SUMMARY OF DATA PRESENTED IN THE BACKGROUND DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS - MINERAL MINING AND PROCESSING POINT SOURCE CATEGORY

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Mining Waste Section
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DISCLAIMER

SUMMARY OF DATA PRESENTED IN THE DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS - MINERAL MINING AND PROCESSING POINT SOURCE CATEGORY

In the late 1970s, the U.S. Environmental Protection Agency (EPA) conducted a study of the mineral mining and processing industry. The study encompassed the following non-metallic "minerals":

- Dimension Stone
- Construction Sand & Gravel
- Gypsum
- Asbestos and Wollastonite
- Mica and Sericite
- Flourspar
- Borax
- Trona Ore
- Rock Salt
- Sulfur
- Lithium Minerals
- Fire Clay
- Kaolin and Ball Clay
- Kyanite
- Shale and other Clay Minerals
- Garnet
- Graphite
- Crushed Stone
- Industrial Sand
- Asphaltic Materials
- Lightweight Aggregates
- Barite
- Salines from Brine Lakes
- Potash
- Sodium Sulfate
- Phosphate Rock
- Mineral Pigments
- Bentonite
- Fullers Earth
- Feldspar
- Magnesite
- Talc, Soapstone and Pyrophyllite
- Diatomite Mining
- Miscellaneous Minerals

The results of the study are presented in the "Development Document for Effluent Limitations Guidelines and Standards - Mineral Mining and Processing Industry Point Source Category," (EPA 440/1-79/0596, July 1979). The data are grouped by mineral and subgrouped primarily by processing technology. However, some mineral categories are subgrouped by types of materials (e.g. asbestos and lightweight aggregates) and phosphate is subgrouped by Region (Eastern and Western).

The EPA's Office of Solid Waste has recompiled the data contained in the effluent guideline for possible use in its effort to develop a rational mining program. Data contained in this report is taken from the effluent guideline document and does not represent new research. Further, it should be noted that the data represented has not been reviewed for quality control/quality assurance. The source documents detailing sampling methodolgies and protocols were not consulted for this review.

The attached Table 1 summarizes the information published in the Development Document. For each mineral and sector, Table 1 provides:

- Category, SIC Code, and Subcategories
- Number of known active plants in 1979
- Number of facilities with data available (including facilities sampled during this study and facilities where existing data were used)
- Number of facilities sampled under this study
- Parameters or pollutants analyzed for in wastewaters
- Comments on treatment method(s) employed[1]
- Development Document page numbers for accessing more detailed data

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[1] The most common form of wastewater treatment used in this category is settling ponds. Individual ponds, or several ponds used in series, provide a cost effective method of reducing TSS in receiving streams. This treatment also allows a number of facilities to retain process wastewater for subsequent reuse in ore beneficiation/processing. Other common treatments which may be used singly or in combination include: flocculation, lime treatment, spiral screening and dewatering screws to remove solids and/or adjust pH.

Generally, the parameter most important in the mineral industry is suspended or dissolved solids. Other parameters measured in wastewaters include:

- pH
- hardness
- Biochemical Oxygen Demand (BOD)
- oil and grease
- fluoride
- chloride
- sulfate
- cadmium
- barium
- lead
- aluminum
- asbestos
- turbidity
- alkalinity/acidity
- Chemical Oxygen Demand (COD)
- phenols
- nitrate
- sodium
- sulfide
- chromium
- iron
- manganese
- zinc
- radium

Sampling methodologies and protocols for the data contained in Table 1 were not documented in the Development Document. Because proposed effluent guidelines have frequently been subject to litigation, data must be completely defensible. Therefore, it is assumed that the sampling and analysis data described here were collected according to standard Agency protocols, (including QA).

In addition, several aspects of the sampling data presentation should also be noted:

- In some cases, information on the number of facilities sampled and the use of existing data is not provided (i.e., crushed stone mine dewatering - where TSS data is presented, while numbers of facilities with data available and facilities sampled are not);

- In some cases, the availability of sampling data was indicated, however, no data were included in the Development Document (i.e., for crushed stone shell dredging, four facilities are listed as having data available, however no results are presented);

- Where the number of facilities sampled is zero, it is assumed that only existing data were used; and

- Where no discharge occurs and data is presented, it is assumed that sampling was performed internally.

Table 2 provides a list of the applicable standards for many of the contaminants detected in ore processing wastewater. This Table was included to assist the reader in assessing the levels of specific pollutants detected in the wastewaters.

TA
MINERAL MINING AND PROCESSING
FACILITIES AND EFFLUENT PARAMETERS MEASURED

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Dimension Stone (1441)	194	20	5	TSS (1.0 - 1658 mg/l) pH (7.8 s.u.) BOD (<1 mg/l)	Level of treatment contingent upon State requirements	254
Crushed Stone (1422, 1423, 1424)	4,800	N/A	N/A			
Dry Process	N/A	2	No discharge	No data presented		
Wet Process	N/A	130	9	TSS (2.0 - 42 mg/l) pH (7.5 - 8.4 s.u.) Turbidity (16 - 18 NTU)	Dewatering screws and flocculating agents employed to recover salvageable material from waste stream	256, 259
Flotation	N/A	3	1	TSS (4.0 - 10 mg/l) BOD (<1.0 - 1.0 mg/l) COD (<1.0 - 4.0 mg/l) Sulfate (<2.0 - 19 mg/l) Turbidity (2 - 6 NTU) Chloride (4.1 - 20 mg/l) Total Solids (128 - 154 mg/l)	Wastewater is settled and recycled or lagooned before discharge	260
Shell Dredging	N/A	4	0	No data presented		
Mine Dewatering	N/A	N/A	N/A	TSS (<1 mg/l - 67 mg/l)		258

TABLE 1
MINERAL MINING AND PROCESSING
FACILITIES AND EFFLUENT PARAMETERS MEASURED
(continued)

Category (SIC)/ Process Subcategory	Number of Facilities: No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled	Data Summary	Comments on Treatment	Reference Page
Construction Sand and Gravel (1442)	N/A	N/A	N/A			
Dry Process	750	50	No discharge	No data presented		
Wet Process	4,250	100	15	TSS (2.0 - 154 mg/l)	Predominant treatment method uses settling ponds and mechanical dewatering devices	261-3
Dredging (on-land)	50	15	0	TSS (50 - 300 mg/l)		264
Dredging (on-board)	100	25	0	No data presented		
Industrial Sand (1446)	N/A	N/A	N/A			
Dry Process	20	5	No discharge	No data presented		265
Wet Process	130	10	2	No data presented		
Flotation	17	10	2	pH (5.0 - 7.8 s.u.) TDS (192 mg/l) TSS (4 - 47 mg/l) Sulfate (38 - 330 mg/l) Oil and grease (<1.0 mg/l) Fe (0.06 mg/l) Nitrate (0 - 9 mg/l) Chloride (57 - 76 mg/l) Fluoride (1.8 - 6.6 mg/l) Phenols (Not detected)	No point discharge from any of the acid flotation operations.	266

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MINERAL MINING AND PROCESSING
FACILITIES AND EFFLUENT PARAMETERS MEASURED
(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Industrial Sand (Cont'd)						
Acid Leaching	3	3	0	pH (6.4 - 7.2 s.u.) TSS (2.02 lb/ton) Fe (0.13 lb/ton)	Settling, pH adjustment and chemical flocculating agents added to wastewater prior to discharge from acid leach operations	266
Flotation (HF)	1	1	No discharge	No data presented		
Gypsum (1492)	N/A	N/A	N/A			
Dry, Wet Scrubbing and HMS	80	64	3	TSS (4 - 130 mg/l) pH (5 - 8.1 s.u.)	Mine pumpout and non-contact cooling water discharged without treatment	267
Asphaltic Materials	N/A	N/A	N/A			
Diatomite (Oil Impregnated) (1499)	1	1	0	(All water recycled)		
Gilsonite (1499)	1	1	1	Processing discontinued		
Asbestos (1499)	N/A	N/A	N/A			
Dry Process	4	4	1	TSS (2.0 mg/l) Fe (0.15 mg/l) pH (8.4 - 8.7 s.u.) Asbestos (1.0 - 1.8 x 10^6 fibers/liter)	Quarry pumpout treated with sulfuric acid at one facility. Diversion ditches, berms and check dams used to direct and hold stormwater runoff.	268

TABLE 1
MINERAL MINING AND PROCESSING
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(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Asbestos (Cont'd)						
Wet Process	1	1	No discharge Percolation Pond tested	TSS (1,160 mg/l) pH (7.8 s.u.) Mg (48 mg/l) Na (345 mg/l) Chloride (104 mg/l) Ni (0.1 mg/l)	All facilities settle wastewater, no discharge to surface water reported	269
Wollastonite	1	1	No discharge	No data presented		
						270
Lightweight Aggregates (1499)	N/A	N/A	N/A			
Perlite	13	4	No discharge	No data presented		
Pumice	7	7	No discharge	No data presented		
Vermiculite	2	2	No discharge	No data presented		
Mica and Sericite (1499)	N/A	N/A	N/A			
Dry Process	7	7	No discharge	No data presented		270
Wet Process	3	3	No discharge	No data presented		
Wet Beneficiation	7	7	No discharge	pH (6.5 - 9 s.u.) TSS (<15 - 400 mg/l)		272
Barite (1472)	N/A	N/A	N/A			
Dry Process	9	8	No discharge	No data presented		

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MINERAL MINING AND PROCESSING
FACILITIES AND EFFLUENT PARAMETERS MEASURED
(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Barite (Cont'd)						
Wet Process	14	14	No discharge	pH (8.0 s.u.) TSS (32 mg/l) Ba (0.5 mg/l) Fe (0.09 mg/l) Pb (0.10 mg/l)		273
Flotation	4	4	1	TSS (3 - 6 mg/l) TDS (1000 - 1815 mg/l) Ammonia (5 - 35 mg/l) Cn (0.100 - 0.120 mg/l) Fe (0.030 - 0.070 mg/l) Pb (0.040 - 0.090 mg/l) Mn (0.004 - 0.008 mg/l) Ni (0.030 - 0.070 mg/l) Zn (0.030 - 0.090 mg/l)	Water is settled in a series of ponds with most being recycled. Lime is used for pH adjustment. Lime and ferric chloride are used for settling prior to discharge at one facility.	274
Mine Dewatering	N/A	N/A	N/A	pH, Acidity, Hardness, TDS, TSS, SO_4, Fe, Al, Pb, Mn, Ni, Zn (No levels reported)	Lime neutralization for pH adjustment, gravity settling prior to discharge	276
Flourspar (1473 & 3295)	N/A	N/A	N/A			
HMS	6	6	No discharge	Fluoride (3.0 mg/l) TSS (10.0 mg/l) Pb (0.015 mg/l) pH (7.8 s.u.) Zn (0.09 mg/l)		276

TABLE 1
MINERAL MINING AND PROCESSING
FACILITIES AND EFFLUENT PARAMETERS MEASURED
(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Flourspar (Cont'd)						
Flotation	6	5	2	pH (7.2 - 8.2 s.u.) TSS (318 - 1800 mg/l) fluoride (5.1 - 9.8 mg/l) alkalinity (340 - 359 mg/l) hardness (222 - 235 mg/l) TDS (1056 - 1702 mg/l) F (0.742 - 10 mg/l) Fe (2.9 - 5.0 mg/l) Cd (0.02 - 0.13 mg/l) Cr (0.05 - 0.11 mg/l) Cu (0.35 - 2.39 mg/l) Pb (0.20 - 0.86 mg/l) Mn (0.17 - 0.43 mg/l) Zn (<0.01 - 1.13 mg/l)	Settling, clarification ponds and flocculants used prior to discharge. Recycling efforts attempted at one facility but abandoned due to chemical buildup in various flotation circuits.	277
Drying and Pelletizing	2	2	No discharge	No data presented		

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(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Flourspar (Cont'd)						
Mine Dewatering	N/A	N/A	N/A	pH (7.2 - 8.1 s.u.) alkalinity (197 - 864 mg/l) hardness (221 - 1600 mg/l) Cl (17 - 185 mg/l) TSS (2 - 135 mg/l) TDS (364 - 3417 mg/l) SO_4 (32 - 575 mg/l) F (1.3 - 3.2 mg/l) Fe (0.05 - 1.33 mg/l) Pb (<0.02 - 0.09 mg/l) Mn (0.01 - 0.62 mg/l) Zn (<0.01 - 0.76 mg/l)	At 3 mines, effluent is discharged with no treatment. At one facility water passes through a small settling pond prior to discharge.	279
Salines (Brine Lakes) (1474)	3	3	No discharge	No data presented		280
Borax (1474)	1	1	No discharge	No data presented		280
Potash (1474)	5	5	No discharge	No data presented		280
Trona Ore (1474)	4	4	Usually no discharge	TSS (9,000 mg/l)		281
Sodium Sulfate (1474)	6	2	No discharge	No data presented		281
Rock Salt (1476)	21	15	3	TSS (72 - 4750 mg/l) TDS (4,660 - 323,000 mg/l) pH (7.5 - 9.0 s.u.)	Generally, no treatment of miscellaneous saline wastewater is performed	281

TABLE 1
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(continued)

Category (SIC)/ Process Subcategory	Number of Facilities: No. of Facilities (1979)	Number of Facilities: Facilities With Data Available	Number of Facilities: No. of Facilities Sampled	Data Summary	Comments on Treatment	Reference Page
Phosphate Rock (1475)	N/A	N/A	N/A			
Eastern	22	20	3	TSS (7 - 1961 mg/l) pH (6.2 - 9.1 s.u.)	Most wastewater recycled, and solids used in reclamation efforts	283
Western	6	6	2	Radium 226 (0.26 - 1.1 pCi/liter)	Solids retained in settling ponds - no treatment for radium is noted	285
Sulfur (1477)	N/A	N/A	N/A			
Anhydrite	2	2	No discharge	No data presented		286
On-shore	9	9	5	TSS (5 - 95 mg/l) sulfide (0.4 - 51 mg/l)		290
Off-shore	2	1	No discharge	No data presented		292
Mineral Pigments (1479)	11	3	No discharge	No data presented		294
Lithium Minerals (1479)	2	2	2	pH (6.1 - 7.9 s.u.) TSS (3 - 256 mg/l)		294
Bentonite (1452)	37	2	No discharge	No data presented		295
Fire Clay (1453)	81	9	No discharge	No data presented		295
Mine Pumpout	N/A	N/A	N/A	pH (3.0 - 9.2 s.u.) TSS (1 - 392 mg/l) Fe (20 - 1900 mg/l)	Discharged after settling with little or no other treatment	

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(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Fullers Earth	N/A	N/A	N/A			
Attapulgite (1454)	10	5	2	pH (6.8 - 7.5 s.u.) TSS (17 - 19 mg/l)	Most facilities use settling ponds, one discharges with no treatment	296
Montmorillonite (1454)	4	3	3	pH (3.8 - 9 s.u.) TSS (2.0 - 436 mg/l)	Water neutralized where recycling; some settling employed where discharged	297
Kaolin and Ball Clay (1455)	37	N/A	N/A			
Dry Process	N/A	4	No discharge	No data presented		
Wet Process	N/A	6	0	Turbidity (24.5 - 58.2 NTU long term average) TSS (35 - 50 mg/l)	Lime used to adjust pH and remove excess zinc	298
Mine Dewatering	N/A	N/A	N/A	TSS (7.4 - 95.2 mg/l) Turbidity (44.6 - 232 NTU)	Pumpout is usually discharged without treatment	299
Feldspar (1459)	N/A	N/A	N/A			
Wet (Flotation)	5	5	5	TSS (21 - 349 mg/l) Fluoride (1.3 - 34 mg/l) pH (6.5 -8.0 s.u.)	Clarification and use of polymers employed to aid flocculation: lime and alum are used at 2 facilities	301
Dry Process	2	2	No discharge	No data presented		302
Kyanite (1459)	3	2	No discharge	No data presented		303
Magnesite (1459)	1	1	No discharge	No data presented		303

TABLE 1
MINERAL MINING AND PROCESSING
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(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Shale & Common Clay (1459)	129	20	No discharge	No data presented		303
Talc Minerals (1496)	N/A	N/A	N/A			
Dry Process	27	20	No discharge	No data presented		304
Washing	2	2	No discharge	No data presented		305
HMS[2], Flotation	4	4	4	TSS (8 - 100 mg/l) pH (5.6 - 8.5 s.u.)	Settling, effluent stream mixing and lime additions used prior to discharge	306
Garnet (1499)	3	2	0	pH (7.0 s.u.) TSS (25 mg/l)	Caustic added to adjust pH at one facility	307
Diatomite (1499)	9	3	No discharge	No data presented		307
Graphite (1499)	1	1	0	Total solids (750 mg/l) TSS (10 mg/l) Volatile solids (1 mg/l) Mn (0.1 mg/l) Fe (0.1 mg/l) BOD (9 mg/l) COD (20 mg/l) pH (7.3 - 8.5 s.u.)	Overflow from ponds is discharged. Lime is used to neutralize acidity and precipitate Fe.	308

[2] HMS = Heavy Media Separation

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(continued)

Category (SIC)/ Process Subcategory	Number of Facilities			Data Summary	Comments on Treatment	Reference Page
	No. of Facilities (1979)	Facilities With Data Available	No. of Facilities Sampled			
Miscellaneous Materials	N/A	N/A	N/A			
Jade (1499)	10	1	No discharge	No data presented		308
Novaculite (1499)	1	1	No discharge	No data presented		308

Source: "Development Document for Effluent Limitations Guidelines and Standards - Mineral Mining and Processing Industry - Point Source Category," EPA 440/1 76/0596, July 1979.

TABLE 2

APPLICABLE STANDARDS FOR CONTAMINANTS DETECTED IN ORE PROCESSING EFFLUENT

Constituent of Concern	Maximum Allowable Level (in mg/l except where noted)	Regulation
pH	6.5 - 8.5 s.u.	NSDWR
Flouride	4	NPDWR
Chloride	250	NSDWR
Sulfate	250	NSDWR
Cadmium	0.010	NPDWR
Barium	1.0	NPDWR
Lead	0.05	NPDWR
Aluminum (pH 6.5 - 9.0 s.u.)	0.05	NSDWR
Asbestos	7 MFL[2]	NPDWR
Turbidity	1 NTU	NPDWR
Nitrate	10	NPDWR
Sulfide	2 ug/l (criterion continuous concentration)	NSDWR
Chromium	0.05	NPDWR
Iron	0.3	NSDWR
Manganese	0.05	NSDWR
Zinc	5	NSDWR
Radium	5 pCi/l	NPDWR

NPDWR = National Primary Drinking Water Regulations
NSDWR = National Secondary Drinking Water Regulations
MFL = Million Fibers per Liter
NTU = National Turbidity Units

(1) $SO_4^{=} + Ca(OH)_2 = CaSO_4 + 2OH^-$

(2) $2F^- + Ca(OH)_2 = CaF_2 + 2OH^-$

(3) $Zn^{++} + Na_2CO_3 = ZnCO_3 + 2Na^+$

EXAMPLES OF WASTE WATER TREATMENT

The following text discusses how these technologies are employed by the subcategories covered in this document and the effluent quality.

DIMENSION STONE

The single important water effluent parameter for this industry is suspended solids. In dimension stone processing facilities, water is only occasionally recycled. The following summarizes waste treatment practices.

Stone	Facility	Waste Water Treatment
Mica Schist	5600	settling
Slate	3017	100% recycle
	3018	none
	3053	settling
Dolomitic	3039	settling
Limestone	3040	settling
Limestone	3007	settling
	3008	settling, 100% recycle
	3009	settling
	3010	settling, 100% recycle
Granite	3001	settling
	3029	settling
	3038	flocculants, settling, 100% recycle
	3002	settling
	3003	settling
Marble	3034	settling
	3051	none
	3304	settling
	3305	settling
	3306	settling, polymer, alum

At facility 3038 chemical treatment, solids separation via a raked tank with filtration of tank underflow, plus total recycle of tank overflow is practiced. This is necessary since the facility hydraulic load would otherwise overwhelm the small adjacent river. Furthermore, the facility has a propfietary process for separating silicon carbide particles from other solids for eventual reuse. Since granite facilities are the only users of silicon carbide, non-granite processors could not obtain any cost benefits from this SiC recovery practice.

Disposition of quarry and facility waste stone is more a function of state requirements than of any other factor. Thus, waste stone and settling pond solids are conscientiously used to refill and reclaim quarries where the state has strict reclamation laws. Corporate policy regarding disposition of solid wastes is the second most important factor, and type and yield of stone is the least important factor. Thus, where both state and corporate policy are lenient, solid wastes are accumulated in large piles near the quarry (facilities 3017, 3053, and to some extent 3051).

In addition to refilling abandoned quarries, some facilities make real efforts to convert waste stone to usable rubble stone (facilities 3034, 3040), crushed stone (facilities 3051, 3038, 3018), or rip rap (facilities 3051, 3039). Successful efforts to convert low grade stone to low priced products are seen only in the marble, granite, and dolomitic limestone industries.

Pit pumpout does occur as a seasonal factor at some locations, but suspended solids have generally been found to be less than 25 mg/l. The quality of mine water can be attributed more to stone type than to any other factor. For example, granite quarry pumpout at facility 3001 is 25 mg/l TSS. However, limestone, marble, and dolomitic limestone quarry water is generally very clear and much lower in suspended solids.

Several analyses of treated effluents available are as follows:

Facility 3007	7.8 pH
	7.1 mg/l TSS (range 0-24.5)
Facility 3304	<10 JTU
Facility 3305	<100 mg/l total solids
	<5 mg/l TSS
	<1 BOD
Facility 3306	<1 JTU
Facility 3002	600 mg/l TSS
Facility 3003	34 mg/l TSS
Facility 3001	Water including runoff from 2 quarries
	1 mg/l TSS
	4 mg/l TSS
	Finishing Facility-37 mg/l TSS
Facility 5600	Quarry - 7 mg/l TSS

Facility 3051 Quarry - 7 mg/l TSS
Facility-1658 mg/l TSS
Second Facility-4008 mg/l TSS

CRUSHED STONE (WET PROCESSING)

In all of the facilities contacted, the effluent from the washing operation is sent through a settling pond system prior to discharge. This system generally consists of at least two settling ponds in series designed to reduce the suspended solids in the final discharge. At facility 1439 the suspended solids concentration entering the first settling pond is 7000-9000 mg/l which is reduced to a level of 15-20 mg/l after flowing through the two ponds. Facility 3027 reports its settling pond system reduces the total suspended solid level in the facility washwater by 95 percent.

In some instances (facility 1222), flocculating agents are added to the waste stream from the wash facility prior to entering the first settling pond to expedite the settling of the fine particles. Mechanical equipment may be used in conjunction with a settling pond system in an effort to reduce the amount of solids entering the first pond. At facility 1040, the waste water from the washing operation flows through a dewatering screw which reportedly removes 50 percent of the solid material which represents a salvageable product. The waste water flows from the screw into the first settling pond.

Facility 1039 has an even more effective method for treating waste water from the washing operation. As with facility 1040, the waste water flows into a dewatering screw. Just prior to this step, however, facility 1039 injects a flocculating agent into the waste water which leads to a higher salvage rate.

Of the facilities contacted that wash crushed stone, 33 percent do not discharge their wash water. Many of the remaining facilities recycle a portion of their waste water after treatment. It should be noted that evaporation and percolation have a tendency to reduce the flow rate of the final discharge in many instances. The main concern with the final effluent of a wet crushed stone operation is the level of suspended solids. This may vary depending on the deposit, the degree of crushing, and the treatment methods employed.

The waste water from the wet scrubber in facility 1217 is sent to the first of two settling ponds in series. After flowing through both ponds, the water is recycled back to the scrubber with no discharge. Effluent data from some of the facilities that do discharge wash water after treatment by settling ponds are:

facility	effluent	source
1004	Flow - 8.7 x 10^6 l/day (2.30 mgd) pH - 7.5 Turbidity - 16 FTU	treated discharge composed of wash water (4%) and pit pumpout (96%)
1053	Flow - 1.8 x 10^6 l/day (0.48 mgd) pH - 8.4 Turbidity - 18 FTU	wash water after treatment
1218	Flow - 6.2 x 10^6 l/day (1.64 mgd) TSS - 20 mg/l	wash water after treatment then combined with pit pumpout

Of the facilities contacted the following are practicing total or partial recycle of process generated waste water:

1001	1062	1220	3027
1002	1063	1222	5662
1003	1064	1227	5612
1022	1161	1228	5663
1039	1212	1253	5664
1040	1217	1439	

The types of treatment used and the TSS values for raw and treated waste are shown below for a number of facilities.

Facility	Treatment System	TSS Raw Waste	TSS Treated Effluent
1001*	Settling pond	1,054[2]	8[2]
1003	Settling pond (with total recycle)	7,687[2]	7[2]
1004	Settling pond	5,710[2]	12[2]
1021	Settling ponds	7,064, 142[2] 772[2]	28[2] 3[2]
1023*	Settling pond (with partial recycle)	----	34[1]
1039*	Flocculation, dewatering screw and		

	settling pond (with total recycle)	10,013[2]	7[2]
1053	Settling pond	21,760[2]	56[2]
1218	Settling pond (with total recycle)	----	20[1]
1219*	Settling pond (with partial recycle)	----	2[1]
1439	Settling ponds (with total recycle)	7,000-8,000[1]	15-20[1]
5662*	Settling pond (with partial recycle)	----	9[1]
5664*	Settling pond (with partial recycle)	----	40, 42[1]

[1] Company supplied data
[2] Contractor verification data
* These facilities use a common pond for treating process waste water and mine water.

Many treatment ponds experience ground seepage. Facility 1974 is an example of a facility achieving no discharge because of seepage.

Many of the operators in this subcategory must periodically clean their settling ponds of the fines which have settled out from wash water. A clamshell bucket is often used to accomplish this task. The fines recovered are sometimes in the form of a saleable product (facility 1215) while in most instances these fines are a waste material. In this instance, the material is either stockpiled or used as landfill (facilities 1053 and 1212). The quantity of waste materials entering the pond varies for each operator and the processes involved. Facility 1002 reports that the washwater entering the settling ponds contains 4-5 percent waste fines. The frequency of pond cleaning depends not only on the processes involved but also on the size of the pond. Facility 1217 must clean its settling ponds once per month,- the recovered material serving as landfill. The disposal of these fines presents problems for many operators.

CRUSHED STONE (MINE DEWATERING)

Pit pumpout may either be discharged directly with no treatment (facility 1039), discharged following treatment (facilities 1020 and 5640), or discharged with the treated effluent from the washing operation (facility 1001). In the latter case, the quarry water may be combined with the untreated facility effluent and then flow through a settling pond system prior to discharge (facility 5662). The quarry water may instead join the semi-treated effluent as flow to the second of two settling ponds (facility 1213). There are many variations to the handling of pit pumpout.

Mine dewatering data from several facilities of this subcategory are:

facility	TSS mg/l
1001	3
1003	7
1004	12
1020	(1) 5, (2) 1
1021	1, 1, 6, 1, 12, 2
1022	15
1023	34
1039	7
1040	25
1214	<1, 2, 3
1215	(1) 42, (2) 28
1219	2
1224	10-30
3319	1, 1, 1, 1, 2, 4, 5, 5, 5, 9, 11, 15, 17, 21, 35, 38, 38, 55, 64
3320	5, 9, 9, 10, 11, 14, 15, 19, 27, 28, 32, 35, 65, 103, 128
3321	1, 2, 2, 2, 3, 3, 4, 4, 5, 6, 7, 9, 14, 15, 17, 20, 21, 22, 22, 26, 45, 51, 67
5660	14
5661	0
5663	1
5664	42.4

(1) first pit
(2) second pit

CRUSHED STONE MONITORING DATA

NPDES Discharge Monitoring Reports (DMRS) were obtained for more than 65 plants in the crushed stone subcategory. Treatment technologies used at these facilities is unknown. The total number of DMRS was 755, however, only 631 reports had comparable sampling frequencies: one sample in thirty days. The average TSS values for these 631 facilities (some plants have more than one discharge) are given below:

# of DMRS	sample type	avg. mean/avg. max. TSS mg/l
575	quarry dewatering	13.1/24.5
115	commingled	28.0/45.3
9	process water	8.8/29.0

CRUSHED STONE (FLOTATION)

At facility 1975, all waste water is combined and fed to a series of settling lagoons to remove suspended materials. The water is then recycled back to other washing operations with the exception of about 5 percent which is lost by percolation and evaporation from the ponds. This loss is made up by the addition of fresh water.

At facility 3069 a considerable portion of the waste water is also recycled. The individual waste streams are sent to settling tanks for removal of suspended solids. From these, about 70 percent of the process water and all of the cooling and boiler water is recycled. The remainder is released to settling ponds for further removal of suspended solids prior to discharge.

At facility 1021, lagooning is also used for removal of suspended solids. No recycle is practiced.

For facilities 3069 and 1021 the effluents are listed as follows along with corresponding intake water compositions. In the case of facility 1021 the data presented are analytical measurements made by the contractor.

	intake water (3069)	effluent (3069)	intake water (1021)	effluent (1021)
TSS (mg/l)	5	10	3	4
BOD (mg/l)	1.0	<1.0	---	---
COD (mg/l)	1.0	<1.0	0	4
sulfate (mg/l)	3.5	<2.0	13	19
turbidity (FTU)	10	6	4	2
chloride (mg/l)	3.8	4.1	50	20
total solids (mg/l)	32	128	464	154

At Facility 1044, only non-contact cooling water is discharged. The pH of facility 1007 effluent ranges from 6.0-8.0, and the significant parameters are:

Flow, l/kkg of product (gal/ton)	625	(150)
TSS, mg/l	55	
TSS, kg/kkg of product (1 lb/1000 lb)	0.034	

SAND AND GRAVEL

The predominant method of treating process waste water is to remove sand fines and clay impurities by mechanical dewatering devices and settling basins or ponds. Removal of -200 mesh sand and clay fines is much more difficult and requires settling times that are usually not achievable with mechanical equipment. Some facilities use settling aids to hasten the settling process. The best facilities in this subcategory are able to recycle the clarified water back to the process. Water with a total suspended solids content less than 200 mg/l is generally clean enough to reuse in the process. The following tabulates data from facilities which recirculate their process water resulting in no discharge of process waste water:

Facility	Input TSS (mg/l)	Treatment	Output TSS (mg/l)
1055	unknown	spiral classifiers, 4-hectare (10-acre) settling basin	25
1235	unknown	mechanical thickeners, settling ponds	54
1391	4,550	mechanical thickeners, cyclones, 2-hectare (5-acre) settling basin	32
1555	15,000	cyclones, 14-hectare (35-acre) settling basin	35
3049	5,000	cyclones, vacuum disc filter, 2-hectare (5-acre) settling pond with polymer floc	30
5617	unknown	dewatering screws, settling ponds	unknown
5631	unknown	dewatering screws, 10-hectare (25-acre) settling pond	unknown
5674	unknown	dewatering screws, 0.8-hectare (2-acre) settling pond	unknown

Facilities 1012 and 5666 are hydraulic dredging facilities. Slurry from these facilities is sent to a settling basin to remove waste fines and clays. The decant from the settling basin is returned to the wet pit to maintain a constant water level for the dredge resulting in no discharge of process water to navigable waters. Facilities 3339 and 3340 likewise achieve no discharge.

Lack of land to a major extent will impact the degree to which a facility is able to treat its process waste water. Many operations are able to use worked-out sand and gravel pits as settling basins. Some have available land for impoundment construction. The following lists the suspended solids concentration of treated waste water effluents from facilities discharging:

Facility	Treatment	TSS, mg/l
1006	dewatering screw, settling ponds	55
1044	dewatering screw, settling pond	154
1056	settling ponds	25
1083	dewatering screw, settling ponds	47
1129	dewatering screw, settling ponds	44
5630	dewatering screw, settling ponds	2, 3, 4

Facility 1981, using heavy-media separation, recovers the magnetite and/or ferrosilicon pulp, magnetically separates the media from the tailings, and returns the media to the process. Separation tailings from the magnetic separator are discharged to settling basins and mixed with process water.

Pit pumpout and non-contact cooling water are usually discharged without treatment. Facilities 1006 and 5630 discharge pit pumpout water through the same settling ponds which handle process water. Facility 1044 discharges non-contact cooling water through the same settling ponds used for treating process water. Dust suppression water is adsorbed on the product and evaporated.

Half the facilities visited are presently recirculating their process water resulting in no discharge. Those facilities recirculating all process generated waste water include:

1007	1059	1206	1391	1235
1013	1084	1207	1555	5617
1014	1200	1208	1629	3341
1048	1201	1230	3049	
1055	1202	1233	5622	
1056	1203	1234	5631	
1057	1204	1236	5656	
1058	1205	1250	5674	

The following facilities achieve no discharge to navigable waters by percolation:

1231	1232	5666	5681

The following facilities previously mentioned as recycling all process generated waste waters declared that significant perculation occurs in their ponds:

1057 1058 1233 1234 5656

Facilities 1005, 1012, 5670 dredge closed ponds on their property and discharge all process waste waters back to the pond being dredged. Only very large rainfalls would cause a discharge from these ponds to navigable waters. Facility 3342 discharges pit water (never exceeding 21 mg/l TSS) in order to maintain the pond level.

The rest discharge process water. Characteristics of some discharges are:

Facility	Flow l/kkg of product (gal/ton)	TSS kg/kkg of product (lb/1000 lb)
1006	2500 (600)	0.14
1044	1670 (400)	0.26
1056	1750 (420)	0.04
1083	1040 (250)	0.05
1129	1150 (275)	0.05
5630	1170 (290)	0.006

Solid wastes (fines and oversize) are disposed of in nearby pits or worked-out areas or sold. Clay fines which normally are not removed by mechanical equipment settle out and are routinely cleaned out of the settling pond. Facilities 1391 and 1629 remove clay fines from the primary settling pond, allow them to drain to approximately 20 percent moisture content, truck the wastes to a landfill site, and spread them out to enhance drying.

SAND AND GRAVEL (DREDGING-ON LAND PROCESSING)

At dredge 1009, there is no treatment of the sand slurry discharged to the river. Removal of waste fines at land facilities with spiral classifiers, cyclones, mechanical thickeners, or rake classifiers and settling basins, is the method of process waste water treatment. These are similar to methods used in the wet processing subcategory. Facilities 1046, 10[illegible], 1051 and 1052, by utilizing mechanical devices and settling basins, recirculate all process water thereby leaving no discharge. The following is a list of treatment methods, raw waste loads, and treated waste water suspended solids for these operations:

Facility	Raw Waste Load, TSS (mg/l)	Treatment	Treated Recycle Water, TSS (mg/l)
1046	8,500	dewatering screw, cyclone, drag classifier, settling basin	275
1048	10,000	dewatering screw, cyclones, settling basins	50
1051	9,000	dewatering screw, drag classifier, settling basin	300
1052	7,500	dewatering screw, drag classifier, settling basin with flocculants	200

Availability of land for settling basins influences the method of process water treatment. Many operations use worked-out sand and gravel pits as settling basins (Facility 1048) or have land available for impoundment. Facility 1010 is not able to recirculate under current conditions due to lack of space for settling basins. Land availability is not a problem at facilities 1011 and 1009. Sand fines (+200 mesh) are removed with mechanical devices and conveyed to disposal areas. Clay fines and that portion of the silica fines smaller than 200 mesh, which settle out in a settling basin, are periodically dredged and stockpiled. Facility 1051 spends approximately 120 days a year dredging waste fines out the primary settling pond. These fines are hauled to a landfill area. Non-contact cooling water is typically discharged into the same settling basins used for treating process water. Dust suppression water is adsorbed onto the product and evaporates. Effluent parameters at facilities 1010 and 1009 are:

Facility	TSS mg/l	TSS, kg/kkg of product (lb/1000 lb)
1010	16,000	22
1009	50	0.10

INDUSTRIAL SAND (DRY)

Scrubber water at facility 1107 is treated in a settling pond where suspended solids are settled and the clarified decant is returned to the scrubber, resulting in no discharge. Facility 1108 discharges wet scrubber water without any treatment at 160,000 l/day (43,000 gpd) and 33,000 mg/l TSS. Solid waste (oversize and sand fines) at all of the facilities is landfilled.

INDUSTRIAL SAND (WET)

Under normal conditions facilities 1019, 1989, and 3066 are able to recirculate all process water by using clarifiers and pond the sludge. During periods of heavy rainfall, area runoff into the containment ponds cause a temporary discharge. Facility 1102 discharges process water, including wet scrubber water, after treatment in settling ponds. The treatment methods used by the facilities are shown as follows:

Facility	Treatment
1019	thickener, clarifier, settling pond, recycle
1102	cyclone, thickener and flocculant, settling ponds
1989	settling pond and recycle
3066	settling pond and recycle

INDUSTRIAL SAND (FLOTATION)

At the acid flotation facilities, facilities 1101, 1019, 1980, and 1103, all process wash and flotation waste waters are fed to settling lagoons in which muds and other suspended materials are settled out. The water is then recycled to the process.

Facilities 1101 and 1980 are presently producing products of a specific grade which allows them to totally recycle all their process water. In two other facilities, facilities 1019 and 1103, all facility waste waters leave the operations either as part of a wet sludge which is land disposed or through percolation from the settling ponds. There is no point source discharge from any of the acid flotation operations.

At the alkaline flotation facility 5691, the washwaters are combined and fed to a series of settling lagoons to remove suspended materials and then partially recycled. Alum is used as a flocculating agent to assist in settling of suspended materials, and the pH is adjusted prior to either recirculation or discharge.

At facility 5980, the only facility found that uses HF flotation, all waste waters are combined and fed to a thickener to remove suspended materials. The overflow containing 93.2 percent of the water is recycled to the process. The underflow containing less than 7 percent of the water is fed to a settling lagoon for removal of suspended solids prior to discharge. The pH is also adjusted prior to discharge. Fluoride ion concentration in the settled effluent ranges from 1.5 to 5.0 mg/l. The composition of the intake and final effluent waters for the alkaline flotation facility 5691, and the HF flotation facility 5980 are presented as follows.

Pollutants (mg/l)	Facility 5691		Facility 5980	
	Intake	Effluent	Intake	Effluent
pH	7.8	5.0	7.6	7.0-7.8
TDS	209	192	---	---
TSS	5	4	10	5,47
Sulfate	9	38	285	27-330
Oil and Grease	<1.0	<1.0	---	---
Iron	0.1	0.06	---	---
Nitrate	---	---	23	0-9
Chloride	---	---	62	57-76
Fluoride	---	---	0.8	1.8,6.6
Phenols	Not detectable			

INDUSTRIAL SAND (ACID LEACHING)

Process water at facility 3215 is treated by neutralization with slaked limestone and lagooning to settle part of the iron. The existing system of settling ponds is an extensive one: this treatment system contains approximately ten acres of ponds.

The effluent from the treatment system is combined with the effluent from the company's construction sand plant. The combined effluents are discharged to surface waters. The composition of the combined effluent is given below:

	kg/kkg (lb/ton) of product
pH (units)	
max.	7.2
min.	6.4
TSS	
average	1.01 (2.02)
Iron	

average	0.065 (0.13)

GYPSUM

Mine or quarry pumpout is generally discharged without treatment. Most facilities discharge non-contact cooling water without treatment. Effluent data for some facilities discharging mine or quarry water are given as follows:

facility	flow, 10^6 l/day (mgd)	TSS, mg/l	pH
1041	4.4 (1.17)	6	7.7
1042	6.4 (1.70)	4	7.8
1110	.19 (0.05)	60	7.8
1112	5.1 (1.35)	14	8.1
1997	0.68 (0.18)	5	7.9
1999	6.5 (1.71)	24	7.4

Non-contact cooling water discharge from these facilities is given below:

facility	flow, l/kkg of product (gal/ton)	TSS mg/l	pH
1041	none	--	--
1042	246 (59)	not known	not known
1112	none	--	--
1997	250 (60)	6	7.9
1999	4.5 (1)	130	5

Land plaster dust collected in cyclones is either recycled to the process or hauled away and landfilled.

All process water used for heavy media separation at facility 1100 and the one other facility in this subcategory is re-circulated through settling basins, an underground mine settling sump, and returned to the separation circuit, resulting in no discharge of process waste water. In the recycle circuit, the HMS media (magnetite/ferrous silica) is reclaimed and is reused in the separation process.

Part of the waste rock from the HMS is sold as road aggregate, with the remainder being landfilled in old worked-out sections of the quarry. Waste fines at facility 1100 settle out in the primary settling basin and must be periodically dredged. This waste is hauled to the quarry and deposited.

BITUMINOUS LIMESTONE

No water is used in these operations hence there is no effluent.

OIL IMPREGNATED DIATOMITE

All scrubber water at facility 5510 is completely recycled; hence there is no process waste water discharge.

GILSONITE

The compositions of the intake water, the discharged facility process water and the mine pumpout water are listed below. There is a considerable concentration of suspended solids in the mine pumpout water. These discharges are currently being eliminated. The process and mine pumpout waters currently discharged at facility 5511 will soon be employed on site for other purposes.

	Concentration (mg/l)		
	intake	effluent	mine pumpout
Suspended solids	33	17	3375
BOD	35	43	12
pH	7.7	8.2	7.9 - 8.1
TDS	401	2949	620
Turbidity	--	--	70 JTU
Arsenic	--	--	0.01
Barium	--	--	<0.01
Cadmium	--	<0.001	0.004
Chloride	--	0.15	8.9
Sulfate	--	363	195

ASBESTOS

Facility 3052 treats the quarry pumpout discharge with sulfuric acid (approximately 0.02 mg/l of effluent) to lower the pH of the highly alkaline ground water that collects in the quarry. The following tabulates the analytical data for this discharge:

flow, l/day (mgd)	545,000-3,270,000 (0.144-0.864)
TSS, mg/l	2.0
Fe, mg/l	0.15
pH	8.4-8.7
asbestos (fibers/liter)	$1.0 - 1.8 \times 10^6$

At all facilities, both at the mine and facility site, there exists the potential of rainwater runoff contamination from asbestos waste tailings. Facility 1061 has constructed diversion ditches, berms, and check dams to divert and hold area runoff from the waste tailing pile. Due to soil conditions, water that collects in the check dams eventually percolates into the soil thereby resulting in no discharge to surface waters.

At the wet processing facility the process water discharge is treated in settling/percolation ponds. Suspended asbestos fibers settle out in the primary settling pond prior to decanting the clarified effluent to the secondary settling/percolation pond. Facility 1060 does not discharge to surface waters. Non-contact cooling water is not treated prior to discharge. Runoff from asbestos tailings at the facility and the quarry is controlled with diversion ditches, berms, and check dams. All facility drainage is diverted to the settling/percolation ponds. Data on the waste stream to the percolation pond includes the following:

	Intake Well Water	Discharge to Percolation Pond
flow, l/kkg feed (gal/ton)	unknown	856 (205)
total solids, mg/l	313	1,160
pH	7.5	7.8
magnesium, mg/l	14	48
sodium, mg/l	44	345
chloride, mg/l	19	104
nickel, mg/l	0.02	0.1

Asbestos fiber tailings are stockpiled near the facility where the water is drained into the settling/percolation ponds. After some drying, the tailings are transported and landfilled near the facility in dry arroyos or canyons. Check dams are constructed at the lower end of these filled-in areas.

The primary settling pond must be periodically dredged to remove suspended solids (primarily asbestos fibers). This is done with a power shovel, and the wastes are piled alongside the pond, allowed to dry, and landfilled.

WOLLASTONITE

Non-contact cooling water is discharged with no treatment to a nearby river. There is no process waste water.

PERLITE

There is no water used.

PUMICE

At all facilities except facility 1705, there is no waste water to be treated. At facility 1705, the scrubber water is discharged to a settling pond for removal of suspended materials prior to final discharge. Facility 1705 operates on an intermittent basis, and no information is available on the composition of its discharge. This facility produces less than 0.1 percent of U.S. pumice.

VERMICULITE

Both vermiculite operations have no discharge of waste waters. At facility 5506, the waste stream is pumped to a series of three settling ponds in which the solids are impounded, the water is clarified using aluminum sulfate as a flocculant, and the clear water is recycled to the process facility. The only water escape from this operation is due to evaporation and seepage from the pond into ground water. The overburden and sidewall waste is returned to the mine upon reclamation.

At facility 5507, the waste streams are pumped to a tailings pond for settling of solids from which the clear water underflows by seepage to a reservoir for process water to the process facility. Local lumbering operations are capable of drastically altering water runoff in the watersheds around the mine. This requires by-pass streams around the ponding system.

MICA AND SERICITE (WET GRINDING)

At facility 2055, the raw waste stream is collected in surge tanks and about 20 percent of the decanted water is recycled to the process. The remainder is pumped to a nearby facility for treatment. The treatment consists of adding polymer, clarification and filtration. The filter cake is stockpiled and the filtrate discharged. At facility 2059, the waste stream flows to settling tanks. The underflow from the settling tanks is sent back to the process for mica recovery. The overflow goes into a 0.8 hectare (2 acre) pond for settling. The decanted water from this pond is recycled to the process. However, during heavy rainfall, the settling pond overflows.

MICA (WET BENEFICIATION)

In facilities 2050, 2051, 2053, and 2058 the wastes are treated by settling in ponds, and the supernatant from the last pond is recycled to the facility. The sizes of the ponds used at each facility are given as follows.

Facility	hectares	acres
2050	7.3	18
2051	3.2	8
2053	0.8, 1.6, 2.8	2, 4, 7
2058	8.1	20

During normal operations there is no discharge from ponds 2050 and 2051. However, these ponds discharge during exceptionally heavy rainfalls (4" rain/24 hours). The only discharge at facility 2058 is the drainage from the sand stockpiles which flows into a 0.4 hectare (1-acre) pond and discharges.

At facility 2054 waste water is treated in a 1.2 hectare (3-acre) pond. This facility has suspended its operation since June, 1974, due to necessary repairs to the pond, and plans to convert the water flow system of this operation to a closed circuit "no discharge" process by the addition of thickening and filtration equipment.

At facilities 2052 and 2057 the waste water is treated in a series of ponds and the overflow from the last pond is treated by lime for pH adjustment prior to discharge. Facility 2052 has three ponds of 1.2, 1.6, and 3.6 hectares (3, 4, and 9 acres, respectively) in size. In addition to mica, these two facilities produce clay for use by ceramic industries. According to responsible company officials, these two facilities cannot operate on a total water recycle basis. The amine reagent used in flotation circuits is detrimental to the clay products as it affects their viscosity and plasticity. The significant constituents in the effluent from these facilities are given below:

facility	2052	2054	2057
pH before lime treatment	4.2	---	4.3
pH after lime treatment	6.5	6 - 9	6.5
TSS, mg/l	20	400	<15
TSS, kg/kkg	1.5		<1.3
settleable solids, ml/liter	<0.1	<0.1	<0.1

BARITE (WET)

The waste water streams are combined and sent to settling ponds and the reclaimed water from the ponds is recycled to the washing facilities. At facilities 2012 and 2046, the overflow from the settling pond percolates through gravel piles amassed around the settling pond, and enters clarification ponds. The supernatant water from the clarification pond is then recycled to the facilities for reuse. Also, in these facilities (2012 and 2046), there are several small ponds created around the main impoundment area to catch any accidental overflow from the clarification ponds. Besides ponding, facilities 2015 and 2016 also use coagulation and flocculation to treat their process waste water. A summary of the treatment systems for the barite facilities in this subcategory follows:

Facility	Discharge	Source	Treatment
2011	Intermittent*	Mill tailings, runoff	Pond recycle, 18 ha (45 ac)
2012	Intermittent* from clear water pond	Well water	Pond 8 ha (20 ac)
	None from tailings pond	Mill tailings	Pond, 36 ha (90 ac) Clarification Pond, recycle
2013	None	Mill tailings	Pond, recycle
2015	Intermittent*	Mill tailings, runoff	Pond, coagulation Flocculation, recycle
2016	Intermittent*	Mill tailings, runoff	Pond, coagulation Flocculation, recycle
2017	Intermittent*	Mill tailings, runoff	Pond, recycle
2018	Intermittent*	Mill tailings, runoff	Pond, recycle Pond 24 ha (60 ac)

2020	Intermittent* from clear water pond	Well water	
	None from settling pond	Mill tailings	Pond, 2 ha (6 ac)
2046	Intermittent* from clear pond	Well water	Pond, 12 ha (30 ac) clarification
	None from tailings pond	Mill tailings	Pond, recycle
2112	None	Slime Pond	Pond recycle

*Indicates overflow due to heavy rainfall.

In normal circumstances, there is no effluent discharge from any of these facilities. During heavy rains six facilities (2011, 2015, 2016, 2017, 2018 and 2020) have an overflow from the impoundment area. Facilities 2012 and 2046 have no overflow from their tailings impoundment area. However, during heavy rainfall, they do have overflow from clear water ponds. Due to its geographical location, facility 2013 has no pond overflow. The amounts of these intermittent discharges are not known. Data concerning tailings pond effluent after heavy rainfall was obtained from one facility. The significant constituents in this effluent are reported as follows:

Facility	2011 Daily Avg. - Max.	
pH	6.0	- 8.0
TSS, mg/l	15	32
Total barium, mg/l	0.1	- 0.5
Iron, mg/l	0.04	- 0.09
Lead, mg/l	0.03	- 0.10

BARITE (FLOTATION)

Wastewater is treated by clarification and either recycled or discharged. A summary of the treatment systems is given as follows:

Facility	Discharge	Source	Treatment
2010	Intermittent [1]	Mill tailings	Pond, recycle
	Intermittent	Runoff, spills, washdown water	Pond
2014	None	Mill tailings	Pond, evaporation and seepage
	None	Washdown water	Pond, evaporation and seepage
2019	Intermittent [2]	Mill tailings	Pond

[1] Indicates overflow due to heavy rainfall
[2] Overflow by facility to maintain pond level

Facility 2010 has two ponds with a total capacity of 16 hectares (40 acres) to handle the process waste water. The flotation tailings are pumped into one of the ponds and the clear water is pumped to the other pond. The mill tailings water is in closed circuit, with occasional overflow from the tailings pond. This overflow depends upon the amount of surface water runoff from rainfall and the amount of evaporation from this pond. The overflow varies from 0 to 760 l/min (0 to 200 gpm). At times, there is no overflow from this pond for a year or more. The clear water pond catches the surface runoff water, spills from the thickener, water from use of hoses, clear water used in the laboratory, etc. This pond has also an intermittent discharge varying from 0 to 380 l/min (0-100 gpm). The significant constituents in these effluent streams are as follows:

Waste Material	Tailings Pond Daily Average Max. Conc. (mg/l)	Amount kg/day	(lb/day)	Clear Water Pond Daily Average Max. Conc. (mg/l)
TSS	3-5	1.8	(3.5)	3-6
TDS	800-1271	467	(934)	1000-1815
Ammonia	<0.1-0.1	<0.5	(1)	5-35
Cadmium	0.004-0.003	<0.5	(1)	--
Chromium	0.200-0.400	<0.5	(1)	0.100-0.120
Iron, total	0.030-0.060	<0.5	(1)	0.030-0.070
Lead, total	0.020-0.080	<0.5	(1)	0.040-0.090
Manganese, total	0.002-0.003	<0.5	(1)	0.004-0.008
Nickel, total	0.0[illegible]0-0.070	<0.5	(1)	0.030-0.070
Zinc, total	0.005-0.010	<0.5	(1)	0.030-0.090

At facility 2014, there are no effluent discharges from the property. The mill tailings and the spent brine from the water softening system are pumped into the tailings settling pond and the washdown of the floors is pumped to a separate pond. These ponds eventually dry by evaporation and seepage. This facility has no problem in terms of pond overflow due to its geographical location.

At facility 2019, process waste water is collected into a large pipe which crosses under the nearby river into a 40 hectare (100 acre) pond. The pond water pH is maintained at about 7.2 by application of lime. An overflow is necessary from this pond to maintain a constant pond elevation. The discharge from this pond is intermittent. Of the 4,731,000 l/day (1.25 mgd) input to the pond, there is an estimated 3,785,000 l/day (1.0 mgd) percolation through the pond berm. The pond berm is built primarily of river bottom sands. On a regular discharge basis (9 hours a day and 4 1/2 days per week operation), the effluent discharge from this facility would be 946,000 l/day (250,000 gal/day). This pond is seven years old and has an estimated life cycle of eighteen years. When overflow to the river is desired, lime and ferric chloride are used to decrease suspended solids. It has been reported that the average TSS concentration in this effluent is 250 mg/l.

BARITE (MINE DEWATERING)

There is one underground mine in this category at facility 2010. The other mining operations are in dry open pits. The underground mine workings intercept numerous ground water sources. The water from this mine is directed through ditches and culverts to sumps in the mine. The sumps serve as sedimentation vessels and suction for centrifugal pumps which discharge this water to the upper level sump. This mine water is neutralized with lime (CaO) by a continuously monitored automated system for pH adjustment and sent to a pond for gravity settling prior to discharge into a nearby creek. The discharge from this mine is estimated to be 897,000 l/day (237,000 gal/day).

The raw waste from the mine has a pH of about 3.0. The pH is raised to 6-9 by addition of lime and then pumped into a pond for gravity settling. There are currently two ponds, and a third pond is under construction to treat the mine discharge. Presently one of these ponds is in use and the other one is being excavated and cleaned so that it will be ready for use when the first pond is filled.

The significant constituents in this effluent are reported to be as follows:

Parameter	Facility Data	New Pond Design	Verification Sampling
pH			2.6
Acidity			404
Hardness			3920
TDS			4348
TSS	23	25	1167
$SO_4^=$			1515
Fe, total	2.6	0.5	225
Fe, dissolved			177
Al	0.6	0.1	13.8
Pb	0.06	0.1	>0.2
Mn	1.3	0.5	156
Ni	0.05	0.05	1.52
Zn	0.01	0.1	2.1

The facility stated that the verification data reflect new acid seepage from adjoining property. The column "new pond design "represents the company's design criteria for building the third pond.

FLUORSPAR (HMS)

At four facilities (2004, 2005, 2006 and 2008) process water from the thickener is pumped to either a holding pond or reservoir, and then back to the facility on a total recycle basis. At facility 2009, there are four ponds to treat the HMS tailings. Three of these ponds are always in use. The idle pond is allowed to dry and is then harvested for settled fluorspar fines. There is no discharge from this facility. At facility 2007 the HMS tailings enter a 1.8 hectare (4.5 acre) pond which has eight days of retention capacity. The water from this pond is then discharged. The significant constituents in the effluent from facility 2007 is given as follows:

Waste Components	mg/l	kg/kkg of product (lb/1000 lb)
Fluoride	3.0	0.04
TSS	10.0	0.13
Lead	0.015	0.0002
Zinc	0.09	0.0012
pH	7.8	

The waste water of the facilities in this subcategory is treated in settling and clarification ponds. At facility 2000, the mill tailings are pumped into a 7 hectare (17 acre) settling pond for gravity settling. The overflow from the settling pond flows into three successive clarification ponds of 2.8, 1.6, and 2.4 hectares (7, 4, and 6 acres, respectively). The effluent of the third clarification pond is discharged. Settling in the third clarification pond is hindered by the presence of carp and shad which stir up the sediments. Experiments are in progress using a flocculant in the influent line of the second clarification pond to reduce the total suspended solids in the effluent. These clarification ponds are situated below the flood stage level of the nearby river, and during flood seasons, the water from the river backs into the ponds. Some mixing does occur but when flood waters recede, but it is claimed that most of the sludge remains in the ponds.

At facility 2001, the tailings from the fluorspar rougher flotation cells, are pumped into a settling pond from which the overflow is discharged. Facility 2001 has a new 4 hectare (10 acre) clarification pond with a capacity of approximately 106 million liters (28 million gallons). The effluent from the first settling pond will be pumped to the new clarification pond. A flocculant will be added to the influent of the new pond in quantities sufficient to settle the suspended solids to meet the state specifications (TSS 15 mg/l). A portion of the water from the clarification pond (approximately [illegible]0 percent) will be recycled to the processing facility and the remainder which cannot be recycled will be discharged.

Total recycle operation has been attempted on an experimental basis by one of these operations for a period of eight months, without success. The failure of this system has been attributed to the complexity of chemical buildups due to the numerous reagents used in the various flotation circuits.

The non-contact cooling water and the boiler blowdowns are discharged at facility 2001 without treatment. Facility 2000 includes these wastes in the process waste water treatment system. Facility 2003 mines an ore which is different from the ores processed in the other two facilities. This facility produces only fluorspar. The tailings from the mill go to two settling ponds in series. The overflow from the second settling pond is sent to the heavy media facility, and there is no discharge. A new pond is being constructed at facility 2003.

Effluents reported by facilities 2000 and 2001 for their current operation and anticipated performance are:

	concentration (mg/l)			
	2000		2001	
	Current operation	Antici-pated	Current operation	Antici-pated
pH	7.2	no change	8.2	no change
TSS	500	30-60	1,800	15-20
Fluoride	5.1	5.1	9.8	9.8

	kg/kkg of product (lb/1000 lb)			
	2000		2001	
	Current operation	Antici-pated	Current operation	Antici-pated
TSS	4.8	0.29-0.57	34.4	0.29-0.38
Fluoride	0.05	0.05	0.19	0.19

Additional sampling are by concentration (mg/l):

	2000	2001
pH	7.7	8.2
Alkalinity	359	340
Hardness	222	325
TSS	316	235
TDS	1056	1702
F	0.742	10
Fe (total)	5	2.9
Cd	0.13	0.02
Cr	0.11	0.05
Cu	2.39	0.35
Pb	0.86	0.20
Mn	0.43	0.17
Zn	<0.01	1.13

FLUORSPAR (MINE DEWATERING)

Presently at only three mines the effluent stream is discharged without any treatment (2085, 2091 and 2092). Only effluent from mine 2091 passes through a very small pond, 0.1 hectare (1/4 acre), prior to being discharged into a creek. Table 13 summarizes the effluent quality of several mine dewatering operations. Hydrogen sulfide concentrations up to 0.37 mg/l have been detected in the effluent of mine 2085. It has been reported that the H_2S content in the effluent has been steadily decreasing since an H_2S pocket was encountered.

TABLE 13

FLUORSPAR MINE DEWATERING DATA

mg/l	2080	2081	2082	2083	2085 mine	2085 settling pond	2086	2088	2089	2090	2091	2092 mine	2092 settling pond	2093
pH	8.1		7.1	7.6	7.6	7.4		7.7	8.1	7.7	7.2	7.9	8.0	
Alkalinity				224	276	216	245		864			210	197	
Hardness				336	1600	1600			221			235	222	
Cl				35	185	162			48			23	17	
TSS	38	10	8	2-12	15	29	12	20	122-135	4-69	10	53	20	17
TDS	469	697	400	478	3417	1753		1078	583	536		379	364	
$SO_4^=$		35		107	480	575			61	56		38	32	
F	1.4	2.4	1.4	1.3		2.75	1.7	2.3	1.4	2.3	1.2		1.6	
Fe		1.0		0.05	0.66	0.26	.05		2.0	0.05	.05	1.33	0.50	0.9
Pb	.03	0.1	.02	< 0.2	< 0.2	< 0.2	.03	.03	< 0.2	< 0.2	0.9	< 0.2	< 0.2	0.075
Mn		0.16		0.05	0.05	0.62			0.11	0.01		0.18	0.18	0.1
Zn	0.7	0.03	.08	0.76	< 0.01		0.34	0.54	0.06	0.5	0.2	0.17	0.08	0.235

SALINES (BRINE LAKES)

As the evaporation-crystallization process involves only recovery of salts from natural saline brines, with the addition of only process water, the only wastes are depleted brines and end liquors which are returned to the salt body without treatment.

BORAX

Present treatment consists of percolation-proof evaporation ponds with no discharge.

POTASH

All waste streams from the sylvinite facilities are disposed of in evaporation ponds with no discharge. At the langbeinite facilities 20-30 percent of the cooling water is evaporated. All the process waste water from the langbeinite purification facilities are fed to evaporation ponds with no discharge. All known deposits of sylvinite and langbeinite ore in the U.S. are located in arid regions.

TRONA

Process waste waters go to tailings separation ponds to settle out the rapidly settling suspended materials and then to the final disposal ponds which serve as evaporation ponds. Where process water discharge takes place (at present only facility 5933), the overflow is from these latter ponds. Facility 5933 has plans to eliminate this discharge. The ground water and runoff waters are also led to collection ponds where settling and large amounts of evaporation take place. The excess of these flows at the 5962 and 5976 facilities is discharged.

Evaporation of the saline waste waters from these facilities takes place principally in the summer months since the ponds freeze in the winter. The net evaporation averaged over the year apparently requires an acre of pond surface for each 2,000 to 4,000 gal/day (equivalent to 19,000 to 37,000 l/day per hectare) based on present performance.

There is no discharge from facility 5999. Facility 5976 only mines ore and discharges only mine water. The facility 5962 discharge is only ground and runoff waters. The waste constituents after treatment of the discharge at 5933 were at the time of permit application:

	mg/l	kg/day (lb/day)
total solids	9,000	860 (1,900)
dissolved solids	8,300	793 (1,750)
suspended solids	700	67 (150)

SODIUM SULFATE

There are no discharges due to total evaporation at the arid locations involved.

ROCK SALT

Generally there is no treatment of the miscellaneous saline waste water associated with the mining, crushing and sizing of rock salt. Some of the facilities have settling ponds. Facility 4028 is unique in that the mine shaft passes through an impure brine aquifer and entraps hydrogen sulfide gas. The seepage from this brine stream around the shaft is contained by entrapment rings. The solution is filtered, chemically treated and re-injected into a well to the aquifer.

The effluents from these facilities consist primarily of waste water from the dust collectors, miscellaneous washdown of operating areas, and mine seepage. The compositions of some of the facility effluents expressed in mg/l are as follows:

Facility	Volume l/day	Volume gal/day	TDS mg/l	TSS mg/l	pH
4013	4,090,000	1,080,000	4,660	trace*	--
4026	150,000	40,000	30,900	72	7.5
4027	500,000	132,000	--	150	6.5
4033	76,000	20,200	30,200	trace**	--
4034 (001)	306,000	81,000	53,000 - 112,000	470 -	8.5-9.0
(002b)	522,000	138,000	319,000 - 323,000	1,870 4,750	7.6

* due to dilution
** runoff only, remainder of waste re-injected to well.

The suspended solids content in the process water discharges from facilities 401[illegible], 4026, and 4027 range up to 0.02 kg/kkg of product. At least one of these facilities discharges an average of as little as 0.002 kg/kkg of product.

PHOSPHATE

Some facilities use well water for pump seal water (>2000 gpm) claiming that this is necessary in order to protect the seals. Others, facility 4015 for example, use recycled slime pond water with no problems. Some facilities also claim that well water is necessary for air scrubbers on dryers in order to prevent nozzle plugging and utilize the cooler temperature of the well water to increase scrubber efficiency. Other facilities also recycle this with no apparent difficulty. Facility 4018 recycles this water through a small pond that treats no other wastes.

The treatment of the process waste streams consists of gravity settling through an extensive use of ponds. The slimes which are common to all phosphate ore beneficiation processes, although differing in characteristics, are the major waste problem with respect to disposition. The slimes at 3-5 percent solids either flow by gravity via open ditch with necessary lift stations or are pumped directly to the settling ponds. The pond overflow is one of the primary sources of the recycle process water. Those facilities that include flotation discharge sand tailings at 20-30 percent solids to a mined out area. Settling occurs rapidly with a part or all of the water returned to recycle and the solids used in land reclamation. The pond sizes are quite large, 160 hectares (400 acres) being typical. A single process facility will have several such ponds created from mined areas. Because the slimes have such a great water content, they will occupy more space than the ore. Hence dams need to be built in order to obtain more volume. Because of past slime pond dam breaks, the construction of these dams is rigorously overseen in the state of Florida. The treatment of the mine pit seepage and dust scrubber slurries are handled similarly to the other waste streams. Facility 4003 discharges some of the mine pumpout.

Effluents are intermittently or continuously discharged from one or more settling areas by all of the beneficiation facilities. Volumes of effluents are related to: (1) % recycle; (2) frequency of rainfall; (3) surface runoff; and, (4) available settling pond acreage. The pH of the effluents from these facilities range from 6.2 to 9.1 with over 70 percent of the averages between 7 and 8.

Sufficient data was available from the Florida phosphate and processing facilities to use statistical methods. For a given plant normal and logarithmic normal distributions were tested on the individual daily values for TSS and the monthly averages for TSS. It was found that a three parameter logarithmic normal distribution best fit the data. Figure 57 plots log TSS (mg/l) versus probability for one facility. At higher values of Tau, the TSS values fit a straight line determined by a least squares program very well.

The following data summarize the results of the statistical analyses:

PHOSPHATE EFFLUENT QUALITY
TSS, mg/l

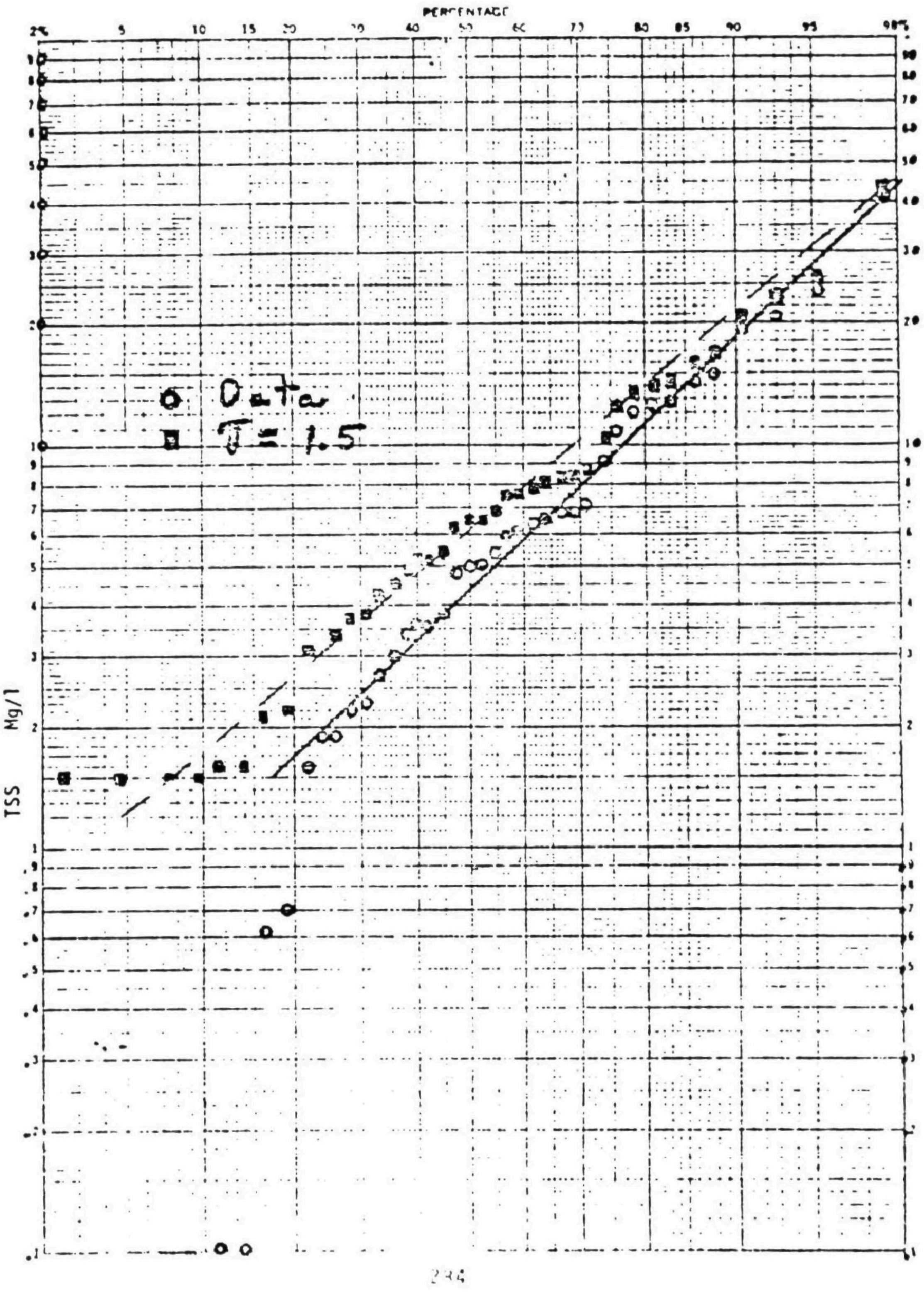
	Long Term Average		Monthly 99 Percentile	Observed Maximum Monthly Average		Daily 99 Percentile		Observed Daily Maximum	
	*	**	*	*	**	*	**	*	**
4002	9.2	-	38.6	26	-	220	-	64	-
4004A(1)	9.7	10.8	17.4	14	27	50.7	50.4	50	44
4004A(2)	11.3	6.2	-	-	15	47.3	39.8	30	32
4004B(1)	13.5	8.3	70.3	53	8	68.5	12.8	103	12.0
4004B(2)	3.5	3.1	7.3	6	5	16.1	10.7	12	7
4004B(3)	2.5	2.3	8.1	5	4	8.5	7.9	10	7
4005A(1)	18.1	21.7	35.5	29	33	59.8	51.3	75	49
4005A(2)	-	19	-	-	26	-	48.4	-	47
4005B(1)	18.7	13.1	28.7	25	27	56.4	71.5	67	62
4005B(2)	16.0	16.9	25.7	22	27	38	41.6	35	41
4005C(1)	13.2	17.0	29.4	23	29	44.6	43.0	47	47
4005C(2)	15.0	19.1	-	-	26	75.9	46.1	55	37
4005C(3)	28.2	14.6	-	-	23	116.1	74.4	105	70
4015(1)	15.8	18.3	20.7	18	24	39	52.4	36	55
4015(2)	46.5	34.0	190.8	109	91	303	221	18?	182
4015(3)	14.9	7.9	-	-	18	24.0	32.8	20	24
4016	7.4	9.2	[illegible].5	13	16	20.2	47.9	17	46
4018	158	26.4	798	453	137	1334	-	1072	1961
4019A	7.0	-	17.3	13	-	43.1	-	41	-
4019B	5.6	5.2	24.5	18	9	33.3	18.6	-	15
4019C	6.3	4.9	36.2	17	9	54.0	20.7	43	15
4020A	2.8	3.7	6.8	5	37	21.1	68.0	14	143
4020B	5.5	7.5	7.0	6	14	12.3	21.3	12	28

*1974-1975 Data
**1975-1976 Data

Some caution must be exercised when reviewing the data. For instance some of the data noted are weekly composites and it can be expected that the daily variability will be somewhat higher. Some of the analyses, on the other hand, were

FIGURE 57

Normal Distribution of Log TSS
for a Phosphate Slime Pond Discharge



performed on less than 12 data points. This was the case for some monthly data.

In other cases poor sampling techniques were employed by the facilities, and some data were not analyzed because of facility admissions of improper sampling. In other cases high TSS values resulted from erosion of the earthen discharge ditches or the inclusion of untreated facility and road surface runoff.

In addition to TSS, the slimes from beneficiation and facility effluents contain radium 226 resulting from the presence of uranium in the ores. Typical radium 226 concentrations in slimes and effluents are presented in the following table:

Radium 226 Concentrations (pCi/liter)

	Slime Discharge			Effluent Discharge		
Facility	dissolved	undis-solved	g/liter	discharge point	dissolved	undis-solved
			*12			
4005	0.82	10.2	0.48	A-4*	0.66	0.26
				K-4*	0.52	0.28
				K-8*	0.68	0.28
			*86			
4015	4.8	1074	14.8	002*	0.02	0.56
				003*	0.34	1.1
4016	2.0	97.6	3.2	001*	2.2	0.7[illegible]
4017	0.60	37.7	3.85	001	0.24	0.74

*4 hour composite sample

The concentration of total radium 226 appears to be directly related to the concentration of TSS.

The treatment of the process waste stream for the Western operations consists typically of flocculation and gravity settling with some facilities having a thickening stage prior to ponding. The slimes consist primarily of fine clays and sands. At facility 4022, the flotation tailings (primarily sands) are combined with the slimes with treatment common to the other operations. The waste slurries vary in percent solids from 5 to 15. Generally a flocculating agent is added before pumping to a thickener or directly to a settling pond where the solids settle out rapidly.

Of the six facilities surveyed, only facility 4022 currently has a discharge. Some part of the overflow and seepage from the settling pond flows into a small retention basin which occasionally discharges. This facility received a discharge permit stipulating no discharge and intends to have complete recycle and/or impoundment of process water.

SULFUR (FRASCH - ANHYDRITE)

There are no process waste waters emanating from these facilities. The only waste from these facilities is sludge which originates from the water purification operation, and it is sent to a thickener where as much water as possible is reclaimed for recycling back to the system. At facility 2020 approximately 90 percent of the thickener sludge is used as an additive to the mud that is injected into the ore body in order to improve the thermal and hydrologic efficiency of the mine. The remaining 10 percent is pumped into a settling pond for evaporation. At facility 2095, the entire thickener sludge is used as drilling mud.

SULFUR (FRASCH - SALT DOME)

The major waste from the sulfur mines is the bleedwater from the formation. Due to the nature of the mining operation, it is not possible to significantly reduce the quantity of the bleedwater produced. Large aeration ponds are considered to be the best technology available for treating the water from the bleed wells. However, due to the scarcity of land space for ponds near some of these mines, each facility uses a unique treating system to reduce the hydrogen sulfide and suspended solid concentrations in the bleedwater effluent streams.

There are four waste streams at facility 2021. Outfalls #1 (power facility effluent), #2 (sludge from the domestic water treating facility), and #5 (water from sealing wells, miscellaneous sanitary waste and drips and drains) are disposed of in a seawater bay leading into the Gulf without any treatment. Outfall #3 (bleedwater) is first flashed into a large open top tank which causes reduction in hydrogen sulfide concentrations. After a short residence in the tank, this effluent is mixed with seawater to effect further oxidation of the hydrogen sulfides to sulfates and to dilute it before discharge. A flash stripping and oxidation system was chosen for this facility primarily because of a new procedure of up-flank bleeding which precluded the continued use of the existing treatment reservoir.

The location of mine 2022, some 9.6 to 11.2 km (6 to 7 miles) offshore in the Gulf, does not lend itself to the conventional aeration reservoir. Mechanical aeration systems are considered undesirable by this company due to the large quantities of gaseous hydrogen sulfide that would be released to the atmosphere and come in contact with personnel on the platform. Some quantities of dissolved hydrogen sulfide are swept out of the solution through gaseous evolution of carbon dioxide and methane present in the formation water. Additionally, oxidation of sulfides occurs through the reaction with the dissolved oxygen in the seawater by using a diffuser system. The results of water sampling, since the mine began operations, have shown an absence of sulfides within 150 m (500 ft) of the discharge points. Because conventional treatment systems (ponds) cannot be used and because relocation is impossible, situations such as this will be regulated in a separate subcategory.

Presently, there is only one major waste stream at facility 2023. However, there are 6 other discharge points from this facility primarily for rainwater runoffs. This mine has three pumping stations in the field for rain water runoffs which are newly designated discharge points. In addition, there are 3 discharge points installed to cover rainwater runoffs and the drips and drains from the levee system around the power facility. This levee system has been built to improve the housekeeping in the power facility area. The bleedwater from the mine is aerated in one of three small reservoirs, located in the field area, prior to pumping to the main treatment reservoir which is about 10 hectares (25 acres) in size. Here the water is sprayed to reduce hydrogen sulfide concentrations. It is then impounded for 3-4 days where further aeration occurs. Finally, it is mixed with pumped-in seawater at a ratio of 20 to 1 in a 1830 meter (6000-foot), man-made canal to oxidize any remaining sulfides to sulfates prior to discharge. Power facility wastes are also piped into the canal where temperatures are equilibrated and solids are settled. Oxidation is effecting sulfide removal in this ditch rather than just dilution as evidenced by the avearage reduction of sulfide from 107 mg/l to less than 0.1 mg/l before and after mixing with the seawater. A spray system was chosen for aeration in this facility due to the lack of suitable land space for the construction of a large conventional reservoir.

Four discharge streams emanate from facility 2024. Discharges #1 and #3, the power facility discharges and mining water from sealing wells, respectively, discharge into a river without treatment. Discharge #2, the bleedwater, flows by gravity through a ditch into a 50 hectare (125 acre) reservoir where oxidation of hydrogen sulfide is accomplished. The effluent residence time in this reservoir is about 15 to 18 days. The treated bleedwater flows into a swift flowing tributary of a river just before it enters tidal waters. All sewage effluents entering into discharge #4, which is primarily rain runoff, are treated through a septic tank system prior to discharge.

At mine 2025 the bleedwater flows to a small settling basin from where it is routed through a mixing zone. Sulfurous acid and deposition inhibitor are added to the bleedwater in this mixing zone and then the waste water is routed to packed towers for hydrogen sulfide removal. In the packed towers, the bleedwater flows counter current to cooled boiler flue gas. The treated bleedwater is next aerated and sent to a 10 hectare (25 acre) settling basin. The overflow from the settling basin flows through two 10-12 hectare (25 to 30 acre) clarification ponds, prior to discharge into the tidal section of a river through a 35 km (22 mile) long disposal canal. The effluents from the water softening and treating operations are discharged into an earthen pond to settle the solids and the sludge. The supernatant water from this pond is discharged into a river. The solids are mixed with some clay and used as substitute drilling mud. Rainfall runoffs, boiler blowdown and other facility area wastes are discharged without treatment. The sanitary waste is treated in a septic tank system and then discharged into oxidation ponds. The overflows from these ponds are discharged into a river.

In mine 2026, the bleedwater is treated in a series of three ponds for settling and oxidation. Pond #1 is about 14 hectares (35 acres) and ponds #2 and #3 are about 52 hectares (130 acres) each on size. The overflow from pond #1 flows through a 3.2 km (2 mile) ditch into pond #2. The overflow from the third pond is discharged into a river. Part of the rainfall runoff, a small part of the boiler blowdown (the continuous blowdown is returned to the mine water system), zeolite softener regeneration water, pump gland water, and washwater are sent into a nearby lake without treatment. The blowdown from the hot process softening system and clarifier system is discharged to pits where the excess supernatant is discharged with the remaining rainfall runoffs into the creek. The settled solids are used as drilling mud. The sanitary waste of this mine is treated in a septic tank system and reused in the mine water system.

At mine 2027 the bleedwater treatment process used consists of contacting the waste water from the bleedwells with sulfurous acid with provisions for adequate mixing followed with sufficient retention time. Sulfurous acid is made both by burning liquid sulfur or from hydrogen sulfide originating from the bleedwater. In this process, the soluble sulfides in the bleedwater are converted to elemental sulfur and oxidized sulfur products in a series of reaction vessels. The excess acid is next neutralized with lime and the insoluble sulfur is removed by sedimentation. The effluent thus treated passes through five basins in series having a total retention capacity of about one day. The overflow from the last basin is discharged into a salt water canal which flows into the tidal section of a river. The waste stream from the water clarification operation is discharged into an earthen pond to settle the solids and the sludge. The supernatant water from this pond is mixed with boiler blowdown waste and other waste streams prior to discharge into the salt water canal. Rainfall runoffs are sent into the canal without any treatment. The sanitary waste of this mine is treated in a septic tank system and then discharged into a disposal field.

In mine 2028, the water from the bleedwells is sent into two separate tanks from where it flows through 24 km (15 miles) of underground piping into a ditch about 5 km (3 miles) in length. From there it flows into a 325 hectare (800 acres) pond for oxidation and settling. Treated effluent from this pond is discharged 60 days per year into a ditch. This is because the canal water, while subject to tidal influence, is selectively used for irrigation supply water. The waste stream from the water clarifier and zeolite softening operation is discharged into an earthen pond to settle the solids and the sludge. The supernatant water from this pond is intermittently pumped out into a creek. The solids are mixed with some clay and used as drilling mud. Boiler blowdown water, facility area wastes and rainfall runoffs are sent into a nearby creek. The sanitary waste of this mine is treated in a septic tank system and then discharged in a disposal field.

The rainfall runoffs, boiler blowdowns, waste resulting from the water softening and treating operations, facility area wastes are sent into receiving waterways without any treatment. Therefore, the composition of these streams are as given in the raw waste load section. Table 14 compares the discharges from these facilities. Alternate forms of sulfur treatment are discussed in the following paragraphs.

Oxidation-Reduction Reactions

The modification or destruction of many hazardous wastes is accomplished by chemical oxidation or reduction reactions. Hexavalent chromium is reduced to the less hazardous trivalent form with sulfur dioxide or bisulfites. Sulfides can be oxidized with air to relatively innocuous sulfates. The oxidation reactions for a number of sulfur compounds pertinent to the sulfur industry are discussed below.

TABLE 14

SULFUR FACILITIES
COMPARISON OF DISCHARGES

Plant	2021	2023	2024	2025	2026	2027	2028	2029	2097
Age	14	41	21	45	26	22	17	28	6
Location	La *	La *	La	Tx	Tx	Tx	Tx	Tx	Tx
Total Discharge, 10^6 l/day	74	420	19	38	17	23	11.5	8.7	11.5
Total Discharge 10^3 l/kkg	180	260	6.9	12.1	20	20.5	21.5	11.8	22.1
Bleedwater discharge, 10^6 l/day	4.6	27	19	38	17	23	11.5	8.7	11.5
Bleedwater discharge, 10^3 l/kkg	11.2	16.4	6.9	12.1	20	20.5	21.5	11.8	22.1
Pollutants (in total discharge)									
TSS, mg/l	57	33	95	30	20	5	40	50	30
TSS, kg/kkg	10.3	8.6	0.7	0.4	0.4	0.1	0.9	0.6	0.7
Sulfide, mg/l	16	0.4	51	nil	nil	nil	nil	not de-	2
Sulfide, kg/kkg	2.7	0.1	0.4	nil	nil	nil	nil	tected	0.04
TSS (seawater contribution omitted) kg/kkg	4.8	0.3	0.7	0.4	0.4	0.1	0.9	0.6	0.7

* Bayou

Inorganic Sulfur Compounds

Inorganic sulfur compounds range from the very harmful hydrogen sulfide to the relatively innocuous sulfate salts such as sodium sulfate. Intermediate oxidation products include sulfides, thiosulfates, hydrosulfites, and sulfites. Oxidation of sulfur compounds is accomplished with air, hydrogen peroxide, chlorine, amoung others.

(1) Sulfides

Sulfides are readily oxidizable with air to thiosulfate. Thiosulfates are less harmful than sulfides (of the order of 1000 to 1).

$$2HS^- + 2O_2 = S_2O_3^{=} + H_2O$$

The reaction goes to 90-95 percent completion.

(2) Thiosulfates

Thiosulfates are difficult to oxidize further with air (21). They can be oxidized to sulfates with powerful oxidizing agents such as chlorine or peroxides. However, the Frasch sulfur industry has experienced oxidation of sulfides with air to elemental sulfur and oxidation of thiosulfides to sulfates.

(3) Hydrosulfites

Hydrosulfites can also be oxidized by such oxidizing agents and perhaps with catalyzed air oxidation.

(4) Sulfites

Sulfites are readily oxidized with air to sulfates at a 90-99 percent completion level. Chlorine and peroxides are also effective.

Salt dome sulfur producers have large quantities of bleedwater to treat and dispose of. This presents two problems: removal of sulfides and disposal of the remaining brine. Since there is currently no practical or economical means of removing the salt from the brine, it must be disposed of either in brackish or salt water, or impounded and discharged intermittently during specified times.

Removal of sulfides prior to discharge of the brine is also a major treatment problem. There are two types of bleedwater treatment facilities found in this industry for removal of sulfides. Examples of each are given in Figure 58.

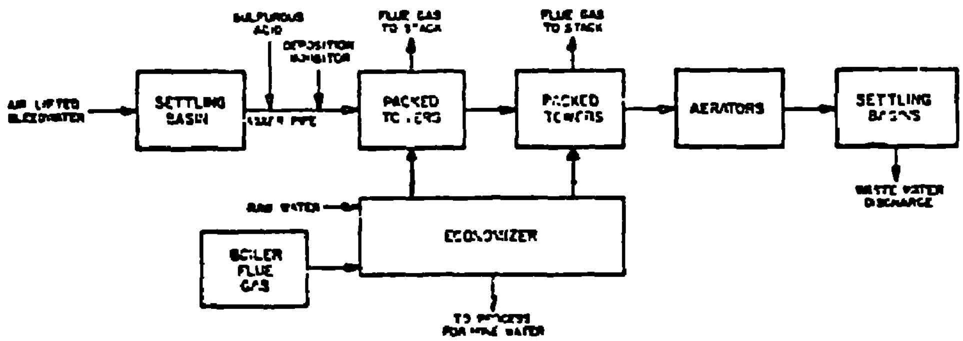
In treatment type 1 the bleedwater is air lifted to a small settling basin and then sent to a mixing zone where sulfurous acid and deposition inhibitor are added. The bleedwater is then sent to packed towers for removal of hydrogen sulfide. In the packed towers the bleedwater flows countercurrent to cooled boiler flue gas. The treated bleedwater is then aerated and sent to a series of settling and clarification ponds prior to discharge. This method is effective for removal of sulfides in the bleedwater.

In treatment type 2 the bleedwater is mixed with sulfurous acid which is generated by burning liquid sulfur or from hydrogen sulfide originating from the bleedwater. In this process the soluble sulfides in the bleedwater are converted to elemental sulfur and oxidized sulfur products in a series of reaction vessels. Excess acid is then neutralized with lime. The insoluble sulfur is removed by sedimentation, and the treated effluent is then sent to a series of basins prior to discharge. This method is very effective for removal of sulfides.

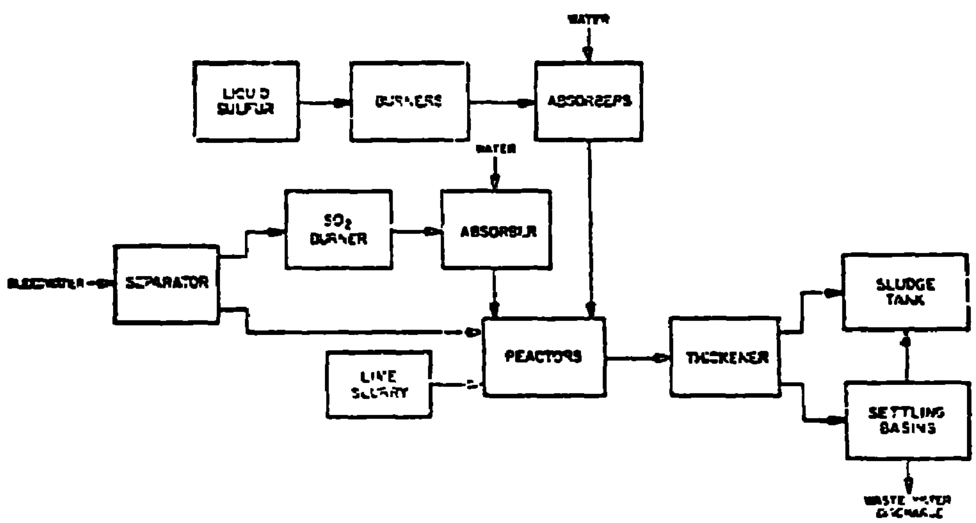
SULFUR (FRASCH - OFFSHORE)

At the one off-shore salt dome sulfur facility currently operating, the bleedwater is discharged without treatment through a diffuser system. The treatment technologies used by on-shore salt dome facilities, ponding and bleedwater treatment facilities are not considered feasible here due to non-availability of land and space restrictions on a platform.

FIGURE 58



BLEEDWATER TREATING PLANT
TYPE 1



BLEEDWATER TREATING PLANT
TYPE 2

PIGMENTS

In the wet processing of iron oxide pigments, water overflow from the rake thickener drains to a large settling pond. It is then recycled to the process with no further treatment. At facility 3022 the waste water is discharged to a 41 hectare (100 acres) settling pond which is also used for effluent from a barite operation. The discharge from the large pond is mainly attributable to the barite operations.

LITHIUM

The treatment of the process waste stream consists of flocculation and gravity settling. The slimes and flotation tailings are primarily alkali aluminum silicates and quartz. A flocculating agent is added and the slurry is pumped to settling ponds, and the major part of the overflow is returned to the facility for re-use. The mine water which is pumped intermittently is both discharged and recycled to the process water circuit. An additional waste stream which is unique to facility 4009 arises from the scrubbing circuit of the low-iron process which removes certain impurities from the spodumene concentrate product. This stream is currently being impounded for future treatment prior to being discharged.

For facility 4009 the point of measurement of the discharge encompasses significant flow from two streams which pass through the property and serve as an intake water source to the facility. The significant dilution by stream water makes it impossible to assess the effluent quality directly. Effluent data are as follows:

	Facility 4001		Facility 4009	
	Mine	Mill	Mine	Mill
Flow l/day			0.57	7.9
mgd			0.15	2.088
pH		6.1-7.9		7.0-7.5
TSS, mg/l	14	41	256	3 3 6 6 6 7 10 13 14 14 15 18 25

Facility 4001 is currently constructing an impoundment and will recycle all process waste water. Facility 4009 is essentially achieving no discharge. Discharge does occur as seepage from the tailings dam and as overflow from the tailings pond during heavy rainfall.

The mine water at mine 4001 was observed by the project officer to be very muddy, possibly requiring use of flocculants.

BENTONITE

There is no discharge of any waste water from bentonite operations. The solid overburden removed to uncover the bentonite deposit is returned to mined-out pits for land disposal and eventual land reclamation. Dust collected from processing operations is either returned to storage bins as product or it is land-dumped. Mine dewatering was not found.

FIRE CLAY

There is no discharge of process waste waters. Mine pumpout is discharged either after settling or with no treatment. The effluent quality of mine pumpout at a few mines are as follows:

Mine	Treatment	pH	TSS mg/l	Total Fe mg/l
3083	Pond	7.25	3	
3084	Lime & Pond	6.5	26.4,62	
3087	lime, combined with other waste streams	4.0	45	
3300	None	6.0-6.9	4	
3301	None	6.9	2	
3302	None	8.3	30	
3303	None	7.0	1	
3307	None	9.2	5	
3308	Pond	5.0	16	20
3309	Pond	4.2		80
3310	None	3.0	16	
3332	None	--	30	--
3333	None	--	10	--
3334	None	--	45	--

3335	None	--	27,144	--
3336	None	--	37	--
3337	None	--	15	--
3338	None	2.6-3.0	253-392	530-1900

ATTAPULGITE

Bearing cooling water at facility 3060 is discharged with no treatment while water used in pugging and kiln cooling is evaporated in the process. Dusts and fines are generated from drying and screening operations at facility 3060. This slurried waste is sent to worked-out pits which serve as settling ponds. In the last year the ponds have been enlarged and modified to allow for complete recycle of this waste water. The ponds have not yet totally filled however, and the company anticipates no problems. There is no discharge at this time of process water. At facility 3058 waste is generated from screening operations as fines which until presently were slurried and pumped to a settling pond. With the installation of new reconstituting equipment these fines are recycled and there is no discharge of process water. The settling pond, however, is maintained in event of breakdown or the excessive generation of fines. Facility 3088 also has installed recycle ponds recently and anticipates no trouble. Facility 3089 uses a dry micro-pulsair system for air pollution control, therefore there is no discharge of process water. According to the company they are within state air pollution requirements.

Mine pumpout at facilities 3060 and 3058 is discharged without treatment. Facility 3089 uses two settling ponds in series to treat mine pumpout, however they do not attempt to treat wet weather mine pumpout. Data of the mine dewatering discharges follow.

Mine	pH	TSS, mg/l
3058	6.8	17
3060	7.5	19

MONTMORILLONITE

Facilities 3059 and 3073 recycle essentially 100 percent of the scrubber water, while facility 3072 recycles only about 70 percent. Scrubber water must be kept neutral because sulfate values in the clay become concentrated, making the water acidic and corrosive. Facilities 3059 and 3073 use ammonia to neutralize recycle scrubber water, forming ammonium sulfate. Facility 3072 uses lime ($Ca(OH)_2$), which precipitates as calcium sulfate in the settling pond. To keep the scrubber recycle system working, some water containing a build-up of calcium sulfate is discharged to a nearby creek. However, facility 3072 intends to recycle all scrubber water by mid-1975. Mine pumpout can present a greater problem for montmorillonite producers than for attapulgite producers, due to the very slow settling rate of some of the suspended clay. Accumulated rain and ground water is pumped to abandoned pits for settling to the extent possible and is then discharged. At facility 3073 the pit water is used as makeup for the scrubber water.

Data on mine dewatering follows.

Mine	pH	TSS, mg/l				
3059	4.5-5.5	200-400				
3323	3.8-4.4	2	4.33	6.3	6.3	
		6.7	8	8	9	9.5
		10.3	12.33	16	18	
		24	33	42	52	
		258				
3324	6-9	25.7	26	30	37	
		53	137	436		
3325	7-8	0.67	1.67	2	3	
		4.33	5.5	8	11	
		12	18	21.3	60	

The high value of 258 mg/l TSS at mine 3323 occurred during a 6.6 cm (2.6 in) rainfall. However, the mine was not being dewatered.

In June 1975, the representatives of a flocculant manufacturer conducted a study of the mine dewatering quality at plant 3059. By use of a flocculant, TSS was reduced from 285 to 15 mg/l and turbidity from 580 to 11 JTU. The flocculant manufacturer's representatives were confident that a full scale system would also produce significant reduction of TSS. Flocculation tests were also conducted at mine 3324. With a cationic polyelectrolyte 50 mg/l TSS was achieved. With supplemental alum 10 mg/l TSS was achieved.

KAOLIN (DRY)

The solid waste generated is land-disposed on-site. There is no process effluent discharged.

KAOLIN (WET)

The facilities treat the process waste water ponds with lime to adjust pH and remove excess zinc which is used as a bleaching agent. This treatment effects a 99.8% removal of zinc, 99.9% removal of suspended solids, and 80% removal of dissolved solids. These facilities are considering the use of sodium hydrosulfite as bleach to eliminate the zinc waste. Facilities with large ponds and a high freeboard have the capability of discontinuing discharge for one or more days to allow unusually high turbidities to decrease before resuming a discharge.

Solid wastes generated in kaolin mining and wet processing are land-disposed with overburden being returned to mined-out pits, and dust, fines, and other solids to settling ponds.

Waste waters are in all cases sent to ponds where the solids settle out and the water is discharged after lime treatment. A statistical analysis was performed on five Georgia kaolin treatment systems. Based on a 99 percent confidence level of the best fitting distribution (normal and logarithmic normal) the following turbidities were achieved.

Facility	Turbidity, JTU or NTU		
	long term average	daily maximum	monthly average maximum
3024	26.4	48.2	<43
3025	24.5	83	62.5
3314	58.2	202	
3315(1)	32.9	140	113.7
3315(2)	32.7	76.7	

Long term TSS data was not available. What TSS values were available were correlated with the corresponding turbidity values as follows:

Facility	TSS, mg/l	
	50 JTU(NTU)	100 JTU(NTU)
3024	45	90
3025	35	70
3315	50	100

Two interesting items were noted in additional data collected at the request of EPA at facility 3315. Approximately one-half of the total suspended solids were of a volatile nature confirming the company's concern that aquatic growth in part was contributing to the suspended solids. This is expected, since organic reagents are used in kaolin processing and the treatment ponds are situated in swampy areas having an abundance of plant growth. The second point is that only about one-half of the turbidity was removed after waste water samples were filtered in the determination of TSS. This indicated that the kaolin and possibly the volatile solids are sub-micron in size and are not necessarily measured by TSS alone.

KAOLIN (MINE DEWATERING)

Open pit mining of kaolin does not utilize any water. However, when rainwater and ground water accumulate in the pits it must be pumped out and discharged. Usually this pumpout is discharged without treatment, but, in at least one case, pH adjustment is necessary prior to discharge.

The following mine drainage concentrations were measured.

Mine	TSS, mg/l	JTU
3074	10	
3080	10	
3081	10	
3311	22	
3312	7.4	
3313	41	
3316	95.2*	44.6*
3317		232*
3318		79.5*

*daily maximum achieved in 99 percent of samples

Mine 3316, 3317 and 3318 blunge the ore at the mine site and add a dispersant such as sodium tripolyphosphate to the slurry to facilitate pumping the ore to the process plant. It is this dispersant that causes the relatively high values.

BALL CLAY

Mine pumpout is discharged either after settling in a pond or sump or without any treatment. Data are as follows:

Mine	TSS, mg/l	
3326	0	23143
3327	48	
3328	0	312
3329	0	
3330	53	
3331	15	200
5664	146	

The extreme variability of the effluent quality is due to the presence of colloidal clays, as observed by the project officer after a substantial rainfall.

Scrubber water at these facilities is sent to settling ponds. In addition, facilities 5684 and 5689 treat the scrubber water with a flocculating agent which improves settling of suspended solids in the pond. Facility 5689 has three ponds of a total of 1.0 hectare (2.5 acres) area.

The amounts of process wastes discharged by these facilities are calculated to be:

facility	discharge, l/kkg of product (gal/ton)	TSS, kg/kkg of product (lb/1000 lb)	TSS mg/l	TDS mg/l
5684	88 (21)	0.0004	4	240
5685	1,080 (260)	0.43	400	10[illegible]7
			2970	236
			82	511
			1016	433
			1054	
5689	834 (1,030)	0.17	10046	3216
			49	153
			107	164
			4	273

There are two significant types of operations in ball clay manufacture insofar as water use is concerned: those having wet scrubbers, which have a waste water discharge, and those without wet scrubbers, which have no process waste water. There is a discrepancy in discharge flow rates since not all the production lines in each facility have wet scrubbers. Baghouses are also employed by this industry.

FELDSPAR (FLOTATION)

Treatment at three facilities (3054, 3065, 3068) consists of pumping combined facility effluents into clarifiers, with polymer added to aid in flocculation. Both polymer and lime are added at one facility (3065). At the other two facilities, (3026, 3067) there are two settling ponds in series, with one facility adding alum (3026).

Measurements by EPA's contractor on the performance of the treatment system at facility 3026, consisting of two ponds in series and alum treatment, showed the following reductions in concentration (mg/l):

	TSS	Fluoride
waste water into system	3,790	14
discharge from system	21	1.3

The process water effluents after treatment at these five facilities have the following quality characteristics:

facility	pH	TSS mg/l	Fluoride mg/l
3026	6.5-6.8	21	8, 1.3
3054	6.8	45	15
3065	10.3*	349	23
3067	7.5-8.0	35	34
3068	7-8	40-150	32

Facility 3065 adds lime to the treatment, which accounts for the higher than average pH.

The average amounts of the suspended solids and fluoride pollutants present in these waste effluent streams calculated from the above values are given in the following table together with the relative effluent flows.

facility	ore processed basis flow, l/kkg (gal/ton)	TSS, kg/kkg (lb/1000 lb)	fluoride, kg/kkg (lb/1000 lb)
3026	14,600 (3,500)	0.31	0.12
3054	12,500 (3,000)	0.56	0.18
3065	11,000 (2,640)	1.1	0.25
3067	6,500 (1,560)	0.23	0.22
3068	18,600 (4,460)	0.7-2.8	0.6

The higher than average suspended solids content of the effluents from 3065 and 3068 is caused by a froth carrying mica through the thickerners to the discharges. Facility 3026 uses alum to coagulate suspended solids, which may be the cause of the reduction in fluoride. Alum has been found in municipal water treatment studies to reduce fluoride by binding it into the sediment. The effectiveness of the treatment at 3026 to reduce suspended solids is comparable to that at facilities 3054 and 3067.

The treatment at facility 3054 results in little or no reduction of fluoride, but good reduction of suspended solids. Nothing known about this treatment system would lead to an expectation of fluoride reduction.

The treatment at facility 3067 apparently accomplishes no reduction of fluoride, but its suspended solids discharge is significantly lower than average in both amount and concentration.

Solid wastes are transported back to the mines as reclaiming fill, although these wastes are sometimes allowed to accumulate at the facility for long periods before removal.

FELDSPAR (NON-FLOTATION)

Waste water is spilled on the ground (Facility 3032) or is evaporated during crushing and milling operations (Facility 3064). There is no waste water treatment at either facility, since there is no discharge.

KYANITE

Process water used in the several beneficiation steps is sent to settling ponds from which clear water is recycled to the process. There is total recycle of the process water with no loss through pond seepage.

There is normally no discharge of process water from facility 3015. The only time pond overflow has occurred was after an unusually heavy rainfall. Facility 3028 has occasional pond overflow, usually occurring in October and November.

The solid waste generated in kyanite processing is land-disposed after removal from the settling ponds. An analysis of pond water at facility 3015 showed low values for BOD_5 (2 mg/l) and oil and grease (4 mg/l). Total suspended solids were 11 mg/l and total metals 3.9 mg/l, with iron being the principal metal.

MAGNESITE

The waste stream at the one magnesite facility is the underflow of the tailings thickener which contains large quantities of solid wastes. Make-up water is added to transport these wastes to the tailings pond. The estimated area of this pond is 15 hectares (37 acres). The estimated evaporation at this area is 21 cm/yr (54 in/yr) and the annual rainfall is 2.4 cm/yr (6 in/yr). The waste water is lost about 40 percent by evaporation and about 60 percent by percolation. No discharge from the mill is visible in any of the small washes in the vicinity of the tailings pond, and also, no green vegetative patches, that would indicate the presence of near surface run-offs, were visible. The tailings pond is located at the upper end of an alluvial fan. This material is both coarse and angular and has a rapid percolation rate. This could account for the lack of run-off.

SHALE AND COMMON CLAY

There is no waste water treatment necessary for shale and common clay mining and processing since there is no process water used. When there is rainfall or ground water accumulation, this water is generally pumped out and discharged to abandoned pits or streams.

APLITE

Facility 3020 discharges effluent arising from wet scrubber operations to a creek after allowing settling of suspended solids in a series of ponds. Aplite clays represent a settling problem in that a portion of the clays settles out rapidly but another portion stays in suspension for a long time, imparting a milky appearance to the effluent. The occasional mine pumpout due to rainfall is discharged without treatment.

Facility 3016 recycles water from the settling ponds to the process with only infrequent discharge to a nearby river when pond levels become excessive (every 2 to 3 years). This discharge is state regulated only on suspended solids at 649 mg/l average, and 1000 mg/l for any one day. Actual settling pond water analyses have not been made. When this occurs, the pond is treated with alum to lower suspended solids levels in the discharge. Likewise, when suspended solids levels are excessive for recycle purposes, the pond is also treated with alum.

The solid wastes generated in these processes are land-disposed, either in ponds or as land-fill, with iron bearing sands being sold as beach sand.

TALC MINERALS
(LOG WASHING AND WET SCREENING)

The waste streams emanating from the washing operations are sent to settling ponds. The ponds are dried by evaporation and seepage. In facility 2035, when the ponds are filled with solids, they are harvested for reprocessing into saleable products. There is no discharge from these properties.

TALC (MINE DEWATERING)

Underground mine workings intercept numerous ground water sources. The water from each underground mine is directed through ditches and culverts to sumps at each mine level. The sumps serve as sedimentation basins and seals for centrifugal pumps which discharge this water to upper level sumps or to the surface. In some mines, a small portion of the pump discharge is diverted for use as drill wash water and pump seal water; the remainder is discharged into a receiving waterway. The disposition and quantities of mine discharges are given as follows:

Mine	pH	TSS mg/l	l/day (gal/day)	Disposition
2036	7.5-8.3	4, 9	545,000 (144,000)	Pumped to a swamp
2037	7.8	3	878,000 (232,000)	Pumped to a swamp
2038	8.1	4	1,920,000 (507,000)	Pumped to a swamp
2039	7.0-7.8	1, 3	1,900,000 (507,000)	Open ditch
2040	7.2-8.5	15	1,100,000 (300,000)	Settling basin than to a brook
2041	8.7	28	49,200 (13,000)	Settling basin then to a brook
2042	7.8	9	496,000 (131,000)	Settling basin then to a brook
2043	7.6	5	76,000 (20,000)	Settling basin then to a river

TALC (FLOTATION AND HMS)

At facility 2031, the mill tailings are pumped into one of the three available settling ponds. The overflow from these settling ponds enters by gravity into a common clarification pond. There is a discharge from this clarification pond. The tailings remain in the settling ponds and are dried by natural evaporation and seepage.

At facility 2032, the mill tailings are pumped uphill through 3000 feet of pipe to a pond 34,000,000 liters (9,000,000 gal) in capacity for gravity settling. The overflow from this pond is treated in a series of four settling lagoons. Approximately 40 percent of the last lagoon overflow is sent back to the mill and the remainder is discharged to a brook near the property.

In facility 2033 the filtrate with a pH of 3.5-4.0, the flotation tailings with a pH of 10-10.5 and the primary thickener overflow are combined, and the resulting stream, having a pH of 4.5-5.5, is sent to a small sump in the facility for treating. The effluent pH is adjusted by lime addition to a 6.5-7.5 level prior to discharge into the settling pond. The lime is added by metered pumping and the pH is controlled manually. The effluent from the treating sump is routed to one end of a "U" shaped primary settling pond and is discharged into a secondary or back-up pond. The total active pond area is about 0.8 hectare (2 acres). The clarification pond occupies about 0.3 hectare (0.75 acre). The back-up pond (clarification pond) discharges to an open ditch running into a nearby creek. The non-contact cooling water in facilities 2031 and 2033 is discharged without treatment. Facility 2044 uses a 1.6 hectare (4 acres) settling pond to treat the waste water; the overflow from this pond is discharged. It has been estimated that the present settling pond will be filled within two years' time. This company has leased a new piece of property for the creation of a future pond.

As all process water at facility 2031 is impounded and lost by evaporation, there is no process water effluent out of this property. Facility 2035 a washing facility also has no discharge.

At facilities 2032, 2033, and 2044, the effluent consists of the overflow from their clarification or settling ponds. The significant constituents in these streams are reported to be as follows:

Waste Material Facility Number	2032	2033	2044
pH	7.2-8.5	5.6	7.0
TSS, mg/l	<20 (26)*	80 (8)*	100

*Contractor verification

The average amounts of TSS discharged in these effluents were calculated from the above data to be:

facility	kg/kkg (lb/1000 lb) product
2032	<0.34
2033	0.29
2044	0.50

GARNET

Facility 3037 recycles untreated pit water used in screening operations, and sends water from jigging operations to a settling pond before discharge. Waste water from flotation underflow at facility 3071 is first treated with caustic to stabilize the pH which was acidified from flotation reagents. Then the underflow is sent to a series of tailings ponds. The solids settle out into the ponds and the final effluent is discharged. Water from the dewatering screen is recycled to the heavy media facility. Effluent arising from flotation underflow at facility 3071 is discharged. The pH is maintained at 7. The suspended solids content averaged 25 mg/l.

DIATOMITE

All waste water generated in diatomite preparation at facility 5500 is evaporated. There is no process water, cooling, or mine pumpout discharge. Facilities 5504 and 5505 send waste water to settling ponds with water being recycled to the process at facility 5505 and evaporated and percolated to ground water at facility 5504. But in late 1974 a pump is being installed to enable facility 5504 to decant and recycle the water from the pond to the process. Thus, all of these diatomite operations have no discharge of any waste water.

The oversize fraction and dust fines waste is land-dumped on-site at facility 5500. The solids content of this land-disposed waste is silica (diatomite) in the amount of about 300,000 mg/l. The waste slurries from facilities 5504 and 5505 consisting of scrubber fines and dust are land-disposed with the solids settling into ponds. The solids content of these slurries is 24,000 mg/l for facility 5505 and 146,000 mg/l for facility 5504.

GRAPHITE

The waste streams associated with the operation are flotation tailings and seepage water. The tailings slurry at about 20 percent solids and at a near neutral pH (adjustment made for optimum flotation) is discharged to a partially lined 8 hectare (20 acre) settling pond. The solids settle rapidly and the overflow is discharged. The seepage water from the tailings pond, mine and extraneous surface waters are collected through the use of an extensive network of ditches, dams and sumps. The collected waste waters are pumped to a treatment facility where lime is added to neutralize the acidity and precipitate iron. The neutralized water is pumped to the tailings pond where the iron floc is deposited. The acid condition of the pond seepage results from the extended contact of water with the tailings which dissolve some part of the contained iron pyrites.

It is discharged into a stream that flows into the lake that serves as the intake water source for the facility. The effluent composition falls within the limits established by the Texas State Water Quality Board for the following parameters: flow; pH; total suspended solids; volatile solids; BOD; COD; manganese and iron. Facility measurements compared to the state limitations are:

	facility average mg/l	State Standards 24 hr. maximum mg/l	State Standards monthly average mg/l
Flow l/day (gal/day)		1,160,000 (300,000)	1,820,000 (480,000)
total solids	750	1600	1300
TSS	10	20	10
Volatile Solids	1	10	0.2
Mn	0.1	0.5	-
Total Fe	0.1	2	1
BOD	9	15	10
COD	20	20	15
pH	7.3-8.5	6.8	7.5

This facility has no problem meeting this requirement because of a unique situation where the large volume of tailings entering the pond assists the settling of suspended solids from the acid mine drainage treatment more than that normally expected from a well designed pond.

JADE

Waste waters generated from the wire saw, sanding, and polishing operations are sent to settling tanks where the tailings settle out, and the water is discharged onto the lawn where it evaporates and/or seeps into the ground. Solid wastes in the form of tailings which collect in settling tanks are eventually land-disposed as fill.

Water from the scrubber is sent to a settling tank and clear water is recycled to the scrubber. Cooling water is discharged onto the lawn with no treatment.

PRETREATMENT TECHNOLOGY

Most minerals operations have waste water containing only suspended solids. Suspended solids is a compatible pollution parameter for publicly-owned treatment works. However, most of these mining and processing operations are located in isolated regions and have no access to these treatment facilities. No instances of discharge to publicly-owned treatment facilities were found in the industry. In the relatively few instances where dissolved materials are a problem, pH control and some reduction of hazardous constituents such as fluoride would be required. Lime treatment is usually sufficient to accomplish this. Sulfides would require air oxidation or other chemical treatment.