Tables

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Table 1. Computation of Consolidated Black Sand Areal Coverage in Study Area

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

Cross-Section	Total Length (feet)	Total Length Consolidated Black Sand (feet)	Percentage of Cross-Section Without Consolidated Black Sand
A-A'	20,700	15,500	25.1%
B-B'	19,400	15,200	21.6%
C-C'	25,900	22,000	15.1%
D-D'	20,100	14,900	25.9%
E-E'	23,300	11,500	50.6%
F-F'	23,500	11,400	51.5%
G-G'	25,500	23,000	9.8%
H-H'	7,700	5,900	23.4%
I-I'	17,900	14,600	18.4%
J-J'	11,500	11,500	0.0%
K-K'	26,000	7,800	70.0%
L-L'	25,500	17,000	33.3%
M-M'	22,000	14,300	35.0%
N-N'	15,700	12,700	19.1%
O-O'	13,500	5,800	57.0%
P-P'	21,800	12,400	43.1%
Q-Q'	25,000	16,000	36.0%
R-R'	19,200	11,500	40.1%
S-S'	14,800	11,000	25.7%
T-T'	6,000	3,000	50.0%
U-U'	5,600	5,600	0.0%
V-V'	6,700	6,700	0.0%
W-W'	26,800	22,500	16.0%
X-X'	13,800	10,200	26.1%
Total	437,900	302,000	31.0%

GSI ENVIRONMENTAL

Table 2. Calibration Statistics for Steady-State Simulation

Twin Pines Minerals, LLC, St. George

Charlton County, Georgia

Statistic	Model Values
Number of targets	87
Number of observations	87
Range in observed values	63.79
Minimum residual	-6.09
Maximum residual	9.02
Sum of squared residuals	9.05E+02
Root mean square (RMS) error	3.23
Residual mean	0.76
Absolute residual mean	2.39
Standard deviation	3.14
Scaled residual mean	0.012
Scaled absolute residual mean	0.037
Scaled standard deviation	0.049
Scaled RMS error	0.051

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Table 3. 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)	Lateral Outflows	1.1%	5.4%	6.5%
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%
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.

GSI ENVIRONMENTAL

Table 4. 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)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.4%	6.5%
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	52.0%	41.6%	93.5%
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)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.4%	6.5%	1.1%	5.4%	6.5%
	Outflow to Modflow Drain Package[3]	52.0%	41.6%	93.5%	52.1%	41.5%	93.6%	52.0%	41.6%	93.5%
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.

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Table 5. 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)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.8%	7.0%	1.0%	5.2%	6.2%
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	51.6%	41.4%	93.0%	52.3%	41.5%	93.8%
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)	Lateral Outflows	1.1%	5.4%	6.5%	1.1%	5.8%	7.0%	1.0%	5.2%	6.2%
	Outflow to Modflow Drain Package	52.1%	41.5%	93.6%	51.7%	41.4%	93.1%	52.2%	41.5%	93.8%
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.

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Table 6. 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)	Lateral Outflows	1.1%	5.4%	6.5%	1.0%	4.9%	5.9%	1.1%	5.7%	6.8%
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	52.0%	42.1%	94.1%	52.8%	40.5%	93.2%
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)	Lateral Outflows	1.1%	5.4%	6.5%	1.0%	4.9%	5.9%	1.1%	5.7%	6.8%
	Outflow to Modflow Drain Package	52.1%	41.5%	93.6%	52.1%	42.0%	94.0%	52.6%	40.6%	93.2%
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.

Table 7. 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)	Lateral Outflows	1.1%	5.4%	6.5%	1.8%	7.9%	9.7%	0.7%	4.1%	4.8%
	Outflow to Modflow Drain Package[3]	52.0%	41.5%	93.5%	48.4%	41.9%	90.3%	53.5%	41.7%	95.2%
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)	Lateral Outflows	1.1%	5.4%	6.5%	1.8%	7.9%	9.7%	0.7%	4.1%	4.8%
	Outflow to Modflow Drain Package	52.1%	41.5%	93.6%	48.4%	41.9%	90.3%	53.4%	41.8%	95.2%
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.

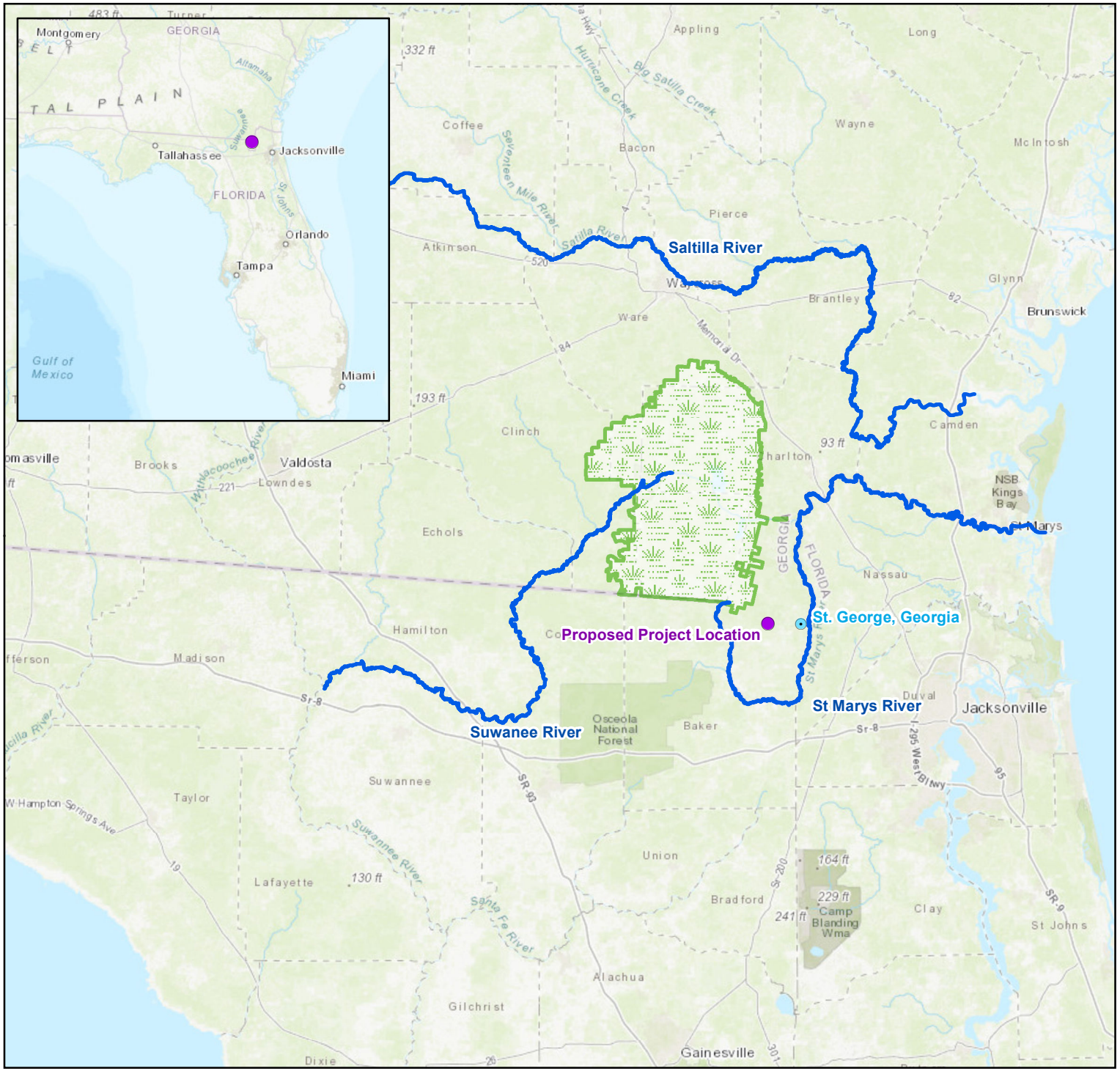
Table 8. Model Sensitivity Categorization
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

Sensitivity Simulation	Calibration Sensitivity	Predictive Sensitivity	ASTM Sensitivity Type
Recharge Rate	Low	Low	Type I
Consolidated Black Sands Hydraulic Conductivity	Low	Low	Type I
Unconsolidated and Semi-Consolidated Sand Hydraulic Conductivity	High	High	Type III

GSI ENVIRONMENTAL

Figures

Figures (cont.)



N

LEGEND

- St. George, Georgia
- Proposed Project Location
- Major Regional River Networks
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 10 20

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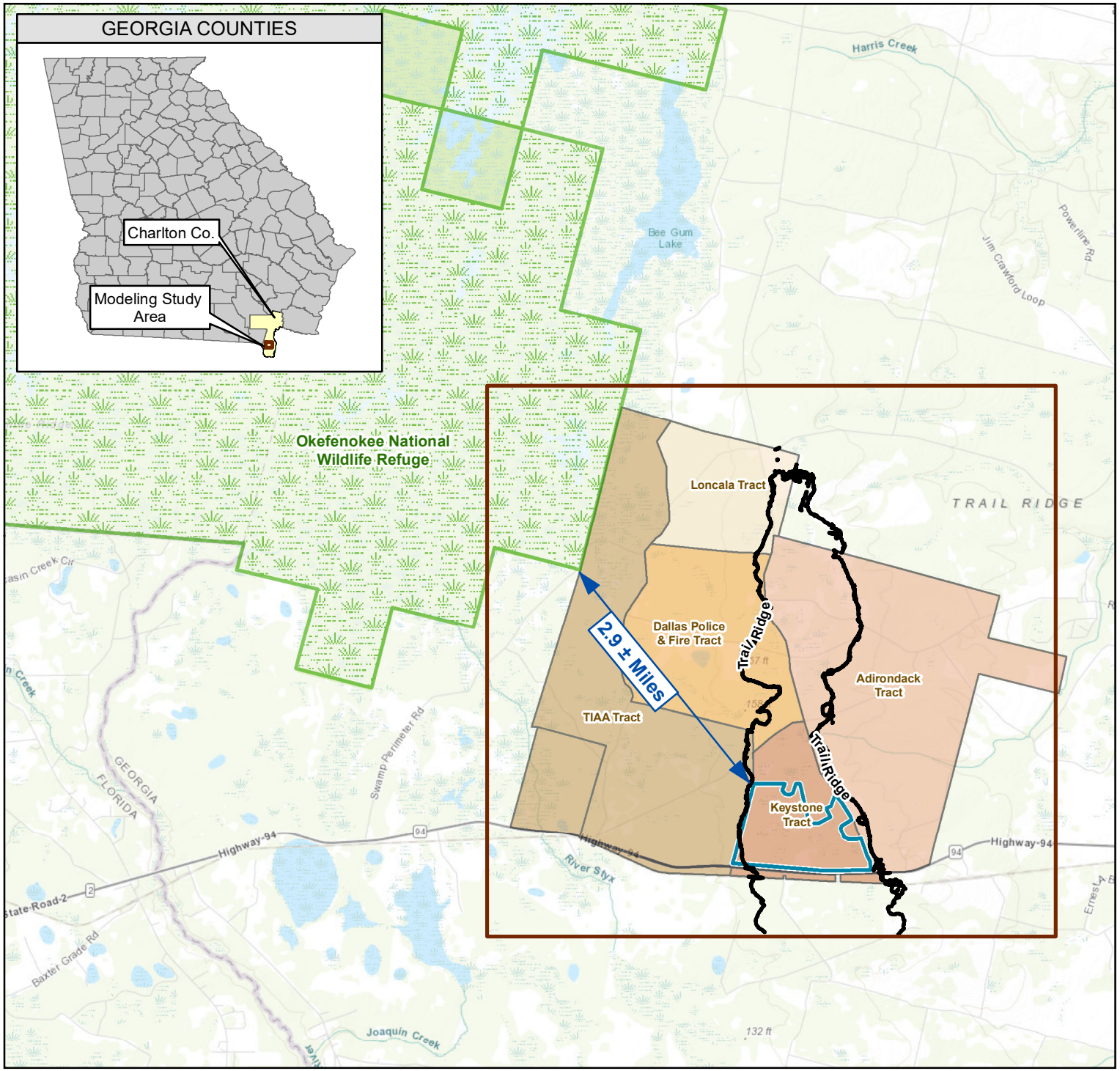
Figure 1
Location of Proposed
Twin Pines Minerals Mine

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

GSI Job No. 5844	Drawn By: RLW
Issued: 15-Jul-2021	Chk'd By: SP
Map ID: Figure01	Appv'd By: SP

FIGURE 1



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Adirondack Tract
- Dallas Police & Fire Tract
- Keystone Tract
- Loncala Tract
- TIAA Tract
- Okefenokee National Wildlife Refuge
- Modeling Study Area

Notes:

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

Scale in Miles

0 0.75 1.5

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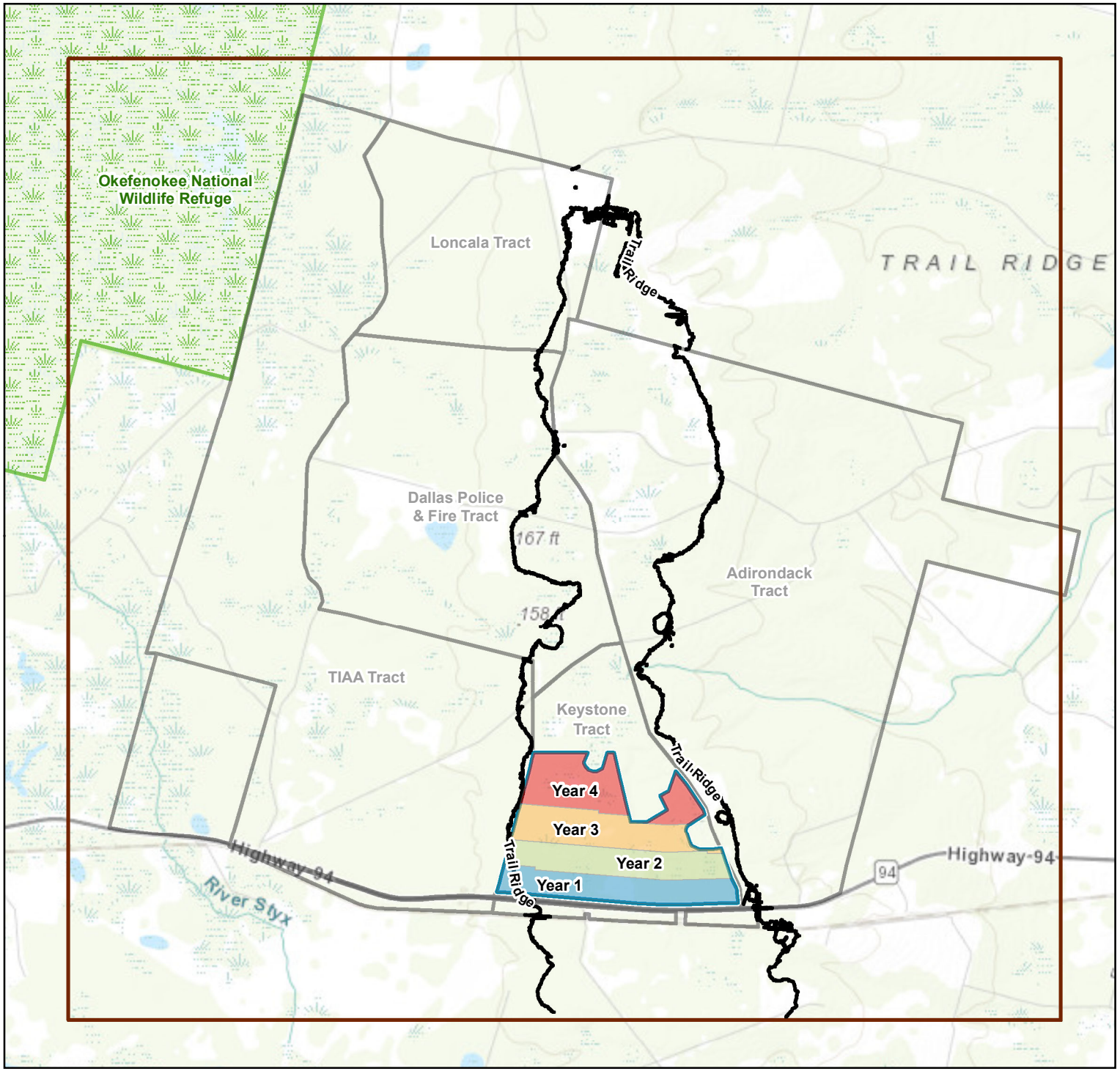
Figure 2
Project Study & Proposed Mining Area

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure02	Appv'd By: SP

FIGURE 2



N

LEGEND

Mine Schedule

- Year 1
- Year 2
- Year 3
- Year 4
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 0.5 1

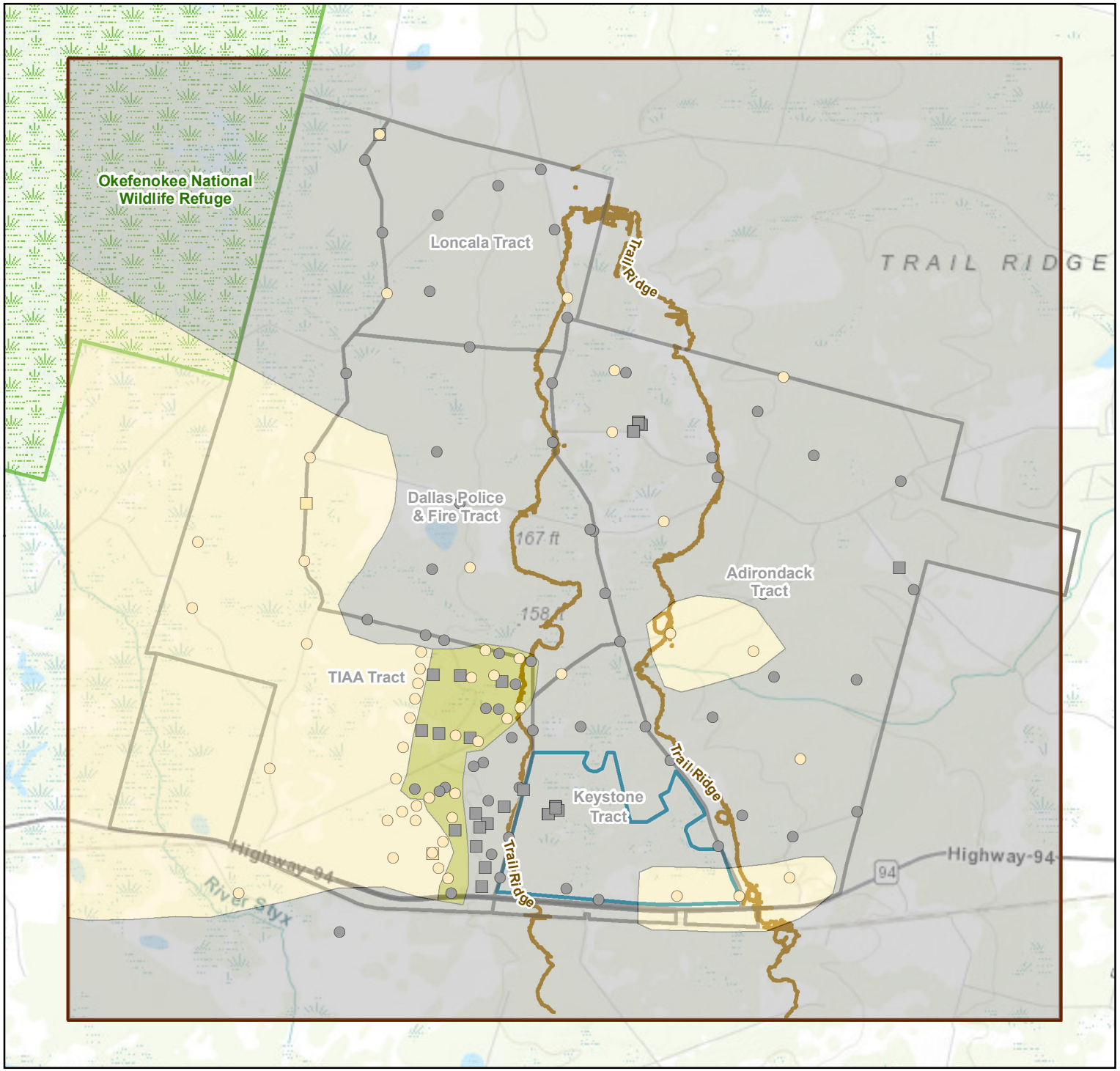
GSI ENVIRONMENTAL

Figure 3
Mining Schedule

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

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure03	Appv'd By: SP

FIGURE 3



N

LEGEND

- Well With Consolidated Black Sands Absent - Cross Sections
- Well With Consolidated Black Sands Absent - Additional Wells
- Well With Consolidated Black Sands Present - Cross Sections
- Well With Consolidated Black Sands Present - Additional Wells

Consolidated Black Sands (CBS) Classification

- Interpreted Area of Present CBS
- Interpreted Area of Absent
- Interpreted CBS Transition Zone
- Modeling Study Area
- Okefenokee National Wildlife Refuge
- Proposed Mining Area
- Trail Ridge (Elevation > 165 feet)

Notes:
1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Cross Sections refer to those included in Holt et al. (2019g). Additional wells refers to well log information not included in the 2019 cross sections.

Scale in Miles
0 0.5 1

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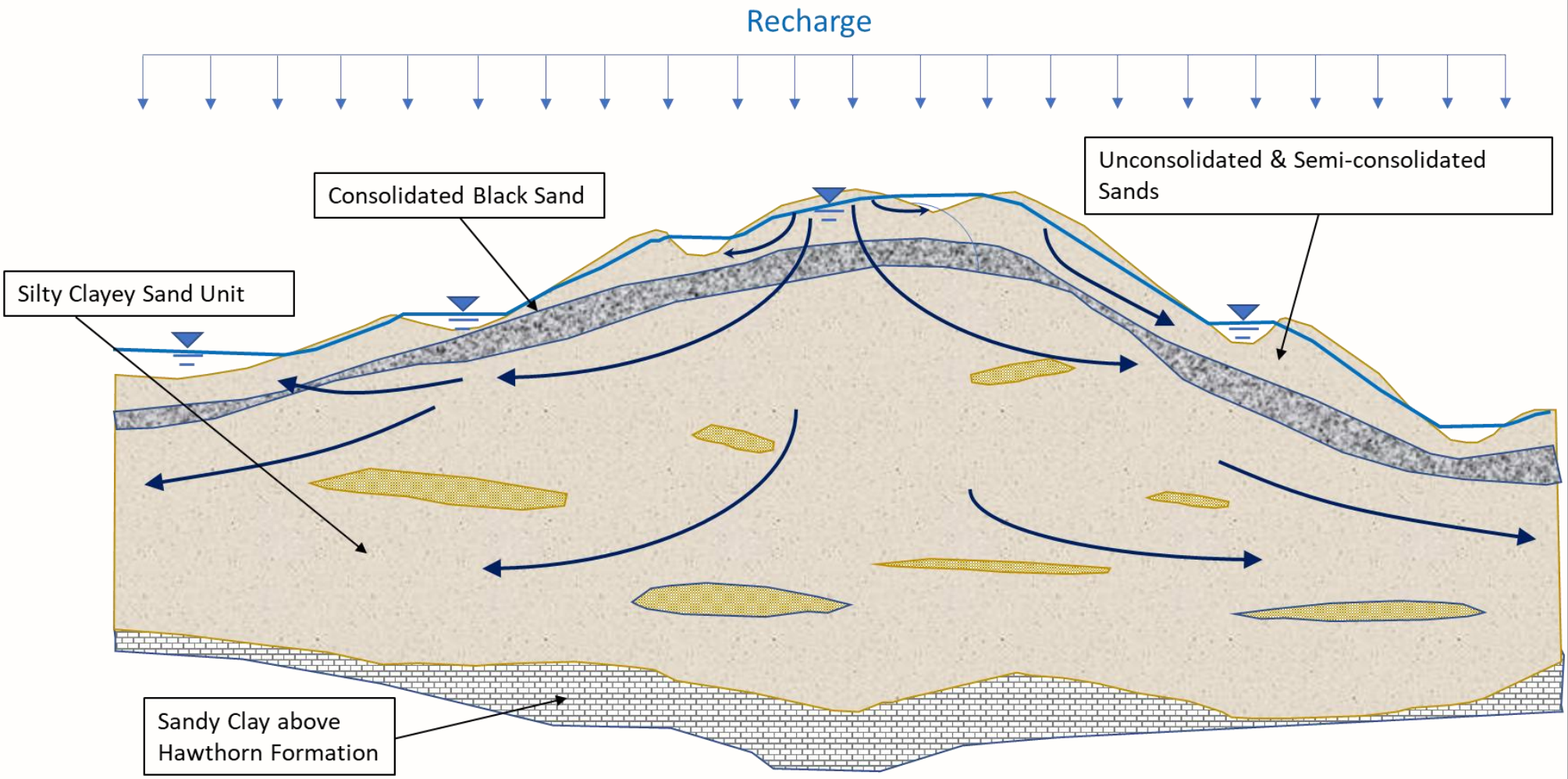
Figure 4
Aerial Distribution of Consolidated Black Sands

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure04	Appv'd By: SP

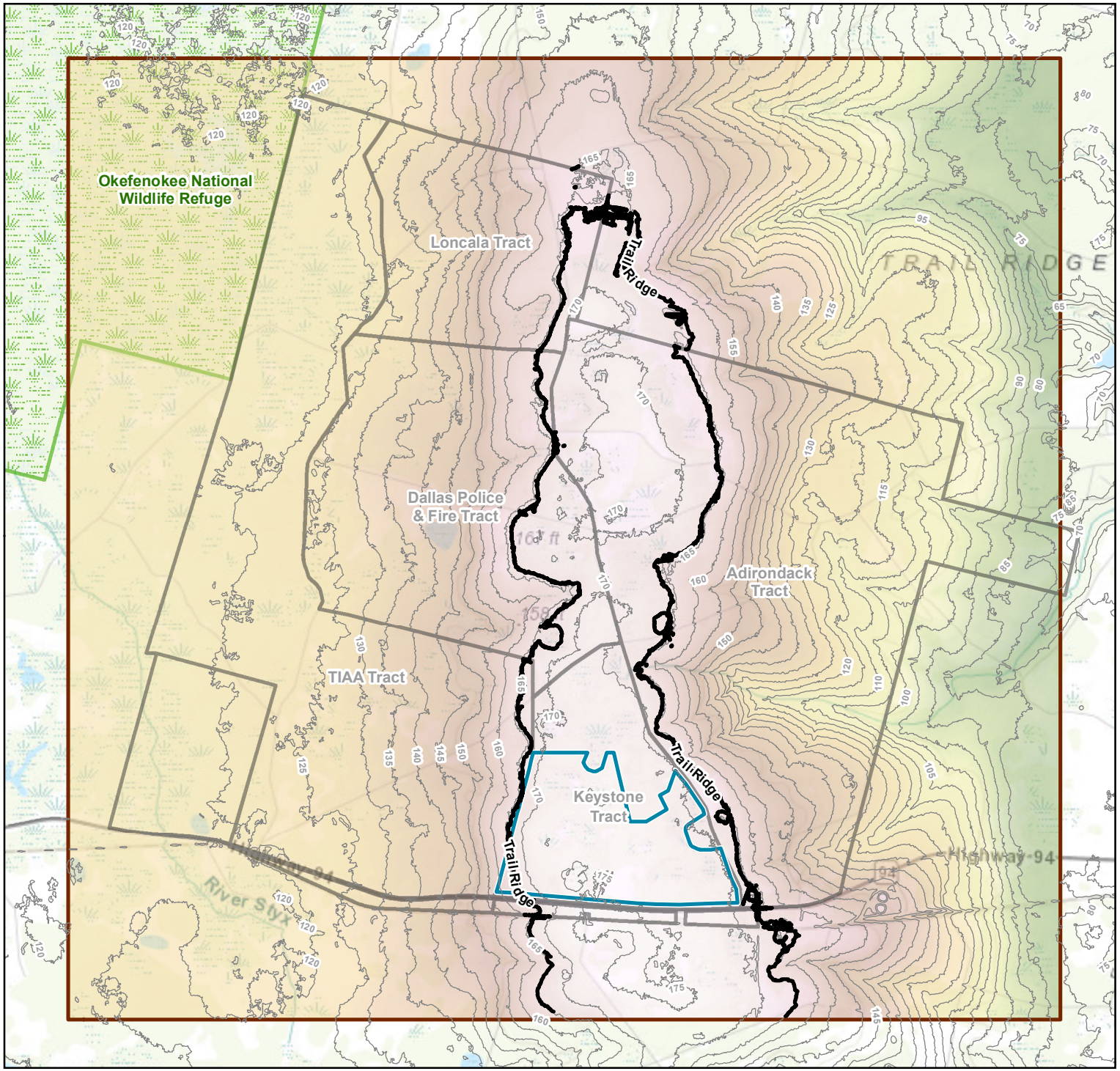
FIGURE 4



GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	GM
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 5**	

Conceptual Hydrogeologic Model of the Surficial Aquifer
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- USGS 10 Feet Elevation Contours
- Modeling Study Area
- Okefenokee National Wildlife Refuge

USGS 10m Digital Elevation Model (Feet)

High : 180.044

Low : 62.99

Notes:

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

Scale in Miles

0 0.5 1

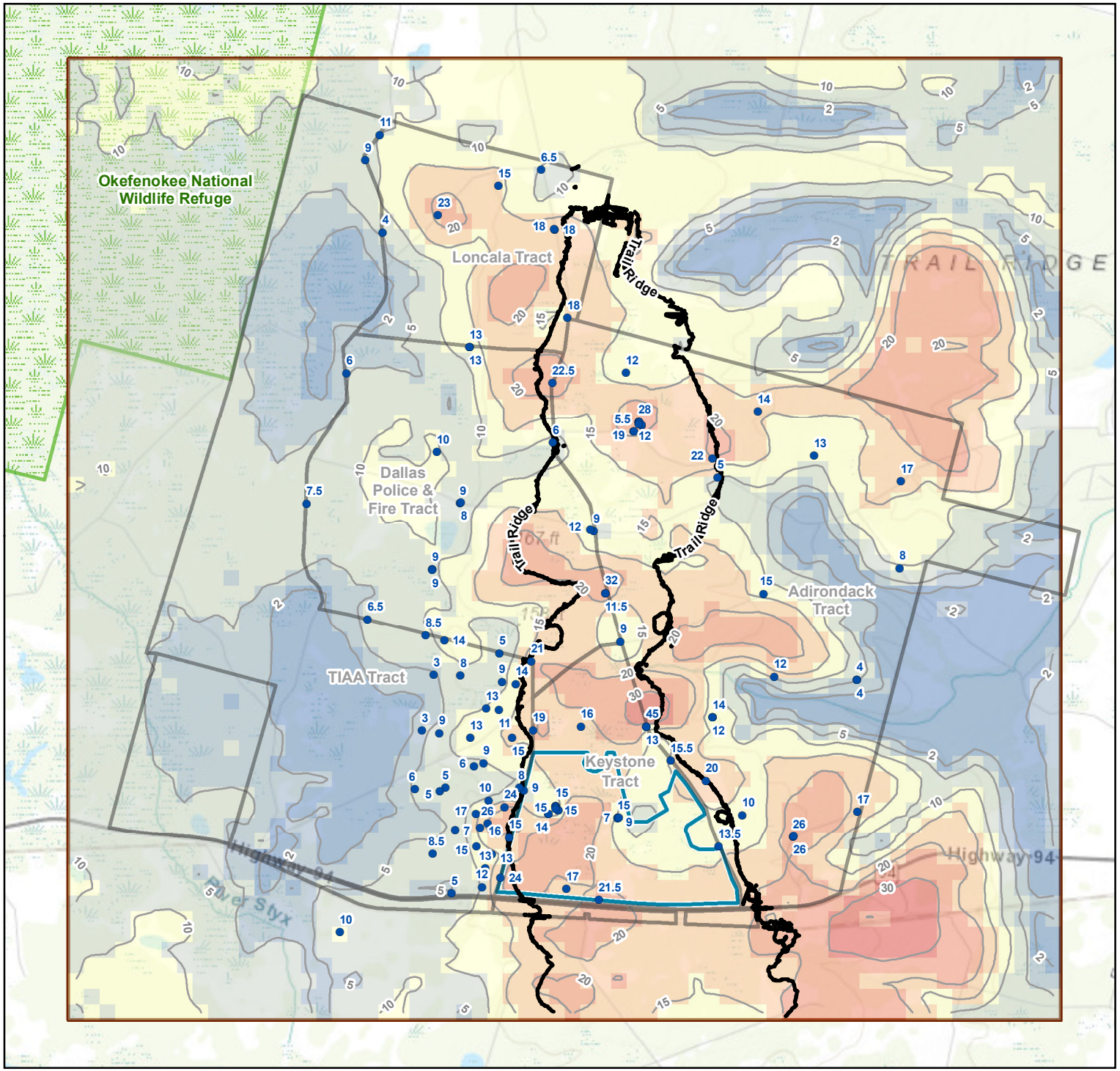
GSI ENVIRONMENTAL

Figure 6
Project Study Area
Ground Surface Elevation

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure06	Appv'd By: SP

FIGURE 6



N

LEGEND

- Well Log Unconsolidated & Semiconsolidated Sand Thickness (Feet)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 1 Thickness Contours (Feet)

Hydrostratigraphic Unit 1 Thickness (Feet)

- 0.50 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00
- 15.01 - 20.00
- 20.01 - 30.00
- 30.01 - 41.17
- Modeling Study Area
- Okefenokee National Wildlife Refuge

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

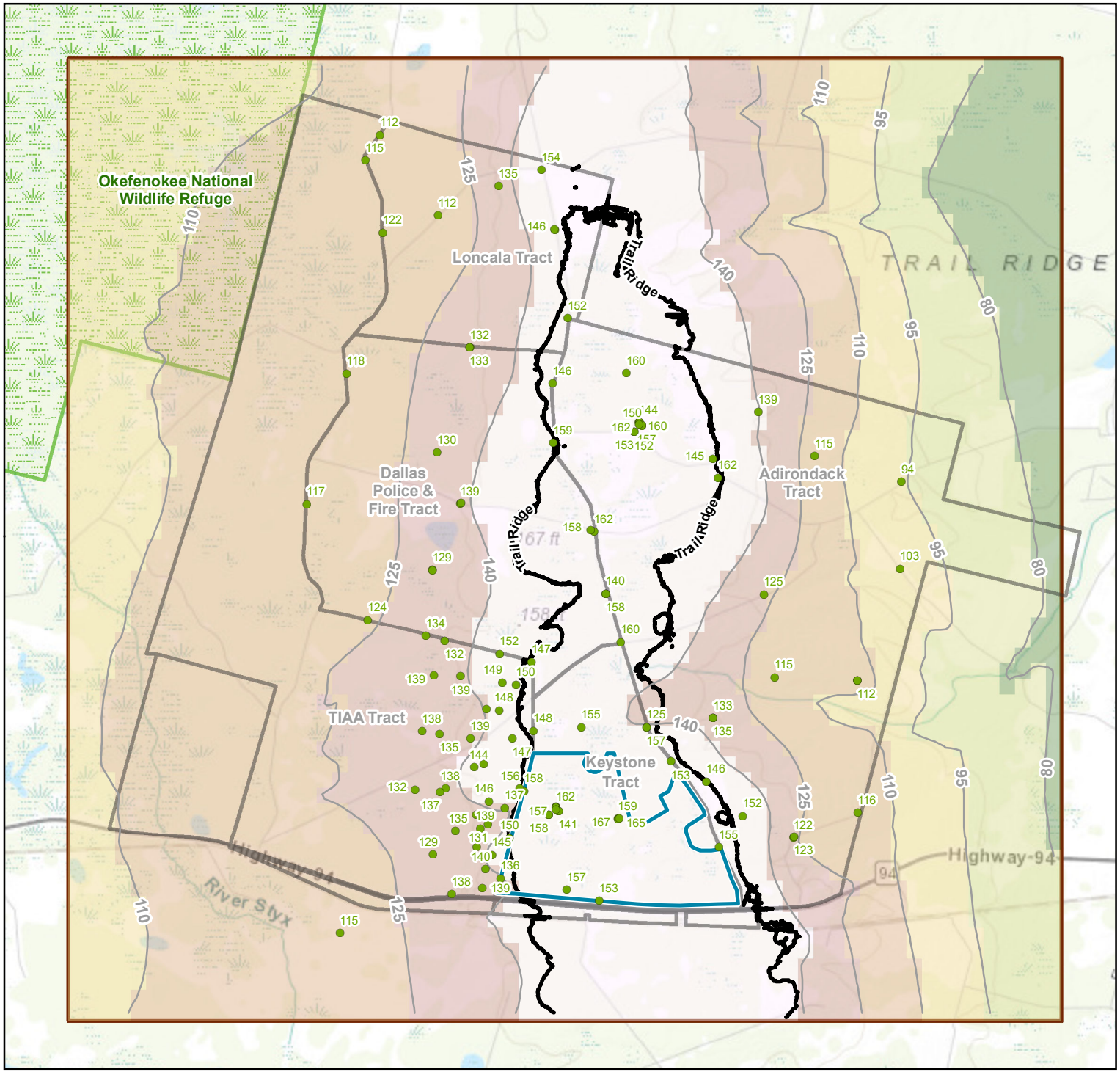
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 7
Unconsolidated & Semiconsolidated Sand (Hydrostratigraphic Unit 1) Thickness
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure07	Appv'd By: SP

FIGURE 7



N

LEGEND

- Well Log Upper CBS Contact Elevations (Feet)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 2 Upper Contact Elevation Contours (Feet)

Hydrostratigraphic Unit 2 Upper Contact Elevation (Feet)

- 65.47 - 80.00
- 80.01 - 95.00
- 95.01 - 110.00
- 110.01 - 125.00
- 125.01 - 140.00
- 140.01 - 166.02
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2., CBS = Consolidated Black Sands

Scale in Miles

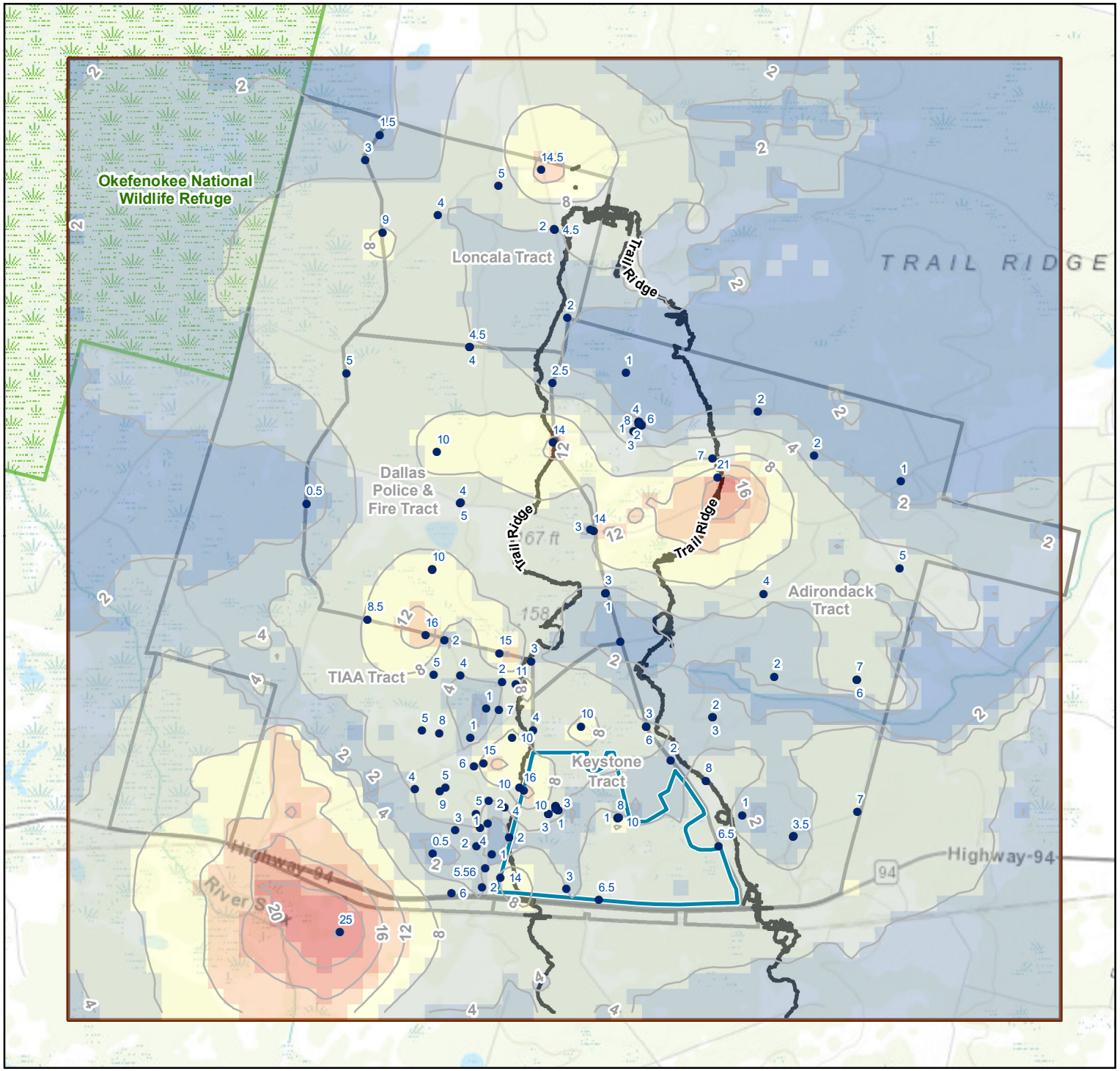
0 0.5 1

GSI ENVIRONMENTAL

Figure 8
Consolidated Black Sands (Hydrostratigraphic Unit 2) Upper Contact Elevation
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure08	Appv'd By: SP

FIGURE 8



N

LEGEND

- Well Log Consolidated Black Sand Thickness (Feet)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 2 Thickness Contours (Feet)

Hydrostratigraphic Unit 2 Thickness (Feet)

- 0.50 - 2.00
- 2.01 - 4.00
- 4.01 - 8.00
- 8.01 - 12.00
- 12.01 - 16.00
- 16.01 - 20.00
- 20.01 - 24.52
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

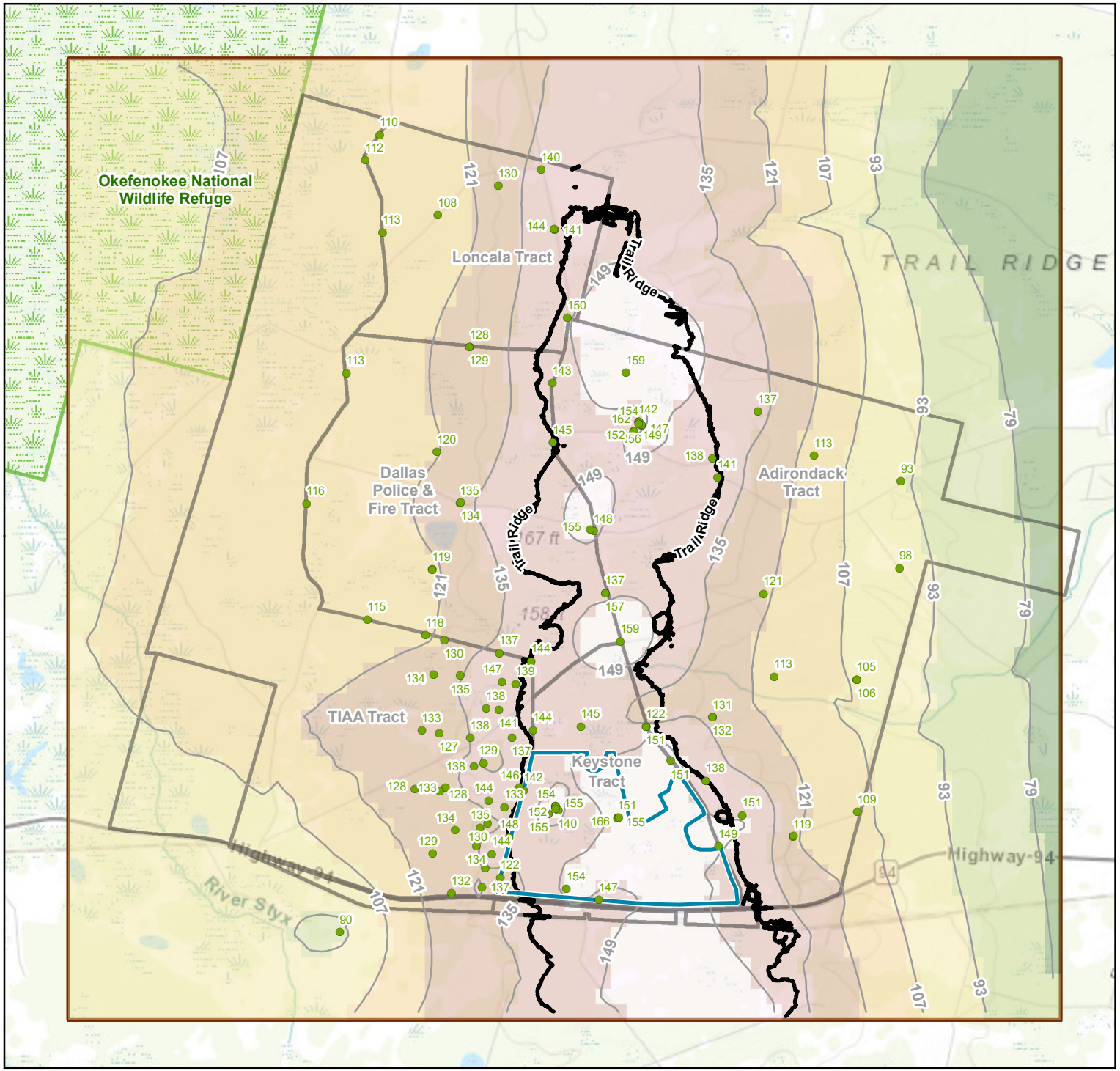
0 0.5 1

GSI ENVIRONMENTAL

Figure 9
Consolidated Black Sands Sand (Hydrostratigraphic Unit 2) Thickness
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure09	Appv'd By: SP

FIGURE 9



N

LEGEND

- Well Log Upper Silty Clayey Sand Contact Elevations (Feet)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 3 Upper Contact Elevation Contours (Feet)

Hydrostratigraphic Unit 3 Upper Contact Elevation (Feet)

- 64.97 - 79.00
- 79.01 - 93.00
- 93.01 - 107.00
- 107.01 - 121.00
- 121.01 - 135.00
- 135.01 - 149.00
- 149.01 - 162.26
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

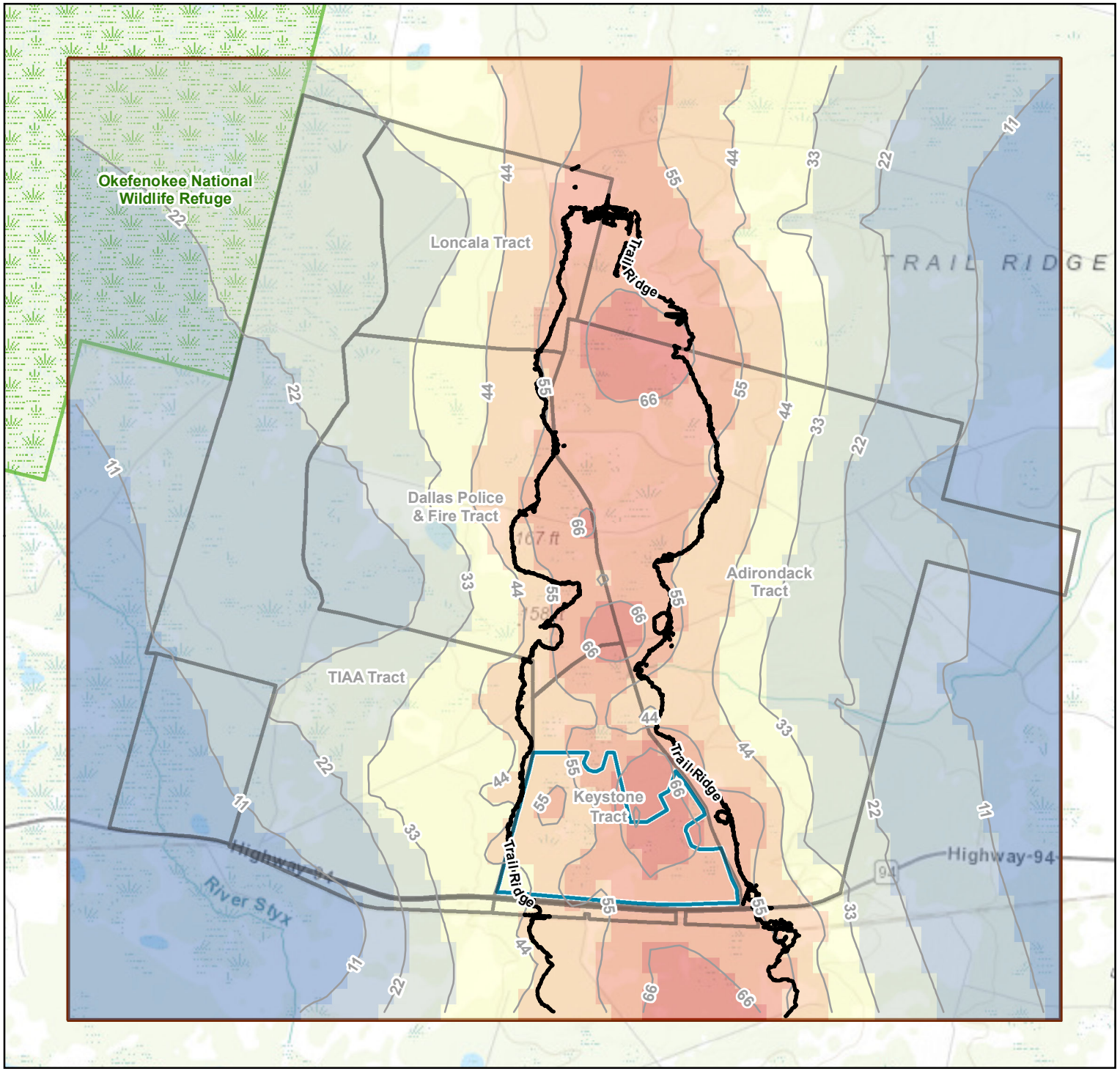
0 0.5 1

GSI ENVIRONMENTAL

Figure 10
Silty Clayey Sand Unit
(Hydrostratigraphic Unit 3)
Upper Contact Elevation
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure10	Appv'd By: SP

FIGURE 10



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 3 Thickness Contours (Feet)

Hydrostratigraphic Unit 3 Thickness (Feet)

- 1.61 - 11.00
- 11.01 - 22.00
- 22.01 - 33.00
- 33.01 - 44.00
- 44.01 - 55.00
- 55.01 - 66.00
- 66.01 - 75.93
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

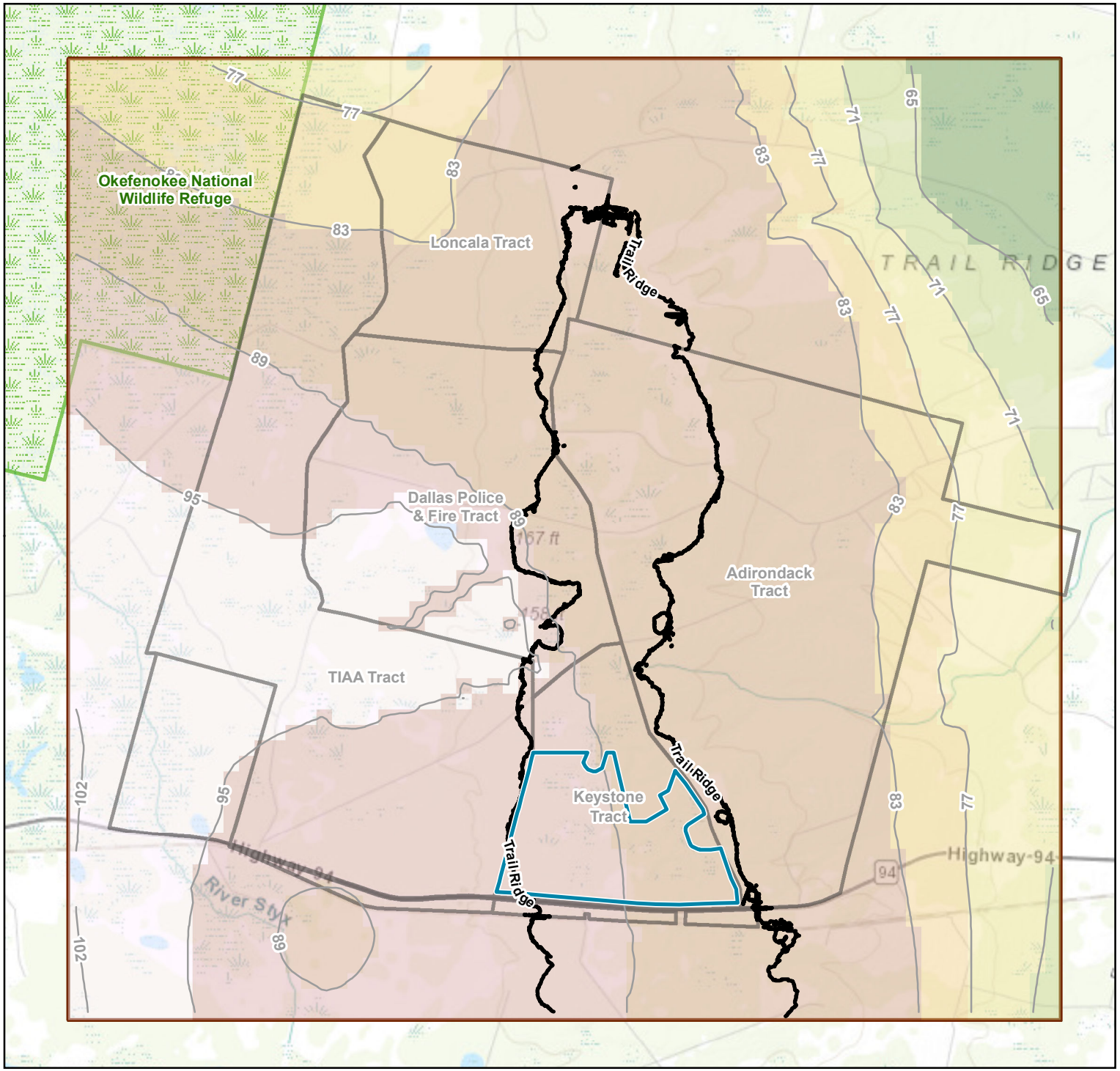
0 0.5 1

GSI ENVIRONMENTAL

Figure 11
Silty Clayey Sand Unit (Hydrostratigraphic Unit 3) Thickness
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure11	Appv'd By: SP

FIGURE 11



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 4 Upper Contact Elevation Contours (Feet)

Hydrostratigraphic Unit 4 Upper Contact Elevation (Feet)

- 59.01 - 65.00
- 65.01 - 71.00
- 71.01 - 77.00
- 77.01 - 83.00
- 83.01 - 89.00
- 89.01 - 95.00
- 95.01 - 102.81
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

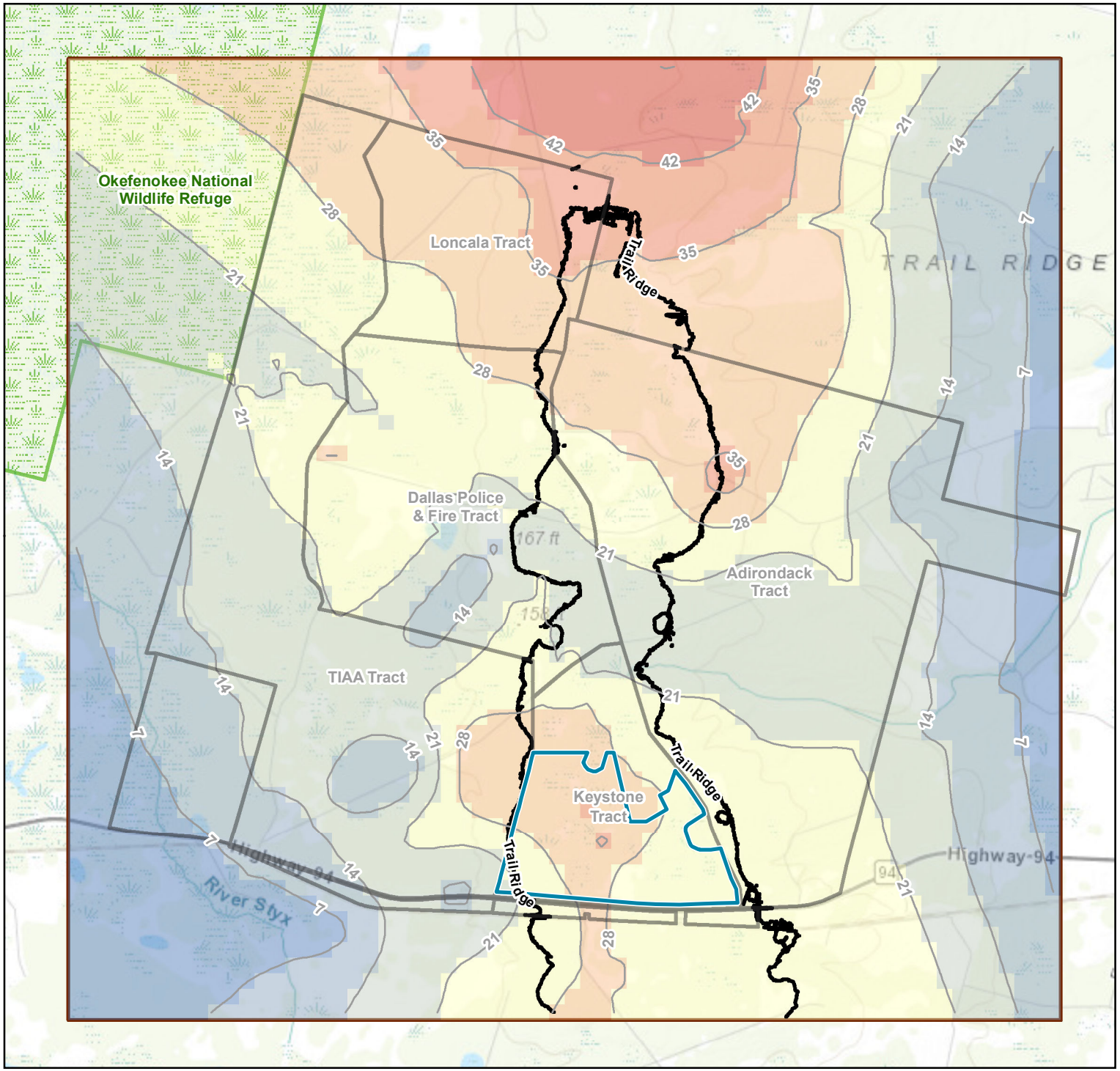
0 0.5 1

GSI ENVIRONMENTAL

Figure 12
Sandy Clay Unit
(Hydrostratigraphic Unit 4)
Upper Contact Elevation
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure12	Appv'd By: SP

FIGURE 12



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hydrostratigraphic Unit 4 Upper Contact Elevation Contours (Feet)

Hydrostratigraphic Unit 4 Thickness (Feet)

- 1.80 - 7.00
- 7.01 - 14.00
- 14.01 - 21.00
- 21.01 - 28.00
- 28.01 - 35.00
- 35.01 - 42.00
- 42.01 - 49.14
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 0.5 1

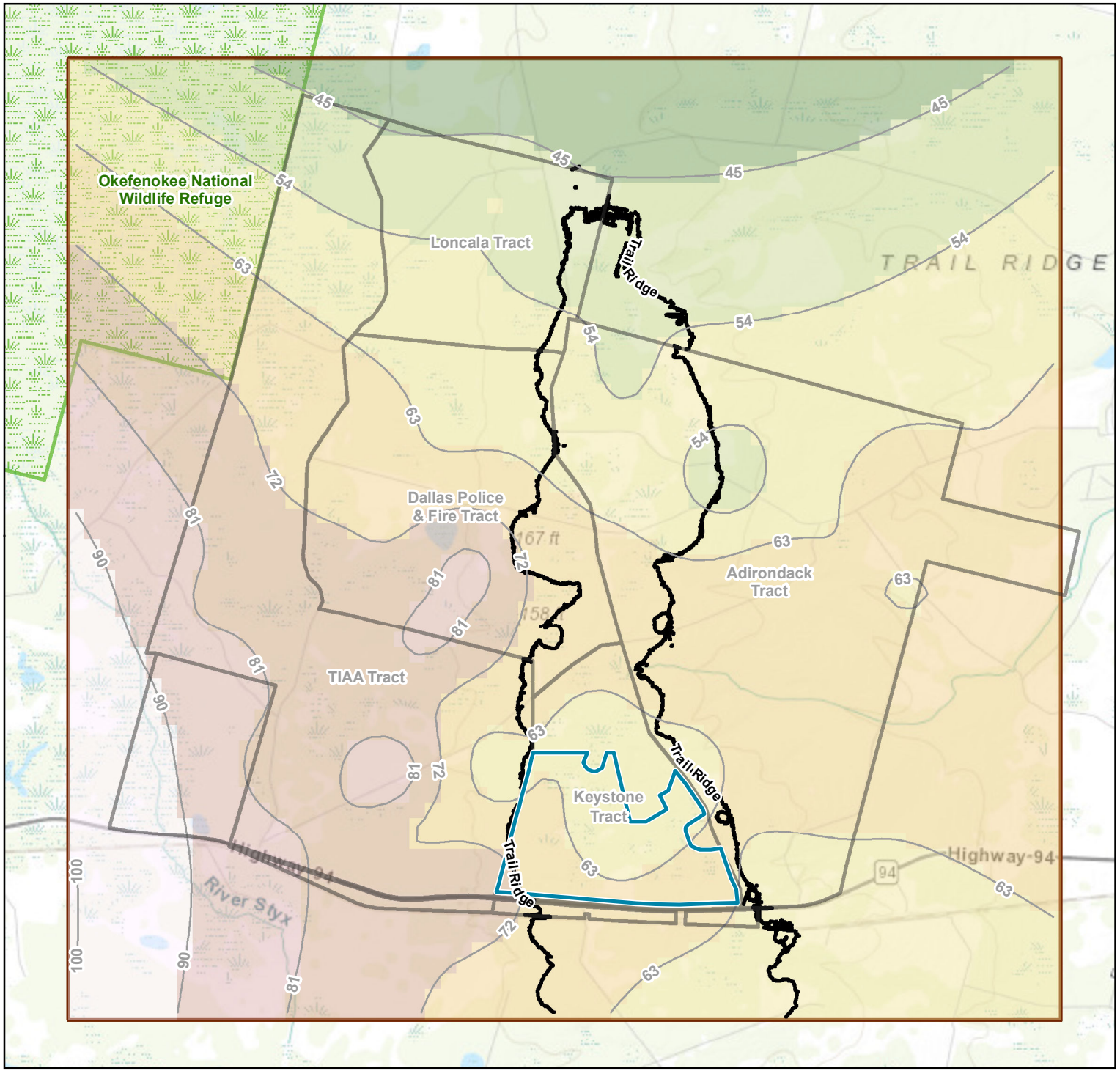
GSI ENVIRONMENTAL

Figure 13
Sandy Clay Unit
(Hydrostratigraphic Unit 4)
Thickness

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure13	Appv'd By: SP

FIGURE 13



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Hawthorn Confining Unit Bottom Contact Elevation Contours (Feet)

Hawthorn Confining Unit Bottom Contact Elevation (Feet)

- 36.20 - 45.00
- 45.01 - 54.00
- 54.01 - 63.00
- 63.01 - 72.00
- 72.01 - 81.00
- 81.01 - 90.00
- 90.01 - 100.20
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 0.5 1

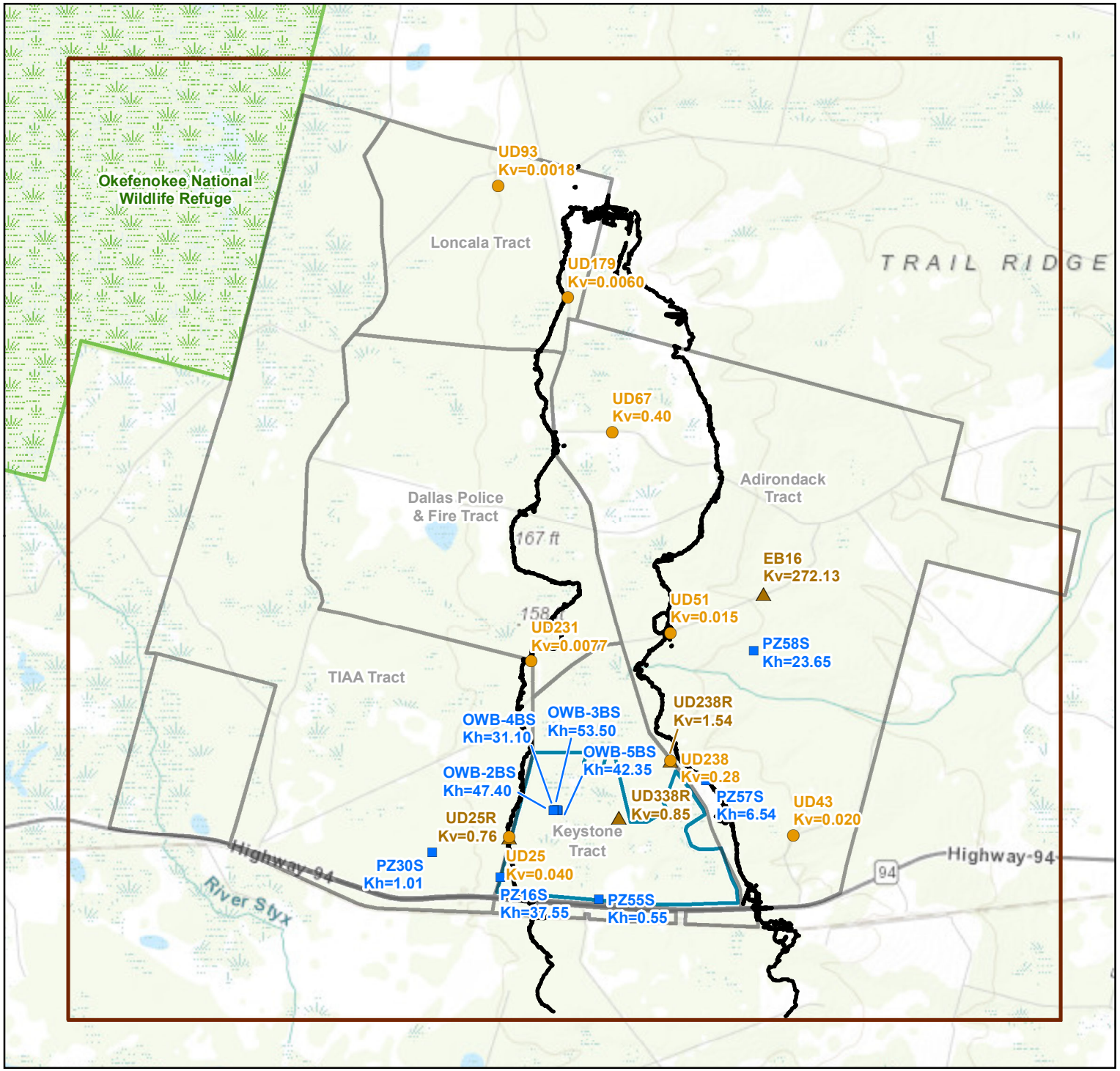
GSI ENVIRONMENTAL

Figure 14
Hawthorn Confining Unit Contact Elevation

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure14	Appv'd By: SP

FIGURE 14



N

LEGEND

- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Soil Sample Potentially Affected by Drilling Muds
- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Soil Sample

Aquifer and Slug Test Horizontal Hydraulic Conductivity (Kh)

- Reported Test Value (Feet/Day)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Where lab or field tests result in multiple K estimates at a given location for the layer, the arithmetic average is shown for Kh; harmonic mean shown for Kv.

Scale in Miles

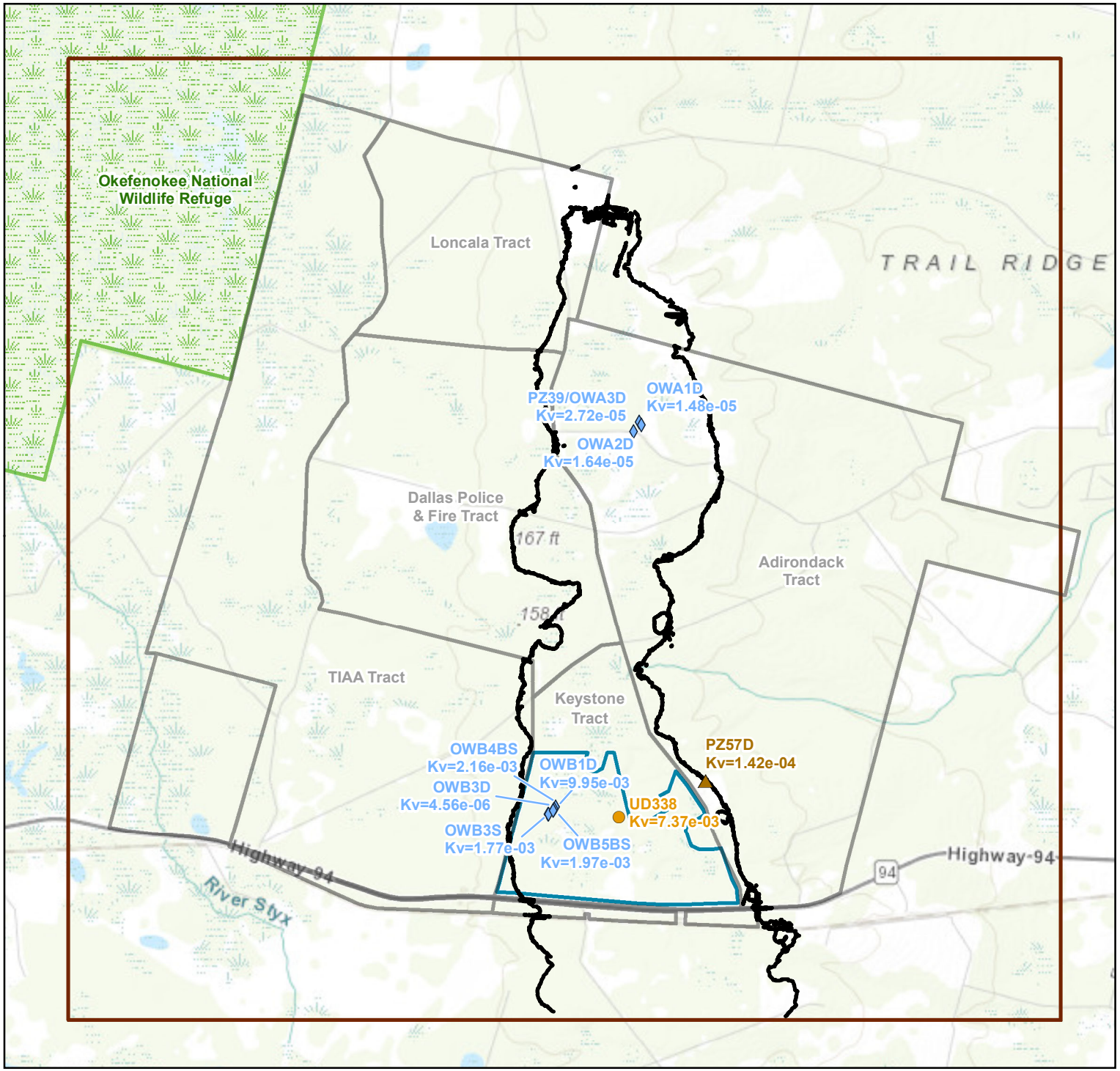
0 0.5 1

GSI ENVIRONMENTAL

Figure 15
Unconsolidated & Semiconsolidated Sand (Hydrostratigraphic Unit 1) Hydraulic Conductivity
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure15	Appv'd By: SP

FIGURE 15



N

LEGEND

- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Soil Sample Potentially Affected by Drilling Muds
- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Soil Sample
- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Aquifer Test Derived
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Where lab or field tests result in multiple K estimates at a given location for the layer, the arithmetic average is shown for Kh; harmonic mean shown for Kv.
3. Only available lab and field data with K values of less than 0.014 feet/day (5e-6 cm/sec) are shown and considered representative of consolidated black sands.

Scale in Miles

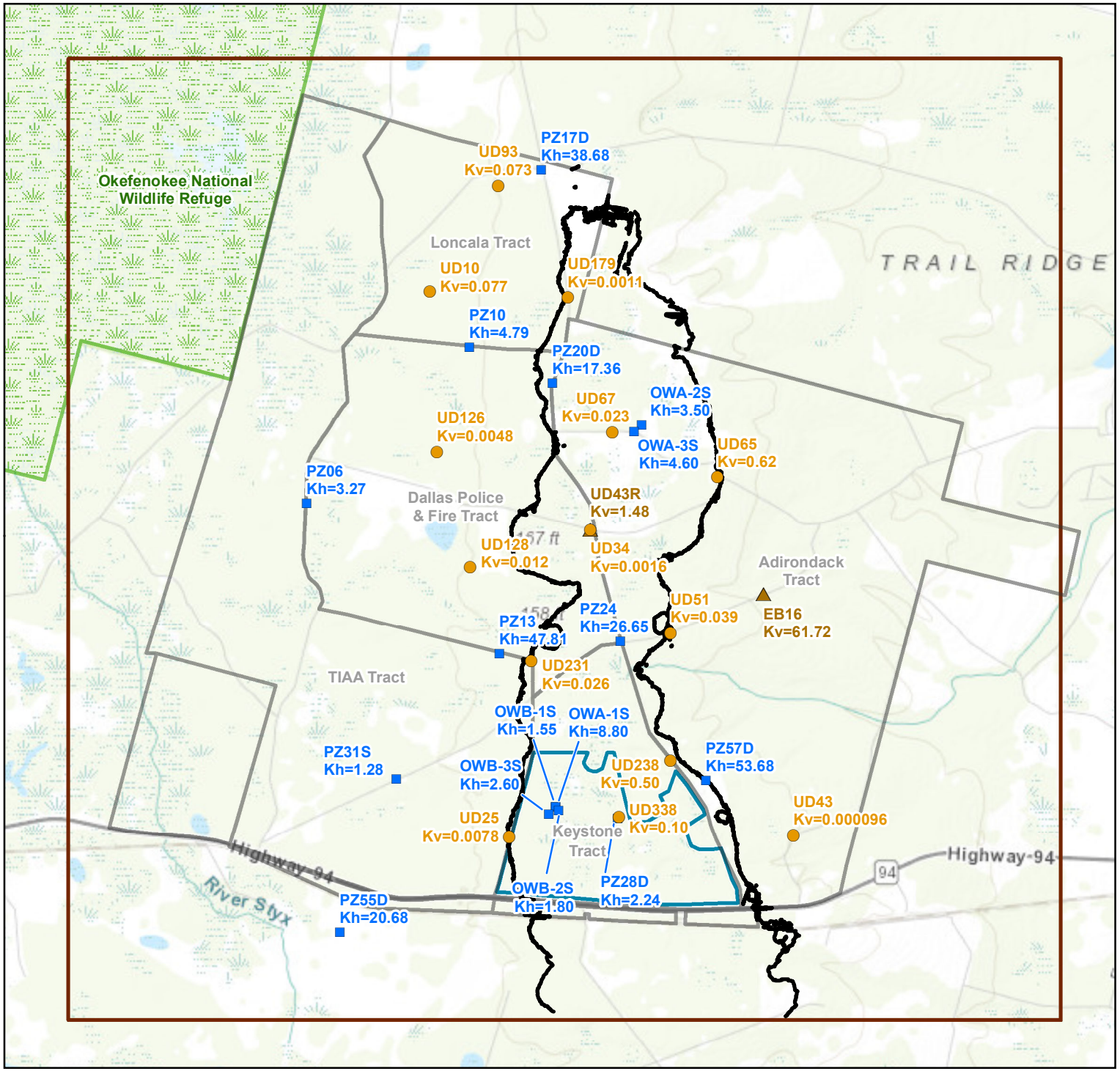
0 0.5 1

GSI ENVIRONMENTAL

Figure 16
Consolidated Black Sands (Hydrostratigraphic Unit 2) Hydraulic Conductivity
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure16	Appv'd By: SP

FIGURE 16



N

LEGEND

- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Soil Sample Potentially Affected by Drilling Muds
- Vertical Hydraulic Conductivity (Kv) Values (Feet/Day) - Soil Sample

Aquifer and Slug Test Horizontal Hydraulic Conductivity (Kh)

- Reported Test Value (Feet/Day)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Where lab or field tests result in multiple K estimates at a given location for the layer, the arithmetic average is shown for Kh; harmonic mean shown for Kv.

Scale in Miles

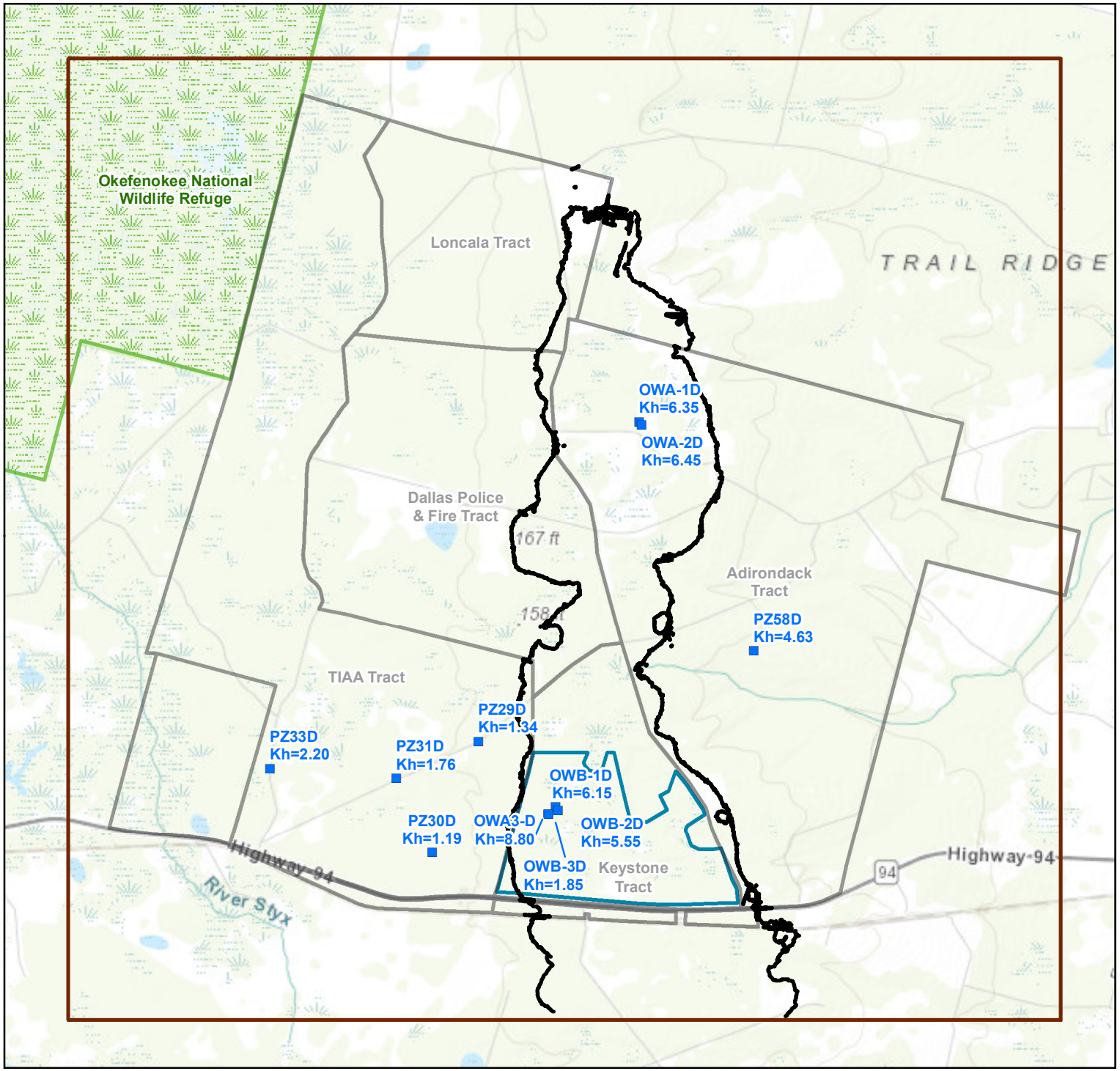
0 0.5 1

GSI ENVIRONMENTAL

Figure 17
Silty Clayey Sand Unit (Hydrostratigraphic Unit 3) Hydraulic Conductivity
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure17	Appv'd By: SP

FIGURE 17



N

LEGEND

Aquifer and Slug Test Horizontal Hydraulic Conductivity (Kh)

- Reported Test Value (Feet/Day)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Where lab or field tests result in multiple K estimates at a given location for the layer, the arithmetic average is shown for Kh.

Scale in Miles

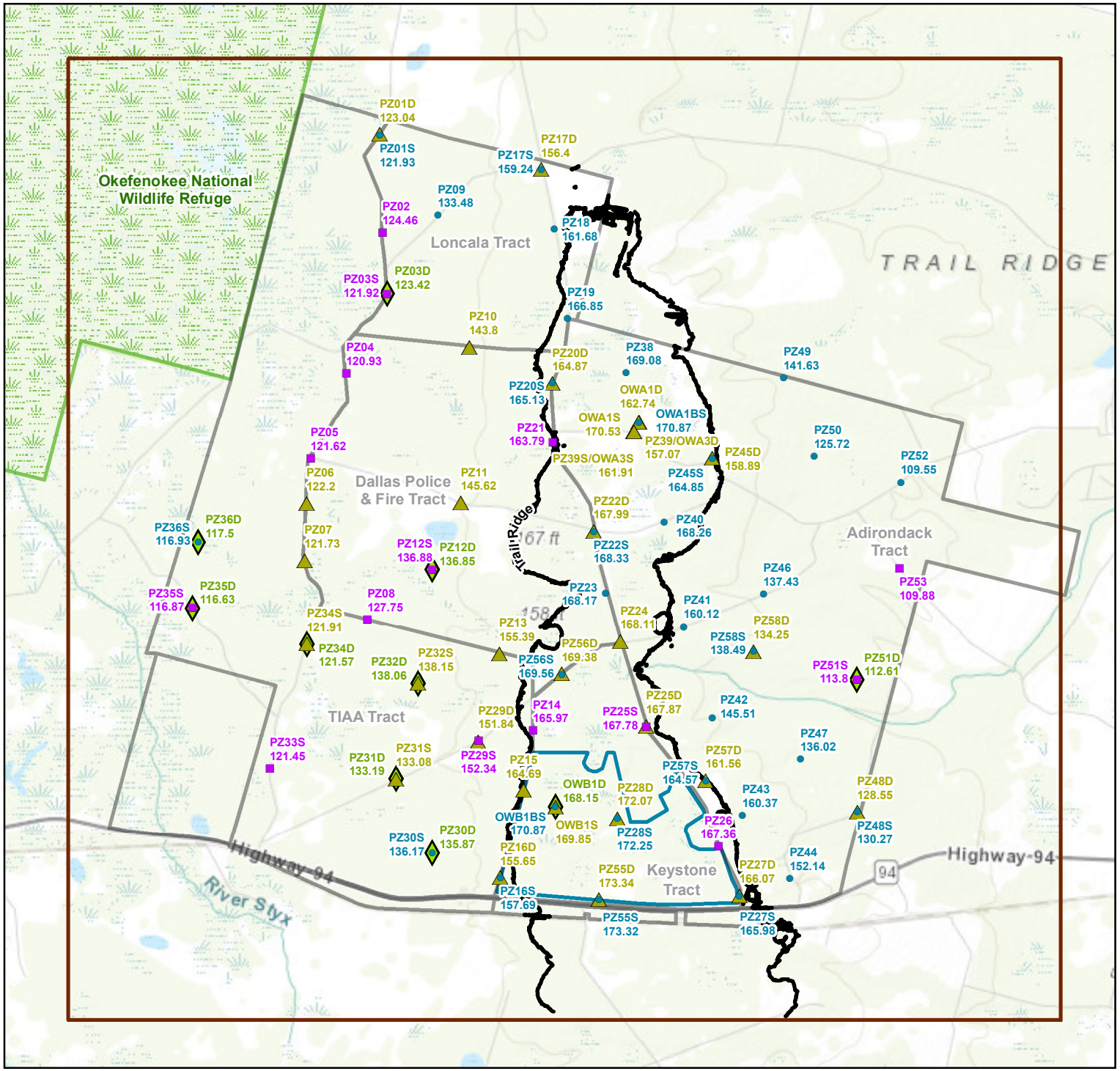
0 0.5 1

GSI ENVIRONMENTAL

Figure 18
Sandy Clay Unit
(Hydrostratigraphic Unit 4)
Hydraulic Conductivity
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure18	Appv'd By: SP

FIGURE 18



N

LEGEND

- HSU 1 (Unconsolidated & Semiconsolidated) Average Groundwater Elevations (Feet)
- HSU 2 (Consolidated Black Sands) Average Groundwater Elevations (Feet)
- HSU 3 (Silty Clayey Sand) Average Groundwater Elevations (Feet)
- HSU 4 (Sandy Clay Unit) Average Groundwater Elevations (Feet)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:
1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. HSU = Hydrostratigraphic Unit

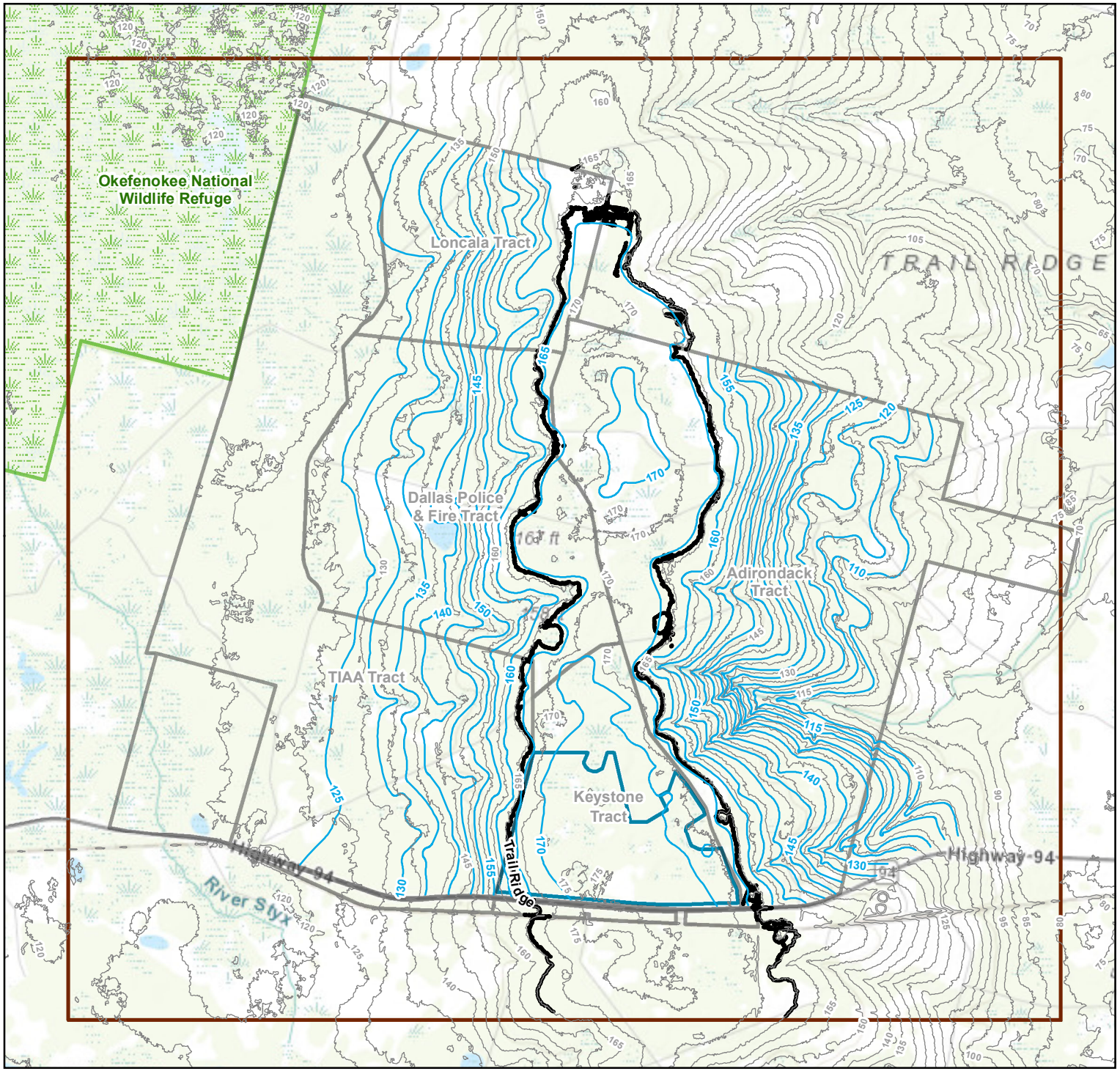
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 19
Average Well and Piezometer Groundwater Elevations January 2019 - October 2019
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure19	Appv'd By: SP

FIGURE 19



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- USGS 10 Feet Elevation Contours
- Surficial Aquifer Potentiomentric Surface Contours (Feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 0.5 1

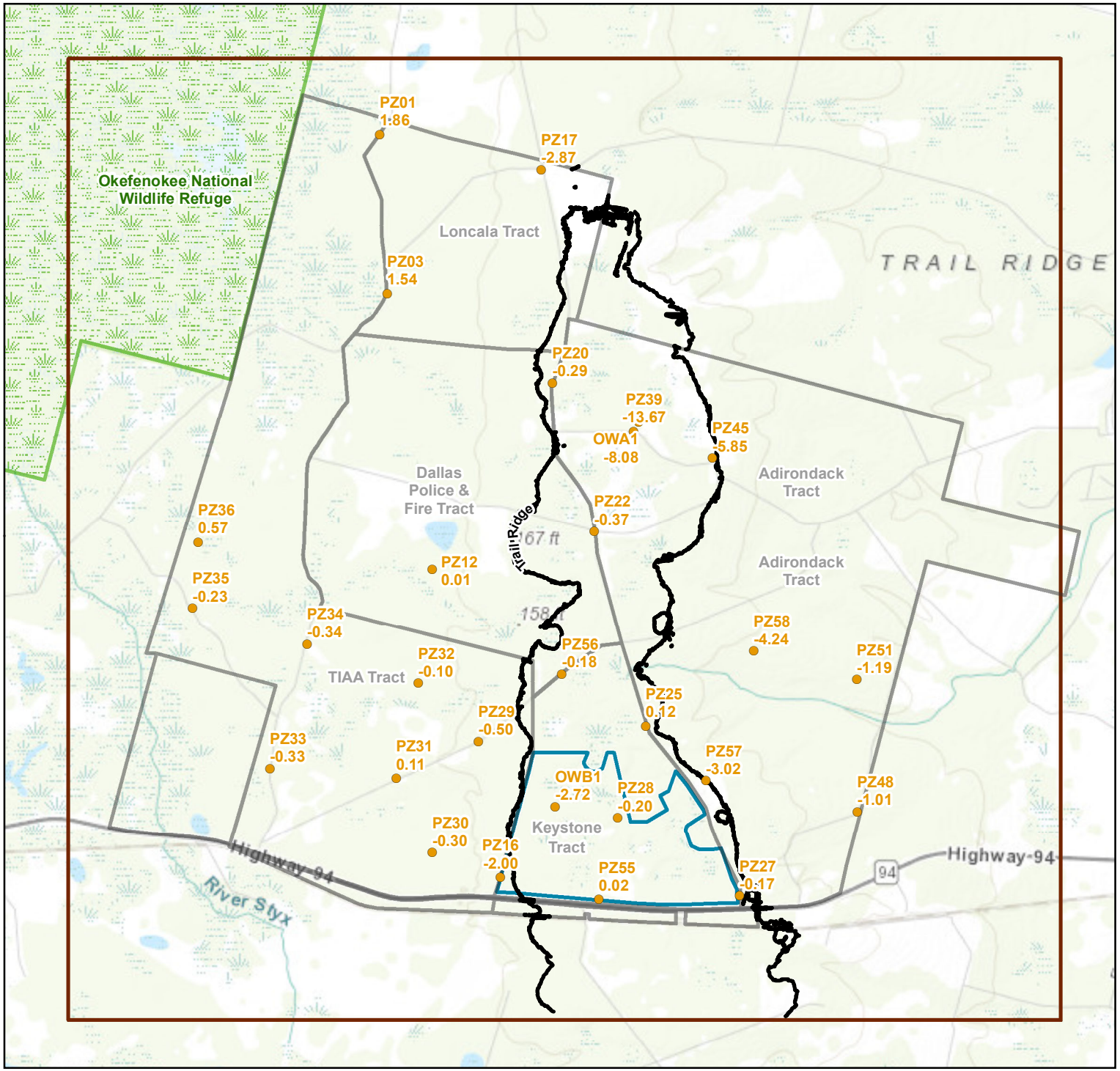
GSI ENVIRONMENTAL

Figure 20
Surficial Aquifer Potentiometric Surface Map January 26, 2019

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure20	Appv'd By: SP

FIGURE 20



N

LEGEND

- Shallow/Deep Piezometer Pairs - Average Groundwater Differences (Feet)
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Negative (Positive) values indicated downward (upward) flow.

Scale in Miles

0 0.5 1

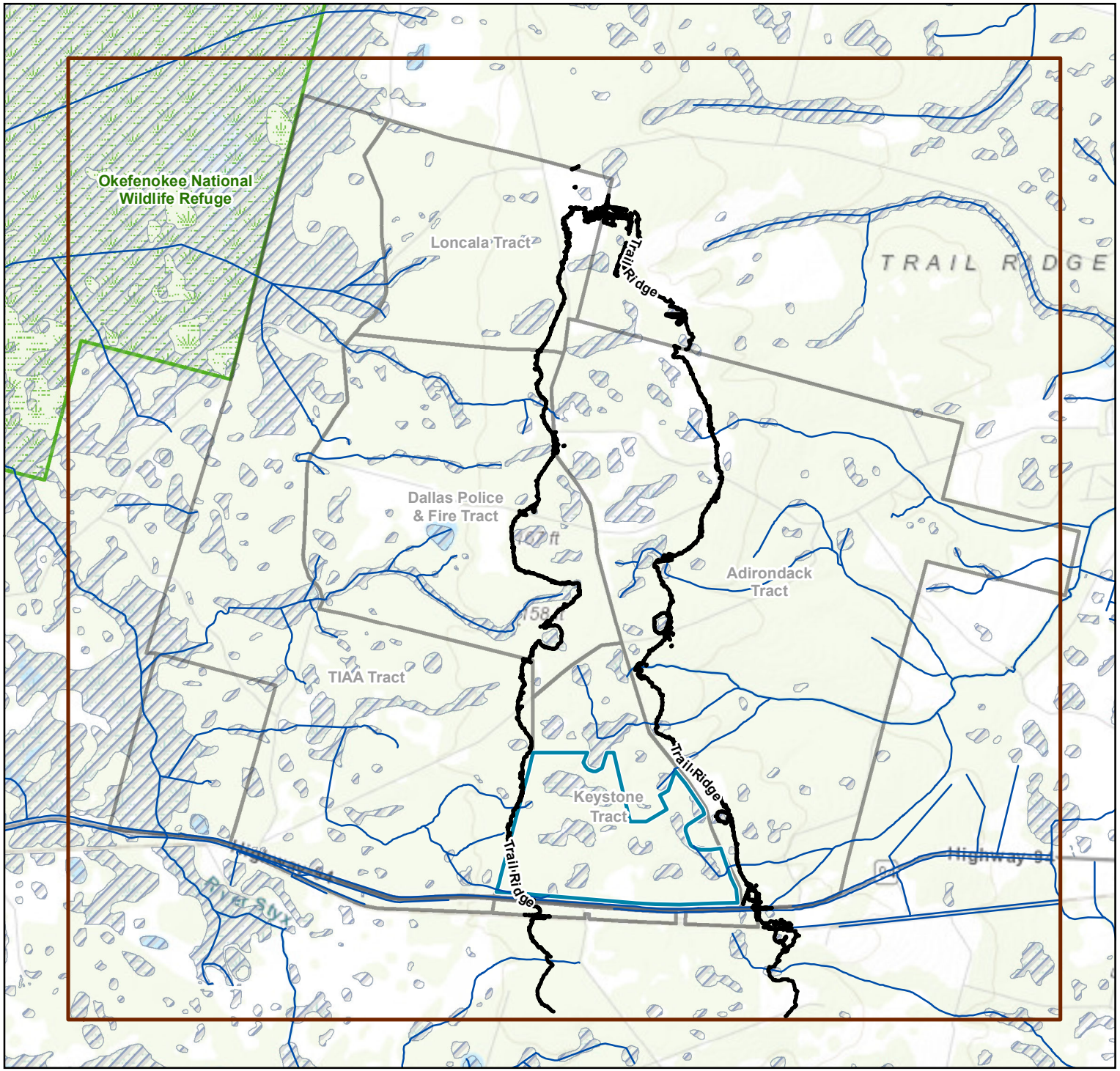
GSI ENVIRONMENTAL

Figure 21
Average Water Level Differences - Shallow and Deep Piezometer Pairs

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure21	Appv'd By: SP

FIGURE 21



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- National Hydrography Dataset (NHD) Stream Channels
- National Hydrography Dataset (NHD) Wetlands
- Modeling Study Area
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

1. Wetlands and stream channels are from the National Hydrography Dataset by the USGS.
2. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Scale in Miles

0 0.5 1

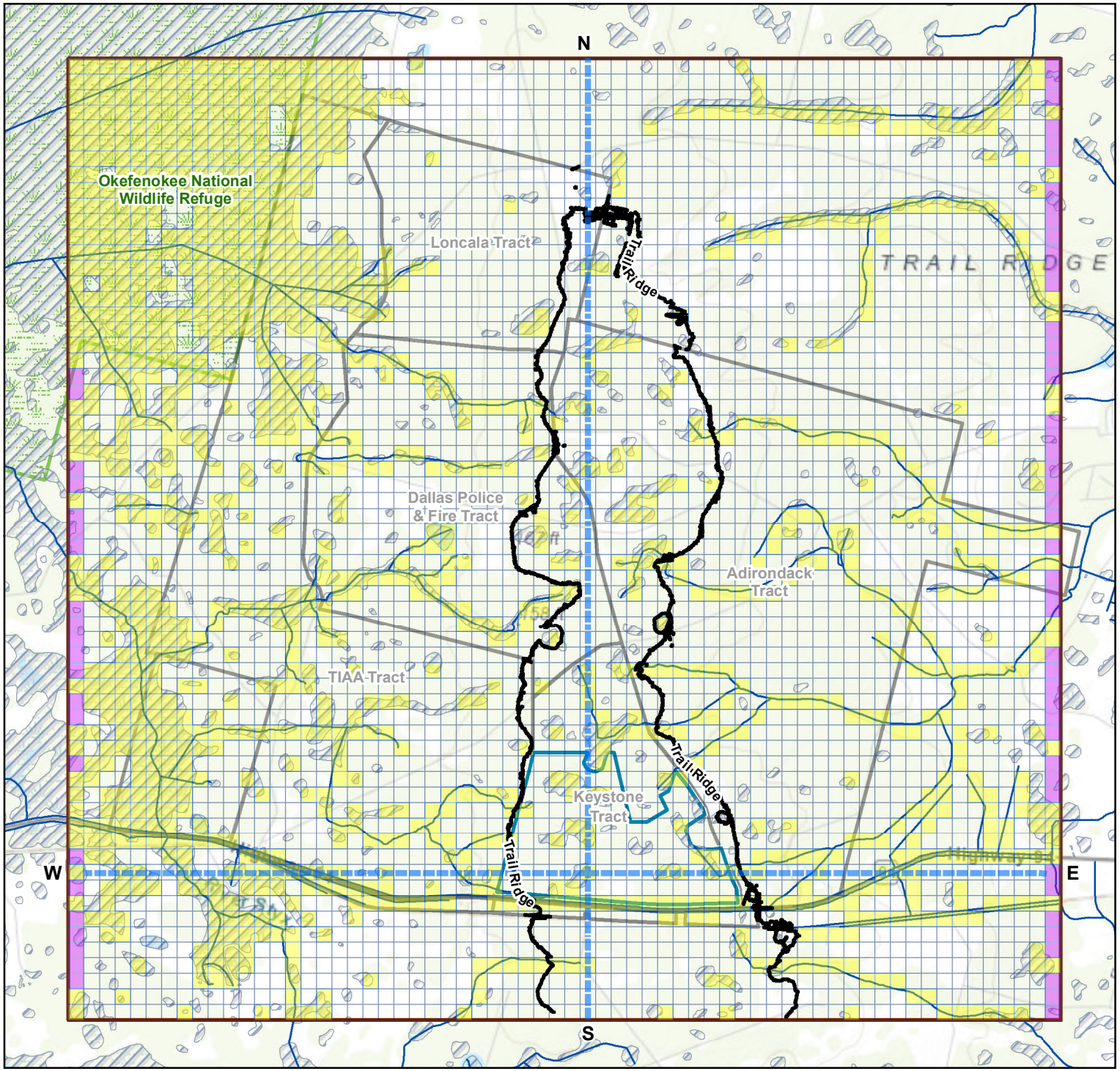
GSI ENVIRONMENTAL

Figure 22
National Hydrography Dataset Delineated Wetlands and Stream Channels in Study Area

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

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure22	Appv'd By: SP

FIGURE 22



N

LEGEND

- Cross Section Locations
- Trail Ridge (Elevation > 165 feet)
- Constant Heads Boundary Condition - Layer 1
- Drain Package Boundary Condition - Layer 1
- Numerical Groundwater Flow Model Grid - Cells with No Boundary Conditions
- Modeling Study Area
- National Hydrography Dataset (NHD) Stream Channels
- National Hydrography Dataset (NHD) Wetlands
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

1. Model grid cells are 500 by 500 feet wide, forming 62 rows and 64 columns in each of the 4 layers.
2. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Scale in Miles

0 0.5 1

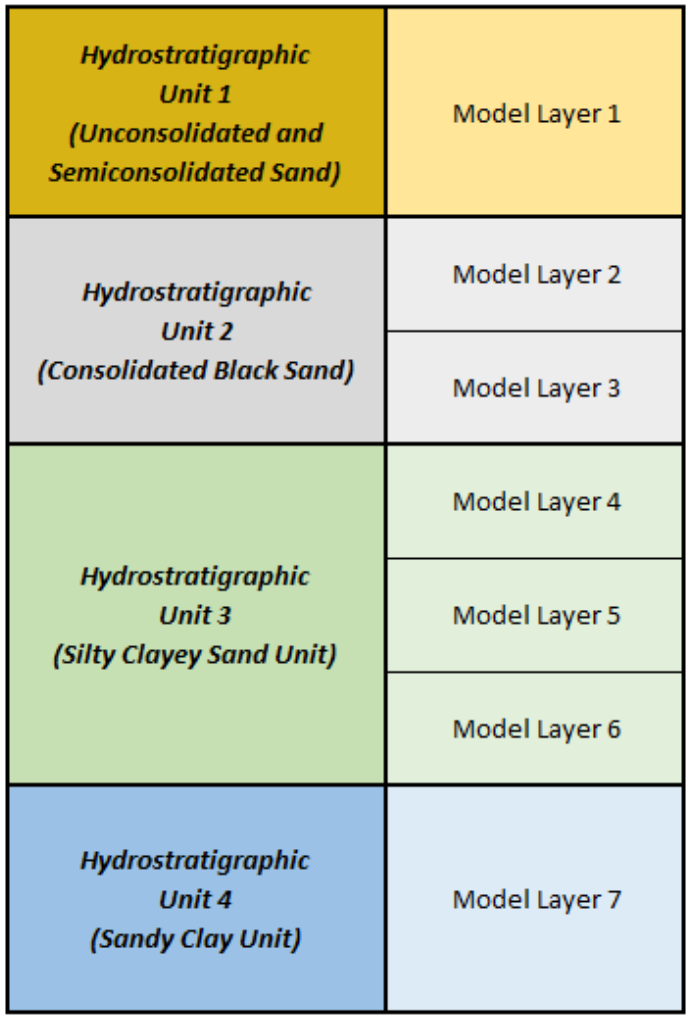
GSI ENVIRONMENTAL

Figure 23
Model Grid & Layer 1 Boundary Conditions

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

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure23	Appv'd By: SP

FIGURE 23



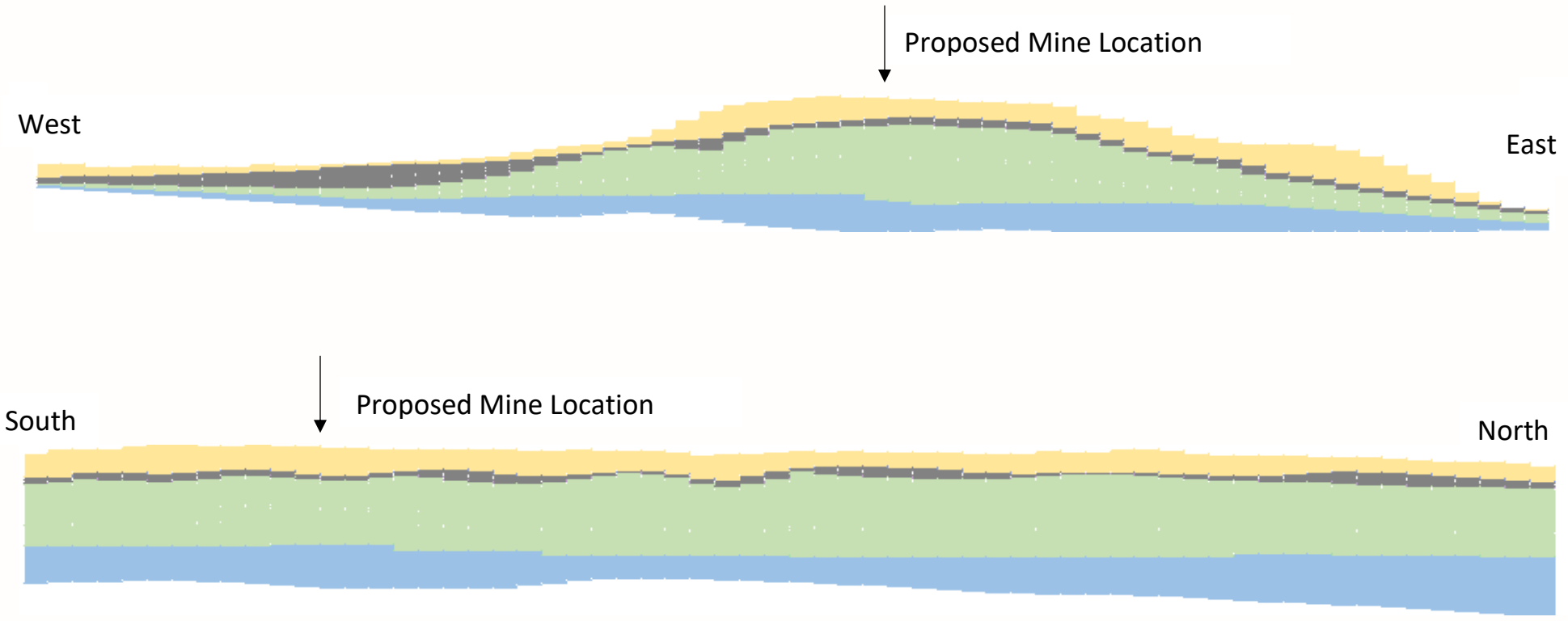
GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	RLW
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 24**	

Correlation Between Hydrostratigraphy and Numerical Model Layers

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia



Hydrostratigraphic Unit 1 (Unconsolidated & Semiconsolidated Sand)

Hydrostratigraphic Unit 3 (Silty Clayey Sand Unit)

Hydrostratigraphic Unit 2 (Consolidated Black Sand)

Hydrostratigraphic Unit 4 (Sandy Clay Unit)

Note: Cross section locations provided on Figure 23.

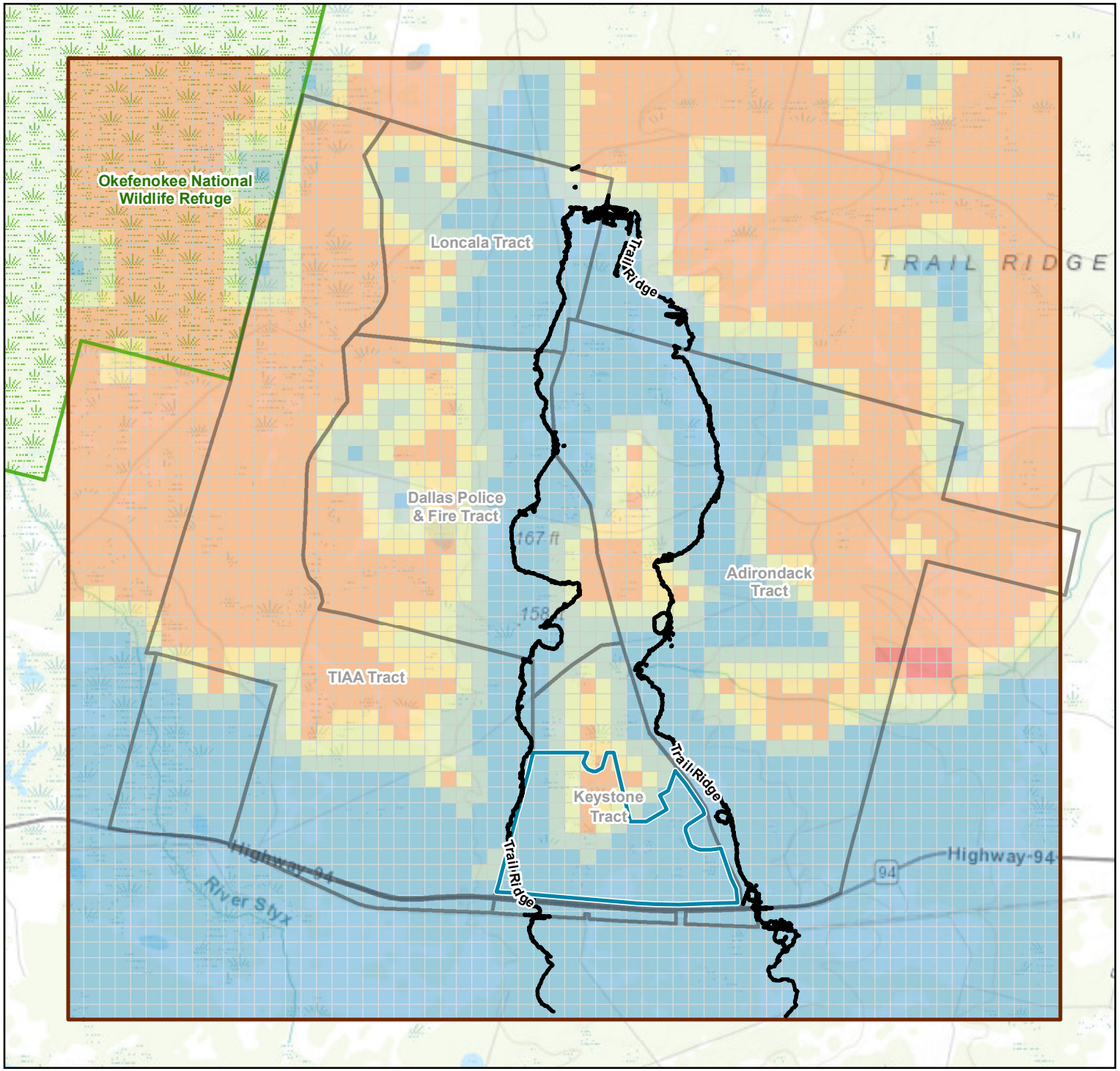
GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	RLW
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 25**	

Numerical Model North-South and East-West Cross Sections

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia



N

LEGEND

- Trail Ridge (Elevation > 165 feet)

Horizontal Hydraulic Conductivity (Feet/Day)

- 0.1 to 15
- 15 to 30
- 30 to 45
- 45 to 60
- 60 to 75
- 75 to 77.5
- Modeling Study Area
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

1. HSU = hydrostratigraphic unit
2. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Scale in Miles

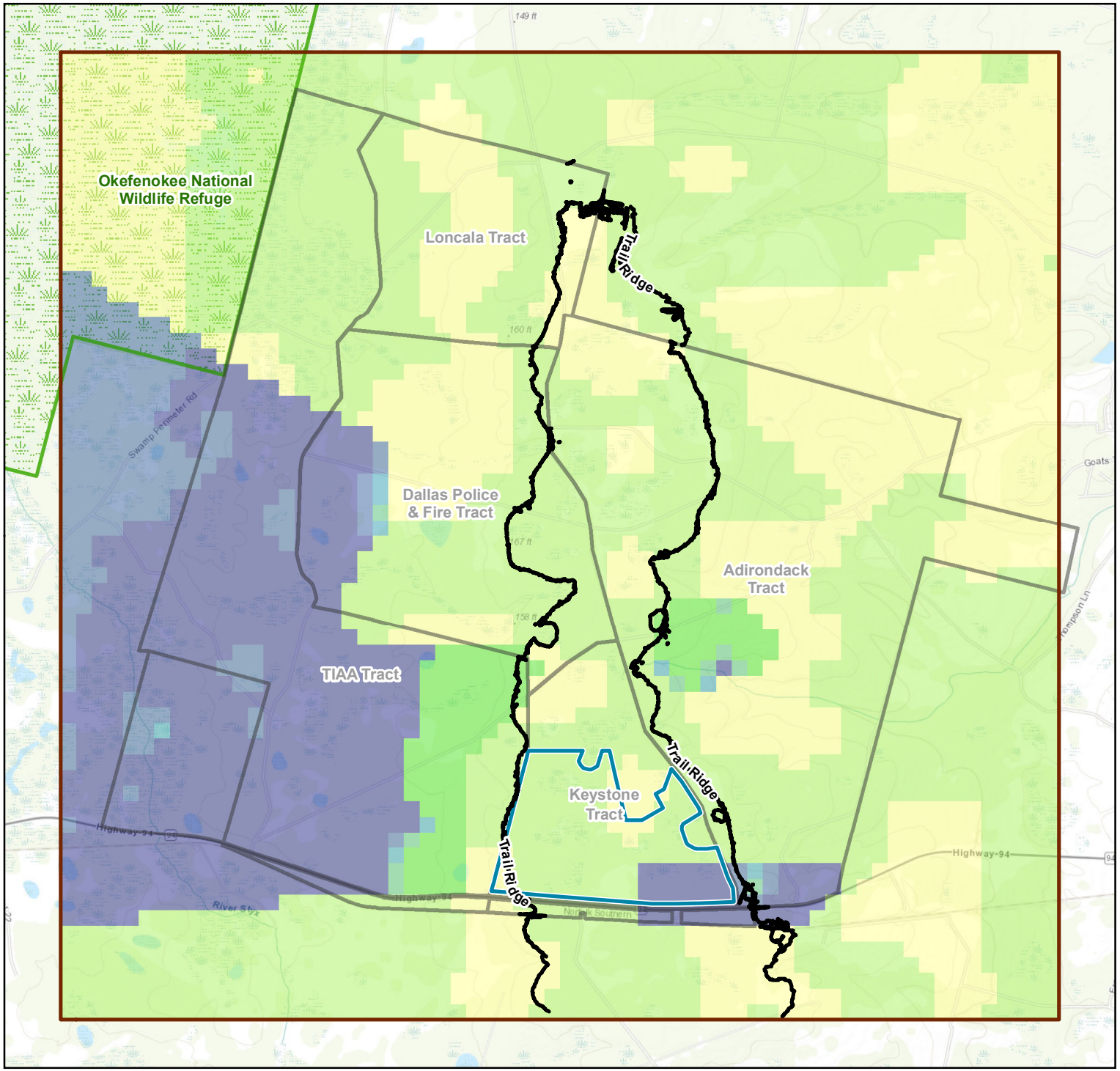
0 0.5 1

GSI ENVIRONMENTAL

Figure 26
Calibrated Horizontal Hydraulic Conductivity in Unconsolidated and Semiconsolidated Sand (HSU 1)
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure26	Appv'd By: SP

FIGURE 26



N

LEGEND

- Trail Ridge (Elevation > 165 feet)

Horizontal Hydraulic Conductivity (Feet/Day)

- 0.000040 (1e-8 cm/s) - 0.00028 (1e-7 cm/s)
- 0.00029 (1e-7 cm/s) - 0.0028 (1e-6 cm/s)
- 0.0029 (1e-6 cm/s) - 0.50 (1.8e-4 cm/s)
- 0.51 - 1.0
- 1.1 - 2.0
- 2.1 - 4.0
- 4.1 - 9.3
- Modeling Study Area
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

1. HSU = hydrostratigraphic unit
2. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Scale in Miles

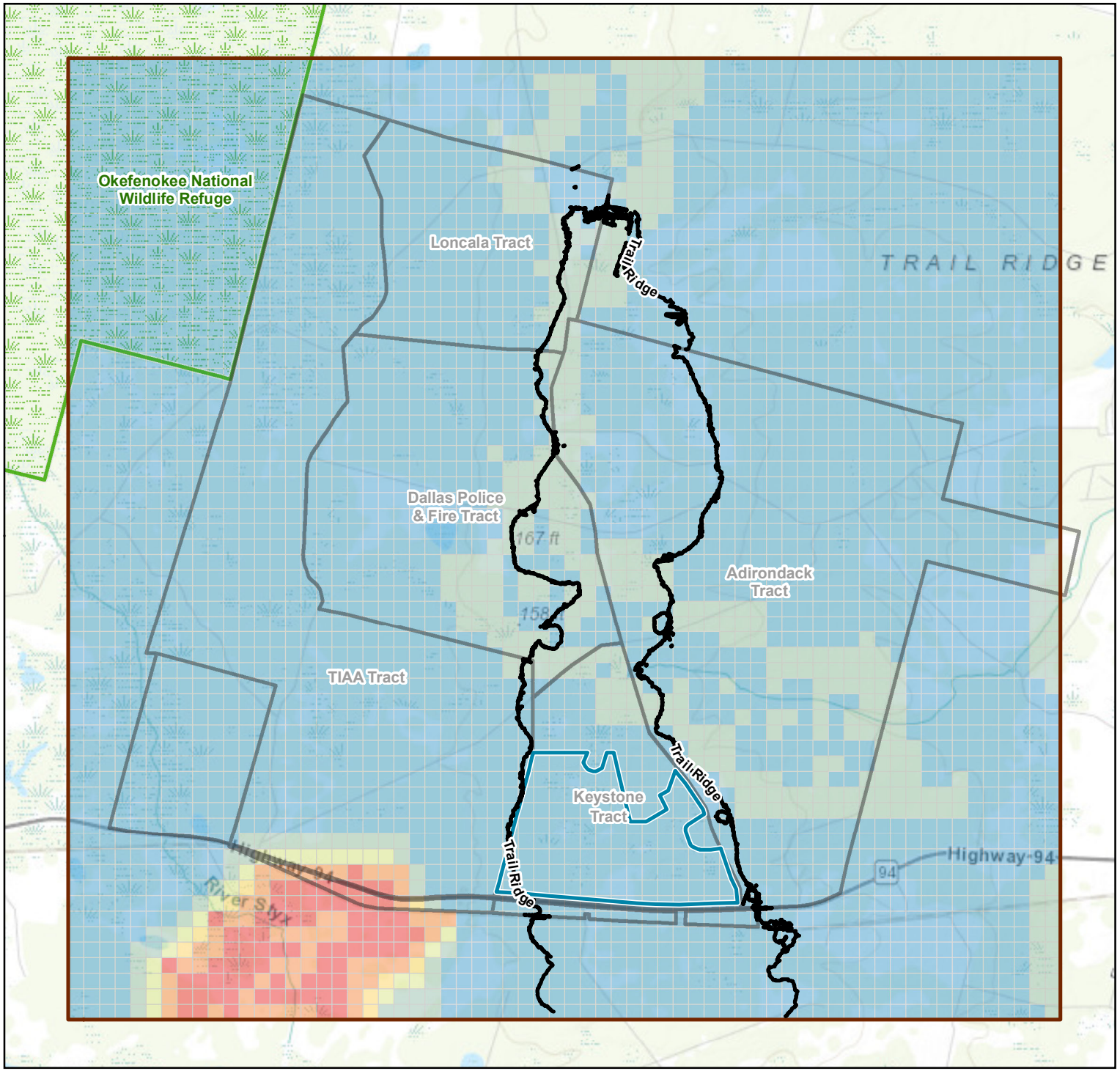
0 0.5 1

GSI ENVIRONMENTAL

Figure 27
Calibrated Horizontal Hydraulic Conductivity Consolidated Black Sands (HSU 2)
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure27	Appv'd By: SP

FIGURE 27



N

LEGEND

- Trail Ridge (Elevation > 165 feet)

Horizontal Hydraulic Conductivity (Feet/Day)

- 0.1 to 15
- 15 to 30
- 30 to 45
- 45 to 60
- 60 to 75
- 75 to 87.5
- Modeling Study Area
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

1. HSU = hydrostratigraphic unit
2. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Scale in Miles

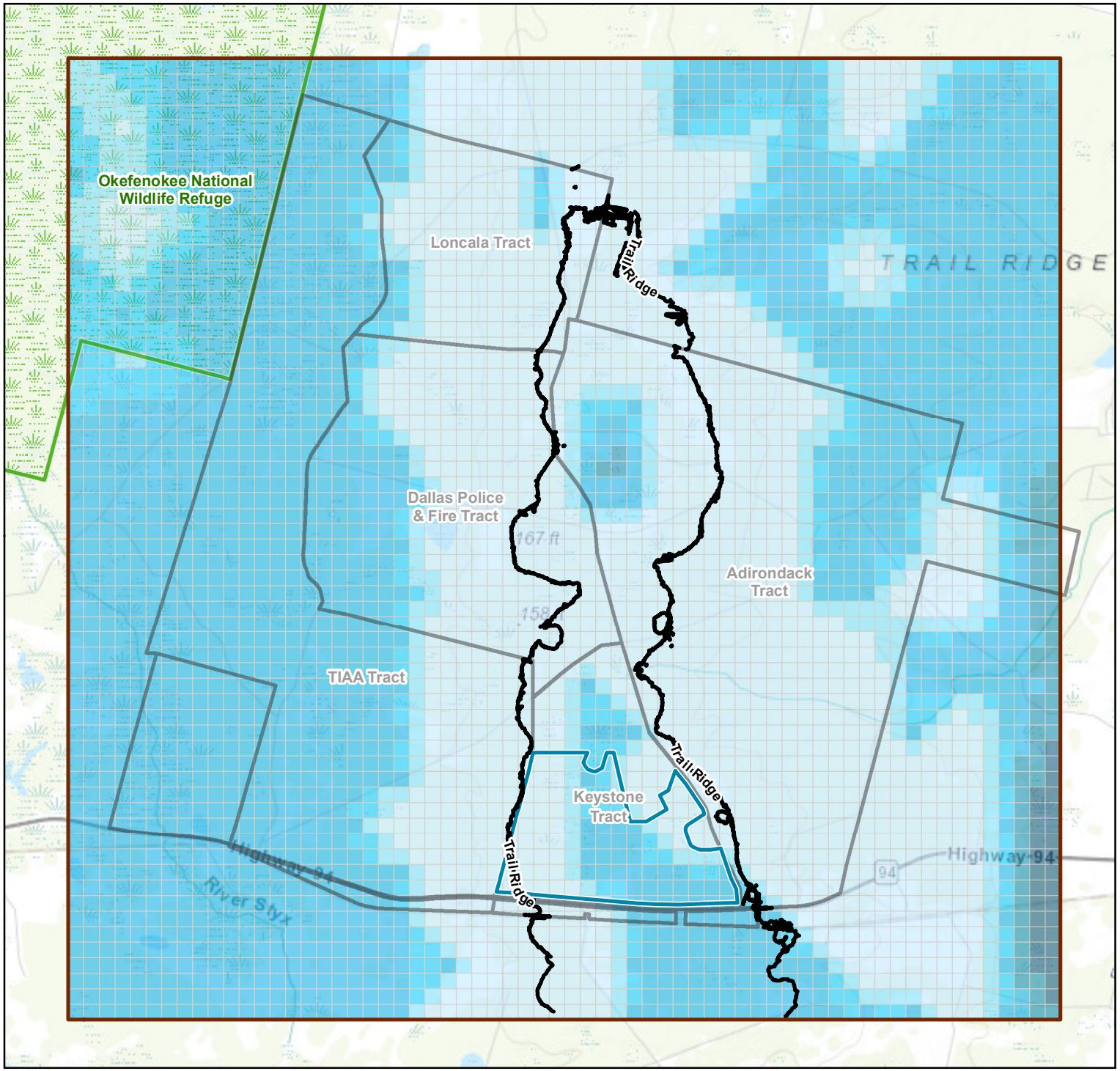
0 0.5 1

GSI ENVIRONMENTAL

Figure 28
Calibrated Horizontal Hydraulic Conductivity in Silty Clayey Sand Unit (HSU 3)
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure28	Appv'd By: SP

FIGURE 28



N

LEGEND

- Trail Ridge (Elevation > 165 feet)

Horizontal Hydraulic Conductivity (Feet/Day)

- 0.87 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 17.1
- Modeling Study Area
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

1. HSU = hydrostratigraphic unit
2. Projection: North American Datum 1983 Georgia State Plane East (Feet)

Scale in Miles

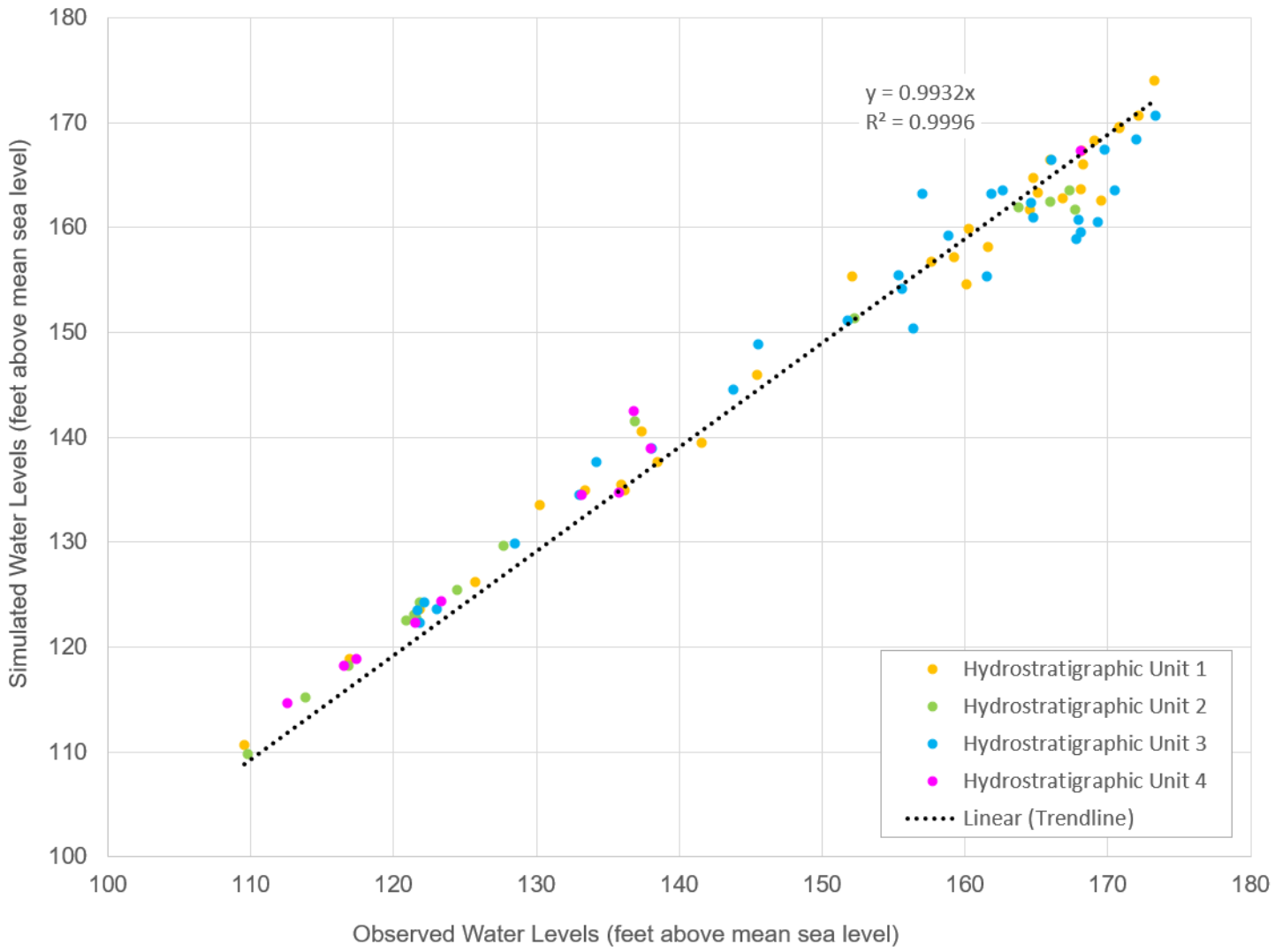
0 0.5 1

GSI ENVIRONMENTAL

Figure 29
Calibrated Horizontal Hydraulic Conductivity in Sandy Clay Unit (HSU 4)
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure29	Appv'd By: SP

FIGURE 29

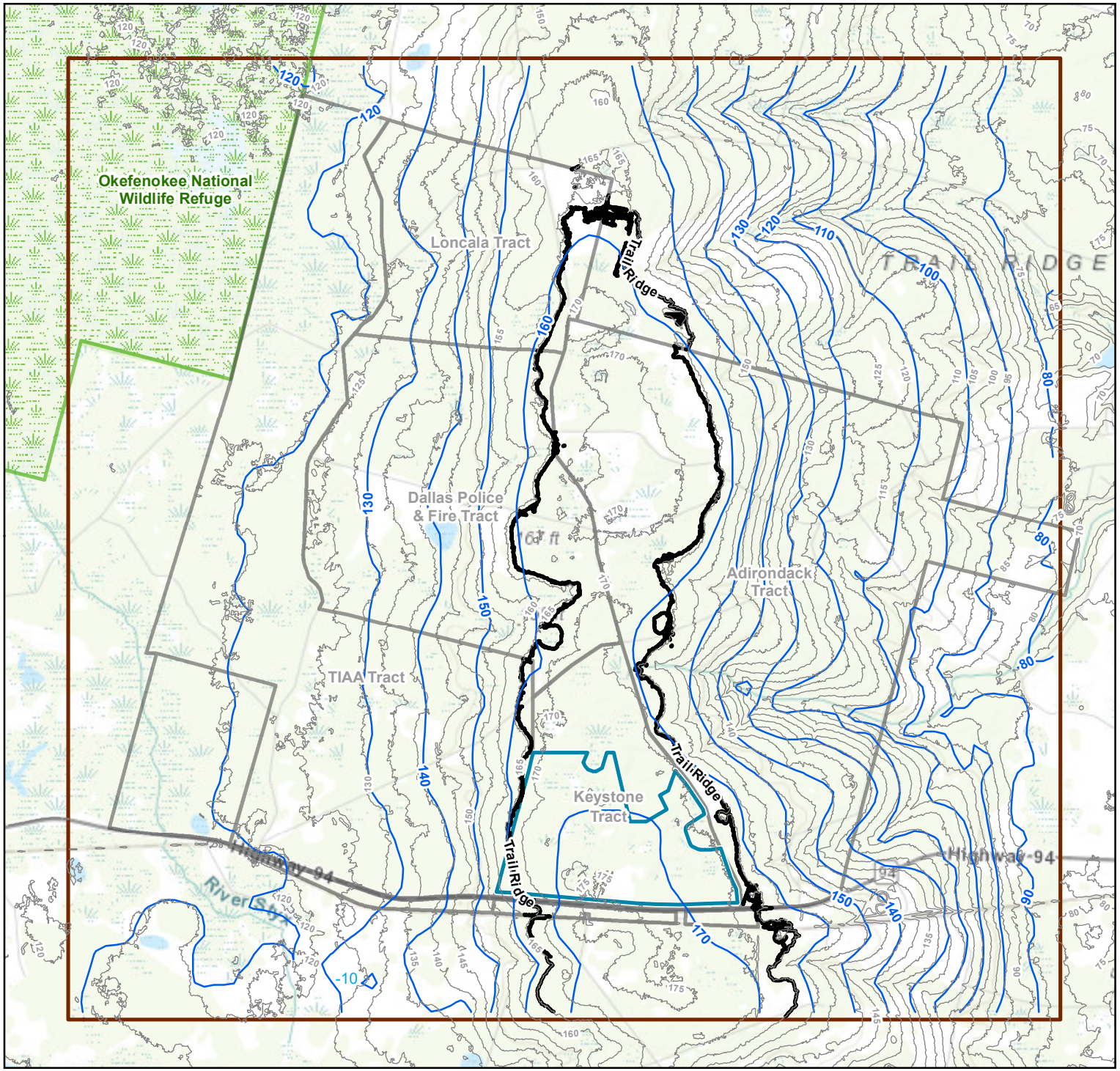


GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	GM
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 30**	

Observed vs. Simulated Water Levels for Calibrated Simulation

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



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- USGS 10 Feet Elevation Contours
- Simulated Water Level Contours (feet above mean sea level)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 0.5 1

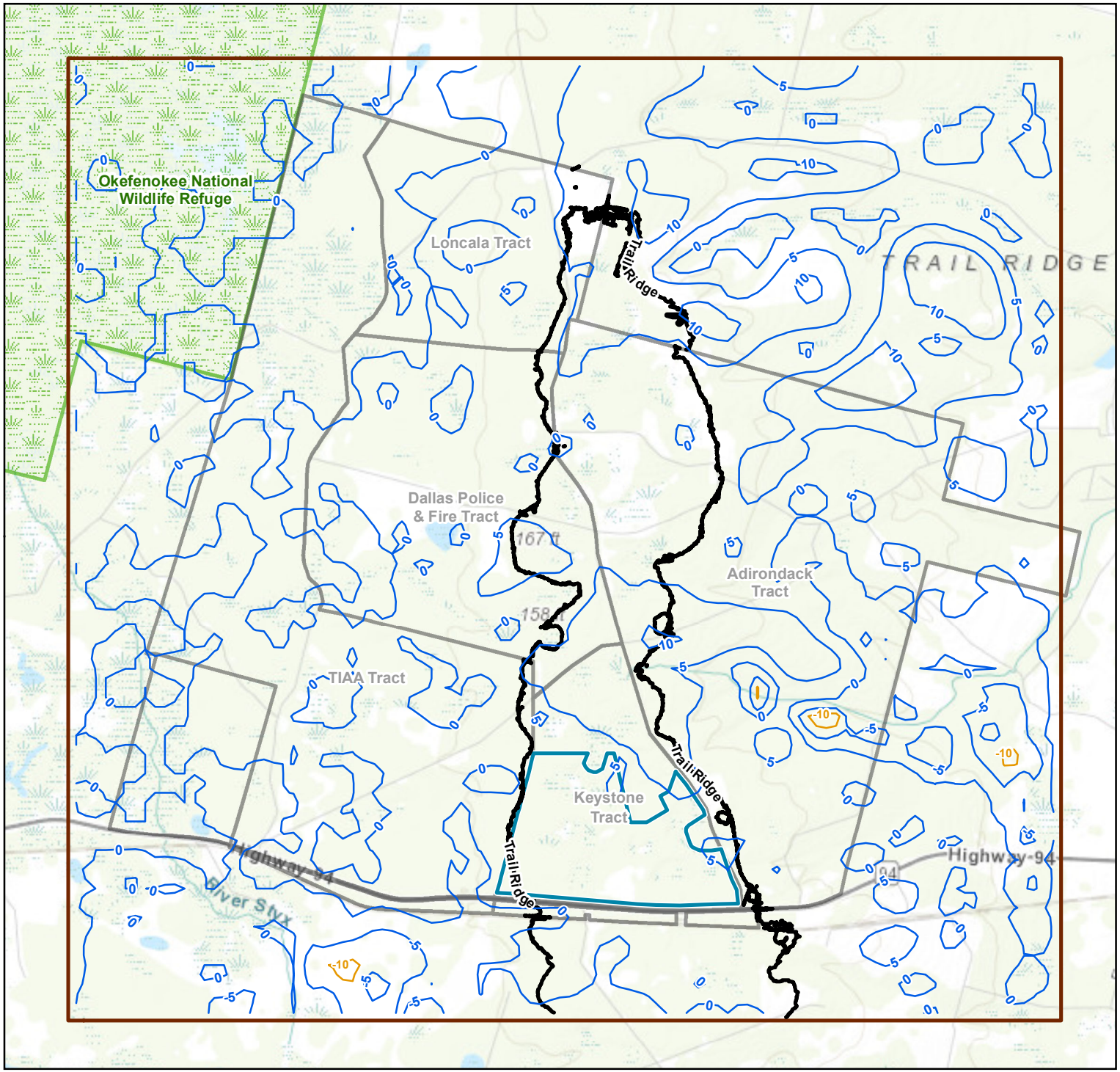
GSI ENVIRONMENTAL

Figure 31
Simulated Water Level Contours

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

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure31	Appv'd By: SP

FIGURE 31



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- Simulated Depth to Water Table (Feet)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

1. Projection: North American Datum 1983 Georgia State Plane East (Feet)
2. Negative values indicate water levels above ground surface.

Scale in Miles

0 0.5 1

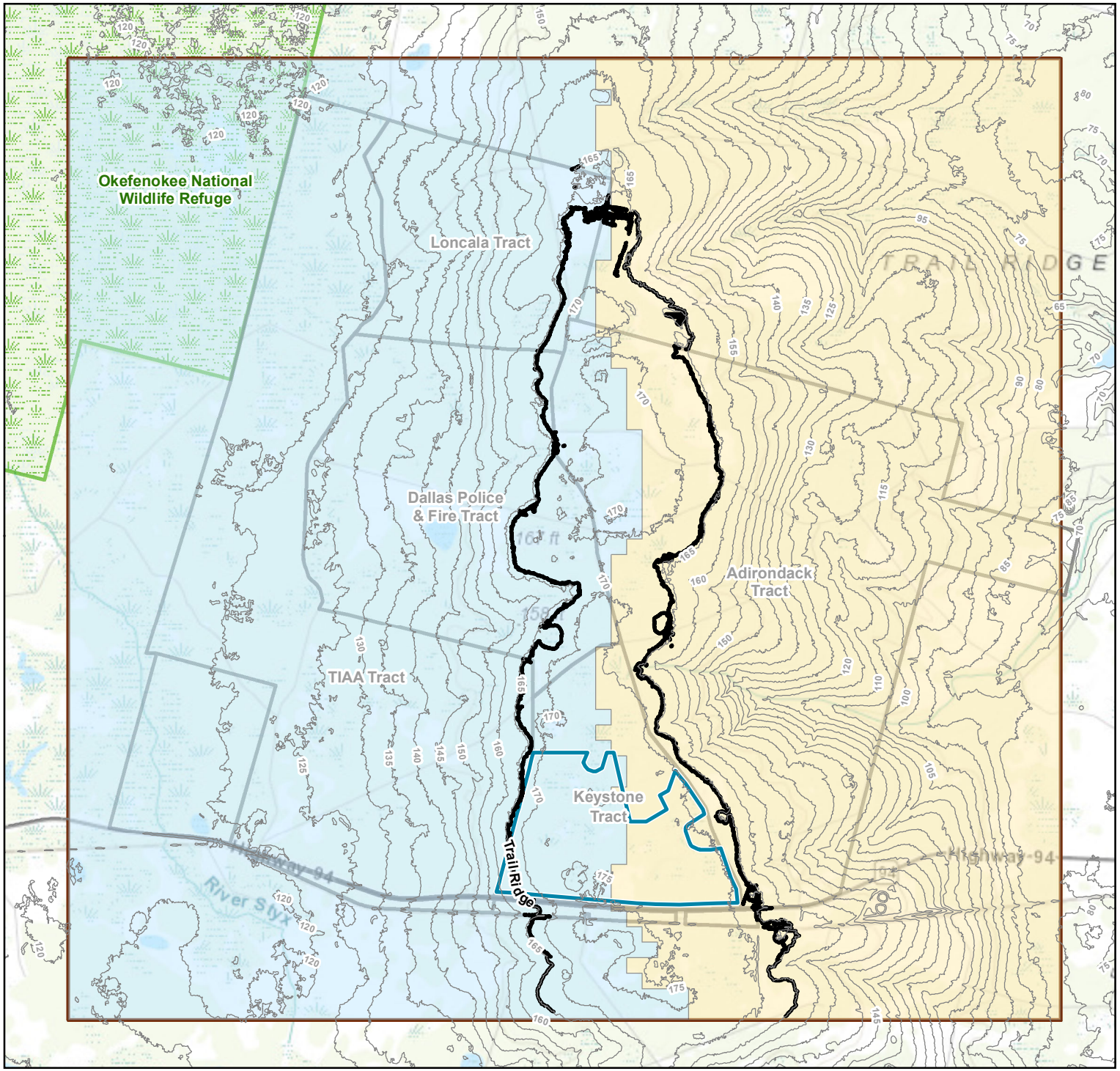
GSI ENVIRONMENTAL

Figure 32
Simulated Depth to Water Table

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

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure32	Appv'd By: SP

FIGURE 32



N

LEGEND

- USGS 10 Feet Elevation Contours
- Trail Ridge (Elevation > 165 feet)
- Proposed Mining Area
- Mass Balance Calculation Area - East of Trail Ridge
- Mass Balance Calculation Area - West of Trail Ridge
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

0 0.5 1

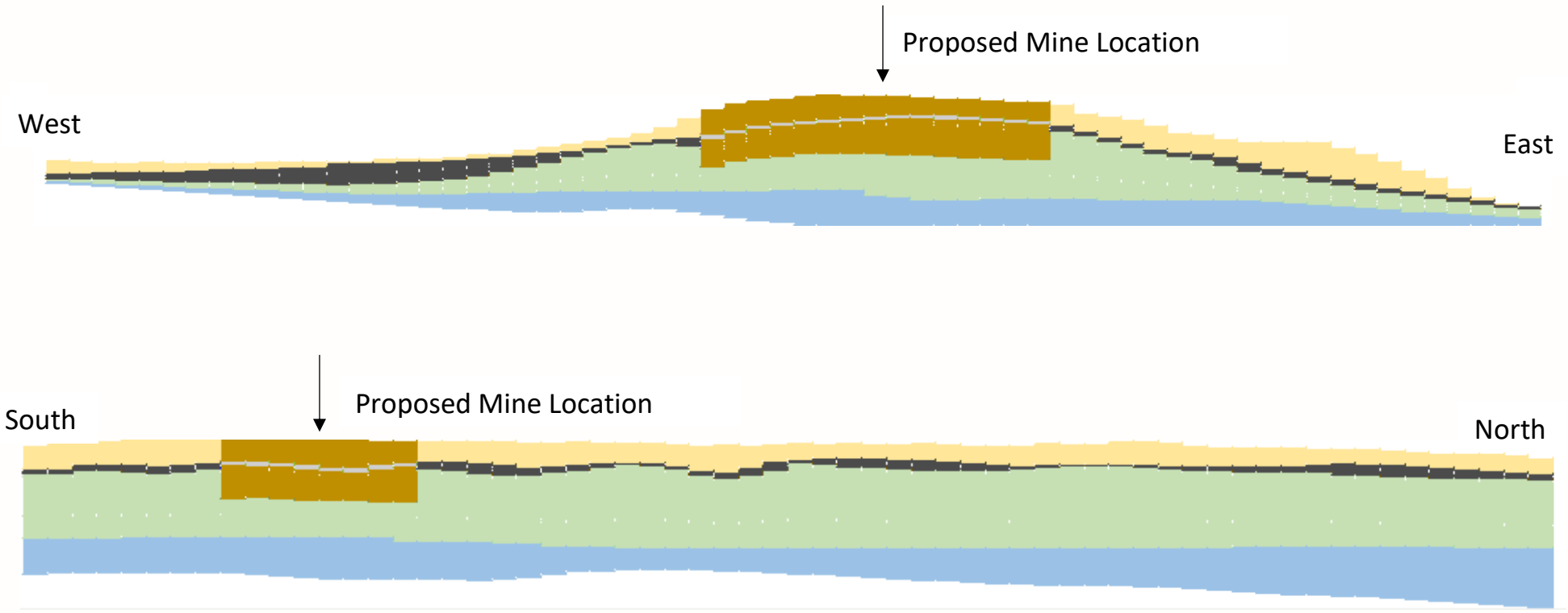
GSI ENVIRONMENTAL

Figure 33
Pre-Mining Simulation Water Budget Calculation Areas

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

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure33	Appv'd By: SP

Figure 33



Hydrostratigraphic Unit 1 (Unconsolidated & Semiconsolidated Sand)

Hydrostratigraphic Unit 3 (Silty Clayey Sand Unit)

Hydrostratigraphic Unit 2 (Consolidated Black Sand)

Hydrostratigraphic Unit 4 (Sandy Clay Unit)

Homogenized Reclaimed Sands

Bentonite Treated Sands

Note: Cross section locations provided on Figure 23.

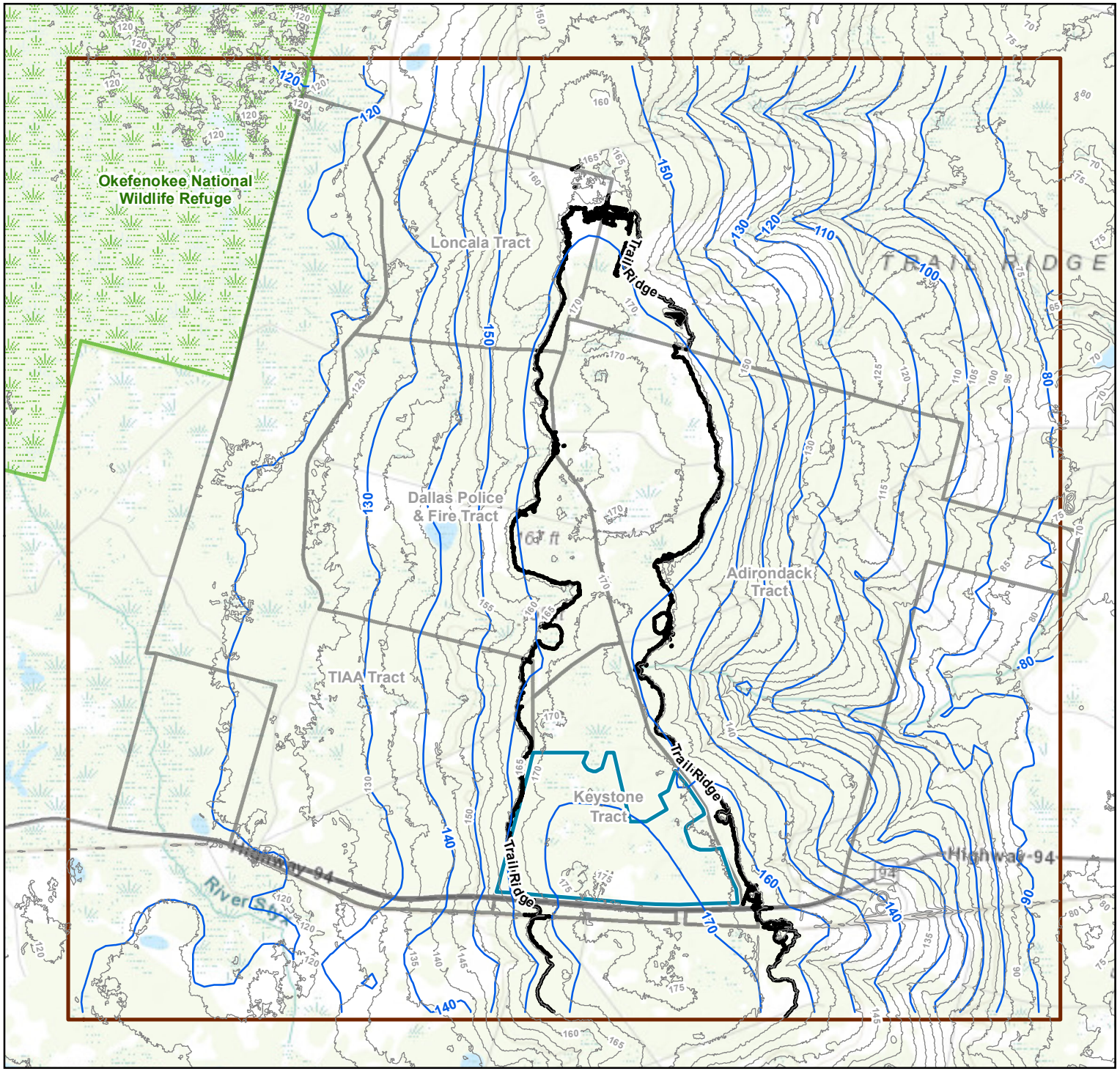
GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	RLW
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 34**	

Post-Mining Conditions Cross Section

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- USGS 10 Feet Elevation Contours
- Simulated Water Level Contours (feet above mean sea level)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

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

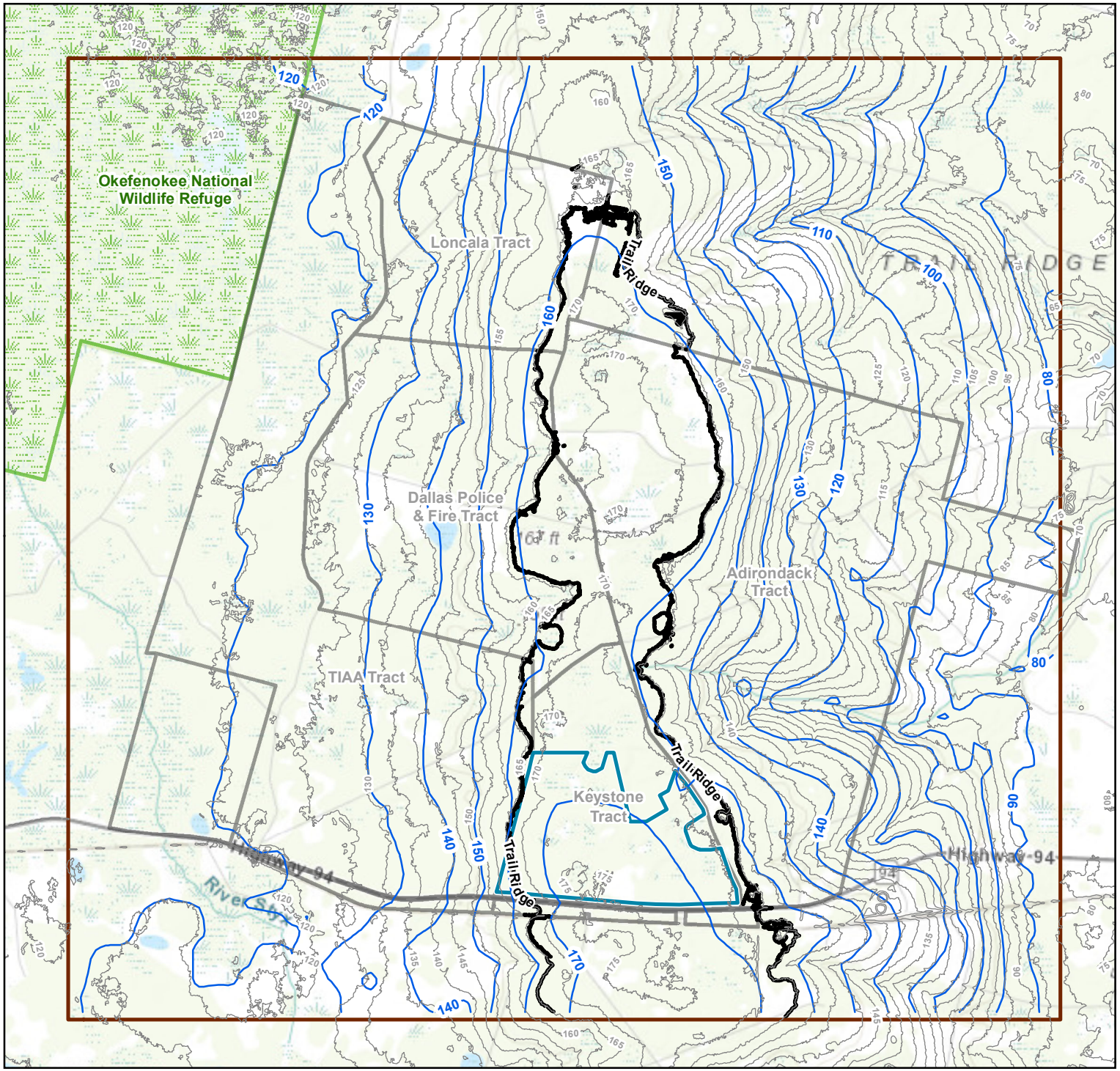
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 35
Simulated Water Level Contours for Post-Mining Conditions with No Bentonite
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure35	Appv'd By: SP

FIGURE 35



LEGEND

- Trail Ridge (Elevation > 165 feet)
- USGS 10 Feet Elevation Contours
- Simulated Water Level Contours (feet above mean sea level)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

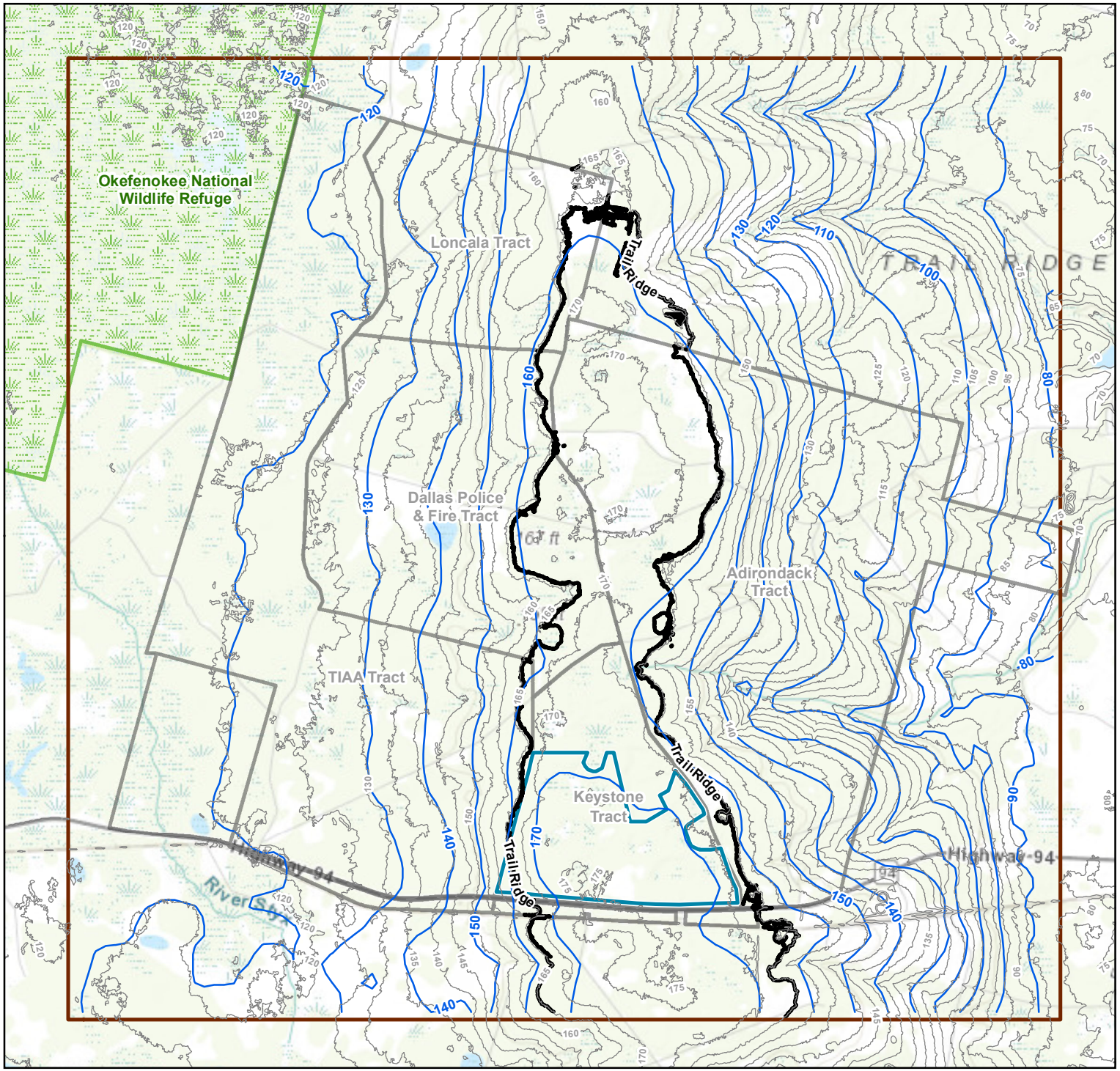
0 0.5 1

GSI ENVIRONMENTAL

Figure 36
Simulated Water Level Contours for Post-Mining Conditions with 5.3% Bentonite
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure36	Appv'd By: SP

FIGURE 36



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- USGS 10 Feet Elevation Contours
- Simulated Water Level Contours (feet above mean sea level)
- Modeling Study Area
- Proposed Mining Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

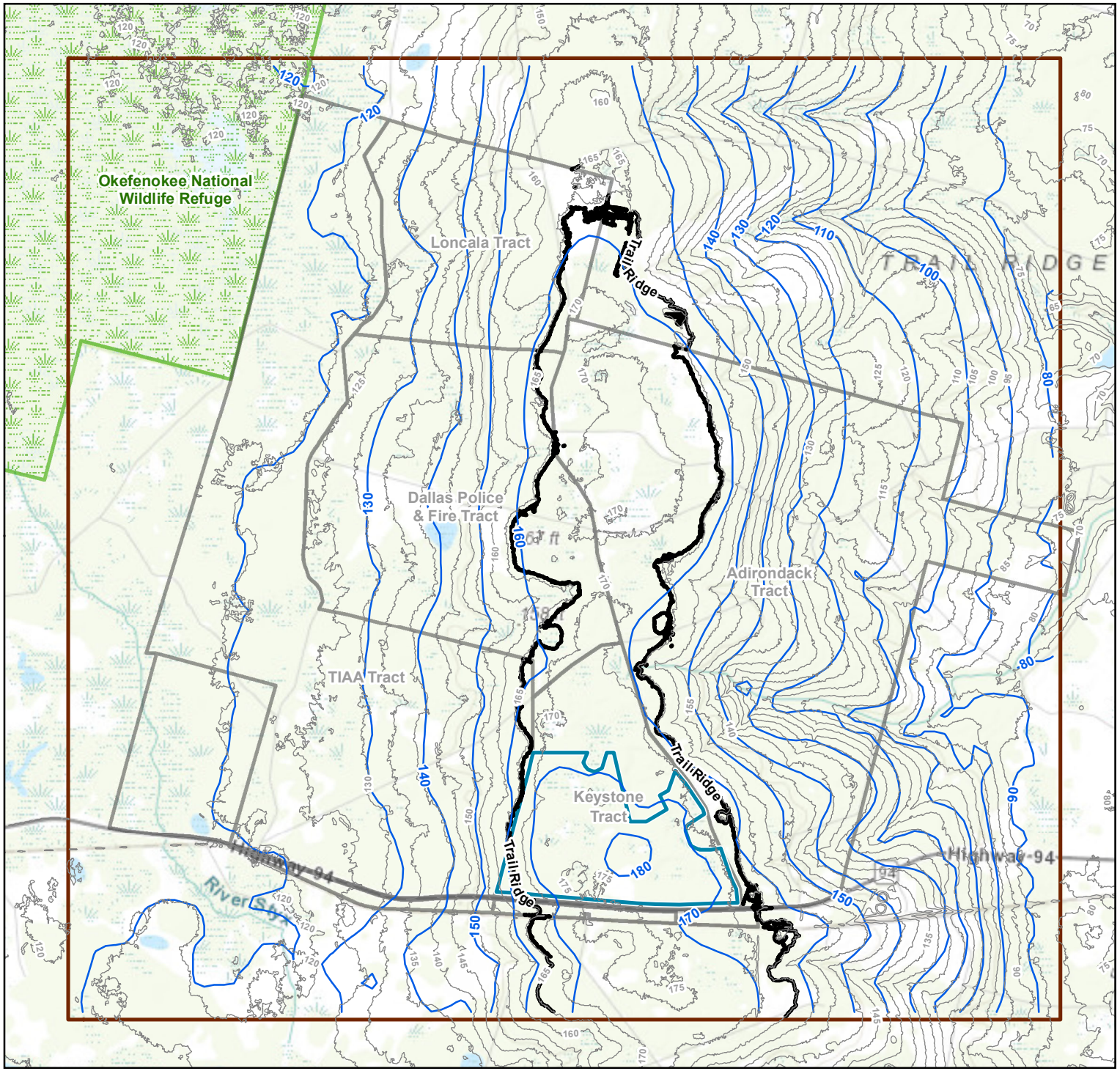
0 0.5 1

GSI ENVIRONMENTAL

Figure 37
Simulated Water Level Contours for Post-Mining Conditions with 10.9% Bentonite
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure37	Appv'd By: SP

FIGURE 37



N

LEGEND

- Trail Ridge (Elevation > 165 feet)
- USGS 10 Feet Elevation Contours
- Simulated Water Level Contours (feet above mean sea level)
- Proposed Mining Area
- Modeling Study Area
- Okefenokee National Wildlife Refuge

Notes:

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

Scale in Miles

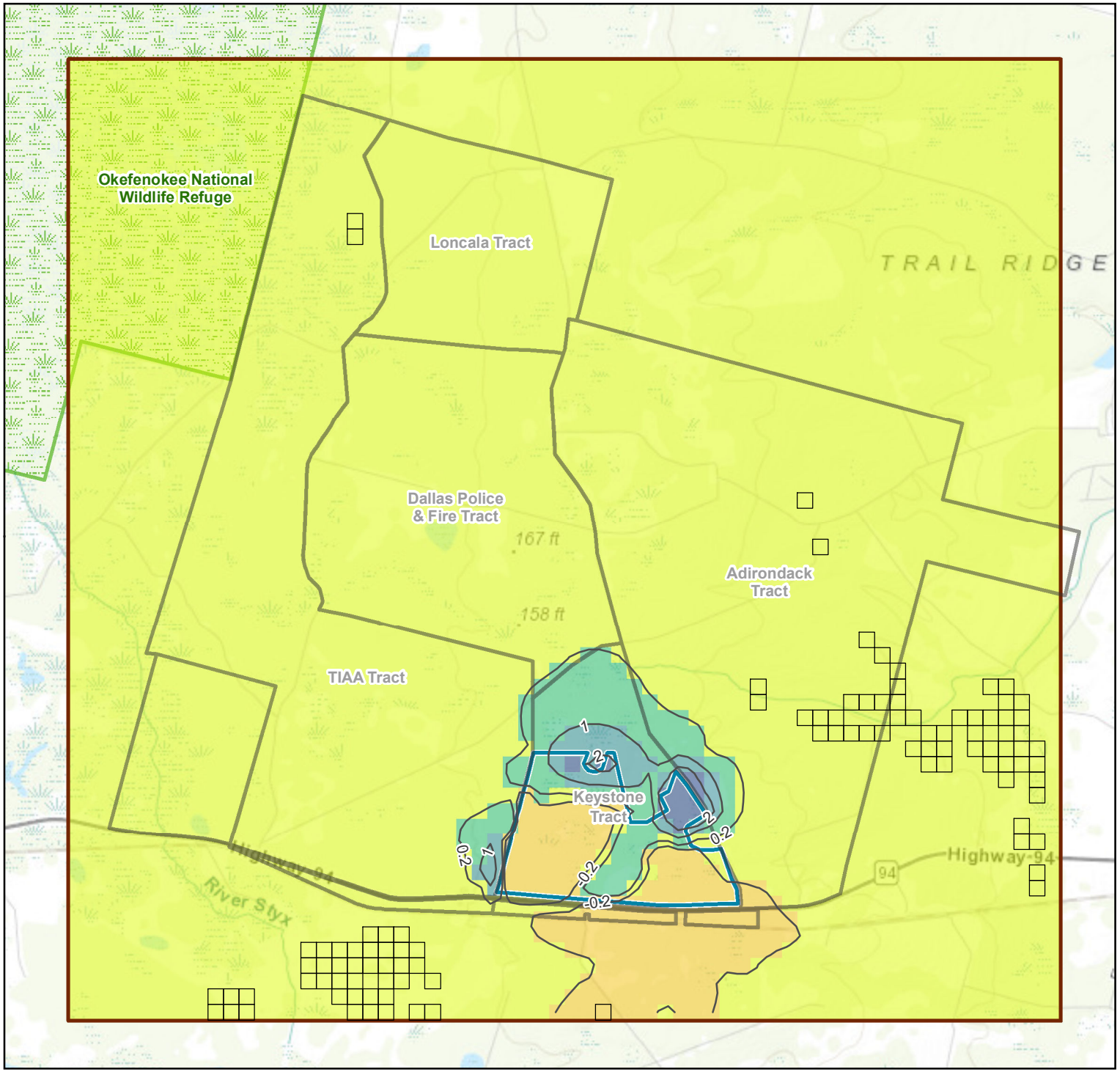
0 0.5 1

GSI ENVIRONMENTAL

Figure 38
Simulated Water Level Contours for Post-Mining Conditions with 12.5% Bentonite
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: GM
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure38	Appv'd By: SP

FIGURE 38



N

LEGEND

- Simulated Head Difference (Feet) - Negative (Positive) Values Indicate Water Level Rise (Decrease)
- Simulated Water Levels > 5 feet Above Ground Surface
- Proposed Mining Area
- Modeling Study Area

Simulated Head Difference (Feet) - Negative (Positive) Values Indicate Water Level Rise (Decrease)

- -1.76 - -0.20
- -0.19 - 0.20
- 0.21 - 1.00
- 1.01 - 2.00
- 2.01 - 6.65
- Okefenokee National Wildlife Refuge

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

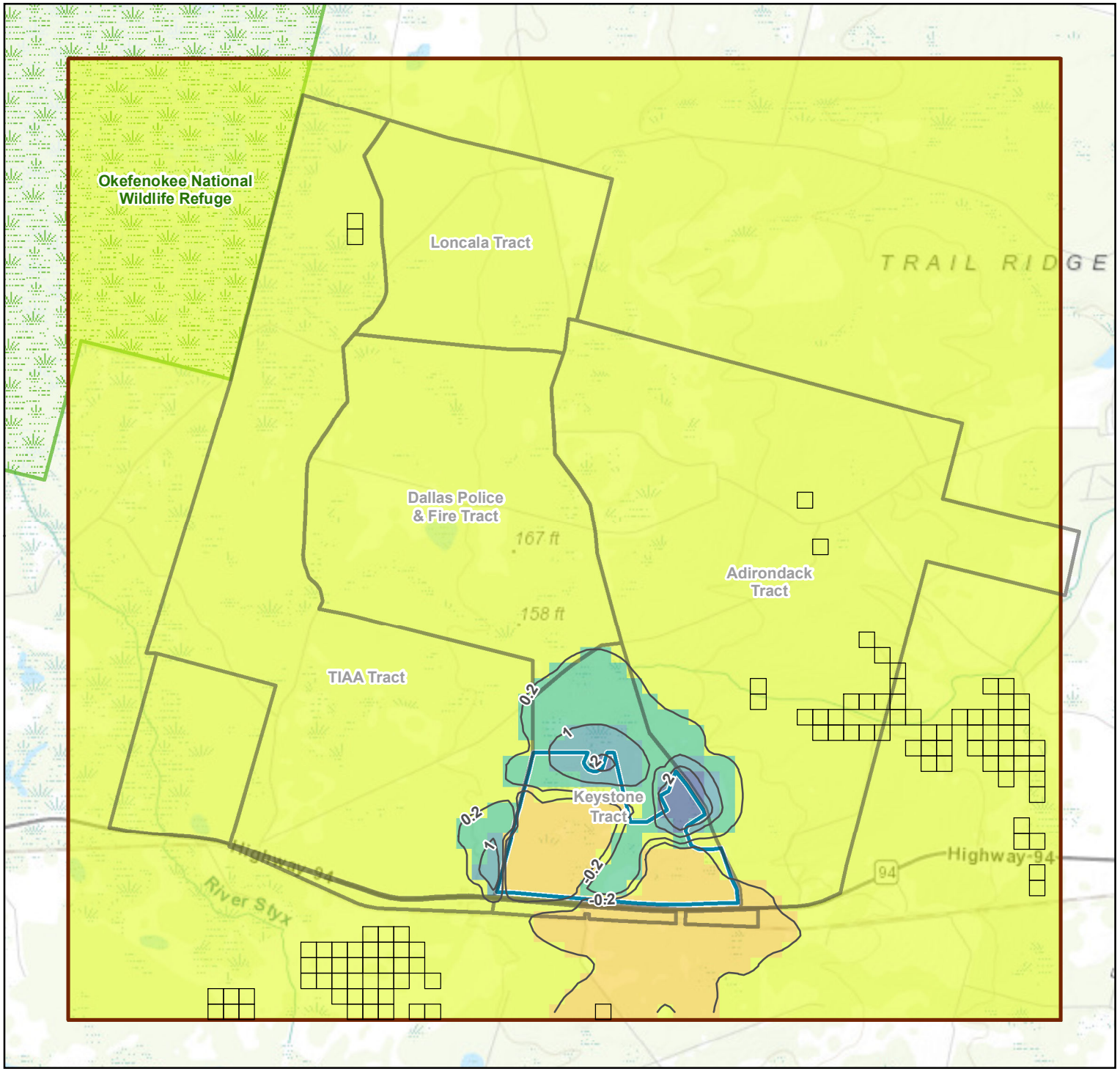
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 39
Water Table Difference
No Bentonite Soil Amendment
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure39	Appv'd By: SP

FIGURE 39



N

LEGEND

- Simulated Head Difference (Feet) - Negative (Positive) Values Indicate Water Level Rise (Decrease)
- Simulated Water Levels > 5 feet Above Ground Surface
- Proposed Mining Area
- Modeling Study Area

Simulated Head Difference (Feet) - Negative (Positive) Values Indicate Water Level Rise (Decrease)

- -1.84 - -0.20
- -0.19 - 0.20
- 0.21 - 1.00
- 1.01 - 2.00
- 2.01 - 6.48
- Okefenokee National Wildlife Refuge

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

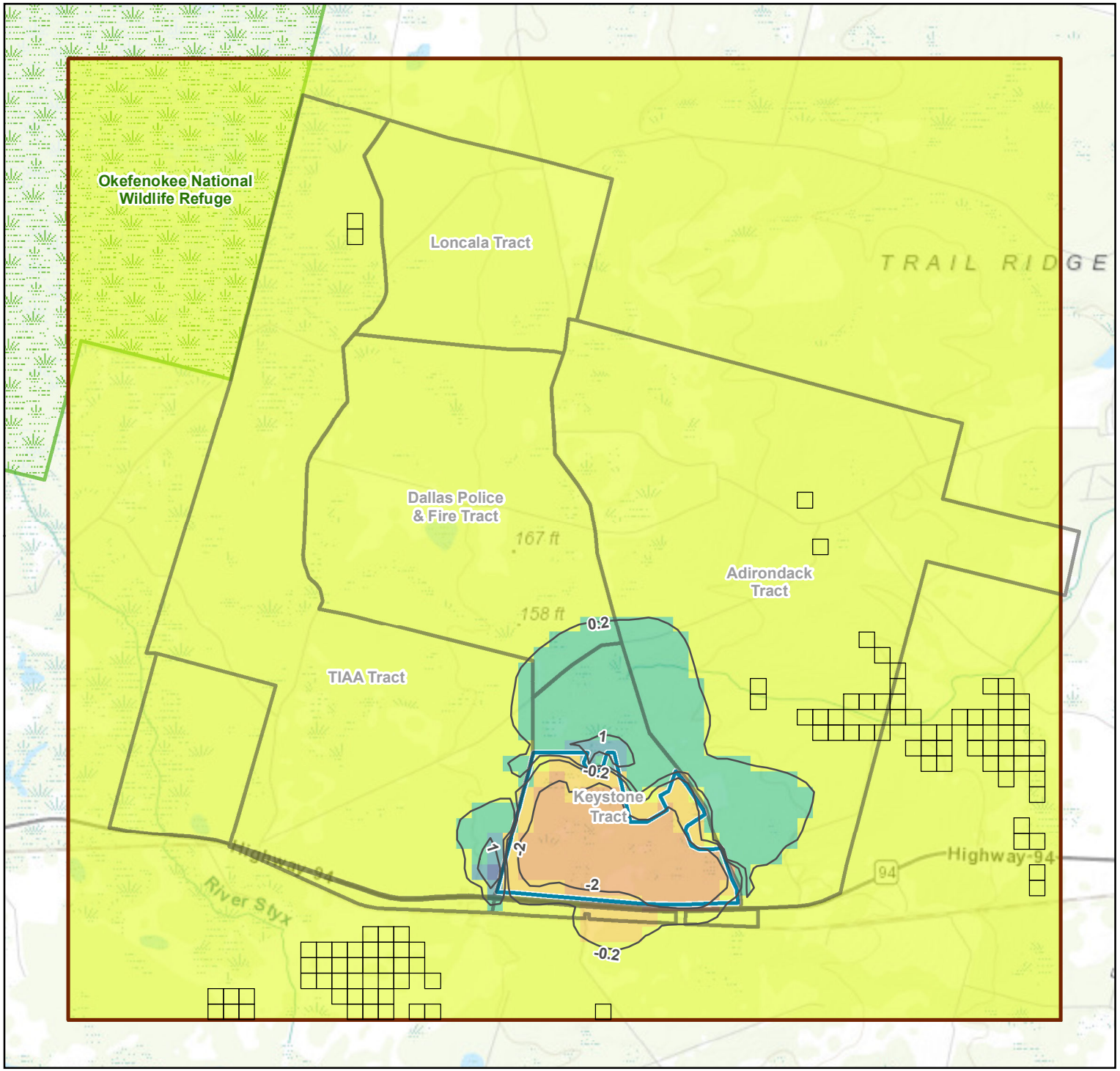
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 40
Water Table Difference
5.3% Bentonite Soil Amendment
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure40	Appv'd By: SP

FIGURE 40



N

LEGEND

- Simulated Head Difference (Feet) - Negative (Positive) Values Indicate Water Level Rise (Decrease)
- Simulated Water Levels > 5 feet Above Ground Surface
- Proposed Mining Area
- Modeling Study Area

Simulated Head Difference (Feet) - Negative (Positive) Values Indicate Water Level Rise (Decrease)

- -5.31 - -2.00
- -1.99 - -0.20
- -0.19 - 0.20
- 0.21 - 1.00
- 1.01 - 2.00
- 2.01 - 2.03
- Okefenokee National Wildlife Refuge

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

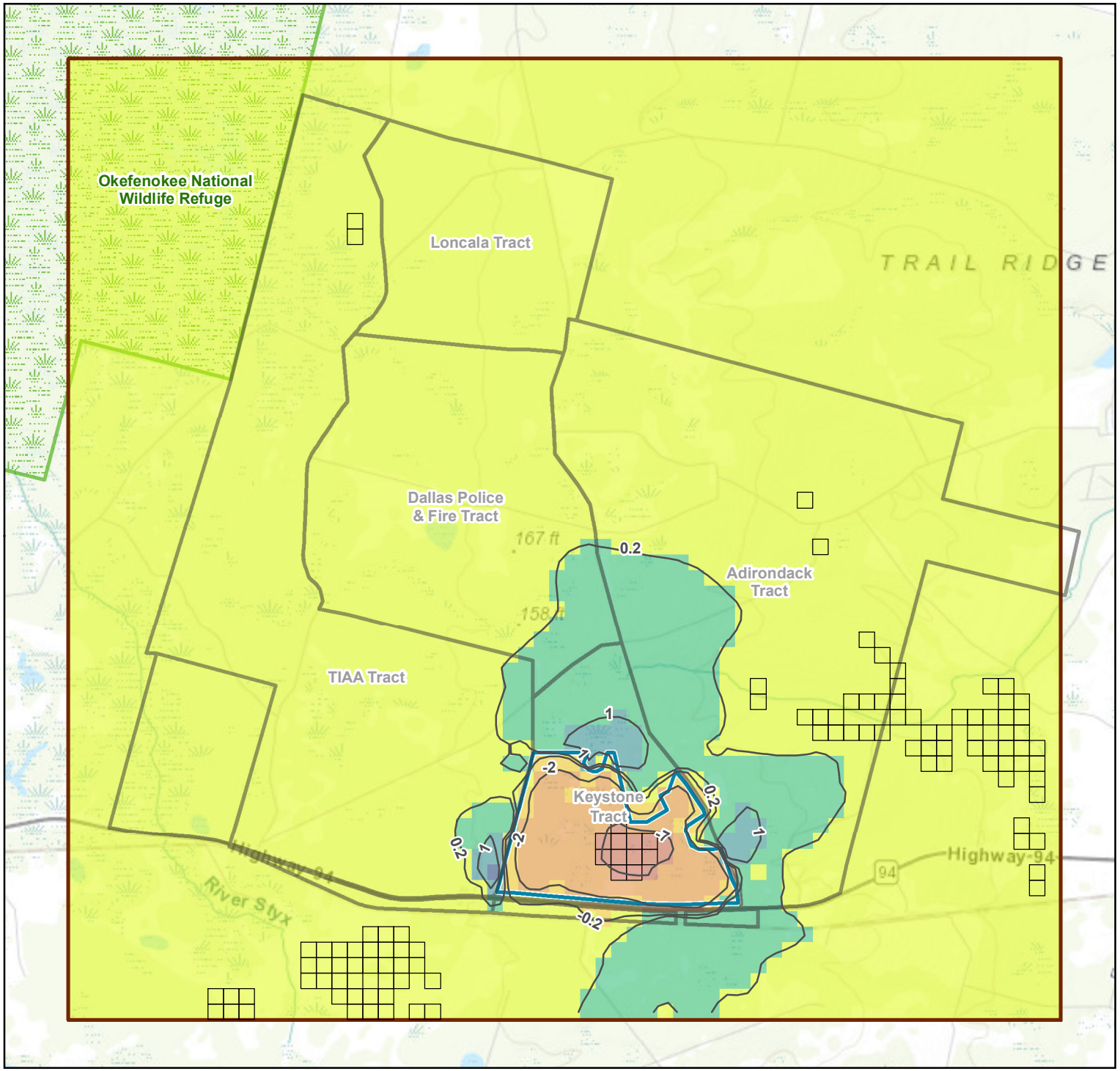
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 41
Water Table Difference
10.9% Bentonite Soil Amendment
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure41	Appv'd By: SP

FIGURE 41



N

LEGEND

- Simulated Head Difference (Feet) - Negative (Positive) values Indicate Water Level Rise (Decrease)
- Simulated Water Levels > 5 feet Above Ground Surface
- Proposed Mining Area
- Modeling Study Area

Simulated Head Difference (Feet) - Negative (Positive) values Indicate Water Level Rise (Decrease)

- -9.58 - -7.00
- -6.99 - -2.00
- -1.99 - -0.20
- -0.19 - 0.20
- 0.21 - 1.00
- 1.01 - 2.00
- 2.01 - 2.02
- Okefenokee National Wildlife Refuge

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

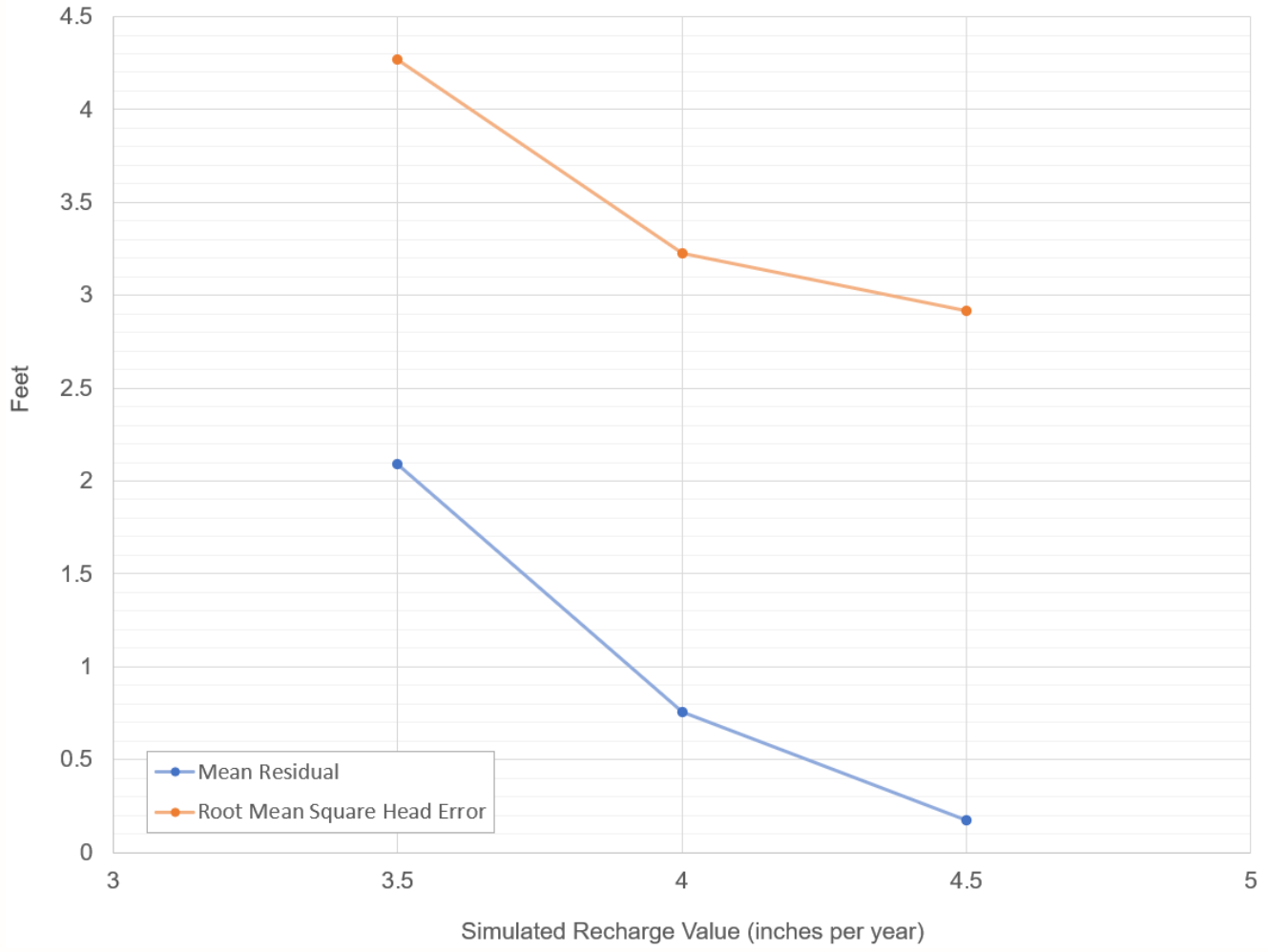
Scale in Miles
0 0.5 1

GSI ENVIRONMENTAL

Figure 42
Water Table Difference
12.5% Bentonite Soil Amendment
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia

GSI Job No. 5844	Drawn By: RLW
Issued: 20-Jul-2021	Chk'd By: SP
Map ID: Figure42	Appv'd By: SP

FIGURE 42

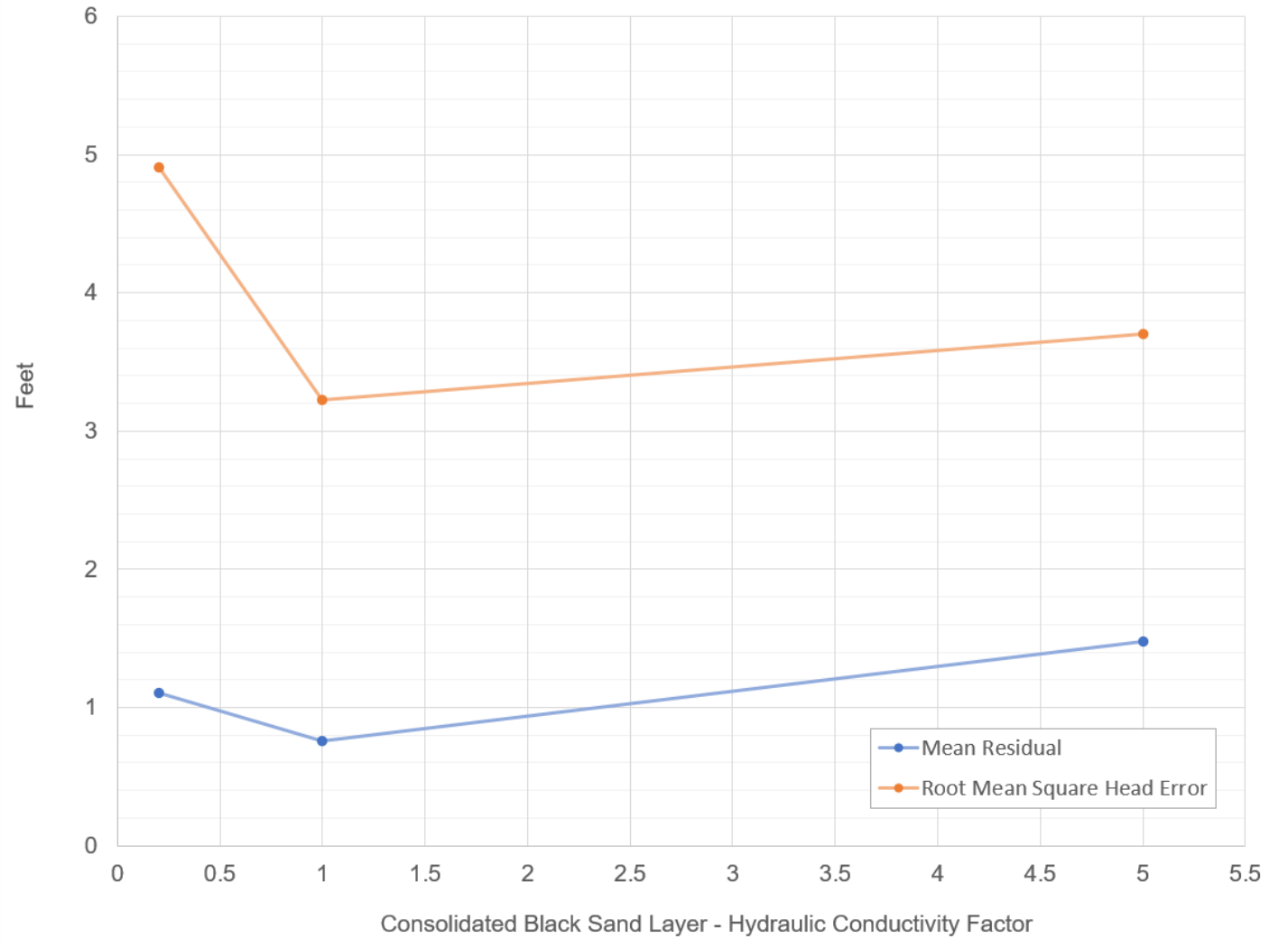


Note:
The calibrated model recharge value was 4 inches per year.

GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	GM
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 43**	

Pre-Mining Model Statistics For Recharge Sensitivities
Twin Pines Minerals, LLC
St. George, Charlton County, Georgia



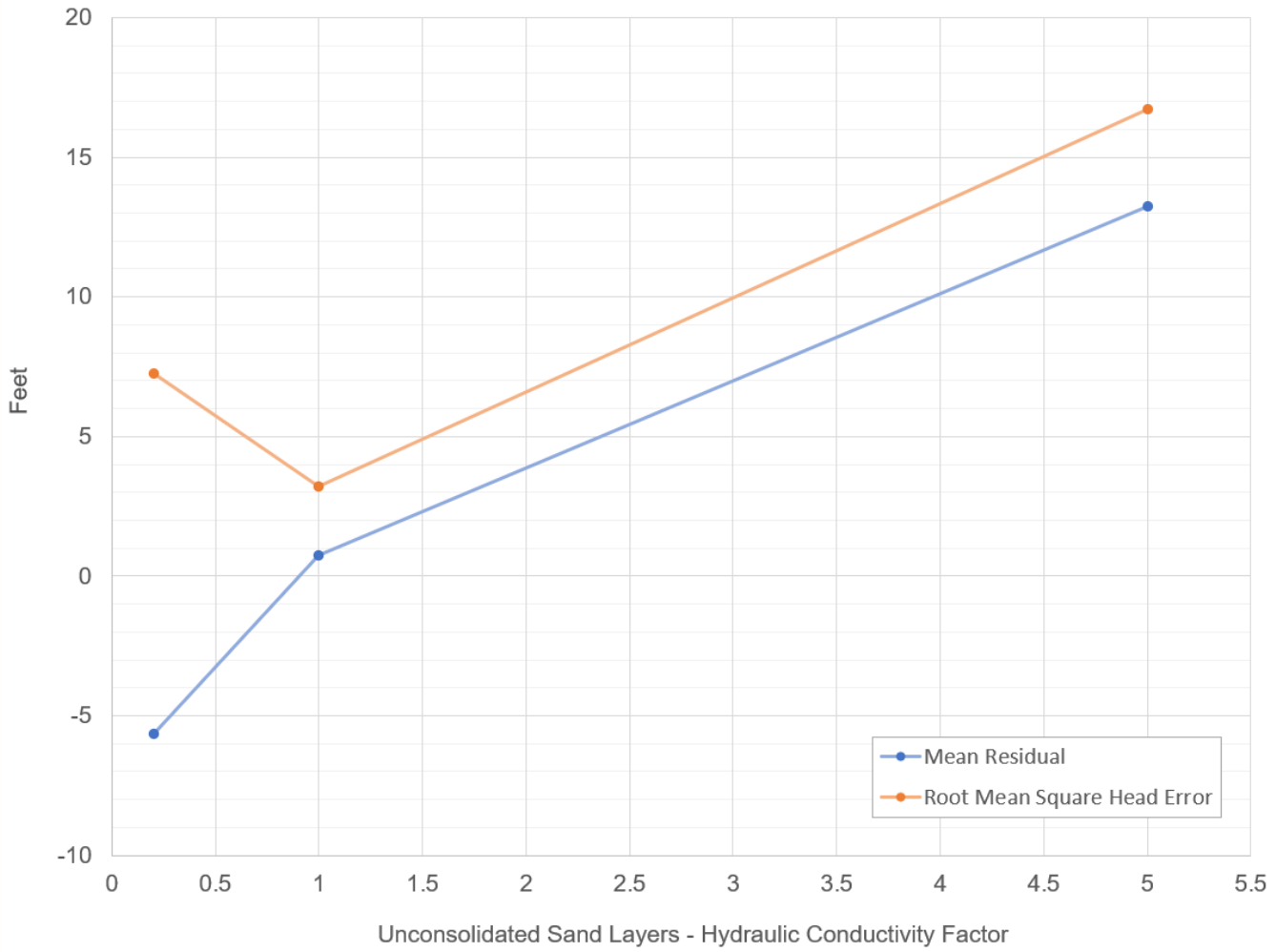
GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	GM
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 44**	

Pre-Mining Model Statistics for Consolidated Black Sand Hydraulic Conductivity Sensitivities

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia



GSI ENVIRONMENTAL

GSI Job No.	5844	Drawn By:	GM
Issued:	15 July 2021	Chk'd By:	SP
Revised:		Aprv'd By:	SP
Scale:		**Figure 45**	

Pre-Mining Model Statistics for Unconsolidated Sand Layers Hydraulic Conductivity Sensitivities

Twin Pines Minerals, LLC

St. George, Charlton County, Georgia

APPENDICES

Appendix A

Response to Comments Provided to TTL on 4/14/21

APPENDIX A
RESPONSE TO COMMENTS PROVIDED TO TTL ON APRIL 14, 2021 BY DR. JAMES KENNEDY (KENNEDY, 2021) AS PART OF A TWIN PINES PERMIT COORDINATION DOCUMENT

Permit application documents have been submitted by Twin Pines Minerals (TPM) to develop a heavy mineral sand mine along Trail Ridge in Charlton County, Georgia. These include site studies and modeling studies which were summarized in the permit application document (TTL, 2020). The documents have gone through several rounds of review and comments from the Georgia Environmental Protection Division (GA EPD) by the State Geologist, Dr. Kennedy. This document is a response to comments by GA EPD on the impact of mining, on the hydrogeology of the region, as part of the Twin Pines Permit Coordination Document for Charlton County (Kennedy (2021)). In general, a new numerical model was developed that addresses the major concerns of the previous modeling efforts. The model development and results are reported in GSI (2021).

The entire comment from Dr. Kennedy will not be repeated here since he has done detailed examinations and reported them as part of his comments. Instead, the comment number will be noted, and the comment will be summarized for the response.

Comment 5a: Attach documents to the MLUP.

Response: Not model related.

Comment 5b: Initial groundwater recharge rate at the site was estimated as 4.54 inches/year, however, the model applied 2.8 inches/year. Calculations using USGS Open File Report (OFR) 2003-311 data show an average of 4.13 inches/year. The comment essentially requests justification for the use of 2.8 inches/year.

Response: A recharge value of 4.13 inches/year was used for the steady-state groundwater flow model. This is the value estimated for the study area from the USGS data cited above.

An evaluation of recharge over the study area was conducted and it was noted that recharge could vary between 4.5 inches/year and 3.5 inches/year as noted in GSI (2021). The USGS data was examined further and was noted to be a reasonable approach to estimating long-term recharge for the model. Also, a sensitivity analysis was conducted on the range of recharge values to note the impact on calibration to pre-mining conditions and on post-mining conditions.

Comment 5c: The comment requests clarification on requirement of soil amendments.

Response: Soil amendments were modeled in different amounts to note the most effective bentonite mix for the soil amendment layer. A mix using 10.9 % bentonite over the entire mined area was simulated to be the best amendment for minimizing hydrogeologic impacts at and around the mine site.

Comment 5d: The comment indicates that the groundwater flow modeling of soil amendments should be done and that will help to determine how hydrology changes from pre-mining conditions.

Response: We have conducted groundwater flow modeling with various mixtures of bentonite in the amendments and noted how and where the amendments impact the pre-mining hydrogeology. Larger amounts of bentonite in the amendment cause water levels to rise higher to where they may be intercepted by wetlands and stream channels. It was determined that minimal impacts occurred with a 10.9% mixture of bentonite.

Comment 5e: The comment requests clarification on continuity of black sands.

Response: We have conducted similar computations to those conducted by Dr. Kennedy regarding continuity of black sands and have come to a similar conclusion that about 69% of the area contains consolidated black sands.

Comment 5f: The comment requests further analyses of consolidated black sands if it is not conceptualized to be continuous enough to affect the presence of the shallow water table along Trail Ridge.

Response: We have conducted similar computations to Dr. Kennedy regarding continuity of black sands and have come to a similar conclusion that about 69% of the area contains consolidated black sands.

Comment 5g: The comment requests that a hydrogeologic layer of consolidated black sands be included in the model for several reasons listed.

Response: We agree with the reasons and have a layer of consolidated black sands included in the model.

Comment 5h: The comment requests clarification on how rainwater interacting with the reclaimed mine may affect the chemistry of the groundwater discharge to surface waters.

Response: Not model related.

Comment 6a: Attach documents to the MLUP.

Response: Not model related.

Comment 6b: This comment requests use of data to determine presence or absence of consolidated black sands.

Response: We have mapped the logs with presence and absence of consolidated black sands and used that information to delineate locations where consolidated black sands are present and where they may be absent. This is detailed in GSI (2021). This data indicated that the study area was mostly covered with continuous black sands with small areas where they did not exist, and a small zone showing a transition between where the continuous black sands exist and where they do not.

Comment 6c: This comment requests use of hydraulic conductivity values for consolidated black sands that are in line with data from the site. Also, the comment indicates that slug test data that show higher values may not be appropriate for consolidated black sands.

Response: We have mapped the hydraulic conductivity estimates from laboratory and field experiments in GSI (2021). They are low in the range of 10^{-6} to 10^{-8} cm/sec as noted by GA EPD and that higher values in the range of 5 x 10^{-5} to 10^{-2} cm/sec may indicate composite conductivities with overlying and underlying materials. The model developed in GSI (2021) also uses values in the range of 10^{-6} to 10^{-8} cm/sec for the consolidated black sands.

REFERENCES

GSI (2021). Modeling the Groundwater Flow System at the Proposed Twin Pines Mine on Trail Ridge, July 16, 2021.

Kennedy (2021), Twin Pines Permit Coordination Document Charlton County: Saunders Demonstration Mine, Comments from April 14, 2021.

TTL (2020), Individual Permit Application for Twin Pines Minerals, LLC, Saunders Demonstration Mine Saint George, Charlton County, Georgia (SAS-2018-00554), March 4, 2020.

Appendix B

Response to Comments Provided to Twin Pines Minerals, LLC on 9/10/21

APPENDIX B
RESPONSE TO COMMENTS PROVIDED TO TWIN PINES MINERALS, LLC ON SEPTEMBER 10, 2021, BY GEORGIA DEPARTMENT OF NATURAL RESOURCES ENVIRONMENTAL PROTECTION DIVISION AND DR. JAMES KENNEDY (EPD, 2021)

Permit application documents have been submitted by Twin Pines Minerals (TPM) to develop a heavy mineral sand mine along Trail Ridge in Charlton County, Georgia. This document is a response to comments by the Georgia Department of Natural Resources Environmental Protection Division (EPD) regarding the development of a groundwater model to assess the impact of mining, on the hydrogeology of the region, as part of an Application for a Surface Mining Permit and Mining Land Use Plan (MLUP) Twin Pines Permit Coordination Document for Charlton County (TTL, 2021).

The entire comment from EPD will not be repeated here but does include the EPD comments specific to development of the groundwater model.

2. Exhibit I Modeling the GW Flow System Comments James L. Kennedy Ph.D., P.G.

Page 1: The description of the method to be used to place the bentonite-enhanced layer of soil will not work given that the mine pit will not be dewatered. It was noted that placement of the bentonite-enhanced soil layer is not a modeling issue, which is correct, but the description of the process on Page 1 must say placement of the bentonite-enhanced soil layer cannot be simulated by the model.

Response: The modeling report text has been updated as requested in Section 1.0 that provides the Executive Summary (page 1) as well as in Section 7.0 on Post-Mining Analysis section (page 11).

Page 8: Explicitly explain what use of the drains versus rivers means in the model. In MODFLOW drains can receive water from the modeled aquifer but cannot recharge the modeled aquifer. A river can both receive water from the modeled aquifer and discharge water to the modeled aquifer. Explain that the drains were modeled based on the surface water courses shown on Figures 22 and 23. Explain that no rivers were modeled because there are no rivers within the model domain.

Response: The modeling report text (Section 4.3 Model Boundary Conditions – page 9) has been updated as requested.

Page 8: Say how many grids there are in the mining area (there are enough grids).

Response: The modeling report text has been updated as requested, in Section 4.1 on Model Discretization (page 8).

Page 12: Please say explicitly if the addition of bentonite was simulated in the mining area shown on Figure 3 (and later figures) or if it was simulated for the entire are (it was simulated in the mining area shown on Figure 3 but that needs to be clarified in the report).

Response: The modeling report text has been updated as requested in Section 7.0 on Post-Mining Analysis section (page 12).

Does the software used for the model include an LGR (Local Grid Refinement) capability? If it does LGR should be used to model the mine area. LGR could be used to model the mine area at a grid size of 250 ft. x 250 ft. LGR is not needed to make the model acceptable, but it would be helpful to see a more detailed numerical analysis of the mining area.

Response: Local grid refinement (LGR) capability can be directly implemented for models built using MODFLOW-2005 but not with the MODFLOW-NWT code that was used for simulation of the proposed Twin Pines Minerals project.

Revising the code to MODFLOW-USG would allow grid refinement specific to the proposed mine area; however, this would also introduce unnecessary complexity to the modeling effort and, therefore, no changes to the modeling code have been implemented.

REFERENCES

GSI (2021). Modeling the Groundwater Flow System at the Proposed Twin Pines Mine on Trail Ridge, September 14, 2021.

Georgia Department of Natural Resources Environmental Protection Division (EPD) (2021), Twin Pines Permit Coordination Document Charlton County: Saunders Demonstration Mine, Comments from September 10, 2021.

TTL (2021). Part 2 Response to EPD Permit Coordination Comments, July 16, 2021.