DRAFT

DEVELOPMENT DOCUMENT
for
EFFLUENT LIMITATIONS GUIDELINES
and
STANDARDS OF PERFORMANCE

MINERAL MINING AND PROCESSING INDUSTRY

VOLUME III

Clay, Ceramic, Refractory and Miscellaneous Minerals

Contract No. 68-01-2633

December 1974

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Notice

The attached document is a DRAFT CONTRACTOR'S REPORT. It includes technical information and recommendations submitted by the Contractor to the United States Environmental Protection Agency ("EPA") regarding the subject industry. It is being distributed for review and comment only. The report is not an official EPA publication and it has not been reviewed by the Agency.

The report, including the recommendations, will be undergoing extensive review by EPA, Federal and States agencies, public interest organizations, and other interested groups and persons during the coming weeks. The report and in particular the contractor's recommended effluent limitations guidelines and standards of performance is subject to change in any and all respects.

The regulations to be published by EPA under Section 304 (b) and 306 of the Federal Water Pollution Control Act, as amended, will be based to a large extent on the report and the comments received on it. However, pursuant to Sections 304 (b) and 306 of the Act, EPA will also consider additional pertinent technical and economic information which is developed in the course of review of this report by the public and within EPA. EPA is currently performing an economic impact analysis regarding the subject industry, which will be taken into account as part of the review of the report. Upon completion of the review process, and prior to final promulgation of regulations, an EPA report will be issued setting forth EPA's conclusions concerning the subject industry, effluent limitation guidelines and standards of performance applicable to such industry. Judgments necessary to promulgation of regulations under Sections 304 (b) and 306 of the Act, of course, remain the responsibility of EPA. Subject to these limitations, EPA is making this draft contractor's report available in order to encourage the widest possible participation of interested persons in the decision making process at the earliest possible time.

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U. S. Environmental Protection Agency
Office of Water and Hazardous Materials
Effluent Guidelines Division
Washington, D. C. 20460

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ABSTRACT

This document presents the findings of an extensive study of selected minerals in the clay, ceramic, refractory and miscellaneous minerals segment of the mineral mining industry for the purpose of developing effluent limitations guidelines for existing point sources and standards of performance and pretreatment standards for new sources, to implement Sections 304, 306 and 307 of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1551, 1314, and 1316, 86 Stat. 816 et. seq.) (the "Act").

Effluent limitations guidelines contained herein set forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available (BPCTCA) and the degree of effluent reduction attainable through the application of the best available technology economically achievable (BATEA) which must be achieved by existing point sources by July 1, 1977 and July 1, 1983, respectively. The standards of performance and pretreatment standards for new sources contained herein set forth the degree of effluent reduction which is achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives.

Based on the application of best practicable technology currently available, 15 of the 22 production subcategories (comprising 18 minerals) under study can be operated with no discharge of process wastewater pollutants to navigable waters. With the best available technology economically achievable, 17 of the 22 production subcategories can be operated with no discharge of process wastewater pollutants to navigable waters. No discharge of process wastewater pollutants to navigable waters is achievable as a new source performance standard for all production subcategories except kaolin (wet), feldspar (wet), talc minerals (flotation), garnet, and graphite.

Supporting data and rationale for development of the proposed effluent limitations guidelines and standards of performance are contained in this report.

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SECTION I

CONCLUSIONS

For purposes of establishing effluent limitations guidelines and standards of performance, and for ease of presentation, the mineral mining industry has been divided into three segments to be published in three volumes: minerals for the construction industry; minerals for the chemical and fertilizer industries; and clay, ceramic, refractory and miscellaneous minerals. This division reflects the end use of the mineral after mining and beneficiation. In this volume covering clay, ceramic, refractory, and miscellaneous minerals, the 18 minerals were grouped into 22 production subcategories for reasons explained in Section IV.

Based on the application of best practicable technology currently available, 15 of the 22 production subcategories under study can be operated with no discharge of process wastewater pollutants to navigable waters. With the best available technology economically achievable, 17 of the 22 production subcategories can be operated with no discharge of process wastewater pollutants to navigable waters. No discharge of process wastewater pollutants to navigable waters is achievable as a new source performance standard for all production subcategories except kaolin (wet), feldspar (wet), talc minerals (flotation), garnet, and graphite. Mine water discharge is not considered process wastewater and is addressed separately.

This study included 18 clay, ceramic, and refractory minerals of SIC categories, 1452, 1453, 1454, 1455, 1459, 1496 and 1499 with significant waste discharge potential. Table I-1 lists the minerals studied in this report.

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

TABLE I-1

LIST OF CLAY, CERAMIC, AND REFRACTORY MINERALS

1. Bentonite
2. Fire Clay
3. Fuller's Earth
    A. Attapulgite
    B. Montmorillonite
4. Kaolin and Ball Clay
5. Feldspar
6. Kyanite
7. Magnesite (Naturally Occurring)
8. Shale and other Clay Minerals
    A. Shale
    B. Aplite
9. Talc, Soapstone, and Pyrophyllite
10. Natural Abrasives
    A. Garnet
    B. Tripoli
11. Diatomite
12. Graphite
13. Miscellaneous Non-Metallic Minerals
    A. Jade
    B. Novaculite

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SECTION II

RECOMMENDATIONS

The recommended effluent limitations guidelines based on best practicable control technology currently available (BPCTCA), are no discharge of process wastewater pollutants (defined in Section IX) to navigable waters for the following minerals/processes:

- bentonite
- fire clay
- fuller's earth (montmorillonite)
- kaolin (dry process)
- feldspar (dry process)
- kyanite
- magnesite (naturally occurring)
- shale
- aplite
- talc minerals group (dry)
- talc minerals group (ore mining and washing)
- tripoli
- diatomite
- jade
- novaculite

The above effluent limitations guidelines are also recommended as the best available technology economically achievable (BATEA) and the new source performance standards (NSPS) for those minerals/processes listed.

The recommended effluent limitations guidelines based on best practicable control technology currently available for the remaining subcategories (not listed above) of the clay, ceramic, refractory, and miscellaneous minerals segment of

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the mineral mining and processing industry are listed in Table II-1.

The recommended effluent limitations guidelines based on best available technology economically achievable are no discharge of process wastewater pollutants to navigable waters for the following minerals/processes:

ball clay

Fuller's earth (attapulgite)

The effluent limitations guidelines based on best available technology economically available for the remaining subcategories (not listed above) of this segment of the mineral mining and processing industry are also listed in Table II-1.

The new source performance standards for those subcategories other than for those for which no discharge of pollutants in process wastewater has been recommended (listed above) are listed in Table II-2.

The recommended mine water discharge limitations for all three levels are a pH of 6-9 and TSS of 20 mg/liter for all subcategories in this segment of the industry except bentonite and fuller's earth (montmorillonite).

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TABLE II-1. Recommended BPCTCA and BATEA for the Clay, Ceramic, Refractory, and Miscellaneous Minerals Segment of the Mineral Mining and Processing Industry, for Process Water Only

Subcategory	Recommended BPCTCA Guideline (kg/kkg) **		BPCTCA	Recommended BATEA Guideline(kg/kkg) **		BATEA
	TSS	other		TSS	other	
Bentonite	none	none	*1	none	none	Same as BPCTCA
Fire Clay	none	none	1	none	none	Same as BPCTCA
Fuller's Earth						
Attapulgite	0.017	none	2	none	none	2+12+8
Montmorillonite	none	none	3	none	none	Same as BPCTCA
Kaolin						
Dry	none	none	1	none	none	Same as BPCTCA
Wet	0.1	Zn 0.002	4;2	0.06	none	2+Sodium hydrosulfite as bleaching agent
Ball Clay	0.17	none	5;2 if wet scrubbers	none	none	Same as BPCTCA +recycle of scrubber water, where required.
Feldspar						
Dry	none	none	11	none	none	Same as BPCTCA
Wet	0.6	F^- 0.15	8;7;2	0.6	F^- 0.1	Same as BPCTCA + additional F^- reduction
Kyanite	none	none	8;2	none	none	Same as BPCTCA
Magnesite (nat.occurring)	none	none	8;2	none	none	Same as BPCTCA
Shale	none	none	1	none	none	Same as BPCTCA
Aplite	none	none	8;2	none	none	Same as BPCTCA
Talc Minerals Group						
Dry	none	none	1	none	none	Same as BPCTCA
Ore Mining & Washing	none	none	8;2	none	none	Same as BPCTCA
Flotation	0.5	none	7;2 and/or 10	0.3	none	Same as BPCTCA +conversion to 5 +additional 2
Garnet	0.4	none	7;2	0.25	none	Same as BPCTCA +13 where necessary
Tripoli	none	none	1	none	none	Same as BPCTCA
Diatomite	none	none	9 and/or 8	none	none	Same as BPCTCA
Graphite	1.6	Mn 0.03 Fe 0.16 BOD 1.6 COD 2.3	7;2	Same as BPCTCA		Same as BPCTCA No proven technology exists to lower levels
Jade	none	none	2;9	none	none	Same as BPCTCA
Novaculite	none	none	3	none	none	Same as BPCTCA

* LEGEND
1 No process water used in mining or processing
2 Settling pond
3 Recycle scrubber water
4 Lime treatment (ppt.zinc)
5 Dry bag dust collector
6 Segregation of plant waste streams
7 pH monitoring and adjustment
8 Recycle
9 Evaporation pond
10 Clarification pond
11 Natural evaporation
12 Flocculants
13 Sand bed filtration

**Kg/kkg of product in all cases except feldspar (wet) which is kg/kkg of ore processed.

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TABLE II-2

RECOMMENDED NEW SOURCE PERFORMANCE STANDARDS

Subcategory		Limitations kg/metric ton (lbs/ton) of product* Monthly average	Daily maximum
Kaolin (wet)		Same as BATEA	Same as BATEA
Feldspar (wet)	TSS	0.4 (0.8)	2.0 (4.0)
	fluoride	0.05 (0.1)	0.1 (0.2)
Talc Minerals (Flotation)		Same as BATEA	Same as BATEA
Garnet		Same as BATEA	Same as BATEA
Graphite		Same as BATEA	Same as BATEA

* For feldspar (wet) only, the limitations are expressed as kg/metric ton (lbs/ton) of ore processed.

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SECTION III

INTRODUCTION

1.0 PURPOSE AND AUTHORITY

The United States Environmental Protection Agency (EPA) is charged under the Federal Water Pollution Control Act Amendments of 1972 with establishing effluent limitations which must be achieved by point sources of discharge into the navigable water of the United States.

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) to the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants. Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of the best practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operation methods and other alternatives. The regulations proposed herein set forth effluent limitations guidelines pursuant to Section 304(b) of the Act for the Mining of Clay, Ceramic, Refractory and Miscellaneous Minerals segment of the Mineral Mining and Processing Industry point source category. Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b)(1)(A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administration published in the Federal Register of January 16, 1973 (38 F.R. 1624), a list of 27 source categories. Publication of an amended list will constitute announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the mineral mining and processing industry. The list will be amended when proposed regulations for the Mineral Mining and Processing Industry are published in the Federal Register.

2.0 SUMMARY OF METHODS USED FOR DEVELOPMENT OF EFFLUENT LIMITATION GUIDELINES AND STANDARDS OF PERFORMANCE

The effluent limitations guidelines and standards of performance proposed herein were developed in a series of systematic tasks. The Mineral Mining and Processing Industry was first studied to determine whether separate limitations and standards are appropriate for different segments within a point source category. Development of reasonable industry categories and subcategories, and establishment of effluent guidelines and treatment standards requires a sound understanding and knowledge of the Mineral Mining and Processing Industry, the processes involved, wastewater generation and characteristics, and capabilities of existing control and treatment methods.

This report describes the results obtained from application of the above approach to the mining of clay, ceramic, refractory, and miscellaneous minerals segment of the mineral mining and processing industry. Thus, the survey and testing covered a wide range of processes, products, and types of wastes.

The products covered in this report are listed below with their SIC designations:

a. Bentonite (1452)
b. Fire Clay (1453)
c. Fuller's Earth (1454)
d. Kaolin and Ball Clay (1455)
e. Feldspar (1459)
f. Kyanite (1459)
g. Magnesite (1459)
h. Shale and other clay minerals, N.E.C. (1459)
i. Talc, Soapstone and Pyrophyllite (1496)
j. Natural abrasives (1499)
k. Diatomite mining (1499)
l. Graphite (1499)
m. Miscellaneous Non-metallic minerals, N.E.C. (1499)

Any of the above minerals which are processed only (3295) are also included.

2.1 Categorization and Waste Load Characterization

The effluent limitation guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first categorized for the purpose of determining whether separate limitations and standards are appropriate for different segments within a point source category. Such subcategorization was based upon raw material used, product produced, manufacturing process employed, and other factors. The raw wastes characteristics for each subcategory were then identified. This included an analysis of (1) the source and volume of water used in the process employed and the sources of waste and waste waters in the plant; and (2) the constituents of all wastewaters including harmful constituents and other constituents which result in degradation of the receiving water. The constituents of wastewaters which should be subject to effluent limitations guidelines and standards of performance were identified.

2.2 Treatment and Control Technologies

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each control and treatment technology, including both in-plant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification of the amount of constituents (including thermal) and the characteristics of pollutants resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology were also identified. In addition, the non-water quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were also identified. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

2.3 Data Base

Cost information contained in this report was obtained directly from industry during plant visits, from engineering firms and equipment suppliers, and from the literature. The information obtained from the latter three sources has been used to develop general capital, operating and overall costs for each treatment and control method. Costs have been put on a consistent industrial calculation basis of ten year straight line depreciation plus allowance for interest at ten percent per year (pollution abatement tax free money) and inclusion of allowance for insurance and taxes for an overall fixed cost amortization of fifteen percent per year. This generalized cost data plus the specific information obtained from plant visits was then used for cost effectiveness estimates in Section VIII and wherever else costs are mentioned in this report.

The data for identification and analyses were derived from a number of sources. These sources included EPA research information, published literature, qualified technical consultation, on-site visits and interviews at numerous mining and processing plants throughout the U.S., interviews and meetings with various trade associations, and interviews and meetings with various regional offices of the EPA. All references used in developing the guidelines for effluent limitations and standards of performance for new sources reported herein are included in Section XIII of this report.

2.4 Exemplary Plant Selection

The following selection criteria were developed and used for the selection of exemplary plants.

a) Discharge effluent quantities

Plants with low effluent quantities or the ultimate of no discharge of process wastewater pollutants were preferred. This minimal discharge may be due to reuse of water, raw material recovery and recycling, or to use of evaporation. The significant parameter was minimal waste added to effluent streams per weight of product manufactured. The amounts of wastes considered here were those added to waters taken into the plant and then discharged.

b) Effluent contaminant level

Preferred plants were those with lowest effluent contaminant concentrations and lowest total quantity of waste discharge per unit of product.

c) Water management practices

Use of good management practices such as water re-use, planning and in-plant water segregation, and the proximity of cooling towers to operating units where airborne contamination of water can occur were considered.

d) Land utilization

The efficiency of land use was considered.

e) Air pollution and solid waste control

Exemplary plants must possess overall effective air and solid waste pollution control where relevant in addition to water pollution control technology. Care was taken to insure that all plants chosen have minimal discharges into the environment and that exemplary sites are not those which are exchanging one form of pollution for another of the same or greater magnitude.

f) Effluent treatment methods and their effectiveness

Plants selected shall have in use the best currently available treatment methods, operating controls, and operational reliability. Treatment methods considered included basic process modifications which significantly reduce effluent loads as well as conventional treatment methods.

g) Plant facilities

All plants chosen as exemplary had all the facilities normally associated with the production of the specific product(s) in question. Typical facilities generally were plants which have all their normal process steps carried out on-site.

h) Plant management philosophy

Plants were preferred whose management insists upon effective equipment maintenance and good housekeeping practices. These qualities are best identified by a high operational factor and plant cleanliness.

i) Geographic location

Factors which were considered include plants operating in close proximity to sensitive vegetation or in densely populated areas. Other factors such as land availability, rainfall, and differences in state and local standards were also considered.

j) Raw materials

Differences in raw materials purities were given strong consideration in cases where the amounts of wastes are strongly influenced by the purity of raw materials used. Several plants using different grades of raw materials were considered for those minerals for which raw material purity is a determining factor in waste control.

k) Diversity of processes

On the basis that all of the above criteria are met, consideration was given to installations having a multiplicity of manufacturing processes. However, for sampling purposes, the complex facilities chosen were those for which the wastes could be clearly traced through the various treatment steps.

l) Production

On the basis that other criteria are equal, consideration was given to the degree of production rate scheduled on water pollution sensitive equipment.

m) Product purity

For cases in which purity requirements play a major role in determining the amounts of wastes to be treated and the degree of water recycling possible, different product grades were considered for subcategorization.

3.0 GENERAL DESCRIPTION OF INDUSTRY BY PRODUCT

Clays and other ceramic and refractory materials differ primarily because of varying crystal structure, presence of significant non-clay materials, variable ratios of alumina and silica, and variable degrees of hydration and hardness. This industry, together with ore mining and coal mining, differs significantly from the process industries for which effluent limitation guidelines have previously been developed. The industry is characterized by an extremely variable raw waste load, depending almost entirely upon the characteristics of then natural deposit. The prevalent pollutant problem is suspended solids, which vary significantly in quantity and treatability.

Clays are a group of important fine-grained nonmetallic minerals which are mostly hydrous aluminum silicates containing various amounts of other inorganic and some organic materials. Some clays, notably the bentonites, have small but important components of exchangeable ions which impart desirable characteristics such as, for the sodium-base bentonite, the ability to swell to many times the original clay volume in water and thus to form a thixotropic gel. Many clays, in particular the fuller's earths, are highly absorptive and others also can be activated by various treatments to become effective absorbents.

Most clays are mined from open pits, using modern surface mining equipment such as draglines, power shovels, scraper-loaders, and shale planers. A few clay pits are operated using crude hand-mining methods. A small number of clay mines (principally underclays in coal-mining areas) are underground operations employing mechanized room and pillar methods. Truck haulage from the pits to processing plants is most common, but other methods involve use of rail transport, conveyor belts, and pipelines in the case of kaolin. Recovery is near 100 percent of the minable beds in open-pit mines, and perhaps 75 percent in the underground operations. The waste-to-clay ratio is highest for kaolin (about 7:1) and lowest for miscellaneous clay (about 0.25:1).

Processing of clays ranges from very simple and inexpensive crushing and screening for some common clays to very elaborate and expensive methods necessary to produce paper coating clays and high-quality filler clays for use in rubber, paint, and other products. Waste material from processing consists mostly of quartz, mica, feldspar, and iron minerals.

Clays are classified into six groups in Bureau of Mines publications. These are kaolin, ball clay, fire clay, bentonite, fuller's earth, and miscellaneous clay. Halloysite is included under kaolin in Bureau of Mines statistical reports. Specifications of clays are based on the method of preparation (crude, air separated, water washed, delaminated, air dried, spray dried, calcined, slip, pulp, slurry, or water suspension), in addition to specific physical and chemical properties.

3.1 Bentonite (SIC 1452)

Bentonites are composed essentially of minerals of the montmorillonite group. The swelling type has a high sodium ion concentration which causes a material increase in volume when the clay is wetted with water, whereas the nonswelling types usually contain high calcium ion concentrations. Standard grades of swelling bentonite increase from 15 to 20 times their dry volume on exposure to water. Specifications are based on pertinent physical and chemical tests, particularly those relating to particle size and swelling index. Bentonite clays are processed using the following processes: weathering, drying, grinding, sizing, and granulation. The supply-demand relationships for bentonite and other clays for 1968 are shown in Figure III-3.1.1.

3.2 Fire Clay (SIC 1453)

The terms "fire clays" and "stoneware clays" are based on refractoriness or on the intended usage (fire clay indicating potential use for refractories, and stoneware clay indicating use for such items as crocks, jugs, and jars). Fire clays are basically kaolinitic but usually include other clay minerals and impurities. Included under the general term fire clay are the diaspore, burley, and burley-flint clays. The fired colors of fire clays range from reds to buffs and grays. Specifications are based on pertinent physical and chemical tests of the clays, and of products made from them.

The fire clays are processed by crushing, calcining and final blending.

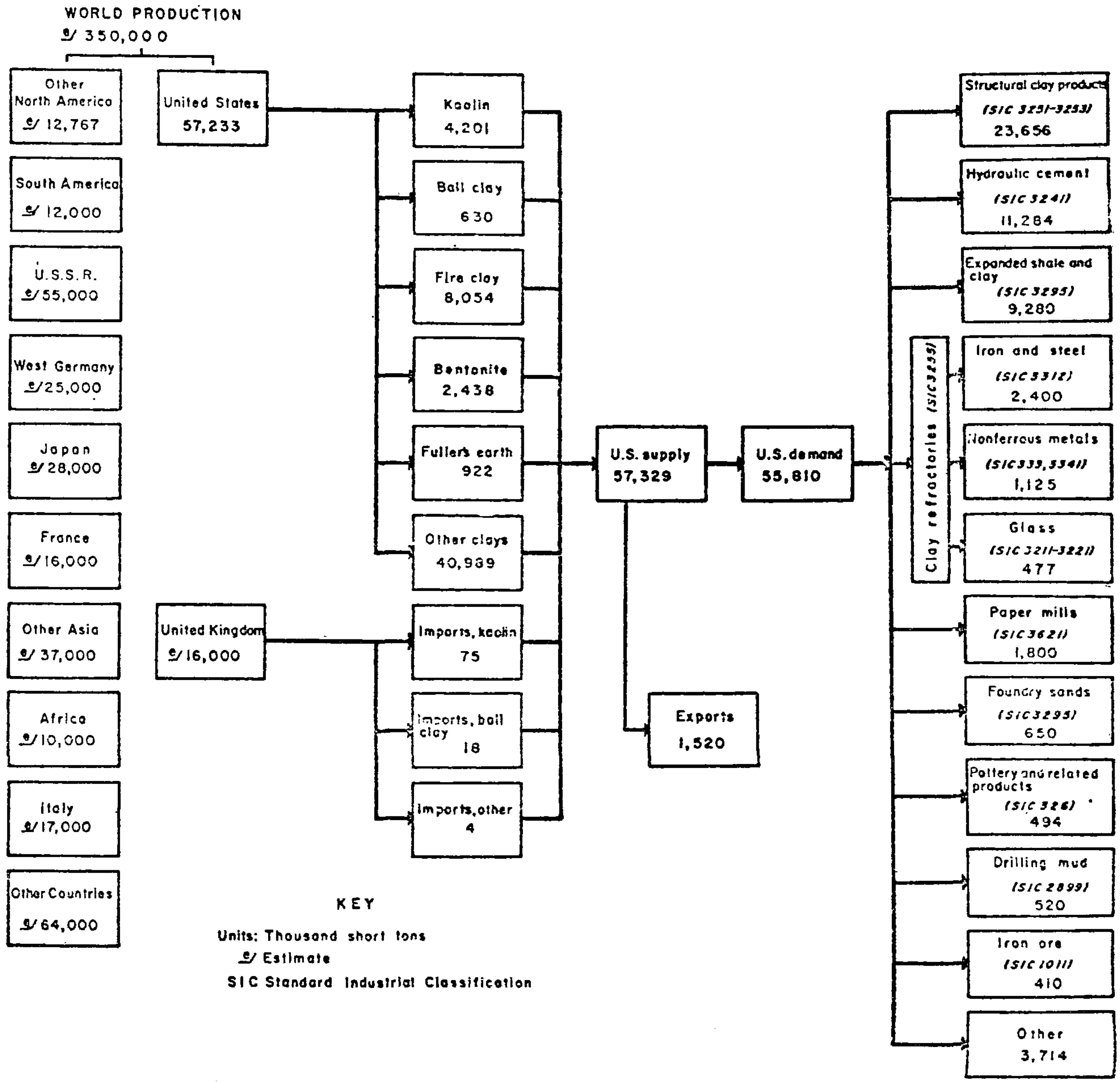

Figure III-3.1.1 Supply-Demand Relationships for Clays, 1968.

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3.3 Fuller's Earth (SIC 1454)

The term "fuller's earth" is derived from the first major use of the material, which was for cleaning wool by fullers. Fuller's earths are essentially montmorillonite or attapulgite for which the specifications are based on the physical and chemical tests of the products. Major uses are for decolorizing oils, edible fluids, and for cat litter.

The fuller's earth clays are processed by blunging, extruding, drying, crushing, grinding and finally sizing according to the requirements of its eventual use.

3.4 Kaolin and Ball Clay (SIC 1455)

Ball clays consist principally of kaolinite, but have a higher silica-to-alumina ratio than is found in most kaolins in addition to larger quantities of mineral impurities and, often, much organic material. They are usually much finer grained than kaolins and, in general, set the standards for plasticity of clays. Specifications for ball clays are based on methods of preparation (crude, shredded, air floated) and pertinent physical and chemical tests, which are much the same as those for kaolin.

The last Bureau of Mines category of clays, is the miscellaneous clay category. Miscellaneous clay may contain some kaolinite and montmorillonite, but usually illite predominates, particularly in the shales. There are no specific recognized grades based on preparation, and very little based on usage, although such a clay may sometimes be referred to as common, brick, sewer pipe, or tile clay. Specifications are based on the physical and chemical tests of the products.

Most of the environmental disturbance related to clay mining and processing is concerned with miscellaneous clays, which are used mostly for making heavy clay construction products, lightweight aggregates, and cement. The environmental considerations are significant, not because the waste products from clay mining are particularly offensive, but because of the large number of operations and the necessity for locating them in or near heavily populated consumption centers. The principal environmental factors involved are dust, noise, and unsightly or incongruous appearance.

Inadequate long-range area planning has often contributed to the environmental disturbance in the past, but the growing awareness of the need for orderly development of area resources should result in improvements in the future.

Environmental disturbances in kaolin mining and processing are of major concern in central Georgia, where most of the high-quality filler grades are produced. Although the clay mining for the most part is not in areas of high population density, the mined areas are extensive, and large amounts of materials are generated. On occasion, flash floods may dump significant quantities of clay wastes into local streams, and although the wastes are not reactive, temporary overloading of the streams might be harmful to some types of marine life. Steps are being taken to alleviate the undesirable conditions by rapid rehabilitation of mined areas and by using the waste materials as fill.

Ball clay mining contributes little mineral waste each year, and since it is spread over several states, does not contribute substantially to environmental disturbance by the clay industry.

3.5 Feldspar

Feldspar is a general term used to designate a group of closely related minerals, especially abundant in igneous rocks and consisting essentially of aluminum silicates in combination with varying proportions of potassium, sodium, and calcium. The principal feldspar species are orthoclase or microcline (both $K_2O \bullet Al_2O_3 \bullet 6SiO_2$), albite ($Na_2O \bullet Al_2O_3 \bullet 6SiO_2$), and anorthite ($CaO \bullet Al_2O_3 \bullet 2SiO_2$). Specimens of feldspar closely approaching the ideal compositions are seldom encountered in nature, however, and nearly all potash feldspars contain significant proportions of soda. Albite and anorthite are really the theoretical end members of a continuous compositional series known as the plagioclase feldspars, none of which, moreover, is ordinarily without at least a minor amount of potash.

Originally, only the high-potash feldspars were regarded as desirable for most industrial purposes. At present, however, in many applications the potash and the soda varieties, as well as mixtures of the two, are considered to be about equally acceptable. Perthite is the name given to material consisting of orthoclase or microcline, the crystals of which are intergrown to an indefinite and variable degree with crystals of albite. Most of the feldspar of commerce can be classified most correctly as perthite. Anorthite and the plagioclase feldspars are of limited commercial importance.

Until a few decades ago virtually all the feldspar employed in industry was material occurring in pegmatite deposits as massive crystals pure enough to require no treatment other than hand cobbing to bring it to usable grade. More recently, however, stimulated by the often unfavorable location of the richer pegmatite deposits relative to markets and by the prospect of eventual exhaustion of such sources, technological advances have created a situation in which more than 90 percent of the total current domestic supply is extracted from such feldspar-bearing rocks as alaskite and from beach sands. A large part of the material obtained from beach sands is in the form of feldspar-silica mixtures that can be used, with little or no additional processing, as furnace feed ingredients in the manufacture of glass. In fact, this use is so predominant that feldspathic sands are considered in volume II of this document under industrial sands.

Feldspar and feldspathic materials in general are mined by various systems depending upon the nature of the deposits being exploited. Because underground operations entail higher costs, as long as overburden ratio will permit and unless land-use conflicts are a decisive factor, most feldspathic rocks will continue to be quarried by open-pit procedures using drills and explosives. Feldspathic sand deposits are mined by dragline excavators.

High-grade, selectively mined feldspar from coarse-structured pegmatites can be crushed in jaw crushers and rolls and then subjected to dry milling in flint-lined pebble mills.

Feldspar ores of the alaskite type are mostly beneficiated by froth flotation processes. The customary procedure begins with primary and secondary comminution and fine grinding in jaw crushers, cone crushers, and rod mills, respectively. The sequence continues with acid-circuit flotation in three stages, each stage preceded by desliming and conditioning. The first flotation step depends on an amine collector to float off and remove mica, and the second uses sulfonated oils to separate iron-bearing minerals. The third step floats the iron- and mica-free feldspar with another amine collector, leaving behind a residue that consists chiefly of quartz.

The supply-demand relationships for feldspar in 1968 are shown in Figure III-3.5.1.

3.6 Kyanite (SIC 1459)

Kyanite and the related minerals --- andalusite, sillimanite, dumortierite, and topaz --- are natural aluminum silicates which can be converted by heating to mullite, a stable refractory raw material with some interstitial glass also being formed. Dumortierite contains boron, and topaz contains fluorine, both of which vaporize during the conversion to mullite.

With exception of the production of a small amount of by-product kyanite-sillimanite from Florida heavy mineral operations, the bulk of domestic kyanite production is derived from two mining operations in Virginia, operated by the same company, and one in Georgia. The mining and process methods used by these producers are basically the same. Mines are open pits in which the hard rock must be blasted loose. The ore is hauled to the nearby plants in trucks where the ore is crushed and then reduced in rodmills. Three-stage flotation is used to obtain a kyanite concentrate. This product is further treated by magnetic separation to remove most of the magnetic iron in a high iron fraction which is wasted. Some of the concentrate is marketed as raw kyanite, while the balance is further ground and/or calcined to produce mullite.

Florida beach sand deposits are worked primarily for zircon ant titanium minerals, but the tailings from the zircon recovery units contain appreciable quantities of sillimanite and kyanite, which can be recovered by flotation and magnetic separations. Production and marketing of Florida sillimanite-kyanite concentrates started in 1968.

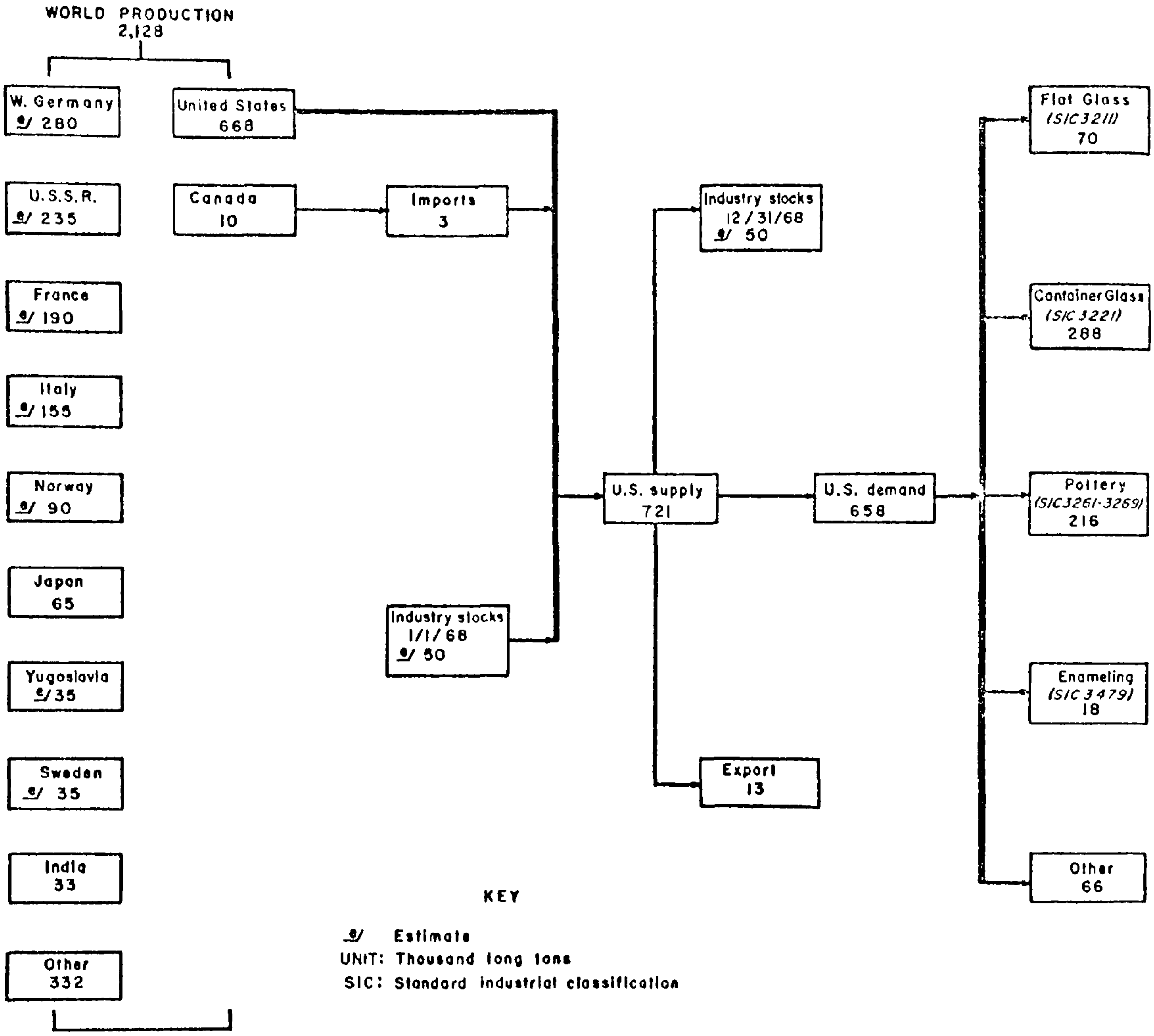

Figure III-3.5.1 Supply-Demand Relationships for Feldspar, 1968

The kyanite producers are located in areas of low population density, and since the waste minerals generated by mining and processing of kyanite ore are relatively inert, and settle rapidly, they present no appreciable environmental problem. The land area involved in kyanite operations is not extensive.

The production and uses of kyanite and related minerals are shown in Figure III-3.6.1.

3.7 Magnesite (SIC 1459)

Magnesium is the eighth most plentiful element in the earth and, in its many forms, makes up about 2.06 percent of the earth's crust. Although it is found in 60 or more materials, only four, dolomite, magnesite, brucite, and olivine, are used commercially to produce its compounds. Currently dolomite is the only domestic ore used as principal raw material for producing magnesium metal. Sea water and brines are also principal sources of magnesium, which is the third most abundant element dissolved in sea water, averaging 0.13 percent magnesium by weight.

Dolomite, the double carbonate of magnesium and calcium and a sedimentary rock commonly interbedded with limestone, extends over large areas of the United States. Most dolomites are probably the result of replacement of calcium by magnesium in preexisting limestone beds.

Magnesite, the natural form of magnesium carbonate, is found in bedded deposits, as deposits in veins, pockets, and shear zones in ferro-magnesium rocks, and as replacement bodies in limestone and dolomite. Significant deposits occur in Nevada, California, and Washington. Brucite, the natural form of magnesium hydroxide, is found in crystalline limestone and as a decomposition product of magnesium silicates associated with serpentine, dolomite, magnesite, and chromite.

Olivine, or chrystolite, is a magnesium iron silicate usually found in association with other igneous rocks such as basalt and gabbro. It is the principal constituent of a rock known as dunite. Commercial deposits are in Washington, North Carolina, and Georgia.

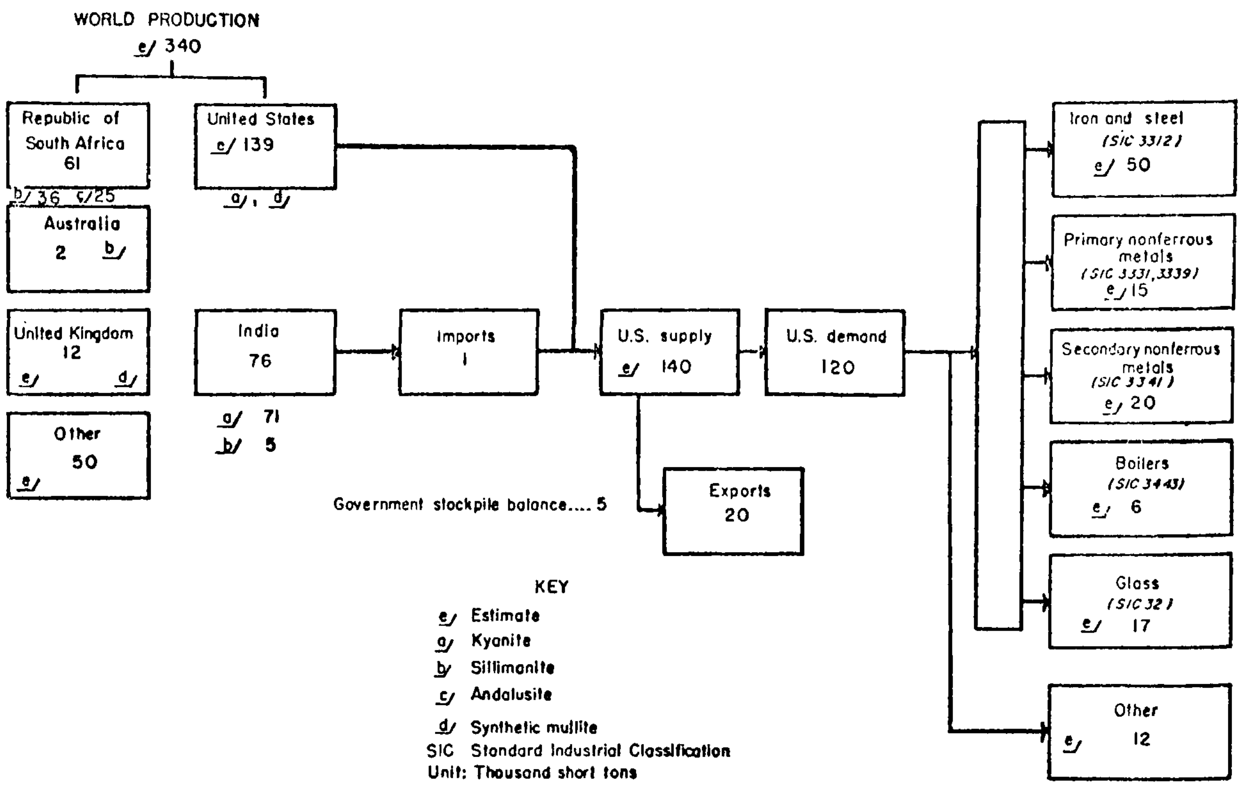

Figure III-3.6.1 Supply-Demand Relationship for Kyanite and Related Minerals, 1968

Evaporites are deposits formed by precipitation of salts from saline solutions. They are found both on the surface and underground. The Carlsbad, New Mexico, and the Great Salt Lake evaporite deposits are sources of magnesium compounds. The only significant commercial source of magnesium compounds from well brines is in Michigan, although brines are known to occur in many other areas.

<u>Mining</u>. Selective open-pit mining methods are being used to mine magnesite at Gabbs, Nevada. This plant is the only known U.S. facility that produces magnesia from naturally occurring magnesite ore.

<u>Processing</u>. Dolomite, magnesite, and brucite ore is delivered from the mines to gyratory or jaw crushers where it is reduced to a minus 5-inch size and carried by belt conveyors to storage piles. The crushed ore is processed according to the manner in which it is to be used. In the case of dolomite, an appreciable quantity of raw, crushed ore is delivered directly to the iron and steel plants and is used as dead-burned dolomite.

In the magnesite refractory plants, the minus 5-inch ore is conveyed to cone crushers which reduce it to sizes averaging 5/8-inch to minus 3/8-inch, and it is screened and washed. The screens are equipped with washing sprays. The minus 3/8-inch ore is then passed over rake classifiers to remove slimes and is ground in ball mills to 98 percent minus 100 mesh; the ground discharge from the ball mills is conveyed to flotation cells where a silicate flotation removes the impurities. The cleaned concentrate is filtered and dried, then conveyed to the reduction plant.

Refractory magnesia is produced from crude magnesite by calcining the ore in rotary kilns at temperatures ranging from 2,640° to 3,200°F. Two classes of refractory magnesia are made: brick grade and maintenance grade. Periclase is produced when a pure grade of MgO is calcined at temperatures above 3,100°F. Brucite is beneficiated in a heavy media process for use as refractory material.

When the source of magnesia is sea water or well brine, the waters are treated with calcined dolomite or lime obtained from oyster shell by calcining, to precipitate the magnesium as magnesium hydroxide. The magnesium hydroxide slurry is filtered to remove water, after which it is conveyed to rotary kilns fired to temperatures that may be as high as 1850°C (3,360°F). The calcined product contains approximately 97 percent MgO.

The principal uses for magnesium compounds follow:

Compound and grade	Use
Magnesium oxide:	
Refractory grades	Basic refractories.
Caustic-calcined	Cement, rayon, fertilizer, insulation, magnesium metal, rubber, fluxes, refractories, chemical processing and manufacturing, uranium processing, paper processing.
U.S.P. and technical grades	Rayon, rubber (filler and catalyst), refractories, medicines, uranium processing, fertilizer, electrical insulation, neoprene compounds and other chemicals, cement.
Precipitated magnesium carbonate	Insulation, rubber, pigments and paint, glass, ink, ceramics, chemicals, fertilizers.
Magnesium hydroxide	Sugar refining, magnesium oxide, pharmaceuticals.
Magnesium chloride	Magnesium metal, cement, ceramics, textiles, paper, chemicals.

Basic refractories used in metallurgical furnaces are produced from magnesium oxide and accounted for over 80 percent ot total domestic demand for magnesium in 1968. Technological advances in steel production required higher temperatures which were met by refractories manufactured from high-purity magnesia capable of withstanding temperatures above 1930°C (3,500°F).

3.8 Shale and Other Clay Minerals N.E.C. (SIC 1459)

3.8.1 Shale

Shale is a soft laminated sedimentary rock in which the constituent particles are predominantly of the clay grade. Just as clay possesses varying properties and uses, the same can be said of shale. Thus, the word shale does not connote a single mineral, inasmuch as the properties of a given shale are largely dependent on the properties of the originating clay species.

Mining of shales depends on the nature of the specific deposit and on the amount and nature of the overburden. Some deposits are mined underground, however, the majority of shale deposits are worked as open quarries.

Shales and common clays are used interchangeably in the manufacture of formed and fired ceramic products and are frequently mixed prior to processing for optimization of product properties. This type of product consumes about 70 percent of shale production. Certain impure shales (and clays) have the property of expanding to a cellular mass when rapidly heated to 1000°-1300°C. On sudden cooling, the melt forms a porous slag-like material which is screened to produce a lightweight concrete aggregate (60-110 lb/ft.^{3}). Probably 20-25 percent of the total market for shale goes into aggregate production.

3.8.2 Aplite

Aplite is a granitic rock of variable composition with a high proportion of soda or lime-soda feldspar. It is therefore useful as a raw material for the manufacture of container glass. Processing of the ore is primarily for the purpose of obtaining sufficient particle size reduction and for removing all but a very small fraction of iron-bearing minerals.

Aplite of sufficient quality is produced in the U.S. from only two mines, both in Virginia (Nelson County and Hanover County). The aplite rock in Hanover County has been decomposed so completely that it is mined without resort to drilling and/or blasting.

3.8.3 Nepheline Syenite

Nepheline syenite is a feldspathic, igneous rock which contains little or no free silica, but does contain nepheline ($K_2O \cdot 3Na_2O \cdot 4Al_2O_3 \cdot 9SiO_2$). The valuable properties of nepheline are the same type as those of feldspar, therefore, nepheline syenite, being a mixture of the two, is a desirable ingredient of glass, whiteware and ceramic glazes and enamels.

A high quality nepheline syenite is mined in Ontario, Canada, and is being imported into the U.S. in ever-increasing quantities for ceramics manufacture.

Deposits of the mineral exist in the U.S. in Arkansas, New Jersey, and Montana, but mining occurs only in Arkansas, just outside of Little Rock. There, the mineral is mined in open pits as a secondary product to crushed rock. Since this is the only mining of this material in the U.S., it will not be considered further.

3.9 Talc, Soapstone and Pyrophyllite (SIC 1496)

The mineral talc is a soft, hydrous magnesium silicate, $3MgO \cdot 4SiO_2 \cdot H_2O$. The talc of highest purity is derived from sedimentary magnesium carbonate rocks; less pure talc from ultra basic igneous rocks; and pyrophyllite, a hydrous aluminum silicate similar to talc in most properties and applications, from acidic igneous rocks.

Steatite has been used to designate a grade of industrial talc that is especially pure and is suitable for making electronic insulators. Block steatite talc is a massive form of talc that can be readily machined, has a uniform low shrinkage in all directions, has a low absorption when fired at high temperature, and gives proper electrical resistance values after firing. Phosphate bonded talc which is approximately equivalent to natural block can be manufactured in any desired amount.

French chalk is a soft, massive variety of talc used for marking cloth.

Soapstones refer to the sub-steatite, massive varieties of talc and mixtures of magnesium silicates which with few exceptions have a slippery feeling and can be carved by hand.

Pyrophyllite is a hydrous aluminum silicate similar to talc in properties and in most applications, and its formula is $Al_2O_3 \bullet 4SiO_2 \bullet H_2O$.

Wonderstone is a term applied to a massive block pyrophyllite from the Republic of South Africa.

During 1968 talc was produced from 52 mines in Alabama, California, Georgia, Maryland, Montana, Nevada, New York, North Carolina, Texas, and Vermont. Soapstone was produced from 13 mines in Arkansas, California, Maryland, Nevada, Oregon, Virginia, and Washington. Pyrophyllite was produced from 10 mines in California and North Carolina. Sericity-schist, closely resembling pyrophyllite in physical and chemical properties, was produced in Pennsylvania and included with pyrophyllite statistics.

Slightly more than half of the industrial talc is mined underground and the rest is quarried as is soapstone and pyrophyllite. Small quantities of block talc also are removed by surface method. Underground operations are usually entirely within the ore body and thus require timber supports that must be carefully placed in talc operations because of the slippery nature of the ore.

Mechanization of underground mines has become common in recent years, especially in North Carolina and California where the ore body ranges in thickness from 10 to 15 feet and dips 12 to 19 degrees from horizontal. In those mines where the ore body suffers vein dips of greater than 20 degrees, complex switch backs are introduced to provide the gentle slopes needed for easier truck haulage of the ore. At one quarry in Virginia, soapstone for decorative facing is mined in large blocks approximately 4 by 8 by 10 feet which are cut into slices by gang saws with blades spaced about 3 inches apart. In the mining of block talc of crayon grade, a minimum of explosive is used to avoid shattering the ore; extraction of the blocks being accomplished with hand equipment to obtain sizes as large as possible.

When mining ore of different grades within the same deposit, selective mining and hand sorting must be used. Operations of the mill and mine are coordinated, and when a certain specification is to be produced at the mill, the desired grade of ore is obtained at the mine. This type of mining and/or hand sorting is commonly used for assuring the proper quality of the output of crude talc-group minerals.

Roller mills, in closed circuit with air separators, are the most satisfactory for fine grinding (100- to 325-mesh) of soft talcs or pyrophyllites. For more abrasive varieties, such as New York talc and North Carolina ceramic-grade pyrophyllite, grinding to 100 to 325 mesh is effected in quartzite- or silex-lined pebble mills, with quartzite pebbles as a grinding medium. These mills are ordinarily in closed circuit with air separators but some times are used as batch grinders, especially if reduction to finer particle sizes is required.

Talc and pyrophyllite are amenable to processing in an additional microgrinding apparatus. Microgrinding or micronizing is also done in fluid-system with subsequent air drying of the product.

The production and uses of talc, soapstone and pyrophyllite are shown in Figure III-3.9.1.

3.10 Natural Abrasives (SIC 1499)

Abrasives consist of materials of extreme hardness that are used to shape other materials by grinding or abrading action. Such materials may be classified as either natural or synthetic (manufactured). Of interest here are the natural abrasive minerals which include cleamorid, corundum, emery, pumice, tripoli and garnet. Of lesser importance, other natural abrasives include feldspar, calcined clays, chalk and silica in its many forms such as sandstones, sand, flint and diatomite.

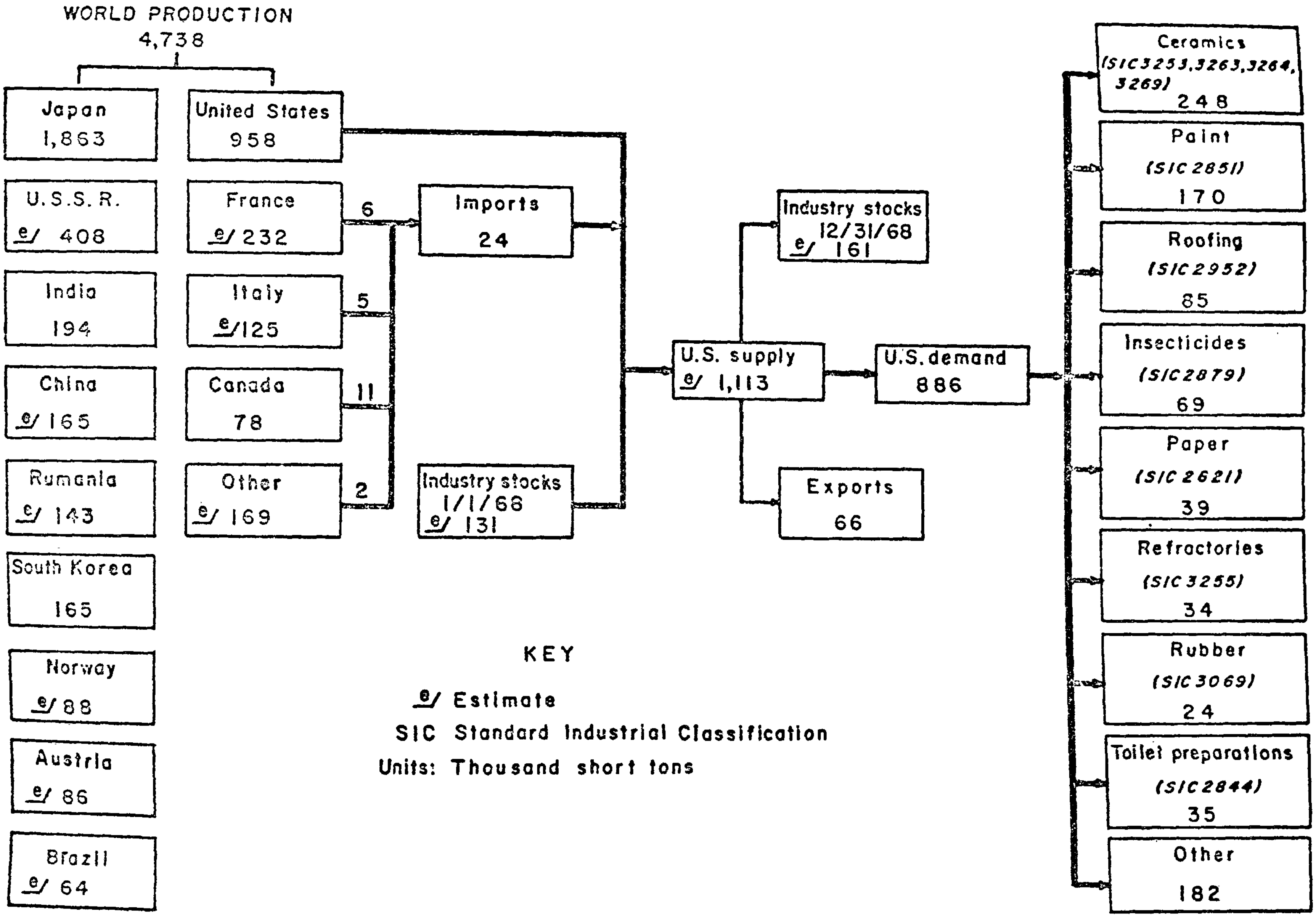

Figure III-3.9.1 Supply-Demand Relationships for Talc, Soapstone, and Pyrophyllite, 1968

Corundum

Corundum is a mineral with the composition Al_2O_3 crystallized in the hexagonal system which was formed by igneous and metamorphic processes.

Abrasive grade corundum has not been mined in the United States for more than 60 years. There is no significant environmental problem posed by the processing of some 2,360 kkg of corundum per year (1968 data).

Emery

Emery consists of an intimate admixture of corundum with magnetite or hematite, and spinel.

The major domestic use of emery involves its incorporation into aggregates as a rough ground product for use as heavy duty non-skid flooring and for skid resistant highways. Additional quantities (25 percent of total consumption) are used in general abrasive applications.

Recent statistics show the continuing down-turn in demand for emery resulting from the increasing competition with such artificial abrasives as Al_2O_3 and SiC. Emery was not considered further in this report because it was not deemed economically significant.

Tripoli

Tripoli is the generic name applied to a number of fine grained, light weight, friable, minutely porous, forms of decomposed siliceous rock, presumably derived from siliceous limestones or calcareous cherts. Tripoli is often confused, in both the trade and technical literature, with tripolite, a diatomaceous earth (diatomite), found in Tripoli, North Africa.

The two major working deposits of tripoli are those in the Seneca, Missouri area and in southern Illinois. The Missouri ore resembles tripolite and was incorrectly named tripoli---the name has persisted and now has definite physical and trade association with the ore from the Missouri-Oklahoma field. The material from the southern Illinois area is often refered to as "amorphous" or "soft" silica. In both cases the ore contains 97 to 99 percent SiO_2 with minor additions of alumina, iron, lime, soda and potash. The rottenstone obtained from Pennsylvania is of higher density and has a composition approximately 60 percent silica, 18 percent alumina, 9 percent iron oxides, 8 percent alkalies and the remainder lime and magnesia.

Tripoli mining involves two different processes depending on the nature of the ore and of the overburden. In the Missouri-Oklahoma area, the small overburden of approximately six feet in thickness coupled with tripoli beds ranging from 2 to 14 feet in thickness, lends itself to open pit mining. The tripoli is first hand sorted for texture and color, then piled in open sheds to air dry (the native ore is saturated with water) for three to six months. The dried material is subsequenly crushed with hammer mills and rolls.

In the southern Illinois field, due to the terrain and the heavy overburden, underground mining using a modified room-and-pillar method is practiced. The resulting ore is commonly wet milled after crushing to 1/4 to 1/2 inch sizing, the silica is fine-ground in tube mills using flint linings and flint pebbles in a closed circuit system with bowl classifiers. The resulting accurately sized product is thickened, dried and packed for shipment.

Tripoli is primarily used as an abrasive or as a constituent of abrasive materials for such uses as polishing and buffing of such materials as copper, aluminum, brass and zinc. In addition, the pulverized product is widely used as the abrasive element in scouring soaps and powders, in polishes for the metal-working trades and as a mild mechanical cleaner in washing powders for fabrics. The pure white product from southern Illinois, when finely ground, is widely used as a filler in paint. The other colors of tripoli are often used as fillers in the manufacture of linoleum, phonograph records, pipe coatings and so forth.

Total U. S. production of tripoli (1971) was of the order of 68,000 kkg, some 70 percent of which was used as abrasive, the remainder as filler.

Garnet

Garnet is an orthosilicate having the general formula $3RO \bullet R_2O_3 \bullet 3SiO_2$ where the bivalent element may be calcium, magnesium, ferrous iron or manganese; the trivalent element, aluminum, ferric iron or chromium, rarely titanium; further, the silicon is occasionally replaced by titanium.

The members of the garnet group of minerals are common accessory minerals in a large variety of rocks, particularly in gneisses and schists. They are also found in contact metamorphic deposits, in crystalline limestones; pegmatites; and in serpentines. Although garnet deposits are located in almost every state of the United States and in many foreign countries, practically the entire world production comes from New York and Idaho. The Adirondack deposit consists of an alamandite garnet having incipient lamellar parting planes which cause it to break under pressure into thin chisel-edge plates. Even when crushed to very fine size this material still retains this sharp slivery grain shape----a feature of particular importance in the coated abrasive field.

The New York mine is a surface site worked by open quarry methods. The ore is quarried in benches about 35 ft. in height, trucked to the mill and dumped on a pan conveyor feeding a 24 x 36 inch jaw crusher. The secondary crusher which is a standard 4 feet Symonds cone is in closed circuit with a 1-1/2 inch screen. The minus 1-1/2 inch material is screened on a 10 mesh screen. The oversize from the screen goes to a heavy media separation plant while the undersize is classified and concentrated on jigs. The very fine material is treated by flotation. The combined concentrates, which have a garnet content of about 98 percent, are then crushed, sized and heat treated. It has been found that heat treatment, to about 700 to 800 degrees C. will improve the hardness, toughness, fracture properties and color of the treated garnets.

The only other significant production of garnets in the United States is situated on Emerald Creek in Benewah County, Idaho. This deposit is an alluvial deposit of alamandite garnets caused by the erosion of soft mica schists in which the garnets have a maximum grain size of about 3/16 inch. The garnet bearing gravel is mined by drag line, concentrated on trommels and jigs then crushed and screened into various sizes. This garnet is used mainly for sandblasting and as filtration media.

Approximately 45 percent of the garnet marketed is used in the manufacture of abrasive coated papers, about 35 percent in the glass and optical industries with the remainder for sand blasting and miscellaneous uses.

3.11 Diatomite (SIC 1499)

Diatomite is siliceous rock of sedimentary origin which may vary in the degree of consolidation but which consists mainly of the fossilized remains of the protective silica shells formed by diatoms, single-celled non-flowering microscopic plants. The size, shape and structure of the individual fossils and their mass packing characteristics result in microscopic porous material of low specific gravity.

There are numerous sediments which contain diatom residues, admixed with substantial amounts of other materials including clays, carbonates or silica; these materials are classified as diatomaceous silts, shales or mudstones; they are not properly diatomite, a designation restricted to material of such quality that it is suitable for commercial uses. The terms diatomaceous earth and kieselgur are synonymous with diatomite; the terms infusorial earth and tripolite are considered obsolete.

Diatomaceous silica is the most appropriate designation of the principal component of diatomite; that is, the substance of the fossil silica shell is the major constituent of beneficiated diatomite of processed diatomaceous products. Commercially useful deposits of diatomite show SiO_2 concentration ranging from a low of 86 percent (Nevada) to a high of 90.75 percent (Lompoc, CA) for the United States producers; the SiO_2 content of foreign sources is somewhat lower. The remainder consists of alumina, iron oxide, titanium oxide, and lesser quantities of phosphate, magnesia, and the alkali metal oxides. In addition, there is usually some residual organic matter as indicated by ignition losses which are typically of the order of 4 to 5 percent.

The formation of diatomite sediments was dependent upon the existence of the proper environmental conditions over an adequate period of time to permit a significant accumulation of the skeletal remains. These conditions include a plentiful supply of nutrients and dissolved silica for colony growth and the existence of relatively quiescent physical conditions such as exist in protected marine estuaries or in large inland lakes. In addition, it is necessary that these conditions existed in relatively recent times in order that subsequent metamorphic processes would not have altered the diatomite to the rather more indurated materials such as porcelanite and the opaline cherts.

The upper tertiary period was the period of maximum diatom growth and subsequent deposit formation. The great beds near Lompoc, CA are upper Miocene and lower Pliocene (about 20×10^6 years old); formations of similar origin and age occur along the California coast line from north of San Francisco to south of San Diego. Most of the dry lake deposits of California, Nevada, Oregon and Washington are of freshwater origin formed in later tertiary of Pleistocene (less than 12×10^6 years old.)

Currently, the only significant production of diatomite within the U.S. is in the western states, with California the leading producer, followed by Nevada, Oregon and Washington. Commonly, beds of ordinary sedimentary rocks such as shales, sandstones, or limestone overlie and underlie the diatomite beds, thus the first step in mining requires the removal of the overburden (which ranges from zero to about 15 times the thickness of the diatomite bed) by ordinary earth moving machinery. The ore is ordinarily dug by power shovels without the necessity of previous fragmentation by drilling or blasting although such operations may be carried out.

Initial processing of the ore involves size reduction by a primary crusher followed by further size reduction and drying (some diatomite ores contain up to 60 percent water) in a blower-hammer mill combination with a pneumatic feed and discharge system. The suspended particles in the hot gases pass through a series of cyclones and a baghouse where they are separated into appropriate particle size groups.

The uses of diatomite result from the size (from 10 to greater than 500 microns in diameter), shape (generally spiny structure of intricate geometry) and the packing characteristics of the diatom shells. Since physical contact between the individual fossil shells is chiefly at the outer points of the irregular surfaces, the resulting compact material is microscopically porous with an apparent density of only 5 to 16 pounds per cubic foot for ground diatomite. The processed material has dimensional stability to temperatures of the order of 400 degrees C. The domestic consumption of diatomite is shown in Figure III-3.11.1.

3.12 Graphite (SIC 1499)

Natural graphite is the mineral form of elemental carbon, crystallized predominately in the hexagonal system, found in silicate minerals of varying kind and percentage. The three principal types of natural occurrence of graphite are classified as lump, amorphous and crystalline flake; a classification based on major differences in geologic origin and occurrence.

Lump graphite occurs as fissure-filled veins wherein the graphite is typically massive with particle size ranging from extremely fine grains to coarse, platy intergrowths or fibrous to acicular aggregates. The origin of vein-type deposits is believed to be either hydrothermal or pneumatolytic since there is no apparent relationship between the veins and the host rock. A variety of minerals generally in the form of isolated pockets or grains, occur with graphite, including feldspar, quartz, mica, pyroxene, zircon, rutile, apatite and iron sulfides.

Amorphous graphite, which is fine-grained, soft, dull black, earthy looking and usually somewhat porous, is formed by metamorphism of coalbeds by nearby intrusions. Although the purity of amorphous graphite depends on the purity of coalbeds from which it was derived, it is usually associated with sandstones, shales, slates and limestones and contains accessory minerals such as quartz, clays and iron sulfides.

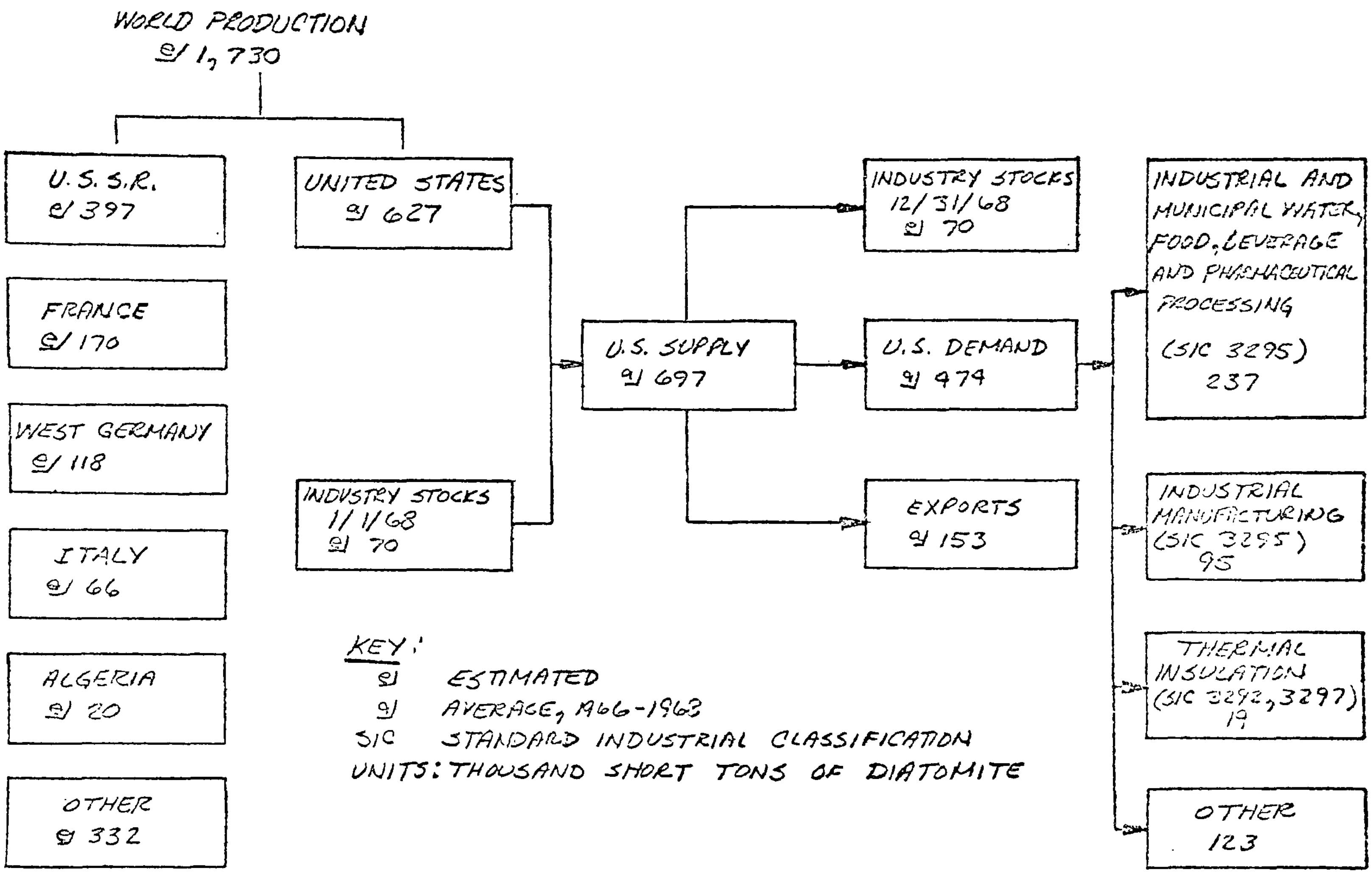

Figure III-3.11.1 Supply-Demand Relationships for Diatomite, 1968

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Flake graphite, which is believed to have been formed by metamorphism from sedimentary carbon inclusions within the host rocks, commonly occurs disseminated in regionally metamorphosed sedimentary rocks such as gneisses, schists and marbles.

Southwestern Graphite Co., near Burnet, Texas, the only domestic producer, mines the flake graphite by open pit methods utilizing an 18-foot bench pan. The ore is hard and tough and thus requires much secondary blasting. The broken ore is hauled by motor-trucks to the mill.

Because of the premium placed upon the mesh size of flake graphite, the problem in milling is one of grinding to free the graphite without reducing the flake size excessively; this is difficult because during grinding, the graphite flakes are cut by quartz and other sharp gangue materials, thus rapidly reducing the flake size. However, if the flake can be removed from most of the quartz and other sharp minerals soon enough, subsequent grinding will usually reduce the size of the remaining gangue, with little further reduction in the size of the flake. Impact grinding or essentially pure flake in a ball mill reduces flake size rather slowly, the grinding characteristics of flake graphite under these conditions being similar to those of mica.

Graphite floats readily and does not require a collector; hence, flotation has become the accepted method for beneficiating disseminated ores. Although high recoveries are common, concentrates with acceptable graphitic carbon content are difficult to attain and indeed with some ores impossible. The chief problem lies with the depression of the gangue minerals since relatively pure grains of quartz, mica, and other gangue minerals inadvertently become smeared with fine graphite, making them floatable resulting in the necessity for repeated cleaning of the concentrates to attain high-grade products. Regrinding a rougher concentrate reduces the number of cleanings needed. Much of the natural flake either has a siliceous skeleton (which can be observed when the carbon is burned) or is composed of a layer of mica between outer layers of graphite making it next to impossible to obtain a high-grade product by flotation.

The supply-demand relationships for 1968 are shown at Figure III-3.12.1.

3.13 Miscellaneous Non-Metallic Minerals, N.E.C. (SIC 1499)

3.13.1 Jade

The term jade is applied primarily to the two minerals jadeite and nephrite, both minerals being exceedingly tough with color varying from white to green. Jadeite, which is a sodium aluminum silicate ($NaAlSi_2O_6$) contains varying amounts of iron, calcium and magnesium is found only in Asia.

Nephrite is a tough compact variety of the mineral tremolite ($Ca_2Mg_5Si_8O_{22}(OH)_2$) which is an end member of an isomorphous series where in iron may replace the magnesium.

In the U.S. production of jade minerals is centered in Wyoming, California and Alaska.

3.13.2 Novaculite

Novaculite is a generic name for massive and extensive geologic formations of hard, compact, homogenous, microcrystalline silica located in the vicinity of Hot Springs, Arkansas. There are three strata of novaculite --- lower, middle, and upper. The upper strata is not compacted and is a highly friable ore which is quarries, crushed, dried and air classified prior to packaging. Chief uses are as filler in plastics, pigment in paints, and as a micro-inch metal polishing agent.

3.13.3 Whetstone

Whetstones, and other sharpening stones, are probably produced in small volume across the U.S. wherever deposits of very hard silaceous rock occur. However, the largest center of sharpening stone manufacture is in the Hot Springs, Arkansas, area. This area has extensive out-cropping deposits of very hard and quite pure silica, called "Novaculite", which are mined and processed into whetstones. Most of the mining and processing is done on a very small scale by individuals or very small companies.

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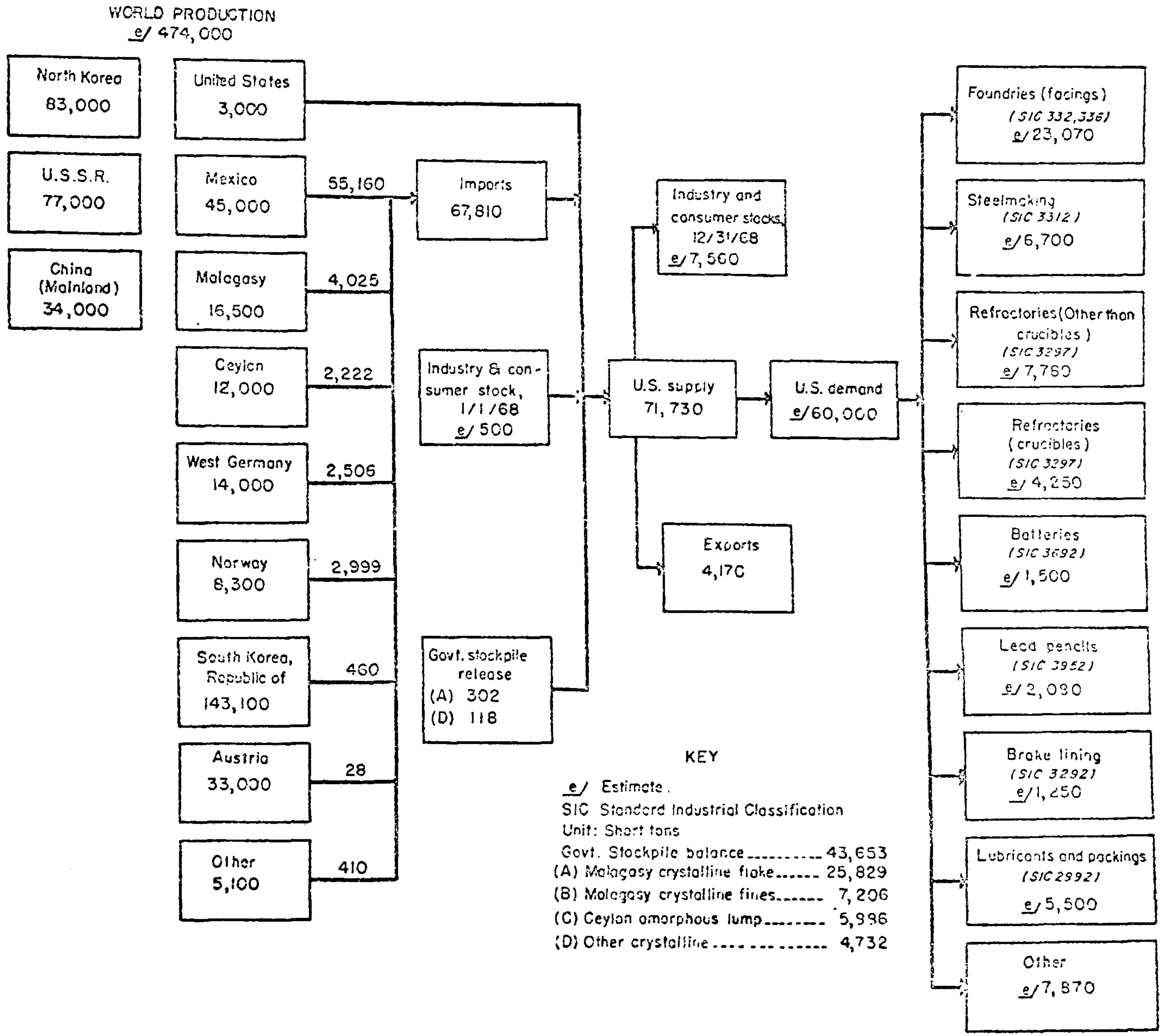

Figure III-3.12.1 Supply-Demand Relationships for Natural Graphite, 1968

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The total production in 1972 of all special silica stone products (grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones) was only 2,940 kkg (3,240 tons), with a value of $670,000. This production and value is not economically significant and will not be treated further in this report.

4.0 PRODUCTION OF CLAY, CERAMIC, REFRACTORY, AND MISCELLANEOUS MINERALS

The 1972 production and employment figures for the clay, ceramic, refractory and miscellaneous minerals industries were derived either from the Bureau of the Census (U.S. Department of Commerce) publications or the Commodity Data Summaries (1974) Appendix I to Mining and Minerals Policy, Bureau of Mines, U.S. Department of the Interior. These figures are tabulated in Table III-1.

Table III-1

1972 U.S. Production and Employment Figures For Clay, Ceramic, Refractory, and Miscellaneous Minerals

Sic Code	Product	Production kkg (tons)	Employment
1452	Bentonite	2,150,000 (2,767,000)	900
1453	Fire clay	3,250,000 (3,581,000)	500
1454	Fuller's Earth	896,000 (988,000)	1,200
1455	Kaolin	4,810,000 (5,318,000)	3,900*
1455	Ball clay	612,000 (675,000)	
1459	Feldspar	664,000 (732,000)	450
1459	Kyanite	Est. 108,000 (Est. 120,000)	165
1459	Magnesite	Withheld	Unknown
1459	Aplite	190,000 (210,000)	Unknown
1459	Crude common Clay	41,840,000 (46,127,000)	2,600
1496	Talc		
1496	Soapstone	1,004,000	950
1496	Pyrophyllite		
1499	Abrasives		
	Garnet	17,200 (19,000)	Unknown
	Tripoli	80,000 (88,000)	Unknown
1499	Diatomite	522,000 (576,000)	500
1499	Graphite	Withheld	54
1499	Jade	107 (118)	Unknown
1499	Novaculite	Withheld	15

* includes ball clay

SECTION IV

INDUSTRY CATEGORIZATION

1.0 INTRODUCTION

In the development of effluent limitations guidelines and recommended standards of performance for new sources in a particular industry, consideration should be given to whether the industry can be treated as a whole in the establishment of uniform and equitable guidelines for the entire industry or whether there are sufficient differences within the industry to justify its division into categories. For this segment of the mineral mining and processing industry, which includes eighteen mineral types, the following factors were considered as possible justifications for industry categorization and subcategorization:

1) manufacturing processes;

2) raw materials

3) pollutants in effluent wastewaters;

4) product purity;

5) water use volume;

6) plant size;

7) plant age; and

8) plant location.

2.0 INDUSTRY CATEGORIZATION

The first categorization step was to segment the mineral mining and processing industry according to product use. Thus, Volume I is "Mining of Minerals for the Construction Industry," Volume II is "Mining of Minerals for the Chemical and Fertilizer Industries," and this volume, Volume III, is

"Mining of Clay, Ceramic, Refractory and Miscellaneous Minerals."

This segment of the industry was categorized on a commodity basis. Each commodity sweeps up in itself some or all of the above-mentioned criteria (processing, raw materials, etc.). However, some differences do exist within a given commodity, e.g., wet and dry process kaolin. Differences such as these were used as a basis for subcategorization. Table IV-1 lists the thirteen categories and twenty-two subcategories discussed in this report.

TABLE IV-1

Industry Categorization

Commodity	SIC Code	Category	Subcategory
Bentonite	1452	1	None
Fire clay	1453	2	None
Fuller's earth	1454	3	3.1 Attapulgite 3.2 Montmorillonite
Kaolin and ball clay	1455	4	4.1.1 Dry Kaolin Mining and Processing 4.1.2 Kaolin Mining and Wet Processing for High Grade Product 4.2 Ball Clay
Feldspar	1459	5	5.1 Feldspar Wet Processing 5.2 Feldspar Dry Processing
Kyanite	1459	6	None
Magnesite	1459	7	None
Shale & Common Clay, NEC	1459	8	8.1 Shale 8.2 Aplite
Talc Minerals Group	1496	9	9.1 Talc Minerals Group, Dry Process 9.2 Talc Minerals Group, Ore Mining & Washing 9.3 Talc Minerals Group, Ore Mining, Heavy Media and Flotation
Natural Abrasives	1499	10	10.1 Garnet 10.2 Tripoli
Diatomite	1499	11	None
Graphite	1499	12	None
Misc. Minerals, NEC	1499	13	13.1 Jade 13.2 Novaculite

3.0 FACTORS CONSIDERED

3.1 Manufacturing Processes

This segment of the mineral mining and processing industry can be divided into three very general classes - dry crushing and grinding, wet crushing and grinding (shaping), and crushing and beneficiation (including flotation, heavy media, et al). Each of these processes is described in detail in Section V of this report, including process flow diagrams pertinent to the specific facilities using the process.

Upon examination of the various processes and wastes generated therefrom, it is evident that the process was justification for subcategorization of the minerals mining industry but not for major segmentation of the industry. An example of this is talc minerals group processing which is carried out by all three general processes mentioned above.

3.2 Raw Materials

The raw materials used are principally ores, which vary across this segment of the industry and also vary within a given deposit. Raw materials are not a suitable basis for categorization.

3.3 Pollutants in Effluent

The principal pollutant from this segment of the mineral mining and processing industry is total suspended solids. There are occasional limited instances of deleterious materials, specifically, zinc from the processing of high grade kaolin and fluoride from feldspar processing. Although suspended solids are ubiquitous, the treatability of the effluents varies widely, depending heavily, among other things, upon the other constituents present in the ore and overburden. Because of the across-the-board presence of suspended solids, distinguished by widely varying degrees of treatability, pollutants in the effluent were not judged to be an adequate basis for categorization.

3.4 Product Purity

The mineral extraction processes covered in this report yield products which vary in purity from what would be considered a chemical technical grade to an essentially analytical reagent quality. Product purity was not considered to be a viable criterion for categorization of the industry. Pure product manufacture usually generates more waste than the production of lower grades of material, and thus may be a basis for subcategorization.

3.5 Water Use Volume

In this segment of the mineral mining industry, water use is determined by the needs of the individual facility and varies greatly depending on both the material extracted and the grade of the ore. For mineral extractive processes studied herein, water use varies from zero to 250,000 liters per metric ton of product.

Water use was not considered to be a workable criterion for industry categorization.

3.6 Plant Size

For this segment of the industry, information was obtained from more than 90 different mineral mining sites. Capacity varied from as little as two metric tons per day to 6,800 metric tons per day. The variance of this factor was so great that plant age was not felt to be useful in categorizing this segment of the industry.

3.7 Plant Age

The newest plant studied was less than a year old and the oldest was 90 years old. There is no correlation between plant age and the ability to treat process wastewater to acceptable levels of pollutants. Therefore, plant age was not an acceptable criterion for categorization.

3.8 Plant Location

The locations of the more than 90 mineral mining and processing sites studied are in twenty states spread from coast to coast and north to south.

Some plants are located in arid regions of the country, allowing the use of evaporation ponds and surface disposal on the plant site. Other plants are located near raw material mineral deposits which are highly localized in certain areas of the country.

In these instances geographical location was felt to be a legitimate criterion for industry subcategorization.

Thus, plant location was used for further segmentation within a category, but not for categorization.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

1.0 INTRODUCTION

This section discusses the specific water uses in the clay, ceramic, refractory, and miscellaneous minerals segment of the mineral mining and processing industry, and the amounts of process waste materials contained in these waters. The process wastes are characterized as raw waste loads emanating from specific processes in the extraction of the materials involved in this study and are given either in terms of kilograms per metric ton of product produced or ore processed (pounds per short ton). The specific water uses and amounts are given in terms of liters per metric ton of product produced or ore mined (gallons per short ton) for each of the facilities contacted in this study. The treatments used by the mining and processing facilities studied are specifically described and the amount and type of water borne waste effluent after treatment is characterized.

The verification sampling data measured at specific exemplary facilities for each subcategory is set forth in Supplement B of this report. A description of the analytical techniques used for this verification of plant data is also provided in Supplement B.

2.0 SPECIFIC WATER USES

Water is used in the mineral mining and processing industry for seven principal purposes falling under three major characterization headings. The principal water uses are:

(1) Non-contact cooling water
(2) Process water - wash water
    transport water
    scrubber water
    process and product consumed water
    miscellaneous water
(3) Auxiliary processes water

Non-contact cooling water is defined as that cooling water which does not come into direct contact with any raw material, intermediate product, by-product or product used in or resulting from the process.

Process water is defined as that water which, during the manufacturing process comes into direct contact with any raw material, intermediate product, by-product or product used in or resulting from the process.

Auxiliary processes water is defined as that used for processes necessary for the manufacture of a product but not contacting the process materials. For example, water treatment regeneration is an auxiliary process.

The quantity of water usage for facilities in the clay, ceramic, refractory and miscellaneous minerals segment of the mineral mining and processing industry generally ranges from zero to 2,200,000 liters per day (0 to 580,000 gallons per day). In general, the plants using very large quantities of water use it for heavy media separation and flotation processes and, in some cases, wet scrubbing and non-contact cooling.

2.1 Non-Contact Cooling Water

The largest use of non-contact cooling water in this segment of the mineral mining industry is for the cooling of equipment, such as kilns, pumps and air compressors.

2.2 Contact Cooling Water

Insignificant quantities of contact cooling water is used in this segment of the mineral mining industry. When used, it usually either evaporates immediately or remains with the product.

2.3 Wash Water

This water also comes under the heading of process water because it comes into direct contact with either the raw material, reactants or products. Examples of this type of water usage are ore washing to remove fines and filter cake washing. Waste effluents can arise from these washing sources, due to the fact that the resultant solution or suspension may contain impurities or may be too dilute a solution to reuse or recover.

2.4 Transport Water

Water is widely used in the mineral mining industry to transport ore to and between various process steps. Water is used to move crude ore from mine to plant, from crushers to grinding mills and to transport tailings to final retention ponds.

2.5 Scrubber Water

Particularly in the dry processing of many of the minerals in this industry, wet scrubbers are used for air pollution control. These scrubbers are primarily used on dryers, grinding mills, screens, conveyors and packaging equipment.

2.6 Process and Product Consumed Water

Process water is primarily used in this industry during blunging, pug milling, wet screening, log washing, heavy media separation and flotation unit processes. The largest volume of water is used in the latter two processes. Product consumed water is often evaporated or shipped with the product as a slurry or wet filter cake.

2.7 Miscellaneous Water

These water uses vary widely among the facilities with general usage for floor washing and cleanup, safety showers and eye wash stations and sanitary uses. The resultant streams are either not contaminated or only slightly contaminated with wastes. The general practice is to discharge such streams without treatment or combine with process water prior to treatment.

Another miscellaneous water use in this industry involves the use of sprays to control dust at crushers, conveyor transfer points, discharge chutes and stockpiles. This water is usually low volume and is either evaporated or absorbed in the ore.

2.8 Auxiliary Processes Water

Auxiliary processes water include blowdowns from cooling towers, boilers and water treatment. The volume of water used for these purposes in this industry is minimal. However, when they are present, they usually are highly concentrated in waste materials.

3.0 PROCESS WASTE CHARACTERIZATION

The mineral products are discussed in SIC Code numerical sequence in this section. For each mineral product the following information is given:

-- a short description of the processes at the facilities studied and pertinent flow diagrams;

-- raw waste load data per unit weight of product or raw material processed;

-- water consumption data per unit weight of product or raw material processed;

-- specific plant waste effluents found and the post-process treatments used to produce them.

3.1 Bentonite

3.1.1 Process Description

Bentonite is mined in dry, open pit quarries. After the overburden is stripped off, the bentonite ore is removed from the pit using bulldozers, front end loaders, and/or pan scrapers. The ore is hauled by truck to the processing plant. There, the bentonite is crushed, if necessary, dried, sent to a roll mill, stored, and shipped, either packaged or in bulk.

Dust generated in drying, crushing, and other plant operations is collected using cyclones and bags. In plant 3030 this dust is returned to storage bins for shipping. A general process flowsheet is given in Figure V-3.1.1.

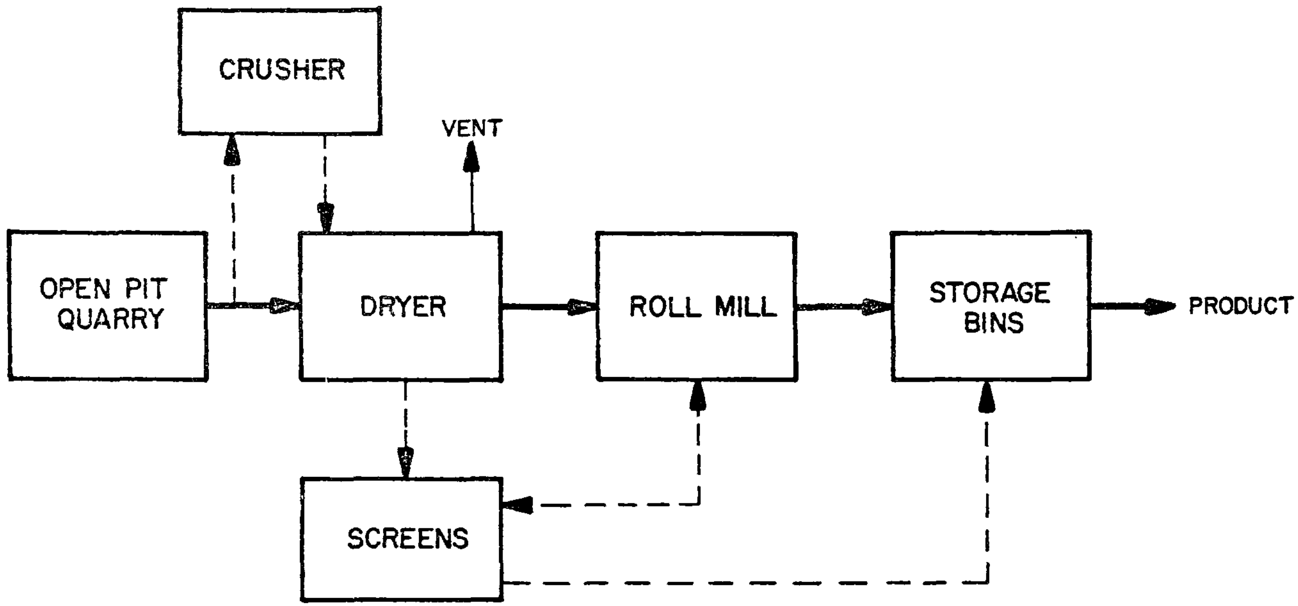

FIGURE V-3.1.1
BENTONITE MINING AND PROCESSING

DRAFT

3.1.2 Raw Waste Load

Waste is generated in the mining of bentonite in the form of overburden, which must be removed to reach the bentonite deposit.

Waste is generated in the processing of bentonite as dust from drying, crushing, and other plant operations.

3.1.3 Water Use

There is no water used in the mining or processing of bentonite.

3.1.4 Waste Water Treatment

Since there is no water used in bentonite mining or processing, no wastewater is generated.

3.1.5 Effluent and Disposal

There is no discharge of any wastewater 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.

3.2 Fire Clay

Fire clay is principally kaolinite but usually contains other materials such as diaspore, ball clay, bauxitic clay, and shale. Its main use is in refractory production and only the mining is covered here. Due to the similarity in all types of clay mining, this section will also serve for common clay mining not in conjunction with manufacturing.

3.2.1 Process Description

Fire clay is obtained from open pits using bulldozers and front-end loaders for removal of the clay. Blasting is occasionally necessary for removal of the hard shale-like flint clay. The clay is then transported by truck to the plant for processing. This processing includes crushing, screening, and other specialized steps, for example, calcination. There is at least one case (plant 3047) where the clay is shipped without processing. However, most of the fire clay mined is used near the mine site for producing refractories. A general process diagram is given in Figure V-3.2.1.

3.2.2 Raw Waste Load

The solid waste generated in fire clay mining is overburden which is used as fill to eventually reclaim mined-out areas. Pit pumpout is the only other waste in this subcategory.

3.2.3 Water Use

There is no water used in fire clay mining. However, due to rainfall and ground water seepage, there can be water which accumulates in the pits and must be removed. Pit pumpout is intermittent depending on frequency of rainfall and geographic location. Flow rates are not generally available. In many cases, however, the plants provide protective earthen dams and ditches to prevent accumulation of rainwater in the clay pits.

3.2.4 Waste Water Treatment

There is no processing wastewater. In some cases, settling ponds are employed to reduce the amount of suspended solids in the pit pumpout before discharge. Usually, pit pumpout is discharged to a nearby body of water, to a watershed, or is evaporated on-land.

3.2.5 Effluent and Disposal

Pit pumpout is discharged either after settling or with no treatment. There is no discharge of process wastewaters.

3.3 Fuller's Earth

Fuller's Earth is a clay, usually high in magnesia, which has decolorizing and absorptive properties. Production from the region that includes Decatur County, Georgia, and Gadsden County, Florida, is composed predominantly of the distinct clay mineral attapulgite. Most of the Fuller's

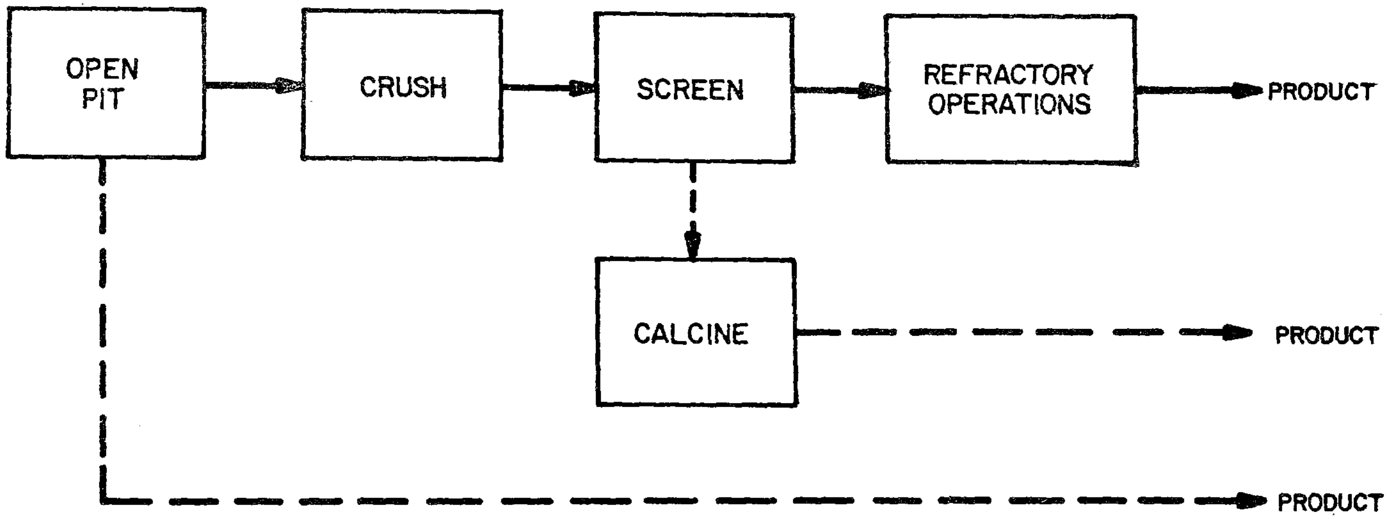

FIGURE V-3.2.1
FIRE CLAY MINING AND PROCESSING

Earth occurring in the other areas of the U.S. contains primarily montmorillonite. Thus, two subcategories are pertinent in this section: attapulgite and montmorillonite.

Five plants, representing 83 percent of the total U.S. production of Fuller's Earth, provided the data for this section.

3.3.1 Attapulgite

3.3.1.1 Process Description

Attapulgite is mined from open pits, with removal of overburden using scrapers and draglines. The clay is also removed using scrapers and draglines and is trucked to the plant for processing. Processing consists of crushing and grinding, screening and air classification, pug milling (optional), and a heat treatment that may vary from simple evaporation of excess water to thermal alteration of crystal structure. A general process diagram is given in Figure V-3.3.1.

3.3.1.2 Raw Waste Load

Solid waste is generated in attapulgite mining as overburden which is used as fill to reclaim worked-out areas.

Waste in the form of dusts and fines is generated from drying and screening operations at plant 3060. This waste is sent to worked-out pits which serve as settling ponds, and the solids settle out.

At plant 3058 waste is generated from screening operations as fines which are slurried and pumped to settling ponds.

No data is available on the amounts of these solid wastes generated in attapulgite processing.

3.3.1.3 Water Use

No water is used in the mining, but rain and ground water do collect in the pits, particularly during the rainy season. This type of clay settles rapidly and pit pumpout is generally clear except when overburden gets into the water.

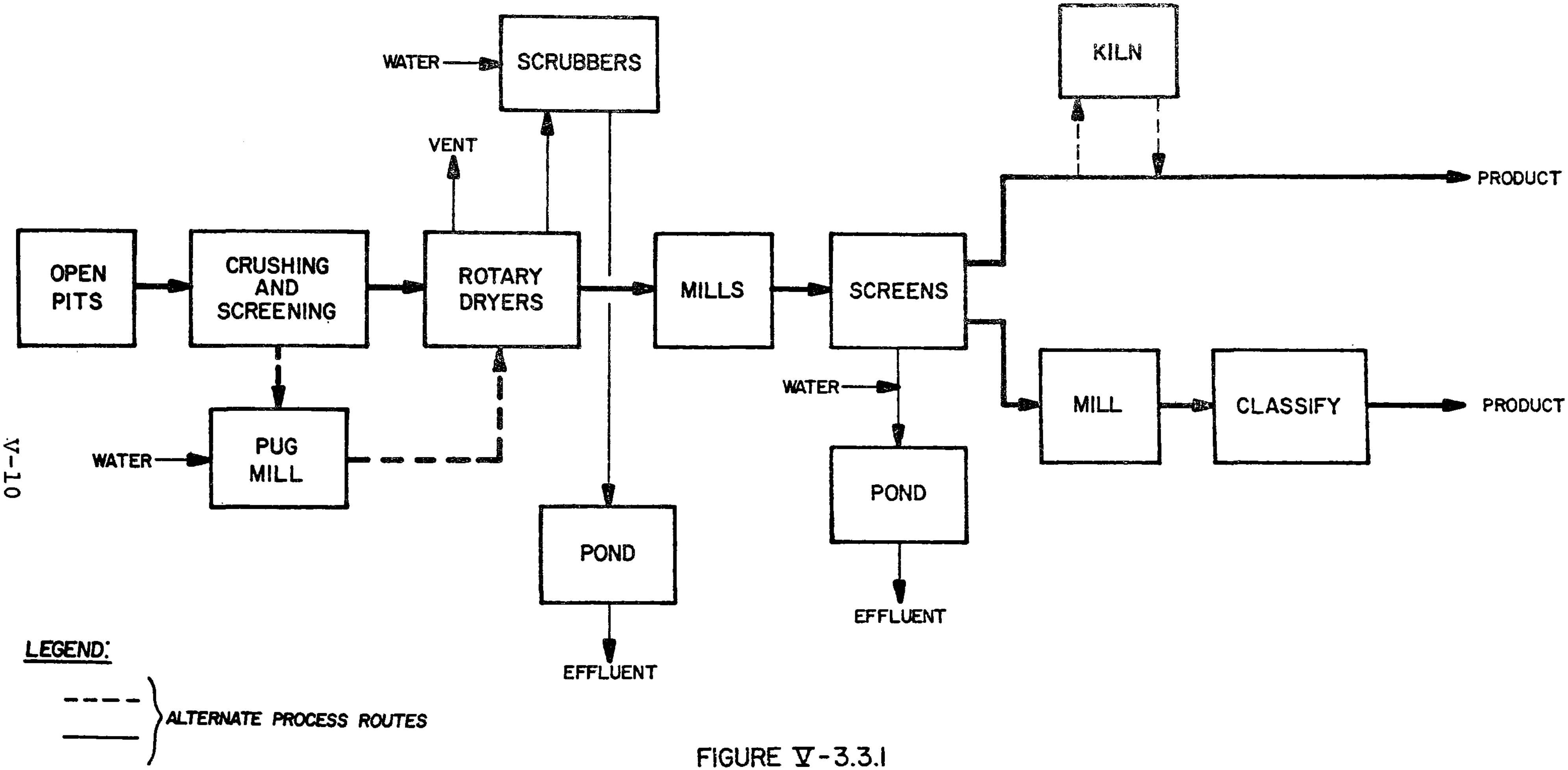

FIGURE V-3.3.1
FULLER'S EARTH MINING AND PROCESSING
(ATTAPULGITE)

There are no settling ponds used at the mines for pit pumpout.

Untreated creek water serves as source and make-up for plants 3058 and 3060. Water is used by plant 3058 for cooling, pug milling, and waste fines slurrying. Plant 3060 also uses water for cooling and pug milling, and, in addition, uses water in dust scrubbers for air pollution control. There is no recycle of process water at either plant, all being evaporated, sent to ponds, and/or eventually discharged. Typical flows are:

	liter/metric ton of product (gal/ton) 3058	3060
Intake:		
Make-up	460 (110) includes average intermittent needs	total unknown
Use:		
cooling	184 (44)	unknown amount
waste disposal and dust collection	230 (55) intermittent	345-515 (82-122)
pug mill	46 (11)	42 (10)
Consumption:		
cooling water discharge	none	unknown
process discharge	230 (55)	440 (105)
evaporation	230 (55)	42 (10)
Total	460 (110)	unknown

3.3.1.4 Waste Water Treatment

Pit pumpout at both attapulgite plants is discharged without treatment to a nearby creek.

Bearing cooling water at plant 3060 is pumped directly back to the creek, with no treatment, while water used in pugging and kiln cooling is evaporated in the process. Scrubber waters are directed to worked-out pits which serve as settling ponds before discharge back to the creek.

At plant 3058 cooling and pug mill water is evaporated in the process. Water used to slurry waste fines for disposal is pumped to settling ponds, from which clear effluent is returned to the creek.

3.3.1.5 Effluent and Disposal

Effluents from both plants arise from waste disposal; slurrying of waste fines at 3058 and scrubber water from dust collection at 3060. Both plants send these effluents through settling ponds for reduction of suspended solids and then discharge to a nearby creek.

There is no data available from plant 3058 on effluent quality. A water analysis, based on one twenty-four hour composite, shows effluent quality of plant 3060:

parameter	discharge
suspended solids	21 mg/liter
pH	7.4

Based on this analysis, the calculated average amount of suspended solids discharged at plant 3060 is 0.01 kg per metric ton of product (0.02 lb/ton).

3.3.2 Montmorillonite

Montmorillonite wastes present more of a settling problem in water than attapulgite wastes. The information presented below is based on 3 of 4 plants in this subcategory. This represents over 80 percent of the U.S. montmorillonite production.

3.3.2.1 Process Description

Montmorillonite is mined from open pits. Overburden is removed by scrapers and/or draglines, and the clay is draglined and loaded onto trucks for transport to the plant. Processing consists of crushing, drying, milling, screening, and, for a portion of the clay, a final drying prior to packaging and shipping. A general process diagram is given in Figure V-3.3.2.

3.3.2.2 Raw Waste Load

Solid waste generated in mining montmorillonite is overburden which is used as fill to reclaim worked-out pits.

Waste is generated in processing as dust and fines from milling, screening, and drying operations. The dust and fines which are gathered in bag collectors from drying operations are hauled, along with milling and screening fines, back to the pits as fill. Slurry from scrubbers is sent to a settling pond with the muds being returned to worked-out pits after recycling the water. There are no data available on the amount of these solid wastes.

3.3.2.3 Water Use

There is no water used in the mining operations. However, rain water and ground water collect in the pits forming a murky colloidal suspension of the clay. This water is pumped to worked-out pits where it settles to the extent possible and is discharged intermittently to a nearby body of water, except in the case of plant 3073 which uses this water as scrubber water makeup. The estimated flow is up to 1140 liters per day (300 GPD).

Water is used in processing only in dust scrubbers. Typical flows are:

	liter/metric ton product (gal/ton)		
Plant	3059	3072	3073
Intake	1,930 (460)	500 (120)	143 (34)
Use:			
Dust Scrubbers	1,930 (460)	500 (120)	143 (34)
Consumption:			
Discharge	none	150 (36)	none
Evaporation plus Landfill of Solid Wastes	1,930 (460)	350 (84)	143 (34)

Plants 3059 and 3073 recycle essentially 100 percent of the scrubber water.

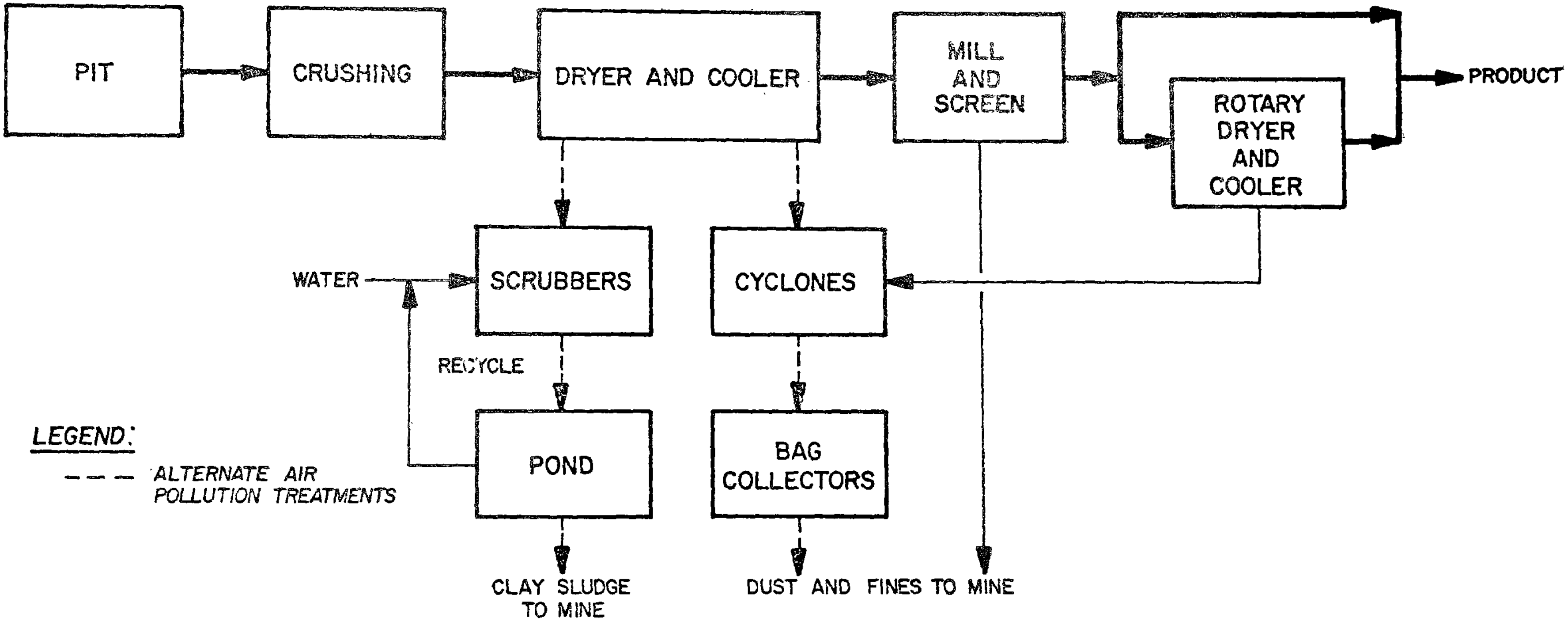

FIGURE V-3.3.2
FULLER'S EARTH MINING AND PROCESSING
(MONTMORILLONITE)

3.3.2.4 Waste Water Treatment

Plants 3059 and 3073 recycle essentially 100 percent of the scrubber water, while plant 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. Plants 3059 and 3073 use ammonia to neutralize recycle scrubber water, forming ammonium sulfate. This ammonium sulfate settles into the muds collected in the settling pond, which are then returned to worked-out pits. Plant 3072 uses lime ($Ca(OH)_2$), which forms 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, plant 3072 intends to recycle all scrubber water by mid-1975.

Pit pumpout presents a greater problem for montmorillonite producers than for attapulgite producers, due to the very slow settling rate of the suspended clay. Accumulated rain and ground water is pumped to abandoned pits for settling to the extent possible and is then discharged. No data was furnished on the volume or quality of the discharge. A pit pumpout sample from plant 3059 (Versar data) had a TSS of 215 mg/liter. At plant 3073 the pit water is used as makeup for the scrubber water.

3.3.2.5 Effluent and Disposal

There is no process discharge from plants 3059 and 3073. Plant 3072 discharges a small amount of scrubber water after settling and lime treatment. This effluent contains 0.2 percent suspended solids and has a pH of 8. This effluent corresponds to an average TSS of 0.3 kg per metric ton of product (0.6 lb/ton).

The settling pond muds at all three plants are landfilled in worked-out pits.

3.4 Kaolin and Ball Clay (SIC 1455)

3.4.1 Kaolin

Kaolin is produced in mines in 17 states with Georgia accounting for the bulk (75%) of the U.S. production. Six kaolin mines and plants distributed between eastern and western U.S. were contacted representing 48 percent of the total kaolin production in the U.S.

Plants were found having different water usages, so two subcategories are established for kaolin processing; wet for high grade product, and dry, for general purpose use.

3.4.1.1 Dry Process

3.4.1.1.1 Process Description

The clay is mined in open pits using shovels, caterpillars, carry-alls and pan scrapers. Trucks haul the kaolin to the plant for processing. At plants 3035, 3062, 3063 the clay is crushed, screened, and used for processing to refractory products. Processing at plant 3036 consists of grinding, drying, classification and storage. A general dry process diagram is given in Figure V-3.4.1.

3.4.1.1.2 Raw Waste Load

There is no waste generated in the mining of the kaolin other than overburden, and in the processing, solid waste is generated from classification. No data is available on the amount of this waste.

3.4.1.1.3 Water Use

There is no water used in the mining or processing of kaolin at these four plants. There is rainwater and ground water which accumulates in the pits and must be pumped out. The quantity of this pit pumpout is unknown.

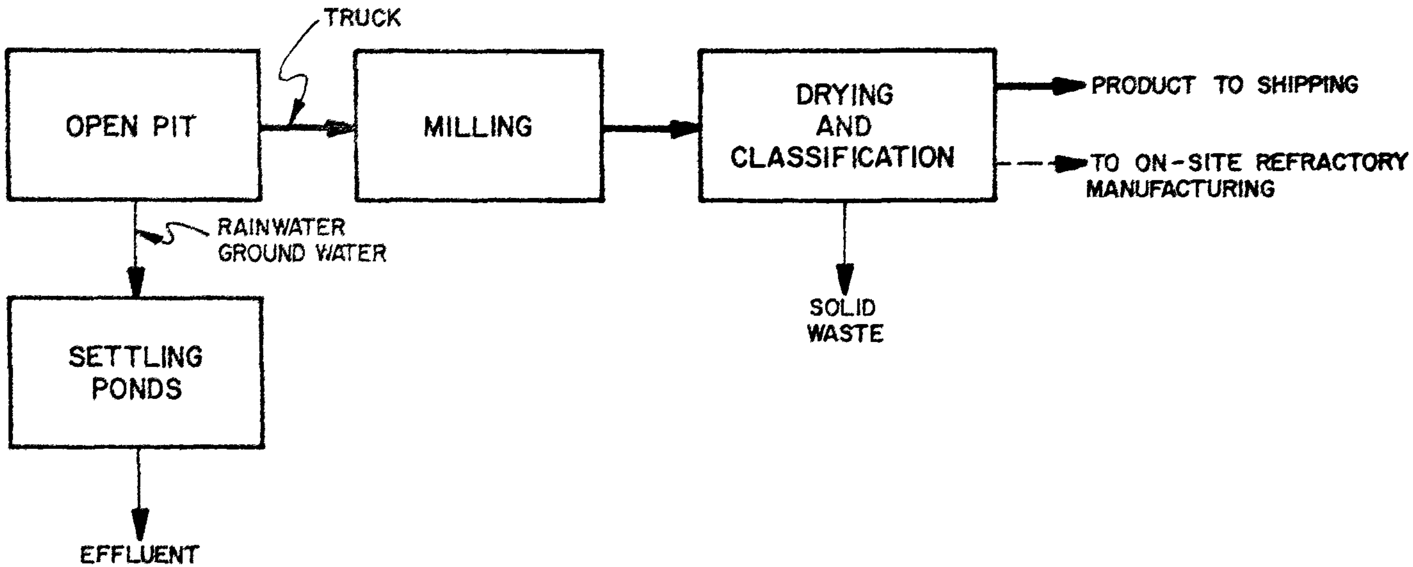

FIGURE V-3.4.1
DRY KAOLIN MINING AND PROCESSING
FOR GENERAL PURPOSE USE

3.4.1.1.4 Waste Water Treatment

There is no process wastewater generated at any of the four plants, but the pit pumpout is normally sent through a series of small settling ponds before discharge.

3.4.1.1.5 Effluent and Disposal

The solid waste generated is land-disposed on-site. There is no process effluent discharged. The pit pumpout is, in most instances, sent through a series of settling ponds to reduce the suspended solids. The effluent composition is unknown.

3.4.1.2 Wet Process

3.4.1.2.1 Process Description

Sixty percent of the U.S. production of kaolin is by this general process.

Mining of kaolin is an open pit operation using draglines or pan scrapers. The clay is then trucked to the plant or, in the case of plant 3025, some preliminary processing is performed near the mine site including blunging or pug milling, degritting, screening and slurrying to pump the clay to the main processing plant. Subsequent operations are hydroseparation and classification, chemical treatment (principally bleaching with zinc hydrosulfite), filtration, and drying (via tunnel dryer, rotary dryer or spray dryer). For special properties, other steps can be taken such as magnetic separation, delamination or attrition (plant 3024). Also, plant 3025 ships part of the kaolin product as slurry (70% solids) in tank cars. A general wet process diagram is given in Figure V-3.4.2.

3.4.1.2.2 Raw Waste Load

Waste is generated in kaolin mining as overburden which is stripped off to expose the kaolin deposit.

In the processing, waste is generated as underflow from hydroseparators and centrifuges (plant 3024), and sand and muds from filtration and separation operations. Zinc ion is

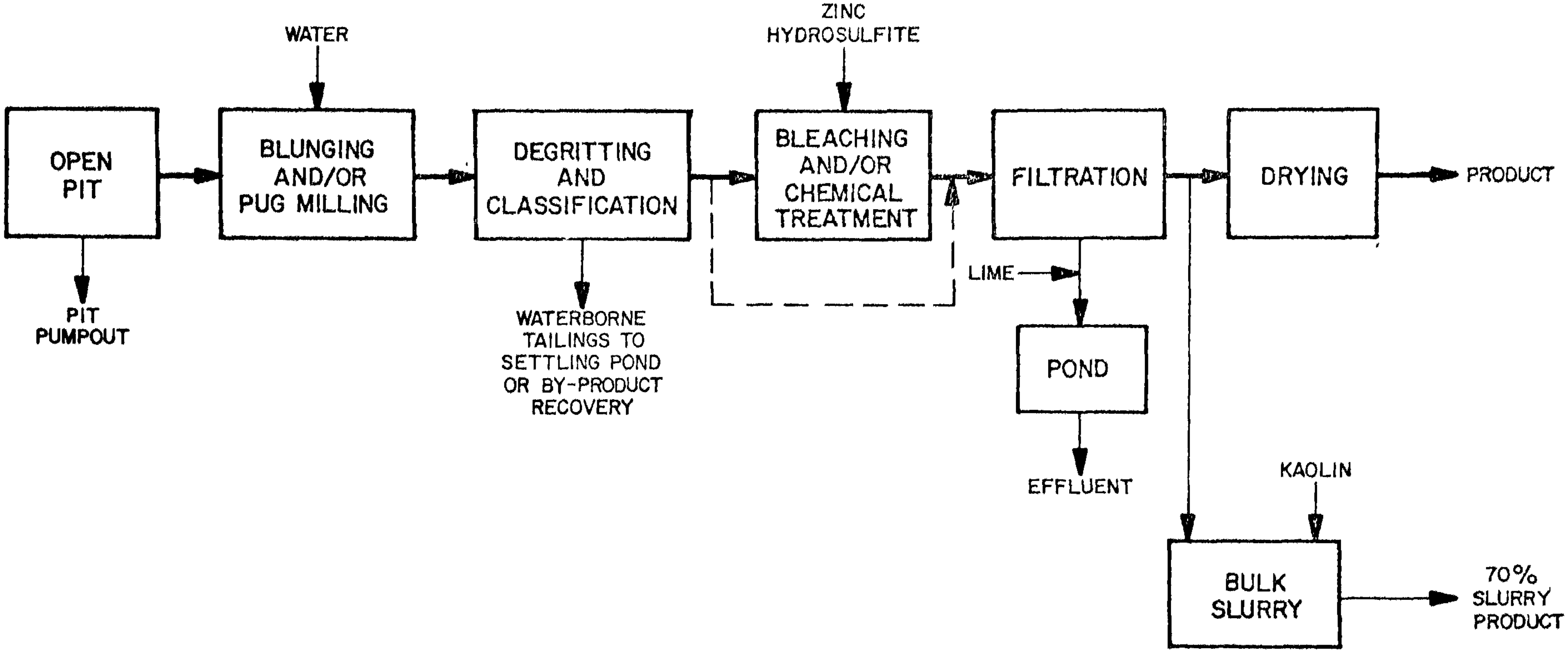

FIGURE V-3.4.2
WET KAOLIN MINING AND PROCESSING
FOR HIGH GRADE PRODUCT

carried through to wastewater from the bleaching operations. The raw waste loads at these two plants are:

Waste Material	kg/kkg product (lb/ton) 3024	3025
zinc	0.37 (0.74)	0.5 (1.0) est.
dissolved solids	8 (16)	10 (20) est.
suspended solids	35 (70)	100 (200) est.

The dissolved solids are principally sulfates and sulfites and the suspended solids are ore fines and sand.

3.4.1.2.3 Water Use

Water is used in wet processing of kaolin for pug milling, blunging, cooling, and slurrying. At plant 3024, water is obtained from deep wells, all of which is chlorinated and most of which is used as plant process water with no recycle. Plant 3025 has a company-owned ground water system as a source and also incoming slurry provides some water to the process none of which is recycled. Typical water flows are:

	liters/kkg product (gal/ton) 3024	3025
water intake	4,250 (1,020)	4,290 (1030)
process wastewater	3,400 (810)	4,000 (960)
water evaporated, etc.	850 (210)	290 (70)

These plants do not recycle their process water but discharge it after treatment. Recycle of this water would interfere with the process operation.

3.4.1.2.4 Waste Water Treatment

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 plants treat the ponds with lime to adjust pH and remove excess zinc which has been introduced 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 plants are considering the use of sodium hydrosulfite as bleach to eliminate the zinc waste.

3.4.1.2.5 Effluent and Disposal

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. Plants 3024 and 3025 discharge an effluent containing 0.25 mg/liter Zn, 6-25 mg/liter suspended solids and 480 mg/liter dissolved solids (mostly $CaSO_4$). On the basis of the average waste flow these parameters amount to:

	3024	3025	average
waste flow, l/kkg (gal/ton)	3,400 (810)	4,000 (960)	3,700 (890)
parameter quantity kg/kkg (lb/ton):			
zinc	0.0009 (0.0018)	0.001 (0.002)	0.001 (0.002)
suspended solids	0.022 (0.044)	0.10 (0.20)	0.06 (0.12)
dissolved solids	1.6 (3.2)	1.1 (2.2)	1.4 (2.8)

3.4.2 Ball Clay

Ball clay is a plastic, white-firing clay used principally for bonding in ceramic ware. Four ball clay producers representing 40 percent of total U.S. ball clay production provided data for this section. There are twelve plants in this category.

3.4.2.1 Process Description

After overburden is removed, the clay is mined using front-end loaders and/or draglines. The clay is then loaded onto trucks for transfer to the processing plant. Processing consists of shredding, milling, air separation and bagging for shipping. Plants 5684 and 5685 have additional processing steps including blunging, screening, and tank storage for sale of the clay in slurry form, and rotary drying directly from the stockpile for a dry unprocessed ball clay. A general process diagram is given in Figure V-3.4.3.

3.4.2.2 Raw Waste Load

Ball clay mining generates a large amount of overburden which is returned to worked-out pits for land reclamation.

The processing of ball clay generates dust and fines from milling and air separation operations. These fines are gathered in baghouses and returned to the process as product. At the plants where slurrying and rotary drying are done, there are additional process wastes generated. Blunging and screening the clay for slurry product generates lignite and sand solid wastes after dewatering. The drying operation uses wet scrubbers which result in a slurry of dust and water sent to a settling pond.

There are no data available on the amount of wastes generated in producing the slurry or the dry product, but the waste materials are limited to fines of low solubility minerals.

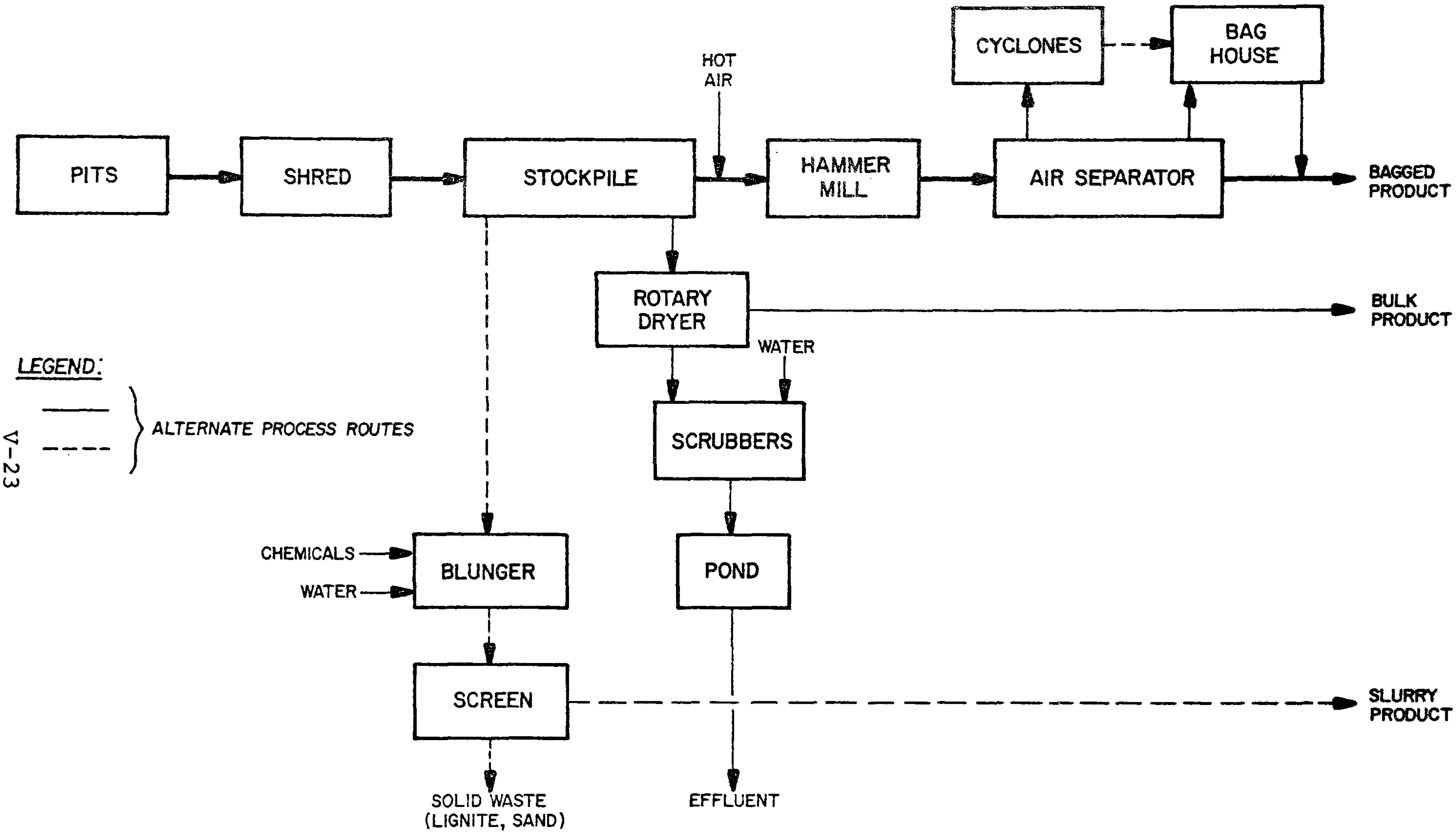

FIGURE V-3.4.3
BALL CLAY MINING AND PROCESSING

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3.4.2.3 Water Use

There is no water used in ball clay mining, however, when rain and ground water collects in the pits, there is an intermittent discharge. Pit pumpout is either discharged without treatment, or pumped to a settling pond before discharge to a nearby body of water. There is usually some diking around the pit to prevent run-off from flowing in. There are no flow rates or water quality data available on pit pumpout.

In ball clay processing, two of the plants visited use a completely dry process. The others produce a slurry product using water for blunging, a product dried directly from the stockpile with water used for wet scrubbers, and/or the dry process product. Well water serves as the source for the plants which use water in their processing. Typical flows are:

	liters/metric ton of product (gal/ton)		
	5684	5685	5689
Intake	total unknown	1,130 (270)	4,300 (1,030)
Use:			
Blunging	unknown	42 (10)	none
Scrubber	88 (21)	1,080 (260)	4,300 (1,030)
Consumption	total unknown	1,130 (270)	4,300 (1,030)

Water used in blunging operations is consumed both as product and evaporated from water material. Scrubber water is impounded in settling ponds and eventually discharged. Plants 5685 and 5689 use water scrubbers for both dust collection from the rotary driers and for in-plant dust collection. Plant 5684 has only the former.

3.4.2.4 Waste Water Treatment

Pit pumpout is discharged either after settling in a pond or sump or without any treatment.

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

3.4.2.5 Effluent and Disposal

There are no data available on the quality of the intermittent pit pumpout from any of the ball clay producers visited.

Effluent discharged from the settling pond at plant 5685 has the following parameters: a pH of 6.4 and TSS of 400 mg/l. Total suspended solids at plant 5689 averages less than 40 mg/liter.

No data are available on effluent from plant 5684.

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

plant	discharge, liters/kkg of product (gal/ton)	TSS, kg/kkg of product (lb/ton)
5684	88 (21)	------
5685	1,080 (260)	0.43 (0.86)
5689	4,300 (1,030)	0.17 (0.34)

There are two significant types of operations in ball clay manufacture insofar as water use is concerned: those having wet scrubbers, which have a wastewater discharge, and those without wet scrubbers, which have no process wastewater.

Insofar as plants having scrubbers is concerned, plant 5689 is exemplary in its treatment, discharging a low concentration of TSS and a moderate total amount.

3.5 Feldspar

Feldspar mining and/or processing has been sub-categorized as follows:

(1) wet processing - dry quarries - flotation processing
(2) dry processing - dry quarries - dry crushing and classification

Feldspathic sands are included in the Industrials Sands category in Volume I of this report.

3.5.1 Feldspar - Wet Processing

This subcategory of feldspar mining and processing is characterized by dry operations at the mine and wet processing in the plant. This is the most important subcategory of feldspar, since about 73 percent of the total tonnage of feldspar sold or used (in 1972) was produced by this process.

Wet processing is carried out in five plants owned by three companies. All five of these plants (Plant nos. 3026, 3054, 3065, 3067, and 3068) are represented in the data below. A sixth plant is now coming into production and will replace one of the above five plants in 1975.

3.5.1.1 Process Description

At all five plants, mining techniques are quite similar: after overburden is removed, the ore is drilled and blasted, followed by loading of ore onto trucks by means of power shovels, draglines, or front end loaders for transport to the plant. In some cases, additional break-up of ore is accomplished at the mine by drop-balling. No water is used in mining at any location.

The first step in processing the ore is crushing which is generally accomplished at the plant, but may be accomplished at the mine (Plant 3068). Subsequent steps for all wet processing plants vary in detail, but the basic flow sheet, as given in Figure V-3.5.1, contains all the fundamentals of these plants.

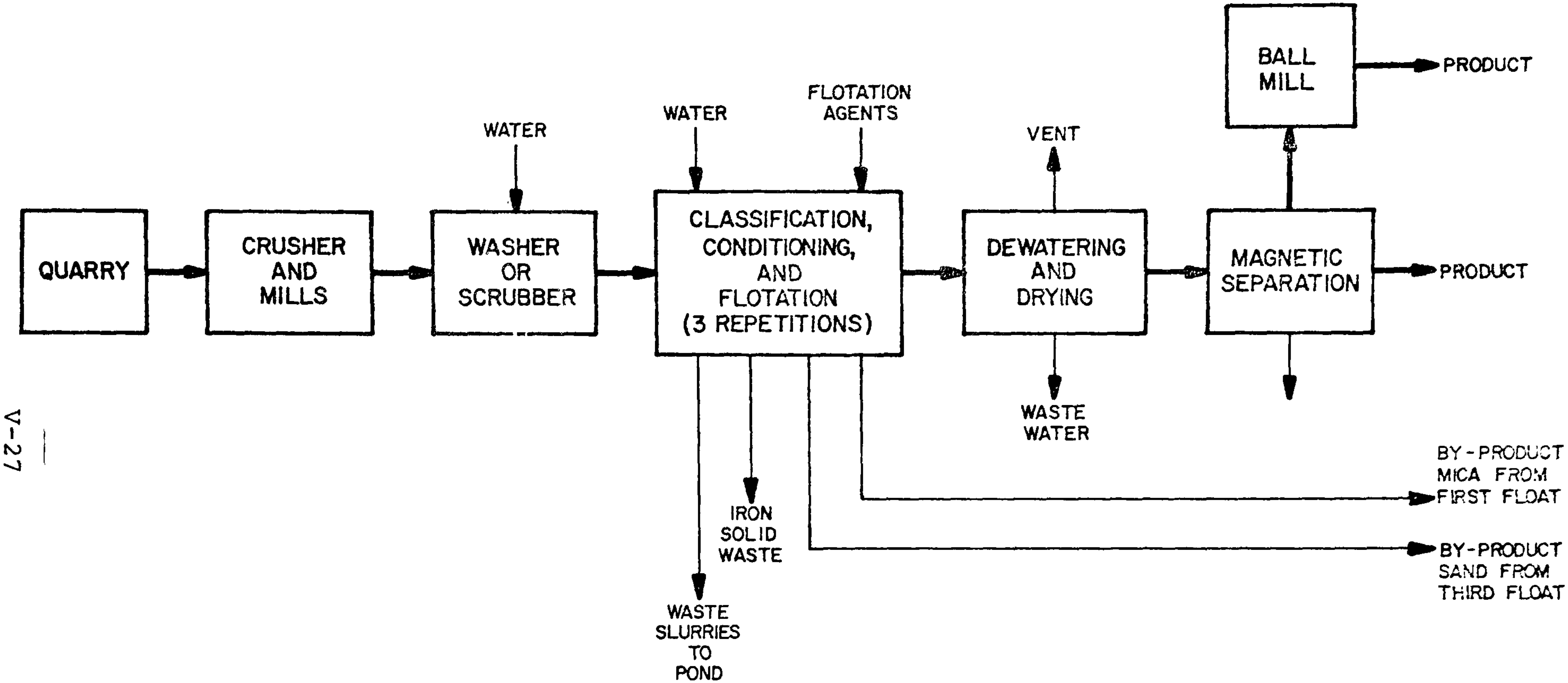

FIGURE V-3.5.1
FELDSPAR MINING AND PROCESSING
(WET)

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By-products from flotation include mica, which may be further processed for sale (at Plants 3054, 3065, 3067, and 3068), and quartz or sand (at Plants 3026, 3054, and 3068). At Plants 3065 and 3067, a portion of the total flow to the third flotation step is diverted to dewatering, drying, guiding, etc., and is sold as a feldspathic sand.

3.5.1.2 Raw Waste Loads

Mining operations at the open pits result in overburden of varying depth. The overburden is applied to land reclamation of nearby worked-out mining areas.

Waste recovery and handling at the processing plants is a major consideration, as large tonnages are involved. Waste varies from a low of 26 percent of mined ore at Plant 3065 to a high of 53 percent at Plant 3067. The latter value is considerably larger due to the fact that this plant does not sell the sand from its feldspar flotation. Most of the other plants are able to sell all or part of their by-product sand. Typical flotation reagants used in this production subcategory contain hydrofluoric acid, sulfuric acid, sulfonic acid, frothers, amines and oils.

The raw waste data calculated from information supplied by these plants are:

plant	kg/kkg of ore processed (lb/ton) ore tailings and slimes	fluoride
3026	270 (540)	0.22 (0.44)
3054	410 (820)	0.24 (0.48)
3065	260 (520)	0.20 (0.40)
3067	530 (1,060)	est. 0.25 (0.50)
3068	350 (700)	est. 0.25 (0.50)

These raw wastes are generally settled in ponds or sent to thickeners. The bulk of the solids and adsorbed organics would then be separated from the liquid containing dissolved fluoride and some suspended solids.

3.5.1.3 Water Use

Water is not used in the quarrying of feldspar. There is occasional drainage from the mine, but pumpout is not generally practiced.

Wet processing of feldspar does result in the use of quite significant amounts of water. At the plants visited, water was obtained from a nearby lake, creek, or river and used without any pre-treatment. Recycle of water is minimal, varying from zero at several plants to a maximum of about 17 percent at Plant 3026. The primary reason for little or no water recycle is the possible build-up of undesirable soluble organics and fluoride ion in the flotation steps. However, some water is recycled in some plants to the initial washing and crushing steps, and some recycle of water in the fluoride flotation step is practiced at plant 3026.

Total water use at these plants varies from 7,000 to 22,200 liters/kkg of ore processed (1,680 to 5,300 gal/ton). Most of the process water used in these plants is discharged as a wastewater. Some water is lost in tailings and drying. This is of the order of 1 percent of the water use at plant 3065.

The use of the process water in the flotation steps amounts to at least one-half of the total water use. The water used in the fluoride reagent flotation step ranges from 10 to 25 percent of the total flow depending on local practice and sand-to-feldspar ratio. Only two of these five plants use any significant recycling of water. These are:

plant 3026 - 17 percent of intake (on the average)

plant 3067 - 10 percent of intake

3.5.1.4 Waste Water Treatment

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

Measurements by Versar on the performance of the treatment system at plant 3026, consisting of two ponds in series and alum treatment, showed the following reductions in concentration (mg/liter):

	TSS	fluoride
wastewater into system	3,790	14
discharge from system	21	1.3

3.5.1.5 Effluents and Disposal

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

plant	pH	mg/liter	mg/liter
3026	6.5-6.8	21*	8
3054	6.8	45	15*
3065	10.8*	349	23*
3067	7.5-8.0	35*	34*
3068	7-8	40-150	32

The asterisked values are Versar measurements in lieu of plant-furnished data not available. Plant 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 below together with the relative effluent flows.

plant	ore processed basis flow, liters/kkg (gal/ton)	TSS, kg/kkg (lb/ton)	fluoride, kg/kkg (lb/ton)
3026	14,600 (3,500)	0.31 (0.62)	0.12 (0.24)
3054	12,500 (3,000)	0.56 (1.12)	0.18 (0.36)
3065	11,000 (2,640)	1.1 (2.2)	0.25 (0.50)
3067	6,500 (1,560)	0.23 (0.46)	0.22 (0.44)
3068	18,600 (4,460)	0.7-2.8 (1.4-5.6)	0.6 (1.2)

The higher than average suspended solids content of the effluents of 3065 and 3068 is caused by froth carrying of mica through the thickeners to the discharges. Therefore, the waste treatment systems in these two plants are not performing in an exemplary fashion. Plant 3026 is exemplary in regard to the levels of discharge of both suspended solids and fluoride. The fluoride content of the discharge is almost one-half of the raw waste load, whereas the other plants discharge nearly all the fluoride raw waste. This plant 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 (references 4 and 12) to reduce fluoride by binding into the sediment. The effectiveness of the treatment at 3026 to reduce suspended solids is comparable to that at plants 3054 and 3067. All three of these plants have exemplary suspended solids discharge levels for this subcategory.

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

Based on these conclusions, plant 3026 is exemplary in regard to both suspended solids and fluoride discharges. In addition, plants 3054 and 3067 exhibit exemplary reduction of suspended solids only.

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

3.5.2 Feldspar - Dry Processing

This subcategory of feldspar mining and processing is characterized by completely dry operations at both the mine and the plant. Only two such plants were found to exist in the U.S. and both were visited. Together they represent approximately 8.5 percent of total U.S. feldspar production. However, there are two important elements of difference between these two operations as follows:

All of plant 3032 production of feldspar is sold for use as an abrasive in scouring powder. At plant 3064, the high quality orthoclase (potassium aluminum silicate) is primarily sold to manufacturers of electrical porcelains and ceramics.

3.5.2.1 Process Description

Underground mining is accomplished at Plant 3032 on an intermittent, as-needed, basis using drilling and blasting techniques. A very small amount of water is used for dust control during drilling. At Plant 3064, the techniques are similar, except mining is in an open pit and is carried on for 2-3 shifts/day and 5-6 days/week depending on product demand. Hand picking is accomplished prior to truck transport of ore to the plant.

At the two plants ore processing operations are virtually identical. They consist of crushing, ball milling, air classification, and storage prior to shipping. Product grading is a function of air classification operation. A schematic flow sheet is shown in Figure V-3.5.2.

3.5.2.2 Raw Waste Loads

At Plant 3032, there are no mine wastes generated, and only a small quantity of high-silica solids emanate from the plant. The quantity of waste is unknown, and the material is used as land fill. At Plant 3064, rejects from hand picking are used as mine fill. There is very little waste at the plant.

3.5.2.3 Water Use

At the Plant 3032 mine, water is used to suppress dust while drilling. It is spilled on the ground and is readily absorbed; volume is only about 230 liters/day (about 60 GPD). No water is used in plant processing at the mine. At Plant 3064, no water is used at the mine. Plant water is used at a daily rate of <1,900 liters/day (500 GPD) to suppress dust in the crushers.

No pre-treatment is applied to water used at either plant.

3.5.2.4 Wastewater Treatment

Any wastewater is spilled on the ground (Plant 3032) or is evaporated off during crushing and milling operations (Plant 3064). There is no wastewater treatment at either plant.

3.5.2.5 Effluents and Disposal

There are no effluents from either mine or plant locations.

3.6 Kyanite

Kyanite is produced in the U.S. from 3 open pit mines, two in Virginia and one in Georgia. In this study two of these three mines were visited, one in Virginia, and one in Georgia, representing approximately 75 percent of the U.S. production of kyanite.

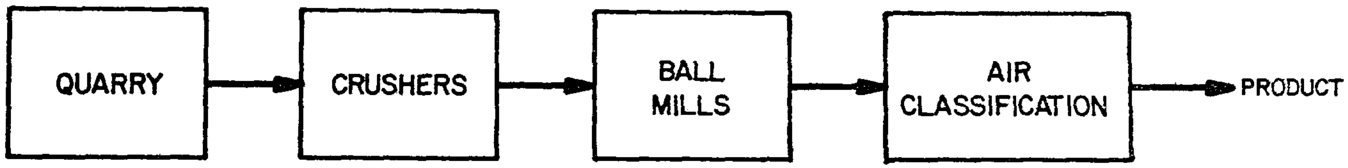

FIGURE V-3.5.2
FELDSPAR MINING AND PROCESSING
(DRY)

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3.6.1 Process Description

Kyanite is mined in dry open quarries, using blasting to free the ore. Power shovels are used to load the ore onto trucks which then haul the ore to the processing plant. Processing consists of crushing and milling, classification and desliming, flotation to remove impurities, drying, and magnetic separation. Part of the kyanite is converted to mullite via high temperature firing at 1540°-1650°C (2800-3000°F) in a rotary kiln. A general process diagram is given in Figure V-3.6.1.

3.6.2 Raw Waste Load

Wastes are generated in the processing of the kyanite, in classification, flotation and magnetic separation operations. These wastes consist of pyrite tailings, quartz tailings, flotation reagents, muds, sand and iron scalpings. These wastes are greater than 50 percent of the total mined material.

	waste material	kg/kkg of kyanite (lbs/ton)
plant 3015	tailings	2,500 (5,000) (est.)
plant 3028	tailings	5,700 (11,300) (est.)

3.6.3 Water Use

Water is used in kyanite processing in flotation, classification, and slurry transport of ore solids. This process water amounts to:

	liters/kkg of kyanite (gal/ton)
plant 3015	29,200 (7,000)
plant 3028	87,600 (21,000)

The process water is recycled, and any losses due to evaporation and pond seepage are replaced with make-up water. Make-up water for plant 3028 is used at a rate of 4,200,000 liters/day (0.288 MGD) and plant 3015 obtains

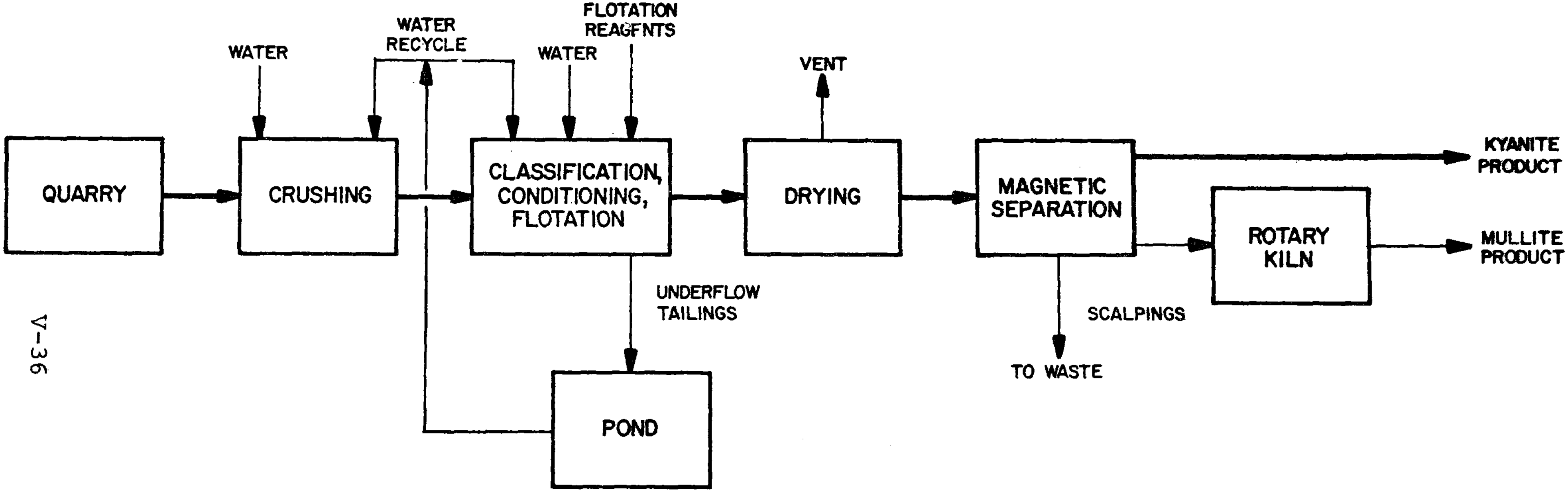

FIGURE V-3.6.1
KYANITE MINING AND PROCESSING

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make-up water from run-off draining into the settling pond and also from an artesian well.

3.6.4 Waste Water Treatment

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 that is not lost through evaporation and pond seepage.

3.6.5 Effluent and Disposal

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

The solid waste generated in kyanite processing is land-disposed after recovery from settling ponds. An analysis of pond water at plant 3015 showed low values for BOD (2 mg/liter) and oil and grease (4 mg/liter). Total suspended solids were 11 mg/liter and total metals 3.9 mg/liter, with iron being the principal metal. No analyses were available on the occasional overflow at plant 3028.

3.7 Magnesite

There is only one known U.S. plant that produces magnesia from naturally occurring magnesite ore. This facility, plant 2063, mines and beneficiates magnesite ore and produces dead burned magnesia, caustic burned magnesia and flotation concentrate. The company's current holdings in this category consist of three dry open pit mines, one heavy media separation (HMS) plant and a flotation mill.

3.7.1 Process Description

All mining operations are accomplished by the open pit method. The deposit is chemically variable, due to the interlaid horizons of dolomite and magnesite, and megascopic identification of the ore is difficult. The company has devised a selective quality control system to obtain the various grades of ore required by the processing plants.

The pit is designed with walls inclined at 60°, with 20-foot catch benches every 50 feet of vertical height. The crude ore is loaded by front end loaders and shovels and then trucked to the primary crusher. The quarry is located favorably so that there is about 2 kilometers (1.25 miles) distance to the primary crusher.

About 2260 kkg/day (2500 tons/day) of ore are crushed in the mill for direct firing and beneficiation. The 5 percent waste from this operation is primarily silicates. The remainder of the crusher product (95% of the input) is distributed to the kiln, Heavy Media Separation (HMS) and flotation at 15, 50 and 30 percent respectively.

The flow of material through the plant, for direct firing, follows two major circuits: (1) the dead burned magnesite circuit, and (2) the light burned magnesite circuit.

In the dead burned magnesite circuit, the ore is crushed to minus 3/4 inch in a cone crusher. All raw materials including iron oxide, chrome, and other ingredients required for a particular mix are stored ahead of grinding. The raw materials are dry ground in two ball mills that are in closed circuit with an air classifier. The minus 65 mesh product from the classifier is transported by air slides to the blending silos. From the silos the dry material is fed to pug mills where water and binding materials are added. From the pug mills the material is briquetted, dried, and stored in feed tanks ahead of rotary kilns. The oil- or natural-gas-fired kilns convert the magnesite into dense magnesium clinker of various chemical constituents, depending upon the characteristics desired in the product. After leaving the kiln, the clinker is cooled by an air quenched rotary or grate type coolers, crushed to desired sizes, and stored in large storage silos for shipment.

In light burned magnesite circuit, minus 3/4" magnesite is fed to two Herreshoff furnaces. By controlling the amount of liberated CO_2 from the magnesite a caustic oxide is produced from these furnaces. The magnesium oxide is cooled and ground in a ball mill into a variety of grades and sizes, and is either bagged or shipped in bulk.

Magnesite is beneficiated at plant 2063 by either HMS and/or froth flotation methods.

In the HMS plant, the feed is crushed to the proper size, screened, washed and drained on a vibratory screen to eliminate the fines as much as possible. The screened feed is fed to the separating cone which contains a suspension of finely ground ferro-silicon and/or magnetite in water, maintained at a predetermined specific gravity. The light fraction floats and is continuously removed by over-flowing a weir. The heavy particles sink and are continuously removed by an airlift.

The float weir overflow and sink airlift discharge go to a drainage screen where 90 percent of the medium carried with the float and sink drains through the screen and is returned to the separatory cone.

The "float" product passes from the drainage section of the screen to the washing section where the fines are completely removed by water sprays. The solid wastes from the wet screening operations contain -3/8 to +1-1/2" material which is primarily used for the construction of settling pond contour. The fines from the spray screen operations, along with the "sink" from the separating cone, are sent into the product thickener.

In the flotation plant, the feed is properly crushed, milled, and classified and then sent into the cyclone clarifier. Make-up water, along with the process recycled water, is introduced into the cyclone classifier. The oversize from the classifier is ground in a ball mill and recycled back to the cyclone. The cyclone product is distributed to the rougher flotation and the floated product is then routed to cleaner cells which operate in series. The flotation concentrate is then sent into the product thickener. The underflow from this thickener is filtered, dried, calcined, burned, crushed, screened and bagged for shipment.

The tailings from the flotation operation and the filtrate constitute the waste streams of these plants and are sent into the tailings thickener for water recovery. The overflows from either thickener are recycled back to process. The underflow from the tailings thickener containing about 40 percent solids is impounded in the plant. A simplified flow diagram for this plant is given in Figure V-3.7.1.

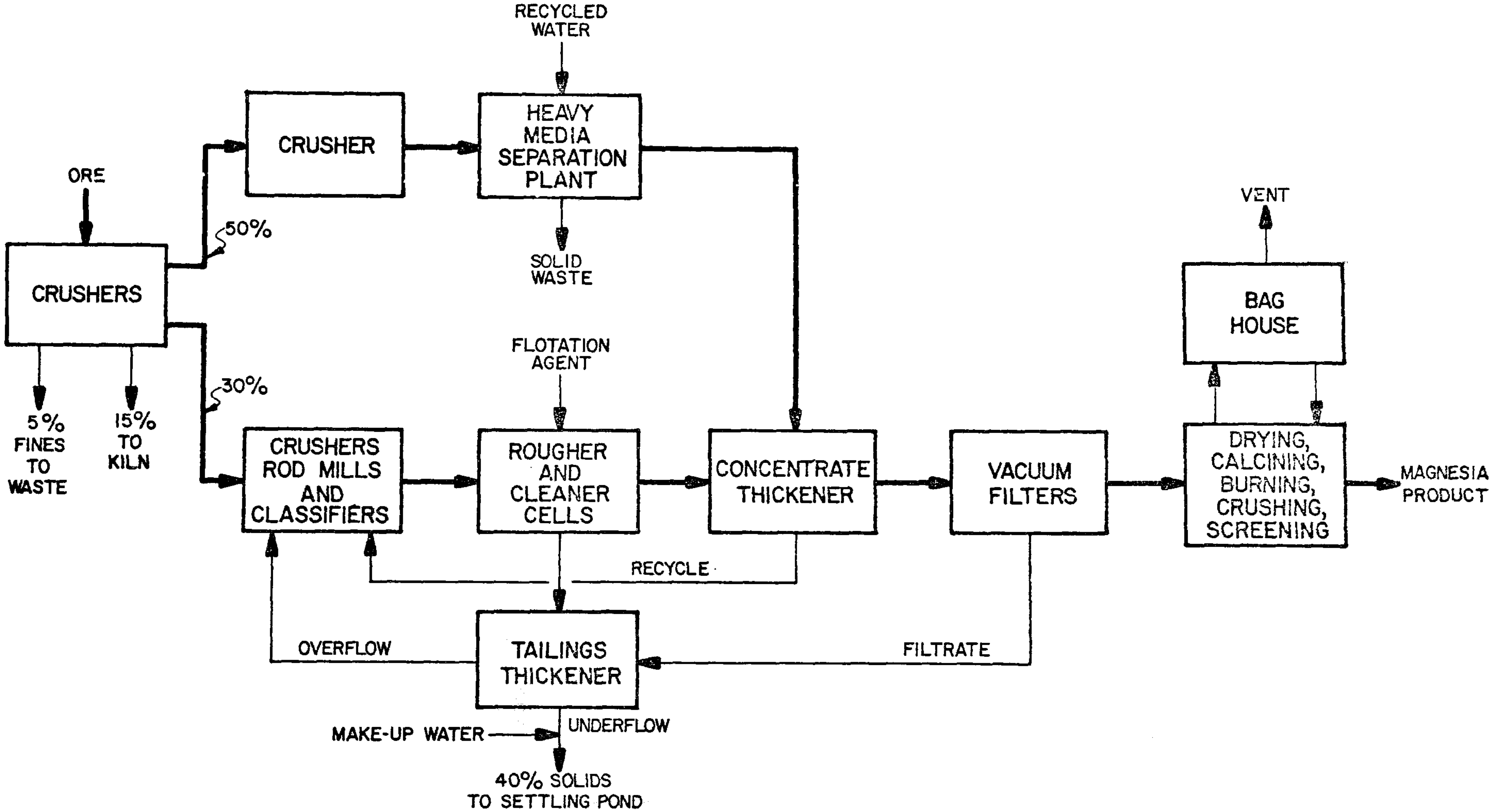

FIGURE V-3.7.1
MAGNESITE MINING AND PROCESSING

3.7.2 Raw Waste Loads

The raw waste from this plant consists of the underflow from the tailings thickeners and it includes about 40 percent suspended solids. The average values reported are given below:

waste material	kg/day (lbs/day)
suspended solids	590,000 (1,300,000)

No data were supplied on daily production rates. These figures are considered confidential by this company.

3.7.3 Plant Water Use

This plant's fresh water system is serviced by eight wells. All wells except one are hot water wells, 50 to 70°C (121° to 160°F).

The total mill intake water is 2,200,000 liters per day (580,000 gal/day), 88 percent of which is cooled prior to usage. The hydraulic load of this plant is given below:

water consumption	liters/day (gal/day)
process water to refine the product	163,000 (43,000)
road dust control	227,000 (60,000)
sanitary	11,360 (3,000)
tailing pond evaporation	492,000 (130,000)
tailing pond percolation	757,000 (200,000)
evaporation in water sprays, Baker coolers & cooling towers	545,000 (144,000)

No process wastewaters are discharged out of the property at this plant. There is no mine water pumpout at this facility.

3.7.4 Waste Water Treatment

The waste stream at this plant is the underflow of the tailings thickener which contains large quantities of solid wastes. To aid the flow, make-up water is added to this waste stream and then discharged into the tailings pond.

The estimated area of this pond is 15 hectares (37 acres). The estimated evaporation at this area is 54 inches per year and the annual rainfall is 6 inches per year. The wastewater is, therefore, dried about 40 percent by evaporation and about 60 percent by percolation.

No stream 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 and the total recharge of the basin.

3.7.5 Effluent

As all process waters at plant 2063 are either recycled or lost by evaporation and percolation, there is no process water effluent discharge out of this property.

3.8.1 Shale

Shale is a consolidated sedimentary rock composed chiefly of clay minerals, occurring in varying degrees of hardness. Shales and common clays are for the most part used by the producer in fabricating or manufacturing structural clay products (SIC 3200) so only shale mining is discussed here. Less than 10 percent of total clay and shale output is sold outright. Therefore, for practical purposes, nearly all such mining is captive to ceramic or refractory manufactures.

3.8.1.1 Process Description

Shale is mined in open pits using rippers, scrapers, bulldozers, and front-end loaders for removal of the shale from the pit. Blasting is needed to loosen very hard shale deposits. The shale is then loaded on trucks or rail cars for transport to the plant. There, primary crushing, grinding, screening, and other operations are used in the manufacture of many different structural clay products. A general process diagram is given in Figure V-3.8.1.

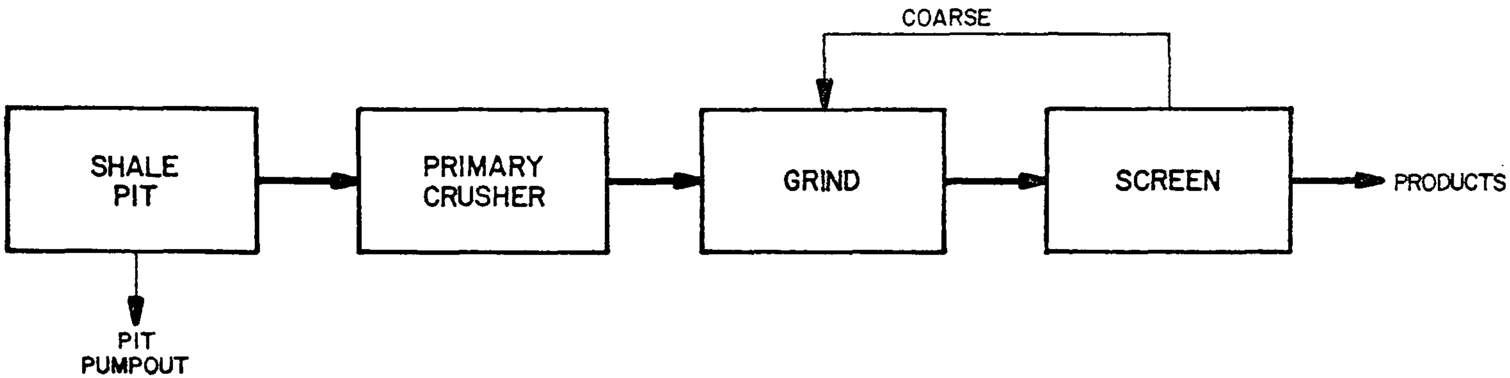

FIGURE V-3.8.1
SHALE MINING AND PROCESSING

3.8.1.2 Raw Waste Load

Solid waste is generated in shale mining as overburden which is used as fill to reclaim mined-out pits. Since ceramic processing will not be discussed here, no processing waste is accounted for.

3.8.1.3 Water Use

There is no water used in shale mining, however, due to rainfall and ground water seepage, there can be water which accumulates in the pits and must be removed. Pit pumpout is intermittent depending on rainfall frequency and geographic location. In many cases, plants will build small earthen dams or ditches around the pit to prevent inflow of rainwater. Also shale is, in most cases, so hard that run off water will not pickup significant suspended solids. Flow rates are not generally available for pit pumpout.

3.8.1.4 Waste Water Treatment

There is no wastewater treatment necessary for shale 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.

3.8.1.5 Effluent and Disposal

Pit pumpout is discharged without treatment. There is no other effluent.

3.8.2 Aplite

Aplite is found in quantity in the U.S. only in Virginia and is mined and processed by only two plants, both of which are discussed below.

3.8.2.1 Process Description

The deposit mined by plant 3016 is relatively soft and the ore can be removed with bulldozers, scrapers, and graders, while that mined by plant 3020 requires blasting to loosen from the quarry. The ore is then loaded on trucks and hauled to the processing plant.

Plant 3016 employs a wet process consisting of wet crushing and grinding, screening, removal of mica and heavy minerals via a series of wet classifiers, dewatering and drying, magnetic separation and final storage prior to shipping.

Plant 3020 processing is dry, consisting of crushing and drying, more crushing, screening, magnetic separation and storage for shipping. However, water is used for wet scrubbing to control air pollution. A process flow diagram is given in Figure V-3.8.2 depicting both processes.

3.8.2.2 Raw Waste Load

Mining waste is overburden and pit pumpout. The processing wastes are dusts and fines from air classification, iron bearing sands from magnetic separation, and tailings and heavy minerals from wet classification operations. The latter wastes obviously do not occur at the dry plant.

	Water-borne Waste Materials	kkg/year (TPY)	kg/kkg of product (lbs/ton)
plant 3016 (wet)	tailings and heavy minerals and fines	136,000 (150,000)	1,000 (2,000)
plant 3020 (dry)	dust and fines	9,600 (10,600)	175 (350)

Other, non-waterborne wastes come from the magnetic separation step at plant 3020.

3.8.2.3 Water Use

Water is used at plant 3020 (dry process) only for wet scrubbers which cut down on airborne dust and fines. This water totals 1,230,000 liters/day (324,000 GPD) with no recycle. There is occasional pit pumpout.

Water is used at plant 3016 for crushing, screening and classifying at a rate of 38,000,000 l/day (10,000,000 GPD) which is essentially 100% recycled. Dust control requires about 1,890,000 l/day (500,000 GPD) of water which is also recycled. Any make-up water needed due to evaporation

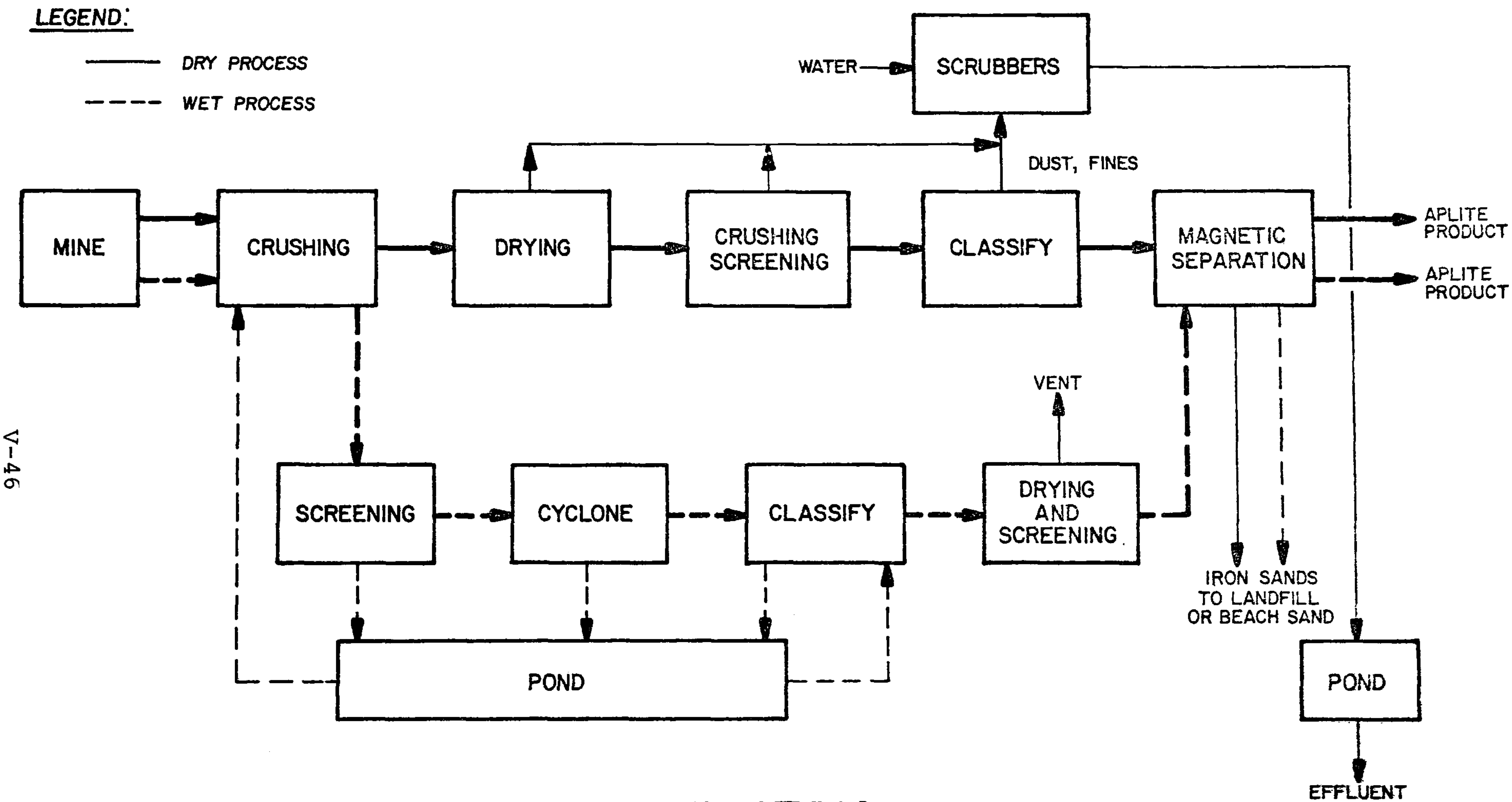

FIGURE V-3.8.2
APLITE MINING AND PROCESSING

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losses comes from the river. The amount was not disclosed. There is no pit pumpout at plant 3016 and any surface water which accumulates drains to a nearby river.

The plant water use in this industry can be summarized:

	liters/kkg of product (gal/ton)	
process use:	3016	3020
scrubber or dust control	3,600 (870)	5,900 (1,420)
crush, screen, classify	12,700 (3,040)	0
net discharge (less pit pumpout)	approx. 0	5,900 (1,420)
pit pumpout	0	not given
make-up water intake	not given	5,900 (1,420)

3.8.2.4 Waste Water Treatment

The wastewater generated in these aplite operations is sent to tailings ponds where solids are allowed to settle. The scrubber water from plant 3020 is discharged after settling while the occasional pit pumpout is discharged without settling. The water from the wet process plant 3016 is essentially 100% recycled to the process. Every few years, when the pond level becomes excessive, plant 3016 discharges from the pond to a river. 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. There is no other water loss from plant 3016 except for evaporation and pond seepage.

3.8.2.5 Effluent and Disposal

Plant 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. Analytical data on the effluent is not presently available.

The occasional pit pumpout due to rainfall is discharged without treatment.

Plant 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/liter average, and 1000 mg/liter for any one day. Actual settling pond water analyses have not been made.

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.

3.9 Talc, Steatite, Soapstone and Pyrophyllite

There are 33 known significant plants in the U.S. producing talc, steatite, soapstone and pyrophyllite. Twenty-seven of these plants use dry grinding operations, producing ground products, two utilize log washing and wet screening operations producing either crude talc or ground talc and four are wet crude ore beneficiation plants, three using froth flotation and one heavy media separation techniques.

3.9.1 Process Description of Dry Grinding Operations

In a dry grinding mill, the ore is batched in ore bins and held until a continuously cut sample is analyzed by the laboratory. Each batch is then assigned to a separate ore silo, and subsequently dried and crushed in a crushing circuit. The ore, containing less than 12% moisture is reclaimed from these storage silos and sent to fine dry grinding circuits in the mill. In the pebble mill (Hardinge circuit), which includes mechanical air separators in closed circuit, the ore is grinded to minus 200 mesh rock powder. Part of the grades produced by this circuit are used principally by the ceramic industry; the remainder is used as feed to other grinding or classifying circuits. In a few plants, some of this powder is introduced into the fluid energy mill and ground at high energy levels to manufacture a series of minus 325 mesh products for the paint industry.

Following grinding operations, the finished grades are pumped, in dry state, to product bulk storage silos. The product is reclaimed from these silos, as needed, and either pumped to bulk hopper cars or to the bagging plant where it is packed in bags for shipment. A generalized process diagram for a dry grinding mill is given in Figure V-3.9.1.

There is no water used in dry grinding plants; therefore, there is no generation of water-borne pollutants by these plants. Bag house collectors are use throughout this industry for dust control. In fluid energy mills using steam in the process, steam is non- recuperative. The steam generated in boilers is used in process and vented to atmosphere after being passed through a baghouse dust collector to remove dust product from the steam. The waste streams emanating from the boiler operations are the sludge generated from conventional hot or cold lime softening process and/or zeolite softening operations, filter backwash, and boiler blowdown wastes which are addressed under general water guidelines in Section IX of this report.

Even though these plants do not use water in their process, some of them do have mine water discharge from their underground mine workings.

3.9.2 Process Description of Log Washing and Wet Screening

At log washing plant 2034 and wet screening plant 2035, the water is used to wash fines from the crushed ore. In either plant, the washed product is next screened, sorted and classified. The product from the classifier is either shipped as is or it is further processed in a dry grinding mill to various grades of finished product.

At plant 2034 wash water is sent into a hydroclone system for product recovery. The slimes from the hydroclone are then discharged into a settling pond for evaporation and drying. At plant 2035, the wash water, which carries the fines, is sent directly into a settling pond.

The wet plants in this subcategory are operational on a six-month per year basis. During freezing weather, these plants are shut down. Stockpiles of the wet plant products are accumulated in summer and used as source of feed in the dry grinding plant in winter. Simplified diagrams for plants 2034 and 2035 are given in Figures V-3.9.2 and V-3.9.3, respectively.

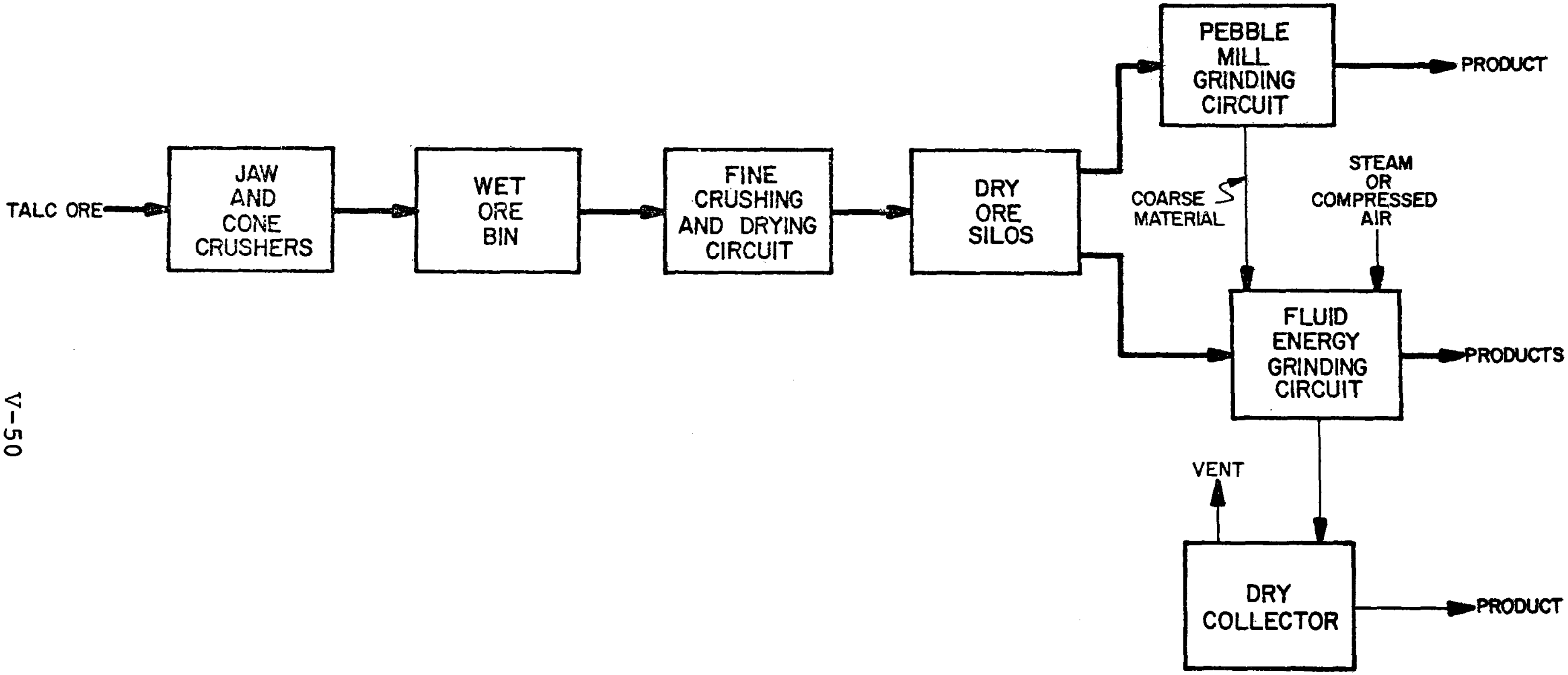

FIGURE V-3.9.1

TALC, STEATITE, SOAPSTONE AND PYROPHYLLITE MINING AND PROCESSING (DRY)

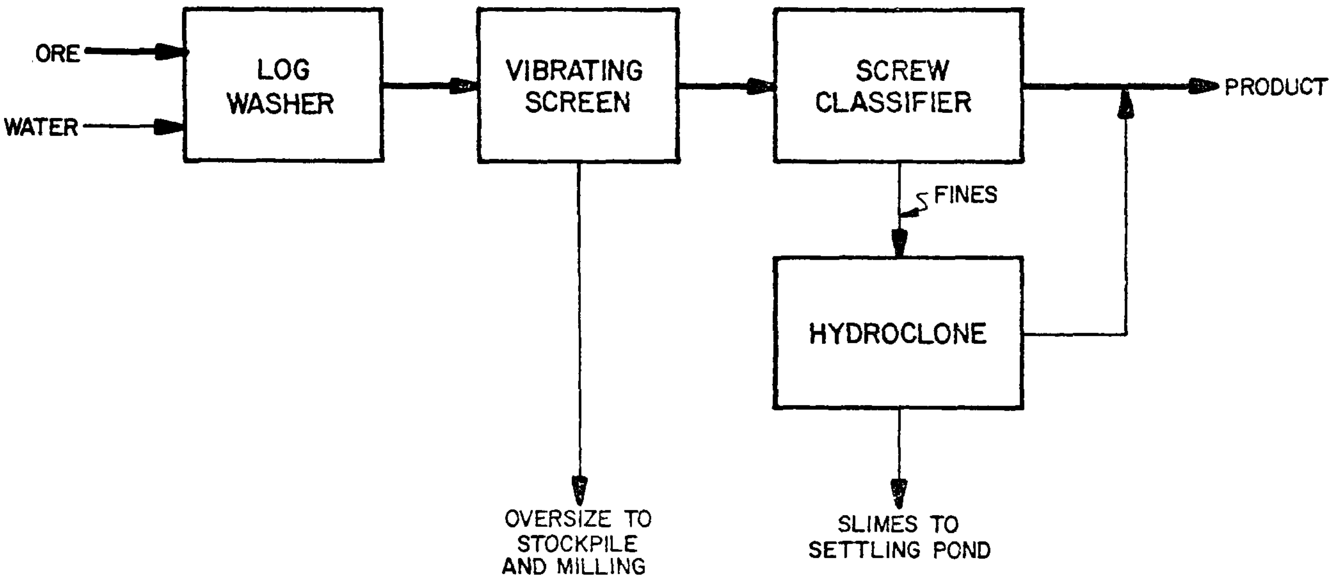

FIGURE V-3.9.2
TALC, STEATITE, SOAPSTONE AND PYROPHYLLITE MINING AND PROCESSING
(LOG WASHING PROCESS)

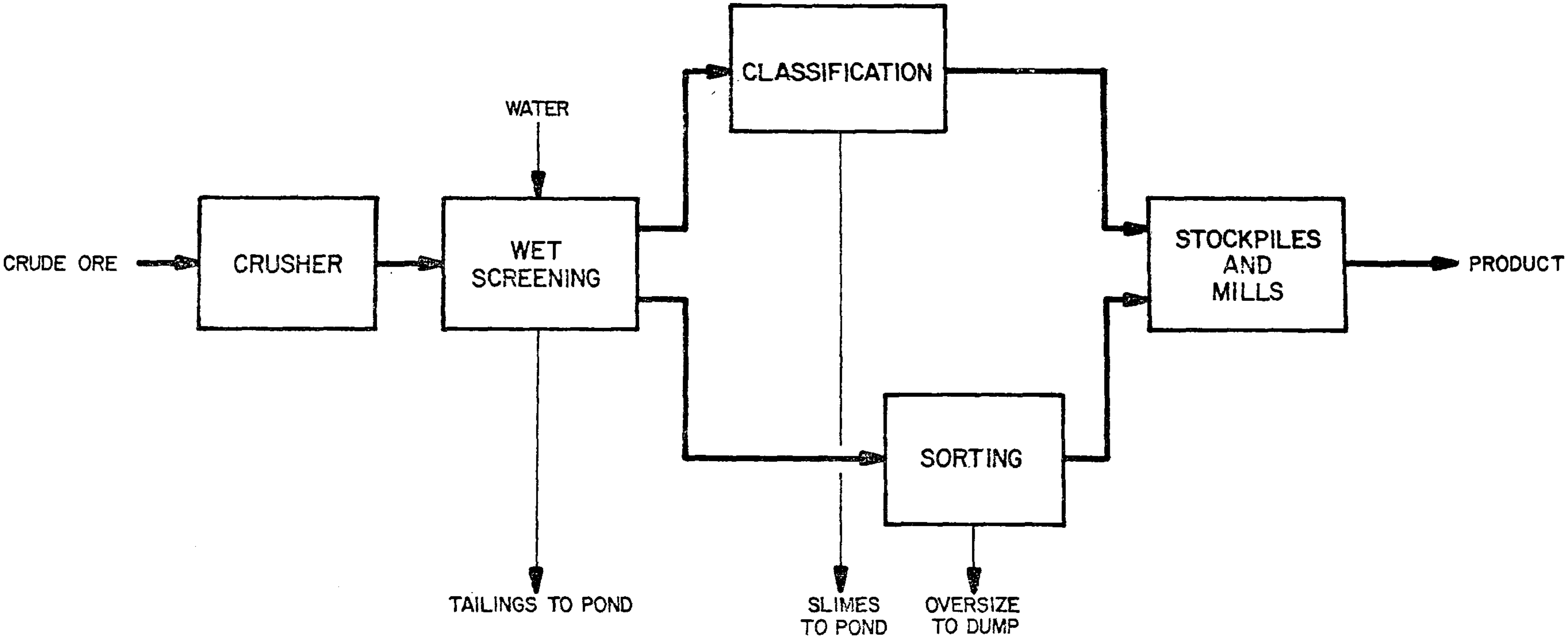

FIGURE V-3.9.3
TALC, STEATITE, SOAPSTONE AND PYROPHYLLITE MINING AND PROCESSING
(WET SCREENING PROCESS)

3.9.2.1 Raw Waste Loads

The raw waste from plant 2034 consists of the slimes from the hydroclone operation, that of plant 2035 is the tailings emanating from the wet screening operation and the slimes from the classifiers. No data was supplied by either company on the quantity of the wastes. Since no water is discharged out of these properties, records on the wastes are not kept.

3.9.2.2 Plant Water Use

Both plants are supplied by water wells on their property. Essentially all water used is process water. Plant 2034 has a water intake of 182,000 liters per day (48,000 gal/day) and plant 2035 has a water intake of 363,000 liters per day (96,000 gal/day). No data were supplied on daily production rates. These figures were considered confidential by the companies.

3.9.2.3 Waste Water Treatment

The waste streams emanating from the washing operations are sent into settling ponds. The ponds are dried by evaporation and seepage. In plant 2035, when the ponds are filled with solids, they are harvested for reprocessing into saleable products.

3.9.2.4 Effluent

There is no discharge out of these properties.

3.9.3 Mine Water Discharge

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 vessels and suctions 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 below:

Mine #	Solids mg/l	Liquid liters/day (gal/day)	Waste Load Relative to Product Load liters/kkg (gal/ton)
2036	9	545,000 (144,000)	1000 (240)
2037	negli-gible	Data not available	Data not available
2038	negli-gible	Data not available	Data not available
2039	negli-gible	946,000 (250,000)	5,200 (1,250)
2040	200	1,100,000 (300,000)	8,900 (2,140)
2041	200	76,000 (20,000)	500 (125)
2042	200	76,000 (20,000)	500 (125)
2043	200	76,000 (20,000)	500 (125)

3.9.3.1 Mine Water Treatment

In mines 2040,2041,2042 and 2043, the water from each mine is directed through ditches and culverts to sumps at each mine level. The sumps serve as sedimentation vessels and suctions for centrifugal pumps which discharge this water to upper level settling basins. The overflows from these basins are discharged into a receiving stream. The remaining mines employ no surface settling basins. The water from the underground sump is directly discharged into a receiving ditch, waterway or mine without further settling.

3.9.3.2 Effluent Composition

No information was available on mines 2037 and 2038. The significant constituents, however, in the remaining mine effluents are reported to be as follows:

Waste Material Mine Number	2036	2039	2040-2043
TSS, mg/l	9	3	<20
Iron, mg/l	0.08	0.05	---
pH min-max	7.5-7.8	7.0-7.3	7.2-8.5

3.9.4 Process Description of Flotation and Heavy Media Separation Plants

All four plants in this subcategory use either flotation or heavy media separation techniques for upgrading the product. In two of the plants, 2031 and 2032, the ore is crushed, screened, classified and milled and then taken by a bucket elevator to a storage bin in the flotation section. The flotation feed is discharged through a feeder into the conditioner. The well and recycled water flows into the conditioner. The conditioner feeds special processing equipment, which then sends the slurry to a pulp distributor. In plant 2031, the distributor splits the conditioner discharge over three concentrating tables. The concentrates from these tables are the gangue material, which is sent to the tailings pond. The talc middlings from the tables are then pumped to the flotation machines. However, in plant 2032, the distributor discharges directly into rougher flotation machines. A reagent is added directly into the cells and the floated product next goes to cleaning cells. The final float concentrate feeds a rake thickener which raises the solids content of the flotation product from 10 to 35 percent. The product from thickener is next filtered on a rotary vacuum filter and water from the filter flows back into the thickener. The filter cake is then dried and the finished product is sent into storage bins. The flotation tailings, along with thickener overflow, are sent to the tailings pond. A simplified flow diagram is given in Figure V-3.9.4.

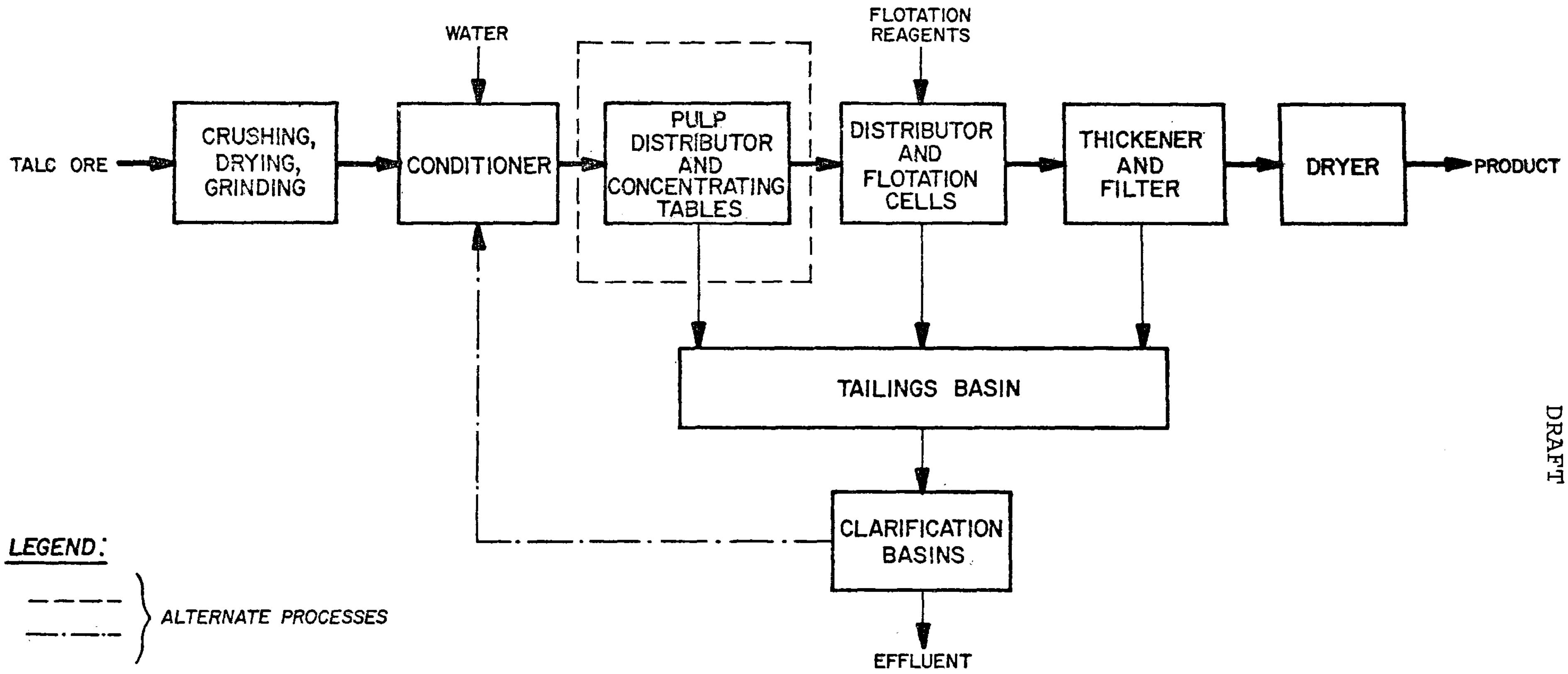

FIGURE V-3.9.4
TALC MINING AND PROCESSING
(FLOTATION PROCESS)

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Plant 2033 processes ores which contain mostly clay and it employs somewhat different processing steps. In this plant, the ore is scrubbed with the addition of liquid caustic to raise the pH, so as to suspend the red clay. The scrubbed ore is next milled and sent through thickening, flotation and tabling. The product from the concentrating tables is acid treated to dissolve iron oxides and other possible impurities. Acid treated material is next passed through the product thickener. The underflow from this thickener contains the finished product. The thickener underflow is filtered, dried, grinded and bagged. The waste streams consist of the flotation tailings, the overflow from the primary thickener and the filtrate. A generalized flow diagram is given in Figure V-3.9.5.

Plant 2044 uses heavy media separation (HMS) technique for the beneficiation of a portion of their product. At this plant, the ore is crushed in a jaw crusher and sorted. The -2" material is dried before further crushing and screening operations whereas the +2" fraction is crushed, screened and sized as recovered from the primary crushing stage. The -3 to +20 mesh material resulting from the final screening operation is sent to HMS plant for the rejection of high silica grains. The -20 mesh fraction is next separated into two sizes by air classification.

Plant 2044 uses a wet scrubber on their #1 drier for dust control. On drier #2 (product drier) a baghouse collecting system is used and the dust recovered is marketed. A simplified process flow diagram for this plant is given in Figure V-3.9.6.

3.9.4.1 Raw Waste Loads

In plants 2031 and 2032, the raw waste consists of the mill tailings emanating from the flotation step. In plant 2033, in addition to the mill tailings, the waste contains the primary thickener overflow and the filtrate from the product filtering operation. In plant 2044 the raw waste stream is the composite of the HMS tailings and the process waste stream from the scrubber. The average values given are listed below:

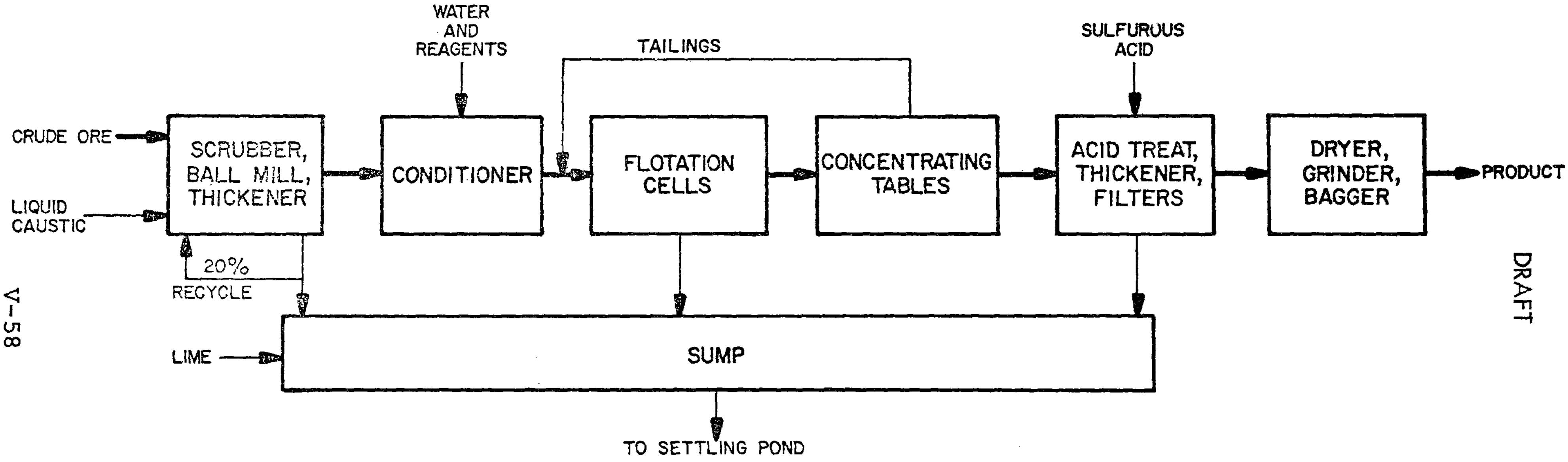

FIGURE V-3.9.5
TALC MINING AND PROCESSING
(IMPURE ORE)

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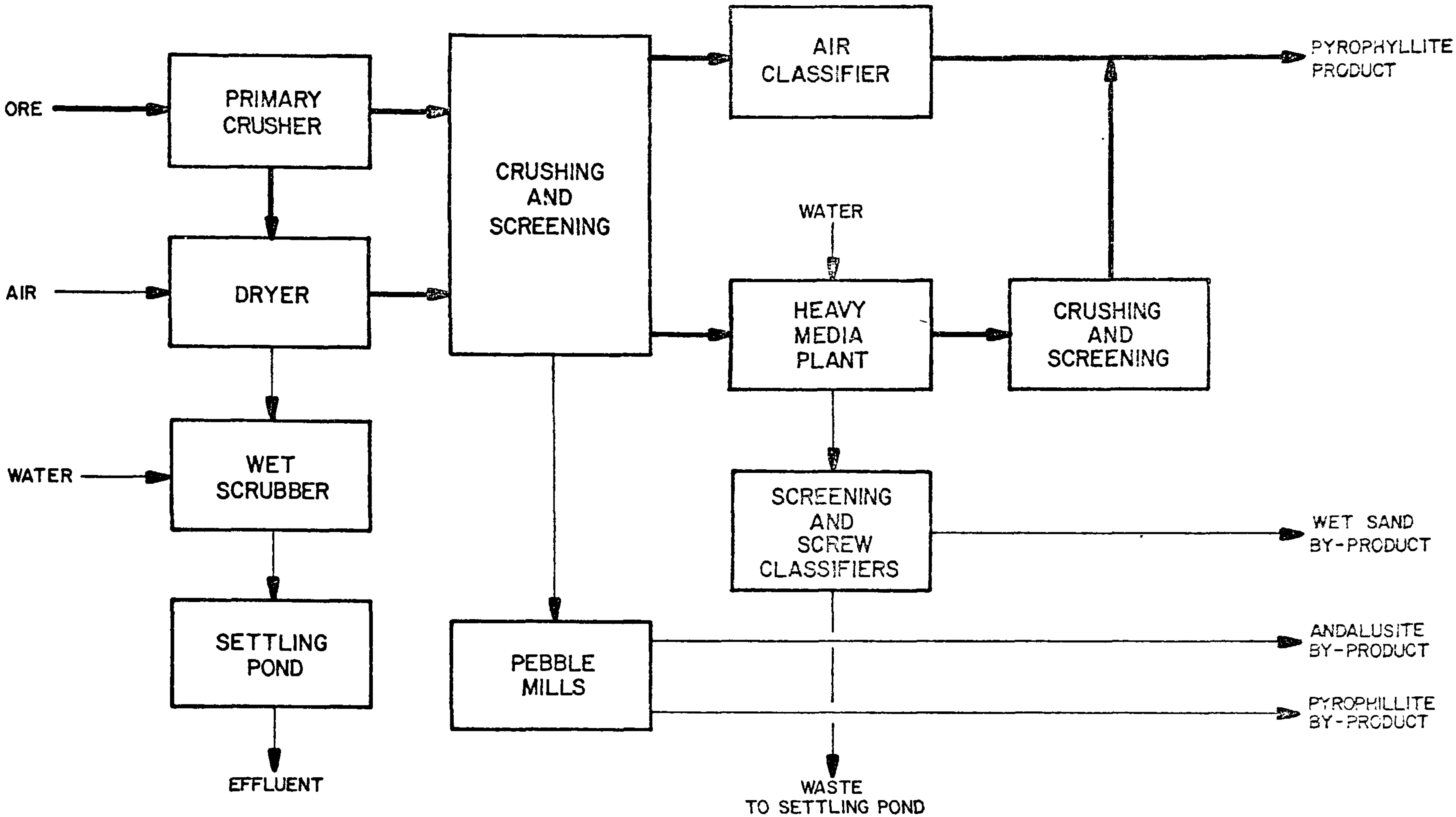

FIGURE V-3.9.6
PYROPHYLLITE MINING AND PROCESSING
(HEAVY MEDIA SEPARATION)

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Waste Material at Plant No.	kg/kkg of flotation product (lb/ton) 2031	2032	2033	2044
Suspended solids	1800 (3600)	1200-1750 (2400-3500)	800 (1600)	26 (52)

3.9.4.2 Plant Water Use

The flotation mill at plant 2031 consumes, on the average, 25,400 liters of water per metric ton (6,070 gallons/ton) of product. This includes 200 liters of non-contact cooling water per metric ton (48 gallons/ton) of products which is used in cooling the bearings of their crushers.

Plant 2032 consumes 17,200 liters of water per metric ton (4150 gallon/ton) of product; 40 percent of which may be recycled back to process, after clarification. Recycled water is used in conditioners and as coolant in compressor circuits and for several other miscellaneous needs.

Plant 2033 consumes 16,800 liters of water per metric ton of (4000 gal/ton) product; 20 percent of which is recycled back to process from the primary thickener operation. Plant 2044 consumes on the average 5,400 liters of process water per metric ton (1,305 gal/ton) of total product. The hydraulic load of these plants is summarized below:

Consumption at Plant No.	Liters/day (gal/day) 2031	2032	2033	2044
Process consumed	730,000 (192,000)	2,200,000 (583,000)	757,000 (200,000)	1,135,000 (300,000)
Non-contact cooling	37,000 (9,600)	---	54,000	--- (14,400)

3.9.4.3 Plant Waste Treatment

At plant 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 no point discharge from this clarification pond. The tailings remain in the settling ponds and are dried by natural evaporation and seepage.

At plant 2032, the mill tailings are pumped uphill through 3000 feet of pipe to a pond of 34,000,000 liters (9,000,000 gallons) 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 may be sent back to the mill and the remainder is discharged to a brook near the property.

In plant 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 plant 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 into a "U" shaped primary settling pond. The flow follows the "U" 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 acres). The back-up pond (clarification pond) discharges to an open ditch running into a nearby creek. The non-contact cooling water in plants 2031 and 2033 is discharged without treatment. Plant 2044 uses a 1.6 hectare (4 acres) settling pond to treat the wastewater; the overflow from this pond is discharged into the river. 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.

3.9.4.4 Effluent Composition

As all process water at plant 2031 is impounded and lost by evaporation, there is no process water effluent out of this property.

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

Waste Material Plant Number	2032	2033	2044
pH	7.2-8.5	5.6	7.0
TSS, mg/l	<20	80	100

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

plant	kg/kkg of product (lb/ton)
2032	<0.34 (<0.68)
2033	1.34 (2.68)
2044	0.50 (1.00)

Exemplary performance of wastewater treatment was attained by plants 2032 and 2044. Also plant 2031 is a special case in that it has no discharge by virtue of evaporation and seepage of all wastewater.

3.10 Natural Abrasives

Garnet and tripoli are the major natural abrasives mined in the U.S. Other minor products, e.g. emery and special silica-stone products, are of such low volume production (2,500-3,000 kkg/yr) as to be economically insignificant and will not be considered further.

3.10.1 Natural Abrasives, Garnet

Garnet is mined in the U.S. almost solely for use as an abrasive material. Two garnet abrasive producers, representing more than 80 percent of the total U.S. production, provided the data for this section. There are 4 plants in the U, S. producing garnet, one of which produces it only as a by-product.

3.10.1.1 Process Description

The two garnet operations studied are in widely differing geographic locations, and so the garnet deposits differ, one being a mountain schists (3071), and the other an alluvial deposit (3037).

Plant 3071 mines by open pit methods with standard drilling and blasting equipment. The ore is trucked to a primary crushing plant and from there conveyed to the mill where additional crushing and screening occurs. The screening produces the coarse feed to the heavy-media section and a fine feed for flotation.

The heavy-media section produces a coarse tailing which is dewatered and stocked, a garnet concentrate, and a middling which is reground and sent to flotation. The garnet concentrate is then dewatered, filtered, and dried.

Plant 3037 mines shallow open pits, stripping off overburden, then using a dragline to feed the garnet-bearing earth to a trumble (heavy rotary screen). Large stones are recovered and used for road building or to refill the pits. The smaller stones are trucked to a jigging operation, also in the field, where the heavier garnet is separated from all impurities except some of the high density kyanite. The raw garnet is then trucked to the mill. There the raw garnet is dried, screened, milled, screened and packaged.
Figure V-3.10.1 gives the general flow diagram for these operations.

3.10.1.2 Raw Waste Load

Solid waste is generated in garnet mining as overburden which is used for reclaiming worked-out pits. Large stones recovered from in-the-field screening operations at plant 3037 are also used to refill pits or for road building.

In the processing of the garnet ore, solid waste in the form of coarse tailings is generated from the heavy-media plant at plant 3071. These tailings are stocked and sold as road gravel. The flotation underflow at plant 3071 consisting of waste fines, flotation reagents and water is first treated to stabilize the pH and then is sent to a series of tailings ponds. In these ponds, the solids settle and are removed intermittently by a dragline and used as landfill.

The categories of raw wastes generated at these plants are therefore:

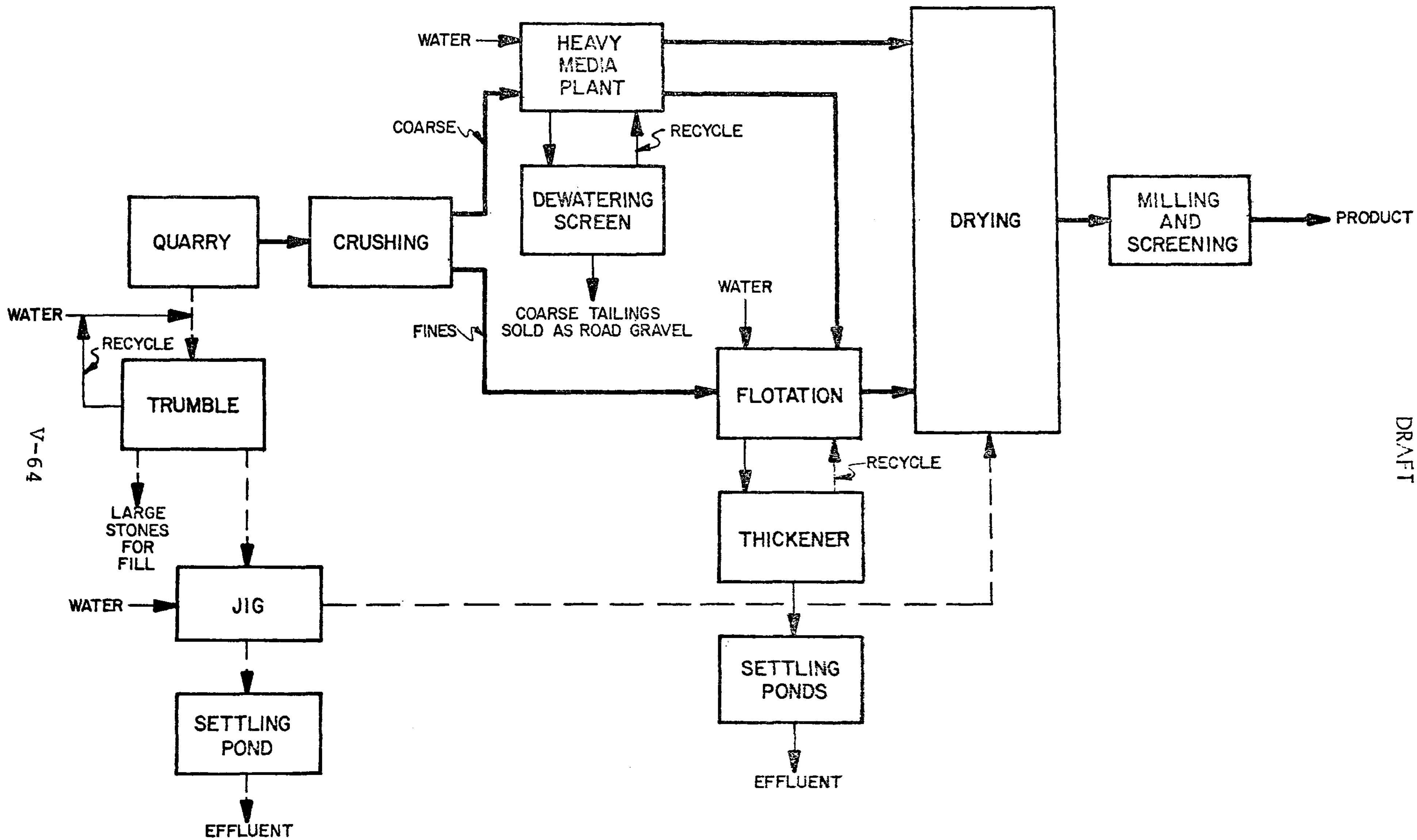

FIGURE V-3.10.1
GARNET MINING AND PROCESSING

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	3037	3071
large stones and coarse tailings	yes	yes
flotation fines and reagents	no	yes
fine tailings	yes	no

3.10.1.3 Water Use

Untreated surface water is pumped to the pits at plant 3037 for initial washing and screening operations and for make-up. This pit water is recycled and none is discharged except as ground water. Surface water is also used for the jigging operation, but is discharged after passage through a settling pond. No data is available regarding the quantity of water used in these operations.

At plant 3071, water is collected from natural run-off and mine drainage into surface reservoirs, and it is used in both the heavy media plant and in flotation. This process water amounts to approximately 380-760 liter/min (100-200 GPM) and is about 50 percent recycled.

Effluent flow varies seasonally from a springtime maximum of 570 liter/min (150 GPM) to a minimum in summer and fall.

The summarized average water flow data given below is based on 50 percent recycle at plant 3071:

	liters/kkg product (gallon/ton)	
	3037	3071
washing and screening	amount not known	none
heavy media separation and flotation	none	24,600 (5,900)
jigging	amount not known	none
discharge of wastes	jigging water only	12,300 (3,000)

3.10.1.4 Waste Water Treatment

Plant 3037 recycles untreated pit water used in screening operations, and sends water from jigging operations to a settling pond before discharging it back into the creek.

Waste water from flotation underflow at plant 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 plant.

3.10.1.5 Effluent and Disposal

Effluent arising from flotation underflow at plant 3071 is discharged. The pH is maintained at 7. The suspended solids content were estimated to average 25 mg/liter in concentration.

Effluent from jigging operations at plant 3037 is discharged after passage through a settling pond. No data is available on the quality of the discharge.

3.10.2 Natural Abrasives, Tripoli

Tripoli encompasses a group of fine-grained, porous, silica materials which have similar properties and uses. These include tripoli, amorphous silica and rottenstone. All four producers of tripoli provided the data for this section.

3.10.2.1 Process Description

Amorphous silica (tripoli) is normally mined from underground mines using conventional room-and-pillar techniques. There is at least one open-pit mine (5688). Trucks drive into the mines where they are loaded using front-end loaders. The ore is then transported to the plant for processing. Processing consists of crushing, screening, drying, milling, classifying, storage, and packing for shipping. A general process diagram is given in Figure V-3.10.2. At one plant only, a minor portion of the production, value approximately $250,000, is made by a unique process using wet-milling and scrubbing and produces

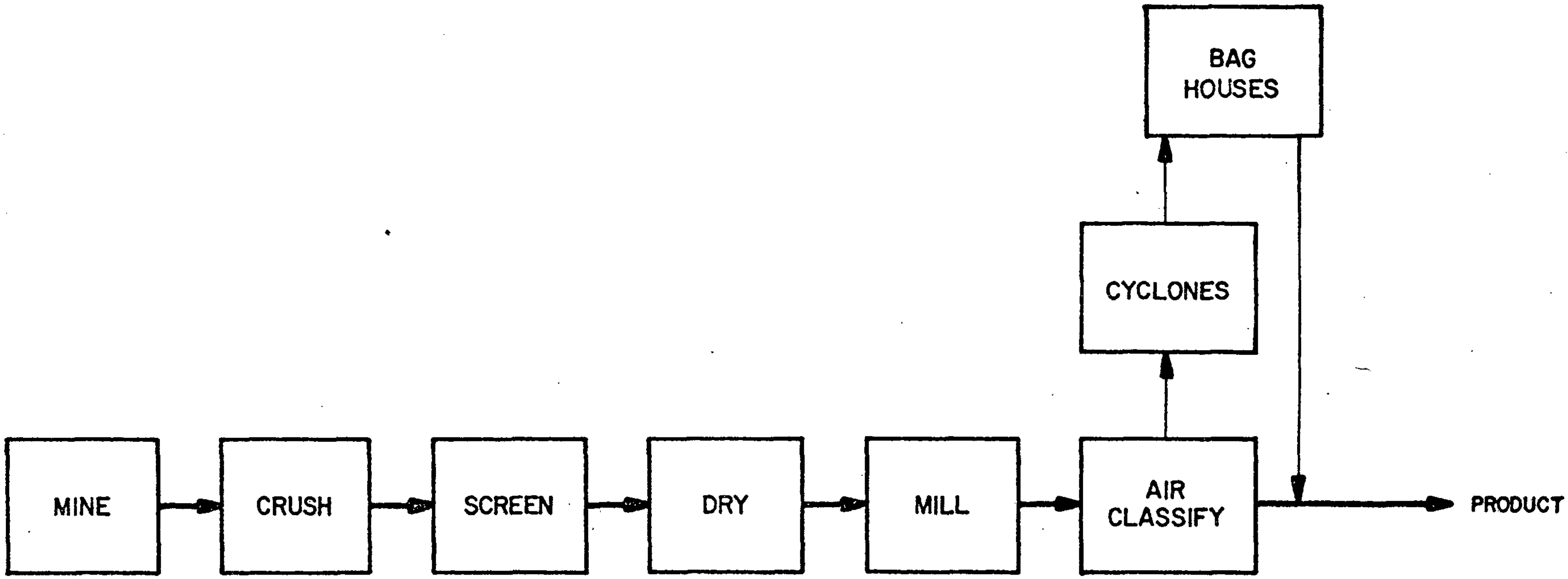

FIGURE V-3.10.2

TRIPOLI MINING AND PROCESSING
BY THE STANDARD PROCESS

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a special grade product. This segment is economically insignificant and will not be considered further.

3.10.2.2 Raw Waste Load

Both plants report no significant waste in processing. Any dust generated in screening, drying, or milling operations is gathered in cyclones and dust collectors and returned to the process as product.

Mining generates a small amount of dirt which is piled outside the mine and gravel which is used to build roads in the mining areas. The product itself is of a very pure grade so no other mining wastes are generated.

3.10.2.3 Water Use

There is no water used in mining, nor is there any ground water or rain water accumulation in the mines.

The standard process is a completely dry process.

3.10.2.4 Waste Water Treatment

Plants using the standard process generate no wastewater.

3.10.2.5 Effluent and Disposal

There is no effluent from plants using the standard process.

3.11 Diatomite Mining

There are nine diatomite mining and processing facilities in the U.S. The data from three are included in this section. These three plants produce roughly one-half of the U.S. production of this material.

3.11.1 Process Description

After the overburden is removed from the diatomite strata by power-driven shovels, scrapers and bulldozers, the crude diatomite is dug from the ground and loaded onto trucks. Plants 5504 and 5505 haul the crude diatomite directly to the mills for processing. At plant 5500 the trucks carry the crude diatomite to vertical storage shafts placed in the formation at locations above a tunnel system. These shafts have gates through which the crude diatomite is fed to an electrical rail system for transportation to the primary crushers.

At plant 5500, after primary crushing, blending, and distribution, the material moves to different powder mill units. For "natural" or uncalcined powders, crude diatomite is crushed and then milled and dried simultaneously in a current of heated air. The dried powder is sent through separators to remove waste material and is further divided into coarse and fine fractions. These powders are then ready for packaging. For calcined powders, high temperature rotary kilns are continuously employed. After classifying, these powders are collected and packaged. To produce flux-calcined powders, particles are sintered together into microscopic clusters, then classified, collected and bagged.

At plants 5504 and 5505, the ore is crushed, dried, separated and classified, collected, and stored in bins for shipping. Some of the diatomite is calcined at plant 5505 for a particular product. Diagrams for these processes are given in Figure V-3.11.1.

One plant surface-quarries an oil-impregnated diatomite, which is crushed, screened, and calcined to drive off the oil. The diatomite is then cooled, ground, and packaged. In the future, the material will be heated and the oil vaporized and recovered as a petroleum product.

3.11.2 Raw Waste Load

Wastes from these operations consist of the oversize waste fraction from the classifiers and of fines collected in dust control equipment. The amount is estimated to be 20 percent of the mined material at plant 5500, 16-19 percent at plant 5504 and 5-6 percent solids as a slurry from scrubber operations at plant 5505.

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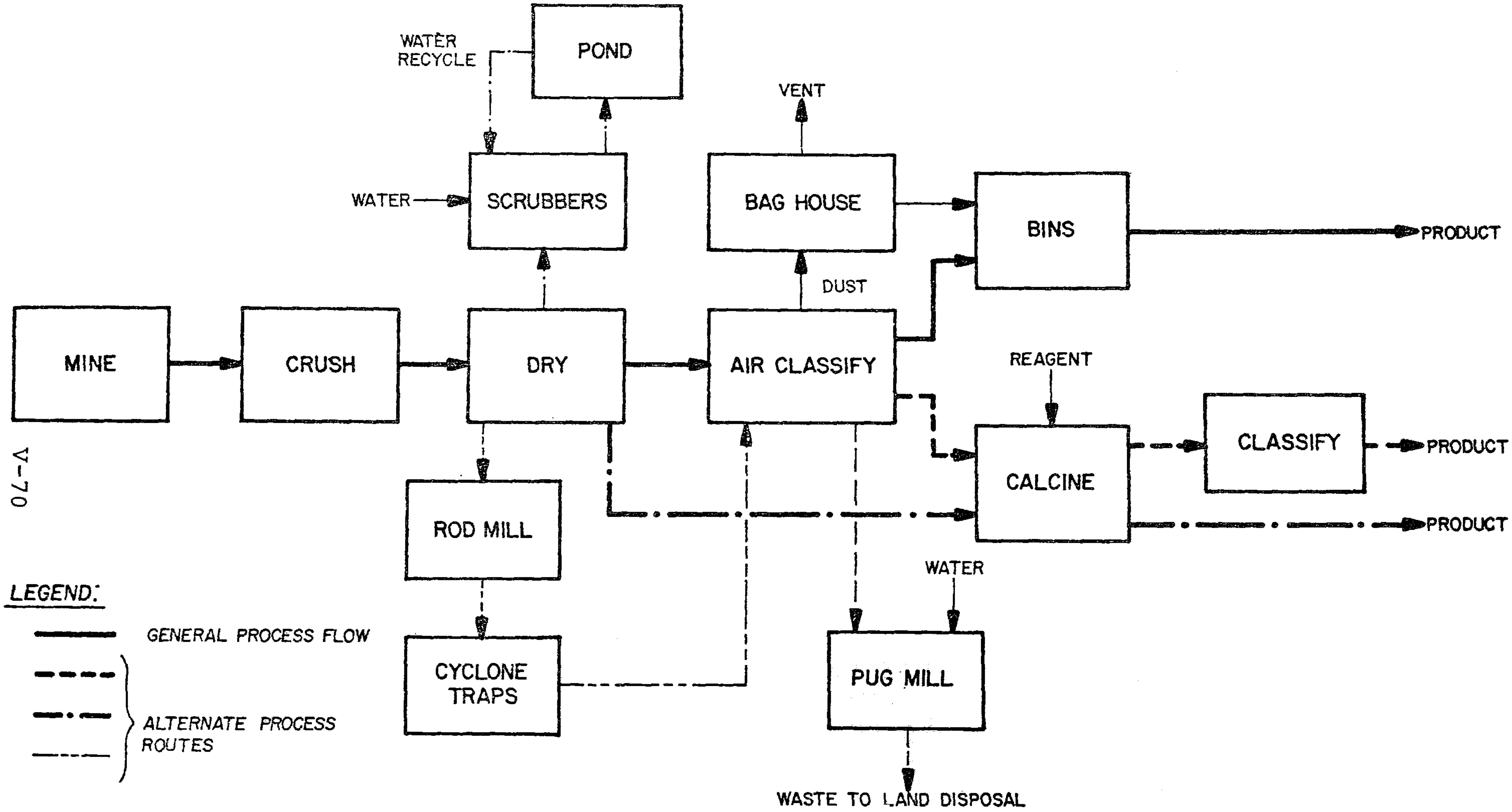

FIGURE V-3.11.1
DIATOMITE MINING AND PROCESSING

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waste material	kg/metric ton of ore (lb/ton)
Plant 5500, oversize, dust fines	200 (400)
Plant 5504, sand, rock, heavy diatoms	175 (350)
Plant 5505, dust fines (slurry)	45 (90)

3.11.3 Water Use

Water is used by plant 5500 in the principal process for dust collection and for preparing the waste oversize material for land disposal. In addition, a small amount of bearing cooling water is used. Water is used in the process at plant 5505 only in scrubbers used to cut down on dust fines in processing, which is recycled from settling ponds to the process. The only loss occurs through evaporation with make-up water added to the system. Water is used in the process at plant 5504 to slurry wastes to a closed pond. This water evaporates and/or percolates into the ground. As yet there is no recycle from the settling pond.

	liters per metric ton of ore processed (gallon/ton)		
	5500	5505	5504
Intake:			
make-up water	2,800 (670)	880 (210)	3,800 (910)
Use:			
dust collection and waste disposal	2,670 (640)	8,700 (2,090)	3,800 (910)
bearing cooling	125-160 (30-38)	----	----
Consumption:			
evaporation (pond and process)	2,800 (670)	880 (210)	3,800 (910)

The much lower consumption of water at 5505 is due to the use of recycling from the settling pond to the scrubbers.

3.11.4 Waste Water Treatment

All wastewater generated in diatomite preparation at plant 5500 is evaporated on the land. Plants 5504 and 5505 send wastewater to settling ponds with water being recycled to the process at plant 5505 and evaporation/percolation of the water at plant 5504.

3.11.5 Effluent and Disposal

The only wastewater at plant 5500 is land-evaporated on-site. There is no process water, cooling, or mine pumpout discharge.

At plants 5504 and 5505, the wastewater from scrubbers and waste fines slurrying is sent to settling ponds. At plant 5505, the water is decanted and recycled to the process, while plant 5504 currently impounds the water in a closed pond and the water evaporates and/or percolates into the ground. But in late 1974 a pump is being installed to enable plant 5504 to decant and recycle the water from the pond to the process. Thus, all of these diatomite operations have no discharge of any wastewater.

The oversize fraction and dust fines waste is land-dumped on-site at plant 5500. The solids content of this land-disposed waste is silica (diatomite) in the amount of about 300 g/liter (2.5 lb/gal).

The waste slurries from plants 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 g/liter (0.2 lbs/gal) for plant 5505 and 146 g/liter (1.2 lbs/gal) for plant 5504.

3.12 Graphite

There is one producer of natural graphite in the United States and data from this operation is presented in the following sections.

3.12.1 Process Description

The graphite ore is produced from an open pit using conventional mining methods of benching, breakage and removal. The ore is properly sized for flotation by passing through a 3-stage dry crushing and sizing system and then to a wet grinding circuit consisting of a rod mill in closed circuit with a classifier. Lime is added in the rod mill to adjust pH for optimum flotation. The classifier discharge is pumped to the flotation circuit where water additions are made and various reagents added at different points in the process flow. The graphite concentrate is floated, thickened, filtered and dried. The underflow or waste tailings from the cells are discharged as a slurry to a settling pond. The process flow diagram for the plant is shown in Figure V-3.12.1.

3.12.2 Raw Waste Loads

There are three sources of waste associated with the plant operation. They are the tailings from the flotation circuit, low pH seepage water from the tailings pond, and an intermittent seepage from the mine.

waste material	kg/metric ton of product (lbs/ton)
flotation tailings	36,000 (72,000)

(The flotation reagents used in this process are alcohols and pine oils.)

	liters/metric ton of product (gal/ton)
low pH seepage water	19,000 (4,500) (1)
mine seepage water	intermittent and unknown

(1) Estimated volume under normal operating and weather conditions.

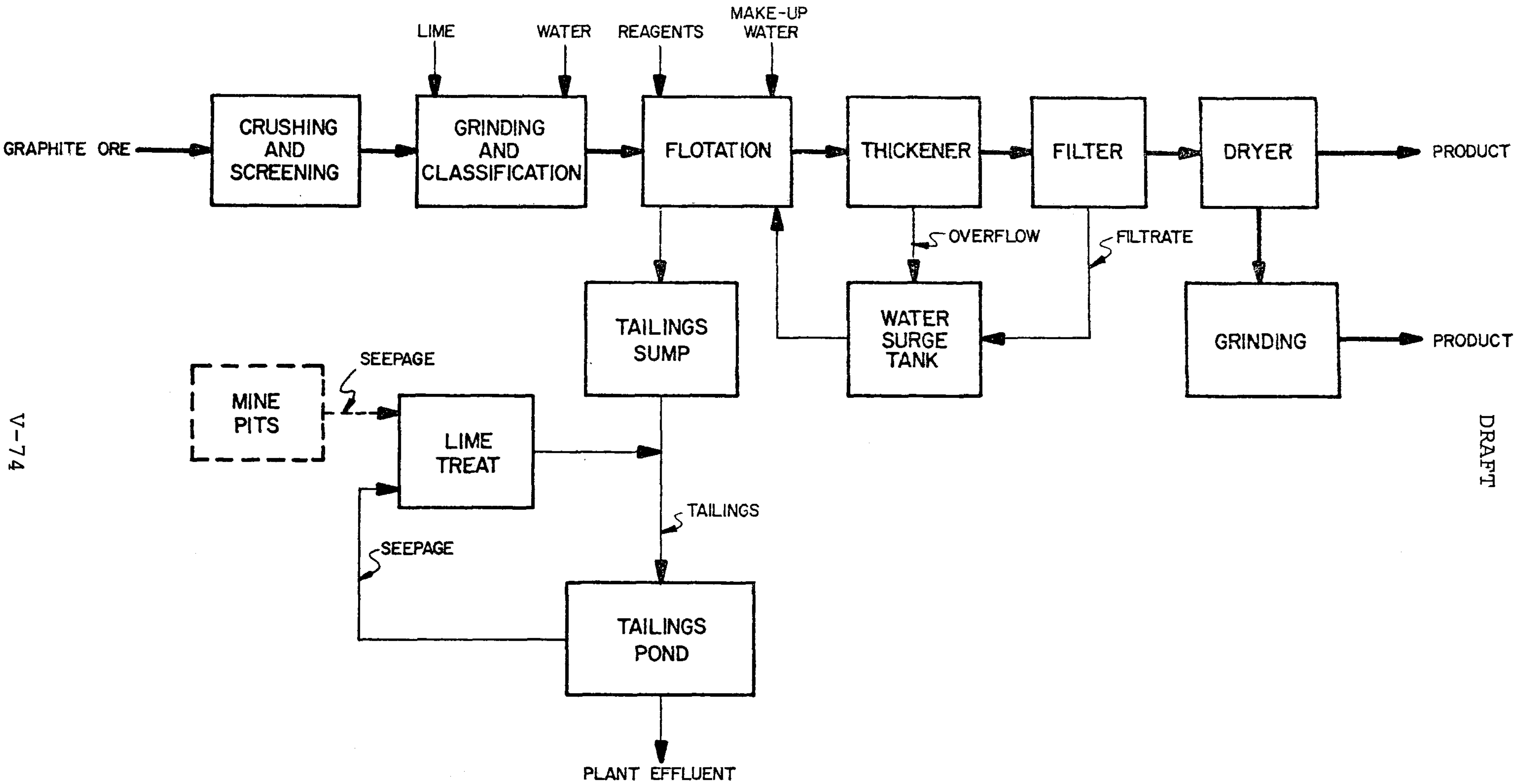

FIGURE V-3.12.1
GRAPHITE MINING AND PROCESSING

3.12.3 Water Use

The source of the intake water is almost totally from a lake. The exceptions are that the drinking water is taken from a well and a minimal volume for emergency or back-up for the process comes from an impoundment of an intermittent flowing creek. Some recycling of water takes place through the reuse of thickener overflow, filtrate from the filter operation and non-contact cooling water from compressors and vacuum pumps.

water consumption	liters/metric ton of product (gal/ton)
total intake	159,000 (38,000)
process waste discharge	107,000 (26,000)
consumed (process, non-contact cooling, sanitation)	52,000 (12,000)

3.12.4 Wastewater Treatment

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 wastewaters are pumped to a treatment facility where lime is added to neutralize the acidity and precipitate the 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.

3.12.5 Effluent

There is one effluent stream from this operation which is the overflow from the tailings pond. It is discharged into a stream that flows into the lake that serves as the intake water source for the plant. 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. The measurements from the June 1974 report to the state compared to the state limitations, both converted to a basis of amount per unit production are:

	June 1974	
	Average	Maximum
Flow, liters/kkg	106,000	156,000
(gal/ton)	(25,500)	(37,500)
Constituents, kg/kkg (lb/ton):		
total residue	80 (160)	--- (---)
total suspended solids	0.3 (0.6)	0.8 (1.6)
volatile solids	0.1 (0.2)	--- (---)
manganese	0.01 (0.02)	--- (---)
iron	0.01 (0.02)	--- (---)
BOD	1.0 (2.0)	--- (---)
COD	2.1 (4.2)	--- (---)

	State Standards	
	Average	Maximum
Flow, liters/kkg	156,000	250,000
(gal/ton)	(37,500)	(60,000)
Constituents, kg/kkg (lb/ton):		
total residue	215 (430)	--- (---)
total suspended solids	1.6 (3.2)	7.5 (15)
volatile solids	0.8 (1.6)	--- (---)
manganese	0.03 (0.06)	0.25 (0.5)
iron	0.16 (0.32)	1.3 (2.6)
BOD	1.6 (3.2)	6.3 (12.6)
COD	2.3 (4.6)	7.5 (15.0)

Note: The above State limitation on TSS as a monthly average of 1.6 kg/kkg is equivalent to only 10 mg/liter. This plant 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 more than that normally expected from a well designed pond.

3.13.1 Jade

The jade industry in the U.S. is very small. One plant representing 55 percent of total U.S. jade production provided the data for this section.

3.13.1.1 Process Description

The jade is mined in an open pit quarry, with rock being obtained by pneumatic drilling and wedging of large angular blocks. No explosives are used on the jade itself, only on the surrounding host rock. The rock is then trucked to the plant for processing. There the rock is sawed, sanded, polished and packaged for shipping. Of the material processed only a small amount (3 percent) is processed to gems and 47 percent is processed to floor and table tiles, grave markers, and artifacts. A general process diagram is given in Figure V-3.13.1.

3.13.1.2 Raw Waste Load

Approximately 50 percent of the rock taken each year from the quarry is unusable or unavoidably wasted in processing, amounting to 29.5 kkg/year (32.5 TPY). There is no pit pumpout associated with this operation.

3.13.1.3 Water Use

Well water is used in the process for the wire saw, sanding, and polishing operations. This water use amounts to 190 l/day (50 GPD) of which none is recycled.

3.13.1.4 Waste Water Treatment

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 plant lawn where it evaporates and/or seeps into the ground. There is no other water treatment employed.

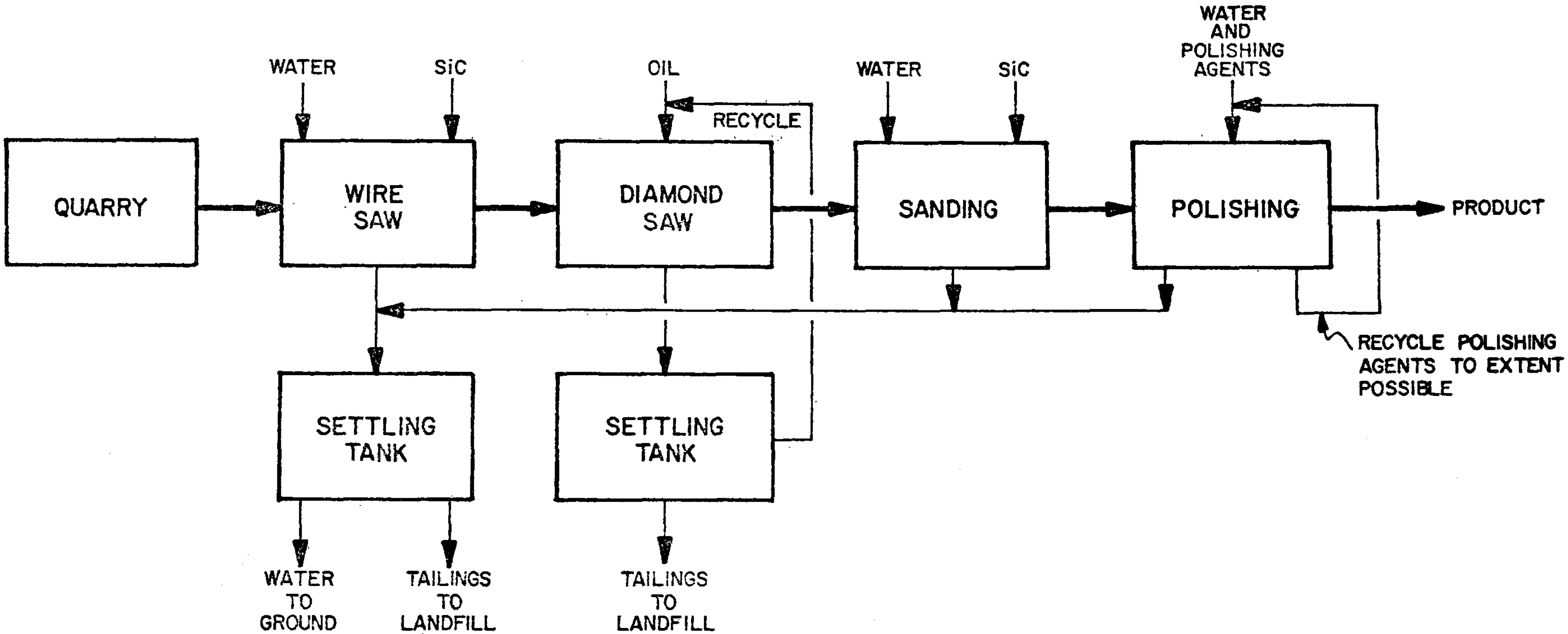

FIGURE V-3.13.1
JADE MINING AND PROCESSING

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3.13.1.5 Effluent and Disposal

Solid wastes in the form of tailings which collect in settling tanks are eventually land-disposed as fill.

There is no discharge of process wastewater to navigable waterways.

3.13.2 Novaculite

Novaculite, a generic name for large geologic formations of pure, microcrystalline silica, is mined only in Arkansas by one plant. The data in this section was provided by that plant.

3.13.2.1 Process Description

Open quarries are mined by drilling and blasting, with a front-end loader loading trucks for transport to covered storage at the plant. Since the quarry is worked for only about 2 weeks per year, mining is contracted out.

Plant processing consists essentially of crushing, drying, air classification and bagging. Normally silica will not require drying but novaculite is hydrophilic and will absorb water up to 9 parts per 100 ore. Part of the air classifier product is diverted to a batch mixer, where organics are reacted with the silica for specialty products. A general process diagram is given in Figure V-3.13.2.

3.13.2.2 Raw Waste Load

Wastes generated in the mining of novaculite remain in the quarry as reclaiming fill, and processing generates only scrubber fines which are settled in a holding tank and eventually used for land-fill. There is no data available on the amount of this material. However, a new plant dust scrubber will be installed with recycle of both water and fines.

3.13.2.3 Water Use

No water is used in novaculite mining and the quarry is so constructed that no pit water accumulates.

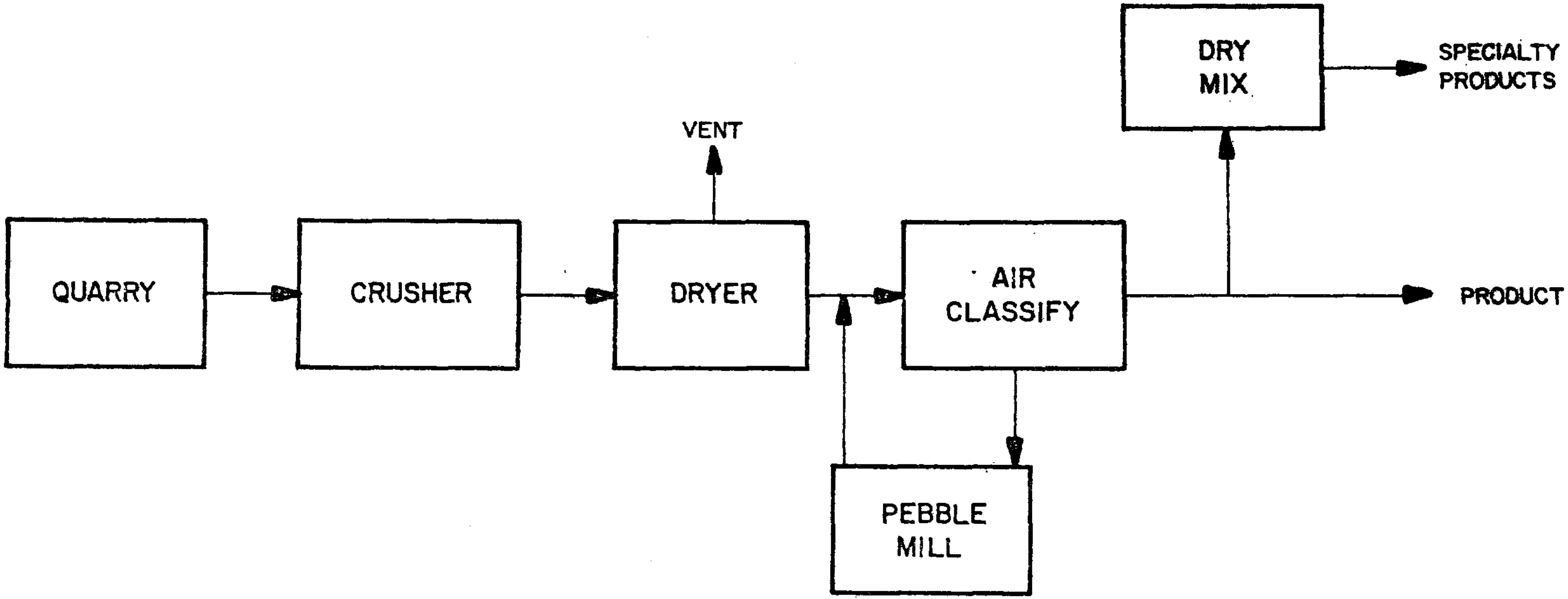

FIGURE V-3.13.2
NOVACULITE MINING AND PROCESSING

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Total water usage at the plant for bearing cooling and the dust scrubber totals approximately 18,900 l/day (5,000 GPD) of city water. Of this total amount 7,300-14,500 l/day (1,900-3,800 GPD) is used for bearing cooling and an equivalent amount is used as make-up water to the dust scrubber.

3.13.2.4 Waste Water Treatment

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

3.13.2.5 Effluent and Disposal

Dust from the scrubber is currently land-disposed. However, with the installment of a new dust scrubber both the water and muds will be recycled to the process.

Scrubber water is recycled to the process after settling out of solids in a tank. Cooling water is discharged onto the lawn at the plant and it either seeps into the ground or evaporates.

4.0 DETERMINING THE RATIONALE FOR EFFLUENT LIMITATIONS GUIDELINES FOR MAXIMUM DAILY VALUES

The bulk of the data used in the technical development of effluent limitations guidelines for the mineral mining and processing industry have been representative of long-term performance values. For all practical purposes, these discharge data may be regarded as equivalent to monthly average data.

It is recognized, however, that day-to-day discharges are subject to a wide variety of factors which result in a distribution of daily effluent values around a monthly mean. Some of the reasons for wider daily variations in the pollutant discharges are built-in process inhomogeneities such as batch-wise process steps, process startups and shutdowns, minor process upsets, the normal imprecision of process controls, day-to- day weather (rainfall, ambient temperature, humidity) variations, and the range of differences among operating personnel.

Daily variability data for the most common pollutant parameter in these industries, suspended solids, is listed in Table V-4.1 as the ratios of the concentrations of daily effluent discharges to monthly average discharges for the 21 plants from which such detailed data were available. The vast majority of facilities in this industry have not sampled frequently enough to establish such a wide data base, so the inference is drawn that the relative variability found in these plants is representative of all the other mineral mining and processing facilities insofar as suspended solids concentration in the effluent is concerned.

The data of Table V-4.1 have been arranged in the order of increasing daily/monthly ratio. The last column is the cumulative probability that a given plant's discharge would have a daily/monthly ratio less than or equal to the value shown. For example, 13 of the 21 plants (61.9 percent) of the plants had a ratio of maximum daily/monthly average suspended solids discharge less than or equal to 2.5.

These data are graphically shown in Figure V-4.1, where the log of the daily/monthly ratio is plotted against the cumulative probability. The straight line implies that the log of the ratio is normally distributed. This assumption seems justifiable in view of the good fit to the data points.

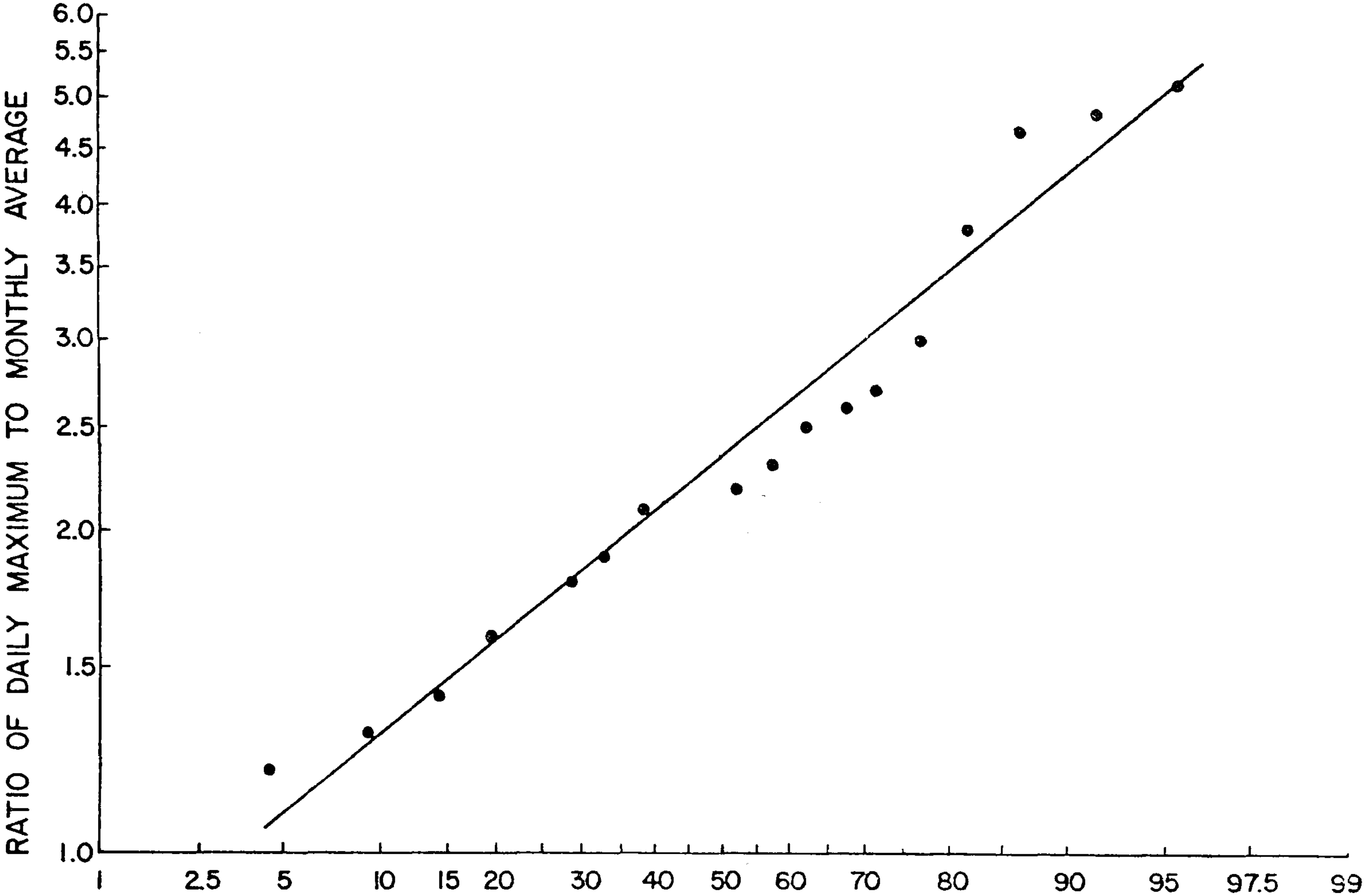

FIGURE V - 4.1

DAILY/MONTHLY RATIO OF SEVERAL PLANTS

TABLE V-4.1

Ratio of Maximum Daily/Monthly Average Effluent Data for 21 Plants (arranged in ascending order)

Plant No.	Ratio of Maximum Daily/ Monthly Average	Cumulative Probability, Percent
1	1.2	4.8
2	1.3	9.5
3	1.4	14.3
4	1.6	19.1
5	1.8	28.6
6	1.8	28.6
7	1.9	33.3
8	2.1	38.1
9	2.2	52.4
10	2.2	52.4
11	2.2	52.4
12	2.3	57.1
13	2.5	61.9
14	2.6	66.7
15	2.7	71.4
16	3.0	76.2
17	3.7	81.0
18	4.6	85.7
19	4.8	90.5
20	5.1	95.2
21	7.0	100.0

Using this distribution curve based on the TSS effluent concentration performance of a very limited sample of mineral processing plants, several reasonable multiplication factors for monthly average to daily maximum could be selected. A daily maximum value based on a factor of 2.5 would contain 50% of normally varying daily values for plants exactly meeting the specified monthly guideline. In practice many plants would average well under the monthly guidelines, so considerably more than 50% would meet daily values based on a factor of 2.5. Similarly, a factor of 5, which corresponds to a two-standard-deviation limit would contain at least 95% of normally varying daily samples from plants falling within a given monthly average limitation. Based on conservative practice, this latter value is recommended.

Other pollutant parameters found in these industries, such as fluoride and zinc, occur infrequently and therefore are handled on a case-by-case basis.

5.0 RATIONALE AND SUPPORTING DATA FOR GENERAL MINE WATER DISCHARGE LIMITATIONS

Of the mines studied in detail in the clay, ceramic, refractory, and miscellaneous materials segment of the mineral mining and processing industry, approximately 40 percent were found not to have any mine pumpout water discharge. Of the discharges found, the preponderances were either intermittent or highly variable in flow. Mine pumpout was also found to be unrelated to production rate except that in certain instances pumpout was necessary to start or maintain production.

The origin of the mine water is rainfall or leakage from aquifers. Surface runoff into mines constitutes poor practice and can be readily overcome by diversion ditches and dikes. Because of the natural origin of this water, volumes are extremely variable from plant-to-plant and from season-to-season.

The mine water discharge quality data from 19 mines in these industries are summarized in Table V-5.1. Ten of these discharges are untreated. The treatment for the others consists generally of pond settling with pH adjustment where necessary.

The mine water discharge from the Fuller's Earth (montmorillonite) mine stands out from the others in its high concentration of suspended solids. This is to be expected in that montmorillonite is a material that readily disperses in water into a stable colloidal suspension. In these industries bentonite is another montmorillonitic mineral mined that has the same characteristic. However, no bentonite mines were found having mine water. Since the pumpout water for the mining of montmorillonitic clay materials will contain non-settlable suspended solids, and a sufficient data base does not exist on effluent concentrations, meaningful mine pumpout effluent limitation guidelines cannot be developed at this time for these categories: Montmorillonite and Bentonite.

TABLE V-5.1

MINE WATER PUMPOUT
CLAY, CERAMIC, REFRACTORY, AND MISC. MINERALS INDUSTRIES

Mineral	Plant	Treatment	Monthly Average pH	Monthly Average TSS (mg/liter)
Talc	2040;2041;) 2042;2043)	1	7.2-8.5	<20
	2036	1	7.5-7.8	9
	2039	1	7.0-7.3	3
Fire Clay and Shale	3078	1;2	6	*
	3075	None	6.5	30
	3076	None	8.3	30
	3077	None	8.3	18
	3082	None	8.5	22
	3083	1	7.3	3
	3084	1;2	6.5	26
	3079	1;2	6	20
	3085	None	8.0	5
	3086	None	8.0	6.1
Kaolin	3074	None	6.2	10
	3080	None	6.4	10
	3081	None	6.0	10
	3035;3036;) 3062;3063)	1	*	*
	3024;3025	None or 1;2	*	*
Ball Clay	5684;5686	1	*	*
	5685;5687	None or 3	*	*
Fuller's Earth (attapulgite)	3058;3060	None	*	*
Fuller's Earth (montmorillonite)	3059	None	6.9	215
	3072;3073	None	*	*
Aplite	3020	None	*	*
Garnet	3071	1;4	*	*
Graphite	4000	1;2	Pumpout is part of process water	

* No Data Available

LEGEND:
1. Ponds
2. Lime Treatment
3. Sump Hole
4. Make-up water

For the mine pumpout from the other subcategories, the discharges were found to be within the pH range of 6-9. Clearly, those with acidic mine water had treated to at lease pH 6 prior to discharge. Those with no treatment had no pH problem. Of the non-montmorillonitic mines, 78 percent were found to discharge an average TSS concentration of 20 mg/liter or less. Of those mines having at least a settling pond treatment for mine water, 89 percent had this quality of discharge.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

1.0 INTRODUCTION

The wastewater constituents of pollution significance for this segment of the mineral mining and processing industry are based upon those parameters which have been identified in the untreated wastes from each subcategory of this study. The wastewater constituents are further divided into those that have been selected as pollutants of significance with the rationale for their selection, and those that are not deemed significant with the rationale for their rejection.

The basis for selection of the significant pollutant parameters was:

(1) toxicity to humans, animals, fish and aquatic organisms;
(2) substances causing dissolved oxygen depletion in streams;
(3) soluble constituents that result in undesirable tastes and odors in water supplies;
(4) substances that result in eutrophication and stimulate undesirable algae growth;
(5) substances that produce unsightly conditions in receiving water; and
(6) substances that result in sludge deposits in streams.

2.0 SIGNIFICANCE AND RATIONALE FOR SELECTION OF POLLUTION PARAMETERS

2.1 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is a measure of the oxygen consuming capabilities of organic matter. The BOD does not in itself cause direct harm to a water system, but it does exert an indirect effect by depressing the oxygen content of the water. Sewage and other organic effluents during their processes of decomposition exert a BOD, which can have a catastrophic effect on the ecosystem by depleting the oxygen supply. Conditions are reached frequently where all of the oxygen is used and the continuing decay process causes the production of noxious gases such as hydrogen sulfide and methane. Water with a high BOD indicates the presence of decomposing organic matter and subsequent high bacterial counts that degrade its quality and potential uses.

Dissolved oxygen (DO) is a water quality constituent that, in appropriate concentrations, is essential not only to keep organisms living but also to sustain species reproduction, vigor, and the development of populations. Organisms undergo stress at reduced D.O. concentrations that make them less competitive and able to sustain their species within the aquatic environment. For example, reduced DO concentrations have been shown to interfere with fish population through delayed hatching of eggs, reduced size and vigor of embryos, production of deformities in young, interference with food digestion, acceleration of blood clotting, decreased tolerance to certain toxicants, reduced food efficiency and growth rate, and reduced maximum sustained swimming speed. Fish food organisms are likewise affected adversely in conditions with suppressed DO. Since all aerobic aquatic organisms need a certain amount of oxygen, the consequences of total lack of dissolved oxygen due to a high BOD can kill all inhabitants of the affected area.

If a high BOD is present, the quality of the water is usually visually degraded by the presence of decomposing materials and algae blooms due to the uptake of degraded materials that form the foodstuffs of the algal populations. BOD was not a major contribution to pollution in this industry.

2.2 Fluorides

As the most reactive non-metal, fluorine is never found free in nature but as a constituent of fluorite or fluorspar, calcium fluoride, in sedimentary rocks and also of cryolite, sodium aluminum fluoride, in igneous rocks. Owing to their origin only in certain types of rocks and only in a few regions, fluorides in high concentrations are not a common constituent of natural surface waters, but they may occur in detrimental concentrations in ground waters.

Fluorides are used as insecticides, for disinfecting brewery apparatus, as a flux in the manufacture of steel, for preserving wood and mucilages, for the manufacture of glass and enamels, in chemical industries, for water treatment, and for other uses.

Fluorides in sufficient quantity are toxic to humans, with doses of 250 to 450 mg giving severe symptoms or causing death.

There are numerous articles describing the effects of fluoride- bearing waters on dental enamel of children; these studies lead to the generalization that water containing less than 0.9 to 1.0 mg/liter of fluoride will seldom cause mottled enamel in children, and for adults, concentrations less than 3 or 4 mg/liter are not likely to cause endemic cumulative fluorosis and skeletal effects. Abundant literature is also available describing the advantages of maintaining 0.8 to 1.5 mg/liter of fluoride ion in drinking water to aid in the reduction of dental decay, especially among children.

Chronic fluoride poisoning of livestock has been observed in areas where water contained 10 to 15 mg/liter fluoride. Concentrations of 30-50 mg/liter of fluoride in the total ration of dairy cows is considered the upper safe limit. Fluoride from waters apparently does not accumulate in soft tissue to a significant degree and it is transferred to a very small extent into the milk and to a somewhat greater degree into eggs. Data for fresh water indicate that fluorides are toxic to fish at concentrations higher than 1.5 mg/liter. Fluoride is found in one industry in this segment, feldspar mining by the wet process.

2.3 Iron

Iron is considered to be a highly objectional constituent in public water supplies, the permissible criterion has been set at 0.3 mg/liter. Iron is found in significant quantities in graphite mining and other categories.

2.4 Manganese

Manganese in various dissolved forms may be present in significant amounts in the wastewater from the mining of graphite. A permissible criterion of 0.05 mg/liter has been proposed for public waters.

2.5 Oil and Grease

Oil and grease exhibit an oxygen demand. Oil emulsions may adhere to the gills of fish or coat and destroy algae or other plankton. Deposition of oil in the bottom sediments can serve to exhibit normal benthic growths, thus interrupting the aquatic food chain. Soluble and emulsified material ingested by fish may taint the flavor of the fish flesh. Water soluble components may exert toxic action on fish. Floating oil may reduce the re-aeration of the water surface and in conjunction with emulsified oil may interfere with photosynthesis. Water insoluble components damage the plumage and costs of water animals and fowls. Oil and grease in a water can result in the formation of objectionable surface slicks preventing the full aesthetic enjoyment of the water.

Oil spills can damage the surface of boats and can destroy the aesthetic characteristics of beaches and shorelines.

2.6 Acidity and Alkalinity

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity and alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms, and foul stenches are aesthetic liabilities of any waterway. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. Metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. The availability of many nutrient substances varies with the alkalinity and acidity. Ammonia is more lethal with a higher pH.

The lacrimal fluid of the human eye has a pH of approximately 7.0 and a deviation of 0.1 pH unit from the norm may result in eye irritation for the swimmer. Appreciable irritation will cause severe pain.

2.7 Total Suspended Solids

Suspended solids include both organic and inorganic materials. The inorganic components include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, animal and vegetable fats, various fibers, sawdust, hair and various materials from sewers. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. They adversely affect fisheries by covering the bottom of the stream or lake with a blanket of material that destroys the fish-food bottom fauna or the spawning ground of fish. Deposits containing organic materials may deplete bottom oxygen supplies and produce hydrogen sulfide, carbon dioxide, methane, and other noxious gases.

In raw water sources for domestic use, state and regional agencies generally specify that suspended solids in streams shall not be present in sufficient concentration to be objectionable or to interfere with normal treatment processes. Suspended solids in water may interfere with many industrial processes, and cause foaming in boilers, or encrustations on equipment exposed to water, especially as the temperature rises. Suspended solids are undesirable in water for textile industries; paper and pulp; beverages; dairy products; laundries; dyeing; photography; cooling systems, and power plants. Suspended particles also serve as a transport mechanism for pesticides and other substances which are readily sorbed into or onto clay particles.

Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These settleable solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the turbidity of the water, reduce light penetration and impair the photosynthetic activity of aquatic plants.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often much more damaging to the life in water, and they retain the capacity to displease the senses. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low. Total suspended solids are the single most important pollutant parameter found in this segment of the mineral mining and processing industry.

2.8 Zinc

Occurring abundantly in rocks and ores, zinc is readily refined into a stable pure metal and is used extensively for galvanizing, in alloys, for electrical purposes, in printing plates, for dye- manufacture and for dyeing processes, and for many other industrial purposes. Zinc salts are used in paint pigments, cosmetics, pharmaceuticals, dyes, insecticides, and other products too numerous to list herein. Many of these salts (e.g., zinc chloride and zinc sulfate) are highly soluble in water; hence it is to be expected that some zinc might be found in natural waters. On the other hand, some zinc salts (zinc carbonate, zinc oxide, zinc sulfide) are insoluble in water and consequently it is to be expected that some zinc will precipitate and be removed readily in most natural waters.

In zinc mining areas, zinc has been found in waters in concentrations as high as 50 mg/liter and in effluents from metal-plating works and small-arms ammunition plants it may occur in significant concentrations. In most surface and ground waters, it is present only in trace amounts. There is some evidence that zinc ions are adsorbed strongly and permanently on silt, resulting in inactivation of the zinc.

Concentrations of zinc in excess of 5 mg/liter in raw water used for drinking water supplies cause an undesirable taste which persists through conventional treatment. Zinc can have an adverse effect on man and animals at high concentrations.

In soft water, concentrations of zinc ranging from 0.1 to 1.0 mg/liter have been reported to be lethal to fish. Zinc is thought to exert its toxic action by forming insoluble compounds with the mucous that covers the gills, by damage to the gill epithelium, or possibly by acting as an internal poison. The sensitivity of fish to zinc varies with species, age and condition, as well as with the physical and chemical characteristics of the water. Some acclimatization to the presence of zinc is possible. It has also been observed that the effects of zinc poisoning may not become apparent immediately, so that fish removed from zinc-contaminated to zinc-free water (after 4-6 hours of exposure to zinc) may die 48 hours later. The presence of copper in water may increase the toxicity of zinc to aquatic organisms, but the presence of calcium or hardness may decrease the relative toxicity.

Observed values for the distribution of zinc in ocean waters vary widely. The major concern with zinc compounds in marine waters is not one of acute toxicity, but rather of the long-term sub-lethal effects of the metallic compounds and complexes. From an acute toxicity point of view, invertebrate marine animals seem to be the most sensitive organisms tested. The growth of the sea urchin, for example, has been retarded by as little as 30 mg/liter of zinc.

Zinc sulfate has also been found to be lethal to many plants, and it could impair agricultural uses.

Zinc is found in the effluent from one process in this industry, high-grade kaolin.

3.0 SIGNIFICANCE AND RATIONALE FOR REJECTION OF POLLUTION PARAMETERS

A number of pollution parameters besides those selected were considered, but had to be rejected for one or several of the following reasons:

1) insufficient data on degradation of water quality;
2) not usually present in quantities sufficient to cause water quality degradation;
3) treatment does not "practicably" reduce the parameter; and
4) simultaneous reduction is achieved with another parameter which is limited.

3.1 Toxic Materials

Although arsenic, antimony, barium, boron, cadmium, chromium, copper, cyanide ion, mercury, nickel, lead, selenium, and tin are harmful pollutants, they were not found to be present in quantities sufficient to cause water quality degradation.

3.2 Aluminum $^{+3}$

Aluminum may be present in significant amounts in the wastewater from this segment of the industry. Soluble aluminum in public water supplies is not considered a health problem and therefore was not included in the Public Health Service Drinking Water Standards.

3.3 Calcium $^{+2}$

Although calcium does exist in quantities in the wastewaters of a number of these mines, there is no treatment to practicably reduce it.

3.4 Carbonate $^{-2}$

There is insufficient data for dissolved carbonate to consider it a harmful pollutant.

3.5 Chloride $^{-}$

Although chloride is present in sufficient quantities in process wastewaters, there is no treatment to practicably reduce it.

3.6 Magnesium $^{+2}$

There is insufficient data for dissolved magnesium to consider it a harmful pollutant.

3.7 Nitrate $^{-}$ and Nitrite $^{-}$

There is insufficient data for dissolved nitrates and nitrites to consider them harmful pollutants, and there is no treatment to practicably reduce them.

3.8 Phosphates

Phosphates, reported as total phosphorus (P), contributes to eutrophication in receiving bodies of water. However, they were not found in quantities sufficient to cause water quality degradation.

3.9 Potassium $^{+}$

Although potassium does exist in quantity in the wastewaters of some of these plants, there is no treatment to practicably reduce it.

3.10 Silicates

Silicate may be present in the wastewaters from the mineral mining and processing industry, but it is simultaneously reduced with another parameter which is limited.

3.11 Sodium $^{+}$

Although sodium does exist in quantity in the wastewaters of a number of these processes, there is no treatment to practicably reduce it.

3.12 Solids, Dissolved

The total dissolved solids is a gross measure of the amount of soluble pollutants in the wastewater. It is an important parameter in drinking water supplies and water used for irrigation. A total dissolved solids content of less than 500 mg/liter is considered desirable. From the standpoint of quantity discharged, TDS could have been considered a harmful characteristic. However, energy requirements, especially for evaporation, and solid waste disposal costs are usually so high as to preclude limiting dissolved solids at this time.

3.13 Sulfate $^{-2}$

Although sulfate does exist in quantity in the wastewaters of some of these processes, there is no treatment to practicably reduce it.

3.14 Temperature

Temperature is a sensitive indicator of unusual thermal loads where waste heat is involved in the process. Excess thermal load, even in non-contact cooling water, has not been and is not expected to be a significant problem in this segment of the mineral mining and processing industry.

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

1.0 INTRODUCTION

Water-borne wastes from the mining of clay, ceramic, refractory and miscellaneous minerals consist primarily of suspended solids. These are usually composed of chemically inert and very insoluble sand, clay or rock particles. Treatment technology is well developed for removing such particles from wastewater and is readily applicable whenever space requirements or economics do not preclude utilization.

In a few instances dissolved substances such as fluorides, metal salts, acids, alkalies, chemical additives from ore processing and organic materials may also be involved. Where they are present, dissolved material concentrations are usually low. Treatment technology for the dissolved solids is also well-known, but may often be limited by the large volumes of wastewater involved and the cost of such large scale operations.

The control and treatment of the usually simple water-borne wastes found in the mineral mining and processing industry are complicated by several factors:

(1) the large volumes of wastewater involved for many of the mining operations,

(2) variable wastewater amount and composition from day to day, as influenced by rainfall and other surface and underground water contributions,

(3) differences in wastewater compositions arising from ore or raw material variability,

(4) geographical location: e.g., wastewater can be handled differently in dry isolated locations than in industrialized wet climates.

Each of these points are discussed in the following sections.

2.0 PROBLEM AREAS IN THE CLAY, CERAMIC, REFRACTORY AND MISCELLANEOUS MINERALS INDUSTRIES

Three significant wastewater problem areas have been found in these industries:

(1) High suspended solids levels in discharged wastewaters caused in some cases by formation of colloidal clay suspensions which are difficult to settle. This problem is encountered in several segments of the industry;

(2) In at least one subcategory of this industry problems are encountered with water-borne fluoride wastes;

(3) In the bleaching of some clay products, zinc hydrosulfite is sometimes employed. The use of this material invariably leads to a wastewater discharge containing zinc salts.

Below are given brief discussions of each of these problem areas.

The principal pollutant encountered in this segment of the minerals mining industry has been found to be suspended solids which arise from two sources:

(1) underground or surface mine pumpouts;

(2) processing washwaters and scrubber waters.

Mine water pumpout was found to be intermittent in nature and to be characterized by TSS loadings of from a few to several thousand parts per million of suspended solids prior to settling. Installation of settling areas for such waters generally has the effect reducing TSS loadings to less than 20 mg/liter for most materials. It should be pointed out that pit pumpout waters from montmorillonite clay mining facilities appear to be an exception to the above statement. This type of clay forms colloidal suspensions in wastewater and are very difficult to settle. These colloidal suspensions can be flocculated by addition of soluble calcium salts at concentrations of about 100 milli-equivalents of calcium salt per 100 grams of suspended montmorillonite (1,2). For other clays which settle more readily, flocculation occurs generally at lower concentrations of added calcium salt. This approach apparently has yet to be tried in the industry. Other approaches mentioned in the literature, such as treatment of clays with alkyl ammonium salts (3,4) are not likely to be applicable to this situation because their use would cause worse environmental problems than those already present.

Process water discharge is encountered in several of the product subcategories. For readily settleable materials, settling lagoons were found to be effective in reducing suspended solids loadings to less than 20 mg/liter in most instances. For a few of the clay materials, such as montmorillonite and fire clays, pond effluent concentrations after simple settling tend to be at least an order of magnitude higher in TSS. For one specific case with a montmorillonite facility, scrubber wastewaters were found with a TSS loading of 25,000 mg/liter before settling. After settling with a retention time of less than five days in a small lagoon, TSS loadings of about 2,000 mg/liter were still present. Table VII-1 shows the settling characteristics of some of the materials treated in this volume. This is an area needing application of available flocculation and clarification technology.

Table VII-1.
Settling Characteristics of Some Suspended Materials

Product	Stream	Plant	Input to Pond (mg/liter)	Retention Time, Condition	Outflow (mg/liter)
Fire Clay	mine seepage, runoff, & cooling	3087	unknown	0.25 hour soda ash added	45
Montmorillonite	scrubber	3072	25,000	4.1 days, lime added	2,000
	pit pumpout	3073	unknown	variable	215
Kaolin	plant raw effluent	3024	10,300 includes sand	unknown, lime added	6
Ball Clay	scrubber	5685	unknown	1-2 months, simple settling	400
	scrubbers	5689	unknown	1 month, flocculant, 3 ponds	40
Feldspar	plant raw effluent	3026	3,800	unknown, alum added, 2 ponds	21
Talc	mine pumpout	2041, 2042, 2043, 2044	200	unknown	<20

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The processing of feldspar ores involves a flotation step in which hydrofluoric acid is one of the added reagents. This gives rise to an acidic fluoride bearing wastewater stream which, prior to treatment, can contain up to 50 mg/liter fluoride ion. At present, treatment of such wastewaters has been only partially effectively practiced. Current fluoride effluent concentrations at feldspar producing facilities range from 8 to about 40 mg/liter. This is another area where improved treatment technology is needed.

In the bleaching of kaolin, solutions of zinc hydrosulfite are generally employed. This gives rise to wastewaters containing up to 25 mg/liter zinc ion prior to treatment. Technology already in use in the pigments and inorganic chemicals industries is available to reduce effluent levels to a few ppm. This will be discussed later in this section.

3.0 CONTROL PRACTICES

Control practices such as selection of raw materials, good housekeeping, minimizing leaks and spills, in-process changes, and segregation of process wastewater streams are not as important in the minerals mining industry as they are in more process-oriented manufacturing operations. Raw materials are fixed by the composition of the ore available; good housekeeping and small leaks and spills have little influence on the waste loads; and it is rare that any non-contact water, such as cooling water, is involved in minerals and mining processes.

There are a number of areas, however, where control is very important. These include:

(1) wastewater containment

(2) separation and control of mine water, process water, and rain water

(3) monitoring of waste streams.

3.1 Containment

The majority of wastewater treatment and control facilities in the minerals and mining industry use one or more settling ponds. Often the word "pond" is an euphemism for swamp, gully, or other low spot which will collect water. In times of heavy rainfall these "ponds" are often washed out and the settled solids may be swept along as well. In many other cases, the identity of the pond may be maintained during rainfall but its function as a settling pond is significantly impaired by the large amount of water flowing through it. In addition to rainfall and flooding conditions, waste containment in ponds can be troubled with seepage through the ground around and beneath the pond, escape through pot holes, faults and fissures below the water surface and physical failure of pond dams and dikes.

In most instances satisfactory pond performance can be achieved by proper design. In instances where it is not possible to achieve satisfactory pond performance, alternative treatment methods can be utilized: thickeners, clarifiers, tube and lamella separators, filters, hydrocyclones, and centrifuges.

3.2 Separation and Control of Wastewater

In these industries wastewater may be separated into different categories:

(1) Mine drainage water. For many mines this is the only water effluent. Usually it is low in suspended solids, but may contain dissolved minerals.

(2) Process water. This is water involved in transporting, classifying, washing, beneficiating, and separating ores and other mined materials. When present in minerals mining operations this water usually contains heavy loads of suspended solids and possibly some dissolved materials.

(3) Rain water runoff. Since minerals mining operations often involve large surface areas, the rain water that falls on the mine or mine property surface constitutes a major portion of the overall wastewater load leaving the property. This runoff entrains minerals, silt, sand, clay, organic matter and other suspended solids.

The relative amounts and compositions of the above wastewater streams differ from one mining category to another and the separation, control and treatment techniques differ for each.

Process water and mine drainage are normally controlled and contained by pumping or gravity flow through pipes, channels, ditches and ponds. Rain water runoff, on the other hand, is often uncontrolled and may either contaminate process and mine drainage water or flow off the land independently as non-point discharges. Rain water runoff also increases suspended solid material in rivers, streams, creeks or other surface water used for process water supply or, in some cases, as point discharge sources from mining property.

3.3 Monitoring

Since most wastewater discharges from these industries contain suspended solids as the principal pollutant, complex water analyses are not usually required. On the other hand, many of these industries today do little or no monitoring on wastewater discharges. In order to obtain meaningful knowledge and control of their wastewater quality, many mines and minerals processing plants need to institute routine monitoring measurements of the few pertinent waste parameters.

4.0 SUSPENDED SOLIDS REMOVAL

The treatment technologies available for removing suspended solids from minerals and mining wastewater are numerous and varied, but a relatively small number are used widely. The following shows the approximate breakdown of usage for the various techniques:

removal technique	percent of treatment facilities using technology
settling ponds (unlined)	95-97
settling ponds (lined)	<1
chemical flocculation (usually with ponds)	2-5
thickeners and clarifiers	1-2
hydrocyclones	<1
tube and lamella settlers	<1
screens	<1
filters	<1
centrifuges	<1

4.1 Settling Ponds

As shown above, the predominant treatment technique for removal of suspended solids involves one or more settling ponds. Settling ponds are versatile in that they perform several waste-oriented functions including:

(1) Solids removal. Solids settle to the bottom and the clear water overflow is much reduced in suspended solids content.

(2) Equalization and water storage capacity. The clear supernatant water layer serves as a reservoir for reuse or for controlled discharge.

(3) Solid waste storage. The settled solids are provided with long term storage.

This versatility, ease of construction and relatively low cost, explains the wide application of settling ponds as compared to other technologies.

The performance of these ponds depends primarily on the settling characteristics of the solids suspended, the flow rate through the pond and the pond size. Settling ponds can be used over a wide range of suspended solids levels. Often a series of ponds is used, with the first collecting the heavy load of easily settleable material and the following ones providing final polishing to reach a desired final suspended level. As the ponds fill with settled solids they can be dredged to remove these solids or the ones may be left filled and new ponds provided. The choice often depends on whether land for additional new ponds is available. When suspended solids levels are low and ponds large, settled solids build up so slowly that neither dredging nor pond abandonment is necessary, at least not for a period of many years.

Settling ponds used in the minerals industry run the gamut from small pits, natural depressions and swamp areas to engineered thousand acre structures with massive retaining dams and legislated construction design. The performance of these ponds varies from excellent to poor, depending on character of the suspended particles, and pond size and configuration.

In general the suspended solids levels from the final pond can be reduced to 10 to 30 mg/liter, but for some wastewaters the discharge may still contain up to 100 mg/liter. Waste waters containing significant amounts of hydrophilic colloids, such as montmorillonite, are especially difficult to clarify.

4.2 Clarifiers and Thickeners

An alternative method of removing suspended solids is the use of clarifiers or thickeners which are essentially tanks with internal baffles, compartments, sweeps and other directing and segregating mechanisms to provide efficient concentration and removal of suspended solids in one effluent stream and clarified liquid in the other.

Clarifiers differ from thickeners primarily in their basic purpose. Clarifiers are used when the main purpose is to produce a clear overflow with the solids content of the sludge underflow being of secondary importance. Thickeners, on the other hand, have the basic purpose of producing a high solids underflow with the character of the clarified overflow being of secondary importance. Thickeners are also usually smaller in size and more massively constructed for a given throughput.

Clarifiers and thickeners have a number of distinct advantages over ponds:

(1) Less land space is required. Area-for-area these devices are much more efficient in settling capacity than ponds .

(2) Influences of rainfall are much less than for ponds. If desired the clarifiers and thickeners can even be covered.

(3) Since the external construction of clarifiers and thickeners consists of concrete or steel tanks ground seepage and rain water runoff influences do not exist.

On the other hand, clarifiers and thickeners suffer some distinct disadvantages as compared with ponds:

(1) They have more mechanical parts and maintenance.

(2) They have only limited storage capacity for either clarified water or settled solids.

(3) The internal sweeps and agitators in thickeners and clarifiers require more power and energy for operation than ponds.

Clarifiers and thickeners are usually used when sufficient land for ponds is not available or is very expensive.

4.3 Hydrocyclones

While hydrocyclones are widely used in the separation, classification and recovery operations involved in minerals processing, they are used only infrequently for wastewater treatment. Even the smallest diameter units available (stream velocity and centrifugal separation forces both increase as the diameter decreases) are ineffective when particle size is less than 25-50 microns. Larger particle sizes are relatively easy to settle by means of small ponds, thickeners or clarifiers or other gravity principle settling devices. It is the smaller suspended particles that are the most difficult to remove and it is these that can not be removed by hydrocyclones but may be handled by ponds or other settling technology. Also hydrocyclones are of doubtful effectiveness when flocculating agents are used to increase settling rates.

Hydrocyclones are used as scalping units to recover small sand or other mineral particles in the 25 to 200 micron range, particularly if the recovered material can be sold as product. In this regard hydrocyclones may be considered as converting part of the waste load to useful product as well as providing the first step of wastewater treatment.

4.4 Tube and Lamella Settlers

Tube and lamella settlers require less land area than clarifiers and thickeners. These compact units, which increase gravity settling efficiency by means of closely packed inclined tubes and plates, can be used for either scalping or wastewater polishing operations depending on throughput and design.

4.5 Centrifuges

Centrifuges are not widely used for minerals mining wastewater treatment. Present industrial-type centrifuges are relatively expensive and not particularly suited for this purpose. Future use of centrifuges will depend on regulations, land space availability and the development of specialized units suitable for minerals mining operations.

4.6 Flocculation

Flocculating agents increase the efficiency of settling facilities and they are of two general types: ionic and polymeric. The ionic types such as alum, ferrous sulfate and ferric chloride function by destroying the repelling double layer ionic charges around the suspended particles and thereby allowing the particles to attract each other and agglomerate. Polymeric types function by forming physical bridges from one particle to another and thereby agglomerating the particles.

Flocculating agents are most commonly used after the larger, more readily settled, particles (and loads) have been removed by a settling pond, hydrocyclone or other such scalping treatment. Agglomeration, or flocculation, can then be achieved with less reagent and less settling load on the polishing pond or clarifier.

Flocculation agents can be used with minor modifications and additions to existing treatment systems, but the costs for the flocculating chemicals are often significant. Ionic types are used in 10 to 100 mg/liter concentrations in the wastewater while the higher priced polymeric types are effective in the 2 to 20 mg/liter concentrations.

4.7 Screens

Screens are widely used in minerals and mining processing operations for separations, classifications and beneficiations. They are similar to hydrocyclones in that they are restricted to removing the larger (<50-100 micron) particle size suspended solids of the wastewater, which can then often be sold as useful product. Screens are not practical for removing the smaller suspended particles.

4.8 Filtration

Filtration is accomplished by passing the wastewater stream through solids-retaining screens, cloths, or particulates such as sand, gravel, coal or diatomaceous earth using gravity, pressure or vacuum as the driving force. Filtration is versatile in that it can be used to remove a wide range of suspended particle sizes.

The large volumes of many wastewater streams found in minerals mining operations require large filters. The cost of these units and their relative complexity, compared to settling ponds, has restricted their use to a few industry segments committed to complex wastewater treatment.

5.0 DISSOLVED MATERIAL TREATMENTS

Unlike the ubiquitous suspended solids which need to be removed from most minerals and mining wastewaters, dissolved materials are a problem only in scattered instances in the industries covered herein.

Treatments for dissolved materials are based on either modifying or removing the undesired materials. Modification techniques include chemical treatments such as neutralization and oxidation-reduction reactions. Acids, alkaline materials, sulfides and other toxic or hazardous materials are examples of dissolved materials modified in this way. Most removal of dissolved solids is accomplished by chemical precipitation. Techniques such as ion exchange, carbon adsorption, reverse osmosis and evaporation are rarely used in the minerals mining industry.

Chemical treatments for abatement of water-borne wastes are common. Included in this overall category are neutralization, pH control, oxidation-reduction reactions, coagulations, and precipitations.

5.1 Neutralization

Some of the water-borne wastes of this study, often including mine drainage water, are either acidic or alkaline. Before disposal to surface water or other medium excess acidity or alkalinity needs to be controlled to the range of pH 6 to 9. The most common method is to treat acidic streams with alkaline materials such as limestone, lime, soda ash, or sodium hydroxide. Alkaline streams are treated with acids such as sulfuric. Whenever possible, advantage is taken of the availability of acidic waste streams to neutralize basic waste streams and vice versa. Neutralization often produces suspended solids which must be removed prior to wastewater disposal.

5.2 pH Control

The control of pH may be equivalent to neutralization if the control point is at or close to pH 7. Sometimes chemical addition to waste streams is designed to maintain a pH level on either the acidic or basic side for purposes of controlling solubility.

Examples of pH control being used for precipitating undesired pollutants are:

(1) $Fe^{+3} + 3OH^- = Fe(OH)_3$

(2) $Mn^{+2} + 2OH^- = Mn(OH)_2 = MnO_2 + 2H^+ + 4e^-$

(3) $Zn^{+2} + 2OH^- = Zn(OH)_2$

(4) $Pb^{+2} + 2(OH)^- = Pb(OH)2$

(5) $Cu + 2OH^- = Cu(OH)_2$.

Reaction (1) is used for removal of iron contaminants. Reaction (2) is used for removing manganese from manganese-containing water-borne wastes. Reactions (3), (4), and (5) are used on wastewater containing copper, lead, and zinc salts.

5.3 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, with large COD values, can be oxidized with air to relatively innocuous sulfates. These examples and many others are basic to the modification of inorganic chemical water-borne wastes to make them less troublesome. In general waste materials requiring oxidation-reduction treatments are not encountered in these industries.

5.4 Precipitations

The reaction of two soluble chemicals to produce insoluble or precipitated products is the basis for removing many undesired water-borne wastes. The use of this technique varies from lime treatments to precipitate sulfates, fluorides, hydroxides and carbonates to sodium sulfide precipitations of copper, lead and other toxic heavy metals. Precipitation reactions are particularly responsible for heavy suspended solids loads. These suspended solids are removed by settling ponds, clarifiers and thickeners, filters, and centrifuges.

The following are examples of precipitation reactions used for wastewater treatment:

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

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

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

6.0 SUMMARY OF TREATMENT TECHNOLOGY APPLICATIONS, LIMITATIONS AND RELIABILITY

Table VII-2 summarizes comments on the various treatment technologies as they are utilized for the minerals and mining industry.

Table VII-2. Summary of Technology, Applications, Limitations and Reliability

Waste Water Constituents	Treatment Process	Application	Percent Solids Removal	Expected Concentration (mg/l)	Minimum Concentration Achievable (mg/l)	Availability of Equipment	Lead Time (months)	Space or Land Needed	Maintenance Required	Sensitivity to Shock Loads	Effects of Shutdown and Startup	Energy Requirements
Suspended Solids	(1) Pond Settling	Used for all concentrations	60-99	5-200	5-30	none needed	1-12	large 1-500 acres small 0.05-1.0 acres	small	small	small	small
	(2) Clarifier Thickeners	Used for all concentrations	60-99	5-1000	5-30	readily available	3-24	<1 acre	nominal	sensitive	nominal	nominal
	(3) Hydro-cyclones	Removal of larger particle sizes	50-99	—	—	ready available	3-12	approx. 10' x 10'	small	sensitive	small	small
	(4) Tube and Lamella Settlers	Removal of smaller particle sizes	90-99	—	—	readily available	3-12	approx. 10' x 10'	small	sensitive	nominal	small
	(5) Screens	Removal of larger particle sizes	50-99	—	—	ready available	3-12	approx. 10' x 10'	nominal	small	small	small
	(6) Rotary Vacuum Filters	Mainly for sludges and other high suspended solids streams	90-99	5-1000	5-30	readily available	3-12	approx. 10' x 10'	nominal	sensitive	nominal	nominal
	(7) Solid Bowl Centrifuge	Mainly for sludges and other high suspended solids streams	60-99	—	—	readily available	3-12	approx. 10' x 10'	nominal	sensitive	small	nominal
	(8) Leaf and Pressure Filters	Used over wide concentration range	90-99	10-100	5-30	readily available	3-6	approx. 10' x 10'	small	sensitive	small	small
	(9) Cartridge and Candle Filters	Mainly for polishing filtrations of suspended solids	50-99	2-10	2-10	readily available	1-3	approx. 10' x 10'	small	sensitive	small	small
	(10) Sand and Mixed Media Filters	Mainly for polishing filtrations of suspended solids	50-99	2-50	2-10	readily available	3-6	approx. 10' x 10'	small	sensitive	small	small
Dissolved Solids	(1) Neutralization and pH Control	General	99	NA	NA	readily available	3-12	small 20' x 20' or less	minor	nominal	small	small
	(2) Precipitation	Broadly used to remove solubles	50-99	0-20	0-10	readily available	3-6	small 20' x 20'	minor	sensitive	small	small

Estimates of the efficiency with which the treatments remove suspended or dissolved solids from wastewater, given in the Table need to be interpreted in the following context.

These values will obviously not be valid for all circumstances, concentrations or materials, but they should provide a general guideline for treatment performance capabilities. Several comments may be made concerning the values:

(1) At high concentrations and optimum conditions, all treatments can achieve 99 percent or better removal of the desired material;

(2) At low concentrations, the removal efficiency drops off.

(3) Minimum concentration ranges achievable will not hold in every case. For example, pond settling of some suspended solids might not achieve less than the 100 mg/liter level. This is not typical, however, since many such pond settling treatments can achieve 10 to 20 mg/liter without difficulty. Failure to achieve the minimum concentration levels listed usually means that either the wrong treatment methods have been selected or that an additional treatment step is necessary (such as a second pond or a polish filtration).

7.0 PRETREATMENT TECHNOLOGY

Mineral mining operations are usually conducted in relatively isolated regions where there is no access to publicly-owned activated sludge or trickling filter wastewater treatment plants. In areas where publicly-owned facilities could be used, pretreatment would often be required to reduce the heavy suspended solids load.

In the relatively few instances where dissolved materials are serious, pH control and some reduction of hazardous constituents such as fluorides and heavy metals would be required. Lime treatment will usually be sufficient for reductions of both categories.

8.0 NONWATER QUALITY ENVIRONMENTAL ASPECTS, INCLUDING ENERGY REQUIREMENTS

The effects of these treatment and control technologies on air pollution, noise pollution, and radiation are usually small and not of any significance.

Large amounts of solid waste in the form of both solids and sludges are formed as a result of all suspended solids operations as well as chemical treatments for neutralization, and precipitations.

Easy-to-handle, relatively dry solids are usually left in settling ponds or dredged out periodically and dumped onto the land. Since mineral mining properties are usually large, space for such dumping is often available.

Sludges and difficultly settled solids are most often left in the settling pond, but may in some instances be landfilled.

In summary, the solid wastes and sludges from the mineral mining industry wastewater treatments are very large in quantity, but the industry, having sufficient space and earth-moving capabilities, manages it with greater ease than could most other industries.

SECTION VIII

COST, ENERGY, WASTE REDUCTION BENEFITS AND NON-WATER ASPECTS OF TREATMENT AND CONTROL TECHNOLOGIES

1.0 SUMMARY

The clay, ceramic, refractory and miscellaneous minerals segment of the mineral mining and processing industry is characterized by individuality of facilities. Unlike manufacturing operations, where raw materials for the process may be selected and controlled as to purity and uniformity, mining and minerals processing operations are themselves largely controlled by the purity and uniformity of the ores or raw materials involved. Operations have to be located, at or near the mineral deposits. This lack of control over raw material quality and location, coupled with the fact that both mines and ore beneficiation processes may have wastewater effluents, leads to several basic treatment costing differences from those for manufacturing operations:

(1) In order to achieve reasonable homogeneity, industries have to be segregated into subcategories such as wet mines, dry mines, dry processes and one or more wet processes.

(2) Solid waste loads vary widely depending on ore composition.

(3) Types of water-borne waste vary with ore and process. Processes are modified according to ore composition.

(4) Treatment costs often vary widely depending on character of pollutants involved. The most widespread example is particle size and composition variation of suspended solids. Deposits with large particle sized wastes have high settling rates while small or colloidal suspended particles are slow and difficult to settle, requiring large ponds, thickeners, flocculating treatments, other devices for removing suspended solids in many cases.

In general, plant size and age have little influence on the type of waste effluent. The amounts and costs for their treatment and disposal are readily scaled from plant size and are not greatly affected by plant age.

Geographical location is important. Mines and processing plants located in dry western areas rarely require major wastewater treatment or have subsequent disposal problems.

Terrain and land availability are also significant factors affecting treatment technology and costs. Lack of sufficient flat space for settling ponds often forces utilization of mechanical thickeners, clarifiers, or settlers. On the other hand, advantage is often taken of valleys, hills, swamps, gullies and other natural configurations to provide low cost pond and solid waste disposal facilities.

In view of the large number of mines and beneficiation facilities and the significant variables listed above, costs have been developed for representative mines and processing plants rather than specific exemplary plants that may have advantageous geographical, terrain or ore composition.

A summary of cost and energy information for the present level of wastewater treatment technology for this segment is given in Table VIII-1. Present capital investment for wastewater treatment in the clay, ceramic, refractory and miscellaneous minerals segment is estimated at $7,500,000.

Table VIII-1

CAPITAL INVESTMENTS AND ENERGY CONSUMPTION OF PRESENT WASTEWATER TREATMENT FACILITIES

Subcategory	Capital Spent Dollars	Present Energy Use - Kcal x 10^6	Total Annual Costs -$/kkg Produced	Percent of Selling price
Bentonite		No Waste Water		
Fire Clay		No Waste Water		
Attapulgite)				
Montmorillonite)	$ 330,000	180	0.22	0.9
Kaolin (dry process)		No Waste Water		
Kaolin (wet process)	2,670,000	6,875	0.29	1.0
Ball Clay	335,000	825	0.26	1.5
Feldspar (dry process)		No Waste Water		
Feldspar (flotation)	1,000,000	4,950	1.65	10.2
Kyanite	375,000	830	2.83	4.0
Magnesite	300,000	small	0.19	0.1
Shale		No Waste Water		
Aplite	695,000	2,230	0.69	price unknow
Talc minerals (dry)		No Waste Water		
Talc minerals (wet washing)	335,000	1,670	1.09	3.2
Talc minerals (heavy media flotation)	450,000	2,500	1.09	3.2
Abrasives, Garnet	370,000	1,250	5.88	5.2
Abrasives, Tripoli		No Waste Water (except one scrubber)		
Diatomite	500,000	small	0.27	0.4
Graphite	<100,000	small	$20-25	<5
Jade	1,000	negligible	negligible	<0.1
Novaculite	negligible	negligible	negligible	<0.1
TOTAL	7,500,000	21,300	---	---

2.0 COST REFERENCES AND RATIONALE

Cost information contained in this report was assembled directly from industry, from waste treatment and disposal contractors, engineering firms, equipment suppliers, government sources, and published literature. Whenever possible, costs are taken from actual installations, engineering estimates for projected facilities as supplied by contributing companies, or from waste treatment and disposal contractors quoted prices. In the absence of such information, cost estimates have been developed insofar as possible from plant-supplied costs for similar waste treatments and disposal for other plants or industries.

2.1 Interest Costs and Equity Financing Charges

Capital investment estimates for this study have been based on 10 percent cost of capital, representing a composite number for interest paid or return on investment required.

2.2 Time Basis for Costs

All cost estimates are based on August 1972 prices and when necessary have been adjusted to this basis using the chemical engineering plant cost index.

2.3 Useful Service Life

The useful service life of treatment and disposal equipment varies depending on the nature of the equipment and process involved, its usage pattern, maintenance care and numerous other factors. Individual companies may apply service lives based on their actual experience for internal amortization. Internal Revenue Service provides guidelines for tax purposes which are intended to approximate average experience.

Based on discussions with industry and condensed IRS guideline information, the following useful service life values have been used:

(1)	General process equipment	10 years
(2)	Ponds, lined and unlined	20 years
(3)	Trucks, bulldozers, loaders and other such materials handling and transporting equipment.	5 years

2.4 Depreciation

The economic value of treatment and disposal equipment and facilities decreases over its service life. At the end of the useful life, it is usually assumed that the salvage or recovery value becomes zero. For IRS tax purposes or internal depreciation provisions, straight line, or accelerated write-off schedules may be used. Straight line depreciation was used solely in this report.

2.5 Capital Costs

Capital costs are defined as all front-end out-of-pocket expenditures for providing treatment/disposal facilities. These costs include costs for research and development necessary to establish the process, land costs when applicable, equipment, construction and installation, buildings, services, engineering, special start-up costs and contractor profits and contingencies.

2.6 Annual Capital Costs

Most if not all of the capital costs are accrued during the year or two prior to actual use of the facility. This present worth sum can be converted to equivalent uniform annual disbursements by utilizing the Capital Recovery Factor Method:

Uniform Annual Disbursement = $P \frac{i\ (1+i)^{n}}{(1+i)^{n} - 1}$

Where P = present value (capital expenditure), i = interest rate, %/100, n = useful life in years

The capital recovery factor equation above may be rewritten as:

Uniform Annual Disbursement = P(CR - i% - n)

Where (CR - i% - n) is the Capital Recovery Factor for i% interest taken over "n" years useful life.

2.7 Land Costs

Land-destined solid wastes require removal of land from other economic use. The amount of land so tied up will depend on the treatment/disposal method employed and the amount of wastes involved. Although land is non-depreciable according to IRS regulations, there are numerous instances where the market value of the land for land-destined wastes has been significantly reduced permanently, or actually becomes unsuitable for future use due to the nature of the stored waste. The general criteria applied to costing land are as follows:

(1) If land requirements for on-site treatment/disposal are not significant, no cost allowance is applied.
(2) Where on-site land requirements are significant and the storage or disposal of wastes does not affect the ultimate market value of the land, cost estimates include only interest on invested money.
(3) For significant on-site land requirements where the ultimate market value and/or availability of the land has been seriously reduced, cost estimates include both capital depreciation and interest on invested money.
(4) Off-site treatment/disposal land requirements and costs are not considered directly. It is assumed that land costs are included in the overall contractor's fees along with its other expenses and profit.

(5) In view of the extreme variability of land costs, adjustments have been made for individual industry situations. In general, isolated, plentiful land has been costed at $2,470/hectare (1,000/acre).

2.8 Operating Expenses

Annual costs of operating the treatment/disposal facilities include labor, supervision, materials, maintenance, taxes, insurance and power and energy. Operating costs combined with annualized capital costs give the total costs for treatment and disposal operations. No interest cost was included for operating (working) capital. Since working capital might be assumed to be one sixth to one third of annual operating costs (excluding depreciation), about 1-2 percent of total operating costs might be involved. This is considered to be well within the accuracy of the estimates.

2.9 Rationale for "Representative Plants"

All plant costs are estimated for "representative plants" rather than for any actual plant. "Representative plants" are defined to have a size and age agreed upon by a substantial fraction of the manufacturers in the subcategory producing the given mineral, or, in the absence of such a consensus, the arithmetic average of production size and age for all plants.

Location is selected to represent the industry as closely as possibly. For instance, if all plants are in northeastern U.S., typical location is noted as "northeastern states". If locations are widely scattered around the U.S., typical location would be not specified geographically. If two plants exist, one on the west coast and one on the east cost, typical location would be "1 east coast - 1 west coast".

It should be noted that the unit costs to treat and dispose of hazardous wastes at any given plant may be considerably higher or lower than the representative plant because of individual circumstances.

2.10 Definition of Levels of Treatment and Control

Costs are developed for various types and levels of technology:

Minimum (or basic level), that level of technology which is equalled or exceeded by most or all of the involved plants. Usually money for this treatment level has already been spent (in the case of capital investment) or is being spent (in the case of operating and overall costs).

B,C,D,E---Levels - Successively greater degrees of treatment with respect to critical pollutant parameters. Two or more alternative treatments are developed when applicable.

2.11 Rationale for Pollutant Considerations

(1) All non-contact cooling water is exempted from treatment (and treatment costs) provided that no harmful pollutants are introduced.

(2) Water treatment, cooling tower and boiler blowdown discharges are not treated provided they contain no harmful pollutants.

(3) Removal of dissolved solids, other than harmful pollutants, is not included.

(4) Mine drainage treatments and costs are considered separately from process water treatment and costs. Mine drainage costs are estimated for all mineral categories for which such costs are a significant factor.

(5) All solid waste disposal costs are included as part of the cost development.

2.12 Cost Variances

The effects of age, location, and size on costs for treatment and control have been considered and are detailed in subsequent sections for each specific subcategory.

3.0 INDIVIDUAL MINERAL WASTE WATER TREATMENT AND DISPOSAL COSTS

3.1 Bentonite

There is no wastewater from mining and processing of bentonite. Therefore, there is no treatment cost involved. Also there is no mine water drainage.

3.2 Fire Clay

The only wastewater from mining and processing of fire clay is mine water discharge. Treatment costs for settling suspended solids in mine water are estimated at $0.01-0.05/kkg of produced fire clay. Since there is no process water discharge in the production of fire clay, there are no costs for process wastewater treatment.

3.3 Fuller's Earth

Fuller's earth was divided into two subcategories - attapulgite and montmorillonite. Suspended solids in attapulgite mine drainage and process water generally settle rapidly. Suspended solids in montmorillonite mine drainage and process water are more difficult to settle.

Estimates of treatment costs for mine water, including use of flocculating agents to settle montmorillonite wastes, range from $0.17 to $0.28/metric ton of montmorillonite produced, see Table VIII-3a.

Process and air scrubber wastewater treatment costs are summarized in Tables VIII-2 and VIII-3.

3.3.1 Cost Variance

Age

In the montmorillonite subcategory, there are three plants ranging in age from 3 to 18 years. Age is not a significant factor in cost variance.

There are two plants representing the attapulgite subcategory ranging in age from 55 to 90 years. Age is not a significant factor in cost variance.

TABLE VIII-2.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT

(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Attapulgite (Process Water Only)

PLANT SIZE 200,000 METRIC TONS PER YEAR OF Attapulgite

PLANT AGE 60 YEARS PLANT LOCATION Georgia-North Florida Region

		LEVEL A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		71,000	77,000	95,000		
ANNUAL CAPITAL RECOVERY		8,400	9,300	11,100		
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		37,400	39,800	39,100		
ANNUAL ENERGY AND POWER		200	200	300		
TOTAL ANNUAL COSTS		46,000	49,300	50,500		
COST/METRIC TON Attapulgite		0.21	0.22	0.23		
WASTE LOAD PARAMETERS (kg/metric ton of ______)	RAW WASTE LOAD					
TSS		0.01-0.02	0.01	0		
pH		6-9	6-9	-		

LEVEL DESCRIPTION:

A — pond settling
B — A plus flocculating agents
C — B plus recycle to process

TABLE VIII-3.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT

(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Montmorillonite (Process Water Only)

PLANT SIZE 182,000 METRIC TONS PER YEAR OF Montmorillonite

PLANT AGE 10 YEARS PLANT LOCATION Georgia

		LEVEL				
		A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		60,000	65,000	80,000		
ANNUAL CAPITAL RECOVERY		7,000	7,900	9,400		
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		30,900	32,900	32,300		
ANNUAL ENERGY AND POWER		200	200	300		
TOTAL ANNUAL COSTS		38,100	41,000	43,000		
COST/METRIC TON Montomorillonite		0.21	0.22	0.24		
WASTE LOAD PARAMETERS (kg/metric ton of montmorillonite)	RAW WASTE LOAD					
TSS		0.3	0.05	0		
pH		6-9	6-9	-		

LEVEL DESCRIPTION:

A — pond settling of scrubber water
B — A plus flocculating agents
C — B plus recycle to process

TABLE VIII-3A.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT
(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Montmorillonite (Mine Water Only)

PLANT SIZE 182,000 METRIC TONS PER YEAR OF Montmorillonite

PLANT AGE 10 YEARS PLANT LOCATION Georgia

		LEVEL				
		A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		0	60,000	62,000		
ANNUAL CAPITAL RECOVERY		0	15,800	16,300		
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		0	12,300	32,300		
ANNUAL ENERGY AND POWER		0	3,000	3,000		
TOTAL ANNUAL COSTS		0	32,300	51,800		
COST/METRIC TON Montmorillonite		0	0.17	0.28		
WASTE LOAD PARAMETERS (kg/metric ton of ______)	RAW WASTE LOAD					
TSS, mg/liter		200–5,000*	200–2,000*	<50*		
*estimates						

LEVEL DESCRIPTION:

A — no treatment
B — pond settling
C — B plus flocculating agents

<u>Location</u>
All the plants in the montmorillonite subcategory are located in Georgia and, thus, location is not a significant factor in cost variance.

The attapulgite plants are located in Georgia and Florida, in close proximity and therefore, location is not a significant factor in cost variance.

<u>Size</u>
The plants in the montmorillonite subcategory range from 13,600 to 207,000 kg/y (15,000-228,000 TPY). The representative plant is 182,000 kkg/y (200,000 TPY).

The attapulgite plants are 213,000 kkg/y (235,000 TPY) and 227,000 kkg/y (250,000 TPY). The representative plant is 220,000 kkg/y (230,000 TPY).

In both these subcategories the cost variance with size is estimated to be a 0.9 exponential function for capital and its related annual costs, and directly proportional for operating costs other than taxes, insurance and capital recovery.

<u>3.3.2 Cost Basis for Table VIII-2.</u>

<u>Capital Costs</u>
Pond cost, dollars/hectare (dollars/acre): 24,700 (10,000)
Mine pumpout settling pond area, hectares (acres):0.1 (0.25)
Process Settling pond area, hectares (acres):2 (5)
Pumps and pipes: $10,000

<u>Operating and Maintenance Costs</u>
Energy unit cost: $0.01/kwh
Labor rate assumed: $10,000/yr

<u>3.3.3 Cost Basis for Table VIII-3.</u>

Capital Costs
<u>Pond cost, dollars/hectare (dollars/acre):24,700 (10,000)</u>
<u>Mine pumpout settling pond hectares (acres):0.1 (0.25)</u>
<u>Process settling pond area, hectares (acres):2 (5)</u>
<u>Pumps and pipes: $10,000</u>

Operating and Maintenance Costs
Treatment chemicals
Flocculating agent: $1.50/kg (0.70/lb)
Energy unit cost: $0.01/kwh
Labor rate assumed: $10,000/yr

3.4 Kaolin and Ball Clay

Kaolin and ball clay mining and processing operations differ widely as to their wastewater effluents. All treatments involve settling ponds for their basic technology. Dry mines need no treatment or treatment expenditures. Wet mines (from rain water and ground seepage) use settling ponds to reduce suspended solids. These settling ponds are small and cost an estimated $0.01-$0.06/metric ton of clay product.

Processing plants may be either wet or dry. Dry plants have no treatment or treatment costs. Wet processing plants have process wastewater from two primary sources: scrubber water from air pollution facilities, and process water that may contain zinc compound from a product bleaching operation.

Scrubber and process water need to be treated to reduce suspended solids and zinc compounds. Costs for reduction are summarized in Tables VIII-4 and VIII-5 for wet process kaolin and ball clay, respectively.

3.4.1 Cost Variance

Age
The kaolin wet process subcategory consists of two plants having ages of 29 and 37 years. Age is not a cost variance factor.

The ball clay subcategory has a range of plant ages from 15 to 56 years. Age has not been found to be a significant factor on costs.

Location
The wet process kaolin operations are only located in Georgia, hence not a variance.

TABLE VIII-4.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT

(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Wet Process Kaolin

PLANT SIZE 450,000 METRIC TONS PER YEAR OF Kaolin

PLANT AGE 30 YEARS PLANT LOCATION Georgia-South Carolina

		LEVEL				
		A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		447,000	463,000	487,000		
ANNUAL CAPITAL RECOVERY		49,200	51,800	55,600		
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		85,000	112,000	90,000		
ANNUAL ENERGY AND POWER		5,000	5,000	5,000		
TOTAL ANNUAL COSTS		139,200	168,800	152,200		
COST/METRIC TON of Kaolin		0.31	0.38	0.34		
WASTE LOAD PARAMETERS (kg/metric ton of Kaolin)	RAW WASTE LOAD					
TSS	35-100	0.02-0.2	<0.1	0		
Dissolved zinc	0.4	0.001	0.001	0		
pH		6-9	6-9	--		

LEVEL DESCRIPTION:

A — pond settling with lime treatment
B — A plus flocculating agents
C — pond settling and recycle to process (This should be satisfactory for cases where only cooling water and scrubber water are present. Process water will build up dissolved solids, requiring a purge.)

TABLE VIII-5.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT

(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Ball Clay

PLANT SIZE 75,000 METRIC TONS PER YEAR OF Ball Clay

PLANT AGE 30 YEARS PLANT LOCATION Kentucky-Tennessee Region

		LEVEL				
		A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		89,000	92,000	97,000		
ANNUAL CAPITAL RECOVERY		9,800	10,300	11,100		
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		14,000	19,000	15,000		
ANNUAL ENERGY AND POWER		800	800	1,100		
TOTAL ANNUAL COSTS		24,600	30,100	27,200		
COST/METRIC TON of Ball Clay		0.33	0.40	0.36		
WASTE LOAD PARAMETERS (kg/metric ton of ball clay)	RAW WASTE LOAD					
TSS		0.4-2.0	0.2	0		
pH		6-9	6-9	-		

LEVEL DESCRIPTION:

A — pond settling
B — A plus flocculating agent
C — closed cycle operation (satisfactory only for scrubbers and cooling water)

Ball clay operations are located in the Kentucky-Tennessee rural areas and hence location is not a significant cost variance factor.

Size

The two wet process kaolin plants are 300,000 and 600,000 kkg/yr (330,000 and 650,000 TPY) size. The representative plant is 450,000 kkg/yr (500,000 TPY). Capital costs over this size range are estimated to be a 0.9 exponential function of size, and operating costs other than taxes, insurance, and capital recovery are estimated to be proportional to size.

The ball clay facilities range from 3,000 to 113,000 kkg/yr (3,300 to 125,000 TPY). The representative plant is 68,000 kkg/yr (75,000 TPY). Capital cost and operating cost variance factors for size are the same as for wet process kaolin above.

3.4.2 Cost Basis for Table VIII-4

Capital Costs

- Pond cost, dollars/hectare (dollars/acre):12,350 (5,000)
- Settling pond area, hectares (acres):20 (50)
- Pumps and pipes: $25,000
- Chemical metering equipment: $10,000

Operating and Maintenance Costs

- Pond dredging: $20,000/yr
- Treatment chemicals
  - Lime: $22/kkg ($20/ton)
  - Flocculating agent: $2.2/kg ($1/lb)
- Energy unit cost: $0.01/kwh
- Maintenance: $10,000-11,000/yr

3.4.3 Cost Basis for Table VIII-5

Capital Costs

- Land cost, dollars/hectare (dollars/acre): 12,350 (5,000)
- Settling pond area, hectares (acres): 20 (50)
- Pumps and pipes: $25,000
- Chemical metering equipment: $10,000

Operating and Maintenance Costs

- Pond dredging: $20,000/yr

<u>Treatment chemicals</u>
<u>Lime: $22/kkg ($20/ton)</u>
<u>Flocculating agent: $2.2/kg ($1/lb)</u>
<u>Maintenance: $10,000-11,000/yr</u>

3.5 Feldspar

Feldspar may be produced as the sole product, as the main product with by-product sand and mica, or as a co-product of processes for producing mica. Co-product production processes will be discussed under mica. Dry processes (in western U.S.) where feldspar is the sole product have no water effluent and no wastewater treatment costs. Therefore, the only subcategory involving major treatment and cost is wet beneficiation of feldspar ore.

After initial scalpings with screens, hydrocyclones or other such devices to remove the large particle sizes, the smaller particle sizes are removed by (1) settling ponds or (2) mechanical thickeners, clarifiers and filters. Often the method selected depends on the amount and type of land available for treatment facilities. Where sufficient flat land is available ponds are usually preferred. Unfortunately, most of the industry is located in hill country and flat land is not available. Therefore, thickeners and filters are often used. Wastewater from the feldspar beneficiation involves as primary pollutants suspended solids and fluorides. There is also a solid waste disposal problem for ore components such as mud, clays and some types of sand, some of which have to be landdumped or landfilled. Fluoride pollutants come from the hydrofluoric acid flotation reagent.

Treatment and cost options are developed in Table VIII-6 for both suspended solids and fluoride reductions. Successive treatments for reducing suspended solids and fluorides are shown.

Reduction of fluoride ion level to less than 10 mg/liter can be accomplished through segregation and separate treatment of fluoride-containing streams. This approach is already planned by at least one producer, and is a good example of in-process modification to reduce pollutant levels. A modest reduction of fluoride of less than 50 percent is presently achieved at only one plant with alum treatment

TABLE VIII-6.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT

(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Feldspar, Wet Process

PLANT SIZE 90,900 METRIC TONS PER YEAR OF Feldspar

PLANT AGE 10 YEARS PLANT LOCATION Eastern U.S.

		LEVEL				
		A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		115,000	260,000	375,000	185,000	415,000
ANNUAL CAPITAL RECOVERY		18,700	42,100	60,800	30,100	70,800
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		107,500	132,500	157,500	118,500	156,500
ANNUAL ENERGY AND POWER		2,000	2,000	2,000	4,000	6,000
TOTAL ANNUAL COSTS		128,200	176,600	220,300	152,600	233,300
COST/METRIC TON Feldspar		1.41	1.95	2.42	1.68	2.56
WASTE LOAD PARAMETERS (kg/metric ton of ore)	RAW WASTE LOAD					
Suspended Solids	260-530	0.6	0.3	0.3	0.3-3	0.1-0.3
Fluoride	0.22-0.25	0.2	0.1	0.03	0.2	0.03
pH	--	6-9	6-9	6-9	6-9	6-9

LEVEL DESCRIPTION:

A — settling pond for suspended solids removal, no fluoride treatment.

B — larger settling ponds plus internal recycle of some fluoride-containing water plus flocculation agents.

C — B plus segregation and separate lime treatment of fluoride water.

D — present treatment by thickeners and filters plus lime treatment for fluoride.

E — D plus segregation and separate lime treatment of fluoride water plus improved suspended solids treatment by clarifier installation.

that has been installed for the purpose of flocculating suspended solids.

3.5.1 Cost Variance

Age
The feldspar wet process subcategory consists of 6 plants ranging in age from 3 to 26 years. Age is not a significant cost variance factor.

Location
The feldspar wet processing operations are located in southeastern and northeastern states in rural areas. Location has not been found to be a significant cost variance factor.

Size
The feldspar wet processing operations range in size from 45,700 to 154,000 kkg/yr (50,400-170,000 TPY). The representative plant is 90,900 kkg/y (100,000 TPY). The range of capital costs for treatment is $36,800 to $250,000, and the range of operating costs is $18,400 to $165,000 as reported by the feldspar wet process producers.

The variance of cost with size is estimated to be for
capital: exponent of 0.9 for treatments based on ponds, exponent of 0.7 for treatments based on thickeners.

Operating costs other than taxes, insurance and capital recovery are approximately proportional to size.

3.5.2 Cost Basis for Table VIII-6.

Capital Costs
Pond cost, dollars/hectare (dollars/acre): 30,600 (12,500)
Settling pond area, hectares (acres): 0.4-0.8 (1-2)
Thickeners, filters, clarifiers: 0-$50,000
Solids handling equipment: $40,000-50,000
Chemical metering equipment: 0-$50,000

Operating and Maintenance Costs
Other solid waste disposal costs: 0-$0.5/ton
Treatment chemicals: $10,000-25,000/yr
Energy unit cost: $0.01/kwh
Monitoring: 0-$15,000/yr

3.6 Kyanite

Kyanite is produced at three locations. Two of the three plants have complete recycle of process water after passing through settling ponds. A summary of treatment technology costs is given in Table VIII-7. Approximately two-thirds of the cost comes from solid wastes removal from the settling pond and land disposal. Depending on solid waste load, costs could vary from approximately $1 to $4 per metric ton of product.

3.6.1 Cost Variance

Age
The three plants of this subcategory range in age between 10 and 30 years. There is no significant treatment cost variance due to this range.

Location
These plants are in two southeastern states in rural locations, not a significant cost variance factor.

Size
The sizes range from 16,000 to 45,000 kkg/yr (18,000 to 50,000 TPY). The costs given are meant to be representative over this size range on a unit production basis, that is, costs are roughly proportional to size.

3.6.2 Cost Basis for Kyanite Category

Capital Costs
- Pond cost, dollars/hectare (dollars/acre): 12,300 (5,000)
- Settling pond area, hectares (acres):10 (25)
- Pipes: $28,000
- Pumps: $4,400

Operating and Maintenance Costs
- Pond dredging and solids waste hauling: $82,500/yr
- Pond: $14,600/yr
- Pipes: $3,300/yr
- Energy unit cost: $0.01/kwh
- Pumps: $1,200/yr
- Labor: $3,000/yr
- Maintenance: $16,900/yr

TABLE VIII-7.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT
(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Kyanite

PLANT SIZE 45,000 METRIC TONS PER YEAR OF Kyanite

PLANT AGE 15 YEARS PLANT LOCATION Southeastern U.S.

		LEVEL				
		A (MIN)	B	C	D	E
INVESTED CAPITAL COSTS:						
TOTAL		80,000	157,400			
ANNUAL CAPITAL RECOVERY		9,700	19,100			
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		75,000	108,100			
ANNUAL ENERGY AND POWER		1,000	1,400			
TOTAL ANNUAL COSTS		85,700	128,600			
COST/METRIC TON of Kyanite		1.90	2.83			
WASTE LOAD PARAMETERS (kg/metric ton of ______)	RAW WASTE LOAD					
Tailings	5500					
TSS		3	0			
pH		6-9	-			

LEVEL DESCRIPTION:

A — pond settling
B — A plus recycle

Note: Most of the above cost at A level (65-70%) is the cost of removal and disposal of solids from ponds.

3.7 Naturally Occurring Magnesite

There is only one known U.S. plant that produces magnesia from naturally occurring magnesite ore. This plant is located in a dry western climate and has no discharge to surface water by virtue of a combination evaporation-percolation pond. Capital costs for this treatment are $300,000 with operation/maintenance costs of $15,000/yr. plus annual capital investment costs of $35,220.

3.8 Shale and Other Clay Minerals

The minerals included in this category are shale and aplite.

3.8.1 Shale

No water is used in either mining or processing of shale. The only water involved is occasional mine drainage from rain or ground water. In most cases runoff does not pick up significant suspended solids. Any needed treatment costs would be expected to fall in the range of $0.01 to $0.05 per ton of shale produced.

3.8.1.1 Cost Variance

Age
Shale facilities range from 8 to 80 years in age. This is not a significant variance factor for the costs to treat mine water.

Location
Shale facilities having significant mine water are located through the eastern half of the U.S. The volume of mine water is the only significant cost factor influenced by location.

Size
Shale facilities range from 700 to 250,000 kkg/yr (770 to 270,000 TPY). Size is not a cost variance factor, since the mine pumpout is unrelated to production rate.

3.8.2 Aplite

Aplite is dry mined produced at two facilities in the U.S.

One plant with a dry process uses wet scrubbers the discharge from which is ponded to remove suspended solids and then discharged. Wastewater treatment costs were calculated to be $0.48 per metric ton of product.

The second processing plant uses a wet classification process and a significantly higher water usage per ton of product than the first plant. Except for a pond pumpout every one to two years, this plant is on complete recycle. The total treatment costs per metric ton of product is $0.78.

The estimated costs to bring the "dry process" plant to a condition of total recycle of its scrubber water are:

capital: $9,000
annual capital recovery:$1,470
annual operating and maintenance, excluding power and energy: $630
annual power and energy: $1,300
total annual cost:$3,400

3.8.2.1 Cost Variance

Age
Aplite is produced by two plants which are 17 and 41 years old. Age has not been found to be a significant cost variance factor.

Location
Both aplite plants are located in Virginia and, therefore, location is not a significant cost variance factor.

Size
The aplite plants are 54,400 kkg/y (60,000 TPY) and 136,000 kkg/y (150,000 TPY). The costs per unit production are applicable for only the plants specified.

3.8.2.2 Cost Basis for Aplite Category

Capital Costs
Pond cost, dollars/hectare (dollars/acre): 12,300-24,500 (5,000-10,000)
Settling pond area, hectares (acres): 5.5-32 (14-80)
Recycle equipment: $9,000

Operating and Maintenance Costs

Treatment chemical costs: $3,500/yr
Energy unit cost: $0.01/kwh
Recycle O & M cost: $1,900/yr
Maintenance: $4,500-16,500/yr

3.9 Talc Minerals Group

Suspended solids are the only major pollutant involved in the wastewater from this category. In some wet processing operations pH control through addition of acid and alkalies is practiced. Neutralization of the final wastewater may be needed to bring the pH into the 6-9 range. Both mines and processing plants may be either wet or dry. Dry operations have no treatment costs.

Mine Water

Rain water and ground water seepage often make it necessary to pumpout mine water. The only treatment normally needed for this water is settling ponds for suspended solids. Ponds are usually small, one acre or less. Costs for this treatment are in the range of $0.01 to $0.05 per ton of talc produced.

Wet Processes

Wet processes are conducted in both the eastern and western U.S.

Eastern Operations

Wastewater from wet processes comes from process operations and/or scrubber water. The usual method of treating the effluent is to adjust pH by addition of lime, followed by pond settling.

Treatment options, costs and resultant effluent quality are summarized in Table VIII-8. Plants not requiring lime treatment would have somewhat lower costs than those given.

TABLE VIII-8.

COST-BENEFIT ANALYSIS FOR A REPRESENTATIVE PLANT
(ALL COSTS ARE CUMULATIVE)

SUBCATEGORY Talc Minerals, Ore Mining, Heavy Media and Flotation

PLANT SIZE 45,000 METRIC TONS PER YEAR OF talc minerals

PLANT AGE 25 YEARS PLANT LOCATION Eastern U.S.

		LEVEL A (MIN)	LEVEL B	LEVEL C	LEVEL D	LEVEL E
INVESTED CAPITAL COSTS:						
TOTAL		100,000	150,000			
ANNUAL CAPITAL RECOVERY		11,700	17,600			
OPERATING AND MAINTENANCE COSTS:						
ANNUAL O & M (EXCLUDING POWER AND ENERGY)		27,000	34,000			
ANNUAL ENERGY AND POWER		2,000	3,000			
TOTAL ANNUAL COSTS		40,700	54,600			
COST/METRIC TON of products		0.89	1.09			
WASTE LOAD PARAMETERS (kg/metric ton of products)	RAW WASTE LOAD					
TSS	800 to 1800	0.3-1.3	0.3			
pH		6-9	6-9			

LEVEL DESCRIPTION:

A — lime treatment and pond settling
B — A plus additional pond settling

Western Operations

Wet process plants in the western part of the U.S. are mostly located in arid regions and can be no discharge facilities through evaporation. Costs for these evaporation pond systems were estimated to be the same cost as Level B of Table VIII-8. The required evaporation pond size in this case is similar to that needed for good settling pond performance.

3.9.1 Cost Variance

Age
Facilities in the talc minerals group range from 2 to 70 years of age. However, the heavy media separation and flotation subcategory with a discharge consists of only three plants of 10 to 30 years of age. This is not a significant treatment cost variance factor.

Location
The heavy media separation and flotation subcategory facilities are located in rural areas of the eastern U.S. This location spread is a minor cost variance factor.

Size
Talc minerals facilities range in size from 12,000 to 300,000 kkg/yr (13,000 to 330,000 TPY). The heavy media separation and flotation subcategory facilities range from 12,000 to 236,000 kkg/yr (13,000 to 260,000 TPY). The representative plant size selected is 45,000 kkg/yr (50,000 TPY). Over this range of sizes, capital costs variance can be estimated by an exponent of 0.8 to size, and operating costs other than capital recovery, taxes and insurance are approximately proportional to size.

3.9.2 Cost Basis for Table VIII-8.

Capital Costs
- Land cost, dollars/hectare (dollars/acre): 24,500 (10,000)
- Mine pumpout, settling pond area, hectares (acres): up to 0.4 (up to 1)
- Process settling pond area, hectares (acres): 2 (5)
- Pumps and pipes: $15,000
- Chemical treatment equipment: $35,000

Operating and Maintenance Costs
Treatment chemicals
Lime: $22/kkg ($20/ton)
Energy cost: $1,000-2,000/yr
Maintenance: $5,000/yr
Labor: $3,000-10,000/yr

3.10 Abrasives

Garnet and tripoli are the major natural abrasives mined in the U.S.

3.10.1 Garnet

There are three garnet producers in the U.S., two in Idaho and one in New York State.

Two basic types of processing are used: (1) wet washing and classifying of the ore, and (2) heavy media and froth flotation.

Washing and classifying plants have already incurred estimated wastewater treatment costs of $0.16 per metric ton of garnet produced.

Heavy media and flotation process wastewater treatment estimated costs already incurred are significantly higher, $5 to $10 per metric ton of product.

The quantity and quality of discharge at the Idaho plants are not known by the manufacturer. Sampling was precluded by seasonal halting of operations. The hydraulic load per ton of product at the Idaho operations is believed to be higher than at the New York operation studied. The costs to reduce the amount of suspended solids in these discharges to that of the New York operation are estimated to be:

capital: $100,000
annual operating costs: $30,000

Further detailing of these estimated costs would be pure speculation.

$3.10.1.1 Cost Variance

Age
There are three garnet producers ranging in age from 40 to 50 years. Age has not been found to be a significant cost variance factor.

Location
Two of the garnet producers are located in Idaho and one in New York State. The regional deposits differ widely making different ore processes necessary. Due to this difference in processes, there is no representative plant in this subcategory. Treatment costs must be calculated on an individual basis.

Size
The garnet producers range in size from 5,100 kkg/y to an estimated 86,200 kkg/y (5,600 TPY to an estimated 95,000 TPY). The differences in size are so great that there is no representative plant for this subcategory. Due to process and size differences, treatment costs must be calculated on an individual basis.

3.10.2 Tripoli

There are several tripoli producers in the United States. The production is dry both at the plants and the mines. One small plant has installed a wet scrubber.

3.10.2.1 Cost Variance

There is only one plant in this subcategory that has any process wastewater. This is only from a special process producing 10 percent of that plant's production. Therefore, there are no cost variances due to age, location or size.

3.11 Diatomite Mining

Diatomite is mined and processed in the western U.S. Both mining and processing are practically dry operations. Evaporation ponds are used for waste disposal in all cases.

3.12 Graphite

There is only one producer of natural graphite in the United States. For this mine and processing plant, mine drainage, settling pond seepage and process water are treated for suspended solids, iron removal and pH level. The pH level and iron precipitation are controlled by lime addition. The precipitated iron and other suspended solids are removed in the settling pond and the treated wastewater discharged.

Present treatment costs are approximately $20-25 per ton of graphite produced.

3.13 Miscellaneous Non-Metallic Minerals

The two minerals included in this category are jade and novaculite.

3.13.1 Jade

The jade industry is very small and involves very little wastewater. One plant represents 55 percent of the total U.S. Production has only 190 liters/day (50 GPD) of wastewater. Suspended solids are settled in a small tank followed by discharge to the company lawn. Treatment costs are considered negligible.

3.13.2 Novaculite

There is only one novaculite producer in the United States. Processing is a dry operation resulting in no discharge. A dust scrubber is utilized and the water is recycled after passing through a settling tank. Both present treatment costs and proposed recycle costs are negligible.

4.0 INDUSTRY STATISTICS

Below are summarized the estimated 1972 selling prices for the individual minerals at this report. These values were taken from minerals industry yearbooks and Bureau of Census publications.

	$/kkg ($/short ton)
Bentonite	11.70 (10.60)
Fire Clay	9.00 (8.15)
Fuller's Earth	25.50 (23.00)
Kaolin	28.40 (25.75)
Ball Clay	17.65 (16.00)
Feldspar	22-28 (24-31)
Kyanite	70.50 (64.00)
Magnesite	165 (150)
Shale & Misc. Clay	1.76 (1.60)
Aplite	not known
Talc Minerals	34 (31)
Abrasives, Garnet	114 (103)
Abrasives, Tripoli	10 (9)
Diatomite	72 (65)
Graphite	withheld
Jade	22,000 (20,000) after cutting
Novaculite	66 (60)

SECTION IX

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

1.0 INTRODUCTION

The effluent limitations which must be achieved by July 1, 1977, are based on the degree of effluent reduction attainable through the application of the best practicable control technology currently available. For the mining of clay, ceramic, refractory, and miscellaneous materials, this level of technology was based on the average of the best existing performance by facilities of various sizes, ages, and processes within each of the industry's subcategories. In Section IV, this segment of the minerals mining and processing industry was divided into thirteen major categories based on similarities of process. Several of these major categories have been further subcategorized and, for reasons explained in Section IV, each subcategory will be treated separately for the recommendation of effluent limitations guidelines and standards of performance.

Best practicable control technology currently available emphasizes treatment facilities at the end of a manufacturing process but also includes the control technology within the process itself when it is considered to be normal practice within an industry. Examples of waste management techniques which were considered normal practice within these industries are:

a) manufacturing process controls;

b) recycle and alternative uses of water; and

c) recovery and/or reuse of some wastewater constituents.

Consideration was also given to:

a) the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application;

b) the size and age of equipment and facilities involved;

c) the process employed;

d) the engineering aspects of the application of various types of control techniques;

e) process changes; and

f) non-water quality environmental impact (including energy requirements).

The following is a discussion of the best practicable control technology currently available for each of the chemical subcategories, and the proposed limitations on the pollutants in their effluents.

2.0 GENERAL WATER GUIDELINES

2.1 Process Water

Process water is defined as any water contacting the ore, processing chemicals, intermediate products, by-products or products of a process including contact cooling water. All process water effluents are limited to the pH range of 6.0 to 9.0 unless otherwise specified.

2.2 Cooling Water

In the minerals mining and processing industry, cooling and process waters are sometimes mixed prior to treatment and discharge. In other situations, cooling water is discharged separately. Based on the application of best practicable technology currently available, the recommendations for the discharge of such cooling water are as follows.

An allowed discharge of all non-contact cooling waters provided that the following conditions are met:

a) Thermal pollution be in accordance with standards to be set by EPA policies. Excessive thermal rise in once through non-contact cooling water in the mineral mining industry has not been a significant problem.

b) All non-contact cooling waters should be monitored to detect leaks of pollutants from the process. Provisions should be made for treatment to the standards established for process wastewater discharges prior to release in the event of such leaks.

c) No untreated process waters be added to the cooling waters prior to discharge.

The above non-contact cooling water recommendations should be considered as interim, since this type of water plus blowdowns from water treatment, boilers and cooling towers will be regulated by EPA at a later date as a separate category.

2.3 Storm Water Runoff

Storm water runoff may present pollution control problems for certain subcategories. This is true where large stockpiles of process or waste materials are stored uncovered or in processes generating large amounts of dust. In these cases, a process water impoundment which is designed, constructed and operated so as to contain the precipitation from the 10 year, 24 hour rainfall event as established by the U.S. National Weather Service for the area in which such impoundment is located, may discharge that volume of process wastewater which is equivalent to the volume of precipitation that falls within the impoundment in excess of that attributable to the 10 year, 24 hour rainfall event, when such event occurs.

2.4 Mine Water Discharge

A mine is defined as that area which is being or has been disturbed during the process of mineral extraction. The area ceases to be a mine when the criteria described below are fulfilled. The desired reclamation goals of regulatory agencies are usually universal: the restoration of affected lands to a condition at least fully capable of supporting the uses which it was capable of supporting prior to any mining, and achievement of a stability which does not pose any threat of water diminution or pollution. The point at which this metamorphosis takes place between unreclaimed and reclaimed surface mined land is difficult to determine, but must be considered in establishing a surface mine operator's term of responsibility for the quality of effluent from the mined area.

In order to accomplish the objectives of the desired reclamation goals, it is mandatory that the surface mine operator regrade and revegetate the disturbed area upon completion of mining. The final regraded surface configuration is dependent upon the ultimate land use of the specific site, and control practices described in this report can be incorporated into the regrading plan to minimize erosion and sedimentation. A diverse and permanent vegetative cover should be established and plant succession at least equal in extent of cover to the natural vegetation of the area. To assure compliance with these requirements and permanence of vegetative cover, the operator should be held responsible for successful revegetation and effluent water quality for a period of five full years after the last year of augmented seeding, fertilization, irrigation, or effluent treatment. In areas of the country where the annual average precipitation is twenty-six inches or less, the operator's assumption of responsibility and liability should extend for a period of ten full years after the last year of augmented seeding, fertilization, irrigation or effluent treatment.

The quantity of the discharges resulting from pumpout of water from mines, pits or quarries in these industries is characteristically intermittent or has a high variability of flow and is unrelated to the production rate at the mine. Such mine water is generally the result of direct rainfall into the mine, leakage from aquifers, or influx of surface runoff. The latter should not be allowed since the construction of simple dikes and ditches is usually sufficient to prevent the flow of surface water into a mine or quarry. The other, largely uncontrollable mine water must be disposed of by pumping to allow proper operation of the mine. Where this pumped water is not otherwise useful for process purposes or disposable by total evaporation or percolation back to the originating aquifer, it must be discharged.

Many of the individual mines studied in these industries have no mine pumpout water at all, or have no point source discharge of mine drainage. For the others, it was found that the ubiquitous suspended solids and pH pollutant problems could be readily brought under control by simple pH adjustment and settling in ponds prior to discharge. The exceptions to this are in the mines where materials readily forming stable colloidal suspensions are mined, as in montmorillonite mining. The other industry subcategory where this situation could be found is in bentonite mining, but no such mines with water needing pumpout were found. The suspended solids picked up in montmorillonite mine waters are generally not amenable to reduction to low concentrations by simple settling.

For all mine pumpout discharges from the clay, ceramic, refractory, and miscellaneous materials segment of the minerals mining and processing industry except for the montmorillonite and bentonite mining subcategories, any such discharges not explicitly covered by the process water discharge guideline limitation are to be limited to, based on the information in Sections V through VIII:

Pollutant Parameter	Limitation	
	Monthly Average	Daily Maximum
pH	6-9	6-9
TSS	20 mg/liter	100 mg/liter

The above limitations are based on whatever flow discharge volume exists for the period under consideration. The discharge of pollutant parameters other than the above should not exceed in concentration those values established for water quality standards.

3.0 PROCESS WASTE WATER GUIDELINES AND LIMITATIONS FOR THE CLAY, CERAMIC, REFRACTORY, AND MISCELLANEOUS MINERALS SEGMENT OF THE MINERAL MINING INDUSTRY POINT SOURCE SUBCATEGORIES

3.1 Bentonite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Identification of BPCTCA

There is no control technology needed for the mining and processing of bentonite, because no water is used in the process.

3.2 Fire Clay Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

There is no control technology needed for the mining and processing of fire clay because no water is used in the process.

3.3.1 Fuller's Earth - Attapulgite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of product Monthly Average	Daily Maximum
TSS	0.017 (0.034)	0.085 (0.17)

The above limitations were based on the average process wastewater discharge of the two plants studied, 340 liters per metric ton (80 gallons per ton) of product and, estimated achievable concentration of 50 mg/liter of TSS.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of Fuller's Earth (attapulgite) is settling of suspended solids.

To implement this technology at plants not already using the recommended control techniques would require the installation of settling ponds.

Reason for Selection

At least two plants in this subcategory are presently using this technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $50,000 to achieve limitations prescribed herein.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. More than 60 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The date obtained on this subcategory represents two plants with ages over 50 years.

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, screening and drying of crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the use of settling ponds in this industry is commonplace.

Process Changes

The recommended control technologies would not require any process changes. These control technologies are presently being used by plants in this production subcategory.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impact or major energy requirements for the implementation of the recommended treatment technologies.

3.3.2 Fuller's Earth - Montmorillonite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Pit pumpout in this subcategory contains non-settleable suspended solids. However, an insufficient data base exists for the establishment of meaningful effluent limitation guidelines.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of Fuller's Earth-Montmorillonite is recycle of all process scrubber water.

To implement this technology at plants not already using the recommended control techniques would require the installation of pumps and associated recycle equipment.

Reason for Selection

Two of the three plants studied presently use the recommended technology.

Total Cost of Applicaton

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $30,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost of less than one percent of the 1971 selling price of this product.

It is concluded that the benefits of the total elimination of the discharge pollutants by the selected control technology outweigh the costs. Approximately 25 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 3 to 18 years and production capacities ranging from 40 to 600 metric tons per day (44 to 660 tons per day).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, drying, milling and screening of the crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the technology of total recycle exists at two facilities. A third facility plans to implement the recommended technology in the near future.

Process Changes

The recommended control technologies would not require major process changes. These control technologies are presently being used by plants in this production subcategory.

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Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impact or major energy requirements for the implementation of the recommended treatment technologies.

3.4.1.1 Kaolin Mining and Dry Processing for General Purpose Use Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

There is no control technology necessary for the dry mining and processing of kaolin for general purpose use.

3.4.1.2 Kaolin Mining and Wet Processing for High Grade Product Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is:

	Effluent Limitation kg/metric ton (lbs/ton) of product	
Effluent Characteristic	Monthly Average	Daily Maximum
TSS	0.1 (0.2)	0.5 (1.0)
Zinc	0.001 (0.002)	0.002 (0.004)

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

The above limitations were based on the performance attainable by the two exemplary plants (3024 and 3025), see Section V.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the wet mining and processing of kaolin for high grade product is lime treatment to precipitate zinc followed by pond settling to reduce suspended solids.

To implement this technology at plants not already using the recommended control techniques would require the installation of lime treatment facilities and settling ponds.

Reason for Selection

The recommended technologies are presently being used by at least 2 exemplary plants accounting for two-thirds of the total production in this subcategory.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $100,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost of less than one percent of the total product value.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. At least 66 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 28 to 37 years and production capacities ranging from 850 to 1700 metric tons per day (940 to 1850 tons per day).

Process Employed

The general process employed in this production subcategory involves mining, blunging and/or pug milling, degritting, classification, bleaching and/or chemical treatment, filtration and drying or bulk slurrying.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because 2 plants accounting for two-thirds of the total production in this subcategory are presently using the recommended technologies.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the protential effect of land disposal of the solids removed from the process wastewaters. These solids may sometimes contain harmful constituents which could be detrimental to the soil system in the area of disposal or possibly contaminate ground waters due to rainwater runoff and percolation through the soil. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.4.2 Ball Clay Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of product Monthly Average	Daily Maximum
TSS	0.17 (0.34)	0.85 (1.7)

The above limitations were based on the performance demonstrated at the exemplary plant of those employing wet scrubbers for dust collection. Other plants have no wet scrubbers and hence no process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of ball clay is either the use of dry bag collection techniques for dust control or, where wet scrubbers are employed, the use of settling ponds to reduce suspended solids in the effluent.

To implement this technology at plants not already using the recommended control techniques would require either the installation of dry bag collectors or settling ponds.

Reason for Selection

All of the plants contacted use either one or the other of the recommended technologies.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $10,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost equivalent to less than one percent of the 1971 selling price of the product.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. Approximately 75 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 15 to 56 years and production capacities ranging from 23,000 to 113,000 metric tons per year (25,000 to 125,000 tons per year).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, shredding, milling or blunging, classification and drying of the crude ore. The discharge of process water in this subcategory is associated only with plants using wet scrubbing to control dust.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the majority of facilities are presently using the recommended technologies.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impact or major energy requirements for the implementation of the recommended treatment technologies.

3.5.1 Feldspar Wet Processing Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable though the application of the best practicable control technology currently available is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of ore processed Monthly Average	Daily Maximum
TSS	0.60 (1.2)	3.0 (6.0)
Fluoride	0.15 (0.3)	0.3 (0.6)

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

The above limitations were based on the performance achieved by three exemplary plants for TSS and one of these three for fluoride reduction.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of feldspar by the wet process is to recycle part of the process wastewater for washing purposes, then neutralize and settle the remaining wastewater to reduce the suspended solids. In addition, fluoride reduction can be accomplished by chemical treatment of wastewater from the flotation circuit and/or partial recycle of the fluoride containing portion of the flotation circuit.

To implement this technology at plants not already using the recommended control techniques would require installation of piping and pumps for recycle of water and installation of neutralization, chemical treatment and settling equipment or ponds.

Reason for Selection

The selected technology of partial recycle and chemical treatment is is practiced at the exemplary facility. All facilities are currently employing settling and neutralization.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $320,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating costs for the plants in this subcategory equivalent to approximately two percent of the total product value.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. Approximately 8 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 15 to 26 years and production capacities ranging from 46,000 to 154,000 metric tons per year (50,000 to 170,000 tons per year).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining and beneficiation by the flotation process of crude feldspar.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because recycle and chemical treatment of process wastewater is currently practiced at one facility and equipment is available for wastewater settling and neutralization.

Process Changes

The recommended control technologies would not require major process changes. These control technologies are presently being used by plants in this production subcategory.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. These solids may sometimes contain harmful constituents which could be detrimental to the soil system in the area of disposal or possibly contaminate ground waters due to rainwater runoff and percolation through the soil. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.5.2 Feldspar Dry Processing Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the processing of feldspar by the dry process is natural evaporation of dust control water used in the process. This is the only water used in the process.

3.6 Kyanite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater. There is no mine water discharge occurring in this subcategory.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of kyanite by the standard process is recycle of process water from settling ponds. To implement this technology at plants not already using the recommended control techniques would require installation of suitable impoundments and recycle where required.

Reason for Selection

One of the three plants in this production subcategory is currently employing the recommended technologies.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $100,000 to achieve limitations prescribed herein. The anticipated increase in the operating cost is approximately one percent of the 1971 selling price of this product.

It is concluded that the benefits of the total elimination of the discharge pollutants by the selected control technology outweigh the costs. Approximately 40 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 10 to 30 years and production capacities ranging from 18 to 90 metric tons per day (20 to 100 tons per day).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, classification, flotation and magnetic separation of the crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because these technologies are in common usage.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.7 Naturally Occurring Magnesite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

There is presently no mine water pumpout in this subcategory.

Identification of BPCTCA

Best practicable control technology currently available for the manufacture of magnesia (MgO) from naturally occurring magnesite is either impoundment or recycle of process wastewater.

Reason for Selection

There is one plant in the U.S. and this plant currently uses the recommended technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest no money to achieve limitations prescribed herein. One hundred percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

Age and size in thare subcategory is irrelevant because there is only one plant.

Process Employed

The general process employed in this production subcategory involves mining, crushing, firing and beneficiation of naturally occurring magnesite ore.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because they are presently employed in the only facility using this process.

Process Changes

The recommended control technologies would not require any process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.8.1 Shale Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

There is no control technology needed for the mining and processing of shale.

3.8.2 Aplite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of aplite is ponding of process wastewater to settle solids and recycle of water. To implement this technology at plants not already using the recommended control techniques would require installation of water recycle equipment.

Reason for Selection

The one plant with an almost 100 percent recycle system can be easily made 100 percent recycle by dredging out the ponds, switching ponds or elevating the dikes rather than periodically discharging the rising level of water.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $9,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost equivalent to less than one percent of the 1971 selling price of this product.

It is concluded that the benefits of the total elimination of the discharge pollutants by the selected control technology outweigh the costs. Approximately 70 percent of this industry subcategory is presently achieving this level of pollutant discharge considering that one plant presently discharges only once every two to three years.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 17 to 41 years and production capacities ranging from 150 to 400 metric tons per day (165 to 440 tons per day).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, drying, classifying and separating the crude ore. The processes used by the establishments in this subcategory are similar in nature and their raw wastes are also similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the recommended technologies are presently being employed at one of the two U.S. facilities and can be installed at the other using state-of-the-art and commercially available equipment.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.9.1 Talc Minerals Group, Dry Process Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge in this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

There is no control technology needed for the mining and processing of talc minerals by the dry process, because no water is used in the process.

3.9.2 Talc Minerals Group, Ore Mining and Washing Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the mining of talc minerals by the ore mining and washing processes is total impoundment or recycle of process wastewater.

Reason for Selection

All plants in this production subcategory currently employ the recommended control technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would not have to invest any money to achieve limitations prescribed herein. One hundred percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents only two plants. Age and size were not disclosed.

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, washing, screening and milling of the ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the recommended technologies are currently employed by all facilities.

Process Changes

The recommended control technologies would not require any changes in the manufacturing process. These control technologies are presently being used by all plants in this production subcategory.

Non-Water Quality Environmental Impact

There are no non-water quality environmental impacts or energy requirements for the implementation of the recommended treatment technologies.

3.9.3 Talc Minerals Group, Ore Mining, Heavy Media and Flotation Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of product Monthly Average	Daily Maximum
TSS	0.5 (1.0)	2.5 (5.0)

The above limitations were based on the performance achievable by the two exemplary plants and a third plant having a special situation.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

Best practicable control technology currently available for the processing of talc minerals by heavy media process is pH adjustment of the flotation tailings, gravity settling and clarification. To implement this technology at plants not already using the recommended control techniques would require the installation of pH monitoring and adjustment equipment and the installation of settling and/or clarification ponds.

Reason for Selection

Plants representing eighty-three percent of the total production in this subcategory are presently using the recommended technologies.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $50,000 to achieve limitations prescribed herein. The anticipated increase in the operating cost is negligible.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. Approximately eighty-three percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 10 to 38 years and production capacities ranging from 30 to 130 metric tons per day (33 to 140 tons per day).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, flotation or heavy media separation, thickening, filtering and drying of the crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because these technologies are in common usage in this subcategory.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.10.1 Natural Abrasives, Garnet Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent attainable through the application of the best practicable control technology currently available is:

	Effluent Limitation kg/metric ton (lbs/ton) of product	
Effluent Characteristic	Monthly Average	Daily Maximum
TSS	0.4 (0.8)	2.0 (4.0)

The above limitations were based on an estimated average process wastewater discharge of 12,500 liters per metric ton (3,000 gallons per ton) of product and an estimated TSS level of 30 mg/liter.

In the two plants studied, mine water is used as process water.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of garnet is pH adjustment, where necessary, and settling of suspended solids.

To implement this technology at plants not already using the recommended control techniques would require the installation of pH adjustment equipment, where necessary, and construction of settling ponds.

<u>Reason for Selection</u>

The two facilities accounting for over 80 percent of the U.S. production are presently using the recommended technologies.

<u>Total Cost of Application</u>

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $100,000 to achieve limitations prescribed herein. There is also an anticipated increase in the annual operating cost of approximately $30,000.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. Approximately 80 percent of this industry subcategory is presently achieving this level of pollutant discharge.

<u>Age and Size of Equipment and Facilities</u>

The data obtained on this subcategory represents plants with ages ranging from 43 to 50 years and production capacities for the two plants studied vary by a factor of 2.

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general processes employed in this production subcategory involve mining and beneficiation of the crude ore.

The processes used by the establishments in this subcategory are sufficiently similar to enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the technologies of pH adjustment and suspended solids settling are widely used in this industry.

Process Changes

The recommended control technologies would not require major process changes. These control technologies are presently being used by plants in this production subcategory.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impact or major energy requirements for the implementation of the recommended treatment technologies.

3.10.2 Natural Abrasives, Tripoli Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BPCTCA

There is no control technology needed for the mining and processing of tripoli.

3.11 Diatomite Mining Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

There is no mine water discharge for this subcategory.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of diatomite by the standard process is use of evaporation ponds and/or recycle of process water.

To implement this technology at plants not already using the recommended control techniques would require the construction of impoundments and/or recycling equipment.

Reason for Selection

Three plants of this subcategory representing approximately half the U.S. production utilize this recommended technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would not have to invest any money to achieve limitations prescribed herein. We estimate 100 percent of this industry subcaterogy is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 27 to 80 years and production capacities ranging from 27 to 400 metric tons per day (30 to 450 tons per day).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves the mining, crushing, drying, milling and classifying of crude diatomite.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the establishments mining crude diatomite are located in geographic areas where land is available for impoundments. Process water recycle is practiced in several plants in this subcategory and is technically feasible in the remainder, if necessary.

Process Changes

The recommended control technologies would not require major process changes. These control technologies are presently being used by plants in this production subcategory.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. These solids may sometimes contain harmful constituents which could be detrimental to the soil system in the area of disposal or possibly contaminate ground waters due to rainwater runoff and percolation through the soil. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.12 Graphite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is:

	Effluent Limitation kg/metric ton (lbs/ton) of product	
Effluent Characteristic	Monthly Average	Daily Maximum
TSS	1.6 (3.2)	8.0 (16.0)
Manganese	0.03 (0.06)	0.25 (0.50)
Iron	0.16 (0.32)	1.3 (2.6)
BOD5	1.6 (3.2)	6.3 (12.6)
COD	2.3 (4.6)	7.5 (15)

The above average limitations were based on the exemplary performance achievable by the single plant in this subcategory.

Mine water discharge for this subcategory is included in the above limitations.

Identification of BPCTCA

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

Best practicable control technology currently available for the mining and processing of graphite is neutralization and pond settling.

Reason for Selection

There is only one plant in the U.S. and this plant currently uses the recommended technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest no money to achieve limitations prescribed herein. One hundred percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

Age and size in this subcategory are irrelevant because there is only one plant.

Process Employed

The general process employed in this production subcategory involves mining, crushing, sizing, flotation separation, filtering and drying of graphite ore.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because they are presently employed in the only facility using this process.

Process Changes

The recommended control technologies would not require any process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.13.1 Jade Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

There is no mine water discharge in this subcategory.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of jade is settling and evaporation of the small volume of wastewater. To implement this technology at plants not already using the recommended control techniques would require installation of a settling tank and appropriate evaporation facilities.

Reason for Selection

The only major U.S. jade production facility presently employs these techniques.

Total Cost of Application

The remainder of this industry is so small and highly fragmented as to be economically insignificant. Therefore, there is no economic impact. Approximately 55 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

Age and size of equipment are irrelevant in this subcategory because there is only one plant.

Process Employed

The general process employed in this production subcategory involves mining, sawing, sanding, and polishing operations.

Engineering Aspects

There are no engineering aspects associated with the implementation of this technology.

Process Changes

The recommended control technologies would not require any process changes.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impact or major energy requirements for the implementation of the recommended treatment technologies.

3.13.2 Novaculite Production Subcategory

Based upon the information contained in Sections III through VIII, a determination has been made that the degree of effluent reduction attainable through the application of the best practicable control technology currently available is no discharge of pollutants in process wastewater.

There is no mine water discharge for this subcategory.

Identification of BPCTCA

Best practicable control technology currently available for the mining and processing of novaculite by the quarrying process is total recycle of process scrubber water.

Reason for Selection

There is only one facility in the U.S. It is presently using this technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest no money to achieve limitations prescribed herein. One hundred percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

Age and size in this subcategory are irrelevant because there is only one plant.

Process Employed

The general process employed in this production subcategory involves surface mining of novaculite, followed by grinding and packaging.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best control technologies currently available is practicable in this production subcategory because the sole plant in this subcategory already practices the recommended technology.

Process Changes

The recommended control technologies would not require any process changes.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impact or major energy requirements for the implementation of the recommended treatment technologies.

SECTION X

EFFLUENT REDUCTION ATTAINABLE THROUGH THE APPLICATION OF THE BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE

1.0 INTRODUCTION

The effluent limitations which must be achieved by July 1, 1983 are based on the degree of effluent reduction attainable through the application of the best available technology economically achievable. For the mining clay, ceramic, refractory and miscellaneous minerals industry, this level of technology was based on the very best control and treatment technology employed by a specific point source within each of the industry's subcategories, or where it is readily transferable from one industry process to another. In Section IV, this segment of the mineral mining and processing industry was divided into thirteen major categories based on similarities of process. Several of those major categories have been further subcategorized and, for reasons explained in Section IV, each subcategory will be treated separately for the recommendation of effluent limitations guidelines and standards of performance.

The following factors were taken into consideration in determining the best available technology economically achievable:

(1) the age of equipment and facilities involved;
(2) the process employed;
(3) the engineering aspects of the application of various types of control techniques;
(4) process changes;
(5) cost of achieving the effluent reduction resulting from application of BATEA; and

(6) non-water quality environmental impact (including energy requirements).

In contrast to the best practicable technology currently available, best available technology economically achievable assesses the availability in all cases of in-process controls as well as control or additional treatment techniques employed at the end of a production process. In-process control options available which were considered in establishing these control and treatment technologies include the following:

(1) alternative water uses
(2) water conservation
(3) waste stream segregation
(4) water reuse
(5) cascading water uses
(6) by-product recovery
(7) reuse of wastewater constituents
(8) waste treatment
(9) good housekeeping
(10) preventive maintenance
(11) quality control (raw material, product, effluent)
(12) monitoring and alarm systems.

Those plant processes and control technologies which at the pilot plant, semi-works, or other level, have demonstrated both technological performances and economic viability at a level sufficient to reasonably justify investing in such facilities were also considered in assessing the best available technology economically achievable. Although economic factors are considered in this development, the costs for this level of control are intended to be for the top-of-the-line of current technology subject to limitations imposed by economic and engineering feasibility. However, this technology may necessitate some industrially sponsored development work prior to its application.

Based upon the information contained in Sections III through IX of this report, the following determinations were made on the degree of effluent reduction attainable with the application of the best available control technology economically achievable in the various subcategories of the inorganic chemical industry.

2.0 GENERAL WATER GUIDELINES

2.1 Process Water

Process water is defined as any water contacting the ore, processing chemicals, intermediate products, by-products or products of a process including contact cooling water. All process water effluents are limited to the pH range of 6.0 to 9.0 unless otherwise specified.

2.2 Cooling Water

In the mineral mining and processing industry, cooling and process waters are sometimes mixed prior to treatment and discharge. In other situations, cooling water is discharged separately. Based on the application of best available technology economically achievable, the recommendations for the discharge of such cooling water are as follows.

An allowed discharge of all non-contact cooling waters provided that the following conditions are met:

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

a) Thermal pollution be in accordance with standards to be set by EPA policies. Excessive thermal rise in once through non-contact cooling water in the mineral mining and processing industry has not been a significant problem.

b) All non-contact cooling waters should be monitored to detect leaks of pollutants from the process. Provisions should be made for treatment to the standards established for the process wastewater discharges prior to release in the event of such leaks.

c) No untreated process waters be added to the cooling waters prior to discharge.

The above non-contact cooling water recommendations should be considered as interim, since this type of water plus blowdowns for water treatment, boilers and cooling towers will be regulated by EPA at a later date as a separate category.

2.3 Storm Water Runoff

Storm water runoff may present pollution control problems for certain subcategories. This is true where large stockpiles of process or waste materials are stored uncovered or in processes generating large amounts of dust. In these cases, a process water impoundment which is designed, constructed and operated so as to contain the precipitation from the 25 year, 24 hour rainfall event as established by the U.S. National Weather Service for the area in which such impoundment is located may discharge that volume of process wastewater which is equivalent to the volume of precipitation that falls within the impoundment in excess of that attributable to the 25 year, 24 hour rainfall event, when such event occurs.

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2.4 Mine Water Pumpout

The quantity of the discharges resulting from pumpout of water from mines, pits and quarries in these industries is characteristically intermittent or has a high variability of flow and is unrelated to the production rate of the mine. Such mine water is generally the result of direct rainfall into the mine, leakage from aquifers, or influx of surface runoff. The latter should not be allowed since the construction of simple dikes and ditches is usually sufficient to prevent the flow of surface water into a mine or quarry. The other, largely uncontrollable mine water must be disposed of by pumping to allow proper operation of the mine. Where this pumped water is not otherwise useful for process purposes or disposable by total evaporation or percolation back to the originating aquifer, it must be discharged.

Many of the individual mines studied in these industries have no mine pumpout water at all, or have no point source discharge of mine drainage. For the others it was found that the ubiquitous suspended solids and pH pollutant problems could be readily brought under control by simple pH adjustment and settling in ponds prior to discharge. The exceptions to this are in the mines where materials readily forming stable colloidal suspensions are mined, as in montmorillonite mining. The other industry subcategory where this situation could be found is in bentonite mining, but no such mines with water needing pumpout were found. The suspended solids picked up in montmorillonite mine waters are generally not amenable to reduction to low concentrations by simple settling.

For all mine pumpout discharges from the clay, ceramic, refractory, and miscellaneous materials segment of the mineral mining and processing industry except for the montmorillonite and bentonite mining subcategories, any such discharges not explicitly covered by the process water discharge guideline limitation are to be limited to, based on the information in Sections V through VIII:

Pollutant Parameter	Limitation Monthly Average	Daily Maximum
pH	6 - 9	6 - 9
TSS	20 mg/liter	100 mg/liter

The above limitations are based on whatever flow discharge volume exists for the period under consideration. The discharge of pollutant parameters other than the above should not exceed in concentration those values established for water quality standards.

3.0 PROCESS WASTEWATER GUIDELINES AND LIMITATIONS FOR THE CLAY, CERAMIC, REFRACTORY, AND MISCELLANEOUS MINERALS SEGMENT OF THE MINERAL MINING INDUSTRY POINT SOURCE SUBCATEGORY

The following industry subcategories were required to achieve no discharge of process wastewater pollutants to navigable waters based on best practicable control technology currently available:

bentonite, fire clay, fuller's earth (montmorillonite), kaolin (general purpose grade), feldspar (dry process), kyanite, magnesite, shale, aplite, talc group (dry process), talc group (ore mining and washing process), tripoli, diatomite, jade and novaculite.

The same limitations guidelines are recommended based on best available technology economically achievable.

3.1 Fuller's Earth - Attapulgite Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is no discharge of pollutants in process wastewater.

Mine water discharge in this subcategory is covered by general water guidelines earlier in this section.

Identification of BATEA

Best available technology economically achievable for the mining and processing of Fuller's Earth-Attapulgite is the use of settling ponds, flocculants where required, and recycle of all process wastewater.

To implement this technology at plants not already using the recommended control techniques would require the installation of settling ponds, facilities to add flocculants where necessary, and recycle piping and equipment.

Reason for Selection

The recommended level of discharge can be readily attained by using the recommended technology.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $60,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost of less than one percent of the selling price of this product.

It is concluded that the benefits of the total elimination of the discharge pollutants by the selected control technology outweigh the costs. None of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represent two plants with ages over 50 years.

The best available technology economically achievable is practicable regardless of the size of age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, screening and drying of crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best available technologies economically achievable is practicable in this production subcategory because the use of settling ponds recycle and flocculants in this industry is commonplace.

Process Changes

The recommended control technologies would require process changes. These control technologies are presently being used by other plants in this industry segment.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impacts or major energy requirements for the implementation of the recommended treatment technologies.

3.2 Wet Kaolin Mining and Processing for High Grade Product Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton of product) Monthly Average	Daily Maximum
TSS	0.06 (0.12)	0.30 (0.60)

The above limitations were based on exemplary plant performance.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BATEA

Best available technology economically achievable for the wet mining and processing of kaolin for high grade product is the elimination of zinc from the process raw waste by substituting sodium hydrosulfite as the bleaching agent and pond settling of suspended solids.

To implement this technology at plants not already using the recommended control techniques would require substitution of bleaching agent.

Reason for Selection

The two plants studied are considering the future bleaching agent substitution to eliminate zinc from their effluents. Recycle of process water in this subcategory is not possible because the build-up of dissolved solids interferes with the process.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would not have to invest any money to achieve limitations prescribed herein. There is no anticipated increase in the operating cost.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. None of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 28 to 37 years and production capacities ranging from 850 to 1700 metric tons per day (940 to 1850 tons per day).

The best control technology currently available is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, blunging and/or pug milling, degritting, classification, bleaching and/or chemical treatment, filtration and drying or bulk slurrying.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best available technologies economically achievable is practicable in this production subcategory because this relatively simple in-process change would eliminate zinc from the process effluent.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impacts or major energy requirements for the implementation of the recommended treatment technologies.

3.3 Ball Clay Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is no discharge of pollutants in process wastewater.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BATEA

Best available technology economically achievable for the mining and processing of ball clay is the use of dry bag collectors where possible or recycle of wet scrubber where wet scrubbers are used.

To implement this technology at plants not already using the recommended control techniques would require the installation of settling ponds or equipment and flocculation plus piping and pumps for recycle of scrubber water where used.

Reason for Selection

Settling of suspended solids and recycle of scrubber water is currently practiced in other portions of this industry.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $25,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost of less than one percent of the selling price of this product.

It is concluded that the benefits of the total elimination of the discharge pollutants by the selected control technology outweigh the costs. Approximately 75 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 15 to 56 years and production rates ranging from 23,000 to 113,000 metric tons per year (25,000 to 125,000 tons per year).

The best available technology economically achievable is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, shredding, milling or blunging, classification and drying of the crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best available technologies economically achievable is practicable in this production subcategory because the technology and equipment are currently employed in other portions of the clay mining category.

Process Changes

The recommended control technologies would not require major process changes. These control technologies are presently being used by plants in this production subcategory.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impacts or major energy requirements for the implementation of the recommended treatment technologies.

3.4 Feldspar (Wet Processing) Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of ore processed Monthly Average	Daily Maximum
TSS	0.6 (1.2)	3.0 (6.0)
Fluoride	0.1 (0.2)	0.2 (0.4)

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

The above limitations were based on an improvement in exemplary plant performance by deliberate chemical treatment to reduce fluorides.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BATEA

Best available technology economically achievable for the mining and processing of feldspar by the wet process is to recycle part of the process wastewater for washing purposes, neutralization to pH 9 with lime to reduce soluble fluoride and settling to remove suspended solids.

To implement this technology at plants not already using the recommended control techniques would require installation of piping and pumps for recycle of water, lime feeding and neutralization equipment and settling equipment or ponds.

Reason for Selection

The selected technology of partial recycle is currently practiced at two facilities. Three plants are currently using lime treatment to adjust pH and can readily adopt this technology to reduce soluble fluoride. All plants are using settling equipment or ponds.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $400,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost for the plants in this subcategory equivalent to approximately four percent of the total product value.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. None of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 15 to 26 years and production rates ranging from 46,000 to 154,000 metric tons per year (50,400 to 170,000 tons per year).

The best available technology economically achievable is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves the mining and beneficiation by the flotation process of crude feldspar.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best available technologies economically achievable is practicable in this production subcategory because a portion of these technologies are currently practiced by plants in this subcategory and the remaining portion is available technology practiced by plants in the chemical industry and readily transferable. The equipment and operating technology is available at the present time.

Process Changes

The recommended control technologies would require major process changes. These control technologies are presently being partially used by plants in this production subcategory.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. These solids may sometimes contain harmful constituents which could be detrimental to the soil system in the area of disposal or possibly contaminate ground waters due to rainwater runoff and percolation through the soil. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.5 Talc Minerals Group, Ore Mining, Heavy Media and Flotation Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of product Monthly Average	Daily Maximum
TSS	0.3 (0.6)	1.5 (3.0)

The above limitations were based on performance of one exemplary plant plus one plant having a special situation.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

NOTICE: THESE ARE TENTATIVE RECOMMENDATIONS BASED UPON INFORMATION IN THIS REPORT AND ARE SUBJECT TO CHANGE BASED UPON COMMENTS RECEIVED AND FURTHER INTERNAL REVIEW BY EPA.

Identification of BATEA

Best available technology economically achievable for the mining and processing of talc minerals by the ore mining, heavy media and/or flotation process is the same as for BPCTCA plus additional settling or in one case, conversion from wet scrubbing to a dry collection method to control air pollution.

To implement this technology at plants not already using the recommended control techniques would require installation of additional ponds or installation of dry dust collectors.

Reason for Selection

Two of the four plants in this subcategory are presently achieving this level of effluent reduction using the recommended treatment technologies.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $100,000 to achieve limitations prescribed herein. There is also an anticipated increase in the operating cost equivalent to less than one percent of the selling price of this product.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. Approximately 55 percent of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represent plants with ages ranging from 10 to 38 years and production rates ranging from 30 to 120 metric tons per day (33 to 130 tons per day).

The best available technology economically achievable is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves mining, crushing, flotation or heavy media separation, thickening, filtering and drying of the crude ore.

The processes used by the establishments in this subcategory are very similar in nature and their raw wastes are also quite similar. These similarities will enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best available technologies economically achievable is practicable in this production subcategory because these technologies are in common usage in this subcategory.

Process Changes

The recommended control technologies would not require major process changes.

Non-Water Quality Environmental Impact

The single major impact on non-water quality factors of the environment is the potential effect of land disposal of the solids removed from the process wastewaters. There appear to be no major energy requirements for the implementation of the recommended treatment technologies.

3.6 Garnet Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of product	
	Monthly Average	Daily Maximum
TSS	0.25 (0.5)	1.25 (2.5)

The above limitations were based on an estimated average process wastewater discharge of 12,500 liters per metric ton (3,000 gallons per ton) of product and an estimated TSS level of 20 mg/liter.

Mine water discharge for this subcategory is covered by the general water guidelines earlier in this section.

Identification of BATEA

Best available technology economically achievable for the mining and processing of garnet is pH adjustment to achieve pH 6 to 9, settling of suspended solids, and sand bed filtration where necessary.

To implement this technology at plants not already using the recommended control techniques would require the installation of pH neutralization equipment, settling ponds, and sand bed filter equipment.

Reason for Selection

Two facilities accounting for over 80 percent of the U.S. production presently use a portion of the recommended technologies and technology exists for further removal of suspended solids.

Total Cost of Application

Based upon the information contained in Section VIII of this report, the subcategory as a whole would have to invest up to an estimated maximum of $150,000 to achieve limitations prescribed herein. There is also an anticipated increase in the annual operating cost of approximately $50,000.

It is concluded that the benefits of the reduction of the discharge pollutants by the selected control technology outweigh the costs. None of this industry subcategory is presently achieving this level of pollutant discharge.

Age and Size of Equipment and Facilities

The data obtained on this subcategory represents plants with ages ranging from 43 to 50 years and production capacities, for the two plants studied, varied by a factor of two.

The best available technology economically achievable is practicable regardless of the size or age of plants since the use of existing technologies is not dependent on these factors.

Process Employed

The general process employed in this production subcategory involves the mining and beneficiation of the crude ore.

The processes used by the establishments in this subcategory are sufficiently similar to enhance the application of the recommended treatment technologies.

Engineering Aspects

From an engineering standpoint, the implementation of the recommended best available technologies economically achievable is practicable in this production subcategory because the technologies of pH adjustment and reduction of suspended solids are widely used in this industry.

Process Changes

The recommended control technologies would not require major process changes. These control technologies are presently being used by plants in this production subcategory.

Non-Water Quality Environmental Impact

There appear to be no major non-water quality environmental impacts or major energy requirements for the implementation of the recommended treatment technologies.

3.7 Graphite Production Subcategory

Based upon the information contained in Sections III through IX, a determination has been made that the degree of effluent reduction attainable through the application of the best available technology economically achievable is the same as that recommended for BPCTCA because no proven technology option exists to reduce the pollutants further without interfering with the process employed.

SECTION XI

NEW SOURCE PERFORMANCE STANDARDS AND PRETREATMENT STANDARDS

1.0 INTRODUCTION

This level of technology is to be achieved by new sources. The term "new source" is defined in the Act to mean "any source, the construction of which is commenced after the publication of proposed regulations prescribing a standard of performance". This technology is evaluated by adding to the consideration underlying the identification of best available technology economically achievable, a determination of what higher levels of pollution control are available through the use of improved production processes and/or treatment techniques. Thus, in addition to considering the best in-plant and end-of-process control technology, new source performance standards are how the level of effluent may be reduced by changing the production process itself. Alternative processes, operating methods or other alternatives were considered. However, the end result of the analysis identifies effluent standards which reflect levels of control achievable through the use of improved production processes (as well as control technology), rather than prescribing a particular type of process or technology which must be employed.

The following factors were considered with respect to production processes which were analyzed in assessing the best demonstrated control technology currently available for new sources:

a) the type of process employed and process changes;
b) operating methods;
c) batch as opposed to continuous operations;
d) use of alternative raw materials and mixes of raw materials;
e) use of dry rather than wet processes (including substitution of recoverable solvents from water); and
f) recovery of pollutants as by-products.

In addition to the effluent limitations covering discharges directly into waterways, the constituents of the effluent discharge from a plant within the industrial category which would interfere with, pass through, or otherwise be incompatible with a well designed and operated publicly owned activated sludge or trickling filter wastewater treatment plant were identified. A determination was made of whether the introduction of such pollutants into the treatment plant should be completely prohibited.

2.0 GENERAL WATER GUIDELINES

The process water, cooling mine water pumpout, water and blowdown guidelines for new sources are identical to those based on best available technology economically achievable. In addition, a process water impoundment should be designed, constructed and operated so as to contain the precipitation from the 25-year, 24-hour rainfall event as established by the U.S. National Weather Service for the area in which such impoundment is located. It may discharge that volume of process wastewater which is equivalent to the volume of precipitation that falls within the impoundment in excess of that attributable to the 25-year, 24-hour rainfall event, when such event occurs.

3.0 EFFLUENT REDUCTION ATTAINABLE BY THE APPLICATION OF THE BEST AVAILABLE DEMONSTRATED CONTROL TECHNOLOGIES, PROCESSES, OPERATING METHODS OR OTHER ALTERNATIVES

Based upon the information contained in Sections III through X of this report, the following determinations were made on the degree of effluent reduction attainable with the application of new source standards for the various subcategories of the clay, ceramic, refractory, and miscellaneous minerals segment of the mineral mining and processing industry.

The following industry subcategories were required to achieve no discharge of process wastewater pollutants to navigable waters based on best available technology economically achievable:

bentonite, fire clay, fuller's earth (montmorillonite), kaolin (general purpose grade), ball clay, feldspar (dry process), kyanite, magnesite, shale, aplite, talc group (dry process), talc group (ore mining and washing process), tripoli, diatomite, jade and novaculite.

The same limitations guidelines are recommended as new source performance standards.

The following industry subcategories are required to achieve specific effluent limitations as given in the following paragraphs.

3.1 Fuller's Earth (Attapulgite)

Same as BATEA

3.2 Wet Kaolin (High Grade Product)

Same as BATEA

3.3 Feldspar (Wet Process)

For new plants, based upon the information contained in Sections III through X, a determination has been made that the degree of effluent reduction attainable as a new source performance standard for the mining and processing of feldspar by the wet process is:

Effluent Characteristic	Effluent Limitation kg/metric ton (lbs/ton) of ore processed	
	Monthly Average	Daily Maximum
TSS	0.4 (0.8)	2.0 (4.0)
fluoride	0.05 (0.1)	0.1 (0.2)

This limitation would be achieved in a newly constructed plant by segregating the fluoride-containing process wastewater (estimated to be 20 percent of the total volume discharged), treating with lime to precipitate the fluoride, recombining supernatant with other process wastewater and further settling with the aid of flocculants, if necessary, to reduce suspended solids before discharge of effluent.

The difference in utilizing the above technology in a newly constructed plant over the technology recommended as BATEA is estimated to be less than one percent of the estimated total construction cost.

3.4 Talc Group (Heavy Media and Flotation Process)

Same as BATEA

3.5 Garnet

Same as BATEA

3.6 Graphite

Same as BATEA

4.0 PRETREATMENT STANDARDS

Recommended pretreatment guidelines for discharge of plant wastewater into public treatment works conform in general with EPA Pretreatment Standards for Municipal Sewer Works as published in the July 19, 1973 Federal Register and "Title 40 - Protection of the Environment, Chapter 1 - Environmental Protection Agency, Subchapter D - Water Programs - Part 128 - Pretreatment Standards" a subsequent EPA publication. The following definitions conform to these publications:

a. Compatible Pollutant

The term "compatible pollutant" means biochemical oxygen demand, suspended solids, pH and fecal coliform bacteria, plus additional pollutants identified in the NPDES permit if the publicly owned treatment works was designed to treat such pollutants, and, in fact, does remove such pollutants to a substantial degree. Examples of such additional pollutants may include:

chemical oxygen demand
total organic carbon
phosphorus and phosphorus compounds
nitrogen and nitrogen compounds
fats, oils, and greases of animal or vegetable origin except as defined below in 4.1 Prohibited Wastes.

b. Incompatible Pollutant

The term "incompatible pollutant" means any pollutant which is not a compatible pollutant as defined above.

c. Joint Treatment Works

Publicly owned treatment works for both non-industrial and industrial wastewater.

d. Major Contributing Industry

A major contributing industry is an industrial user of the publicly owned treatment works that: has a flow of 50,000 gallons or more per average work day; has a flow greater than five percent of the flow carried by the municipal system receiving the waste; has in its waste, a toxic pollutant in toxic amounts as defined in standards issued under Section 307(a) of the Act; or is found by the permit issuance authority, in connection with the issuance of an NPDES permit to the publicly owned treatment works receiving the waste, to have significant impact, either singly or in combination with other contributing industries, on that treatment works or upon the quality of effluent from that treatment works.

e. Pretreatment

Treatment of wastewaters from sources before introduction into the joint treatment works.

4.1 Prohibited Wastes

No waste introduced into a publicly owned treatment works shall interfere with the operation or performance of the works. Specifically, the following wastes shall not be introduced into the publicly owned treatment works:

a. Wastes which create a fire or explosion hazard in the publicly owned treatment works;

b. Wastes which will cause corrosive structural damage to treatment works, but in no case wastes with a pH lower than 5.0, unless the works are designed to accommodate such wastes;

c. Solid or viscous wastes in amounts which would cause obstruction to the flow in sewers, or other interference with the proper operation of the publicly owned treatment works, and

d. Wastes at a flow rate and/or pollutant discharge rate which is excessive over relatively short time periods so that there is a treatment process upset and subsequent loss of treatment efficiency.

4.2 Pretreatment for Incompatible Pollutants

In addition to the above, the pretreatment standard for incompatible pollutants introduced into a publicly owned treatment works by a major contributing industry shall be best practicable control technology currently available; provided that, if the publicly owned treatment works which receives the pollutants is committed, in its NPDES permit, to remove a specified percentage of any incompatible pollutant, the pretreatment standard applicable to users of such treatment works shall be correspondingly reduced for that pollutant; and provided further that the definition of best practicable control technology currently available for industry categories may be segmented for application to pretreatment if the Administrator determines that the definition for direct discharge to navigable waters is not appropriate for industrial users of joint treatment works.

4.3 Recommended Pretreatment Guidelines

In accordance with the preceding Pretreatment Standards for Municipal Sewer Works, the following are recommended for Pretreatment Guidelines for the wastewater effluents:

a. No pretreatment required for removal of compatible pollutants - biochemical oxygen demand, suspended solids (unless hazardous) pH and fecal coliform bacteria;

b. Suspended solids containing hazardous pollutants such as heavy metals, cyanides and chromates should conform to be restricted to those quantities recommended in Section IX Guidelines for Best Practical Treatment and Control Currently Achievable;

c. Pollutants such as chemical oxygen demand, total organic carbon, phosphorus and phosphorus compounds, nitrogen and nitrogen compounds and fats, oils and greases need not be removed provided the publicly owned treatment works was designed to treat such pollutants and will accept them. Otherwise levels should be at or below BPCTCA Guideline Recommendations;

d. Innocuous dissolved solids such as sodium chloride, sodium sulfate, calcium chloride and calcium sulfate should be permitted provided that the industrial plant is not a "major contributing industry".

e. Plants covered under the "major contributing industry" definition should not be permitted to discharge large quantities of dissolved solids into a public sewer even though they might be at the BPCTCA Guideline Recommendations of this report. Each of these cases would have to be considered individually by the sewer authorities, and,

f. Discharge of all other incompatible hazardous or toxic pollutants from the mining and processing plants of this study to municipal sewers should conform to BPCTCA guidelines levels for discharge to surface water.

SECTION XII

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Louisiana Fish and Wildlife Commission
Louisiana Water Pollution Control Board
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National Crushed Stone Association
National Industrial Sand Association
National Limestone Institute
National Sand and Gravel Association
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SECTION XIII

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SECTION XIV

GLOSSARY

1.0 MINING TERMS

Aquifer - an underground stratum that yields water.

Bench - a ledge, which, in open pit mines and quarries, forms a single level of operation above which mineral or waste materials are excavated from a contiguous bank or bench face.

Berm - a horizontal shelf built for the purpose of strengthening and increasing the stability of a slope or to catch or arrest slope slough material; berm is sometimes used as a synonym for bench.

Blunge - to mix thoroughly.

Burden - valueless material overlying the ore.

Dragline - a type of excavating equipment which employs a rope-hung bucket to dig up and collect the material.

Dredge, bucket - a two-pontooned dredge from which are suspended buckets which excavate material at the bottom of the pond and deposit it in concentrating devices on the dredge decks.

Dredge, suction - a centrifugal pump mounted on a barge.

Drill, churn - a drilling rig utilizing a blunt-edged chisel bit suspended from a cable for putting down vertical holes in exploration and quarry blasting.

Drill, diamond - a drilling machine with a rotating, hollow, diamond-studded bit that cuts a circular channel around a core which when recovered provides a columnar sample of the rock penetrated.

Drill, rotary - various types of drill machines that rotate a rigid, tubular string of rods to which is attached a bit for cutting rock to produce boreholes.

Hydraulic Mining - mining by washing sand and dirt away with water which leaves the desired mineral.

Jumbo - a drill carriage on which several drills are mounted.

Outcrop - the part of a rock formation that appears at the surface of the ground or deposits that are so near to the surface as to be found easily by digging.

Overburden - material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials, ores, etc.

Permeability - capacity for transmitting a fluid.

Raise - an inclined opening driven upward from a level to connect with the level above or to explore the ground for a limited distance above one level.

Reserve - known ore bodies that may be worked at some future time.

Ripper - a tractor accessory used to loosen compacted soils and soft rocks for scraper loading.

Room and Pillar - a system of mining in which the distinguishing feature is the winning of 50 percent or more of the ore in the first working. The ore is mined in rooms separated by narrow ribs (pillars); the ore in the pillars is won by subsequent working in which the roof is caved in successive blocks.

Scraper - a tractor-driven surface vehicle the bottom of which is fitted with a cutting blade which when lowered is dragged through the soil.

Shuttle-car - a vehicle which transports raw materials from loading machines in trackless areas of a mine to the main transportation system.

Skip - a guided steel hoppit used in vertical or inclined shafts for hoisting mineral.

Stacker - a conveyor adapted to piling or stacking bulk materials or objects.

Stope - an excavation from which ore has been excavated in a series of steps.

Stripping ratio - the unit amount of spoil that must be removed to gain access to a similar unit amount of ore or mineral material.

Sump - any excavation in a mine for the collection of water for pumping.

Waste - the barren rock in a mine or the part of the ore deposit that is too low in grade to be of economic value at the time.

2.0 MINERAL PROCESSING TERMS

Aeration - the introduction of air into the pulp in a flotation cell in order to form air bubbles.

Baghouse - chamber in which exit gases are filtered through membranes (bags) which arrest solids.

Cell, cleaner - secondary cells for the retreatment of the concentrate from primary cells.

Cell, rougher - flotation cells in which the bulk of the gangue is removed from the ore.

Clarifier - a centrifuge, settling tank, or other device, for separating suspended solid matter from a liquid.

Classifier, air - an appliance for approximately sizing crushed minerals or ores employing currents of air.

Classifier, rake - a mechanical classifier utilizing reciprocal rakes on an inclined plane to separate coarse from fine material contained in a water pulp.

Classifier, spiral - a classifier for separating fine-size solids from coarser solids in a wet pulp consisting of an interrupted-flight screw conveyor, operating in an inclined trough.

Collector - a heteropolar compound chosen for its ability to adsorb selectively in froth flotation and render the adsorbing surface relatively hydrophobic.

Conditioner - an apparatus in which the surfaces of the mineral species present in a pulp are treated with appropriate chemicals to influence their reaction during aeration.

Crusher, cone - a machine for reducing the size of materials by means of a truncated cone revolving on its vertical axis within an outer chamber, the anular space between the outer chamber and cone being tapered.

Crusher, gyratory - a primary crusher consisting of a vertical spindle, the foot of which is mounted in an eccentric bearing within a conical shell. The top carries a conical crushing head revolving eccentrically in a conical maw.

Crusher, jaw - a primary crusher designed to reduce the size of materials by impact or crushing between a fixed plate and an oscillating plate or between two oscillating plates, forming a tapered jaw.

Crusher, roll - a reduction crusher consisting of a heavy frame on which two rolls are mounted; the rolls are driven so that they rotate toward one another. Rock is fed in from above and nipped between the moving rolls, crushed, and discharged below.

Depressant - a chemical which causes substances to sink through a froth, in froth flotation.

Dispersant - a substance (as a polyphosphate) for promoting the formation and stabilization of a dispersion of one substance in another.

Dryer, flash - an appliance in which the moist material is fed into a column of upward-flowing hot gases with moisture removal being virtually instantaneous.

Dryer, fluidized bed - a cool dryer which depends on a mass of particles being fluidized by passing a stream of hot air through it. As a result of the fluidization, intense turbulence is created in the mass including a rapid drying action.

Dryer, rotary - a dryer in the shape of an inclined rotating tube used to dry loose material as it rolls through.

Electrostatic separator - a vessel fitted with positively and negatively charged conductors used for extracting dust from flue gas or for separating mineral dust from gangues.

Filter, pressure - a machine utilizing pressure to increase the removal rate of solids from tailings.

Filter, vacuum - a filter in which the air beneath the filtering material is exhausted to hasten the process.

Flocculant - an agent that induces or promotes gathering of suspended particles into aggregations.

Flotation - the method of mineral separation in which a froth created in water by a variety of reagents floats some finely crushed minerals, whereas other minerals sink.

Frother - substances used in flotation to make air bubbles sufficiently permanent, principally by reducing surface tension.

Grizzly - a device for the coarse screening or scalping of bulk materials.

Hydrocyclone - a cyclone separator in which a spray of water is used.

Hydroclassifier - a machine which uses an upward current of water to remove fine particles from coarser material.

Humphrey spiral - a concentrating device which exploits differential densities of mixed sands by a combination of sluicing and centrifugal action. The ore pulp gravitates down through a stationary spiral trough with five turns. Heavy particles stay on the inside and the lightest ones climb to the outside.

Kiln, rotary - a kiln in the form of a long cylinder, usually inclined, and slowly rotated about its axis; the kiln is fired by a burner set axially at its lower end.

Kiln, tunnel - a long tunnel-shaped furnace through which ware is generally moved on cars, passing progressively through zones in which the temperature is maintained for preheating, firing and cooling.

Launder - a chute or trough for conveying powdered ore, or for carrying water to or from the crushing apparatus.

Log washer - a slightly slanting trough in which revolves a thick shaft or log, carring blades obliquely set to the axis. Ore is fed in at the lower end, water at the upper. The blades slowly convey the lumps of ore upward against the current, while any adhering clay is gradually disintegrated and floated out the lower end.

Magnetic separator - a device used to separate magnetic from less magnetic or nonmagnetic materials.

Mill, ball - a rotating horizontal cylinder in which non-metallic materials are ground using various types of grinding media such as quartz pebbles, porcelain balls, etc.

Mill, buhr - a stone disk mill, with an upper horizontal disk rotating above a fixed lower one.

Mill, chaser - a cylindrical steel tank lined with wooden rollers revolving 15-30 times a minute.

Mill, hammer - an impact mill consisting of a rotor, fitted with movable hammers, that is revolved rapidly in a vertical plane within a closely fitting steel casing.

Mill, pebble - horizontally mounted cylindrical mill, charged with flints or selected lumps of ore or rock.

Mill, rod - a mill for fine grinding, somewhat similar to a ball mill, but employing long steel rods instead of balls to effect the grinding.

Mill, roller - a fine grinding mill having vertical rollers running in a circular enclosure with a stone or iron base.

Neutralization - making neutral or inert, as by the addition of an alkali or an acid solution.

Scrubber, dust - special apparatus used to remove dust from air by washing.

Scrubber, ore - device in which coarse and sticky ore is washed free of adherent material, or mildly disintegrated.

Sink-float - processes that separate particles of different sizes or composition on the basis of specific gravity.

Slimes - extremely fine particles derived from ore, associated rock, clay or altered rock.

Sluice - to cause water to flow at high velocities for wastage, for purposes of excavation, ejecting debris, etc.

Slurry - pulp not thick enough to consolidate as a sludge but sufficiently dewatered to flow viscously.

Table, air - a vibrating, porous table using air currents to effect gravity concentration of sands.

Table, wet - a concentration process whereby a separation of minerals is effected by flowing a pulp across a riffled plane surface inclined slightly from the horizontal, differentially shaken in the direction of the long axis and washed with an even flow of water at right angles to the direction of motion.

Thickener - an apparatus for reducing the proportion of water in a pulp.

Weir - an obstruction placed across a stream for the purpose of channeling the water through a notch or an opening in the weir itself.

Wire saw - a saw consisting of one- and three-strand wire cables, running over pulleys as a belt. When fed by a slurry of sand and water and held against rock by tension, it cuts a narrow channel by abrasion.

TABLE XIV-1

METRIC UNITS

CONVERSION TABLE

Multiply (English Units) by To obtain (Metric units)

ENGLISH UNIT	ABBREVIATION	CONVERSION	ABBREVIATION	METRIC UNIT
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/ pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	F°	0.555 (°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	killowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3,785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig +1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	t	0.907	kkg	metric tons (1000 kilograms)
yard	y	0.9144	m	meters