Twin Pines Minerals, LLC

CLIMATE DATA AT TWIN PINES MINE

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PROPOSED HEAVY MINERALS MINE
ST. GEORGE, CHARLTON COUNTY, GEORGIA

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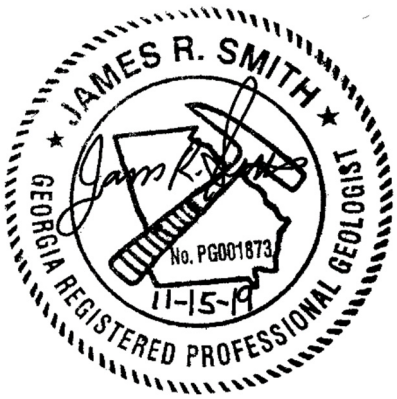

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INTRODUCTION

On July 3, 2019, Twin Pines Minerals (TPM) submitted an individual permit application to the U.S. Army Corps of Engineers for impacts to water of the United States to develop a heavy mineral sand mine along Trail Ridge in Charlton County, Georgia (Figure 1). The proposed mine is located 3.2 miles west of St. George, Georgia, along Georgia State Highway Route 94. Trail Ridge is a 0.6 to 1.2 mile wide and 99 mile long topographic ridge that separates the Okefenokee Basin and Swamp from the coastal plain of Georgia (Force and Rich, 1979). It represents the crest of a former beach complex and was formed as inland sand dunes near the proposed Twin Pines Mine (e.g., Pirkle et al. 1993). The ridge is underlain by a shallow aquifer, locally known as the surficial aquifer, which forms a hydrologic divide between the Okefenokee swamplands to the west and the Saint Mary's River to the east. At the proposed mine site, the water table is very shallow with water depths of only a few feet. The surficial aquifer is perched on the clays of the upper Hawthorn Group, which is considered to be the upper confining unit to the Floridian Aquifer in the region (e.g., Williams and Kuniansky, 2016).

The proposed permit area is approximately 2,414-acres, located southeast of the Okefenokee National Wildlife Refuge (ONWR) boundary; however, TPM will only mine an approximate 1,268-acre area located about 2.7 miles from the ONWR boundary (Figure 2). The portion of the proposed permit area extending from the western mining boundary to the edge of the permit boundary will be avoided and will provide a buffer to the ONWR.

The project study area consists of approximately 12,000-acres of land located near St. George, Charlton County, Georgia. This area is comprised of five (5) tracts identified as Loncala, Dallas Police & Fire, Keystone, TIAA, and Adirondack. To evaluate local groundwater, surface water, and precipitation, field activities were performed both within the proposed mining area and on adjacent properties outside of the proposed mining area footprint. Reference to "project study area" in this report refers to activities conducted within the proposed mining area and adjacent tracts.

The purpose of this report was to compile regional and local climate data in order to evaluate temperature, precipitation, and evapotranspiration (ET) values for the Twin Pines site.

REGIONAL CLIMATE DATA

Data Sources

Historical climate information for temperature, precipitation, and evapotranspiration were obtained from online resource databases from one government and two academic organizations. The table below summarizes source information of historical climate data compiled for this study.

Climate Values	Years Compiled	Dataset Title	Data Source	Data Source Affiliation
Temperature	1986 - 2017	Global Summary of the Month (GSOM)	National Centers for Environmental Information (NCEI)	National Oceanic and Atmospheric Administration (NOAA)
Precipitation	1986 - 2017			
Evapotranspiration	2003 - 2017	Evapotranspiration Data from Water Balance Calculator	Automated Environmental Monitoring Network Page (AEMN)	College of Agricultural and Environmental Sciences - University of Georgia (UGA)
		Evapotranspiration Monthly Average	Florida Automated Weather Network (FAWN)	IFAS Extension – University of Florida

Temperature and Precipitation Data

National Oceanic and Atmospheric Administration (NOAA)

Historical values of temperature and precipitation data for the region of southeast Georgia and northeast Florida were compiled from seven (7) NOAA land-based weather station locations. The weather station locations were selected based on proximity to the project study area. A summary of the NOAA weather station location information is listed in the table below. A regional map showing locations of each weather station is provided in Figure 3.

Location Name (city/state)	NOAA Station ID	Distance from Project Study Area (miles)
Lake City, FL	USC00084731	39
Fargo, GA	USC00093325	25
Folkston, GA	USC00093465	15
Glen St. Mary, FL	USC00083470	18
Nahunta, GA	USC00096219	47
Valdosta, GA	USW00093845	72
Waycross, GA	USC00099186	48

Regional values for temperature and precipitation from 1986 to 2017 were provided by the National Oceanic and Atmospheric Administration's (NOAA) as part of the Global Summary of the Month (GSOM) reports (https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00946). Each GSOM report contains a variety of temperature and precipitation statistics for a monitoring location; however, only the average monthly temperature values and the total monthly precipitation volume were utilized in this report. The monthly average temperature data was used to calculate an annual average temperature at each of the seven monitoring stations between 1986 to 2017. The monthly total precipitation data was summed to calculate a yearly precipitation value at each of the seven monitoring stations between 1986 to 2017. The complete GSOM datasets downloaded from NOAA for each year at each station location are provided in Appendix A. A summary of tabulated total annual precipitation and average annual temperature data each of the seven monitoring stations between 1986 to 2017is provided in Table 1.

Evapotranspiration Data

University of Georgia Weather Network

Historical climate observation data for select sites throughout the state of Georgia is available through the Automated Environmental Monitoring Network (AEMN) established by the College of Agricultural and Environmental Sciences at the University of Georgia (UGA) (http://www.weather.uga.edu/). Evapotranspiration data is calculated daily via AEMN's water balance calculator using the Priestly-Taylor equation (Priestly and Taylor, 1972) for short crop. Instrumentation employed for measurements of atmospheric conditions by the UGA weather network is summarized in the table below.

Measured Parameter	Instrument	Model	Manufacturer
Precipitation	8-inch tipping rain gauge	TB4-L	Hydrological Services
		TE252-L	Texas Electronics
Temperature	HUMICAP humidity and temperature probe	HMP155	VAISALA
Relative Humidity			
Wind Speed/Direction	Wind Sensor	014/024/034	MetOne
Solar Radiation	Pyranometer	LI200	Licor

Historical annual ET values recorded at 83 UGA weather stations between 2003-2017 was obtained from UGA's weather network water balance calculator (Appendix B).

Florida Automated Weather Network (FAWN)

Historical annual ET values for two cities in north Florida were accessed through the Florida Automated Weather Network (FAWN) as part of the Institute of Food and Agricultural Sciences (IFAS) of the University of Florida (https://fawn.ifas.ufl.edu/tools/et/). Evapotranspiration values were derived from the Penman-Monteith method (e.g., Monteith, 1965) utilizing daily measurements of atmospheric conditions from FAWN's tower locations. Instrumentation employed for measurements of atmospheric conditions by the UGA weather network is summarized in the table below.

Measured Parameter	Sensor Type	Model	Manufacturer
Temperature	Thermistor	107-I	Campbell Scientific
Relative Humidity	Capacitive	CS215	Campbell Scientific
Rainfall	Tipping Bucket	H-340	----
Barometric Pressure	Capacitive	CS105	Campbell Scientific
Solar Radiation	Silicon Photovoltaic	LI200X	Campbell Scientific
Wind Speed/Direction	Ultrasonic	425A	Vaisala

Values of evapotranspiration downloaded from FAWN's tower locations were paired with temperature and precipitation data from a contiguous NOAA land-based weather station. The two FAWN stations located in Live Oak, FL and MacClenny, FL were paired with data from NOAA's Lake City, FL and Glen St. Mary, FL. This distance between each station location is 18 and 3.0 miles, respectively.

Evapotranspiration Data Compilation

The annual ET data obtained from the UGA and UF databases is included in Appendix B. The UGA database contained annual ET data for two of the seven weather stations (Nahunta and Valdosta). The two FAWN stations located in Live Oak, FL and MacClenny, FL were paired with data from NOAA's Lake City, FL and Glen St. Mary, FL. Therefore, ET data collected from the 83 UGA and two UF monitoring stations were used generate yearly (2003-2017) contour maps based on ET data across southeast Georgia and northeast Florida (Appendix C). In turn, these contour maps were used estimate ET values in Table 1 for weather stations where ET data was not available (i.e. Fargo, Folkstone, and Waycross, Georgia).

LOCAL PRECIPITATION DATA

Twin Pines Minerals personnel installed three (3) HOBO rain gauge data loggers at the site in September 2018. The three rain gauge locations (RG01, RG02, and RG03) were installed at the northern, central, and southern portions of the project study area. A map showing the rain gauge locations is provided in Figure 4. The data loggers for each rain gauge recorded the cumulative accumulation of precipitation in units of hundredths of an inch. Rain gauge data was manually downloaded in the field by TPM representatives on a monthly or bi-monthly basis. The raw precipitation data was compiled into spreadsheets and the total daily precipitation accumulation (in inches) was computed for each rain gauge. Each rain gauge was reset after a download event. Daily precipitation data for the project study area was collected and analyzed from September 21, 2018 to October 16, 2019 (latest download). A summary of the daily precipitation data recorded at the rain gauges is provided in Table 2.

METHODOLOGY

Following the compilation of annual temperature, precipitation, and evapotranspiration data, contour maps were generated to present the climate data spatially across southeast Georgia and northeast Florida.

Each contour map for temperature and precipitation data was generated using the mean of the average annual values from climate data between 1986 and 2017. Contour maps for evapotranspiration were generated using the mean of the total annual ET values between 2003 and 2017. Contours were generated using Golden Software Surfer version 16.

Temperature

A mean temperature value was calculated for each of the seven NOAA land-based weather stations using the average annual temperature data listed in Table 1. These mean temperature values were then used to generate an average annual temperature contour map based on data collected between 1986 and 2017 (Figure 5). Review of Figure 5 indicates that the estimated average temperature value at the project study area over the 32-year period is 68.60 degrees Fahrenheit.

Precipitation

A mean precipitation value was calculated for each of the seven NOAA land-based weather stations using the total annual precipitation data listed in Table 1. These total annual precipitation values were then used generate an average annual precipitation contour map based on data collected between 1986 and 2017 (Figure 6). Review of Figure 6 indicates that the estimated average precipitation value at the project study area over the last 32-year period is 51.25 inches per year.

In addition to the regional historical precipitation data, local precipitation was monitored with on-site rain gauges. Rain gauges (RG01) and (RG02) contain missing data at select intervals due to either instrument damage or data loss. Precipitation data from RG03 was the only rain gauge to operate without interruption for a one-year period. The total annual precipitation recorded at RG03 between September 21, 2018 and September 21, 2019 was 43.04 inches per year, which is about 8.21 inches lower than the above-referenced historical precipitation value. A summary of monthly data for RG03 is provided below.

Rain Gauge RG03	
Month	Total Monthly Precipitation (inches)
Sep-18	1.92
Oct-18	0.93
Nov-18	1.49
Dec-18	7.80
Jan-19	4.72
Feb-19	1.53
Mar-19	0.28
April-19	2.31
May-19	1.91
Jun-19	3.55
Jul-19	11.66
Aug-19	4.27
Sept-19	0.67
Total Precipitation (inches)	43.04

Evapotranspiration

An average total annual ET value was calculated from data collected between 2003 and 2017 at each of the UGA and UF ET data stations. The average total annual ET data was then used generate a contour map for estimating ET at the project site (Figure 7). Review of Figure 7 indicates that the estimated average total annual ET value at the project study area over the last 15-year period is 39.50 inches per year.

Histograms were generated from data listed in Table 1. The histograms graphically compare total annual precipitation, total annual ET, and average annual temperature data at each of the seven weather station locations. Years where evapotranspiration values exceed those of precipitation are considered to have undergone drought conditions. The histogram plots are provided in Appendix D.

SUMMARY OF RESULTS

Table 3 provides project study area estimated values for average annual temperature, mean total precipitation, and mean total evapotranspiration compared to published climate data (Figures 8-10). The project study area estimated climate data values generally correlated with published climate data generated by USGS personnel.

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