Water Balance Analyses
Proposed Wingate Mine
Manatee County, Florida

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Mine Water Balance

Introduction

The mine recirculation system must contain a large enough volume of water to provide clarification of the recirculating water prior to its reuse in the beneficiation process or its discharge from the system. The volume of water stored in the mine recirculation system varies from day to day depending primarily on rainfall. The change in storage, ΔS, in the mine recirculation system can be calculated using the following equation:

$$\Delta S = R + M + O_d + S_i + C_r - C_e - T_e - P_e - E - ET - O_r - S_o$$

where:

R	=	Rainfall captured by the mine recirculation system,
M	=	Water contained in the matrix,
O_d	=	Water draining from the overburden into the mine cut,
S_i	=	Seepage into the mine recirculation system,
C_r	=	Water released from the clay tailings during consolidation,
C_e	=	Water entrained in the clay tailings after sedimentation,
T_e	=	Water entrained in the sand tailings after deposition in the reclamation areas,
P_e	=	Water leaving the mine with the product,
E	=	Evaporation from open water within the recirculation system,
ET	=	Evaporation from soil surfaces and transpiration from vegetated surfaces within the mine recirculation system,
O_r	=	Water needed to refill the overburden during reclamation, and
S_o	=	Seepage out of the mine recirculation system.

The minimum volume required in the mine recirculation is the volume required for clarification in the active clay settling area. For a detention time of 15 days and a recirculation rate of 150,000 gpm, the minimum storage volume for the recirculation system at a phosphate mine is approximately 10,000 acre-ft.

When the storage within the system drops below the minimum required, makeup water must be added to the system. Conversely, when storage within the system reaches the maximum available, water must be released from the system through the NPDES outfall.

Discussion of Water Budget Components

Rainfall

The most variable component of the mine water budget is rainfall. The average annual rainfall for the rainfall for the NOAA gage at Wauchula for the 25-year period beginning in 1978 is 53.2 inches. The minimum annual rainfall in the record is 32.2 inches. The maximum annual rainfall in the record is 74.1 inches.

Matrix Water

The amount of water supplied by the matrix depends on the *in situ* moisture content of the matrix and the volume of matrix that is mined each year to produce 1.3 million tons of rock. The actual volume of matrix mined varies from year to year depending on production requirements and the quality of the matrix. The average volume of matrix mined each year at the DeSoto Mine is expected to be somewhat more than 10,350,000 cubic yards per year. Matrix moisture of 22.2 percent was calculated from the matrix mass balance.

Overburden Drainage

The amount of water supplied by overburden drainage depends on the specific yield (drainable porosity) of the overburden and the volume of overburden that is removed each year to expose the volume of matrix needed to produce 1.3 million tons of phosphate rock. As with the matrix, this volume varies from year to year. The average volume determined from the reserve analysis is 8,450 acre-ft per year. The specific yield is estimated at 10 percent.

Seepage into the Mine Cuts

The amount of water that seeps into the mine cuts from adjacent ground not already included in the mine recirculation system depends on the net rainfall within the contributing area and the size of the contributing area. Net rainfall is the difference between rainfall and evapotranspiration for the contributing area. The contributing area was estimated at 100 acres.

Clay Consolidation

Water released from the sedimented clay was estimated from an analysis of the tons of clay in the matrix mined each year and the average percent clay solids within each settling area during the period when the clay pond is within the recirculation system. The average clay content of the matrix was determined during the reserve analysis. An average clay solids content of 23 percent was used in the water balance model.

Tailings Entrainment and Product Water

Water remaining with the sand tailings after disposal was estimated using an in-place dry density for the tailings of 105 pounds/cubic ft, which is equivalent to a saturated percent solids of 82 percent. Based on an estimated tailings generation rate of 4.95 million tons per year, the amount of water consumed during tailings disposal is estimated at 1,040 acre-ft/year. Product moisture was taken as 10 percent. Based on the proposed production rate of 1.3 million tons per year, the amount of water consumed as a result of product shipment is estimated at 118 acre-ft/year.

Evaporation and Evapotranspiration

Lake evaporation in the project area is approximately 50 in/year. Evapotranspiration from natural vegetated areas is approximately 39 inches per year and from bare ground is approximately 20 inches per year.

Overburden Re-Saturation

The overburden swell factor was estimated at 10 percent. It was assumed that 90 percent of the overburden would be refilled during reclamation and waste clay disposal. The specific yield was assumed to remain at 10 percent.

Seepage Out of the Recirculation System

Seepage out of the recirculation system due to deep recharge was assumed to be 1 inch per year. Seepage out of the recharge system adjacent to preserved areas and down-gradient property boundaries was calculated using an average groundwater outflow from the captured area of 9 in/year.

Water Budget Calculations

The water budget calculations are provided in Table 1 for an average rainfall year and a capture area of 2,980 acres. All of the input and output variables and constants are presented in the table. As shown the amount of water consumed by the mining and reclamation process is approximately 650 gallons per ton. The amount of water required by the mining and beneficiation process is approximately 1,500 gallons per ton. All of the captured surface water and a portion of the water withdrawn from the Floridan aquifer will be discharged through the NPDES outfall.

Table -1 Water Budget Calculations

Annual Rainfall		53.19	in/yr
Natural ET		39.43	in/yr
Lake Evaporation		50	in/yr
Resting Clay ET		40	in/yr
Mine Cuts ET		50	in/yr
Other Disturbed Area ET		35	in/yr**
Natural Deep Recharge		1	in/yr
Mining Rate		168	ac/yr
P2O5 Production		1.3	mty
Product Moisture		11	Percent
Catchment Area		2,979	acres
Clay Disposal		1.29	mty
Average Clay Solids		23	Percent
Sand Disposal		6.42	mty
Sand Solids		82	Percent
Open Mine Areas		168	acres
Active Disposal Areas		1,100	acres
Inactive Disposal Areas		250	acres
Overburden Thickness		50.3	feet
Overburden Swell		10	Percent
Drainable Porosity		10	Percent
Groundwater Outflow		5.36	in/yr
Sand Clay Ratio		0	
Matrix Moisture		22.18	Percent
Matrix Volume	38.2	6,417.6	acre-ft
Matrix Porosity		43.21%	

AVERAGE ANNUAL WATER BUDGET UNDER NATURAL CONDITIONS

SOURCES	ACRE-FT	MGD	USERS	ACRE-FT	MGD
Rainfall	13,204	11.79	ET	9,788	8.74
			Recharge	248	0.22
			Groundwater Outflow	1331	1.19
			Change in Storage	0	0.00
			Surface Runoff	1,837	1.64
TOTAL	13,204	11.79		13,204	11.79

ANNUAL WATER BUDGET WITH MINING

SOURCES	ACRE-FT	MGD	USERS	ACRE-FT	MGD
Rainfall	13,204	11.79	Evaporation	10,378	9.26
Overburden Drainage	423	0.38	Waste Clay	3,180	2.84
Matrix Water	2,773	2.48	Sand Tailings	1,041	0.93
Deep Well Water	6,000	5.36	Change in Storage	0	0.00
Seepage In	100.00	0.09	Overburden Refill	845	0.75
			Discharge to Manson Jenkins	0	0.00
			Product	118	0.11
			Recharge	248	0.22
			GW Outflow	1,331	1.19
			NPDES Discharge	5,359	4.78
TOTAL	22,500	20.09		22,500	20.09

Consumption	MGD	Gal/ton	Source	MGD	Gal/ton
Change in ET	0.53	148	Captured GW	0.09	25
Clay	0.36	102	Floridan	5.36	1504
Tails	0.93	261	Seal Water	0.00	0
Obrdn	0.38	106	Captured SW	-3.14	-883
Product	0.11	30			
Other Losses	0.00	0			
Mining Total	2.30	646		2.30	646