MEMORANDUM

TO: Messrs. Lewis Jones and John Fortuna
Jones Fortuna LP

Date: November 9, 2022

FROM: Dr. Sorab Panday
Principal Engineer
GSI Environmental

RE: Addendum to *Modeling the Groundwater Flow at The Proposed Twin Pines Mine on Trail Ridge* Report

Introduction

This memorandum details additional information and analyses requested by the Environmental Protection Division of the Georgia Department of Natural Resources (EPD) related to the Twin Pines Mine (TPM) groundwater flow model during a conference call held on Wednesday, October 26, 2022.

Each of the following requests from EPD are addressed below:

- Estimation of groundwater seepage rate into the active pit during dragline excavation mining activities
- A water balance evaluation for pre- and post-mining conditions for portions of the Okefenokee National Wildlife Refuge represented in the GSI (2021) groundwater model
- Sensitivity to elevations assigned to water levels at the specified head boundary along the western portion of the GSI (2021) groundwater model
- Inclusion of absolute volumetric flux values in the water budget tables that were previously included as part of the *Modeling the Groundwater Flow at The Proposed Twin Pines Mine on Trail Ridge* report (GSI, 2021).

Groundwater Seepage Rate Estimations

Model Development

In 2021, GSI Environmental Inc. (GSI) developed a numerical groundwater flow model to evaluate the impact of the proposed TPM mine on the hydrogeologic system of Trail Ridge and surrounding areas including the Okefenokee National Wildlife Refuge (GSI, 2021). Available hydrologic, hydrogeologic and climate data were assimilated and evaluated to develop a conceptual model of the flow system. A numerical model was then developed based on the conceptual model and calibrated to available data for steady-state, pre-mining conditions. The model was then used to evaluate potential changes in post-mining hydrogeologic conditions resulting from mining activities.

The same model is used to estimate groundwater seepage rates into the pit during dragline excavation mining activities. However, the horizontal grid of that model (500 feet x 500 feet grid-block size) was too coarse to analyze seepage from a moving pit that is approximately 500 feet long and 100 feet wide with a maximum depth of 50 feet below ground surface. Thus, the horizontal grid needed refinement in a small part of the domain where the pit analyses were performed.

The overall time required to perform model simulations would significantly increase if a smaller grid cell size were implemented uniformly throughout the entire model domain. Thus, the code was updated to MODFLOW-USG (Panday, 2022), which allows for localized grid refinement within a focused area of interest. For the revised TPM groundwater model, the grid was revised using a quadtree approach that reduces the cell size in a step-wise fashion from 500 feet x 500 feet to 15.6 feet x 15.6 feet in the proposed mining area (Figure 1).

The TPM MODFLOW-USG model was then run for pre-mining steady-state conditions to verify that results were consistent with previous modeling. Table 1 shows the calibration statistics from each model and Figure 2 shows a comparison of the simulated water table. As shown, the model retains its calibration and statistics calculated based upon the difference between simulated and observed groundwater elevations are comparable between the USG refined grid model and the previous MODFLOW-NWT version. Similarly, water table contours plotted in Figure 2 are comparable and only the 170-foot elevation groundwater contour is slightly different, which is attributable to the significantly smaller grid cell size in the proposed mine area. Therefore, the model as translated to MODFLOW-USG is considered appropriate for evaluating potential groundwater seepage rates into the pit.

The mining approach details that excavation of the pit will advance at a rate of 100 ft/day, with the oldest part of the pit filled at the same rate, and the pit dimensions changing minimally over time (TTL, 2020). To evaluate potential changes in hydrogeologic conditions, the MODFLOW-USG model was subsequently converted from a steady-state condition to a transient model that covers the span of a 5-day period, with the steady-state MODFLOW-USG solution representing the initial condition for the seepage analysis modeling. In addition, model cells were made inactive in areas where soils are removed within the pit. Because the model is transient, storage values were assigned to each hydrostratigraphic unit based on aquifer test results (TTL, 2020) and/or literature values (Table 2).

To evaluate the range of potential conditions and seepage rates across the mine site, three locations with differing hydraulic conductivity values were selected for modeling the mine footprint (Figure 3). The drain boundary in MODFLOW-USG was used to represent the pit. Each pit location is simulated using a different model as the remaining areas within the proposed mine footprint would be either undisturbed or backfilled. Aquifer and slug test data (GSI, 2021) were honored during model calibration. It is also assumed that backfilled areas retain hydraulic parameter values that remain generally consistent with pre-mining conditions. Laboratory analyses suggest an approximate hydraulic conductivity of 2.8 feet/day for reclaimed sands, which falls within the range of values evaluated over the 3 different pit locations and, therefore, also with in the range of estimated seepage rates discussed below (GSI, 2021).

The drain boundary allows water to leave the groundwater system when water levels are at or above a prescribed “drain” elevation – no flow occurs when groundwater levels are below the “drain” elevation. The pit vertically extends through the first 5 model layers and the bottom elevation of Layer 5 (which was modeled as 50 feet below ground surface) is set as the drain elevation within the pit bottom, assuming that the pit will be dewatered completely. Drain boundary conditions representing pit walls on the periphery of the moving pit were assigned elevations equal to layer bottoms across the first 5 layers to allow maximum simulated dewatering of the model grid cell. The conductance term in the pit wall drains is a function of the calibrated horizontal hydraulic conductivity while the vertical hydraulic conductivity of layer 6

(Silty Clayey Sand Unit) is used to calculate conductance for cells representing the pit floor (Table 3).

Seepage Estimation Results

Seepage estimation results for the three different scenarios are provided in Figure 4. It is significant to note that the implementation of drains over the 500 feet x 100 feet x 50 feet dimensions of the moving pit with a drain elevation set instantly at the bottom of the pit overestimates initial modeled seepage rates. This is because the drains in the MODFLOW-USG model instantaneously dewater the entire pit volume; in reality, however, pit dewatering will not occur instantaneously as assumed in the model, but rather gradually over time as dragline excavation and associated dewatering proceeds. Thus, while the drain package is commonly used to estimate anticipated pit seepage and dewatering rates in mining projects, this instantaneous lowering of the water table to the pit bottom results in simulated groundwater inflows during early time periods that substantially overestimate actual seepage rates. This effect has been recognized in modeled seepage rates using similar methods at other mining projects (e.g., Tetra Tech, 2010; Hydrometrics, Inc., 2014).

The longer-term simulated pit seepage rates are, therefore, more indicative of what could be expected to flow into the pit as it moves across the proposed mine area. For pit locations 2 and 3, seepage rates stabilize between 681 and 684 gallons per minute (gpm) due to the higher horizontal hydraulic conductivities (Kh) of the Silty Clayey Sand Unit (Table 3) in both those areas. At pit location 1, the seepage rate equilibrates at 201 gpm as a result of the much lower Kh at depth in the area. Note that mechanical evaporator units, described in Wood (2022), are capable of evaporating up to 1,000 gpm of water from the mine holding ponds, which exceeds the long-term expected seepage rate into the moving mine pit.

The 5-day average pit seepage rate was also calculated for each representative location in order to include the rapid initial simulated dewatering rates. For pit locations 1, 2, and 3, the 5-day average seepage rates were 344, 1,087, and 959 gpm, respectively. These averages are higher than the more representative, longer-term seepage rates due, in large part, to the high modeled initial seepage rates resulting from the instantaneous dewatering assumed by the model, described above.

An average seepage rate for the entire mine footprint was also estimated by evaluating the area with high or low Kh values. First, the weighted arithmetic mean was calculated for each column of grid cells using its calibrated horizontal hydraulic conductivities values in model Layers 1 through 5 (Figure 5). The weighted arithmetic mean is typically used to find a single representative horizontal hydraulic conductivity value when averaging across multiple hydrostratigraphic units (Fetter, 2002). Horizontal hydraulic conductivities were used since the seepage into the pit through the pit walls predominantly controls the overall inflow rate. Figure 5 also shows the 3 pit locations where seepage rates were estimated, the range of mean values, and the area represented by each of the hydraulic conductivity ranges. A single weighted average for the entire proposed mine area is then calculated as

$$Average\ Seepage = (P1 * FA1) + (P2 * FA2) + (P3 * FA3),\ \text{where}$$

P1 = average seepage rate at pit location 1 (302 gpm)
RA1 = fractional area where P1 is representative (0.247)
P2 = average seepage rate at pit location 2 (1,087 gpm)

RA2 = fractional area where P2 is representative (0.253)
P3 = average seepage rate at pit location 1 (959 gpm)
RA3 = fractional area where P1 is representative (0.500)

Thus, the weighted average estimate for pit seepage for the entire proposed mine area is 783 gpm. Again, this is a highly conservative estimate of average seepage rates across the site due to the instantaneous dewatering effect, described above.

It should be noted that these estimated inflow rates are also likely to be conservative because they do not account for the effects of water remaining in the pit. Modeled inflow rates assume that the pit will be fully dewatered down to 50 feet below ground surface, and that horizontal inflows will accordingly occur from of the full face of the pit wall. TPM has advised, however, that it intends to dewater the moving pit to maintain water levels less than 8 feet, meaning that up to 8 feet of water may remain in the pit during mining operations (TPM 2022). Also, the pit depth will be less than the modeled maximum of 50 feet below current ground surface, which will further reduce the expected seepage rates. While GSI has not attempted to quantify the resulting reductions in seepage rates, this provides a further level of conservatism to the modeled estimates above.

Okefenokee National Wildlife Refuge Water Balance

The GSI (2021), MODFLOW-NWT, groundwater model was previously used to evaluate the project area water balance for both pre- and post-mining scenarios. The calibrated model (rather than any of the sensitivity analyses versions) was also used here, to evaluate the water balance for the portion of the Okefenokee National Wildlife Refuge (ONWR) located within the active groundwater model domain (Figure 6).

The ONWR water balance for post-mining conditions is evaluated for only the 10.9% bentonite soil amendment approach for consolidated black sands replacement. GSI (2021) demonstrated this mine reclamation approach most closely replicated pre-mining groundwater elevation and water balance conditions, and that the “east” versus “west” water balance components did not change as a result of mining and reclamation, for all of the bentonite amendment cases.

Table 4 provides pre- and post-mining zone-budget for volumetric flow rates for the ONWR area shown in Figure 6. There is no difference between the pre- and post-mining outflow to the drains that depict the ONWR.

Western Constant Head Boundary Sensitivity Analysis

The calibrated MODFLOW-NWT model (GSI 2021) was also used to evaluate potential sensitivity to the elevations assigned within the constant head boundary located on the western portion of the model domain. The western constant head boundary cells were lowered by 10 feet in both the calibrated model and the 10.9% bentonite soil amendment post-mining conditions model. The ONWR water balance was then compared for both scenarios and is provided as Table 5.

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Table 5 provides pre- and post-mining water balance volumetric flow rates for the ONWR area shown in Figure 6. There is no difference between the pre- and post-mining water balance for the ONWR even if the elevations in the constant head boundaries are significantly lowered.

Revised Water Balance Tables

Revised water balance tables from the GSI (2021) are provided as Tables 6 through 10. They have been updated to include both volumetric fluxes as a percentage of recharge and the actual flow rates. Each table contains a note that correlates the revised table to the original table in GSI (2021).

References

Fetter (2001). *Applied Hydrogeology 4th Edition*. Upper Saddle River, New Jersey.

GSI (2021). Modeling the Groundwater Flow System at the Proposed Twin Pines Mine on Trail Ridge, July.

Hydrometrics (2014). Otter Creek Mine Groundwater Flow Model Development, Calibration, and Mine Dewatering Simulation, October.

Panday (2022). USG-Transport: Transport and other Enhancements to MODFLOW-USG. June.

Tetra Tech (2010). Regional Groundwater Flow Model Rosemont Copper Project. November.

TTL (2020). Impact of the Proposed Twin Pines Mine on the Trail Ridge Hydrologic System, January.

Wood (2022). Water Use Management Plan Saunders Demonstration Mine, November.

Tables

Table 1. Calibration Statistics Comparison for Steady-State Simulations

Twin Pines Minerals, LLC, St. George

Charlton County, Georgia

Statistic	Model Values - MODFLOW NWT	Model Values - MODFLOW USG
Number of targets	87	87
Number of observations	87	87
Range in observed values	63.79	63.79
Minimum residual	-6.09	-6.40
Maximum residual	9.02	9.08
Sum of squared residuals	9.05E+02	9.51E+02
Root mean square (RMS) error	3.23	3.31
Residual mean	0.76	0.85
Absolute residual mean	2.39	2.51
Standard deviation	3.14	3.19
Scaled residual mean	0.012	0.130
Scaled absolute residual mean	0.037	0.039
Scaled standard deviation	0.049	0.050
Scaled RMS error	0.051	0.052

Table 2. Storage Values for Dewatering Estimates

Twin Pines Minerals, LLC, St. George

Charlton County, Georgia

Hydrostratigraphic Unit	Model Layers	Specific Yield	Specific Storage (1/foot)
Unconsolidated & Semiconsolidated Sand	1	0.15	2.0E-04
Consolidated Black Sand	2-3	0.01	4.0E-05
Silty Clayey Sand Unit	4-6	0.10	6.0E-05
Sand Clay Unit	7	0.05	4.0E-04

Table 3. Hydraulic Conductivities for Pit Seepage Calculations

Twin Pines Minerals, LLC, St. George

Charlton County, Georgia

Pit Seepage Scenario	Hydrostratigraphic Unit	Model Layers	Pit Wall Horizontal Hydraulic Conductivity (feet/day)	Pit Bottom Vertical Hydraulic Conductivity (feet/day)
Location 1	Unconsolidated & Semiconsolidated Sand	1	11.18 - 11.52	--
	Consolidated Black Sand	2-3	0.00041 - 0.00066	--
	Silty Clayey Sand Unit	4-5	0.45 - 0.62	--
	Slity Clayey Sand Unit	6	--	0.045 - 0.062
Location 2	Unconsolidated & Semiconsolidated Sand	1	24.3 - 29.4	
	Consolidated Black Sand	2-3	0.00065 - 0.00078	
	Silty Clayey Sand Unit	4-5	3.6 - 8.4	
	Slity Clayey Sand Unit	6	--	0.84
Location 3	Unconsolidated & Semiconsolidated Sand	1	3.3 - 4.2	--
	Consolidated Black Sand	2-3	0.6 - 1.8	--
	Silty Clayey Sand Unit	4-5	5.3 - 8.5	--
	Slity Clayey Sand Unit	6	--	0.53 - 0.85

Notes:

1. Location 3 is in an area within the proposed mine footpring where the consolidated black sands were noted to be absent in site boring logs.

Table 4. Pre- and Post-Mining Zone Budget Comparisons for Okefenokee National Wildlife Refuge

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Water Budget Component		Pre-Mining	Post-Mining 10.9 % Bentonite Soil Amendment
Inflows (gallons per minute)	Recharge	322	322
	Lateral Inflows	31	31
Outflows (gallons per minute)	Lateral Outflows	11	11
	Outflow to Okefenokee Wetland	342	342
Percent Mass Balance Error		0.0%	0.0%

Table 5. Pre- and Post-Mining Water Budget Comparisons for Lower Western Boundary Constant Heads

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Water Budget Component		Pre-Mining	Post-Mining 10.9 % Bentonite Soil Amendment
Inflows (gallons per minute)	Recharge	322.1	322.1
	Lateral Inflows	37.5	37.5
Outflows (gallons per minute)	Lateral Outflows	142.9	142.9
	Outflow to Okefenokee Wetlands	216.7	216.7
Percent Mass Balance Error		0.0%	0.0%

Notes:

1. Modflow drain packages represents National Hydrography Dataset wetlands and streams as shown on Figures 22 and 23 in GSI (2021).

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Table 6. Pre-Mining Simulation Water Budget

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Water Budget Component		Pre-Mining		
		West[1]	East[2]	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%
		28	114	309
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%
		1,389	877	4,472
Percent Mass Balance Error		0.0%		

Notes:

1. West refers to the west of the Trail Ridge crest as shown on Figure 33.
2. East refers to the east of the Trail Ridge crest as shown on Figure 33.
3. Modflow drain packages represents National Hydrography Dataset wetlands and streams as shown on Figures 22 and 23.
4. GSI (2021) Table 3.

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Table 7. Pre- and Post-Mining Water Budget Comparisons for Soil Amendment Bentonite Percentages

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Water Budget Component		Pre-Mining			No Bentonite Soil Amendment		
		West[1]	East[2]	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.4%	6.5%
		28	114	309	28	114	309
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	52.0%	41.6%	93.5%
		1,389	877	4,472	1,387	878	4,473
Percent Mass Balance Error		0.0%			0.0%		

Water Budget Component		5.3% Bentonite Soil Amendment			10.9 % Bentonite Soil Amendment			12.5% Bentonite Soil Amendment		
		West	East	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,669	2,113	4,782	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.4%	6.5%	1.1%	5.4%	6.5%
		28	114	309	28	114	309	28	114	309
	Outflow to Modflow Drain Package[3]	52.0%	41.6%	93.5%	52.1%	41.5%	93.6%	52.0%	41.6%	93.5%
		1,387	878	4,472	1,390	877	4,474	1,387	878	4,472
Percent Mass Balance Error		0.0%			0.0%			0.1%		

Notes:

1. West refers to the west of the Trail Ridge crest as shown on Figure 33.
2. East refers to the east of the Trail Ridge crest as shown on Figure 33.
3. Modflow drain packages represents National Hydrography Dataset wetlands and streams as shown on Figures 22 and 23.
4. GSI (2021) Table 4.

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Table 8. Pre- and Post-Mining Water Budget Comparisons for Recharge Rates

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Water Budget Component		Pre-Mining Recharge of 4.13 in/yr			Pre-Mining Recharge of 3.5 in/yr			Pre-Mining Recharge of 4.5 in/yr		
		West[1]	East[2]	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,262	1,791	4,052	2,908	2,303	5,210
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.8%	7.0%	1.0%	5.2%	6.2%
		28	114	309	26	104	283	30	119	323
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	51.6%	41.4%	93.0%	52.3%	41.5%	93.8%
		1,389	877	4,472	1,167	742	3,770	1,520	956	4,886
Percent Mass Balance Error		0.0%			0.0%			0.0%		

Water Budget Component		10.9% Bentonite w/ Recharge of 4.13 in/yr			10.9% Bentonite w/ Recharge of 3.5 in/yr			10.9% bentonite w/ Recharge of 4.5 in/yr		
		West	East	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,262	1,791	4,052	2,908	2,303	5,210
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.8%	7.0%	1.0%	5.2%	6.2%
		28	114	309	26	104	283	30	119	323
	Outflow to Modflow Drain Package	52.1%	41.5%	93.6%	51.7%	41.4%	93.1%	52.2%	41.5%	93.8%
		1,390	877	4,474	1,168	741	3,771	1,519	956	4,886
Percent Mass Balance Error		0.0%			0.0%			0.0%		

Notes:

1. West refers to the west of the Trail Ridge crest as shown on Figure 33.
2. East refers to the east of the Trail Ridge crest as shown on Figure 33.
3. Modflow drain packages represents National Hydrography Dataset wetlands and streams as shown on Figures 22 and 23.
4. GSI (2021) Table 5.

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Table 9. Pre- and Post-Mining Water Budget Comparisons for Consolidated Black Sands Hydraulic Conductivity

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Water Budget Component		Pre-Mining w/ Calibrated Hydraulic Conductivity			Pre-Mining Calibration Value x 5			Pre-Mining Calibration Value ÷ 5		
		West[1]	East[2]	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,669	2,113	4,782	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.0%	4.9%	5.9%	1.1%	5.7%	6.8%
		28	114	309	27	104	284	29	120	323
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	52.0%	42.1%	94.1%	52.8%	40.5%	93.2%
		1,389	877	4,472	1,388	889	4,499	1,408	855	4,458
Percent Mass Balance Error		0.0%			0.0%			0.0%		

Water Budget Component		10.9% Bentonite w/ Calibrated Hydraulic Conductivity			10.9% Bentonite w/ Calibration Value x 5			10.9% bentonite w/ Calibration Value ÷ 5		
		West	East	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,669	2,113	4,782	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.0%	4.9%	5.9%	1.1%	5.7%	6.8%
		28	114	309	27	104	284	29	120	324
	Outflow to Modflow Drain Package	52.1%	41.5%	93.6%	52.1%	42.0%	94.0%	52.6%	40.6%	93.2%
		1,390	877	4,474	1,389	887	4,497	1,403	859	4,458
Percent Mass Balance Error		0.0%			0.0%			0.0%		

Notes:

1. West refers to the west of the Trail Ridge crest as shown on Figure 33.
2. East refers to the east of the Trail Ridge crest as shown on Figure 33.
3. Modflow drain packages represents National Hydrography Dataset wetlands and streams as shown on Figures 22 and 23.
4. GSI (2021) Table 6.

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Table 10. Pre- and Post-Mining Water Budget Comparisons for Unconsolidated & Semi-Consolidated Sands Hydraulic Conductivity

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

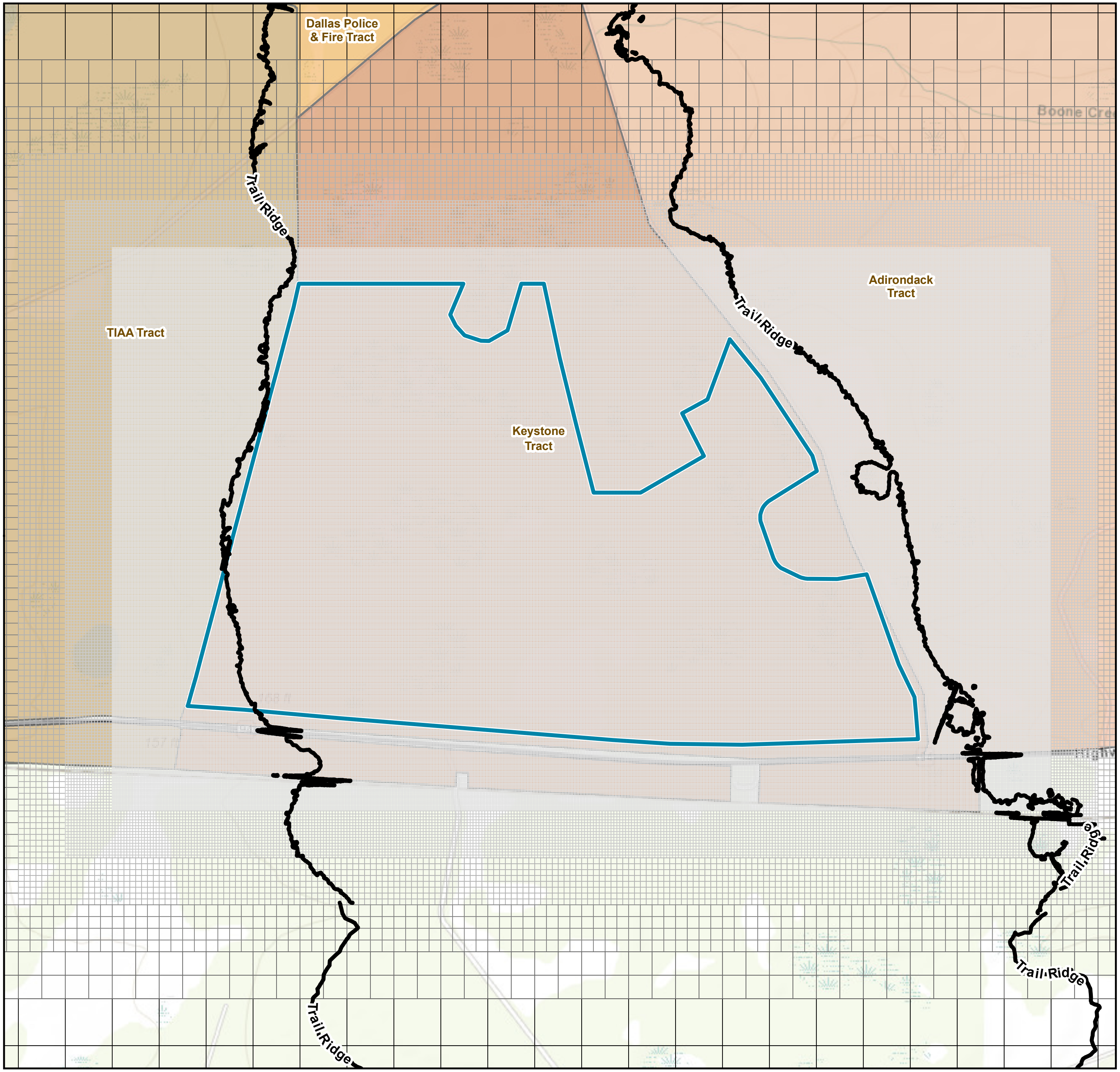
Water Budget Component		Pre-Mining w/ Calibrated Hydraulic Conductivity			Pre-Mining Calibration Value x 5			Pre-Mining Calibration Value ÷ 5		
		West[1]	East[2]	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,669	2,113	4,782	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.8%	7.9%	9.7%	0.7%	4.1%	4.8%
		28	114	309	48	167	464	19	86	230
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	48.4%	41.9%	90.3%	53.5%	41.7%	95.2%
		1,389	877	4,472	1,291	886	4,319	1,426	882	4,551
Percent Mass Balance Error		0.0%			0.0%			0.0%		

Water Budget Component		10.9% Bentonite w/ Calibrated Hydraulic Conductivity			10.9% Bentonite w/ Calibration Value x 5			10.9% bentonite w/ Calibration Value ÷ 5		
		West	East	Total	West	East	Total	West	East	Total
Inflows (gallons per minute)	Recharge	2,669	2,113	4,782	2,669	2,113	4,782	2,669	2,113	4,782
Outflows (as % of Total Recharge and gallons per minute)	Lateral Outflows	1.1%	5.4%	6.5%	1.8%	7.9%	9.7%	0.7%	4.1%	4.8%
		28	114	309	48	167	464	19	86	230
	Outflow to Modflow Drain Package	52.1%	41.5%	93.6%	48.4%	41.9%	90.3%	53.4%	41.8%	95.2%
		1,390	877	4,474	1,291	886	4,317	1,425	883	4,551
Percent Mass Balance Error		0.0%			0.0%			0.0%		

Notes:

1. West refers to the west of the Trail Ridge crest as shown on Figure 33.
2. East refers to the east of the Trail Ridge crest as shown on Figure 33.
3. Modflow drain packages represents National Hydrography Dataset wetlands and streams as shown on Figures 22 and 23.
4. GSI (2021) Table 7.

Figures



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area

Refined Model Grid Cell Length (Feet)

- 15.6
- 31.3
- 62.5
- 125
- 250
- 500
- Adirondack Tract
- Dallas Police & Fire Tract
- Keystone Tract
- TIAA Tract

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Feet

0 750 1,500

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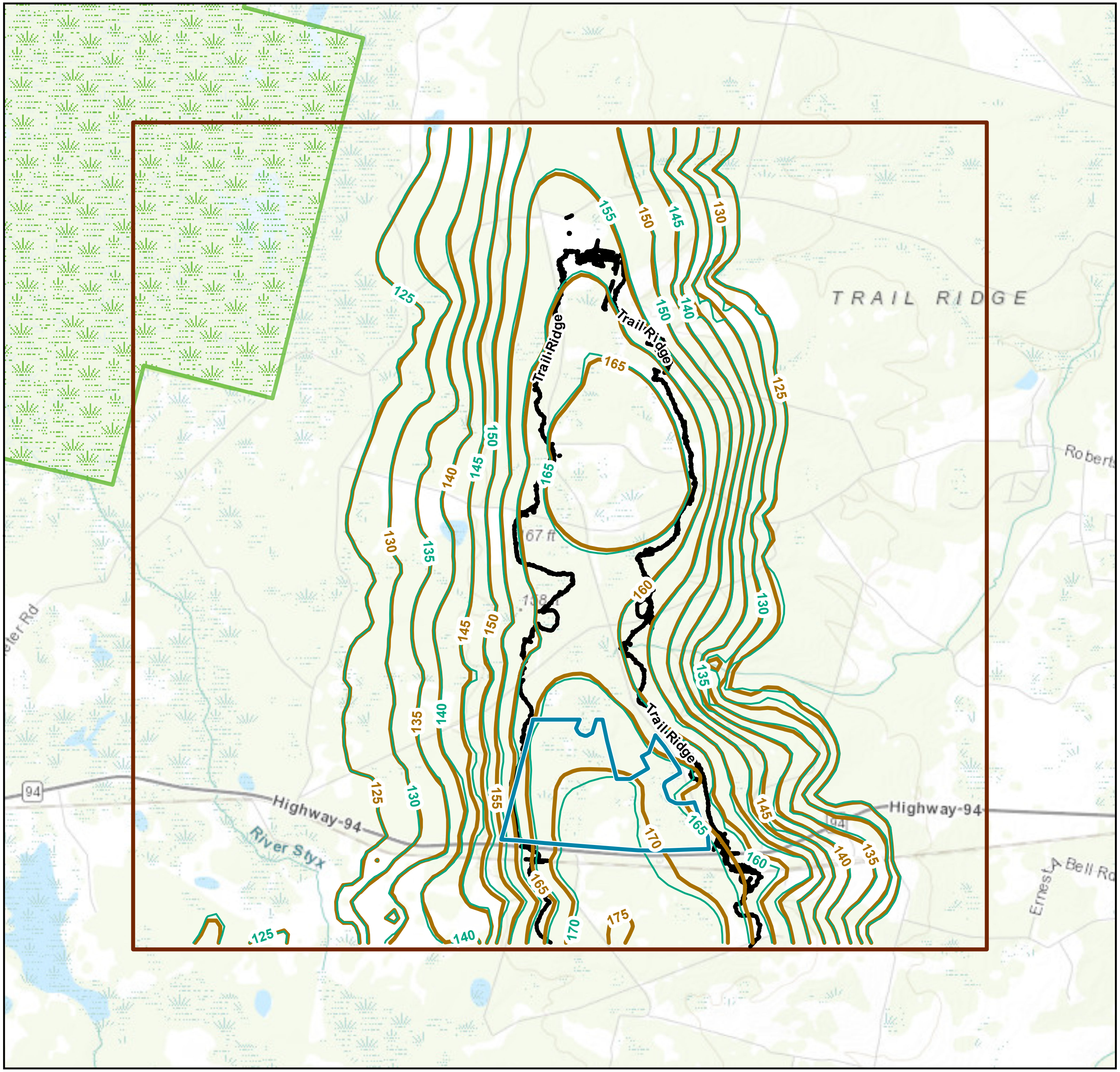
Figure 1
Refined MODFLOW-USG Model Grid

Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 6365	Drawn By: RLW
Issued: 9-Nov-2022	Chk'd By: SP
Map ID: Figure01	Appv'd By: SP

FIGURE 1



N

LEGEND

- Proposed Mining Area
- MODFLOW-USG Simulated Contours
- MODFLOW-NWT Simulated Contours
- Trail Ridge (Elevation > 165 feet)
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Miles
0 0.5 1

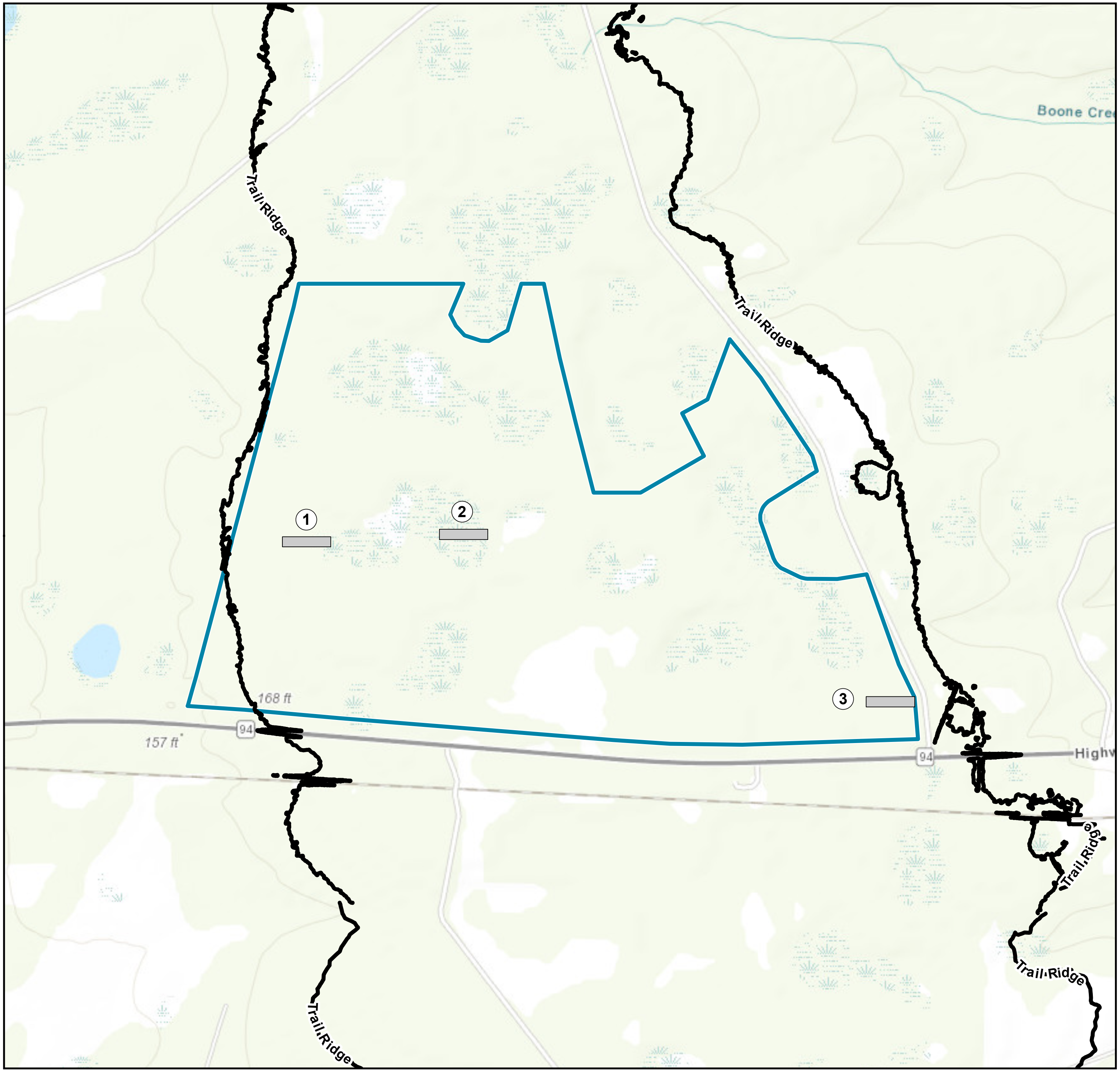
GSI ENVIRONMENTAL

Figure 2
Water Table Contour Comparisons Modflow-NWT and USG

Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 6365	Drawn By: RLW
Issued: 9-Nov-2022	Chk'd By: SP
Map ID: Figure02	Appv'd By: SP

FIGURE 2



N

LEGEND

Trail Ridge (Elevation > 165 feet)

Pit Locations for Seepage Scenarios 1 through 3

Proposed Mining Area

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Feet

0 750 1,500

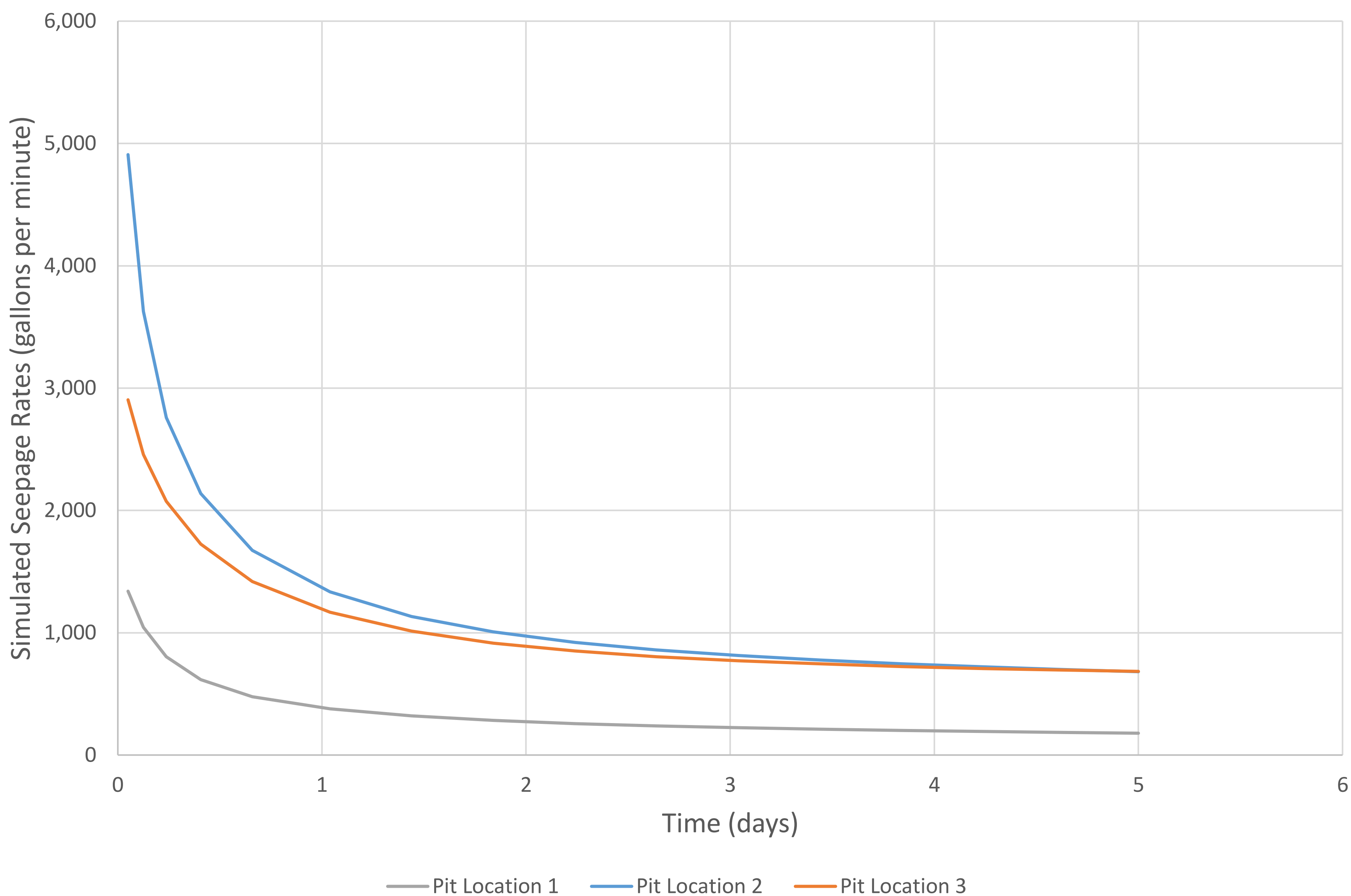
GSI ENVIRONMENTAL

Figure 3
Moving Mine Pit Locations for Seepage Rate Evaluations

Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 6365	Drawn By: RLW
Issued: 9-Nov-2022	Chk'd By: SP
Map ID: Figure03	Appv'd By: SP

FIGURE 3



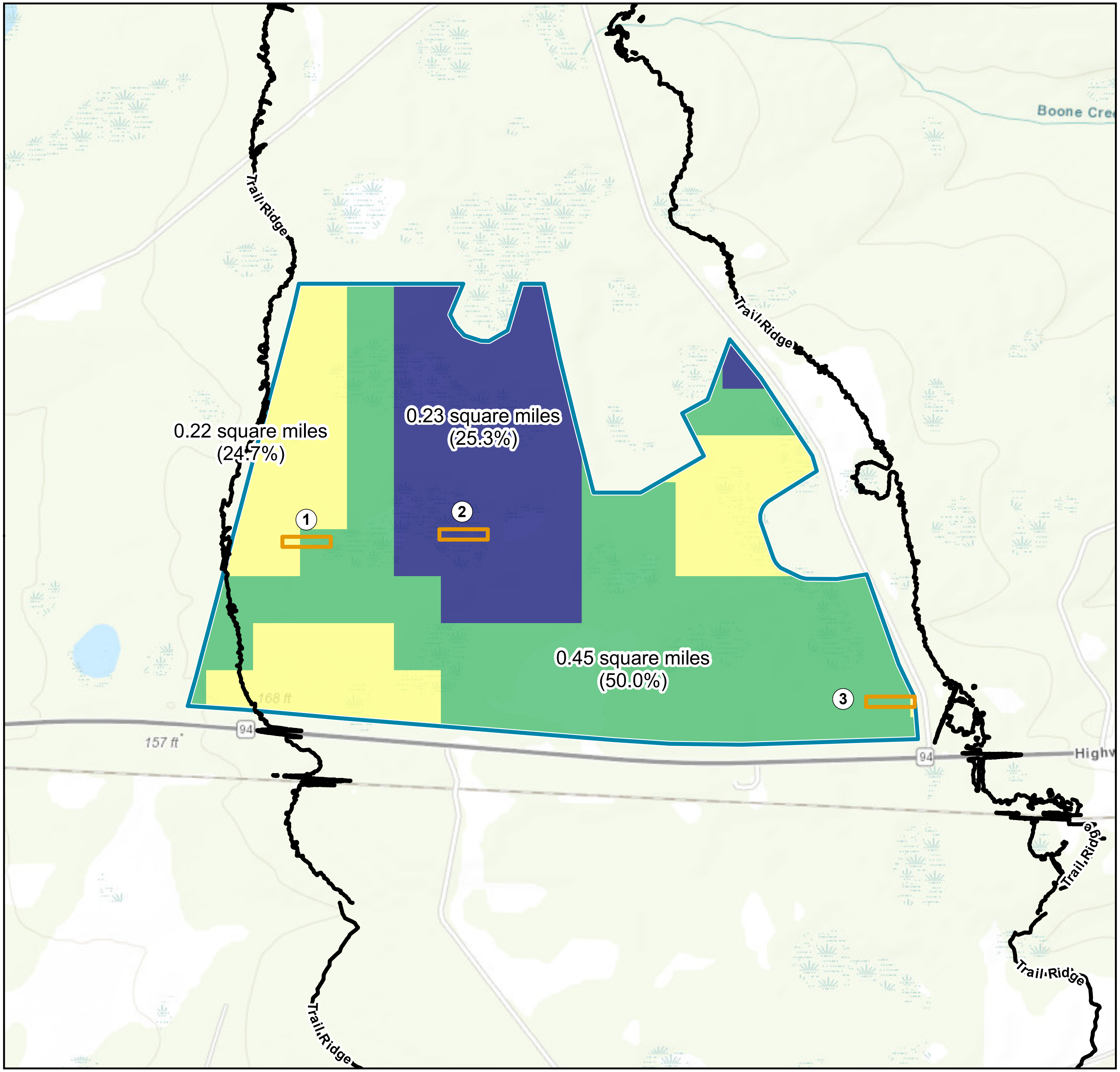
GSI ENVIRONMENTAL

GSI Job No. 6563	Drawn By: RLW
Issued: 9 November	Chk'd By: SP
Revised:	Aprv'd By: SP
Scale:	**Figure 4**

Pit Seepage Estimates for Three Different Moving Mine Locations

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia



Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Areas and percentage are representative for total areas represetned by a single color.

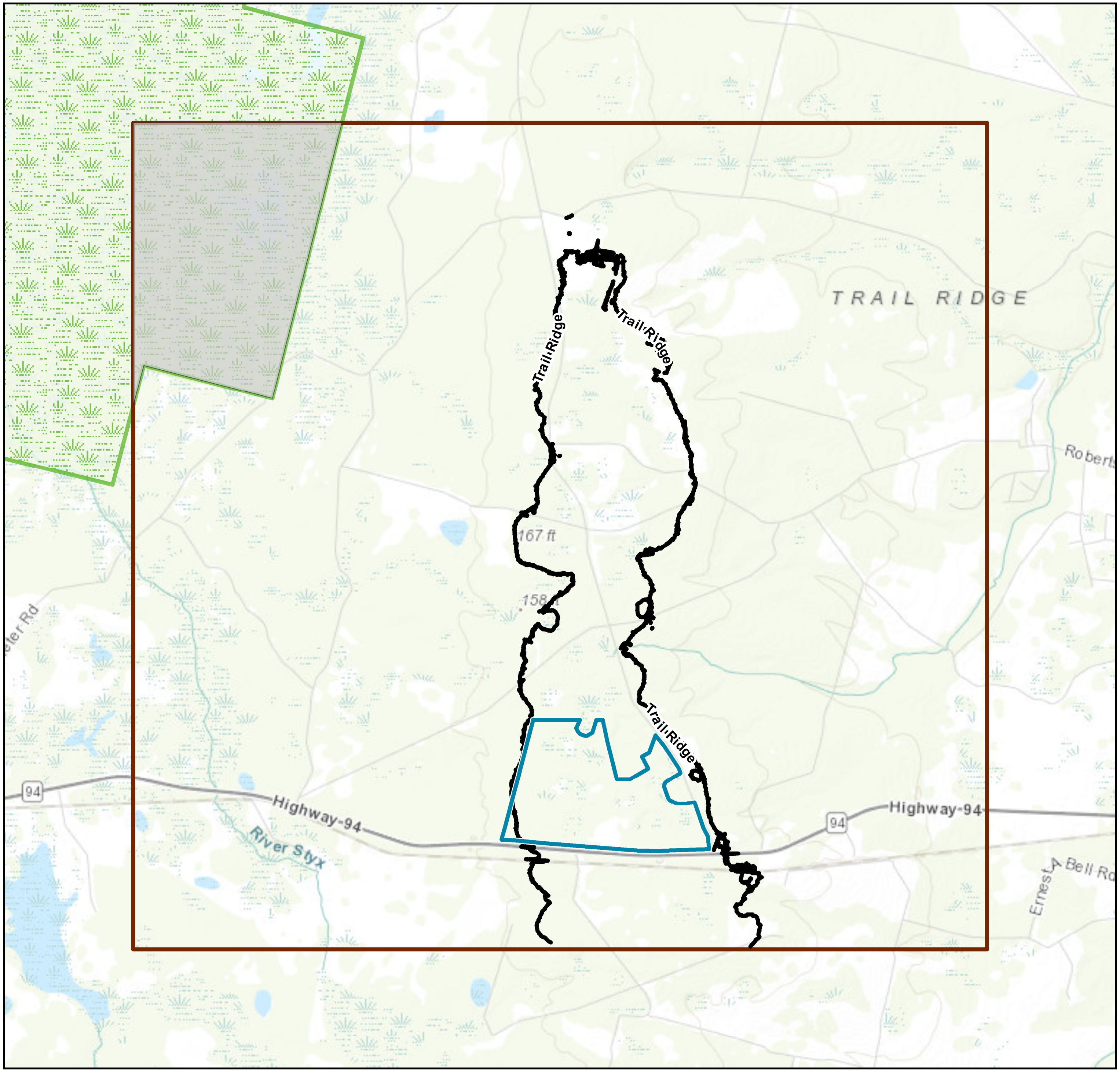
GSI ENVIRONMENTAL

Figure 5
Hydraulic Conductivity Weighted Arithmetic Mean Distributions (Layers 1 through 5)

Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 6365	Drawn By: RLW
Issued: 11-Nov-2022	Chk'd By: SP
Map ID: Figure05	Appv'd By: SP

FIGURE 5



LEGEND

- Area For Simulated Okefenokee Water Balance Calculation
- Proposed Mining Area
- Trail Ridge (Elevation > 165 feet)
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 6
Area For Simulated Okefenokee Water Balance Calculation

Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 6365	Drawn By: RLW
Issued: 9-Nov-2022	Chk'd By: SP
Map ID: Figure06	Appv'd By: SP

FIGURE 6