Appendix G

MTI Draindown Calculation Set

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	Task: MTI Drain Down Est. Update	Computed By: W. Niccoli Date: 07/08/23
		Checked By: T. Cotterell Date: 07/09/23

Calculation Documentation

Problem Statement:

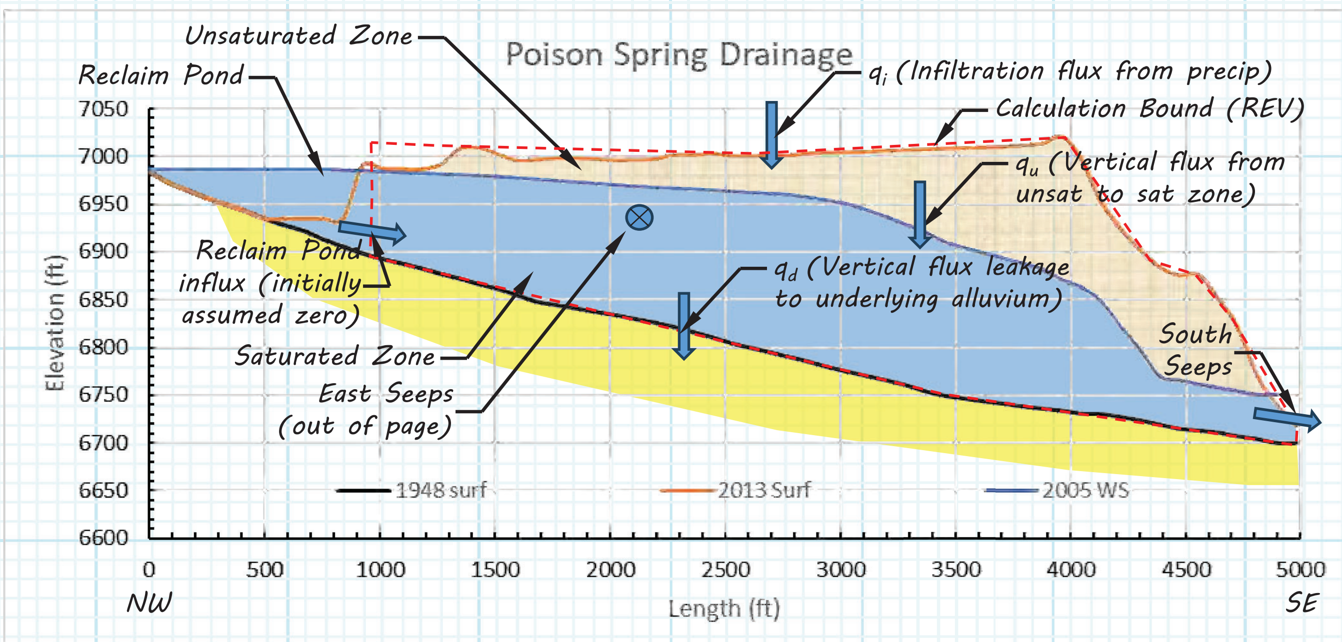
Freeport-McMoRan Chino Mines Company (Chino) is required to estimate the cost of closure every 5 years, for the maximum overall mine closure scenario in the upcoming 5-years. One of the components of closure costs is the management of water draining down (i.e., drain down) from the Main Tailings Impoundment (MTI) that becomes seepage and must be captured. In order to project the costs, an estimate of the drain down and seepage from the MTI over the next 5 years (and beyond) is needed.

Objectives:

1. Provide a reasonable estimate of the drain down rates from the MTI
2. Support the CCP cost estimate

Approach:

1. Utilize the MTI water balance model from the 2004, 2009, 2014, and 2018 CCPs (See 2004, 2009, 2014 and 2019 CCPs for details):



2. Estimate the saturated volume in the MTI based on piezometer readings
3. Verify the model is matching the saturated water volume in the MTI
   a. If the model verifies through 2022, project drain down and seepage going forward after closure
   b. If the model does not verify, then recalibrate the model to the saturated volume estimates from piezometer readings

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Calculation Documentation

Data and Assumptions:

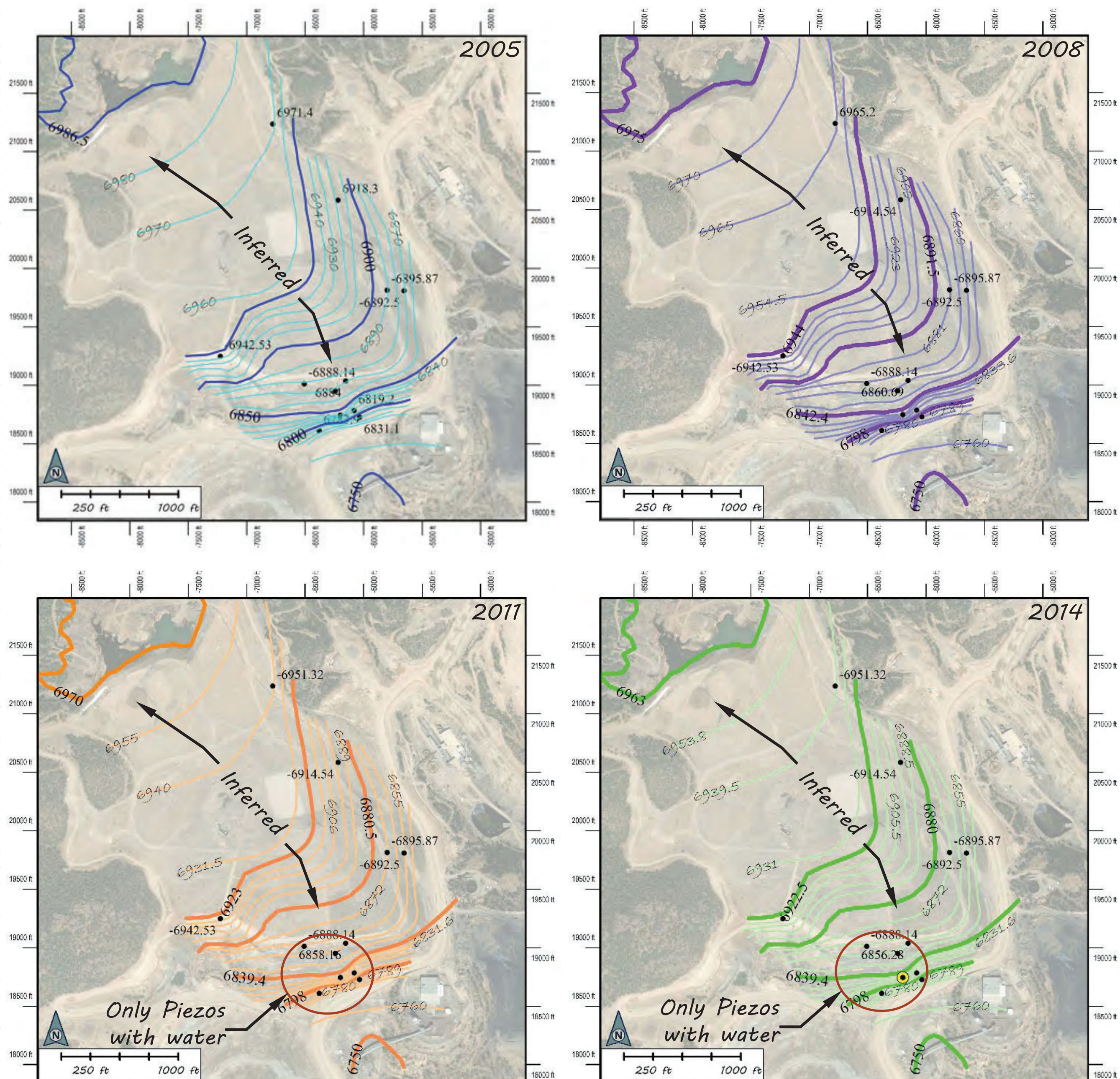
1. 1948 topography (USGS, topo map)
2. 2013 topography (Chino flyover)
3. Choose a 3-year period to estimate volumes from piezometer readings (2005, 2008, 2011, 2014, 2017, 2020, and 2023
4. Tailings closed 2031
   a. Reclaim pond is diverted and zero inflow to MTI
   b. Cover limits precipitation infiltration to 2% of incidental precipitation
5. Keep initial assumption of no inflow from Reclaim Pond
6. Modify infiltration factor if calibration needed (simulates flow from Reclaim Pond and enhanced infiltration from limited cover)
7. URS/AECOM measurements of MTI seepage and piezometers

Chino X	Chino Y	1/22/2005	1/22/2008	1/21/2011	1/21/2014	1/21/2017	1/22/2020	1/21/2023	Name
-7225.33	19246.87	-6942.5	-6942.5	-6942.5	-6942.5	-6942.5	-6942.5	-6942.5	**TH-1**
-6507.65	19011.80	-6888.1	-6888.1	-6888.1	-6888.1	-6888.1	-6888.1	-6888.1	**TH-2**
-6379.56	18608.79	6783.9	6785.3	6783.8	6795.5	6783.2	6794.4	6792.6	**T-7**
-6724.68	18637.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6798.2	**B-C1**
-6724.68	18637.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6804.9	**B-C2**
-6693.46	18795.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6810.6	**B-D1**
-6693.46	18795.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6818.0	**B-D2**
-6679.07	19025.25	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6834.3	**B-E1**
-6673.52	19024.12	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6848.3	**B-E2**
-6677.06	19177.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6832.3	**B-F1**
-6677.06	19177.22	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6869.0	**B-F2**
-6152.76	19037.22	6884.0	6860.7	6858.2	6856.3	-6854.6	-6854.6	-6854.6	**TH-3**
-6242.42	18949.25	-6886.8	-6886.8	-6886.8	-6886.8	-6886.8	-6886.8	-6886.8	**L-1**
-6198.48	18743.60	-6847.6	-6847.6	-6847.6	-6847.6	-6847.6	-6847.6	-6847.6	**T-8**
-6080.59	18782.32	6819.2	6815.0	6816.6	6815.4	6814.6	6814.7	6815.0	**P-1B**
-6034.13	18725.95	6831.1	6822.2	6817.6	6811.6	6811.9	6811.9	6811.4	**TH-4**
-6003.27	18385.67	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6727.4	**C-A1**
-6003.27	18385.67	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6752.4	**C-A2**
-6005.42	18441.66	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6739.5	**C-B1**
-6005.42	18441.66	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6759.0	**C-B2**
-6036.98	18717.30	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6761.1	**C-C1**
-6036.98	18717.30	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6769.9	**C-C2**
-6036.98	18717.30	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6787.8	**C-C3**
-6072.49	18870.87	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6774.0	**C-D1**
-6072.49	18870.87	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6808.5	**C-D2**
-6114.98	19048.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6793.8	**C-E1**
-6114.98	19048.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6857.8	**C-E2**
-6114.98	19048.76	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6871.9	**C-E3**
-6128.89	19176.55	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6810.2	**C-F1**
-6128.89	19176.55	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6821.5	**C-F2**
-6128.89	19176.55	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6830.6	**C-F3**
-5687.29	19177.55	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6827.2	**CD-E1**
-5687.29	19177.55	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6866.2	**CD-E2**
-5798.55	19812.91	-6895.9	-6895.9	-6895.9	-6895.9	-6895.9	-6895.9	-6895.9	**TH-5**
-5653.81	19807.05	-6892.5	-6892.5	-6892.5	-6892.5	-6892.5	-6892.5	-6892.5	**TH-6**
-5806.19	19795.13	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6846.6	**D-E1**
-5806.19	19795.13	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6880.3	**D-E2**
-6218.20	20583.49	6918.3	-6914.5	-6914.5	-6914.5	-6914.5	6916.1	-6914.5	**TH-7**
-6215.94	20575.31	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6921.9	**E-E1**
-6215.94	20575.31	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	6922.7	**E-E2**
-6776.46	21235.17	6971.4	6965.2	-6951.3	-6951.3	-6951.3	-6951.3	-6951.3	**TH-8**

Calculation Documentation

Calculations:

1. Estimate Piezometric Surface in MTI (piezometer readings shown next to dots, negative indicates dry and piezometric surface is below that elevation, contours inferred where no data):



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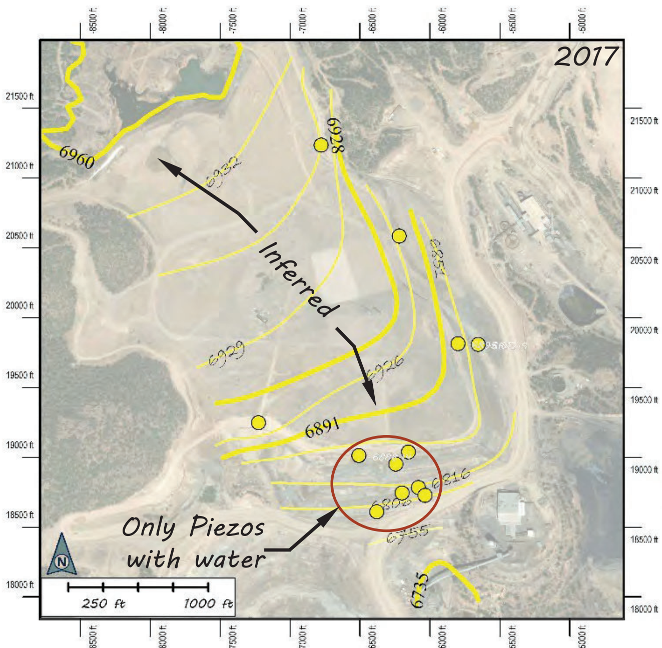
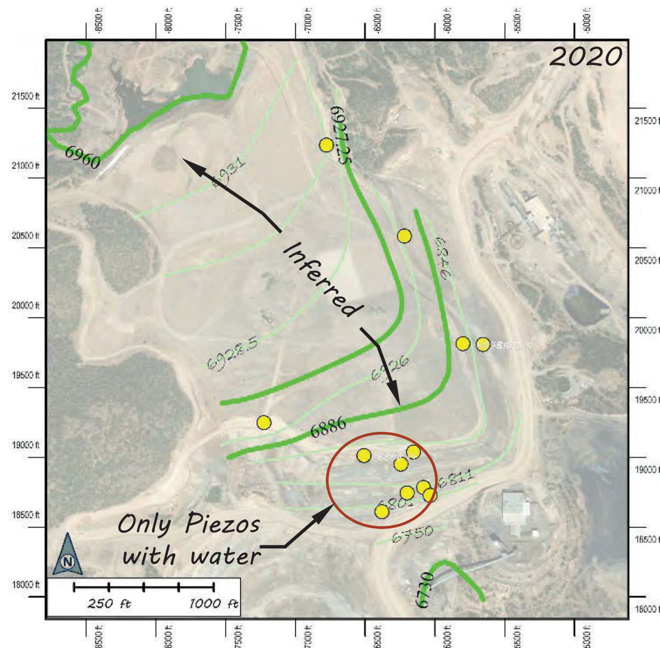
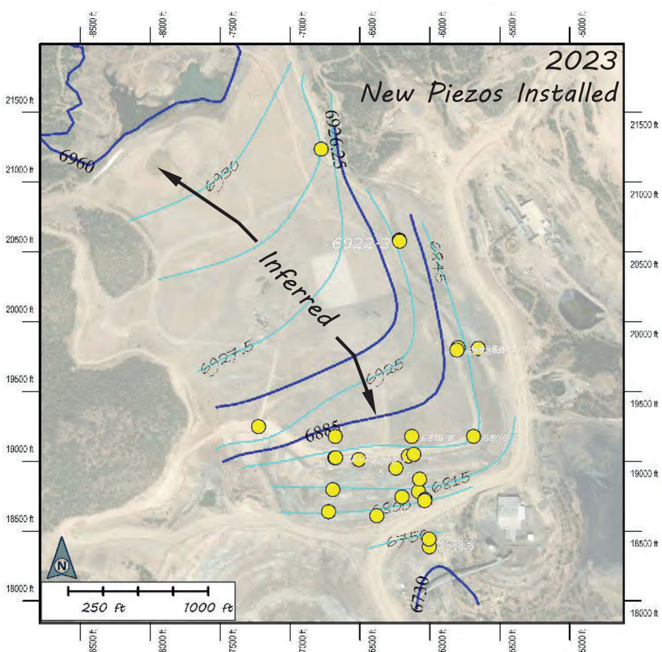
Calculation Documentation

Calculations (con'd):







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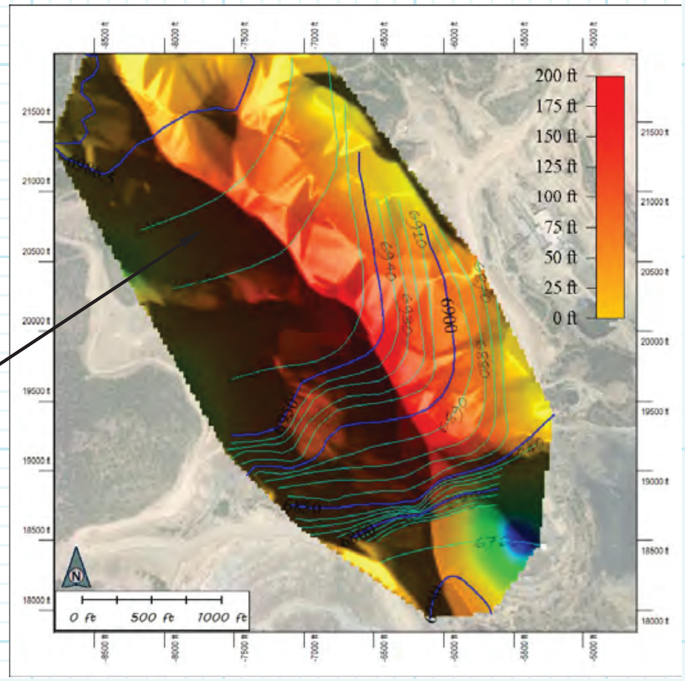
Calculation Documentation

Calculations con'd:

2. Calculate the saturated volume of the tailings beneath the piezometric surface by subtracting the 1948 topography from the piezometric surface (2005 saturated thickness shown as an example). Calculate the water volume from the calculated saturated tailings volume by multiplying by a saturated porosity of 0.42:



Saturated Thickness Surface from Global Mapper

=K4*L1*43560

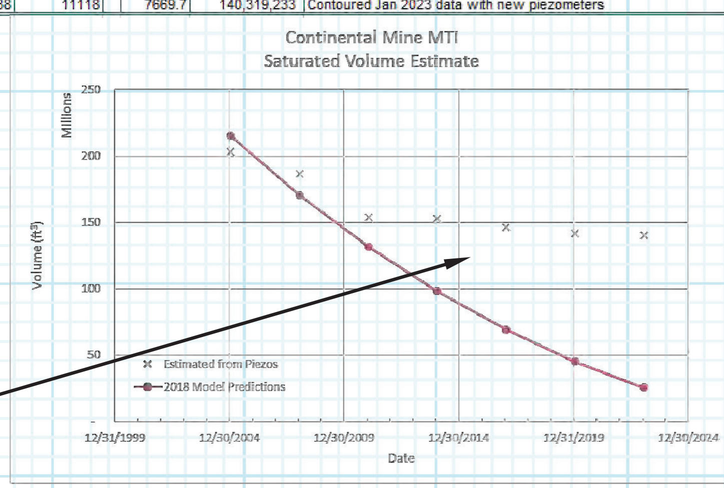
	A	B	C	D	E	F	G	H	I	J	K	L	M
1											Porosity	0.42	
2	From Global Mapper Surfaces												
3	Year (Jan)	CUT_VOLUME (af)	CUT AREA (ac)	CUT AREA 3D (ac)	FILL VOLUME (af)	FILL AREA (ac)	FILL AREA 3D (ac)	ENCLOSED AREA (ac)	PERIMETER (ft)		Sat'd Tailings (af)	Water Vol (cf)	Notes
4	2005	11103.8	128	130.87	10.8	1.266	1.34	129.38	11118		11103.8	203,145,931	Modified URS Map based on piezo data
5	2008	10198.8	126.48	129.21	24.4	2.796	2.934	129.38	11118		10198.8	186,589,433	Modified URS Map based on piezo data
6	2011	8395.1	120.43	122.8	125.3	8.857	9.228	129.38	11118		8395.1	153,590,235	Modified URS Map based on piezo data
7	2014	8340.7	120.15	122.51	131.3	9.134	9.513	129.38	11118		8340.7	152,594,647	Modified URS Map based on piezo data
8	2017	7983.4	115.8	118.34	230.4	13.465	13.924	129.38	11118		7983.4	146,057,816	added 5 feet to the 2020 contours except at top - only 1 foot roughly
9	2020	7742.5	114.52	117.06	249.3	14.745	15.265	129.38	11118		7742.5	141,650,154	added 1' to the 2023 contours
10	2023	7669.7	114.37	116.88	258.2	14.887	15.404	129.38	11118		7669.7	140,319,233	Contoured Jan 2023 data with new piezometers

3. Compare volumes to 2018 model:

$r^2 = 0.895$

$\Sigma Error^2 = 2.3\text{x}10^{16}\ ft^6$

Large Deviation ∴ Recalibrate



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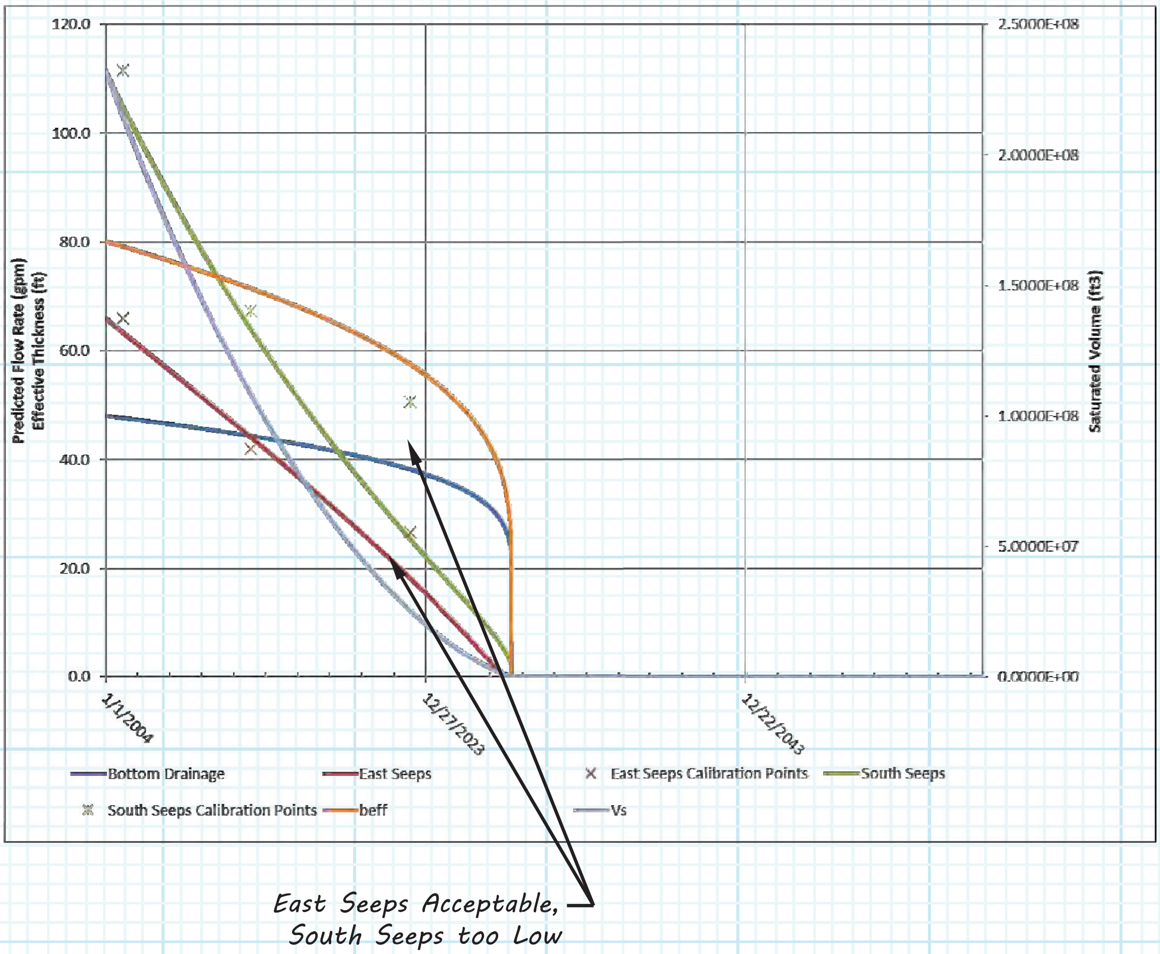
Calculations con'd:

4. Check flow rate predictions at seeps:



Model not matching – requires a recalibration

Because predicted volume is too low AND the flow rates are under predicted, there is water missing from the balance. Evaluate assumption that Reclaim Pond is minimal.

Updated volume estimates also play a role in the apparent divergence between model and measured values. Step 2 volumes slightly lower than those used in 2014. Adjust model to compensate.

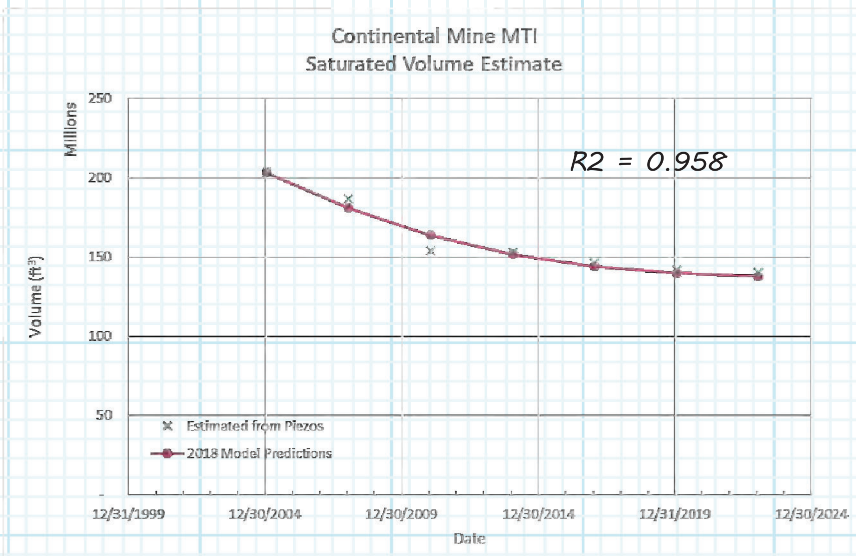
Calculation Documentation

Calculations con'd:

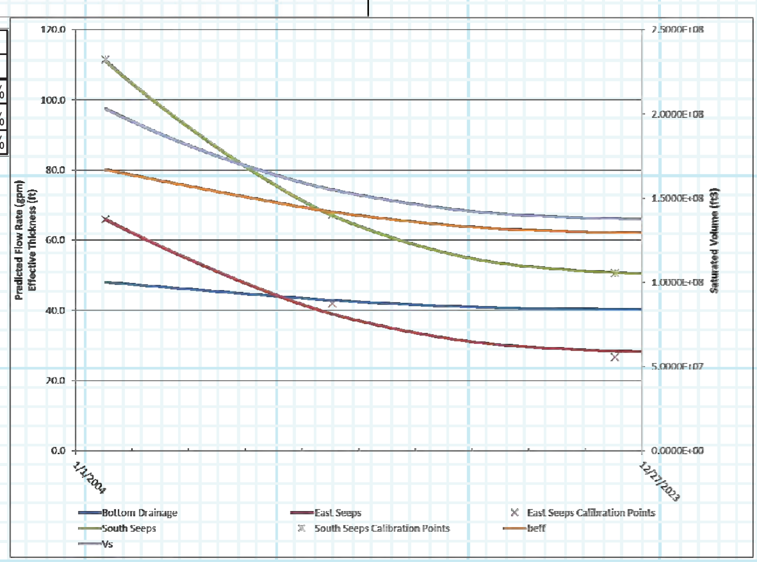
4. Start model at 1/21/2005 and recalibrate by:
   a. Adding a flow from the Reclaim Pond to the saturated volume
   b. Increase the pre-closure infiltration rate factor
   c. Modify the width function, used in Darcy's Law, to drop less quickly for the south seep estimates
   d. Lower the effective thickness at which the East Seeps stop running
   e. Iterate on a through d until the saturated volume, and flow rates to achieve a best match of the observed
   f. See 230706_Tailings_Drainage_Update.xlsx).

Results:

1. Calibration Results:



	Targets		prediction		RPD	
Date	East	South	East	South	East	South
1/24/2005	66	111.5	66.0	111.2	0%	0%
1/22/2013	42	67.3	39.0	67.1	-7%	0%
1/21/2023	26.6	50.6	28.5	50.8	7%	0%



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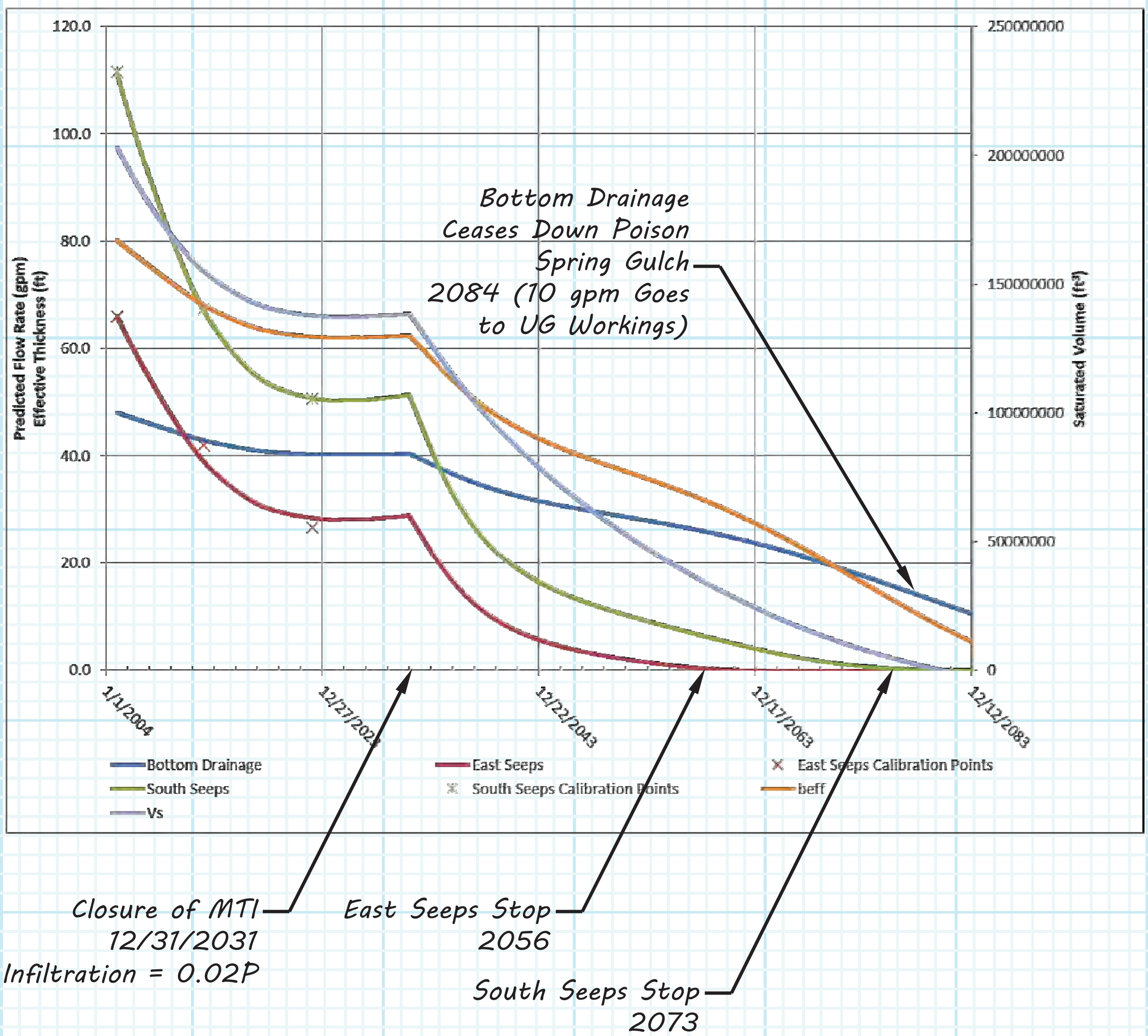
Results:

2. Post Closure Seepage Predictions



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Calculation Documentation

Discussion and Conclusions:

1. The model had zero relative percent difference in the balance of inflows and outflows versus the change in storage, indicating no balance errors

	A	B	L	M	N	O	P	Q	R	S	T	U
21												
22			Saturated Zone Outflows			Sat Zone Inflow	Unsaturated Zone Flows		End of Time Step Values			
23	t	t	Bottom Flux	East Seeps	South Seeps	Unsat Zone Drain+ReclaimPon	Precip et. al.	Usat Drainage	b_eff	Vs	Vu	θu_ave
24	yr	(day)	ft³/day	ft³/day	ft³/day	ft³/day	ft³/day	ft³/day	(ft)	(ft³)	(ft)	
73025	12/5/2204	73000	6.392E-02	0.000E+00	1.911E-05	6.392E-02	0.000E+00	6.392E-02	0.0965	-5.8499E+06	7.0355E+07	0.1540
73026												
73027		Sum	1.772E+08	8.386E+07	1.601E+08	2.122E+08	1.037E+08	6.071E+07		-2.0900E+08	4.2951E+07	
73028						In - out Sat'd						
73029						-2.0900E+08						
73030							Check that model balances on sat zone					
73031							0%	RPD (error)				
73032						In - out Sat'd	Check that model balances on unsat zone					
73033						4.2951E+07	0%	RPD (error)				

2. The additional 11 years of data (from 2012 to 2023) indicated that more water was entering the system than the previous predictions utilized and that storage was not dropping as quickly as predicted
3. Adding more inflow did not help the outflow predictions from the seeps indicating that the parameters utilized in Darcy's law were off
   a. By increasing the head difference for the east seeps, the model reached an acceptable error between measured and predicted flow rates
   b. Adjusting the rate of change of the cross-sectional area for the south seeps resulted in a perfect match between predicted and observed
   c. a and b are justified by the improved volumetric/geometric information related to the saturated portion of the MTI (i.e., volumetric calculations) and the newly installed piezometers
4. The calculation set met its objectives:
   a. Model updates resulted in improved model predictions of the MTI volume and seepage rates
   b. The model shows about a 25 and 43-year timeframe for seepage to cease at the east and south seeps, respectively. This is slightly longer than the previous modeling predictions
   c. The model predicts about a 50-year timeframe for deep percolation to the underlying alluvium to reach a steady state where vertical leakage is less than the vertical flux through the underlying bedrock to the underground workings (i.e., flow down Poison Spring Drainage ceases)