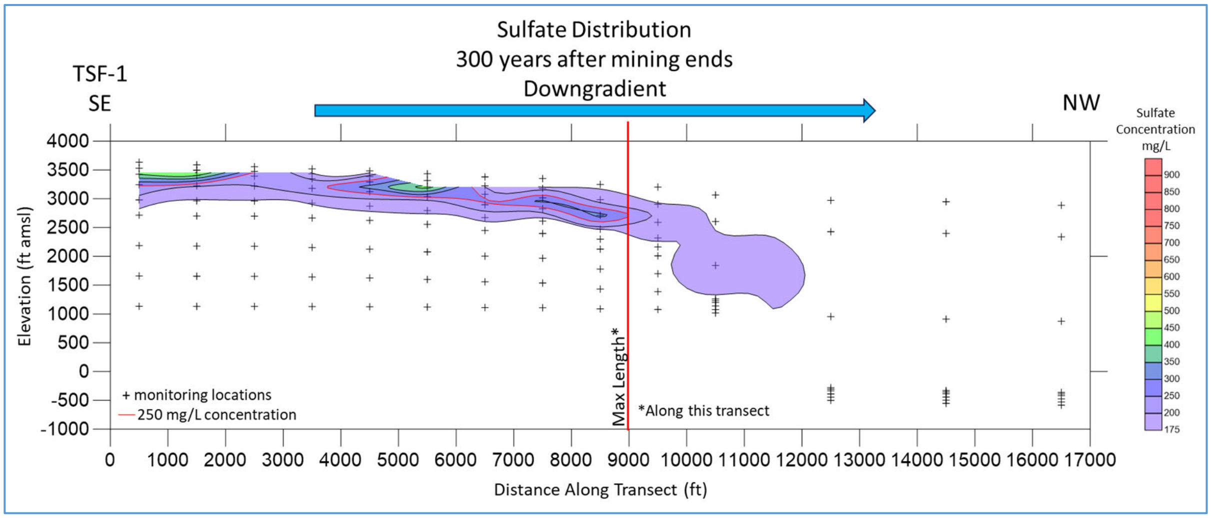

Figure 2.

CONCLUSIONS

Figures 1 and 2 illustrate how a conservative solute such as sulfate becomes diluted during transport. As sulfate from the TSFs moves downgradient via advection (at the speed of groundwater), macrodispersion causes the sulfate to spread. In the horizontal plane, the amount of lateral spreading is over an arc of almost 90 degrees from north to west (Figure 1).

The sulfate also spreads vertically. By 300 years after mining, sulfate concentrations above the background concentration have spread over a vertical depth of more than 2,500 ft (Figure 2).

The Project groundwater model predicts that the maximum extent of sulfate concentrations elevated above 250 mg/L will not transport further than 9,000 ft from the TSFs. As shown in Figure 2, the sulfate elevated above 250 mg/L does not reach residential or municipal drinking water wells.

REFERENCES

Gelhar, L.W., Welty, C. and Rehfeldt, K.R., 1992. A critical review of data on field-scale dispersion in aquifers. Water Resources Research 28.

Piteau Associates, 2022a. Rosemont Copper World Project Geochemical Impacts Assessment. May 2022.

Piteau Associates, 2022b. Rosemont Copper World Project Water Quantity Impacts Assessment. May 2022.

CLOSING

We trust this memorandum is sufficient for your present purposes. Should you require clarification, please contact the undersigned.

Respectfully submitted,

PITEAU ASSOCIATES USA Ltd.

Dwaine Edington, Ph.D.
Senior Hydrogeologist

Reviewed by:

Brian Giroux, P.G.
Senior Hydrogeologist

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