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Draft
South Facilities Groundwater Modeling Studies Work Plan

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Prepared By: Kennecott Utah Copper

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SOUTH FACILITIES
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Introduction

Purpose and Scope of Groundwater Modeling Work Plan

The Groundwater Modeling studies for Kennecott Utah Copper (KUC) Southwestern Jordan Valley (SWJV) flow and transport modeling has been an on-going effort beginning with the South Facilities Remedial Investigation and Feasibility Study (RI/FS). The continuing groundwater modeling objective has been to refine and update the model in order to better reflect subsurface flow. This will result in a more accurate and useful predictive tool, particularly for the Bingham Creek region where contaminated groundwater containment plans are focused. The current model boundary is shown below in Figure 1.

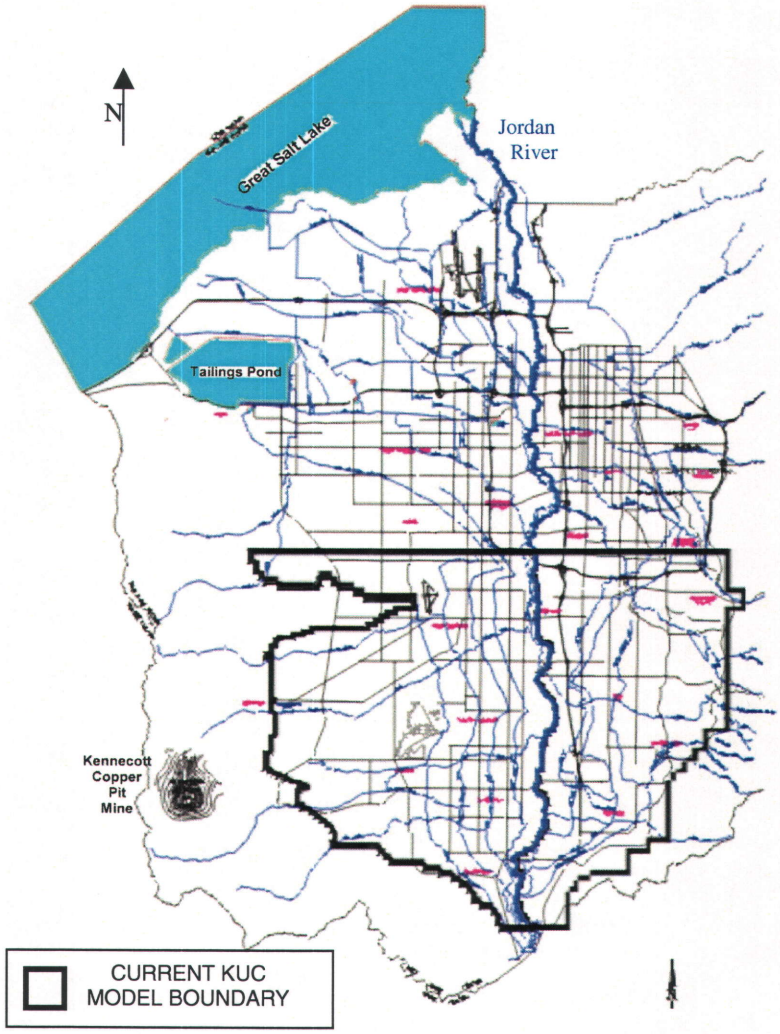

Figure 1. KUC model boundary.

This document supplements the Remedial Design (RD) Work Plan for the groundwater studies and modeling portion of the RD Work Plan. It outlines what has been performed since the RI/FS, what is currently underway, and what is planned for specified portions of the Remedial Design (referred to in Section 3.1.3 of the RD Work Plan).

Additional Studies Section of the FS

As outlined in Section 5.0 of the South Facilities Feasibility Study, the EPA and Technical Review Committee (TRC) recommended that Kennecott gather additional data. The additional data outlined in the FS that falls under the groundwater studies and modeling efforts describe in the Remedial Design Work Plan (RDWP) are:

- Optimization of extraction well placement, design, completion depths and extraction rates, all of which are dependent on aquifer characteristics
- Modification of the Kennecott flow and transport models to address boundary conditions and possible density-driven flow

Specific Items discussed in this Work Plan include:

- Background and Current Model Status
- Model Rediscretization and Recalibration
- Model Sensitivity Analyses
- Density-Modeling Investigations
- Groundwater Modeled Recharge and Injection, and
- Groundwater Extraction Geometry (Including pumping rates and optimization)

The modeling effort is being carried out in close conjunction with the other aspects of the Remedial Design phase such as the Groundwater Monitoring Plan and other related groundwater studies for which the modeling is closely linked.

Background

As part of additional studies related to the Kennecott Utah Copper (KUC) RI/FS and Remedial Design (RD) of groundwater in the southwestern Jordan Valley, KUC has continued optimization of its coupled groundwater flow and transport model. The current modeling has improved analysis of groundwater flow and contaminant migration, including evaluation of (a) water-level trends and (b) containment options for various groundwater response actions.

KUC has made improvements to the original RI/FS flow and transport model used in the RI/FS investigations, including incorporation of a head-dependant (general head) boundary along the western edge of the model, replacing the constant flux boundary used in the original modeling. Also, the eastern model boundary was expanded from the Jordan River east to the base of the Wasatch Mountains. Updated field data are also

incorporated into the current model, as they become available, including updates to water-level data.

KUC's current expanded sub-regional model of the SWJV covers 167 square miles, bounded by the Oquirrh and Traverse mountains (on the west and south, respectively) and by the Wasatch mountains and approximately 6000 South street (on the east and north, respectively). The model contains a grid of 94 rows and 136 columns, with variably sized cells, and eight vertical layers.

Current KUC Model

The current SWJV flow and transport model is being updated using the Groundwater Modeling System (GMS) software developed at Brigham Young University. GMS was selected for its pre- and post-processing functionality and its compatibility with the previous KUC models generated using MODFLOW. Incorporation of the KUC flow and transport model together with the USGS local models (and eventually the Oquirrh Mountain block model) will provide greater workability and a more robust interface between the individual groundwater models.

As mentioned, the current SWJV model covers a 167 square mile area from the bases of the Oquirrh Mountains to the Wasatch Mountains and from approximately 6000 South on the north, to the northern base of the Traverse Mountain Range on the south. For the RD optimization investigations, a rediscretized sub-regional model will be created within the greater SWJV model. The focus area will center on the Bingham Creek groundwater plume and include other important regions of interest. Figure 2 shows the area of the proposed sub-regional model.

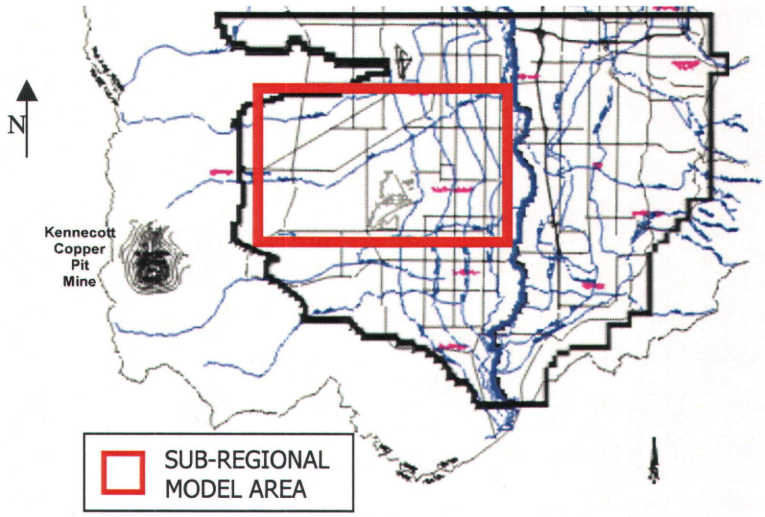

Figure 2. Proposed sub-regional model area.

This model is expected to greatly improve the flexibility and focus of the projected well geometry, extraction optimization, and the density-driven flow aspects of the project (if density effects are deemed necessary following evaluations). By creating the new sub-regional model, KUC can incorporate greater model detail and control, including smaller and more manageable cell sizes to better mimic and predict pumping (and if needed, injection) schemes.

KUC has completed initial modeling studies concerning bedrock influx along the western general head boundary. The model boundary as defined by KUC modeling was found to be consistent with United States Geologic Survey (USGS) modeled estimates based on their regional valley model. However, evaluation of bedrock flows along the Oquirrh range has recently been revisited by KUC. Model-estimated heads and conductance values are being reevaluated along the Oquirrh Mountain boundary region to control the likelihood of over-prediction for valley recharge via bedrock inflow. This investigation is still underway. Based on results to date, it is believed that a reduction of inferred inflow along some or all of the portions of this boundary will be needed to more accurately predict drawdowns, though the amount of such reductions has not yet been determined. A complete summary of the investigation and conclusions is expected to be included as part of the formal sensitivity analysis and modeling report.

Sensitivity Analysis

A more formal and extensive sensitivity analysis of modeling parameters will be performed with the current SWJV model (and for the later rediscretized model as well). This task is a priority, planned for completion in the next few months so that knowledge of the parametric sensitivity can be used throughout the rest of the field and modeling studies efficiently.

Investigation of the use of MODFLOW 2000 code is also underway for aiding in the sensitivity analysis. It is understood that MODFLOW 2000 contains improved sensitivity and parameter estimation functionality over previous versions. However, GMS is currently incompatible with MODFLOW 2000 and is not expected to be upgraded for such until after the fall of this year. It is likely that the priority sensitivity analysis will be conducted using the current MODFLOW 96 code in conjunction with the GMS software package, and KUC considers that this will provide completely satisfactory results for this stage of the RD process.

Findings of the formal sensitivity analysis will be outlined in a separate report and provided for interested parties. Possible improvements that may be incorporated into the newer, rediscretized modeling effort based on the sensitivity analysis would be discussed with the TRC and reviewed prior to incorporation of any such changes into the on-going modeling studies for the rest of the RD/RA process.

Sub-Regional Model

In order to better plan and optimize well-pumping rates and locations for containment, as well as to more accurately represent (and predict) plume movement, KUC is creating a sub-regional model (from the current SWJV model) for incorporation into GMS (as shown in Figure 2). The current SWJV model is approximately 70% converted into the GMS system, and it is expected that the creation of the sub-regional model will begin either concurrently with or immediately following the formal sensitivity analysis of the current SWJV model.

Along with rediscretization of a more focused sub-regional model, KUC will recalibrate and analyze parametric sensitivity of this new model. Results of these calibration and sensitivity analyses would be included in a separate modeling report upon satisfactory completion of these tasks.

Density Modeling Investigations

Some reviewers of the modeling in the RI suggested that prediction of the highly acid portion of the Bingham Creek groundwater plume would be more accurate with the use of a modeling code (such as the finite-element based FEMWATER) that could address density. If density effects were significant, then better plume predictions could lead to better plans for plume containment and optimization strategies during the RD phase.

Incorporation of the FEMWATER modeling code for inclusion into the GMS modeling is being investigated with the current SWJV modeling. Initial investigations found that the timetable for the process of incorporating this code would be quite extensive, and, for most of the model domain, density effects are not expected to be discernible because of relatively low TDS values in the groundwaters. The initial investigations were not definitive, and it is expected that incorporation of FEMWATER in conjunction with GMS into a better-refined sub-regional model might provide a better understanding of plume behavior in the hydrogeologic system. This strategy seems logical because it is only the acidic plume that has dissolved solids concentrations high enough that density effects could be important. A complete summary and analysis on the usefulness of this approach, pertaining to the RD modeling process, will be prepared and included within the aforementioned modeling report.

Groundwater Injection Studies

Previous investigations concerning the possibility of incorporating groundwater injection into the remedial strategy and design have been done using the current SWJV model. A modeling report was prepared about these modeling scenarios ("Additional Modeling Studies for Plume Containment in Southwestern Jordan Valley, Utah"). A summary and presentation about these studies was provided for the South Facilities TRC in June of 1999 by KUC, and the report was submitted to the members present at that meeting.

Additional groundwater injection scenarios are planned for the on-going KUC modeling, especially as West Jordan City continues with plans to incorporate groundwater injection as part of its future plans concerning the local municipal water extraction. Groundwater injection may be a viable hydraulic option for aiding in the Bingham Creek sulfate plume containment. Further investigations concerning the possibility of incorporating injection wells (investigating logistics, rates, placement, etc.) are on going. Regional and local hydraulic impacts from such injection would likely be better quantified using the rediscretized sub-regional model as well as the current SWJV model. Investigations and additional modeling will likely be summarized and provided in a stand-alone report separate from the previous studies. KUC understands that there are other, water-quality and regulatory issues concerning injection that the RD program also would need to address if the KUC were to propose injection as part of its Remedial Design. However, a meaningful discussion of potential injection scenarios cannot be initiated until additional technical studies are completed.

Summary

The following is a summary of the reports and/or deliverables to be expected concerning the Groundwater Modeling Studies portion of the RD:

Task	Anticipated Timing	Provisional Report Title
GMS Model Incorporation	Third Qtr 2001	"KUC Flow and Transport Model Modifications and Updates"
Model Rediscritization and Recalibration	Fourth Qtr 2001	(same as above)
Density-Driven Flow Assessment	First Qtr 2002	(same as above)
Sensitivity Analysis	Fourth Qtr 2001	"Sensitivity Analyses of the Modified KUC Southwestern Jordan Valley Model"
Groundwater Injection Assessment	Fourth Qtr 2001	"KUC Assessment of Groundwater Injection in the Southwestern Jordan Valley, Utah"

Upon completion, these reports will not only satisfy the groundwater modeling elements identified in the RD Work Plan, but also will respond to all of the outstanding groundwater modeling issues identified in the FS.