Appendix 1: List of Attendees

George	Alexander	NRC
David	Esh	NRC
Alec	Hillier	NRC
Ron	Linton	NRC
Jane	Marshall	NRC
Melanie	Wong	NRC
Bill	Von Till	NRC
Sai	Appaji	EPA
Mark	Purcell	EPA
Milovan	Beljin	EPA (Contractor)
Lee	Rhea	EPA (Contractor)
Randall	Ross	EPA (Contractor)
Corey	Dimond	NMED
Miori	Harms	NMED
Amber	Rheubottom	NMED
Brinson	Willis	NMED
Nicole	Olin	DOE
Jennifer	Graham	DOE (Contractor)
Ray	Johnson	DOE (Contractor)
Al	Laase	DOE (Contractor)
Peter	Schillig	DOE (Contractor)
Corey	Wallace	DOE (Contractor)
Adam	Arguello	HMC/Barrick Gold
Brad	Bingham	HMC/Barrick Gold
Eric	Burch	HMC/Barrick Gold
Daniel	Lattin	HMC/Barrick Gold
Charles	Andrews	HMC (Contractor)
Marinko	Karanovic	HMC (Contractor)
David	Levy	HMC (Contractor)

Appendix 2: Comments

By letter dated October 28, 2024, the U.S. Nuclear Regulatory Commission (NRC) staff, in coordination with the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and New Mexico Environment Department (NMED)[1], agreed to conduct an audit of Homestake Mining Company of California (HMC's) groundwater model (ML24176A247), submitted as part of HMC's 2022 Alternate Concentration Limit (ACL) License Amendment Request (LAR) (ML22263A299). The agencies developed an audit plan consistent with NRC's Licensing Process 111, Rev. 1 Regulatory Audits (ML25031A057) which included the objectives of the audit. The audit plan also called for a summary report to be prepared at the conclusion of the audit.

The agencies highlighted three central issues related to the protection of public health and the environment: (1) characterization and release of the source term, (2) saturation conditions in the alluvial aquifer, and (3) attenuation of contaminants in the alluvial aquifer. Specifically, the audit team's discussion focused primarily on the following areas:

i. Site Characterization
ii. Model Construct
iii. Boundary Condition
iv. Model Calibration
v. Conceptual Model
vi. Future Scenarios
vii. Model Validation/Model Confidence Building Activities

Site Characterization

1. **Comment:** The audit team noted that: (1) potentially greater contaminant fluxes from the Large Tailings Pile (LTP) are possible, (2) increasing concentrations, even concentrations that do not reach pre-flushing conditions, could be risk significant; and (3) HMC's Bounding Case, which assumed a uranium concentration from the LTP of 45 mg/L, does not account for potential future conditions (see Comments 13 and 36) and therefore, limits risk insights.

   In the Baseline Case, the drain down model (DDM) predicts that the long-term uranium concentration in the LTP will be approximately 5.34 mg/L. HMC conducted a Seepage Only sensitivity analysis from the LTP (Figure 4-13 in the 2022 ACL LAR), which showed minimal groundwater impacts at 200 years. Accordingly, HMC concluded, "(t)hese results indicate that seepage from the LTP at the baseline DDM seepage rates and concentrations is not predicted to be a significant contributor of uranium mass to the alluvial aquifer in the future." However, the audit team commented that higher contaminant concentrations coupled with potential saturation of the alluvial aquifer could be risk significant and are not fully evaluated by the groundwater model.

[1] NRC, DOE, EPA, and NMED are collectively referred to in this document as the agencies or audit team.

HMC relied upon a 2012 Arcadis study and a 2020 Worthington Miller Environmental study, in conjunction with the groundwater model (see Section 2.1.1.4 of the 2022 ACL LAR), to conclude that no future significant diffusive mass transfer and subsequent rebound of constituents are expected to occur.

For the Arcadis Study, the audit team noted that areas with lower permeability within the LTP were less likely to have been flushed and may have relatively high contaminant concentrations, which could result in diffusive rebound. The audit team further noted that although rebound may be slow, there is potential for rebound to occur and be risk significant over the long regulatory timeframes.

For the 2020 Worthington Miller Environmental Study, the audit team noted that the assumed uranium concentration of 5.34 mg/L may not be representative of the LTP due to heterogeneity of the tailings observed during tracer testing (ML13345A256) and potential dilution due to the flushing program. In addition, the audit team noted that several different methods indicated higher uranium concentrations - slimes samples from Selective Sequential Extractions were potentially greater than 100 mg/L, Humidity Cell Testing results were approximately 40 mg/L, short-screen wells were approximately 20 mg/L, and static column were approximately 30 mg/L. These values are all significantly greater than the values used to calculate the 3.31 mg/L average for the slimes component of the LTP in the DDM.

The audit team also referenced HMC's 2023 Annual Monitoring Report where recent data from HMC's 2023 Annual Monitoring Report sumps and alluvial wells beneath the tailings appear to indicate increasing trends in contaminant concentrations beyond what would be expected for natural variability. These monitoring locations would appear to represent composite samples. If rebound is not occurring, it is not clear to the audit team what would cause increasing trends. For example, several sumps (i.e., East 1, East 2, North 1, South 1) appear to have increasing trends in U concentration and several alluvial wells beneath the tailings (i.e., wells B11, DV, DZ, M3, SUR, S5/SR5, and T19) have increased significantly since 2015.

HMC Discussion

In response to the comment, HMC noted that:

a. Volume-weighted average concentration of LTP porewater was based upon>1600 water quality samples of wells and sumps, and concentration of flushing water over a period of 20 years and is considered most representative of the entire LTP.
b. The agencies comparison of Selective Sequential Extraction solid phase concentrations and humidity cell mass per mass cumulative release to LTP solution concentrations is inappropriate given the differing units amongst these three concentrations.
c. A multi-faceted approach was used to evaluate the potential for rebound in the tailings pile, including (1) LTP average concentrations, (2) LTP sumps, (3) former LTP

rebound monitoring wells, (4) new LTP short screen wells, and (5) LTP static column study.

d. Trends in the sumps noted above showed a general decreasing trend and one has been relatively stable over the last 15 years.
e. There was no indication of LTP-wide diffusive concentration rebound overall.
    a. Stable or decreasing concentrations in short-screen wells
    b. Diffusive rebound not observed in static columns
    c. Average and volume-weighted average concentrations of U, Mo, and Se have been decreasing since flushing ceased

Potentially Acceptable Approaches

HMC's approach could evaluate the potential for greater-than-assumed seepage of contaminants from the LTP in the Baseline case and assumptions in the Bounding Case (e.g., drying conditions that stop plume migration) that limit the usefulness of that sensitivity analysis. The following sensitivity case with consideration of both NRC and NMED/EPA background values could address this issue:

i. An LTP source term bounding evaluation of uranium concentration of 45 mg/L with 2.4 gpm of infiltration,
ii. An Small Tailings Pile (STP) source term evaluation of uranium solubility consistent with Comment 2 below (i.e., including the salt inventory and solubility from (Evaporation Pond) EP-1, EP-2, and EP-2) and a commensurate infiltration rate based on the 40-acre STP, which would be approximately 0.5gpm, and
iii. A period of saturated alluvium, potentially due to natural and/or anthropogenic sources

2. **Comment:** The audit team noted that the Small Tailings Pile (STP), with the contamination from the evaporation ponds (e.g., more than 800,000 pounds of uranium), is not included as a source term in the groundwater model. The STP has a smaller footprint, has limited saturation in the tailings, and is planned to be covered with an evapotranspiration (ET) cover. However, the audit team noted the significant contaminant mass that will be placed in EP-1 from the other evaporation ponds, the solubility of those contaminants (e.g., HMC's semi-annual reports show that uranium concentrations in EP-3 can reach 1,000 mg/L), and the potential for infiltration through ET covers, even if that infiltration is limited.

    HMC Discussion

    Homestake discussed that the smaller areal extent of EP-1, the lack of saturation in the tailings themselves and the ET cover will limit its risk significance.

    Potentially Acceptable Approaches

    HMC's revised groundwater model could include the STP as a source term, which may reduce uncertainty in assessing the long-term performance of the site.

3. **Comment:** The audit team questioned the risk significance of back diffusion from low permeability zones as HMC is currently characterizing these zones in the Dual Domain

Investigation[2]. The audit team questioned what data are available to justify the conclusion that back diffusion from the dual-porosity immobile domains in the aquifer are significant contributors of future uranium mass in the aquifer whereas the forward diffusion from saturated slimes of much higher concentration, volumes, and surface areas are not a significant contributor to future uranium mass in the aquifer.

HMC Discussion
HMC noted that the model is being revised and is expected to include updated secondary source-term characterization and parameterization of the low permeability zones and back diffusion from the Dual Domain Investigation.

Potentially Acceptable Approaches
Staff will review the revised model and supporting data, which could address this issue. Additional information on the comparison of the measured diffusion coefficients of each material, the estimated concentration of uranium in each material, and the relevant surface areas and volumes could help reduce uncertainty.

4. **Comment:** The audit team discussed with HMC the potential contaminant plume migration and assumed attenuation.

HMC Discussion

During the audit, HMC provided additional information regarding the observed decrease in contaminant concentrations. As shown in Figure 1 below, HMC discussed the observation of uranium concentration decreasing by approximately 4 orders of magnitude from beneath the LTP to the distal ends of the plume. HMC discussed that they believe this observation cannot be adequately explained by dilution or dispersion. HMC also discussed and presented that the slope of concentration vs. distance remains nearly constant downgradient of the hydraulic barrier regardless of the time period evaluated, indicating that site activities may not be the primary driver in the observed concentration decreases with distance from the pile.

---

[2] The Dual Domain Investigation is being conducted to characterize the physical and chemical properties of the immobile and mobile zones of the alluvial aquifer to better understand the potential for the silt and clay lenses to act as a secondary source term.

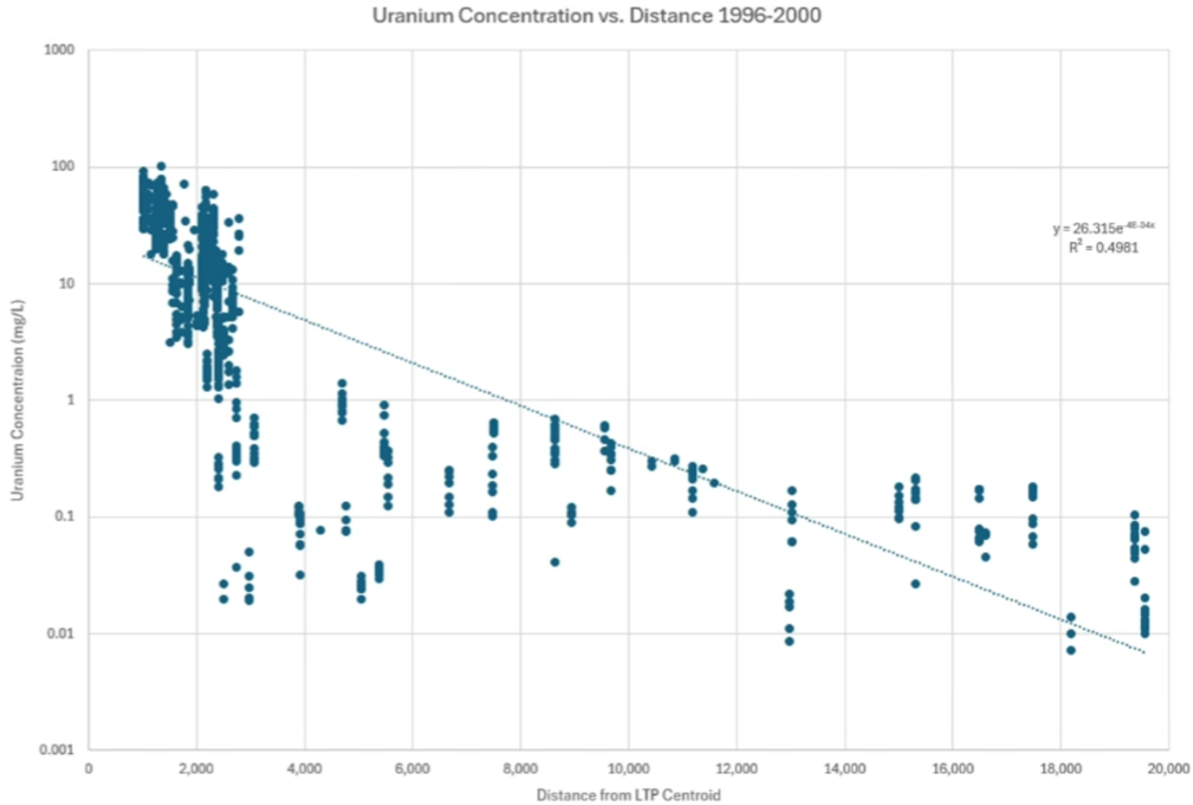

Figure 1 . Observed uranium concentration along primary flow path

The audit team noted that Figure 1 appears to show different mechanisms resulting in contaminant attenuation. First, there is a grouping of monitoring data with elevated concentrations in the vicinity of the LTP followed by a second grouping of monitoring data with a decreased slope. This is shown in Figure 2 by the separation of data points approximately 3000 ft downgradient from the LTP centroid. The audit team hypothesized that this decrease in uranium concentrations is due to plume cutoff from the hydraulic barrier in the immediate vicinity of the LTP followed by a more gradual attenuation of uranium downgradient from the hydraulic barrier. Staff noted that the historic attenuation of approximately 3 orders of magnitude observed in the vicinity of the LTP will not be nearly as significant without the ongoing corrective actions. In other words, without corrective actions, the plume could migrate at elevated concentrations (i.e., the plume could migrate at concentrations greater than currently observed). The audit team also noted that some of the apparent attenuation may be due to the center of mass of the plume having not yet reached the subcrop area. The audit team asserted this is consistent with monitoring well data (e.g., wells 553, 554, 649) in the vicinity of subcrop area recently showing increasing contaminant concentrations. HMC noted that of these three wells, only 649 had recent data more recent than 2017, and it showed a generally stable trend over the last decade. HMC also noted that wells with more recent data in the general vicinity showed either a decreasing or stable trend over the last decade as well.

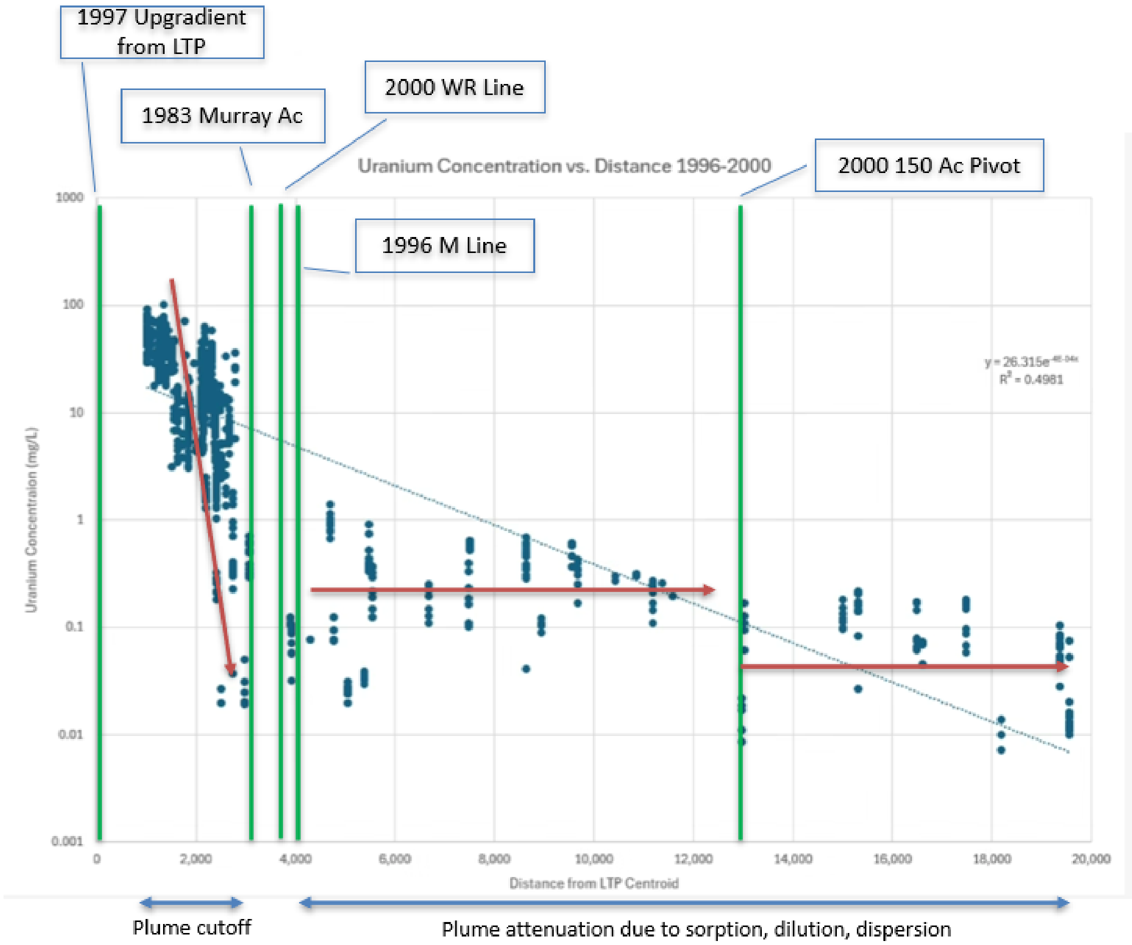

Figure 2. Observed uranium concentration along primary flow path with location and timing of restoration activities

Potentially Acceptable Approaches

The audit team noted that the compilation of uranium concentration monitoring data is informative; however, more information and insights may be required to understand the mechanisms for the observations. The proposed ACL LAR review is expected to include a revised groundwater model and the staff will evaluate support for key assumptions. Additional information could help reduce uncertainty in contaminant transport, including:

- Evaluation of monitoring data for conservative analytes (e.g., sulfate, Total Dissolved Solids [TDS], chloride) could provide insight into mechanisms responsible for attenuation. For example, the difference in attenuation between conservative analytes and uranium could help differentiate between attenuation mechanisms such as sorption. Also, analysis of these conservative analytes could provide insight into the effects of dilution due to injection in the land application areas as uranium was sorbed in the soil column unlike these conservative analytes.
- Ongoing monitoring and evaluation of analytes along the flow path with decreasing groundwater corrective actions will provide direct evidence of attenuation and potential rebound.

Model Construct

5. **Comment:** The audit team noted that it was unclear how the thickness of the alluvium (i.e., layer 1) was determined. There is significant spatial variability in the thickness of the alluvium across the model domain, ranging from as little as ~5 feet to over 200 feet. It is known from monitoring well logs in the vicinity of the Bluewater Disposal Site that the thickness of the Rio San Jose alluvium beneath the Bluewater site ranges from 5 – 25 feet, but the thickness of the alluvium in that area within the model ranges from 22 – 138 feet. The alluvium also thins significantly around the perimeter of the HMC well field (i.e., ~75 feet to ~25 feet northwest of the HMC site). Because the thickness of the alluvium is a strong control on the extent of saturation, its spatial variability is important. Presumably the top elevation of the model domain was assigned using a Digital Elevation Model, so it appears that the bottom surface of the alluvium controls the thickness. The audit team questioned what data was used to inform the elevation of the bottom of the alluvium.

   HMC Discussion
   HMC noted that the elevation of the base of the alluvium was derived from all of the borings at the Site, the Bluewater Site and the San Mateo investigations that penetrated the thickness of the alluvium. This will be noted in revised model report with a map of elevation of base of alluvium, a map of alluvial thickness, and a map of alluvium plus overlying basalt thickness.

   Potentially Acceptable Approaches
   Pursuant to the expected, revised model, discussion of the data relied upon to determine the thickness of the alluvium would be helpful.

6. **Comment:** The audit team commented that it is unclear why powellite dissolution was not included in the 2022 groundwater model. Precipitation of powellite ($CaMoO_4$) below the LTP is indicated (Figure 18 in Worthington Miller Environmental Sept. 2020), which reduces the mobility of molybdenum. As the tailings drain down, the geochemistry of the water contacting the precipitated powellite changes, which can result in the dissolution of powellite (depending on the geochemical changes) and release molybdenum to the groundwater.

   HMC Discussion
   HMC presented information during the meeting to demonstrate that dissolution of powellite in the future would not result in an increase in Mo concentrations. A technical memorandum on powellite precipitation and dissolution will be included as an appendix to the updated groundwater modeling report

   Potentially Acceptable Approaches
   The technical memorandum on powellite precipitation and dissolution may address this issue.

7. **Comment:** The audit team noted that the predictive model fixes the Rio San Jose General Head Boundary (GHB) head at 6532.605 ft Above Mean Sea Level (AMSL), which prevents further groundwater decline in this area.

   HMC Discussion
   HMC noted that the GHBs in the San Jose Alluvium were specified based on water levels in well E(M) and Y2(M). Water levels in these wells, based on monitoring data, have been stable over last decade as the saturated alluvium is very thin.

   Potentially Acceptable Approaches
   The updated model could allow for a transient decline in GHB heads over time rather than keeping them fixed, ensuring that the predicted hydraulic gradients driving uranium migration are realistic. Additionally, alternative boundary conditions could be tested to confirm that the assumed GHB setup does not artificially restrict contaminant movement. HMC's approach could consider this issue to support the staff's review of the revised model.

8. **Comment:** The audit team noted that the existing model's Horizontal Flow Barrier package represents horizontal fault impermeability where layers are offset but may overlook vertical flow along fault zones. This omission could affect the migration of contaminants as faults may allow vertical flow that the current model does not account for.

   Regarding the accuracy of the model's representation of the faults, during the review of simulated groundwater elevations near the LTP, several locations were identified where residuals reached tens of feet. This suggests that the model has difficulty accurately representing flow dynamics in that area. This issue was especially notable to the east of the LTP, near one of the faults, indicating that an unaccounted-for aspect of the flow dynamics may be influenced by the fault system.

   HMC Discussion
   HMC noted that it does not have information to indicate that what is being modeled is incorrect. HMC discussed that monitoring data do not support the hypothesis that the faults provide increased hydraulic conductivity nor transport across them. If the faults conducted vertical flow, the heads in these formations would show that hydraulic connection. If the vertical flow was significant, increases would be seen in hydraulic response of site activities and would show transport of contaminants in the Middle Chinle from the overlying formations. The observed increase in mass in the Upper Chinle aquifer is due to it being in direct hydraulic connection with the alluvium above it at the subcrop beneath the LTP. HMC noted that past modeling efforts at the site, the treatment of faults as low permeability features results in simulation of appropriate water levels and contaminant transport behaviors in the Chinle water-yielding units.

   Potentially Acceptable Approaches
   The audit team notes that the updated model could evaluate the sensitivity of model predictions by reassessing fault hydraulic conductance, incorporate vertical flow pathways, and determine if the model should be updated.

9. **Comment:** The existing predictive model assumes a fivefold increase in pumping in the San Andreas Glorieta aquifer (SAG) over 1000 years, but the audit team notes that it may not fully assess how this affects inter-aquifer flow or uranium migration.

   HMC Discussion
   HMC noted that the basis for the increase in pumping was to account for future population growth. HMC discussed incorporating a similar future pumping scheme in the revised model and a sensitivity analysis with increased saturation in the alluvium.

   Potentially Acceptable Approaches
   The audit team notes that the updated model could test the impact of pumping on vertical gradients and uranium migration to ensure lateral contamination spread is accurately presented. HMC's approach in the updated version of the model and the sensitivity analysis could resolve this issue.

10. **Comment**: The audit team questioned how effectively porosity is assigned and scaled in MODFLOW-USG by the dual-domain porosity approach. The fraction of the total space occupied by the mobile domain is denoted as PHIF in MODFLOW-USG. The Block Centered Transport file currently assigns an effective porosity of 1 to the SAG, which is then adjusted using PHIF to determine mobile porosity rather than explicitly defining total and mobile porosity values. This approach forces all corrections into PHIF, potentially underestimating mass transfer between mobile and immobile zones, which could lead to underprediction of uranium back-diffusion from low-permeability units.

    HMC Discussion
    HMC is revising the groundwater model with updated data from the Dual Domain Investigation.

    Potentially Acceptable Approaches
    The updated model could ensure that total porosity values are reasonable and evaluate whether mass exchange rates properly capture slow uranium release from immobile zones.

Model Inputs

11. **Comment:** The audit team noted that the assumed "time-zero" uranium concentrations in the immobile domain may not be adequately supported as a model input.

    Back-diffusion from the immobile domain to the mobile domain is assumed to be an ongoing uranium source term. The uranium concentration in the immobile domain was initially calibrated using analytical data and interpreted contours from 1980s/1990s datasets. Input concentrations for the predictive model used final output from the 2019 calibration model.

    HMC Discussion
    HMC is revising the groundwater model with updated data from the Dual Domain Investigation.

Potentially Acceptable Approaches

Model revisions, including surrounding source term characterization and model implementation, could address the issue.

12. **Comment:** The audit team commented that it is unclear how much anthropogenic activities contributed to the saturation of the alluvial aquifer in the vicinity of the Grants Reclamation Project.

HMC Discussion

Homestake presented additional information regarding historic anthropogenic activities that resulted in increased saturation of the alluvial aquifer. Based on information from Gallaher and Cary (1986), approximately 128 billion gallons of water were discharged from upgradient mines in the Ambrosia Lake region, most of which never made it past the confluence of Arroyo Del Puerto and San Mateo Creek based upon U.S. Geological Survey (USGS) stream gauge data from the 1970s. Figure 3 below shows the location of historic irrigation in the Bluewater-Toltec District[3] and Figure 16 from Frenzel (1992) estimates 163 billion gallons of irrigation water was applied since the early 1900s in the vicinity of the Homestake site. HMC presented historic stream gauge data from the Rio San Jose at Anzac, demonstrating the observed declining water level trend is not a site-specific observation and consistent with hydrologic data in an area distal to the site. HMC presented data from the neighboring Central Study Area drilling program which found no saturation in the alluvium upgradient of the confluence of Poison Canyon and the San Mateo Creek drainage indicating upgradient flow will continue to diminish with time.

[3] Outline is based on HMC's interpretation of historic areal pictures and quadrangle maps from USGS-delineated irrigation ditches

Figure 3. Historic Bluewater-Toltec District irrigation

Potentially Acceptable Approaches
The additional information on historic anthropogenic activities contributing to alluvial saturation, information about State of NM laws limiting similar future activities (e.g., over-allocation of water rights in the Bluewater Basin, piping of future potential mine-water discharge) coupled with updated model parameterization (e.g., recharge, climate) for the base case and a sensitivity case providing risk information for a scenario with a period of saturated alluvium may address this issue.

13. **Comment:** The audit team noted that additional support could help with understanding the immobile domain porosity values, which were set as a fraction of the total porosity.

HMC Discussion
HMC discussed that they will select effective porosity values for immobile and mobile domains based on characteristics of sediment/bedrock in the respective domains and provide justification.

Potentially Acceptable Approaches
HMC's revised approach to immobile domain porosity values could address this issue.

Comment: The audit team commented that the assumed bulk density values used in PHREEQC (1.86 g/cm³) and MODFLOW (2.12 g/cm³) are inconsistent with the model Calibration Report. The audit team further discussed that this could lead to a possible overestimation of sorption and retardation in the transport model. Because uranium migration is significantly influenced by sorption behavior, using a higher bulk density in MODFLOW than in PHREEQC may artificially increase the calculated retardation factor, slowing the transport of uranium more than it should. This could lead to an underprediction of uranium plume migration distances. The updated model could ensure bulk density values are consistent across PHREEQC and MODFLOW or adjust the Freundlich partition coefficient accordingly if different values are used to ensure that uranium mobility is not underestimated.

HMC Discussion
HMC discussed that they recognized the inconsistency between PHREEQC and MODFLOW-USG parameters and plan to address it in the model revision or explain why it is not risk significant.

Potentially Acceptable Approaches
HMC's approach to this issue in the model revisions will be a part of staff's review.

Boundary Conditions

14. **Comment**: The audit team questioned what assumptions affect saturation in the alluvial aquifer (e.g., precipitation, recharge percentage of precipitation, recharge to other Chinle Aquifers, well pumping).

Each climate scenario assumed a consistent drying in the current multi-decade window. The simulated drying of the alluvial aquifer, which slows and then stops the transport of contaminants to the Milan water sources, is primarily a function of the water inputs to the system and not the groundwater model construction and calibration.

The audit team questioned the sawtooth precipitation pattern assumed in the 2022 ACL LAR. By alternating between wetter and drier periods, the impact of long-term moisture balance changes cannot be assessed. Actual measurements from approximately the past thirty years show no change in trend of long-term annual precipitation even with the increases in temperature.

The climate change modeling forecasts are only valid for a maximum of 100 years whereas the simulations, with a key driver being precipitation input, are needed for 1000 years.

HMC Discussion
Homestake noted that they are revising the model and are expected to include updates to the climatic data.

Potentially Acceptable Approaches
Regarding climate change modeling forecasts, the range of climate inputs could be much broader to encompass sources of uncertainty. The climate in the simulations could mimic historical observations and be generated stochastically (probabilistically) because historical data shows five-year precipitation can range from approximately 10% to 200% of average five-year precipitation. Overall, HMC is revising the model, expecting to include climatic data

which could address this issue. The model revisions and technical bases for key assumptions will be reviewed by staff.

15. **Comment**: The existing model's seepage rates are based on the DDM, which uses historical data but does not incorporate field-measured rates or spatial variability in drainage behavior. The audit team questioned why the actual spatial distribution of uranium and molybdenum concentrations are not used instead of averaging the concentrations across the LTP footprint. In addition, there does not appear to be any contaminant concentrations added to recharge below the STP.

The uranium and molybdenum concentrations in recharge to groundwater below the LTP are spatially assigned as one average concentration (albeit variable with time). Through 2019, actual uranium and molybdenum concentrations in tailings wells are available (see Figure 46 for uranium in Worthington Miller Environmental 2020).

HMC Discussion

Homestake presented draindown model predictions developed in 2018 with the observed flowrates from the LTP sumps through 2025 (see Figure 4) and stated that the data demonstrates the model is providing a reasonable estimation of draindown of the LTP.

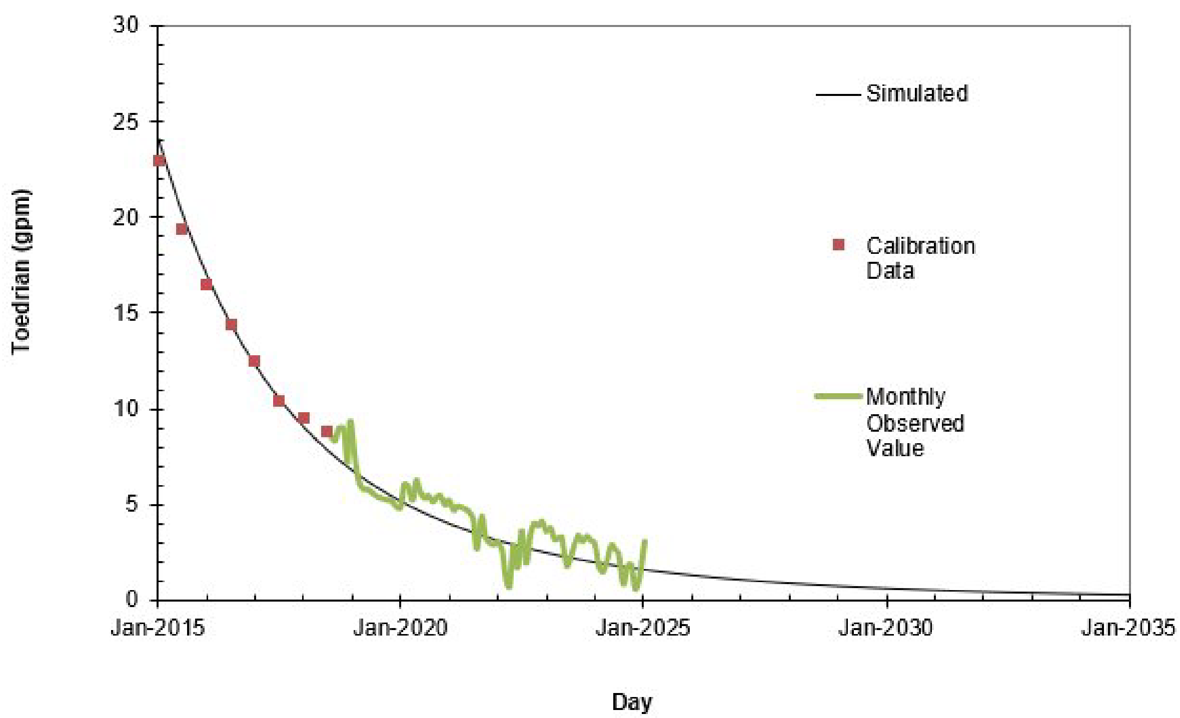

Figure 4. HMC's LTP Draindown Model calibration, prediction, and observations

In addition, HMC noted that they are revising the model and expect to incorporate updated estimates of recharge through the LTP based upon the unsaturated flow modeling done in support of the Evapotranspiration Cover Design Report. HMC noted while spatial variability of concentrations in the LTP could be used to spatially vary the source term, given the tortuous flow path from the bottom of the LTP to the saturated alluvium at any given point, the exercise would likely yield little value in long-term predictions of the site.

Potentially Acceptable Approaches
The updated model could refine seepage estimates using site-specific data, account for differences between slimes and sands, and test for potential higher mass loading scenarios. HMC's approach to this issue in the model revisions will be a part of staff's review.

16. **Comment**: The audit team noted that groundwater recharge was set at 3% of precipitation throughout most of the San Mateo Basin, as discussed in the model calibration report. The audit team commented that an average recharge rate may be representative of bulk groundwater recharge on a regional scale. However, preliminary visual analysis of evapotranspiration rates around the LTP shows significant spatial variability that would likely influence recharge patterns and alter localized groundwater flow patterns.

HMC Discussion
Homestake discussed a recent USGS (2023) study that showed an average annual recharge of 1.2% across the Rio San Jose Basin with a specified recharge rate of 0% for the San Mateo Creek Basins where the site resides. Homestake also presented the results of a estimation of recharge for the state of New Mexico which showed less than 2% of recharge in the area of the site and the assumptions for recharge (0.62-0.75 percent) used in the Intera 2018 Model Update for the Ambrosia Lake Facility Homestake is revising the model using updated estimates of groundwater recharge.

Potentially Acceptable Approaches
HMC is revising the model, including climatic data which could address this issue. The audit team discussed the potential use of a separate model (e.g., UNSAT-H), which may be a suitable model for estimating recharge. In addition, HMC could consider accounting for local recharge variability in the vicinity of the LTP, as this area affects plume migration. The model revisions and technical bases for key assumptions will be reviewed by staff.

17. **Comment:** The audit team commented that the use of GHBs in the first stress period to establish initial conditions appears to be reasonable to account for historical mining-related impacts, but there is potential for localized discrepancy in head distribution in cells where the GHB and recharge boundaries overlap. If the assumed GHBs impose heads that deviate significantly from what would occur naturally under recharge-only conditions, the transient simulation may carry forward artifacts from these imposed heads. The degree of this impact would depend on the system's ability to equilibrate under natural boundary conditions.

HMC Discussion
Homestake discussed that they may change the extent of the domain in the updated model, which would remove these GHBs.

Potentially Acceptable Approaches

To validate the approach, sensitivity analyses could help assess how variations in GHB elevations and conductance during the initial stress period affect the transient simulation results. HMC's approach to this issue in the model revisions will be a part of the staff's review.

18. **Comment:** The audit team commented that there is uncertainty in the specified GHB in the Rio San Jose alluvial aquifer in the vicinity of the Bluewater site, which creates uncertainty in the long-term predictive ability of the groundwater flow model in this area.

The GHB at well E(M) controls the flow system at this location, saturating the alluvium by generating a groundwater mound of approximately 60 feet. This induces southeasterly groundwater flow as stated in the model calibration report, but it's unclear whether this configuration accurately represents the flow system. For example, based on measurements of alluvial thickness and average groundwater flow velocities performed for the Bluewater Disposal Site, simulated southeasterly groundwater flux through the Rio San Jose alluvial aquifer upgradient of the paleochannel confluence zone may be underestimated in the HMC model.

HMC Discussion
HMC discussed that this statement is based on an incorrect interpretation of the model. The top of the Chinle at E(M) is at an elevation of 6533' MSL and land surface is at 6615' MSL – thus the alluvium is 82' thick. Groundwater levels at this well have gradually declined from 6541' in 2002 to 6537' in 2022. Thus, saturated thickness of alluvium has declined from about 8' to 4'. This has in the past and will be in the future appropriately simulated in the model. The model does not simulate a 60' mound.

Potentially Acceptable Approaches
HMC's approach to this issue in the model revisions will be a part of staff's review.

Model Calibration

19. **Comment:** The audit team questioned whether the model is representative of regional water levels, because the majority of targets are so close to the LTP. In addition, the high residual errors have implications for the simulated vertical hydraulic gradients in the vicinity of the LTP, which could influence plume migration.

    In the alluvium (layer 1), positive and negative head residuals of between 50 and 100 feet are observed in several stress periods. There also appears to be a bias in simulated heads in the Upper and Middle Chinle Water-Yielding Units (layers 4 and 6), where lower head values are consistently over-predicted and higher head values are consistently under-predicted. Residuals in these layers often exceed 10 feet, with observed heads between 6525 and 6550 feet under-predicted by more than 50 feet in several stress periods.

    In visualizing the spatial distribution of locations with large positive and negative head residuals, it appears that often they are clustered. This suggests possible bias introduced during well surveying, as each round of installed wells may have been surveyed separately.

Observed and simulated vertical hydraulic gradients were calculated for wells located within 50-ft of one another. In some locations (i.e., wells 497 and CW45), the simulated vertical hydraulic gradient is consistently 2-6 times higher than observed gradients.

HMC Discussion
HMC noted that there are several outlier data points that can skew residuals and that this comment will be addressed during the revision to the groundwater model, including zero-weighting of outliers.

Potentially Acceptable Approaches
The audit team noted that gradient targets would be helpful to supplement head targets for model flow calibration. In addition, well construction records (e.g., method, date of survey, vertical datum) for the calibration targets would help clarify if this observation is a data or model issue.

20. **Comment:** The audit team questioned whether the sharp head gradients between layers are representative of a quasi-equilibrated flow condition, or if the system is unable to fully respond to hydrologic perturbations within the timeframe of the transient stress periods.

    Where the water table transitions between the alluvium (layer 1) and underlying units, a sudden head decline of up to nearly 90 feet is observed. These steep gradients are observed across all transient stress periods, and the magnitude of the sudden change depends on the difference in material properties between layers. Based on the calibrated hydrologic parameters, it was not clear to the audit team how long it takes the head in each layer to respond to changes in boundary conditions (e.g., recharge, pumping).

    HMC Discussion
    HMC discussed that this issue is caused by the downward gradients in the system and the fact that the alluvial aquifer is perched – water level in underlying Chinle unit lower than base of alluvium. HMC also noted the examples given were largely observations of the initial condition of the calibration, with the model equilibrating to a state more representative of observed data.

    Potentially Acceptable Approaches
    HMC’s approach to this issue in the model revisions will be a part of staff’s review.

21. **Comment:** The audit team commented that model projections out to 200-1000 years based on a model calibration period of 17 years results in significant uncertainty.

    HMC Discussion
    HMC discussed that the calibration period has been extended into 2024 in the revised model. However, HMC discussed that extending the calibration period further is likely an intractable problem due to lack of pre-anthropogenic data and that there is more uncertainty in older historical data, which does not add value. HMC also discussed the period of calibration has provided effectively a system wide transient pump test, reducing the uncertainty associated with hydraulic parameters versus a steady state system with limited hydraulic stresses.

    Potentially Acceptable Approaches

The extension of the calibration period to 2024 could help reduce uncertainty in model projections. HMC could also address how uncertainty in model projections due to a relatively short calibration period relative to the prediction period will be accounted for.

22. **Comment**: The audit team commented that GHBs should not be used to approximate historic groundwater elevations in the alluvial aquifer without some hydrogeologic explanation and recommended that the model calibration be based on a specific “real-world” conceptual model.

    HMC Discussion
    In the calibration report, HMC discussed that although GHBs are typically placed at the edge of the active domain, it is not uncommon to have GHBs placed within interior portion of an active model domain to support fluxes and/or heads consistent with the hydrogeologic conceptual model.

    HMC discussed that GHBs in the revised model will be based on the conceptual model and will be located in the alluvial aquifer at Sand Curve and the Bluewater site with a drain located in the vicinity of Grants.

    Potentially Acceptable Approaches
    HMC’s approach to this issue in the model revisions will be a part of the staff’s review.

23. **Comment**: The audit team commented that the use of various target types could improve model calibration in the revised model. Flow direction targets could align simulated hydraulic gradients with observed uranium plume pathways, enhancing spatial calibration. Drawdown targets, based on time-series water level measurements, could refine aquifer storage parameters to better simulate pumping-induced drawdown. Flux targets at the downgradient SAG boundary could help calibrate inter-aquifer connectivity by matching simulated flux with regional data. Uranium concentration censor targets could ensure realistic predictions by enforcing concentration limits in downgradient areas. Lastly, vertical hydraulic gradient targets could improve the model’s representation of vertical flow between units, which is essential for simulating water and contaminant migration.

    HMC Discussion
    HMC discussed that they would consider vertical gradient targets. However, censor targets for uranium are not appropriate as downgradient areas have complication of mixing with the uranium contamination in the Rio San Jose from the Bluewater site.

    Potentially Acceptable Approaches
    The use of various target types could improve model calibration in the revised model and support staff’s review of the model revisions to better understand HMC’s approach.

Conceptual Model

24. **Comment:** The audit team commented that additional sources of information could increase confidence in the predictive capability of the modeling. For example, the site model, without changes to parameters or inputs, should be able to reasonably represent the observed transport of the upstream contaminants since the scale of the model is large and encompasses regional influences.

    There are many confounding factors associated with historical releases from the LTP that make the modeling applied to transport potentially non-unique. These include but are not limited to upstream boundary conditions, remediation activities, and surrounding land and water usage. A variety of different values for key variables can reasonably replicate the observed transport of uranium and selenium from the LTP, but these different values can have large implications for the projected future transport of contaminants. Accordingly, modeling analyses, such as the upgradient plume, can provide additional model confidence.

    HMC Discussion
    HMC discussed that there is significant uncertainty in the upgradient plume data and source term assumptions and that the site was under a separate Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation, and therefore an analysis of the upgradient plume would not add much value.

    Potentially Acceptable Approaches
    The audit team agrees that data are still being collected and that there is uncertainty in the information. However, this plume provides a unique test case and an analysis of the upgradient uranium plume could provide insights into potential attenuation for the HMC plume. This analysis could be conducted with the additional characterization information from the Central Study Area review.

Future Scenarios

25. **Comment:** The audit team noted that HMC's analysis appears to rely on the drying out of the alluvial aquifer to stop the contaminant plume from migrating to demonstrate compliance. However, the groundwater modeling does not appear to account for future land uses that are reasonably foreseeable and may increase the alluvial groundwater saturation, such as mining activities and farming with flood irrigation, which have occurred recently (see NUREG 1757 Vol 2 Rev 2[4]).

    HMC Discussion
    HMC presented additional information regarding historic anthropogenic activities that resulted in increased saturation of the alluvial aquifer. NMED staff provided a discussion on the current State of NM regulations (e.g., piping/transport of mine-water discharge and water allocation) which would limit the recurrence of those historical activities.

[4] *Any land uses that similar property in the region currently has, or may have in the near future (e.g., approximately 100 years), should be characterized as reasonably foreseeable.*

Potentially Acceptable Approaches

Updated model parameterization (e.g., recharge, climate) for the base case and a sensitivity case providing risk information for a scenario with a period of saturated alluvium could help address this issue. The sensitivity case could provide information on potential exposure at the proposed long-term care boundary (LTCB) in the alluvial aquifer and a SAG well at the edge of the LTCB.

Model Validation/Model Confidence Building Activities

26. **Comment*:*** The audit team noted that additional information in the expected ACL LAR on the identification and monitoring of key performance indicators would add confidence in groundwater model projections.

Potentially Acceptable Approaches

Additional information on key performance indicators for staff to better understand long-term performance could include:

1. Contaminant rebound – list of analytes, location of monitoring (e.g., toe drains, monitoring well data beneath and adjacent to LTP with cessation of SAG water injection)
2. Infiltration through cover – sensors with artificial/forced testing, verification of vegetation, erosional stability
3. Saturation of the alluvial aquifer – comparison of model projections and observations with the decrease and ultimately cessation of groundwater corrective actions
4. Plume attenuation, in light of cessation of groundwater corrective actions – list of analytes, including conservative and non-conservative species, location of monitoring, frequency of monitoring, and discussion on how monitoring data should be compared to model projections.

APPENDIX 3: List of References Reviewed

The NRC regulations, guidance, and other relevant standards were identified in the audit plan (ML25031A058), including 10 CFR 40, Appendix A, Criterion 5 and Criterion 7. The NRC staff recognizes that while the guidance provides a methodology for licensees to meet NRC regulations, there may be other pathways to satisfy the regulations. Regarding NUREG-1620, the audit team focused on the criteria in Section 4.0, “Protecting Water Resources”.

Additional Documents reviewed during the audit include:

20.6.2.3103 NMAC - Standards for Ground Water of 10,000 mg/l TDS Concentration or Less https://www.srca.nm.gov/parts/title20/20.006.0002.html

Arcadis. 2012. Rebound Evaluation Summary Report Grants Reclamation Project Grants, New Mexico. December. (Enclosure 4 of ML13345A256)

Frenzel, P.F. 1992. Simulation of ground-water flow in the San Andres-Glorieta aquifer in the Acoma embayment and eastern Zuni uplift, west-central New Mexico: U.S. Geological Survey Water-Resources Investigations Report 91-4099, 381 p.

Gallaher B. M., and Cary, S. J. 1986. Impacts of Uranium Mining on Surface and Shallow Groundwaters, Grants Mineral Belt, New Mexico, Health and Environment Department,

Homestake Mining Company of California, 2022. Alternate Concentration Limit License Amendment Request Application (ML22263A299)

Worthington Miller Environmental LLC, 2020. Geochemical Characterization of Tailings, Alluvial Solids and Groundwater Grants Reclamation Project. May.