

Staff's Preliminary Calculations:
Indications that the Groundwater
Release Criterion may not be met within
the Proposed Remediation Time Frame

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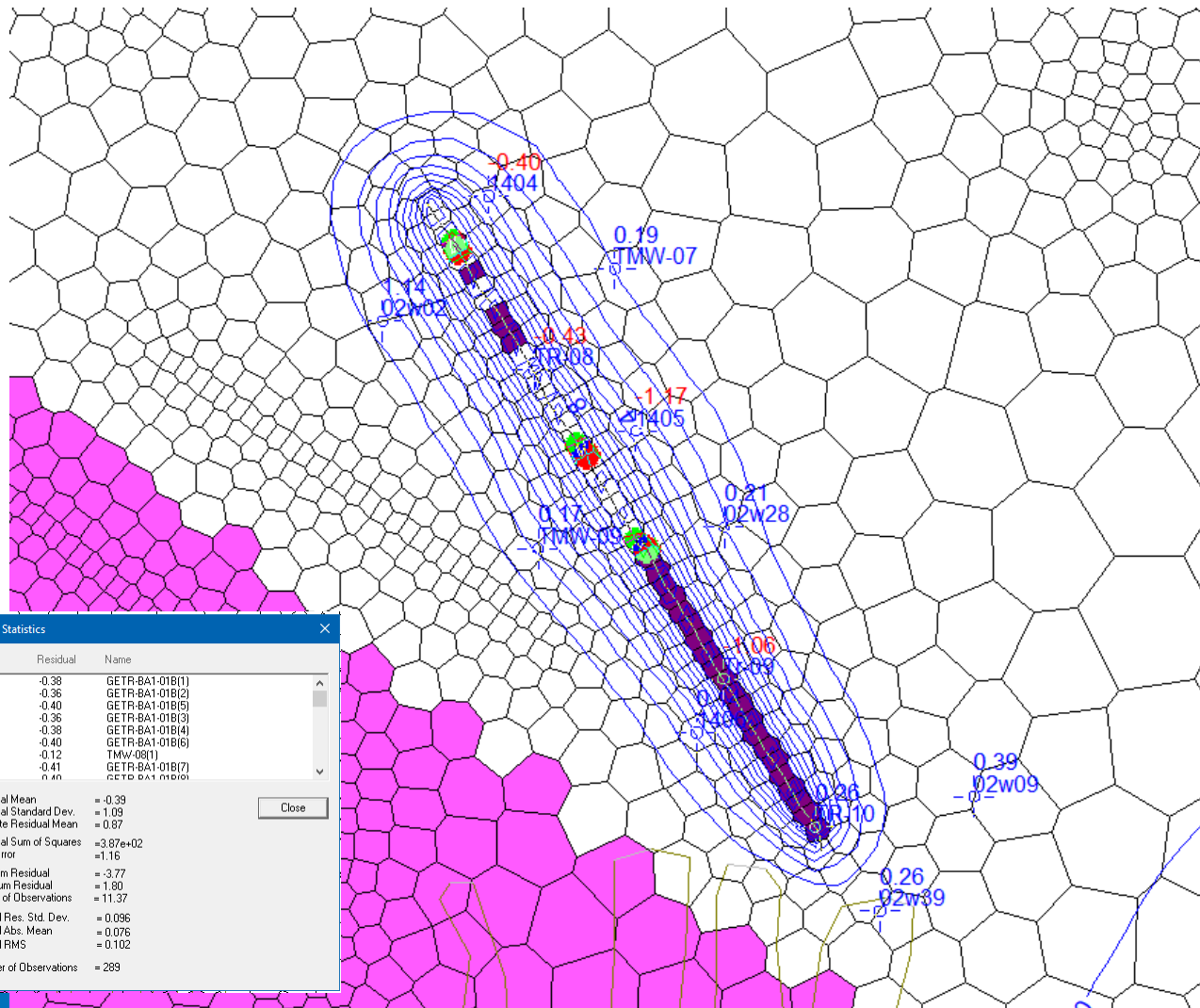
Introduction

- During a recent administrative call, staff expressed a concern that the proposed remedial strategy may not achieve the NRC-approved uranium groundwater release criterion within the estimated timeframe, specifically, 150 months for area BA1-A
- The licensee had requested a public meeting to discuss staff's specific concerns and calculations
- Staff agreed to this meeting to facilitate the ultimate review of the Decommissioning Plan (DP). Information presented is preliminary in nature as staff has not started a detailed technical review, and additional information may be provided, the model further revised to reduce uncertainties, or information that should be considered in the calculations was not identified by staff during the preliminary review

Initial Flow Calculations

- The remedial components proposed for the BA1-A Transition Zone were initially designed using a conceptual flow model
- Revisions to the components for the revised DP are based on results from recent studies, primarily a 2018 Pilot Test Report and a 2018 Environmental Sequence Stratigraphy (ESS) and Porosity Analysis Memorandum
- Preliminary review of the pilot test report suggests some inconsistencies and/or possible errors
- A numeric groundwater flow model was initially developed by staff to verify the interpretations from the 2018 pilot tests
- Results of staff's flow model differ from the licensee's interpretations in the 2018 Pilot Test with respect to calculated hydraulic conductivities
- Staff results are consistent with the analyses from an earlier 2013 pilot test

Staff's Initial Flow Model Results Extraction



Target Statistics

Target	Residual	Name
0.03	-0.38	GETR-BA1-01B(1)
0.06	-0.36	GETR-BA1-01B(2)
0.07	-0.40	GETR-BA1-01B(3)
0.08	-0.36	GETR-BA1-01B(4)
0.08	-0.38	GETR-BA1-01B(5)
0.08	-0.40	GETR-BA1-01B(6)
0.09	-0.12	TMW-08(1)
0.09	-0.41	GETR-BA1-01B(7)
0.13	-0.40	GETR-BA1-01B(8)

Residual Mean	= -0.39
Residual Standard Dev.	= 1.03
Absolute Residual Mean	= 0.87
Residual Sum of Squares	= 3.87e+02
RMS Error	= 1.16
Minimum Residual	= -3.77
Maximum Residual	= 1.90
Range of Observations	= 11.37
Scaled Res. Std. Dev.	= 0.096
Scaled Abs. Mean	= 0.076
Scaled RMS	= 0.102
Number of Observations	= 289

- Layer 1 Transition Zone
 - Magenta – Layer 1 pinch out (bedrock)
 - Trench located in linear array of small rectangular cells
 - Trench extends to Layer 6 (Mudstone B)
 - Purple – cell in Layer 1 is dry
 - Number above well label is residual (observed drawdown minus model-predicted drawdown)
 - Residual statistics in lower left hand corner
-
- Drawdown at the end of the pumping test at GETR-BA1-01
 - The Transition Zone was assigned a hydraulic conductivity of 0.4 feet per day

Fate and Transport

- Concerns which led to the fate and transport model development
 - Analytical model used to estimate the remediation timeframes assumed a homogeneous aquifer and linear isotherm
 - Groundwater divide will exist between extraction trenches
 - Extraction well in alluvium nearest the Transition Zone may draw contaminants from the Transition Zone
- Therefore, the flow model was expanded to include fate and transport to verify the licensee's estimated timeframe
- The 2018 ESS Memorandum documented the heterogenous nature to the Transition Zone materials and was used in staff's fate and transport model
- Note: the information presented today is preliminary in nature

Fate and Transport

- Calibration of the fate and transport model was the time period starting with the initial disposal of materials to the pits until November 2017
- It should be noted that the parameters for fate and transport have a large degree of uncertainty, in particular the original source term
- Various simulations were conducted over a “bounding” range of values, each of which predicted the release criterion was not met in the Transition Zone after 150 months
- The simulation results presented today are from one simulation in which the hydraulic conductivity of low permeable material in the Transient Zone was assigned a value of 0.8 ft/day and the source term was assigned a low concentration (35 mg/L)
- This simulation was not the best fit; it merely represents results that were typically observed from all simulations

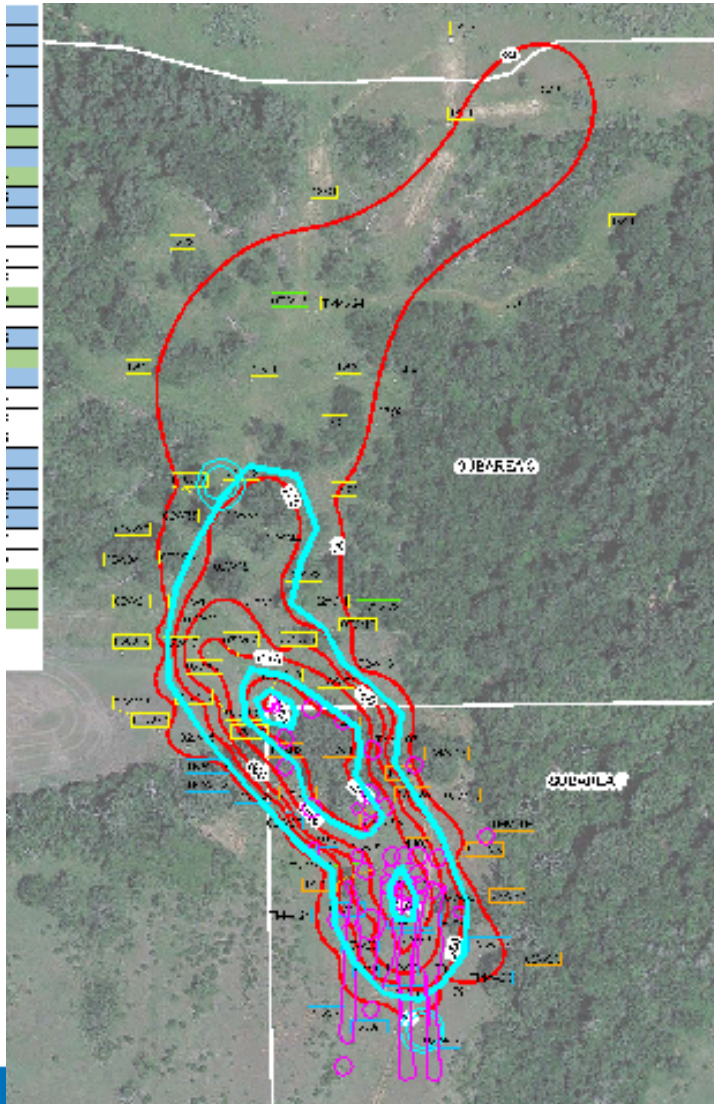
Notes on Uranium Data/Concentrations

- The data use for calibration are from tables provided by the licensee
- Data from the early years are mostly uranium activity concentrations (U234,235,238, pCi/L)
- For a time period, both activity and mass concentrations were measured (U238 ug/L)
- Presently, only mass concentrations are measured (U235 & 238 ug/L)
- The licensee developed a uranium activity ratio, and the model was calibrated to total uranium activity concentrations

- For the model, the units are pCi/ft³
- 200 ug/L = 180 pCi/L = 5,094 pCi/ft³
- 2000 ug/L = 1780 pCi/L = 50,374 pCi/ft³
- 3000 ug/L = 2670 pCi/L = 75,561 pCi/ft³

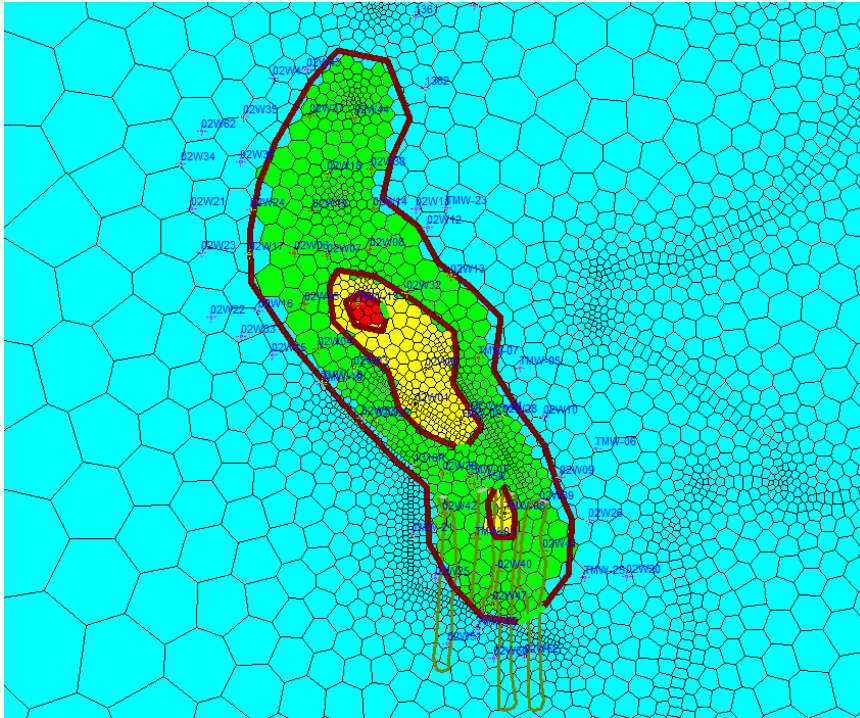
- 28.317 L = 1 ft³

BA1 Uranium Isopleth



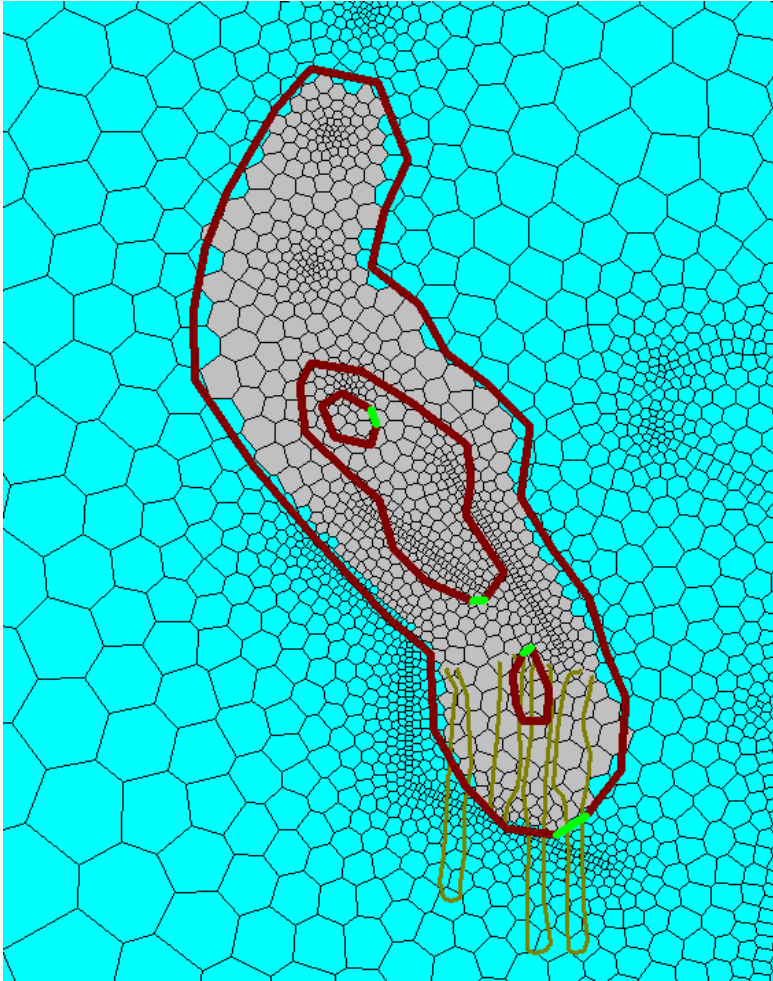
- Not a real Isopleth (Max, UCL95, single value)
- Units (ug/L)
- Plume in bedrock (Sandstone B) (blue)
- Plume in Transition (Orange)
- Plume in Alluvium (Yellow)
- First contour (MCL)
- Second contour (NRC Release Criterion)
- Maximum contour (3000 ug/L)
- Teal color contours used in model calibration (200, 2000, 3000)

Goals for Model Calibration



- The primary goal was to match temporal trends in uranium concentrations at selected wells
- A secondary goal of calibration for model was to match concentrations that are consistent with the representative isopleth
 - **Green** - >release criterion and <1780 pCi/L
 - **Yellow** – >1780 pCi/L and <2670 pCi/L
 - **Red** - >2670 pCi/L

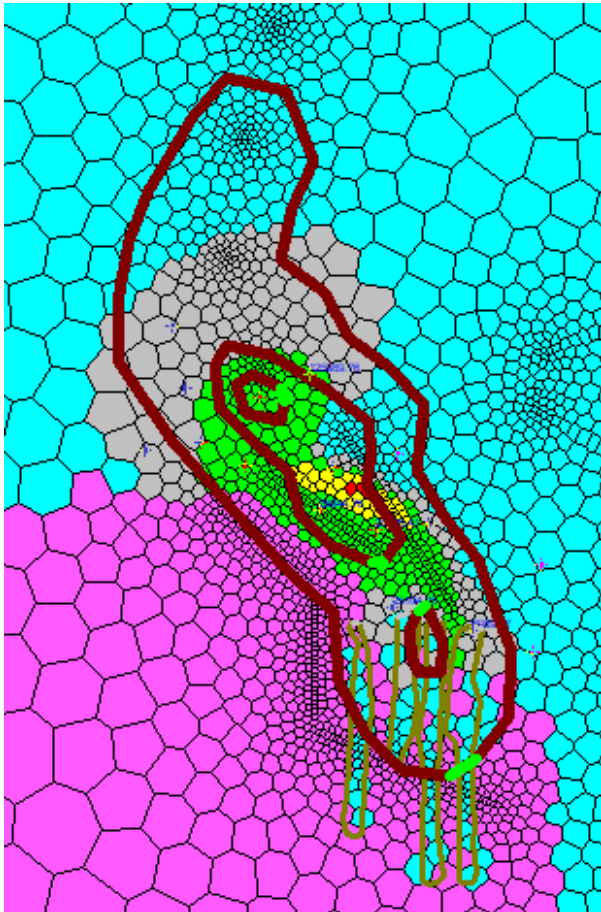
Acceptable Model Prediction to meet Release Criterion



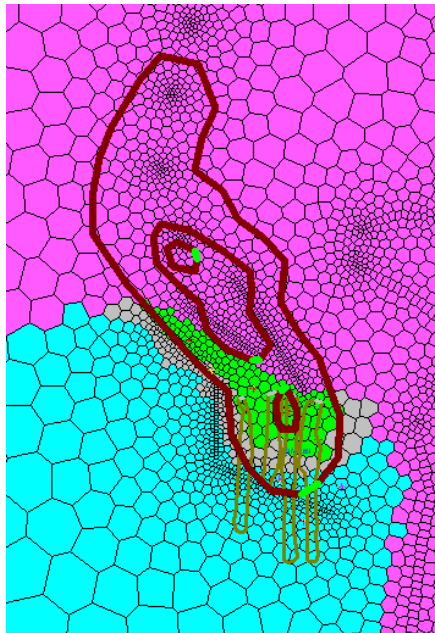
- The model predicted concentrations after 150 months of operation was then visually inspected
- Remediation achieved its goal if the color was **gray** (i.e., the concentrations are >background and <release criterion) or **cyan** (background)
- If the color was **green**, **yellow** or **red**, remediation did not achieve its goal

Model Calibration for this Simulation

- Plume concentrations at the stress period ending in November 2017



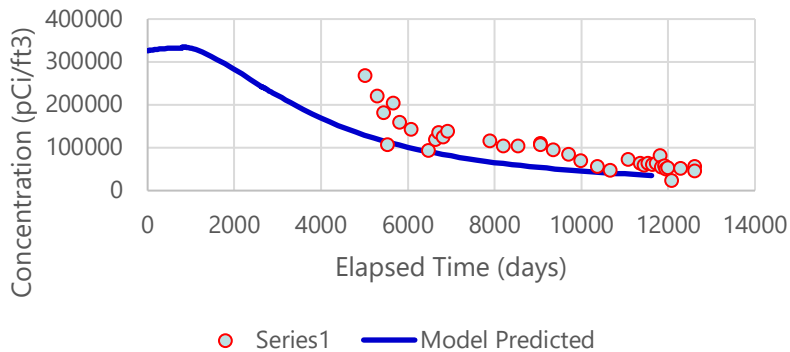
Layer 1 (Transition Zone and Alluvium)



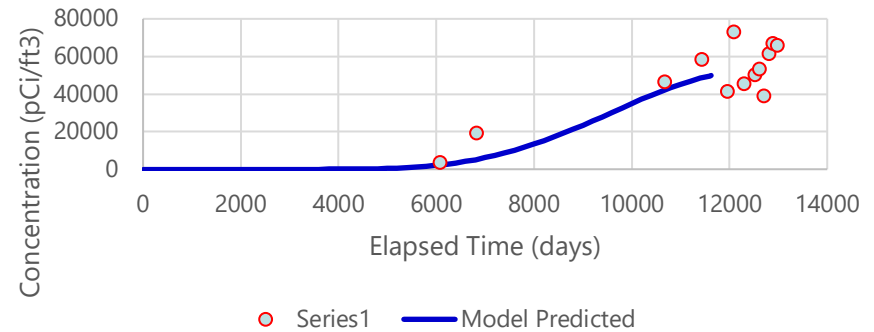
Layer 9 (Sandstone B)

This Simulation Model Calibration

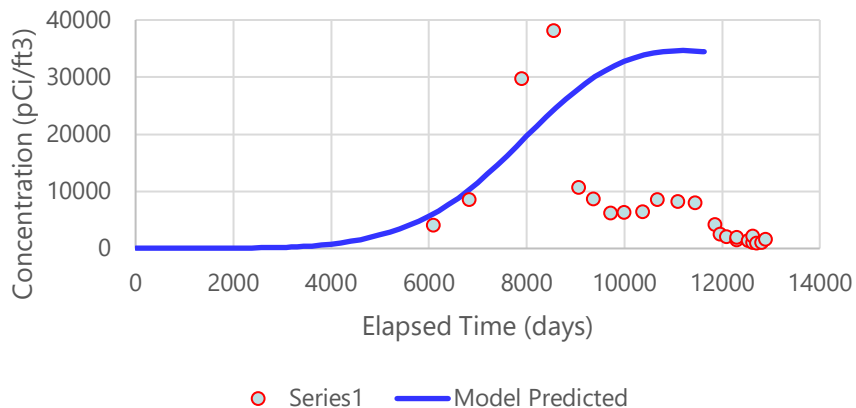
TMW-09



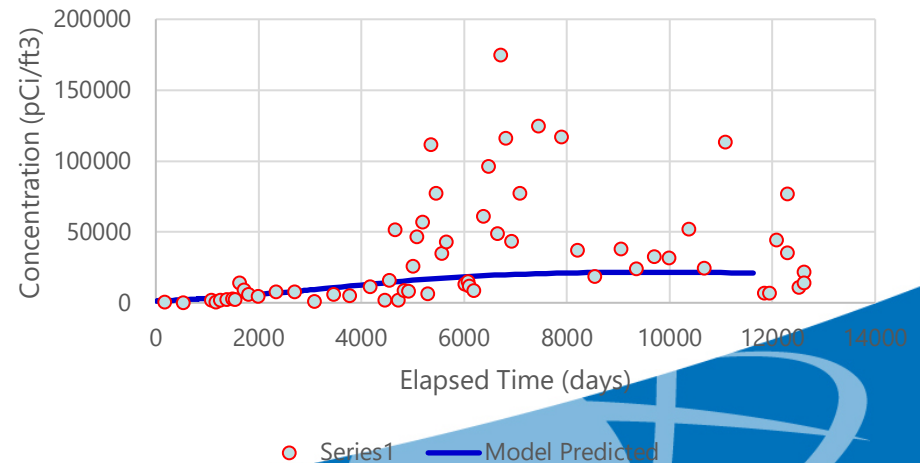
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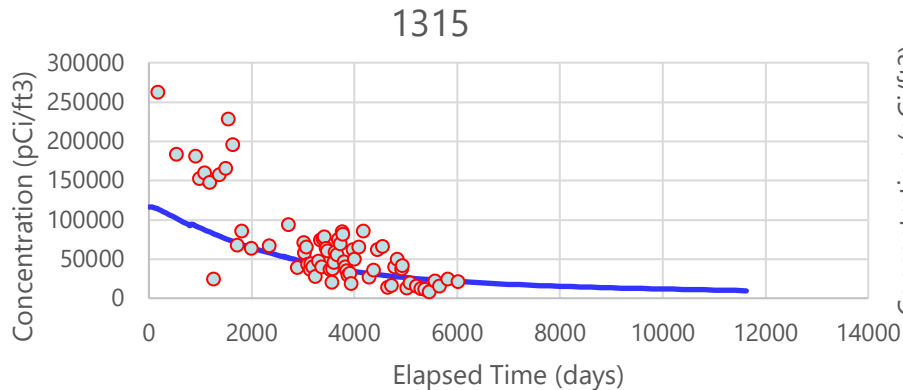
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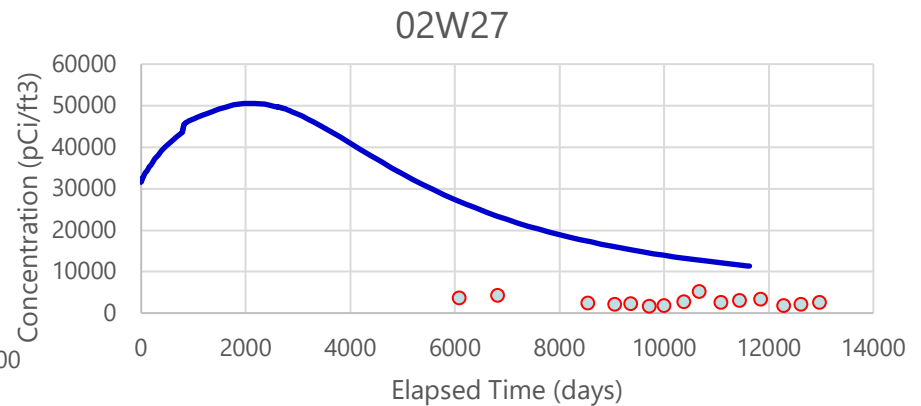
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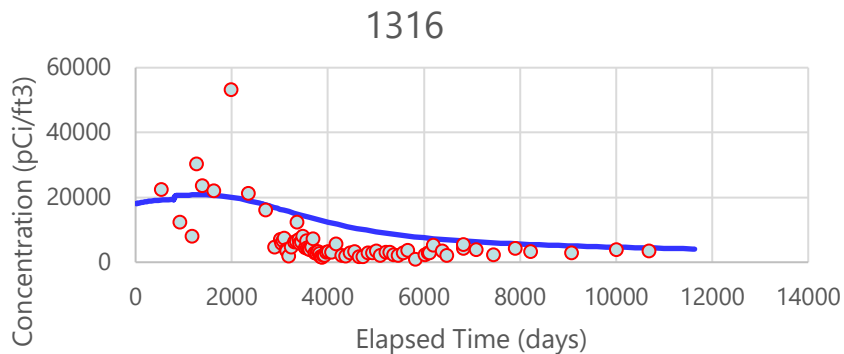
This Simulation Model Calibration



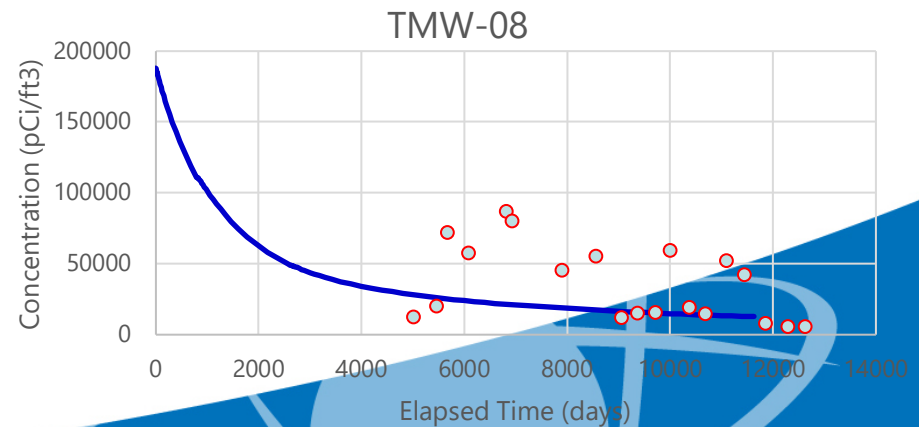
○ Series1 — Model Predicted



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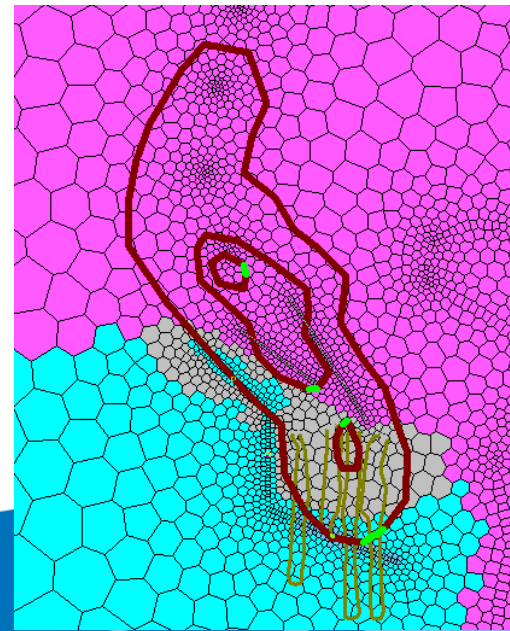
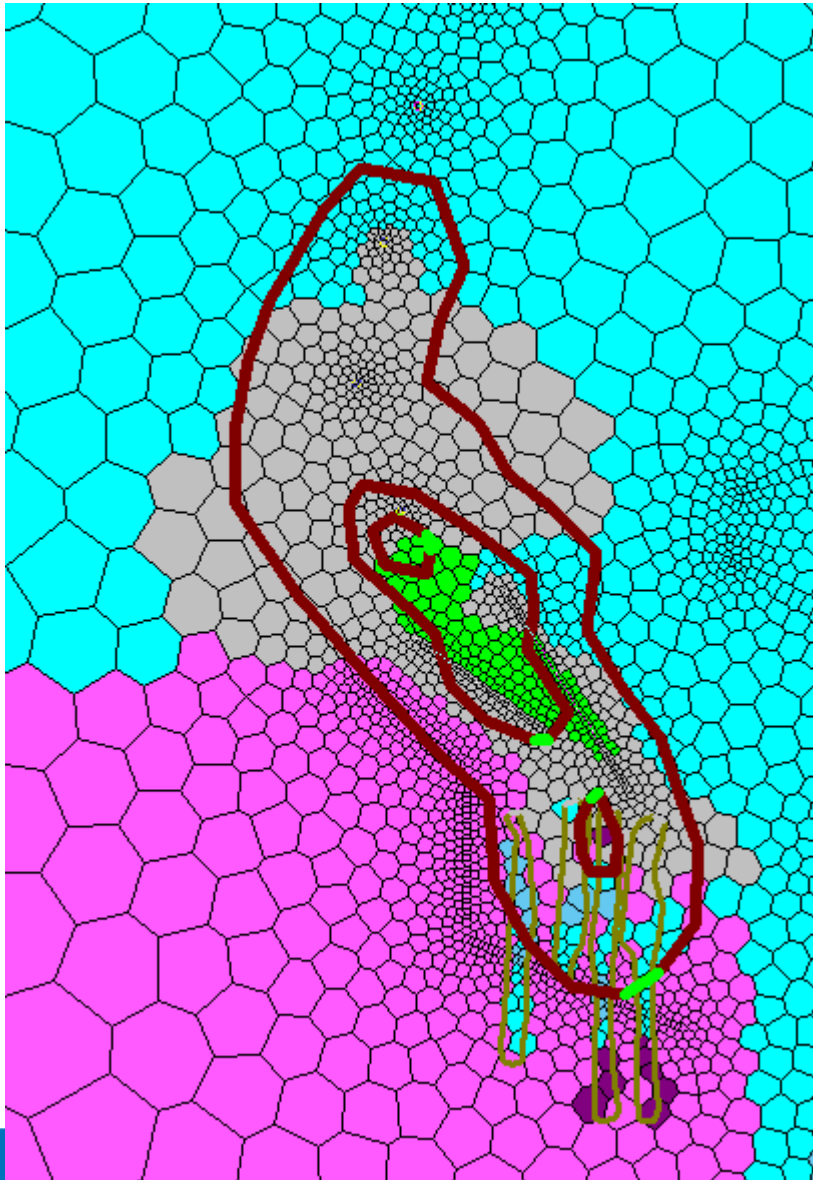
○ Series1 — Model Predicted



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Model Prediction

- After 150 months, the green contour indicates release criterion not achieved



Isotherms

- A linear isotherm could not adequately simulate the observed data
- Freundlich isotherms were used:

$$C_{\text{solid}} = K_f * (C_{\text{groundwater}})^a$$

Where

C_{solid} = concentration on the matrix

K_f = Freundlich constant

$C_{\text{groundwater}}$ = concentration in groundwater

a = Freundlich exponent

Material	Freundlich Parameters	
	Constant (K_f)	Exponent (a)
Alluvium	122.75	0.75
Bedrock	121.7	0.54
Transition Zone	641	0.38
Transition Zone - Preferred Path	285	0.38
Transition Zone - Preferred Path Margins	426	0.5

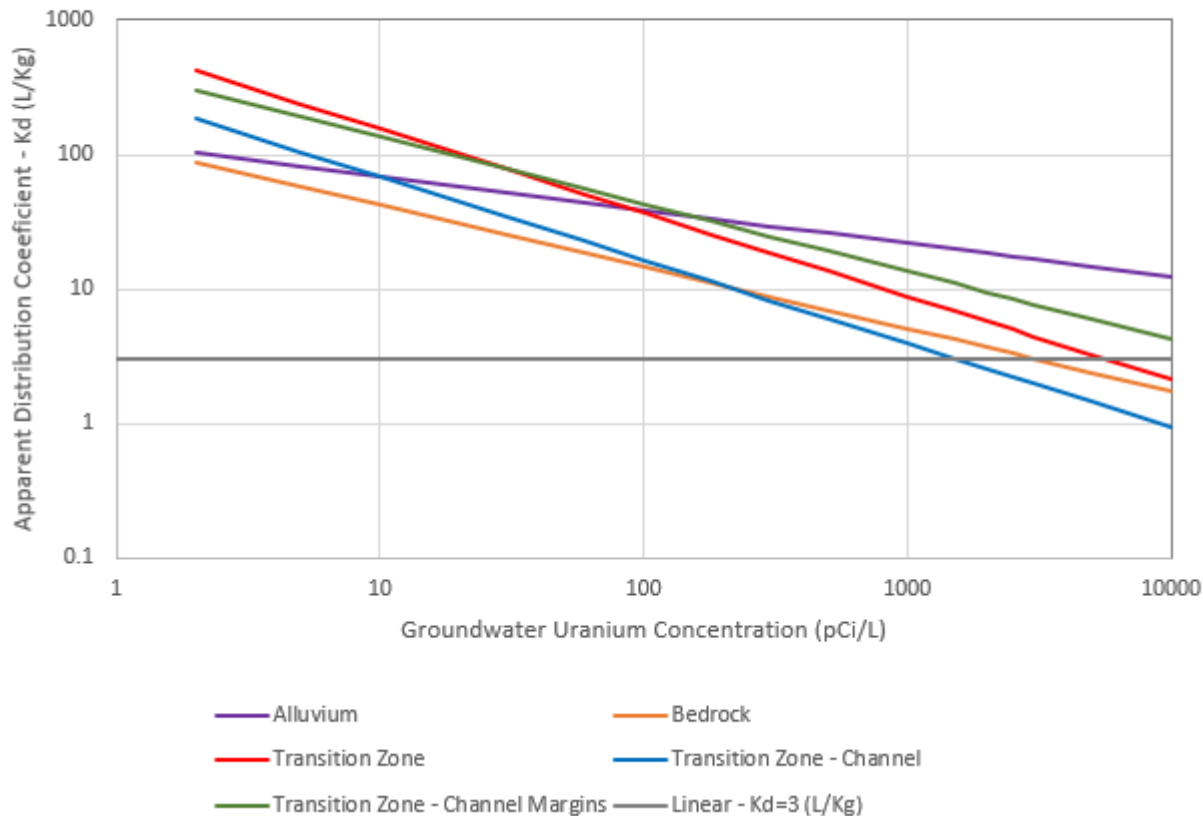
Note: The units for the constant are variable :

$$L^a / (\text{pCi}^{(a-1)} * \text{Kg})$$

Constant used in model multiplied by 28.317^a
to correct units (ft^3 to L)

Model Isotherms and Equivalent Distribution Coefficients

Model Equivalent Distribution Coefficients compared to a Constant Kd of 3 L/Kg



- The equivalent distribution coefficient (Kd) for the Transition Zone at a groundwater uranium concentration of 180 pCi/L is 25.6 L/Kg
- A Kd of 3 L/Kg was used by the licensee to predict remediation timeframes
- The Kd for the Alluvium is high because of the low concentration assigned to the source for this simulation

Other Potential Findings

- Using the expected conductivity for the fine-grained Transition Zone material (i.e., 0.4 feet per day), the system would not achieve the proposed pumping rate
- Conductivity of the pit backfill material is likely higher than bedrock
- Simulations with the source being seepage only (i.e., pit disposed material was unsaturated) required concentrations that were not realistic
 - Recharge concentration was 1300 mg/L
- The CSM for subsequent simulations assumed the lower (northern) end of the pits are saturated because of the perched conditions in Sandstone C
 - A topologic low exists in the upper surface of competent bedrock that collects water which then infiltrates to the perched conditions in Sandstone C
 - Evidence – consistent yet greater variability and higher heads at the perched wells compared to wells screened lower; perched wells align trend coincides with the indentation of the transition zone:bedrock interface as noted in the 2018 ESS Memorandum; reported instability of the overburden in the western end of the injected trench GWI-BA1-01 during its construction is consistent with saturated conditions
 - Perched conditions in Sandstone C are not widespread; a window in the perching layer was assigned near a portion of the proposed topologic low