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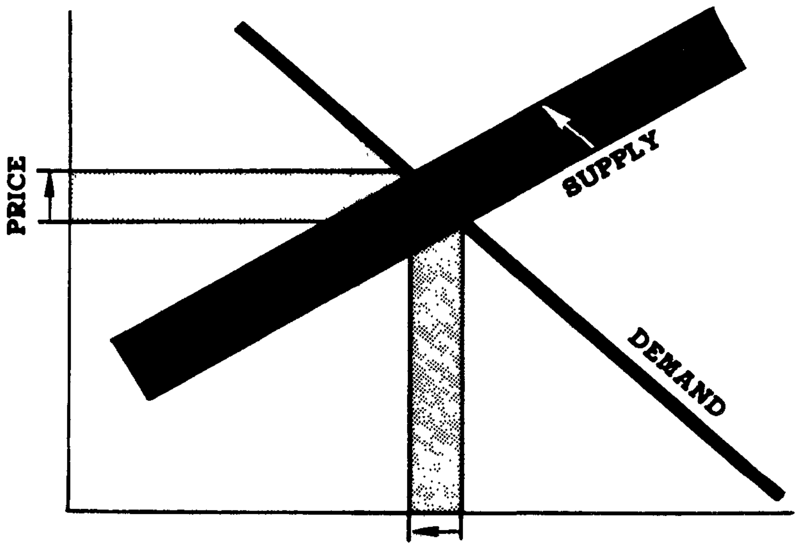
ECONOMIC ANALYSIS OF INTERIM FINAL AND PROPOSED EFFLUENT GUIDELINES

MINERAL MINING AND PROCESSING INDUSTRY

SAND AND GRAVEL
CRUSHED STONE

INDUSTRIAL SAND
PHOSPHATE ROCK



U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Planning and Evaluation
Washington, D.C. 20460

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ECONOMIC IMPACT
OF
INTERIM FINAL AND PROPOSED EFFLUENT GUIDELINES

MINERAL MINING
AND PROCESSING INDUSTRY

Construction Sand and Gravel
Crushed Stone
Industrial Sand
Phosphate Rock

U.S. Environmental Protection Agency
Office of Planning and Evaluation
Washington, D.C. 20460

PREFACE

The attached document is a contractor's study prepared with the supervision and review of the Office of Planning and Evaluation of the U.S. Environmental Protection Agency (EPA). Its purpose is to provide a basis for evaluating the potential economic impact of effluent limitations, guidelines and standards of performance established by EPA pursuant to section 304(b) and 306 of the Federal Water Pollution Control Act.

The study supplements an EPA technical Development Document issued in conjunction with the promulgation of guidelines and standards for point sources within this industry category. The Development Document surveys existing and potential waste treatment and control methods and technologies within this category and presents the investment and operating costs associated with various control technologies. This study supplements that analysis by estimating the broader economic effects (including product price increases, continued viability of affected plants, employment, industry growth and foreign trade) of the required application of certain of these control technologies.

The study has been prepared with the supervision and review of the Office of Planning and Evaluation of EPA. This report was submitted in fulfillment of Contract No. 68-01-1541, Task Order No. 24 by Arthur D. Little, Inc. Work was completed as of July, 1976.

This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of proposed rule making under sections 304(b) and 306 of the Act for the subject point source category.

This report represents the conclusions of the contractor. It has been reviewed by the Office of Planning and Evaluation and approved for publication. Approval does not signify that the contents necessarily reflect the views of the Environmental Protection Agency. The study has been considered, together with the Development Document, information received in the form of public comments on the proposed regulation, and other materials in the establishment of final effluent limitations, guidelines and standards of performance.

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I. SUMMARY

A. PURPOSE AND SCOPE

The purpose of this study was to assess the economic impact of meeting the United States Environmental Protection Agency regulations for pollution abatement applicable to the discharge of water streams from point sources of the mineral mining and processing industry.
The specific industry categories included in this report are:

- SIC 1422 - Crushed and Broken Limestone
- SIC 1423 - Crushed and Broken Granite
- SIC 1429 - Crushed and Broken Stone, not elsewhere classified

- SIC 1442 - Construction Sand and Gravel

- SIC 1446 - Industrial Sand
- SIC 1475 - Phosphate Rock

Compliance with water pollution standards may require the industry to install new physical facilities in its present operations, modify its current technical operations, or incorporate specialized facilities in new installations. Furthermore, the industry may have to install equipment and facilities capable of the following three levels of effluent water treatment:

- Level I - by 1977, for current industry installations, the best practicable control technology currently available (BPCTCA) will be used to control the pollutant content in the streams discharged by the industry;

- Level II - by 1983, for current industry installations, the best available technology that is economically achievable (BATEA) will be similarly used; and

- Level III - new source performance standards (NSPS) for new industry installations discharging directly into navigable waters (constructed after the promulgation of applicable guidelines for water pollution abatement) will incorporate facilities that will be capable of meeting the guidelines.

B. APPROACH

The increased costs of operation caused by the imposition of effluent guidelines will generate an internal conflict within companies. Depending on various factors, a firm can increase prices, thereby passing on cost increases to consumers; or a firm may absorb increased costs and suffer a reduction in net revenue. The latter step may force a plant to cease operations.

Another cost component will be the amount of capital required for effluent control procedures. A plant may be able to protect net revenues, but then face such difficulties in raising the capital required, that the investment cannot be funded. In general, the question of capital constraints is more likely to impact those plants that cannot pass on increased costs but must remain marginally profitable. Should owners require a substantial capital investment to remain in operation for reduced net revenues, they may decide to cease operation.

The analysis of internal conflicts provides a means of estimating conditions in the industry that may lead to plant closures. The aggregate of possible plant closures then provides an estimate of total economic impact on the industry, and from that the secondary impact of lost employment and incomes in affected communities can be evaluated.

Each of the industries considered consist of many plants with a wide range of characteristics. The analysis must account for the different characteristics that exist in each industry, as such differences pertain to the economic impact of effluent controls. The plants of each industry have been placed into various segments and the impact of the effluent control guidelines on each segment is analyzed. The basic criterion for forming an industry segment is that the individual segments exhibit differing response to the guidelines. The actual segmentation is specific for each industry, but in general is developed on the following lines:

* Plant cost structure - a single industry may have very different cost structures on the basis of plant size, product type, or other factors;

* Type of product - demand, particularly the price elasticity of demand, for those products is different than for other segments;

* Nature of the market served - whether the plants sell to national, regional, or local markets has a direct bearing on the industry's competitive structure; and

* Differential effluent control costs

This structure provides a basic hierarchy of segmentation in each industry. The actual tesselation of the segmentation was developed to represent the internal impact of the guidelines on the industry.

The impact in each industry segment is analyzed by means of a model plant which describes the financial structure (revenues, normal operating costs, capital employed, net revenues, etc.) and the control costs required to meet the guideline standards. The model plants are used to estimate the impact for each segment. The following six levels of impact are analyzed:

1. Price Effects - the segment is analyzed in terms of competitive structure, price elasticity, availability of substitutes, etc., all of which will determine the ability of the plants in the segment to pass on the increased costs of operation;

2. Financial Effects - the expected shift in net revenues and capital requirements are analyzed to estimate the

number of plants in the segment which would be expected to close;

3. Production Effects - the impact of expected closures on production in the segment is analyzed;

4. Employment Effects - the employment impact of plant closures is assessed from the anticipated closures;

5. Community Effects - any expected employment or income loss because of plant closures is analyzed for its adverse impact on the region in which the closing plants are located; and

6. Balance of Trade Effects - a substantial shift in production or prices could hamper exports and/or encourage imports. Any such events would impact the nation's balance of trade. Most of the industries produce relatively low-value products that are not a significant part of the nation's foreign trade. Only phosphate rock has any potential impact on balance of trade.

   The application of a general analysis to the specific problems of those industries is not without limitations. This study has attempted to recognize the limitations and to make assumptions that would overstate adverse economic impact generated by the imposition of the effluent guidelines.

7. Industry Growth Effects - any expected change in the projected industry growth rate is assessed from the impact of expected closures, which incorporates the expected shift in net revenues, capital requirements, and prices.

One of the principal limitations of the analysis is that the natural-resource base industries' costs of operations and control will depend on the specific site for each plant. To a certain extent, each plant in the industry is a special case. The use of a model facility cannot take such specificity into account. Thus, the actual financial situation and control costs for any given plant may be different from the model used to represent it.

In many cases, information on the exact numbers of plants in each required analytical segment has not been available. Therefore, estimates were made as to the numbers of firms in each segment and those estimates are a significant factor in determining the expected economic impact.

All these limitations must be considered in light of the results. Very little adverse economic impact is anticipated; so small, in fact, that a doubling or tripling of impact would not make the national aggregate impact significant. However, each plant closure causes a significant adverse impact for its employees and potentially for the community that loses the jobs and incomes generated by the plant.

C. CONCLUSIONS

The economic impact of the interim final effluent guidelines has been assessed for the following segments of the nonmetallic mineral mining and processing industry:

- Construction sand and gravel,
- Crushed stone,
- Industrial sand, and
- Phosphate rock.

It is expected that a total investment of approximately $24 million will be required to install BPT in 1977, with an associated total annual cost of $10 million. No additional costs will be incurred in order to meet BAT. The total cost (in 1974 dollars) of meeting the effluent guidelines is shown below.

	BPT Investment	BPT Annual Costs
Sand and Gravel	7,460,000	2,283,000
Crushed Stone	12,420,000	6,548,000
Industrial Sand	644,000	169,000
Phosphate	3,340,000	1,056,000
Total	23,864,000	10,056,000

For the sand and gravel, crushed stone, and industrial sand segments, the BPT guidelines are based on a technology of settling and complete recycle of process water. For the phosphate segment, settling ponds with discharge is the basis for the BPT guidelines.

- Construction Sand and Gravel

Economic analysis of the sand and gravel industry indicated that the only technology which is economically viable is a settling pond with recycle. More extensive treatment which involves additional ponds or flocculation may be feasible for some plants, but is considered to be economically impractical in general. Therefore, the BPT limitations are based on a technology of settling and recycle. The price of sand and gravel may increase from $0.04 to $0.20 in small cities or rural areas. Up to 26 plants in major metropolitan areas which have to absorb control costs may close. These plants represent a total of 0.3% of present national production number plants--a very small proportion of the 5,150 operations in the industry. The closures could result in the loss of work for up to 86 persons, but are not expected to affect local economies.

- Crushed Stone

Overall production of the crushed stone industry will not be affected by the guidelines. Several hundred plants which presently have no treatment and which are unable to pass control costs on are likely to shift from production of both dry processed and wet processed stone to entirely dry processing. Depending on the local market characteristics, the price for crushed stone could remain stable or increase up to 8%. No closures are expected to occur.

- Industrial Sand

The price of industrial sand will increase less than 1% over present levels of about $5 to $7. Because plants requiring mechanical thickening with no treatment at present could be seriously impacted, it has been determined that this option is economically infeasible and that settling with recycle is the only technology upon which the BPT guidelines are based. Therefore no closures are predicted, and local economies, unemployment, industry growth and the balance of trade will not be significantly affected.

- Phosphate Rock

The impact of the regulations on phosphate mining and processing are not expected to be significant. Prices may increase about $0.11 per ton, or less than 1% over mid-1974 levels of $12.10 per ton. No plants are expected to close, and effects on the balance of trade will be minimal.

1. Construction sand and gravel

a. Internal Costs

There are approximately 5,150 facilities in the sand and gravel industry. Of these, about 750 are dry processors and have no effluent discharge, and the remaining 4,400 use water in the processing. It is estimated that 1,088 plants with wet processing are not presently meeting the BPT requirement of total recycle of process water.

Some 978 facilities already have some treatment in place. These plants will incur additional annual costs of less than 0.5% over present annual expenditures, or less than $0.01 per ton. The incremental investment required to meet BPT will be less than 3% of the book value of assets.

For the 110 plants with no treatment in place, the annual effluent control costs could increase current expenditures by as much as 10.7%. The required investment to meet BPT will be high: 18% to 34% of the book value of assets. Although there are several treatment options available, only settling and recycle of process water (Level C) appears economically viable.

b. External Costs

(1) Price Effects. Because construction sand and gravel are sold in very localized markets, the effects of the effluent guidelines on prices will vary throughout the country. Prices could increase about $0.04 (2.5%) in large markets, where larger plants require additional expenditures to meet BPT. In small metropolitan or rural markets, where plants need to install effluent controls, prices could increase up to 10%.

(2) Production Effects. It is expected that the 978 plants with some treatment in place will not close or reduce production significantly. If they were unable to pass costs on, the profitability of the operation would not decline significantly. (In the case of the model 91,000 metric ton plant, profit on sales before taxes would fall from 8.9% to 8.6%.) These plants are not expected to have any difficulty financing the required investment.

Some of the remaining 110 facilities with no treatment in place could close. In particular, small plants which are in large metropolitan markets will probably be unable to pass control costs on. Three treatment options were examined: "Level C" is a settling pond with recycle of process water; "Level D" is two silt-removal ponds, a settling pond, and recycle; and "Level G" involves flocculation, settling, and recycle. The economic analysis indicated that if a plant needed to install Level D or G treatments, and was unable to pass the costs on, they could not continue operations due to a negative cash flow. However, if the Level C technology was installed, the cash flow would remain positive although profitability would fall by one-third from present levels. Due to the serious economic impacts predicted for plants requiring technologies D and G, the effluent guideline is based on Level C technology. Because of these factors--the uncertainty of whether or not plants will be able to finance the needed investment, even assuming use of a Level C treatment--it is estimated that up to 26 plants may close. At most, these plants represent 0.3% of present national production.

(3) <u>Employment Effects</u>. It is estimated that closure of up to 26 facilities could result in the unemployment of, at most, 86 people. Plant closures will occur in large metropolitan areas and 3 to 4 persons will be displaced per plant closure.

(4) <u>Community Effects</u>. Because it is predicted that most closures will occur in large metropolitan areas, and will be spread through the country, it is not expected that these guidelines will have a significant effect on local economies.

(5) <u>Industry Growth Effects</u>. It is not anticipated that industry growth will be significantly affected by these guidelines. Sand and gravel facilities will tend to incorporate the land required for settling ponds into future siting specifications.

(6) <u>Balance of Trade Effects</u>. Sand and gravel is not exported or imported, so the guidelines will have no effect on the balance of trade.

2. Crushed Stone

a. Internal Costs

There are approximately 4,808 crushed stone facilities, of which 3,200 have completely dry processing and thus have no effluent. About 502 of the 1,608 wet processors are already in compliance with the BPT requirements. The remaining 1,106 non-compliers will be discussed here.

The highest costs will be incurred by the 336 facilities that have no treatment in place at present. The annual costs of operation could increase from 7.3% to 8.3% over present annual costs of about $2.00 per metric ton. An investment of $12,000 to $26,200 would be required, which represents about 9% to 14% of the book value of assets. The 770 operations with some treatment in place would have to increase annual expenditures by about 1%, and would require an investment of about $2,900 to $15,200. The six flotation plants that presently discharge would incur additional costs 0.7% higher than current levels.

b. External Costs

(1) Price Effects. With the exception of flotation processed stone, the effect of the guidelines on crushed stone prices will vary throughout the country, because of the very localized nature of the market for stone. Prices are most likely to be affected in small metropolitan or rural markets where there are crushed stone plants requiring either additional or complete effluent controls. A price increase of as much as 8% could occur in these situations. Prices are not likely to increase in large metropolitan markets. The six flotation processors will probably be able to pass the effluent control costs on, and this is expected to increase the selling price of $22.50 per metric ton by about 0.5%.

(2) Production Effects. It is not expected that the regulations will significantly affect the overall production of crushed stone. Plants that will be unable to pass price increases on will have a lower profitability and may shift production to dry processed stone. In this category, those operations with some treatment in place will have a small drop in profitability. For example, the model 91,000 metric ton, wet process plant's profit on sales before taxes would fall from 7.5% to 7.0%. Although many of these plants produce both wet process and dry process stone, they probably will not shift from their current mix of production. However, those crushed stone plants with no treatment in place, which are unable to pass control costs on, will probably shift all of their production to dry process. The profitability of flotation processors will not decline, because it is expected that they will be able to pass control costs on. For those plants which add effluent treatment, there should be no difficulty in financing the required expenditures. Therefore, no closures are predicted.

(3) Employment Effects. Because no closures are predicted, the guidelines will not have an effect on employment.

(4) Community Effects. Because no closures are predicted, the guidelines will not have a detrimental effect on local economies.

(5) Industry Growth Effects. It is not anticipated that industry growth will be significantly affected by the guidelines. Crushed stone processors will tend to incorporate the land required for settling ponds into future siting specifications.

(6) Balance of Trade Effects. Crushed stone is not generally exported or imported, so the guidelines will have not effect on the balance of trade.

3. Industrial Sand

a. Internal Costs

Of the 168 industrial sand facilities, 128 are judged to be in compliance with the interim final guidelines. The remaining 40 plants would have additional annual costs to meet BPT of 0.4% to 5.1% over present annual expenditures. The highest relative costs will be incurred by wet processors, with no treatment in place, who are expected to need mechanical thickening. The incremental investment represents between 0.6% and 2.6% of present investment in plant and equipment.

b. External Costs

(1) Price Effects. It is expected that most industrial sand producers will be able to pass the incremental control costs on to consumers befause of the price inelasticity of demand for their products. Therefore, the price of low cost sands would increase by only about 0.8%

from present levels of about $5.00 per ton, and the price of more expensive sands will increase by a lesser percentage.

(2) Production Effects. Those industrial sand producers with some treatment are expected to be able to pass control costs on without suffering a decline in revenues, so there will be no change in their financial strength. Capital requirements to fund effluent control equipment are fairly modest, and probably can be financed through retained earnings or as a part of regular borrowing. However, those who don't yet have treatment will probably only be able to pass on $0.04 of the $0.24 control costs to install Level C (mechanical thickening). Present profits on sales before taxes of about 8.0-8.5% could decline by half. Such plants would be likely candidates for closure. Therefore, because of the serious economic impacts predicted for plants requiring Level C treatment, the guideline is based on Level B technology. Hence, no closures are anticipated. Overall production levels should not fall because of the slight increase in prices for industrial sand, so no plant closures are predicted.

(3) Employment Effects. Because no closures are predicted, no changes in employment will occur.

(4) Community Effects. Because no closures are predicted, local economies will not be affected.

(5) Industry Growth Effects. Industry growth is not expected to be slowed by the effluent guidelines.

(6) Balance of Trade Effects. Because of the very minimal increase in the price of industrial sand, it is not expected that the balance of trade will be affected.

4. Phosphate Rock

a. Internal Costs

Of 26 existing phosphate operations, it is estimated that only four facilities in Florida are presently out of compliance. BPT investment costs for a model representing these facilities are $910,000 or about 4% of present investment in plant and equipment. Incremental annual costs to meet BPT are about $.11 per ton or an addition of about 1.5% to current annual expenditures. BAT limitations will not require additional expenses to be incurred or demand more investment.

b. External Costs

(1) Price Effects. These guidelines will have a minimal effect on phosphate prices. If the four non-complying plants are able to pass the effluent control costs on, prices would increase by about .9% from mid-1974 levels of $12.10 per ton. Present phosphate prices are higher, so the commensurate effect would be even less.

(2) Production Effects. No closures are expected to result from the imposition of the interim final guidelines. Even if the facilities were unable to pass costs on, profits after taxes would fall from 12.1% to 11.6%. No financing difficulties are anticipated.

(3) Employment Effects. Employment levels will not change since no closures are predicted.

(4) Community Effects. Local economies will not be affected since no closures are predicted.

(5) Industry Growth Effects. Effluent guidelines are not expected to affect the growth of the phosphate industry significantly.

(6) Balance of Trade Effects. Because effluent treatment costs are expected to cause an increase in prices of less than 1%, it is not anticipated that present export quantities will be reduced.

II. CONSTRUCTION SAND AND GRAVEL (SIC-1442)

A. PRODUCTS, MARKETS AND SHIPMENTS

1. Product Definition

Sand and gravel are predominantly silica, with other minerals such as iron oxide, mica, and feldspar usually present in varying amounts, either as impurities or as useful constituents.* Sand and gravel are products of the weathering of rocks. Sand has a size range of 0.0625 to 2 millimeters and consists primarily of silica. The term "sand" can also be used to describe fine particles of rocks, minerals, slag, and other materials in addition to silica. The size range for gravel is from 4 millimeters to less than 64 millimeters in diameter. Although gravel is primarily silica, other rock constituents are also present. Although these descriptive terms and size ranges are rather arbitrary, some standards have been established. For most sand and gravel applications there are specifications for size, physical characteristics, and chemical composition. Specifically, for construction uses, the specifications depend on the type of construction (concrete or bituminous roads, dams, or buildings), geographic area, architectural standards, climate, and the type and quality of sand and gravel available.

2. Production Processes

Sand and gravel are recovered from both wet and dry land-based pit operations and the dredging of rivers, bays or oceans.

The mining equipment used varies from small, simple units such as tractor-mounted high-loaders and dump trucks to sophisticated mining

*This discussion on product and processing is adapted from Mineral Facts and Problems, 1970, Bureau of Mines.

systems involving large power shovels, draglines, bucket-wheel excavators, belt conveyors and other components. Increasingly, mining systems are being designed to provide for efficient and economical land rehabilitation. Sand and gravel is also dredged from river and lake bottoms that are rich in such deposits.

Processing may consist of simple washing to remove clay and silt and screening to produce two or more products, or it may involve more complex heavy-media separation of slate and other lightweight impurities, and complex screening and crushing equipment designed to produce the optimum mix of salable sand and gravel sizes. Conveyor belts, bucket elevators, and other transfer equipment are used extensively. Ball processing is often required for production of small-size fractions of sand. Permanent installations are built when large deposits are to be operated for many years. Semi-portable units are used in many pits that have an intermediate working life. Several such units can be tied together to obtain large initial production capacity or to add capacity as needed. In areas where large deposits are not available, use is made of mobile screening facilities that can be quickly moved from one deposit to another without undue interruption or loss of production.

Major technologic developments have helped the sand and gravel industry to maintain adequate production at stable or slightly declining real costs. The industry has adopted larger operating units, more efficient portable and semi-portable plants, unitized plants for versatility of plant capacity, new prospecting methods utilizing aerial and geophysical surveying methods, and greatly increased rehabilitation and resale of mined areas for recreational or land-use applications where economically advantageous.

3. Shipments

Domestic shipments of construction sand and gravel, as reported by the Bureau of Mines showed little change from 1965 to 1974

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3. <u>Shipments</u>

Domestic shipments of construction sand and gravel, as reported by the Bureau of Mines showed little change from 1965 to 1974

(Table II-1). Shipments have fluctuated from a low of 871 million short tons (793 million metric tons) in 1972 to a high of 950 million short tons (865 million metric tons) in 1974. (Industrial sand is reported concurrently by the Bureau of Mines, but this analysis focuses on construction sand and gravel. There were 118 operations in 1974, producing industrial sand and 101 producing both industrial sand and construction sand and gravel.)

Caused mainly by price inflation, this essentially flat pattern of shipments is not reflected in the value of construction sand and gravel sold, which increased at an annual rate of 4.7% from $871 million in 1965 to $1.31 billion in 1974. The value of shipments is expected to have remained about the same for 1975, but output in that year probably dropped to a low for the past decade. The sharp drop in 1975 reflected the recessionary impact on the construction industry. In fact, a closer examination of the data for 1974 indicates that the increased production in Alaska--up 93 million metric tons from 1973 to 106 million metric tons--more than accounted for the total increase of 15 million metric tons for the United States and made that state the most productive in the nation. Excluding Alaska, U.S. production declined from 835 million metric tons in 1973 to 757 million metric tons in 1974. Foreign trade in construction sand and gravel is negligible and primarily limited by transportation costs.

As a later table shows, all states share in the national production of construction sand and gravel. Apart from the short-term phenomenon caused by the Trans-Alaska Pipeline, California is generally the most productive state, with nearly twice the production of its closest rival, Michigan. Other states that are important producers include Ohio, Wisconsin, Illinois and Texas.

Table II-1 CONSTRUCTION SAND & GRAVEL SOLD, 1965 - 1974

	Short Tons	$
1965	877.7	870.8
1966	903.2	891.6
1967	874.5	887.5
1968	885.3	919.6
1969	902.0	958.2
1970	906.1	1003.0
1971	883.3	1044.9
1972	871.3	1070.6
1973	933.1	1222.4
1974	949.7	1312.3

Source: U.S. Department of Interior/Bureau of Mines, "Mineral Industry Surveys" Sand and Gravel

4. End Uses

U.S. end uses and volume distribution of sand and gravel as construction aggregates are summarized in Table II-2 and, for each state, in Table II-3. Commercial projects accounted for 76% of total weight sold--864.2 million metric tons in 1974. It is apparent from Table II-2 that the principal single use for sand and gravel is as a concrete aggregate and that the non-residential and residential building construction sectors together account for 24% of all aggregate sold. Other end uses for concrete aggregate include highway and bridge construction, concrete products such as block and pipe, and bituminous paving. About 24% of all sand and gravel is unprocessed and is used either as a fill or for road bases and subbases. In 1974, the average value for processed sand and gravel was $1.78 per metric ton, while the unprocessed material averaged only $0.58 per metric ton. The average value of sand and gravel for publicly funded projects was higher--at $1.56 per metric ton--than that for commercial projects at $1.46 per metric ton.

5. Possibilities of Substitution

The sand and gravel industry has found that changes in zoning and environmental issues have limited its opportunities to participate in the growth of the construction industry and has made it vulnerable to substitution. Historically, sand and gravel operations have been located close to urban or developing areas, partly because of suitable geological conditions existing in the localities, but also because of the low-value-added characteristics of the product and the high weight-to-total-value ratio. As the communities served by these operations have grown, pit operators have found themselves increasingly limited by zoning regulations and by the unavailability of contiguous deposits to be developed once existing deposits are depleted. In many highly urbanized areas, this has led to the gradual movement of sand and gravel sources away from the urban

Table II-2 CONSTRUCTION AGGREGATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES FOR COMMERCIAL OR PUBLICLY FUNDED CONSTRUCTION PROJECTS, OR PRODUCTS (10^3 SHORT TONS AND 10^3 DOLLARS)

	1973				1974 1/			
	Commercial		Publicly funded projects		Commercial		Publicly funded projects	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value 2/
Processed								
Concrete aggregate (including use in Ready Mixed Concrete)								
Nonresidential and residential construction					214,840	376,890	10,001	16,974
Highway and bridge construction					29,389	50,472	44,128	72,169
Other construction (dams, waterworks, airports, etc.)					13,242	23,646	6,373	10,834
---	689,702	982,723	110,389	129,409				
Concrete products (cement blocks, bricks, pipe, etc.)					68,259	125,002	3,504	6,465
Bituminous paving (asphalt and tar paving)					81,053	129,487	62,708	101,897
Road base and sub-base					71,123	110,323	76,220	105,811
Fill 3/	82,106	61,440	15,521	9,243	26,008	32,277	5,283	6,133
Other 4/	46,023	60,330	10,914	6,158	11,647	19,408	3,240	4,695
Unprocessed								
Fill					99,601	58,006	10,065	7,223
Road base and sub-base					97,950	46,123	15,050	8,536
TOTAL 5/	817,831	1,104,493	136,824	144,811	713,112	971,635	236,572	340,737

1/ Data not directly comparable with those of previous years because of changes in canvass form.
2/ Unit value of construction aggregate may be higher than unit value of sand or gravel.
3/ Includes unprocessed sand and gravel (1973).
4/ Includes Railroad ballast, Miscellaneous, some unprocessed sand and gravel (1973).
5/ Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines "Mineral Industry Surveys" Sand and Gravel in 1974

TABLE II-3
CONSTRUCTION SAND AND GRAVEL USED IN THE UNITED STATES IN 1974, BY STATE AND BY USE 1/
(10^3 SHORT TONS AND 10^3 DOLLARS)

Concrete aggregate (including use in Ready Mixed Concrete)

State	Nonresidential and residential construction: Commercial Quantity	Commercial Value	Publicly funded projects Quantity	Publicly funded projects Value	Highway and bridge construction: Commercial Quantity	Commercial Value	Publicly funded projects Quantity	Publicly funded projects Value	Other construction (dams, waterworks, airports, etc.): Commercial Quantity	Commercial Value	Publicly funded projects Quantity	Publicly funded projects Value	Concrete products (cement blocks, bricks, pipe, etc.): Commercial Quantity	Commercial Value	Publicly funded projects Quantity	Publicly funded projects Value	Bituminous paving (asphalt and tar paving): Commercial Quantity	Commercial Value	Publicly funded projects Quantity	Publicly funded projects Value
Alabama	2,398	3,865	47	137	195	339	1,006	1,988	327	586	62	W	1,730	3,015	W	W	906	1,710	765	1,241
Alaska	168	569	W	W	49	138	2	6	50	139	226	1,116	108	291	-----	-----	130	259	5,494	9,113
Arizona	6,566	11,285	634	907	633	1,107	658	965	211	616	W	W	790	1,769	W	W	1,322	2,384	2,274	5,774
Arkansas	5,249	10,536	153	263	452	879	372	736	234	480	61	81	1,388	2,738	W	W	1,558	2,739	755	1,398
California	29,346	49,079	1,769	2,815	5,727	9,165	2,386	3,696	2,643	4,274	446	940	5,942	9,954	740	1,123	11,148	18,659	7,585	13,587
Colorado	4,625	9,346	645	872	287	612	1,023	1,552	193	371	127	212	688	1,159	W	W	1,406	3,139	2,006	3,079
Connecticut	1,378	2,977	85	232	150	229	43	83	203	403	W	W	1,015	1,853	31	68	719	1,566	221	568
Delaware	227	602	W	W	W	W	-----	-----	W	W	-----	-----	261	632	W	W	W	W	-----	-----
Florida	6,746	9,382	W	W	1,075	1,816	1,849	2,111	195	301	68	116	3,749	5,141	-----	-----	589	672	W	W
Georgia	2,394	3,322	23	29	272	396	2	W	105	180	-----	-----	1,284	1,818	17	26	108	491	-----	-----
Hawaii	353	884	-----	-----	14	17	-----	-----	14	17	-----	-----	17	25	-----	-----	W	W	-----	-----
Idaho	1,296	2,348	W	W	233	456	230	869	396	749	153	227	322	880	40	51	318	408	522	543
Illinois	10,357	14,166	68	91	2,348	3,482	1,893	3,136	548	788	136	192	2,875	5,505	74	113	5,332	8,770	1,493	2,287
Indiana	5,590	8,223	156	235	682	978	1,860	2,711	295	418	93	134	1,547	2,089	24	34	6,876	10,495	1,791	2,568
Iowa	3,187	5,237	63	76	896	1,677	1,686	3,167	170	318	15	29	863	1,510	52	99	3,606	4,300	1,734	1,934
Kansas	2,857	3,738	53	66	504	520	1,643	1,844	166	289	W	W	534	611	36	37	760	1,005	584	690
Kentucky	3,519	5,294	-----	-----	232	445	689	910	139	234	380	407	382	670	-----	-----	1,081	1,454	160	279
Louisiana	4,733	11,212	W	W	469	854	1,091	2,015	210	365	W	W	1,438	3,559	82	164	602	1,306	1,022	2,359
Maine	605	1,107	594	753	152	387	1,753	2,454	65	217	742	757	325	656	-----	-----	489	832	1,181	1,299
Maryland	5,002	13,335	175	964	228	637	1,150	3,039	163	405	W	W	1,862	4,650	W	W	642	1,312	864	2,436
Massachusetts	4,714	9,775	241	405	432	956	302	670	278	646	85	143	1,098	2,069	85	93	1,281	2,133	509	974
Michigan	11,675	18,569	116	102	893	1,259	2,986	3,503	731	987	282	293	3,243	5,457	123	160	3,328	4,681	4,190	5,489
Minnesota	6,112	9,631	301	514	1,396	2,095	959	1,405	355	569	21	39	2,835	4,453	W	W	3,787	3,706	3,772	3,995
Mississippi	2,376	3,554	34	87	684	1,092	710	1,213	80	132	75	148	1,505	2,433	79	153	845	1,405	1,376	1,954
Missouri	3,468	4,880	98	210	467	741	501	725	52	78	84	136	642	984	5	5	994	1,629	372	547
Montana	563	1,386	98	182	70	153	219	269	58	186	21	45	808	371	13	27	169	292	294	386
Nebraska	1,735	2,035	180	142	894	1,356	2,795	3,682	242	276	53	52	1,358	1,750	W	W	717	1,109	1,141	1,422
Nevada	1,958	3,677	55	146	65	103	259	547	30	60	W	W	88	147	-----	-----	829	1,186	778	1,511
New Hampshire	1,074	2,086	59	95	291	480	115	193	88	165	W	W	254	447	2	W	774	1,219	225	409
New Jersey	3,773	7,564	W	W	908	2,086	345	698	392	881	W	W	4,137	10,881	51	127	1,183	2,686	540	988
New Mexico	1,903	3,775	99	191	83	209	59	93	45	116	20	31	399	1,094	W	W	351	522	1,481	1,901
New York	10,135	17,960	517	980	1,246	2,442	915	1,729	475	975	349	416	2,205	4,268	255	446	2,222	4,503	857	1,642
North Carolina	3,335	5,647	51	66	288	596	249	376	181	339	3	5	1,945	2,984	W	W	1,033	1,950	327	530
North Dakota	848	2,227	W	W	89	144	17	32	56	106	W	W	72	212	-----	-----	509	446	493	585
Ohio	9,983	16,881	994	1,541	659	1,107	2,027	3,626	227	391	446	863	3,333	5,720	213	351	10,283	16,299	2,607	4,514
Oklahoma	3,298	4,714	85	87	350	584	432	595	179	268	195	356	429	526	-----	-----	289	423	26	43
Oregon	3,149	6,013	261	601	530	802	721	1,258	295	507	18	39	813	1,708	-----	-----	2,317	3,860	1,366	2,649
Pennsylvania	5,639	12,977	195	440	749	1,939	1,559	3,510	257	822	129	292	2,437	5,688	W	W	1,218	2,738	2,012	5,487
Rhode Island	344	516	-----	-----	37	97	W	W	19	45	-----	-----	422	627	-----	-----	497	1,075	226	359
South Carolina	4,617	7,535	W	W	126	139	-----	-----	40	40	-----	-----	466	587	-----	-----	198	171	W	26
South Dakota	737	1,193	2	W	406	652	691	1,000	71	101	-----	-----	362	628	14	31	332	462	981	341
Tennessee	1,850	3,503	184	289	426	946	302	535	311	648	W	W	2,029	3,971	W	W	609	969	283	286
Texas	17,348	34,044	401	670	975	2,008	4,340	8,385	669	1,215	229	432	3,113	5,528	66	88	2,482	4,817	2,589	4,906
Utah	2,262	2,743	31	37	204	307	437	724	148	211	22	31	817	1,071	32	44	1,161	1,576	651	826
Vermont	484	888	W	W	56	197	90	114	44	153	8	16	146	324	16	34	232	454	137	170
Virginia	3,902	8,374	962	1,886	865	1,623	622	1,713	100	232	W	W	1,755	4,555	547	1,326	520	984	159	281
Washington	5,265	8,366	185	323	399	732	321	707	645	896	194	473	1,305	2,505	114	168	1,682	2,837	1,669	2,905
West Virginia	761	1,499	W	W	W	W	W	W	W	W	-----	-----	W	W	-----	-----	W	W	W	W
Wisconsin	4,017	6,088	160	192	1,126	1,285	1,322	1,656	467	607	180	156	2,652	3,261	240	370	1,917	1,950	[illegible]	[illegible]
Wyoming	960	2,351	13	33	48	70	357	668	310	704	30	84	147	277	----		1,412	1,63	[illegible]	[illegible]
Concealments	-----	-----	172	773	91	258	1,255	1,925	65	197	1,481	2,572	1,045	2,127	553	1,130	[illegible]	[illegible]	1,457	2,440
TOTAL 2/	214,840	376,890	10,002	16,974	29,389	50,472	44,126	72,169	11,241	21,646	6,374	10,834	68,258	125,003	3,504	6,465	81,056	129,467	62,706	131,397

W Withheld to avoid disclosing individual company confidential data, included with "Concealments"
1/ Data not directly comparable with those of previous years because of changes in canvass form.
2/ Data may not add to totals shown because of independent rounding

Source: Bureau of Mines "Mineral Industry Surveys" *Sand and Gravel in 1974*

State	Road base and sub-base: Commercial Quantity	Road base and sub-base: Commercial Value	Road base and sub-base: Publicly funded projects Quantity	Road base and sub-base: Publicly funded projects Value	Fill: Commercial Quantity	Fill: Commercial Value	Fill: Publicly funded projects Quantity	Fill: Publicly funded projects Value	Other: Commercial Quantity	Other: Commercial Value	Other: Publicly funded projects Quantity	Other: Publicly funded projects Value	Unprocessed Sand and Gravel — Fill: Commercial Quantity	Unprocessed Sand and Gravel — Fill: Commercial Value	Unprocessed Sand and Gravel — Fill: Publicly funded projects Quantity	Unprocessed Sand and Gravel — Fill: Publicly funded projects Value	Unprocessed Sand and Gravel — Road base and sub-base: Commercial Quantity	Unprocessed Sand and Gravel — Road base and sub-base: Commercial Value	Unprocessed Sand and Gravel — Road base and sub-base: Publicly funded projects Quantity	Unprocessed Sand and Gravel — Road base and sub-base: Publicly funded projects Value
Alabama	937	1,118	318	496	49	62	-----	-----	784	1,674	W	W	400	448	491	127	528	419	928	320
Alaska	137	278	6,156	10,124	116	224	-----	-----	281	W	320	222	35,730	7,429	2,191	3,366	65,019	17,069	1,569	2,065
Arizona	3,246	4,535	2,830	5,969	817	1,530	194	266	114	309	W	W	849	1,236	132	49	304	241	W	W
Arkansas	378	576	519	930	264	285	169	144	73	102	-----	-----	381	199	217	103	416	329	1,724	815
California	8,150	12,993	10,988	19,700	4,970	6,525	718	923	724	1,292	123	211	3,612	2,904	1,844	1,033	3,394	4,874	749	235
Colorado	5,097	9,064	3,344	4,762	476	766	172	221	1,158	1,833	195	354	680	600	664	276	515	415	400	287
Connecticut	737	1,232	48	109	182	214	27	41	175	303	35	51	780	798	W	W	447	477	-----	-----
Delaware	W	W	-----	-----	W	W	-----	-----	-----	-----	-----	-----	359	564	-----	-----	W	W	-----	-----
Florida	755	1,227	1,289	2,180	1,236	1,101	W	W	-----	-----	-----	-----	4,161	2,961	-----	-----	943	975	W	W
Georgia	W	W	-----	-----	83	145	-----	-----	W	W	-----	-----	176	146	-----	-----	76	W	-----	-----
Hawaii	121	290	-----	-----	-----	-----	-----	-----	W	W	-----	-----	W	W	-----	-----	4	W	-----	-----
Idaho	603	734	831	851	396	291	105	190	420	731	2	5	295	228	158	67	662	607	376	130
Illinois	3,274	5,639	2,150	3,492	2,281	3,408	322	511	747	1,218	22	49	4,666	4,623	-----	-----	2,034	2,356	-----	-----
Indiana	1,210	1,656	1,136	1,528	989	1,056	165	192	580	550	64	99	2,532	1,677	76	37	182	160	W	W
Iowa	1,028	1,621	2,015	2,999	661	885	19	29	128	247	16	25	718	849	49	15	51	75	W	W
Kansas	567	613	632	623	1,019	855	70	71	153	185	55	62	243	180	108	71	319	139	824	427
Kentucky	1,530	2,232	71	123	98	173	-----	-----	174	272	-----	-----	225	173	-----	-----	W	W	-----	-----
Louisiana	391	1,069	678	965	77	167	W	W	130	317	-----	-----	287	250	9	3	737	1,190	-----	-----
Maine	168	313	805	757	217	145	739	377	54	128	180	90	500	270	------	-----	223	182	-----	-----
Maryland	306	486	327	666	129	196	W	W	W	W	-----	-----	142	147	5	1	424	754	40	12
Massachusetts	1,142	1,798	440	602	773	813	55	112	446	882	134	257	2,780	1,820	W	W	2,435	1,715	-----	-----
Michigan	8,322	12,489	9,632	9,663	870	1,023	379	362	402	688	92	108	3,639	1,850	1,256	431	1,445	1,091	1,317	431
Minnesota	3,200	3,615	5,891	5,372	1,211	1,438	108	141	415	420	313	343	2,708	1,449	784	238	1,270	559	911	290
Mississippi	2,986	4,299	818	1,294	12	24	W	W	235	295	-----	-----	76	58	-----	-----	1,771	927	758	267
Missouri	1,426	1,739	527	800	202	321	109	187	239	387	-----	-----	116	93	-----	-----	210	97	31	34
Montana	392	725	463	682	54	77	86	90	98	141	5	5	407	364	W	W	690	560	317	159
Nebraska	1,141	1,925	1,693	2,367	543	556	96	71	134	178	6	11	238	371	W	W	9	9	274	138
Nevada	835	1,204	1,441	1,941	286	307	105	312	40	60	-----	-----	341	306	10	13	113	46	303	87
New Hampshire	392	652	693	262	148	137	-----	-----	509	949	115	182	922	636	-----	-----	429	204	-----	-----
New Jersey	521	1,281	229	470	217	328	-----	-----	45	101	42	69	1,938	1,522	-----	-----	308	321	-----	-----
New Mexico	497	712	1,314	1,083	180	232	94	57	6	28	43	80	74	97	135	81	285	128	327	148
New York	1,340	2,018	712	1,066	543	607	58	21	406	809	451	604	5,403	3,861	283	149	1,460	1,476	659	195
North Carolina	560	1,019	387	689	69	107	-----	-----	87	177	-----	-----	1,560	1,298	266	239	1,310	967	78	W
North Dakota	322	285	1,771	1,313	111	169	96	58	11	15	62	W	356	360	73	73	80	53	-----	-----
Ohio	2,613	4,336	937	1,517	1,437	2,248	235	335	466	761	21	34	3,224	2,976	217	153	535	505	40	57
Oklahoma	156	232	78	70	222	145	W	W	W	W	19	6	1,366	694	-----	-----	369	212	264	219
Oregon	2,276	4,032	3,041	5,455	787	1,108	130	162	304	531	46	115	1,473	1,467	17	W	513	360	495	237
Pennsylvania	778	1,623	696	1,147	160	346	42	89	190	451	70	111	355	451	W	W	305	219	W	W
Rhode Island	131	288	105	164	107	187	W	W	27	87	W	W	80	47	-----	-----	518	370	-----	-----
South Carolina	W	W	12	12	64	58	-----	-----	-----	-----	-----	-----	453	173	W	W	536	371	W	9
South Dakota	1,171	990	2,211	2,032	73	69	82	78	218	293	209	238	555	481	51	17	702	430	142	73
Tennessee	734	1,422	791	881	172	229	W	W	116	204	W	W	310	302	92	41	1,139	963	31	130
Texas	2,451	4,600	1,121	1,816	581	780	30	47	368	783	9	33	3,736	2,254	56	31	353	208	159	35
Utah	1,452	1,835	1,030	1,244	119	180	189	143	285	327	11	12	1,604	714	263	230	823	559	-----	-----
Vermont	156	316	101	99	18	18	-----	-----	W	W	28	22	469	382	4	3	238	181	84	28
Virginia	1,064	1,995	555	1,321	1,263	1,075	-----	-----	28	37	W	W	1,401	1,387	-----	-----	107	[illegible]	-----	-----
Washington	2,253	3,994	1,284	2,122	482	655	77	85	284	565	W	W	4,982	4,573	69	24	1,341	[illegible]	15	6
West Virginia	50	W	7	25	W	W	-----	-----	-----	-----	-----	-----	W	W	14	30	-----	-----	11	17
Wisconsin	3,755	3,871	3,563	3,215	936	695	293	166	432	500	146	135	1,895	1,248	409	151	834	11	381	101
Wyoming	253	565	540	815	293	283	W	W	1	1	W	W	75	92	-----	-----	100	123	-----	-----
Concealments	182	796	-----	-----	17	36	319	653	158	696	405	1,164	390	1,002	125	170	1,441	1,186	[illegible]	[illegible]
TOTAL 2/	71,122	110,323	76,220	105,811	26,007	32,277	5,283	6,134	11,647	19,408	3,241	4,695	90,602	58,000	10,068	7,224	97,349	64,124	15,052	8,539

TABLE II-3 (cont.)

areas, in some cases necessitating increased use of rail transportation to maintain competitive economics.

As a result of these trends, users of sand and gravel have explored more economically available alternative materials. In some cases, users have substituted fine-ground crushed stone or cinders; a reverse substitution favoring sand and gravel has also taken place but not as frequently. These substitution trends have taken place at a slow rate and have been stimulated more by increases in relative freight costs (as sand and gravel pits have moved away from urban areas to more remote locations) than in relative processing costs. The use of crushed stone as a substitute does, however, require at least an additional crushing step to reduce the size of the aggregate in order to conform with sand and gravel specifications. This increased processing does increase processing costs.

6. Future Growth

Historically, construction sand and gravel demand has been very closely correlated with constant-dollar Gross National Product. As a function of real GNP, for the 1959-1974 period, $R^2 = 0.822$. These relations provided a better fit than constant dollar expenditures on new construction, housing starts, or the Federal Reserve Board Industrial Production Index.

Thus, by using annual GNP forecasts* of 2.8% for 1975-1980 and 3.3% for 1980-1985 the following demand forecasts were calculated:

*Forecasts and projections in this document are by Arthur D. Little, Inc., unless otherwise stated.

Year	Construction Sand and Gravel (10^6 short tons)	(10^6 metric tons)
1974 actual	950	864.5
1980	1000	910
1985	1100	1001

With the high correlations to GNP growth, demand growth for these products should generally be highest in the regions with the best economic growth potentials. Such high growth areas are expected to be the South and Western states. The Northeast and North Central regions will grow at or below the national average. Within regions, we predict stronger growth in demand to occur on the fringes of urban areas. However, the supply of sand and gravel will become more remote to the points of demand as pits are depleted or zoned out of the close-in locations.

On a yearly basis, 1976 is expected to be a recovery year with strong growth in real GNP (6%) and housing starts (29%). Thus, 1977 should show continuing good growth in GNP and housing starts and a recovery in non-residential building construction. Another downturn in the business cycle is predicted for the 1978 to 1979 period and, so, they will be years of declining demand for crushed stone and sand and gravel. Another recovery is expected in 1980, with real growth in GNP reaching 4.7%.

7. Marketing and Distribution

The marketing intensity of the construction sand and gravel industry is relatively low at the operator level, although national trade associations or similar local groups do expend a limited amount of marketing and promotional effort. Although some pit operators are multi-location or multi-division companies who assist customers with technical problems, the typical pit is a single-location operation serving a restricted geographic market and has marketing efforts limited to order-taking and delivery service.

Distribution of construction sand and gravel, as with crushed stone, is direct from the pit to the end user with no intermediary involved. Production levels closely match anticipated demand, and inventories are only sufficient to ensure uniform production rates over a predetermined length of time. The seasonality of the industry in many Northern regions typically restrict operators to nine months a year, so some stockpiling does take place for winter use.

The Bureau of Mines estimates that over 90% of sand and gravel is moved by truck, with the next most common mode of transportation being rail.

B. INDUSTRY STRUCTURE

1. Types of Firms

The construction sand and gravel industry is characterized by the prevalence of a number of small firms operating sand and gravel pits as their primary or only business. In 1972, the total construction sand and gravel shipped by all industries in the United States had a value of $921.8 million. The special construction sand and gravel industry alone provided approximately 86% of this value. The sand and gravel industry produces other products and services in addition to construction sand and gravel. In 1972, the total value of shipments and receipts (the combination of construction sand and gravel and all other products and services of the construction sand and gravel industry) totaled $879.6 million. About $814 million of the total value is classified by the Burea of the Census as primary products--construction sand and gravel--and relates to the major revenue contributors to the sector, while much of the remaining value of shipments was for secondary products such as industrial sand. The Bureau of Mines, which uses different survey methods than the Census and has a different coverage, indicates that $1.07 billion of construction sand and gravel was sold or used by producers in 1972.

No comprehensive data on the number of firms in operation were available until 1974, when the Bureau of Mines estimated that about 4,750 firms operated 6,849 plants. Many of the firms, as in the crushed stone industry, are small, locally owned proprietorships and private corporations which together account for a large proportion of total U.S. shipments but individually may not even be significant producers in their own local marketplace. Many of the operators are farmers or landowners who exploit the less-productive portion of their landholdings for its natural resources.

In addition to the smaller companies, a number of larger firms are also active in the industry. Such firms include companies that are horizontally diversified into the production of other construction aggregates; for example, Vulcan Materials, Flintkote, Gifford-Hill, and Dravo. However, sand and gravel represents a far less significant part of the business for most of these larger, nationally based corporations which are also diversified into non-construction-related businesses.

A third type of firm operating in the construction sand and gravel industry is the owner of a commercial, portable, processing plant. This type of firm will either service municipal, state or federal projects on a contract basis or supply stone to commercial contractors for specific construction projects.

A fourth group of firms includes those that operate sand and gravel plants as parts of other manufacturing establishments. The 1972 Census reported that only 266 such establishments were in operation in that year, continuing a steady decline that has apparently taken place since 1963. These plants are vertically integrated and usually provide aggregate, through internal corporate transfer, for the manufacture of ready-mixed concrete or other concrete products. These firms are invariably included in SIC's other than 1442, as the bulk of their revenues come from the non-sand-and-gravel products.

2. Types of Plants

Data on plants operating in the construction sand and gravel industry are available from two principal sources: the Bureau of Census and the Bureau of Mines. Industry 1442, Construction Sand and Gravel, is described in the 1972 minerals census as being represented by establishments primarily engaged in operating sand and gravel pits and dredges, and in washing, screening or otherwise preparing sand and gravel for construction uses. The Bureau of Mines reports production and shipments data for operating units in the Minerals Yearbook and also in the Mineral Industry Surveys.

Data from these two sources are not entirely comparable regarding production volume and they vary considerably with respect to the number and characteristics of operating units. The most nearly comparable shipments statistics (for both construction sand and gravel and industrial sand) are shown in Table II-4. The primary differences occur because the Bureau of Mines numbers include federal, state and local government operations, while the Bureau of the Census excludes these operations.

As was indicated earlier, the disparity is widened when plant data are examined. The Bureau of the Census reports that 2,762 establishments produced construction sand and gravel in 1972, while the Bureau of Mines reports about 5,275 plants in operation in that year. Because the Bureau of Mines survey methods obtain a higher coverage, that agency's data will be used in this analysis principally to characterize the production-related elements of the construction sand and gravel industry, while the Bureau of Census data will be used to derive financial operating ratios for the industry.

The number of construction sand and gravel operations increased from about 5,275 in 1972 to 5,575 in 1973 and 6,849 in 1974. (It should be pointed out that the EPA Development Document was prepared prior to the release of Bureau of Mines data for 1974 and was based on the 1972 analysis.) Much of the increase is due to increased survey coverage of the industry. In 1974, approximately 4,750 companies operated the 6,849 operations. About 82% of the operations had processing plants associated with their land or dredging operations, while the remaining 18% had no processing plant and the material was sold as mined. Table II-5 describes the number and production of domestic commercial sand and gravel plants by size of operation for 1973 and 1974. The data clearly indicate that about 30% of the plants in 1974 produced about 2% of domestic output and that this 30% represents plants with an annual production of less than 25,000 short tons (22,750 metric tons).

4. Phosphate Rock

a. Internal Costs

Of 26 existing phosphate operations, it is estimated that only four facilities in Florida are presently out of compliance. BPT investment costs for a model representing these facilities are $910,000 or about 4% of present investment in plant and equipment. Incremental annual costs to meet BPT are about $.11 per ton or an addition of about 1.5% to current annual expenditures. BAT limitations will not require additional expenses to be incurred or demand more investment.

b. External Costs

(1) Price Effects. These guidelines will have a minimal effect on phosphate prices. If the four non-complying plants are able to pass the effluent control costs on, prices would increase by about .9% from mid-1974 levels of $12.10 per ton. Present phosphate prices are higher, so the commensurate effect would be even less.

(2) Production Effects. No closures are expected to result from the imposition of the interim final guidelines. Even if the facilities were unable to pass costs on, profits after taxes would fall from 12.1% to 11.6%. No financing difficulties are anticipated.

(3) Employment Effects. Employment levels will not change since no closures are predicted.

(4) Community Effects. Local economies will not be affected since no closures are predicted.

(5) Industry Growth Effects. Effluent guidelines are not expected to affect the growth of the phosphate industry significantly.

Table II-5 NUMBER AND PRODUCTION OF CONSTRUCTION SAND AND GRAVEL AND INDUSTRIAL SAND AND GRAVEL OPERATIONS, BY SIZE

	1973				1974							
	Operations Construction-Industrial		Production Construction-Industrial		Operations Construction		Production Construction		Operations Construction-Industrial		Production Construction-Industrial	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000------	1,655	29.1	18,054	2.1	2,149	31.8	21,387	2.3	13	12.9	178	.6
25,000 to 50,000------	884	15.6	32,244	3.7	1,141	16.9	41,439	4.5	8	7.9	308	1.0
50,000 to 100,000-----	1,053	18.5	75,822	9.0	1,262	18.7	90,435	9.8	17	16.8	1,228	44.2
100,000 to 200,000----	904	15.9	129,084	15.2	1,085	16.1	152,907	16.6	27	26.7	3,915	13.4
200,000 to 300,000----	450	7.9	109,976	13.0	436	6.5	105,074	11.4	8	7.9	1,890	6.4
300,000 to 400,000----	230	4.1	79,468	9.4	209	3.1	70,924	7.7	6	5.9	2,115	7.2
400,000 to 500,000----	134	2.4	59,977	7.1	135	2.0	60,534	6.6	2	2.0	952	3.2
500,000 to 600,000----	78	1.4	42,472	5.0	97	1.4	53,013	5.7	5	5.0	2,740	9.4
600,000 to 700,000----	79	1.4	51,306	6.1	59	.9	38,043	4.1	1	1.0	653	2.2
700,000 to 800,000----	48	.8	35,345	4.2	44	.6	32,825	3.6	3	3.0	2,269	7.8
800,000 to 900,000----	42	.7	35,708	4.2	21	.3	17,701	1.9	3	3.0	2,504	8.6
900,000 to 1,000,000--	24	.4	22,635	2.7	31	.5	28,428	3.1	1	1.0	908	3.1
1,000,000 and over----	100	1.8	154,713	18.3	79	1.2	209,295	22.7	7	6.9	9,634	32.9
Total 1/ -----	5,681	100.0	846,805	100.0	6,748	100.0	922,005	100.0	101	100.0	29,294	100.0

1/ Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines "Mineral Industry Surveys" Sand and Gravel in 1974

The Bureau of Mines changed its surveying techniques in developing the 1974 industry survey and sought to develop more comprehensive information on the operating characteristics of the plants. Approximately 82% (5,636) of the operations completed the 1974 supplemental survey form, an analysis of which is contained in Tables II-6 through II-8. These tables indicate the following distribution of production and number of operations by source of aggregate:

Source	Percentage of Operations	Percentage of Operations
Dry Pit on Land	70.5	62.3
Wet Pit on Land	20.6	27.4
River Bed	8.3	9.6
Lake, Bay or Ocean	0.6	0.7

The majority of operations (58.5%) utilize a shovel or a front-end loader to recover the mineral, while 22% use a drag line and 14% dredge the aggregate. The data also indicate that 42% of operations mine their own land, 39% lease private land and pay royalties, and the majority of the remainder lease mineral rights and pay royalties.

The use of portable plants is a common occurrence in the construction sand and gravel industry, particularly to service federal, state and local pits, but the frequency of use and the proportion of production represented by such portable units is not documented. Portable plants are used to supplement the productive capabilities of permanent installations, to serve remote locations where the quantity of aggregate required is insufficient to justify a permanent plant, or to provide aggregate to projects (such as highways) that are progressively moving.

Although the level of integration with other manufacturing businesses is not high, many pit operators are also producing ready-mixed concrete or

Table II-6 SAND AND GRAVEL PRODUCTION IN 1974, BY STATE, AND SOURCE 1/
(10^3 short tons and 10^3 dollars)

	Dry pit on land		Number of operations	Wet pit on land		Number of operations	River bed: Not navigable		Number of operations	River bed: Navigable		Number of operations	Lake		Number of operations	Bay		Number of operations	Ocean		Number of operations
	Quantity	Value		Quantity	Value		Quantity	Value		Quantity	Value		Quantity	Value		Quantity	Value		Quantity	Value	
Alabama	5,486	7,253	36	3,107	4,885	21	W	W	4	W	W	3	-----	-----	-----	-----	-----	-----	-----	-----	-----
Alaska	22,510	18,225	91	7,455	5,942	31	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arizona	7,309	13,970	64	W	W	2	12,285	18,478	45	W	W	1	-----	-----	-----	-----	-----	-----	W	W	1
Arkansas	6,776	15,784	148	637	1,055	11	1,221	1,345	11	3,133	6,043	12	-----	-----	-----	-----	-----	-----	-----	-----	-----
California	68,191	114,655	203	11,583	18,223	26	18,678	31,645	96	W	W	3	-----	-----	-----	W	W	3	-----	-----	-----
Colorado	14,198	25,084	115	5,703	8,737	33	2,429	3,742	26	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Connecticut	4,564	8,026	51	W	W	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Delaware	1,875	2,552	6	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Florida	W	W	3	21,400	29,540	50	-----	-----	-----	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Georgia	2,222	2,991	12	1,504	4,148	15	W	W	1	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
Hawaii	W	W	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	4,431	6,051	64	W	W	3	W	W	2	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Illinois	17,144	25,684	103	15,531	23,047	55	W	W	1	794	1,094	8	W	W	3	-----	-----	-----	-----	-----	-----
Indiana	8,983	13,346	74	14,747	19,368	79	W	W	2	452	487	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
Iowa	4,923	7,070	116	10,048	15,544	123	W	W	3	178	226	5	W	W	2	-----	-----	-----	-----	-----	-----
Kansas	2,190	1,824	64	5,488	5,586	46	1,158	1,532	11	1,599	2,261	8	-----	-----	-----	-----	-----	-----	-----	-----	-----
Kentucky	1,043	1,182	19	1,976	2,817	7	-----	-----	-----	4,779	7,153	10	-----	-----	-----	-----	-----	-----	-----	-----	-----
Louisiana	3,134	7,444	17	7,603	15,620	40	W	W	1	100	253	1	W	W	1	-----	-----	-----	-----	-----	-----
Maine	3,050	4,404	44	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Maryland	10,333	26,780	44	W	W	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Massachusetts	14,195	22,404	114	W	W	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Michigan	44,009	58,690	299	9,145	15,461	57	-----	-----	-----	-----	-----	-----	W	W	4	W	W	2	-----	-----	-----
Minnesota	29,210	33,423	325	4,375	5,772	22	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mississippi	8,453	10,448	33	4,602	6,347	16	-----	-----	-----	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
Missouri	1,999	5,930	12	1,180	2,275	10	2,182	3,211	19	4,832	6,287	29	-----	-----	-----	-----	-----	-----	-----	-----	-----
Montana	2,782	3,572	45	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nebraska	669	705	30	10,453	13,854	144	384	362	9	-----	-----	-----	W	73	2	-----	-----	-----	-----	-----	-----
Nevada	6,893	11,111	54	1,379	2,733	4	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New Hampshire	5,666	7,504	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New Jersey	9,620	24,681	48	5,857	17,543	18	-----	-----	-----	W	W	1	W	W	1	-----	-----	-----	-----	-----	-----
New Mexico	6,597	8,417	98	W	W	2	347	1,387	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New York	22,349	33,005	182	2,629	4,480	12	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
North Carolina	5,454	8,365	62	4,497	7,079	44	645	909	25	W	W	7	-----	-----	-----	-----	-----	-----	-----	-----	-----
North Dakota	3,518	4,474	47	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ohio	17,481	30,007	186	20,247	32,153	107	381	595	6	W	W	2	763	1,418	8	W	W	1	-----	-----	-----
Oklahoma	2,190	2,671	34	3,483	7,003	27	2,262	2,992	21	W	W	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Oregon	9,155	14,588	82	3,602	6,390	19	884	1,073	19	3,441	6,256	10	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pennsylvania	8,913	22,735	76	5,982	14,291	11	659	1,679	5	W	W	3	W	W	2	-----	-----	-----	-----	-----	-----
Rhode Island	2,593	4,329	18	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
South Carolina	2,511	4,866	19	4,318	7,354	11	264	346	5	-----	-----	-----	125	188	1	-----	-----	-----	-----	-----	-----
South Dakota	6,346	6,693	114	193	335	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	6,165	9,657	37	547	959	4	W	W	1	1,102	2,355	4	-----	-----	-----	-----	-----	-----	-----	-----	-----
Texas	22,795	44,410	113	16,297	31,149	41	W	W	3	W	W	3	-----	-----	-----	-----	-----	-----	-----	-----	-----
Utah	7,819	8,986	58	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vermont	2,076	3,127	46	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	8,623	18,075	66	3,305	7,676	16	W	W	3	W	43	2	-----	-----	-----	-----	-----	-----	-----	-----	-----
Washington	13,557	20,288	149	1,933	3,325	14	W	W	3	382	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
West Virginia	W	W	2	7	25	1	W	49	3	3,405	6,288	6	-----	-----	-----	-----	-----	-----	-----	-----	-----
Wisconsin	23,125	27,801	251	1,587	2,319	17	-----	-----	-----	W	W	1	-----	-----	-----	-----	-----	-----	-----	-----	-----
Wyoming	4,959	7,903	48	25	W	1	W	W	4	-----	-----	-----	162	757	1	-----	-----	-----	-----	-----	-----
Concealments	4,121	11,872	-----	3,889	6,336	-----	1,628	2,834	-----	5,931	12,039	-----	3,438	7,078	-----	1,087	2,347	-----	3	44	-----
Total 2/	492,145	773,082	3,972	216,313	349,370	1,163	45,405	72,176	338	30,128	50,784	131	4,487	9,512	25	1,087	2,347	6	3	44	1

W Withheld to avoid disclosing individual company confidential data, included with "Concealments".
1/ Based on 5,636 operations which completed the 1974 supplemental form.
2/ Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines "Mineral Industry Surveys" Sand and Gravel in 1974

Table II-7 PRODUCTION OF SAND AND GRAVEL IN 1974, BY STATE, BY METHOD OF MINING 1/
(10^3 short tons and 10^3 dollars)

	Dredge			Dragline			Shovel			Front-end loader			Other		
	Quantity	Value	Number of operations	Quantity	Value	Number of operations	Quantity	Value	Number of operations	Quantity	Value	Number of operations	Quantity	Value	Number of operations
Alabama	3,767	6,613	19	4,561	7,435	15	1,792	1,300	7	1,180	1,817	22	W	79	1
Alaska	-----	-----	-----	1,586	1,728	9	W	W	1	22,190	18,823	85	6,163	W	30
Arizona	-----	-----	-----	W	W	4	8,072	10,161	14	9,434	16,979	81	2,587	W	13
Arkansas	3,238	6,094	14	5,376	9,048	71	434	132	2	2,180	2,573	93	W	6,379	2
California	3,254	6,029	8	28,337	50,252	82	24,214	36,516	37	28,397	45,836	156	14,989	W	46
Colorado	1,046	1,826	9	6,381	10,146	36	66	111	1	13,630	22,873	124	1,248	W	6
Connecticut	W	W	2	907	1,334	6	640	1,137	6	3,302	5,636	40	-----	-----	-----
Delaware	-----	-----	-----	W	W	3	W	W	3	W	W	2	-----	-----	-----
Florida	13,495	18,912	40	9,463	12,605	13	-----	-----	-----	W	W	2	-----	-----	-----
Georgia	2,827	4,643	21	W	W	2	W	W	1	169	68	4	W	7	1
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	W	W	3	-----	-----	-----
Idaho	W	W	1	320	739	4	368	489	6	3,930	5,208	56	W	268	4
Illinois	12,544	17,534	41	12,140	18,583	56	577	1,591	6	8,513	12,415	65	W	636	1
Indiana	7,419	10,011	33	10,251	13,376	70	1,036	1,385	6	4,372	6,801	46	1,181	1,739	1
Iowa	4,752	7,721	40	8,949	12,105	165	W	W	7	1,574	2,559	35	W	86	3
Kansas	8,441	9,568	64	W	W	3	W	W	3	1,739	1,430	56	122	132	3
Kentucky	6,101	9,039	16	W	W	2	-----	-----	-----	1,016	1,222	19	-----	-----	-----
Louisana	8,787	19,906	45	2,649	5,593	12	-----	-----	-----	W	W	3	-----	-----	-----
Maine	-----	-----	-----	W	W	1	237	299	1	2,813	4,104	43	-----	-----	-----
Maryland	434	723	2	2,417	6,984	6	442	965	4	7,683	18,878	33	257	1,001	2
Massachusetts	W	W	3	-----	-----	-----	430	672	6	13,762	20,976	108	-----	-----	-----
Michigan	5,781	10,689	23	24,747	33,209	140	2,364	2,520	19	21,123	29,903	177	W	1,125	3
Minnesota	1,170	1,690	5	3,693	5,843	34	3,127	2,464	8	18,789	21,505	229	6,806	W	71
Mississippi	5,008	7,061	19	3,402	4,962	11	-----	-----	-----	4,737	5,048	20	-----	-----	-----
Missouri	6,530	8,917	32	1,090	2,039	16	W	W	1	2,081	6,128	19	W	443	2
Montana	74	165	1	W	W	2	393	355	2	2,028	2,690	37	340	W	5
Nebraska	10,801	14,221	149	W	W	2	W	W	2	592	631	26	74	W	7
Nevada	20	88	1	W	W	2	W	W	3	5,125	9,495	42	2,168	W	11
New Hampshire	78	88	1	375	631	1	576	1,116	4	4,638	5,669	41	-----	-----	-----
New Jersey	5,543	20,436	24	4,566	11,471	7	908	2,131	6	4,292	7,604	29	W	1,088	2
New Mexico	-----	-----	-----	419	1,507	6	1,177	1,848	4	4,772	6,158	82	744	W	11
New York	1,272	2,089	4	1,442	2,809	13	2,232	3,524	24	19,255	28,220	150	W	845	3
North Carolina	922	1,501	17	8,148	13,267	83	103	85	4	1,476	1,602	33	W	95	3
North Dakota	-----	-----	-----	W	W	2	110	82	1	2,336	3,390	33	1,137	W	13
Ohio	4,081	6,846	28	18,309	28,763	101	1,990	3,842	24	14,489	24,737	153	309	W	4
Oklahoma	4,545	6,044	41	1,396	1,088	11	W	W	2	1,174	1,641	27	W	3,774	2
Oregon	4,335	8,840	11	1,650	2,944	20	3,528	3,838	20	6,241	10,775	71	1,328	W	9
Pennsylvania	5,826	15,280	12	3,220	6,172	13	1,695	4,014	18	6,405	17,226	54	-----	-----	-----
Rhode Island	-----	-----	-----	-----	-----	-----	W	W	2	2,538	3,951	16	W	44	1
South Carolina	1,489	1,771	11	3,295	6,136	9	W	W	1	2,333	4,793	15	-----	-----	-----
South Dakota	W	W	3	334	583	5	W	W	2	4,248	4,294	88	1,581	W	21
Tennessee	1,900	3,279	9	1,390	1,523	11	1,399	1,406	8	3,326	6,977	18	-----	-----	-----
Texas	7,622	13,068	14	25,953	47,116	96	2,907	5,805	14	3,109	7,981	31	649	W	5
Utah	W	W	3	W	W	3	612	W	2	5,658	6,554	45	540	W	6
Vermont	-----	-----	-----	-----	-----	-----	W	W	3	1,875	2,639	43	-----	-----	-----
Virginia	415	933	5	8,358	18,146	33	733	1,316	4	1,890	4,149	42	W	1,345	3
Washington	W	W	3	4,113	5,568	20	672	1,420	6	9,930	15,273	131	681	W	8
West Virginia	3,397	6,290	6	14	30	1	W	W	1	W	W	4	-----	-----	-----
Wisconsin	842	1,332	4	1,367	1,615	29	2,444	2,442	30	19,717	23,832	203	W	960	3
Wyoming	162	757	1	W	W	4	29	23	2	4,048	6,393	32	907	W	15
Concealments	1,932	4,008	-----	3,146	5,760	-----	4,595	8,848	-----	2,602	10,194	-----	5,538	62,660	-----
Total 2/	149,847	254,012	785	213,764	351,110	1,235	69,903	101,836	328	306,706	467,650	2,967	49,343	82,704	321

W Withheld to avoid disclosing individual company confidential data; included with "Concealments".
1/ Based on 5,636 operations which completed the 1974 supplemental form.
2/ Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines "Mineral Industry Surveys" Sand and Gravel in 1974

Table II-8 PRODUCTION OF SAND AND GRAVEL IN 1974, BY STATE, AND LAND OWNERSHIP (WET OR DRY OPERATION ON LAND) 1/ (10^3 short tons)

	Own the land Quantity	Number of operations	Own mineral rights Quantity	Number of operations	Lease mineral rights and pay royalties Quantity	Number of operations	Lease private land and pay royalties Quantity	Number of operations	Lease public land and pay royalties Quantity	Number of operations
Alabama ------	711	7	-----	-----	3,319	10	7,146	47	W	1
Alaska -------	5,824	33	W	1	447	6	948	3	22,655	82
Arizona ------	7,179	34	55	2	3,540	20	5,162	37	4,514	18
Arkansas -----	2,947	18	40	2	2,348	27	4,579	126	1,855	9
California ---	45,209	104	W	3	13,606	42	35,073	158	1,316	21
Colorado -----	11,250	76	96	1	2,561	14	7,249	77	1,215	8
Connecticut --	3,528	43	W	2	W	3	729	5	344	1
Delaware -----	W	3	-----	-----	-----	-----	W	5	-----	-----
Florida ------	12,093	27	-----	-----	1,378	7	10,093	21	-----	-----
Georgia ------	2,842	16	W	1	W	2	783	10	-----	-----
Hawaii -------	4	1	-----	-----	-----	-----	329	1	W	1
Idaho --------	3,000	41	72	1	W	3	1,492	22	278	4
Illinois -----	21,245	75	W	1	3,170	24	9,543	68	W	2
Indiana ------	13,046	83	W	3	2,537	13	8,411	55	W	1
Iowa ---------	5,818	68	W	3	1,918	37	7,521	129	274	13
Kansas -------	4,021	34	-----	-----	1,887	26	3,915	64	612	5
Kentucky -----	1,907	6	-----	-----	W	2	3,801	23	809	6
Louisiana ----	2,314	15	-----	-----	525	4	8,602	40	17	1
Maine --------	1,784	31	-----	-----	-----	-----	1,266	13	W	1
Maryland -----	6,253	30	W	1	1,092	6	3,707	10	-----	-----
Massachusetts-	10,379	82	1,175	6	1,282	11	1,692	17	3	1
Michigan -----	29,224	170	W	3	5,207	29	18,432	154	1,309	6
Minnesota ----	16,456	163	W	1	4,430	54	12,015	127	W	3
Mississippi --	4,079	13	-----	-----	970	9	7,862	27	235	1
Missouri -----	3,892	22	-----	-----	383	5	5,085	37	832	6
Montana ------	2,297	31	-----	-----	177	5	409	10	34	1
Nebraska -----	4,734	46	W	1	1,680	40	5,035	96	W	2
Nevada -------	4,868	23	-----	-----	1,017	7	1,894	18	522	11
New Hampshire-	4,101	38	208	2	945	4	W	3	-----	-----
New Jersey ---	12,259	53	W	2	W	3	2,143	9	W	1
New Mexico ---	3,120	26	77	4	W	3	2,960	54	849	16
New York -----	16,034	127	W	2	1,979	17	4,713	48	-----	-----
North Carolina	4,267	42	941	10	339	7	5,147	73	W	6
North Dakota -	1,573	18	-----	-----	633	7	1,300	23	W	1
Ohio ---------	25,352	172	603	6	4,698	50	7,933	79	592	5
Oklahoma -----	2,795	20	-----	-----	1,724	14	3,428	49	180	1
Oregon -------	8,446	68	W	1	2,108	16	3,168	37	3,343	9
Pennsylvania -	11,192	57	W	1	1,030	10	2,849	21	1,910	8
Rhode Island -	1,031	10	W	2	-----	-----	397	5	W	2
South Carolina	2,201	12	W	1	991	8	3,688	15	-----	-----
South Dakota -	2,537	51	185	5	792	21	3,024	42	-----	-----
Tennessee ----	1,055	12	W	2	2,093	12	3,781	17	W	3
Texas --------	8,865	37	W	2	6,335	23	24,626	95	W	3
Utah ---------	6,460	37	67	1	137	4	1,414	16	W	1
Vermont ------	1,650	24	-----	-----	26	1	400	21	-----	-----
Virginia -----	3,824	36	W	1	3,348	13	4,803	37	-----	-----
Washington ---	10,800	114	W	1	1,280	10	3,065	38	650	5
West Virginia-	W	3	-----	-----	W	1	W	2	1,926	6
Wisconsin ----	12,160	111	W	1	4,175	83	7,246	70	185	4
Wyoming ------	2,969	17	W	1	421	8	1,590	20	245	8
Concealments -	2,169	-----	9,468	-----	2,521	-----	3,606	-----	3,006	-----
Total 2/ -----	371,763	2,380	12,988	77	89,044	721	264,057	2,174	51,711	284

W Withheld to avoid disclosing individual company confidential data, included with "Concealments".
1/ Based on 5,636 operations which completed the 1974 supplemental form.
2/ Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines "Mineral Industry Surveys" Sand and Gravel in 1974

other concrete products such as block at the same location and consuming some of the sand or gravel they produce in those manufacturing operations.

General statistics for the construction sand and gravel industry, as reported by the Bureau of the Census, is shown in Table II-9 by employment size of establishment for 1972. The 2,762 establishments covered by this table averaged:

- A total employment of 11 workers;
- Value added equivalent to 78% of the value of shipments and receipts; and
- Capital expenditures of $44,000 per plant, or 14% of shipments.

The distribution of establishments by number of employees is heavily skewed to the lower end, with 46% of the establishments employing four or fewer workers. Only 3% employ more than 50 workers. The sand and gravel industry, as a seasonal one, experiences peaks and troughs in employment levels for production, development and exploration workers. Consequently, the quarterly distribution of manhours for such workers is 21%, 26%, 28% and 24%.

3. Industry Segmentation

The construction sand and gravel industry included about 5,150 plants producing an estimated 697 million metric tons of commercial product in 1972. The Development Document considered various factors in subcategorizing this industry and concluded that, with the exception of the manufacturing process employed, no factors are of sufficient significance to justify their use in the segmentation process. Consequently, the following subcategories were selected:

Table II-9 GENERAL STATISTICS BY EMPLOYMENT SIZE OF ESTABLISHMENT, 1972

1972 code	Item	Establishments	All employees		Production, development, and exploration workers			Value added in mining	Cost of supplies, etc., and purchased machinery installed	Value of shipments and receipts	Capital expenditures
			Number	Payroll	Number	Man-hours	Wages				
		(number)	(1,000)	(million dollars)	(1,000)	(millions)	(million dollars)	(million dollars)	(million dollars)	(million dollars)	(million dollars)
1442	CONSTRUCTION SAND AND GRAVEL										
	Establishments, total.....E2	2,762	29.7	281.8	23.3	50.4	205.7	684.6	317.0	879.6	122.0
	Establishments with an average of--										
	0 to 4 employees.....E7	1,258	2.2	19.4	2.1	3.8	15.3	54.2	26.5	70.4	10.3
	5 to 9 employees.....E2	563	3.9	37.0	3.1	6.5	28.0	89.4	43.8	117.7	15.5
	10 to 19 employees.....E1	547	7.4	71.4	5.7	12.4	51.8	174.9	81.3	225.9	30.3
	20 to 49 employees.....E1	312	9.0	85.5	7.0	15.7	64.6	206.6	100.1	272.8	33.9
	50 to 99 employees.....E1	63	4.0	38.2	3.0	6.7	26.5	91.8	38.7	109.6	20.9
	100 to 249 employees.....E1	16	2.3	22.8	1.7	3.8	13.6	49.1	18.1	59.6	7.7
	250 to 499 employees.....	3	.9	7.5	.7	1.6	5.9	18.6	8.5	23.6	3.6
	Establishments covered by admin. records[1]......	859	1.3	12.3	1.3	2.5	9.7	33.7	15.4	42.7	6.3

Note: The payroll and sales data for small establishments (generally single-unit companies with less than 5 employees) were obtained from administrative records of other government agencies instead of from a Census report form. These data were then used in conjunction with industry averages to estimate the balance of the items shown in the table for these small establishments. This technique was also used for a small number of other establishments whose reports were not received at the time the data were tabulated. The following symbols are shown for those size classes where administrative records data were used and account for 10 percent or more of the figures shown:

E1--10 to 19 percent E3--30 to 39 percent E5--50 to 59 percent E7--70 to 79 percent E9--90 to 99 percent
E2--20 to 29 percent E4--40 to 49 percent E6--60 to 69 percent E8--80 to 89 percent E0--100 percent

(D) Withheld to avoid disclosing figures for individual companies. Data for this item are included in the underscored figures above.
(Z) Less than half of the unit of measurement shown.

[1]Report forms were not generally mailed to companies with less than 5 employees that operated only 1 establishment. Payroll and sales for 1972 were obtained from administrative records supplied to other agencies of the Federal Government. These payroll and sales data were then used in conjunction with industry averages to estimate the balance of the items shown in the table. Data are also included in the respective size classes shown for this industry.

Source: Sand and Gravel, 1972 Census of Mineral Industries, MIC72(1)-14B, Bureau of the Census, Dept. of Commerce

1. Dry excavation and dry processing;
2. Wet or dry excavation with wet processing;
3. Dredging in navigable waters with on-land processing; and
4. Dredging in navigable waters with on-board processing.

Table II-10 summarizes the distribution of plants, production and employment by each process. The <u>Development Document</u> modeled a single representative plant with an annual production of 227,000 metric tons (250,000 short tons). Because of the distribution in plant size within this industry, described earlier, it is necessary to examine the potential impact on smaller plants, having an annual production of about 91,000 metric tons (100,000 short tons). It is believed that many of the plants in operation today that do not have effluent controls in-place are at the lower end of the size distribution in this industry. Those that are above 227,000 metric tons in size would incur lower unit costs by implementing effluent controls and presumably would face a lower relative impact.

Table II-10 SUMMARY - CONSTRUCTION SAND & GRAVEL SEGMENTS, 1972

Process	Plants Number	Plants %	Production 10^6 Short Tons	Production 10^6 Metric Tons	%	Average Production 10^3 Short Tons/Plant	Average Production 10^3 Metric Tons/Plant	Employment* 10^3	Employment* %
1. Dry	750	14.6	143	130.1	18.8	191	173.8	6.4	18.7
2. Wet	4,250	82.5	573	521.[illegible]	74.7	135	122.8	25.5	74.7
3. Dredging (on-land processing)	50	1.0	16.7	15.19	2.2	334	303.9	0.8	2.2
4. Dredging (on-board processing)	100	1.9	33?	30	4.3	334	303.9	1.5	4.3
INDUSTRY TOTAL	5,150	100.0	766	697	100.0	149	135.5	34.2	100.0

*At an estimated production rate of 22,500 short tons/employee.

Source: Development Document and Arthur D. Little, Inc., estimates

C. FINANCIAL PROFILES

1. Industry Performance

The construction sand and gravel industry has a financial profile similar to the crushed stone industry with which it competes. Average industry profitability is about 7% after tax on sales, while the return on equity is 8 to 10%. The industry is vulnerable to the cyclicality of construction activity and has, along with most construction materials industries, experienced poor years in 1974 and 1975. However, both market growth and profitability are basically healthy and should remain so.

2. Model Plants

Financial profiles for two model plants--having a production of 91,000 metric tons and 227,000 metric tons respectively--are displayed in Tables II-11 and II-12. Variable costs account for about 65% of net revenues, with fixed costs another 27%. Net profit after tax is about 8%. As with the crushed stone industry, depreciation and depletion represent significant sources of funds and can exceed the contribution by net income for the medium-to-large facilities. Average annual capital expenditures (for expansions and to maintain existing assets) are 12 to 15% of net revenues, while the ratio of total assets to sales is about 1.3 for both sizes.

Although there do not appear to be any economies of scale with respect to net income, the ratio of cash flow to net revenues is higher for the medium-sized facility.

3. Constraints on Financing Additional Capital

Many of the points made with respect to the crushed stone industry (Section III.C.3) about the likely distribution of each of the financial parameters also apply to the sand and gravel industry.

Table II-11 FINANCIAL PROFILE - REVENUES FOR CONSTRUCTION SAND & GRAVEL OPERATIONS

	SMALL		MEDIUM	
Production	100,000 short tons/year	91,000 short tons/year	250,000 short tons/year	227,000 metric tons/year
Price per short ton	$ 1.50		$ 1.50	
metric ton		$ 1.64		$ 1.64
REVENUES		$150,000		$375,000
Variable Costs				
labor	$ 30,000		$ 70,000	
materials	32,000		80,000	
repair and maintenance	35,000		85,000	
Total		$ 97,000		$235,000
Fixed Costs				
SG&A	97,000		60,000	
depreciation	8,000		35,000	
depletion	2,000		5,000	
interest	3,000		8,000	
Total		$ 40,000		$108,000
Profit before Taxes		$ 13,000		$ 32,000
taxes	2,000		6,000	
net profit		$ 11,000		$ 26,000

Table II-12 FINANCIAL PROFILE - CASH FLOW FOR CONSTRUCTION SAND & GRAVEL OPERATIONS

	SMALL		MEDIUM	
Production	100,000 short tons/year	91,000 short tons/year	250,000 short tons/year	227,000 metric tons/year
Price per short ton	$1.50		$1.50	
metric ton		$1.64		$1.64
CASH FLOW				
Cash In -				
net profit	$11,000		$ 26,000	
depreciation	8,000		35,000	
depletion	2,000		5,000	
debt increase	5,000		13,000	
Total		$26,000		$79,000
Cash Out -				
capital expenditures	$18,000		$ 59,000	
land purchase	2,000		5,000	
increase working capital	4,000		10,000	
dividends	2,000		5,000	
Total		$26,000		$79,000
Book Values of Assets	$65,000		$200,000	

Source: Arthur D. Little, Inc., estimates.

To summarize: the smaller and older plants, and those operated by a proprietorship as opposed to a larger corporation, have relatively less capital available for capital expenditures than the larger and newer plants; profits after tax are generally lower for the smaller facilities, but return on investment is often greater or equal to those enjoyed by the larger plants.

Table II-13 shows the estimated capital investment in place in 1974, based on 5,636 operations that responded to a Bureau of Mines survey. The following summarizes these data:

Type	Number	Average Investment
Dry Pit on Land	3,909	$243,000
Wet Pit on Land	1,227	593,000
Non-Navigable River Bed	337	736,000
Navigable River Bed	131	402,000
Lake	25	216,000
Bay	6	329,000
Ocean	1	50,000
TOTAL	5,636	$352,000 Average

The average investment in place--$352,000 for 1974--compares to the average incremental capital expenditures of $44,000 in 1972.

Table II-13 ESTIMATED CAPITAL INVESTMENT IN 1974, IN THE PRODUCING SAND AND GRAVEL INDUSTRY BY STATE, AND SOURCE 1/
(10^3 dollars)

	Dry pit on land	Number of operations	Wet pit on land	Number of operations	River bed				Lake	Number of operations	Bay	Number of operations	Ocean	Number of operations
					Not navigable	Number of operations	Navigable	Number of operations						
	Value		Value		Value		Value		Value		Value		Value	
Alabama	7,068	36	3,568	20	305	4	2,162	3	-----	-----	-----	-----	-----	-----
Alaska	26,831	90	10,580	31	100	2	-----	-----	-----	-----	-----	-----	50	1
Arizona	17,466	64	364	2	27,685	45	250	1	-----	-----	-----	-----	-----	-----
Arkansas	41,372	158	91,665	11	1,921	11	5,825	12	-----	-----	-----	-----	-----	-----
California	100,037	187	15,836	39	27,317	96	880	3	-----	-----	700	3	-----	-----
Colorado	23,568	114	8,261	33	6,789	26	125	2	-----	-----	-----	-----	-----	-----
Connecticut	7,115	50	430	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Delaware	2,700	6	250	2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Florida	1,176	3	29,024	50	-----	-----	542	2	-----	-----	-----	-----	-----	-----
Georgia	2,727	12	23,573	15	20	1	50	1	-----	-----	-----	-----	-----	-----
Hawaii	849	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	10,394	63	397	5	375	2	280	2	-----	-----	-----	-----	-----	-----
Illinois	24,359	101	19,335	62	250	1	1,106	8	226	3	-----	-----	-----	-----
Indiana	11,189	74	24,545	79	200	2	400	1	-----	-----	-----	-----	-----	-----
Iowa	9,099	115	18,466	123	369	3	995	5	133	2	-----	-----	-----	-----
Kansas	4,829	61	150,778	45	1,659	11	1,203	8	-----	-----	-----	-----	-----	-----
Kentucky	2,171	20	3,669	7	-----	-----	11,562	10	-----	-----	-----	-----	-----	-----
Louisiana	4,255	17	14,955	40	50	1	50	1	1,200	1	-----	-----	-----	-----
Maine	6,991	43	50	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Maryland	19,444	43	3,759	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Massachusetts	31,223	110	1,435	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Michigan	70,254	298	14,278	57	-----	-----	-----	-----	1,225	4	775	2	-----	-----
Minnesota	66,68[illegible]	324	4,778	24	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Mississippi	9,865	32	4,935	16	-----	-----	50	1	-----	-----	-----	-----	-----	-----
Missouri	2,414	12	1,654	10	3,301	19	7,791	29	-----	-----	-----	-----	-----	-----
Montana	5,658	44	495	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nebraska	7,477	31	45,013	140	420	9	-----	-----	90	2	-----	-----	-----	-----
Nevada	13,556	53	952	5	51	1	-----	-----	-----	-----	-----	-----	-----	-----
New Hampshire	9,528	46	------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New Jersey	20,611	45	12,208	20	-----	-----	200	1	50	1	-----	-----	-----	-----
New Mexico	17,365	92	673	7	746	6	-----	-----	-----	-----	-----	-----	-----	-----
New York	36,939	179	4,981	15	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
North Carolina	9,171	61	6,793	44	1,358	25	350	7	-----	-----	-----	-----	-----	-----
North Dakota	56,539	46	114	3	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ohio	29,198	183	27,830	113	563	6	192	2	1,238	8	500	1	-----	-----
Oklahoma	3,323	34	4,430	27	2,086	21	250	2	-----	-----	-----	-----	-----	-----
Oregon	17,151	79	10,364	22	1,792	18	6,727	10	-----	-----	-----	-----	-----	-----
Pennsylvania	28,423	75	128,996	11	168,527	5	2,250	3	567	2	-----	-----	-----	-----
Rhode Island	4,252	18	240	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
South Carolina	8,928	19	5,040	11	270	5	-----	-----	200	1	-----	-----	-----	-----
South Dakota	25,640	113	525	5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	9,479	34	1,350	5	300	1	795	4	-----	-----	-----	-----	-----	-----
Texas	28,5[illegible]	110	20,166	46	205	3	1,500	3	-----	-----	-----	-----	-----	-----
Utah	12,048	57	592	6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vermont	6,040	45	105	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	16,530	63	3,347	19	130	3	45	2	-----	-----	-----	-----	-----	-----
Washington	27,689	147	3,056	19	180	3	225	1	-----	-----	-----	-----	-----	-----
West Virginia	9,500	2	70	1	116	3	6,890	6	-----	-----	-----	-----	-----	-----
Wisconsin	34,540	250	3,426	18	-----	-----	12	1	-----	-----	-----	-----	-----	-----
Wyoming	8,113	47	68	1	1,059	4	-----	-----	478	1	-----	-----	-----	-----
Total 2/	960,376	3,909	727,419	1,227	248,144	337	52,707	131	5,407	25	1,975	6	50	1

1/ Based on 5,636 operations which completed the 1974 supplemental form.
2/ Data may not add to totals shown because of independent rounding.

Source: Bureau of Mines "Mineral Industry Surveys" Sand and Gravel in 1974

D. PRICES AND PRICE SETTING

1. Historic Prices

FOB prices for construction sand and gravel increased about 40% from 1965 to 1974, reaching an average value of $1.50 per metric ton in 1974 (Table II-14). Prices maintained parity on a constant-dollar basis (using the GNP implicit price inflator) until 1971, but has since lost ground; i.e., prices of construction sand and gravel have increased at a rate less than that of inflation over the past four years. However, it is noteworthy that the FOB price for construction sand and gravel, while still lower than that for crushed stone, has increased at a relatively faster rate since 1967. This historic relative price stability and relative decline in constant dollars is not only due to intra-industry competition at local and regional levels in an inflationary period, but also because some companies in the industry have had to control their FOB prices in order to remain competitive when faced with rapidly escalating freight costs.

2. Current Prices

Quotations in Engineering News Record for sand and gravel as of March 1976 are shown in Table II-15. These prices (given for short tons) represent FOB city values, except where noted, and range from $2.34 per metric ton to $8.18 per metric ton gravel, and $1.47 per metric ton to $7.58 per metric ton for sand. As FOB prices are normally very much the same between locations, and might amount to about $1.90 per metric ton currently, the FOB-city prices reflect the great variations that exist in freight costs, which might average $2.18 to $2.45 per metric ton.

Table II-14 CONSTRUCTION SAND AND GRAVEL PRICES, 1965-1974

Year	$/Short Ton*	Price Indexes (1967 = 100) Actual	Relative**
1965	0.99	96.1	102.0
1966	0.99	97.8	100.9
1967	1.01	100.0	100.0
1968	1.04	104.6	100.6
1969	1.06	108.8	99.8
1970	1.11	115.3	100.3
1971	1.18	120.6	100.3
1972	1.23	123.3	99.3
1973	1.31	127.6	97.3
1974	1.38	139.1	96.1

*Plant shipments value, short tons
**Actual price index ÷ GNP implicit price inflator

Source: U.S. Department of Interior/Bureau of Mines
U.S. Department of Labor/Bureau of Labor Statistics

Table II-15 SAND AND GRAVEL PRICES FOB City, March 1976
(Dollars Per Short Ton)

City	Gravel 1-1/2"	Gravel 1/4"	Sand
Atlanta	2.55	3.00	3.79
Baltimore	4.00	4.00e	-3.35
Birmingham	2.15	2.15	4.00
Boston	5.05	5.25	4.25
Chicago	2.25	2.25	2.25
Cincinnati	2.45f	2.45f	2.15f
Cleveland	6.353	6.15Ez	5.55Eb
Dallas	4.25	4.45	3.80
Denver	31.05a	3.75a	2.30a
Detroit	2.70p	3.48p	1.35pv
Kansas City	7.50	6.00	1.60K
Los Angeles	4.30d	4.30d	4.30d
Minneapolis	5.15kF	5.15kF	4.20kF
New Orleans	----	----	----
New York	----	3.75ay	5.25ay
Philadelphia	----	4.20	3.55
Pittsburgh	6.80e	6.80e	6.40
St. Louis	----	6.95bgr	6.95bgr
San Francisco	6.15	6.15	6.30
Seattle	5.80Bn	5.80Bn	5.80n

e = 2% disc., 10 days
f = 5% disc., 5 ton or more 10 days
Ez = 2% disc., 15th prox., pea gravel
Eb = 2% disc., 15th prox., trucklots
a = per cu. yd.
p = 10¢ disc., per ton 20th
pv = 10¢ disc., per ton 20th, pit price
K = 5¢ disc., per ton, 10th prox.
d = 5¢ disc., per cwt, 10th prox.
kF = 5% disc., 30 days, 10 tons/more
ay = per cu. yd., boatload
e = 2% disc., 10 days
bgr = trucklots, 1% disc., 10th prox., delivered
Bn = bulk, 2% disc., 10th prox.

Source: Engineering News Record, March 4, 1976

3. Price Elasticity and Pricing Dynamics

The demand for construction sand and gravel is price inelastic on an industry basis; i.e., when prices increase, even though quantity demanded may decline, total revenues increase. The cost of sand and gravel is still a very small percentage of the total price of materials and products of which it is a component (10-15% of the FOB price of ready-mixed concrete and a very low proportion of the cost of building construction to which the concrete is being supplied, for example.)

Markets for sand and gravel tend to be geographically limited and plants serving them are generally clustered around one or more population centers. On a plant-by-plant basis within a particular market, competition can be severe and tends to be oligopolistic. The sand and gravel business is also reasonably capital-intensive (the ratio of total assets to net revenues being about 1.3) and producers need to maintain production volume to provide for the amortization of their capital investments. A "typical market" will have a number of potential suppliers competing for the available business and doing so on the basis of a delivered price. These competitors may have a wide range of characteristics, from a small proprietorship to a large public corporation, and from a large to a small plant.

A model regional market for sand and gravel has been constructed for the Baltimore-Washington area separately from the non-existant national market portrayed by examination of national aggregate statistics.

The size distribution of firms within the local market is one of the most important characteristics of that market. Table II-16 summarizes the number of firms by size which were considered to serve the Washington, D.C. Metropolitan area.

The size distribution in the D.C. Metropolitan area is quite different than that for the national aggregate industry. The Metropolitan area shows

Table II-16 SAND AND GRAVEL AND CRUSHED STONE OPERATIONS PROVIDING CONSTRUCTION AGGREGATES FOR THE WASHINGTON, D.C., METROPOLITAN AREA

Operation Size (Annual Production)	Number	Estimated Annual Production Share
Less than 91,000 metric tons	4	0.9%
91,001 to 227,000 metric tons	7	8.6%
227,001 to 454,000 metric tons	10	26.8%
Over 454,000 metric tons	8	63.7%
TOTAL	29	100.0%

Source: Arthur D. Little, Inc., estimates

a much greater concentration of operations in the larger production classes. It seems likely that the bulk of smaller operations in the nation would serve small urban areas and rural areas. It would appear to be appropriate to analyze the economic impact of the effluent standards in two hypothetical model markets, the larger metropolitan area and the smaller urban-rural area. The large market represents one extreme of competitive situation with large and small firms operating in a large market. The small market is composed of a few small firms each of which could dominate the smaller market.

Individual quarries in the typical market will establish a desired FOB selling price based on the production costs they experience in order to achieve a "reasonable" return on investment. What is "reasonable" will vary depending on the type of company; a proprietorship or a private corporation is normally more concerned with cash flow than is a large public company, which is attempting to achieve an acceptable return on investment for its stockholders. However, selling prices that are established by this mechanism are then liable to adjustment based on the perceived competitive environment and transportation costs.

Prices for different sizes/products can be quoted on a delivered basis per short ton for a truckload or on an FOB plant basis with customer pick-up. Both methods are frequently employed, but in both cases the physical transportation is usually carried out by independent truckers working on an on-call or contract basis. Because of price competition, many suppliers to a city will quote a standard FOB city price (a zone price) which will not normally vary between sources or with ultimate destination. Consequently, the customer may sometimes be located close enough to an individual quarry to make it worth his while to arrange pick-up on an FOB plant basis and thus save on freight equalization.

The effects of transportation costs on delivered price can thus be large. Sand and gravel are commodity products which are low in value, and have a high specific gravity. As a result, the pricing of the product for the majority of its applications depends greatly on the distance from the source of supply to the consumer. Transportation costs for the material currently average over 8¢ per metric ton per mile. Given the presumed FOB plant price of $1.63 per metric ton, the effective price to the consumer will double at a distance of approximately 20 miles. The average selling price for sand FOB city is $4.47 per metric ton implying an average shipping distance of 35 miles. A company with a significantly lower total cost structure will eventually be able to obtain a larger market share, if all other factors (such as transportation costs, etc.) are equal. Any operator able to gain a transportation advantage should be able to control a larger share of the market. The actual pricing mechanism, however, is influenced more by such factors as: the rate charged by the independent trucker; access to highways vs. secondary roads; whether return loads can be obtained; the amount of congestion over the route of travel and the customer-supplier-trucker relationships.

Delivered prices normally move in small increments in response to the leadership of one or other of the suppliers. In a typical market, this price leadership will change from time to time, as it does in the other basic industries, and no discernable pattern can be discovered. Because price increases are normally relatively small and are tied to changes in costs which are incurred by all producers, it is highly likely that the other competitors will follow the leader's example. If the leader makes a price increase that is considered unnecessary, or if his competitors wish to gain a strategic advantage and larger market share by holding back on similar price increases, the leader may be forced to roll back his increase. However, there is room in a typical market for a modest spread in FOB prices between suppliers of similar products. The picture is more clouded by inter-industry competition resulting from substitution, but this depends very much on the geology of the region and on product specifications.

E. POLLUTION CONTROL REQUIREMENTS AND COSTS

1. Effluent Control Levels

Table II-17 presents the EPA regulations for point source discharge of water effluents from the construction sand and gravel industry. These regulations require no discharge, either for a maximum average for 30 consecutive days, or a maximum for any one day, at all three levels: BPCTCA, BATEA, and NSPS. Any effluent originating as mine dewatering is to be limited to a maximum total suspended solids (TSS) of 30 mg/l for any one day.

2. Effluent Control Costs

The effluent control costs for process water from the construction sand and gravel industry are associated totally with the treatment and storage of suspended solids. The recommended level of control is no discharge, which requires the use of settling ponds and the total recycle of clarified process water, which is withdrawn as an overflow from the upper level of a settling pond. The ancillary equipment required consists primarily of a water handling system (e.g., pump, piping, etc.). The Development Document indicates that a flocculating agent might be necessary to enhance the settling rate of the suspended solid particles.

The Development Document presents the fixed capital and operating costs for several different compliance levels of a construction sand and gravel operation. (This is presented on Table 17, found on page 209 of Volume I of the October 1975 Development Document.) The wet process construction sand and gravel model plant size is 227,500 metric tons per year (250,000 short tons per year). The base year for the dollar value used for the development of this compliance cost table was mid-1972.

Table II-17 RECOMMENDED LIMITS AND STANDARDS FOR BPCTCA, BATEA, AND NSPS - CONSTRUCTION SAND AND GRAVEL INDUSTRY

	Concentration in Effluent	
	30-Day Average	24-Hour Maximum
Process Waste Water	No Discharge	No Discharge
Mine Dewatering		TSS 30 mg/l

Source: Development Document for Interim Final Effluent Limitations Guidelines and New Source Performance Standards, Mineral Mining and Processing Industry: Point Source Category, EPA 440/1-75/059 (Vol. I) and 0596 (Vol. II)

The following economic impact analysis is based on mid-1974 dollar value. The costs shown in the Development Document have, therefore, been modified by using the GNP inflator of 16.5%*. Mine dewatering costs are either negligible or are included in the costs presented in the Development Document.

Control costs at all levels were developed for three additional plant sizes, to determine the sensitivity of control costs to plant size. The four plant sizes used as the basis for the development of control cost are:

- 100,000 short tons per year (91,000 metric tons per year);
- 250,000 short tons per year (227,000 metric tons per year);
- 500,000 short tons per year (454,000 metric tons per year); and
- 950,000 short tons per year (862,000 metric tons per year.

Fixed capital costs were varied by the appropriate ratio of annual production costs raised to the 0.9 power, based on the 227,000 metric ton-per-year model size plant shown in the Development Document. Operating costs were varied as a direct function of plant capacity. These control costs are presented in Tables II-18 through II-21. A comparison of the cost per ton for compliance at any level among the four different plant sizes shows that control cost is very insensitive to plant size.

The characteristics of the four levels of control which were used in the impact analysis are summarized below:

*Survey of Current Business, Department of Commerce, Jan. 1975, Part I, p. S-1.

Table II-18 COST OF COMPLIANCE FOR MODEL CONSTRUCTION SAND AND GRAVEL FACILITY

Plant Size: 91,000 Metric Tons Per Year of Product
Plant Age: 5 Years Plant Location: Near Population Center
Base Year: Mid-1974

		Level				
		A (min)	B	C	D	G
Invested Capital Costs:						
Total		0	16,900	18,900	22,000	11,100
Annual Capital Recovery		0	2,800	3,100	2,700	1,300
Operating & Maintenance Costs:						
Annual O & M (excluding power & energy)		0	800	900	9,800	13,100
Annual Energy and Power		0	200	300	300	200
Total Annual Costs		0	3,800	4,300	12,800	14,600
Cost/Metric Ton Product		0	0.042	0.047	0.141	0.160
Waste Load Parameters (kg/metric ton of Product)	Raw Waste Load					
Suspended Solids	100	100	0.4	0	0	0

Level Description:

A - direct discharge
B - settling, discharge
C - settling, recycle
D - two silt-removal ponds, settling pond, recycle
G - flocculant, settling basin, recycle

Source: Development Document and Arthur D. Little, Inc., estimates

Table II-19 COST OF COMPLIANCE FOR MODEL CONSTRUCTION SAND AND GRAVEL FACILITY

Plant Size: 227,000 Metric Tons Per Year of Product
Plant Age: 5 Years Plant Location: Near Population Center
Base Year: Mid-1974

		Level				
		A (min)	B	C	D	G
Invested Capital Costs:						
Total		0	38,400	43,100	50,200	25,200
Annual Capital Recovery		0	6,300	7,000	6,100	3,000
Operating & Maintenance Costs:						
Annual O & M (excluding power & energy)		0	1,900	2,300	24,500	32,700
Annual Energy and Power		0	400	700	700	500
Total Annual Costs		0	8,600	10,000	31,300	36,200
Cost/Metric Ton Product		0	0.038	0.044	0.138	0.159
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load					
Suspended Solids	100	100	0.4	0	0	0

Level Description:

A - direct discharge
B - settling, discharge
C - settling, recycle
D - two silt-removal ponds, settling pond, recycle
G - flocculant, settling basin, recycle

Source: Development Document and Arthur D. Little, Inc., estimates

Table II-20 COST OF COMPLIANCE FOR MODEL CONSTRUCTION SAND AND GRAVEL FACILITY

Plant Size: 454,000 Metric Tons Per Year of Product
Plant Age: 5 Years Plant Location: Near Population Center
Base Year: Mid-1974

	Raw Waste Load	Level A (min)	Level B	Level C	Level D	Level G
Invested Capital Costs:						
Total		0	71,700	80,400	93,700	47,000
Annual Capital Recovery		0	11,800	13,100	11,400	5,600
Operating & Maintenance Costs:						
Annual O & M (excluding power & energy)		0	3,800	4,600	49,000	65,400
Annual Energy and Power		0	800	1,400	1,400	1,000
Total Annual Costs		0	16,400	19,100	61,800	72,000
Cost/Metric Ton Product		0	0.036	0.042	0.136	0.159
Waste Load Parameters (kg/metric ton of product)						
Suspended Solids	100	100	0.4	0	0	0

Level Description:

A - direct discharge
B - settling, discharge
C - settling, recycle
D - two silt-removal ponds, settling pond, recycle
G - flocculant, settling basin, recycle

Source: Development Document and Arthur D. Little, Inc., estimates

Table II-21 COST OF COMPLIANCE FOR MODEL CONSTRUCTION SAND AND GRAVEL FACILITY

Plant Size: 862,000 Metric Tons Per Year of Product
Plant Age: 5 Years Plant Location: Near Population Center
Base Year: Mid-1974

		Level				
		A (min)	B	C	D	G
Invested Capital Costs:						
Total		0	127,600	143,200	166,800	83,700
Annual Capital Recovery		0	20,900	23,300	20,300	10,000
Operating & Maintenance Costs:						
Annual O & M (excluding power & energy)		0	7,200	8,700	93,000	124,200
Annual Energy and Power		0	1,500	2,700	2,700	1,900
Total Annual Costs		0	29,600	34,700	116,000	136,100
Cost/Metric Ton Product		0	0.034	0.040	0.135	0.158
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load					
Suspended Solids	100	100	0.4	0	0	0

Level Description:

A - direct discharge
B - settling, discharge
C - settling, recycle
D - two silt-removal ponds, settling pond, recycle
G - flocculant, settling basin, recycle

Source: Development Document and Arthur D. Little, Inc., estimates

Level B - Settling with complete recycle given partial recycle at present, a move to process control C below, cost margins to achieve complete recycle from partial .025 acres of pond per 1,000 metric tons annual capacity.

Level C - Settling, recycle; requires approximately .025 acres of pond area per 1,000 metric tons annual capacity.

Level D - Two silt-removal ponds, settling pond, recycle; requires approximately .025 acres of pond area per 1,000 metric tons annual capacity.

Level G - Flocculant, settling basin, recycle; requires approximately .004 acres of pond-basin area per 1,000 metric tons annual capacity.

Although control levels E and F were included in the Development Document, they were not employed in the following economic impact analysis. These two control levels are for facilities which have such limited land available at the mining and processing site that appropriately sized settling ponds could not be installed.

The field survey of construction sand and gravel facilities which was conducted to provide some of the background and data base for the Development Document identified no construction sand and gravel operations which employ either of these two control levels.

Level E uses a mechanical thickener plus a flocculant, and Level F employs an inclined plate settler and a flocculant to affect settling in a relatively small area. The underflow from the thickener or inclined plate settler would consist of a semi-solid sludge of settled solids which would then be transported to a separate disposal area located where land would be available for this purpose. The total land area including the disposal site for Levels E and F is approximately equal to that of Levels C, D, or G, all of which employ settling ponds.

3. Current Levels of Control

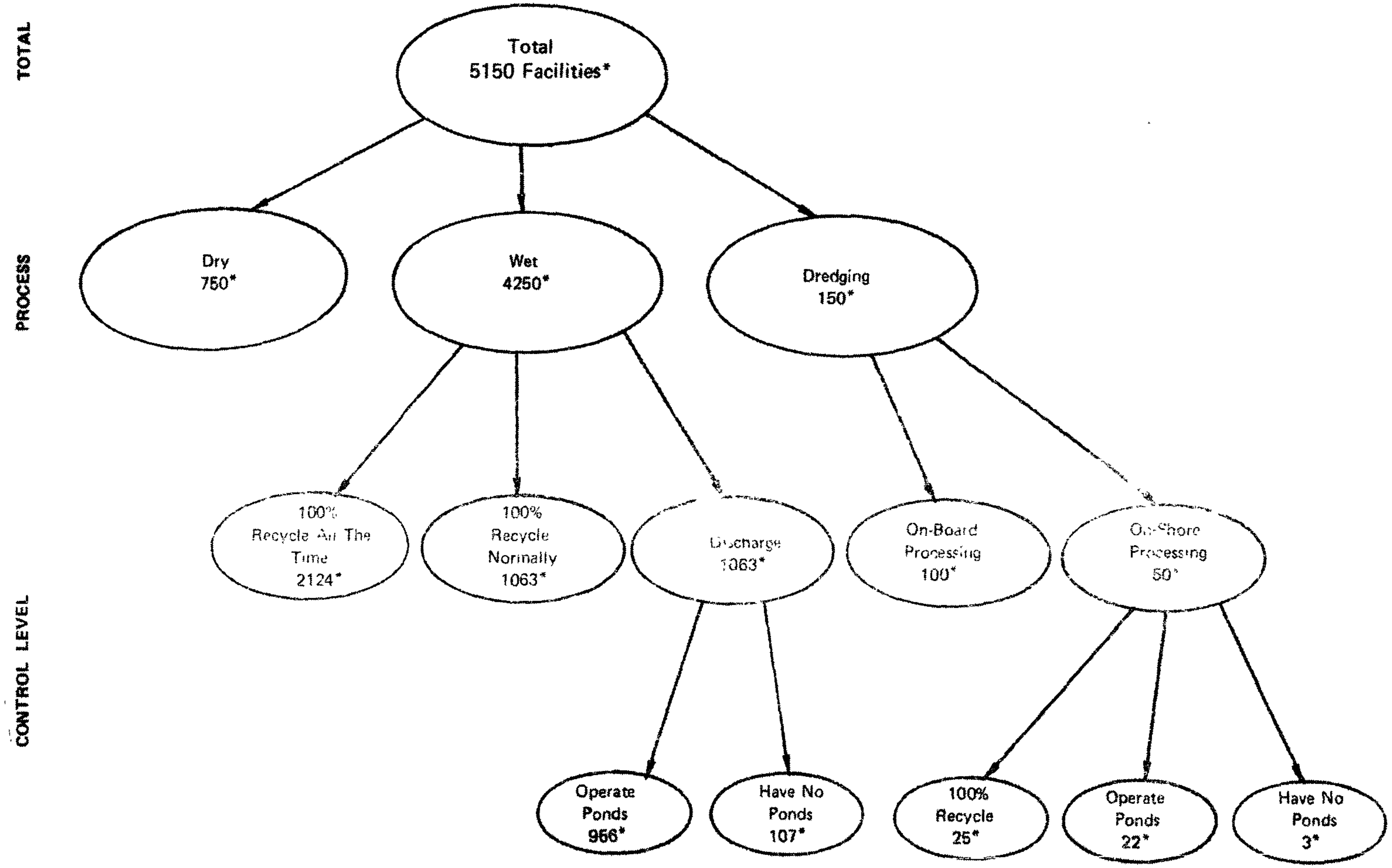
Figure II-1 shows the distribution of the total 5,150 construction sand and gravel facilities, and the way in which they are subdivided into the three main process categories--dry, wet and dredging. The wet and dredging processing categories are further subdivided into groups having the same current effluent control status--100% recycle, discharge from ponds and direct discharge).

Figure II-1 shows that of the total 4,250 wet processing facilities 3,187 (75%) are currently operating on 100% recycle of effluent water all of the time, or during normal operation. The remaining 1,063 facilities (25%) are discharging process water. Of this last category, 956 facilities operate settling ponds, but discharge effluent wastewater streams. The remaining 107 facilities presently discharge their process water directly, and don't operate settling ponds.

The construction sand and gravel industry in the United States can be divided along process technological lines into three subcategories:

a. Dry Process

Table II-10 shows that in 1972, there were 750 dry operations in the construction sand and gravel industry. This represents 14.6% of the total 5,150 sand and gravel operations in the United States. The Development Document indicates that not only is there no process water associated with these dry operations, but that there is no mine dewatering as well. Therefore, because there is no water at all associated with these operations, there is no control either.



*Number of Facilities.

Source: Development Document

FIGURE II-1 DISTRIBUTION OF CONSTRUCTION SAND AND GRAVEL FACILITIES BY PROCESSING AND CURRENT CONTROL LEVEL CATEGORIES – 1972

b. Wet Process

In 1972, there were a total of 4,250 wet process construction sand and gravel operations in the United States, representing 82.5% of the total number of plants, and producing 74.7% of the total annual production.

c. River Dredging

The Development Document indicates that there were a total of 150 construction sand and gravel operations employing dredging in 1972. These are divided into two main subcategories, based on the location of the processing operations. One hundred of the dredging operations use on-board processing and are regulated under Section 404 of the Federal Water Pollution Control Act Amendments. The remaining 50 dredging operations employ on-shore processing. Of the latter facilities, 25 are presently operating with 100% recycle of process water, and thereby comply with the proposed regulations. Some 22 more operations presently employ settling ponds, but operate with some discharge. The remaining three facilities presently do not have ponds.

4. Total Control Costs

Table II-22 indicates the number of plants, etc., requiring no, partial, or full effluent treatment. In summary, about 79% of all plants, representing about 75% of production, either require no treatment because they utilize a dry process or have already implemented BPT/BAT by recycling their process water. Of the remaining facilities, 19% (978 plants) settle their process water before discharging, while 2.2% (110 plants) presently have no controls. These facilities represent 22.9% and 2.4% of total production, respectively.

Table II-23 presents the total fixed capital, and the annual costs associated with the additional required control for the individual segments

Table II-22 INCREMENTAL CONTROL COSTS FOR CONSTRUCTION SAND AND GRAVEL FACILITIES, SEGMENTS AND TOTAL INDUSTRY (BPCTCA, BATEA)

TREATMENT REQUIRED	PROCESS	CURRENT EFFLUENT CONTROL STATUS	CURRENT CONTROL LEVEL	FUTURE CONTROL LEVEL	NUMBER OF PLANTS	PRODUCTION THOUSAND METRIC TONS	ADDITIONAL CONTROL COSTS REQUIRED FOR COMPLIANCE: TOTAL CAP. MILLION $	ADDITIONAL CONTROL COSTS REQUIRED FOR COMPLIANCE: ANNUAL COST $/METRIC TON
None	-Dry	No Process Water	-	-	750			
	-Wet	100% Effluent Recycle	C	C	3,188			
	-Dredging (OLP)*	100% Effluent Recycle	C	C	25			
	-Dredging (OBP)**	No Discharge	-	-	100			
TOTAL					4,063	563,899	0	0
Partial	-Wet	Ponds and Discharge	B	C	956			
	-Dredging (OLP)*	Ponds and Discharge	B	C	22			
TOTAL					978	174,995	3.47	0.006
Full	-Wet	No Ponds	A	C/D/G	107			
	-Dredging (OLP)*	No Ponds	A	C/D/G	3			
TOTAL					110	22,106	3.99	0.058
INDUSTRIAL TOTAL					5,151	761,000	7.46	0.003

*(OLP) = On-Land Processing
*(OBP) = On-Board Processing

Source: Development Document and Arthur D. Little, Inc., estimates

Table II-23 SUMMARY - CONSTRUCTION SAND & GRAVEL SEGMENTS, 1972

Process Treatment Required	Plants Number	Plants %	Production 10^3 Short Tons	Production 10^3 Metric Tons	%	Average Production 10^3 Short Tons/Plant	Average Production 10^3 Metric Tons/Plant	Employment* 10^3	Employment* %
1. Dry - none	750	14.6	143	130.1	18.8	191	173.8	6.4	18.7
2. Wet - none	3,187	61.9	387	352.1	50.5	121	110.1	17.2	50.5
- partial	956	18.5	168	152.8	21.9	176	160.1	7.5	21.9
- full	107	2.1	18	16.3	2.3	168	152.8	0.8	2.3
	4,250	82.5	573	521.4	74.7	135	122.8	25.5	74.7
3. Dredging (on-land processing) - none	25	0.5	8.35	7.59	1.1	334	303.9	0.4	1.1
- partial	22	0.4	7.35	6.68	1.0	334	303.9	0.3	1.0
- full	3	0.1	1.00	.91	0.1	334	303.9	0.1	0.1
	50	1.0	16.70	15.19	2.2	334	303.9	0.8	2.2
4. Dredging (on-board processing)	100	1.9	33?	30	4.3	334	303.9	1.5	4.3
INDUSTRY TOTAL	5,150	100.0	766	697	100.0	149	135.5	34.2	100.0

*At an estimated production rate of 22,500 short tons/employee.

Source: Development Document and Arthur D. Little, Inc., estimates

of the construction sand and gravel industry. The major fixed capital costs are associated with the wet processing segment, which consists of 956 facilities that are currently at the B level of control, through use of settling ponds with some discharge. (From Tables II-18 through II-21, the appropriate incremental control cost is the difference between Level C and Level B.) The final two columns of Table II-22 show total fixed capital and annualized cost, in dollars per metric ton of product for each of the aggregated control segments of the industry. These costs are developed for each of the process segments in the following impact analysis section.

The entire industry will not be subjected to increased costs of operation to meet the discharge standards. The majority of wet process operations already completely recycle, only about 1,100 will experience any increase in costs and about 1,000 of those plants will have to go only from partial recycle to total recycle at small marginal cost. To analyze the economic impact of the required controls each segment of discharge control process and plant size must be analyzed.

The total number of operations which are currently discharging all their process water is known. The total number of plants which are operating settling ponds but have some discharge is also known. In order to incorporate these present levels of control into the plant size segmentation with the available data, several assumptions were required. First, any plant which is already using a settling pond with partial discharge is assumed to be able to use control level C and achieve zero discharge.

Second, the operations which are currently discharging without treatment will be able to use control level C if their annual production is greater than 91,000 metric tons per year. The only reason for using any of the more expensive control technology is due to insufficient land area available at the facility site. Any large producer would have the necessary area available for the required settling ponds. The operations which could be forced to use the higher cost control processes would be the smallest of the model plant sizes.

The estimates of normal costs of operations for the larger model plants have been made with the assistance of information developed from an industry trade association survey of plants in this industry and in the crushed stone industry. This survey is described in the appendix.

To distribute the plants that must shift from total discharge to 100% effluent recycle (total-control plants) and the plants that must shift from ponds and discharge to 100% effluent recycle (incremental-control plants), we have used the national distribution of plants by size. These distributions are shown in Table II-24. Using these distributions we have assigned the plants requiring additional control expenditures into the following classes:

Class I - Plants requiring incremental discharge control segmented by plant size. Costs of control are based on the total costs for these plants estimated by the Development Document.

Class II- Plants which must shift from total discharge to total recycle have been distributed by plant size on the basis of the total industry size distribution.

Class II is further decomposed into estimated numbers of plants which must utilize the various discharge control processes.

Class II-C - The plants which have sufficient land to utilize settling ponds for complete recycle, which is control level C. All plants over 91,000 metric

Table II-24 WET PROCESS SAND & GRAVEL DISTRIBUTION OF PLANTS REQUIRING DISCHARGE CONTROL FACILITIES BY ANNUAL PRODUCTION

	All Plants	Incremental Control	Total Control
Total Plants	4,301	978	110
Less than 100,000	2,900	659	75
100,001-250,000	830	189	21
250,001-500,000	360	82	9
Over 500,000	211	48	5

Source: Arthur D. Little, Inc., estimates and Bureau of Mines tons annual production will fall into this class because the size of the operation presumes that they have sufficient area. The smallest class plants will probably have site constraints due to their lack of land from worked-out areas or areas available for pit expansion. It is unlikely that all would require other than Level C control processes. We have presumed on the basis of field information that 1/3 of the small plants will be able to utilize Level C control.

Class II-D - Of the remaining 50 small plants, site limitations will force 25 to use Control Level D.

Class II-G - The remaining 25 plants will have to use discharge Control Level G which requires the least land.

For the purpose of analyzing economic impact, the industry is segmented on the basis of size and required discharge control process in Table II-25.

Table II-25. SAND AND GRAVEL INDUSTRY SEGMENTED BY SIZE OF PLANT AND REQUIRED DISCHARGE CONTROL PROCESS

	Plants Currently at Total Recycle	Class I Incremental Control (B To C)				Class II-C Type A to C Control				Class II-D Type A-D Control	Class II-G Type A-G Control	Total
		<91,000	91,001-227,000	227,001-464,000	>454,000	<91,000	91,001-227,000	227,001-454,000	>454,000	<91,000	<91,000	
Number	4,063	659	189	82	48	25	21	9	5	25	25	5,150
Estimated Annual Production ($x10^3$)	563,889	36,485	49,000	44,150	50,360	1,554	6,114	5,440	5,890	1,554	1,554	766,000
Employment	25,171	1,630	2,190	1,973	2,250	69	273	243	263	69	69	34,200
Aggregate Control Cost (annual)	0	177,360	285,840	257,526	273,772	73,038	269,016	223,480	235,600	219,114	248,640	2,288,386
Aggregate Capital Required	0	779,604	986,375	822,495	886,087	322,753	1,160,852	963,383	978,478	375,692	189,554	7,465,277
Net Revenue Per Ton	.121	.121	.141	.145	.145	.121	.141	.145	.145	.121	.121	
Annualized Control Cost Per Ton $/Ton	0.000	0.005	0.006	0.006	0.006	0.047	0.044	0.042	0.040	0.141	0.160	
Cost Per Ton	1.648	1.648	1.648	1.648	1.648	1.648	1.648	1.648	1.648	1.648	1.648	

Source: Arthur D. Little, Inc., estimates

F. ANALYSIS OF ECONOMIC IMPACT

The basic result of the implementation of the effluent guidelines on the construction sand and gravel industry will be to increase costs of operation. The impact on the industry and the general economy will depend on the resulting changes in prices and production in the industry and any secondary impact those primary changes might generate. Table II-26 shows the normal operating costs of operation for the model industry plants and the cost of required levels of discharge control for each of the described industry segments. (These costs have been developed in Sections C and E, respectively.)

The table shows the costs of operation for various model plants and the annual costs required to meet effluent standards. The various levels of control costs are associated largely with land area required for various settling ponds or basins. As less land is available for settling ponds, the higher the costs of compliance as more equipment and chemical inputs are required.

Table II-26 demonstrates that the higher control costs are associated with the discharge control procedure which must be applied to sites with limited areas available for settling ponds. The variation of both general operating costs and discharge control costs is quite insensitive to plant size. There are some economies of scale in discharge control costs, but there appear to be only minor scale effects in the normal operating costs. The costs do vary considerably among different operations, but those variations appear to be the result of site specific costs such as land values, specific mining consideration such as depth of overburden, isolation of specific sands and gravels in the deposit, land rehabilitation costs, etc.

Table II-26 indicates that the additional cost on any operation requiring additional discharge control varies considerably.

Table II-26 COST COMPONENTS FOR THE SAND AND GRAVEL INDUSTRY

	Industry Size Segments			
Production level (st)	100,000	250,000	500,000	1,000,000
(mt)*	91,000	227,000	454,000	862,000
Revenues ($)	150,000	375,000	750,000	1,500,000
Normal Operating Costs ($)	137,000	343,000	684,000	1,375,000
Variable Costs	97,000	235,000	469,000	942,000
Labor	30,000	70,000	140,000	281,000
Materials	32,000	80,000	160,000	321,000
Repair & Maintenance	35,000	85,000	169,000	340,000
Fixed Costs	40,000	108,000	215,000	433,000
SG&A	27,000	60,000	120,000	240,000
Depreciation	8,000	35,000	70,000	140,000
Depletion	2,000	5,000	10,000	20,000
Interest	3,000	8,000	15,000	33,000
Net Revenues (pre-tax)	13,000	32,000	66,000	125,000
Net Revenue per mt*	0.143	.141	.145	.145
Compliance Costs ($)				
Level C - Total Costs	4,300	10,000	19,100	34,700
Variable	1,200	3,000	6,000	11,400
Fixed	3,100	7,000	13,100	23,300
Compliance Cost per mt*	.047	.044	.042	.040
Capital Requirement	18,900	43,100	80,400	143,200
Level D - Total Costs	12,800	31,300	61,800	116,000
Variable	10,100	25,200	50,100	95,700
Fixed	2,700	6,100	11,400	20,300
Compliance Cost per mt*	.141	.138	.136	.135
Capital Requirement	22,000	50,200	93,700	166,800
Level G - Total Costs	14,600	36,200	72,000	136,100
Variable	13,300	33,200	66,400	126,100
Fixed	1,300	3,000	5,600	10,000
Compliance Cost per mt*	.160	.159	.159	.158
Capital Requirement	18,900	25,200	47,000	83,700
Incremental Level B-C - Total Costs	800	1,400	2,500	5,100
Variable	500	700	1,200	2,700
Fixed	300	700	1,300	2,400
Compliance Cost per mt*	.005	.006	.006	.006
Capital Requirement	2,000	4,700	8,700	15,600

*Metric ton

Source: Arthur D. Little, Inc., estimates

Because of the value and transport cost of construction sand and gravel there is no national market but rather a series of local markets. The industry would appear to be very competitive on the basis of aggregate national figures, i.e., the existence of many small processors. However, transport costs place definite limits on the area any producer can serve which means each producer is an oligopolist in a very localized market and faces little competition from any other producers 50 to 100 miles from that local market. (Evidence of the highly local structure of markets is seen in the wide disparity of prices shown in Table II-15.)

The basic market for sand and gravel is various forms of construction, an activity which is largely concentrated within major population aglomerations; that is, within metropolitan areas or at the fringes of metropolitan areas. The economic impact of the effluent controls in this industry will depend on the structure of the local market which the impacted firms serve.

The economic impact of the effluent guidelines on a plant and market will depend on the type of plant affected, the control process required, and type of market the plant serves. The following economic impact analysis has been made for two types of markets: the major metropolitan market such as for the Baltimore-Washington area, and the small metropolitan or rural market. The rationale for the use of these model markets was developed earlier in Section D.3 (Prices and Price Setting).

1. Incremental Control in a Major Metropolitan Market (Case 1)

a. Price Effects

In this case, the additional cost of operation due to the guidelines is very slight, at $0.006 per metric ton. If large plants in the market were required to install controls they would possess the market power in the large market to pass costs on. Sand and gravel is an essential component of construction either directly or in other products such as concretes or concrete products. The only substitute products are in the form of crushed stones which are generally significantly more expensive. (Crushed stone prices have been estimated in Chapter III at $2.00 per metric ton or 25% higher than sand and gravel.)

The price elasticity of demand for sand and gravel is very nearly zero in the range of present prices up to the price per ton of the substitute, crushed stone. Sand and gravel is a very small component of total construction costs, so that a price increase in sand and gravel results in a much smaller increase in total construction cost. (Nationally, $135 billion worth of construction required $1.3 billion worth of sand and gravel directly or through other materials such as ready-mix concrete, paving materials, concrete block, etc. Thus a 10% increase in sand and gravel costs would translate into a 0.1% increase in construction costs.)

The $0.006 per ton control cost in this market could be easily passed on to consumers by a plant requiring additional effluent controls. But a small plant in a large market would have to absorb the cost increase, because it would face competition from other plants in the large market. For this case, the price impact would range from zero to $0.006 per ton, or an estimated maximum price increase of 0.3%.

b. Financial Effects

For any large plants requiring incremental control in this case, the rates of return and cash flow position would be unaffected, because they would be able to pass on the cost increase. The essentially zero price elasticity of demand means that these firms would not suffer a decline of sales in the face of a small price increase. Net revenues would be maintained in the face of the cost increase.

Small plants which could not pass on a price increase would have to absorb the $0.006 per ton, a 0.5% decline in net revenues per ton.

Because additional investment is required in the plants that must add effluent controls, not only must net revenues after the increase controls be sufficient to maintain reasonable rates of return, but capital must be made available to fund the required investment. The incremental capital requirements for the change from Control Level B to C for the model firms appears relatively modest. One measure of current capital employed in these plants is the normal depreciation charge. The total required investment for pollution control is 11% or less of annual depreciation. This relatively small addition to capital stock for the model plants should result in little funding difficulty. The smaller plants would have more difficulty raising capital, require a smaller relative investment level, so even though their net revenues could be adversely affected, the small and large plants should be able to fund the required investment from retained earnings or as part of normal borrowings.

c. Production Effects

All 978 plants in this first case are all currently at Control Level B, and therefore, only a relatively small incremental control cost will be needed to meet the guidelines. Consequently even the smaller plants are not expected to experience adverse price and financial effects.

No closures of plants are anticipated, so there is no anticipated change of production for this case.

d. Employment Effects

The lack of expected plant closures for this case would leave employment levels unaffected.

e. Community Effects

The community would face no loss of jobs or incomes.

2. Level C Control for Small Plant in a Major Metropolitan Market (Case 2)

a. Price Effects

As discussed above, the small plants in the major metropolitan market would not be able to pass on the increased costs of compliance. These plants could not raise prices in the face of competition from other firms who did not face control costs. For this case, we shall consider prices unchanged.

b. Financial Effects

The small plants would have to absorb the entire additional control cost or about $0.045 per ton. The impact is a decline in net revenues of about 33%. This decline would be a significant drop in net revenues and a significant deterioration of return on sales and capital. Although the capital required for the small plants is not large, the significant decline in net revenues would make it unlikely that the required investment could be supported by future earnings. The result would be that small plants in larger markets would be expected to close. The closure of such firms is predicted on a rather narrow economic criterion of viability. The plants could continue to operate if their owners were willing to accept lower returns. In cash flow terms, the viability of these operations looks a little better, and if the owner had few alternate opportunities he could continue in operation.

c. Production Effects

The position of the smaller plants in the model large market would indicate that the lost production would be very slight. If all the very small plants (under 91,000 metric tons) were to close in a model market, less than 1% of annual production would be lost from such closures. It is expected that the unaffected plants in the market could easily increase output to make up for the loss. The net effect would be no change in the market's total available production.

d. Employment Effects

The jobs associated with the closed plants would be lost. Estimating employment in our model market via the national employment per ton of production, the closure of these firms would result in the loss of 5 to 10 jobs. This loss would be insignificant in a large market area.

e. Community Impacts

The insignificant employment loss under this case should not generate any significant adverse community impacts.

3. Level D or G Control for Small Plant in a Major Metropolitan Market (Case 3)

Case 3 is a variation on Case 2. In this case, smaller plants would be required to use the much more expensive control procedures of Level D or G. In either case, they would be forced to close. The cost of control to these plants is high enough to almost eliminate net revenues, so they appear to have no choice but to close under the guidelines. The economic impact would be identical to that in Case 2.

4. Level C Control for Large Plant in a Major Metropolitan Market (Case 4)

a. Price Effects

In this case, the larger plants in a large market would have sufficient market power to pass on the increase in price. The $0.04 per ton control cost translates to a 2% price increase. That is not enough to bring competition from crushed stone substitutes, and the virtually zero price elasticity of demand would mean that the cost increase could be passed on with no loss of demand.

b. Financial Effects

The ability to increase prices would mean that net revenues would not be affected, so cash flow return on sales or capital would not be reduced.

Because additional investment is required in the plants which must add effluent controls, not only must net revenues after the controls be sufficient, but capital must be made available to fund the required investment. The capital requirements for control process capital costs for the model plants are significant. Using depreciation as a measure of the capital employed in the normal production process, the total investment would be greater than annual depreciation. The normal cash flow of such plants would likely not generate sufficient retained earnings to fund the investment internally. However, because the larger plants are located in larger market areas, they should have access to funds from regional banks. The capital requirements for a single plant would not be a large share of total regional bank loans, so it should be possible for the industry to fund the required investment.

c. Production Effects

No plant closures are anticipated, so there would be no production changes due to the guideline implementation.

d. Employment Effects

No jobs would be lost through plant closures.

e. Community Effects

There would be no adverse impact on the community in this case.

5. Level D or G Control for Small Plant in a Small Metropolitan or Rural Market (Case 5)

a. Price Effects

In the small market, small firms would not face much competition and would be able to pass cost increases on to consumers. The cost increase due to the effluent controls will be substantial for small firms. Level G, the most expensive, would increase prices by just over 10%. The increase is not expected to be enough to bring about substitution of crushed stone for sand and gravel, and the value of sand and gravel costs in total construction costs would mean only a 0.1% increase construction cost (see Case 1, above), so the costs would probably be passed on.

Because the highest control cost could be passed on, should plants in small market areas require any of the lower-cost control procedures, they certainly should be able to pass on the smaller price increases involved. In small markets with plants facing compliance, sand and gravel costs could be expected to increase 2% to 10%, depending on the actual control required.

b. Financial Effects

Net revenues are expected to be maintained through the anticipated price increases. The capital required is substantial for small firms. Using depreciation as a measure of capital presently used in the model plants, the additional capital required for control is two to three times annual depreciation. It seems likely that the required funds could not come from retained earnings. While capital requirements appear to be a burden on plant finances, the necessary funds should be available from the local banking system. The biggest total capital required even for a moderately sized plant ($50,000) is equivalent to the loan for one substantial single family house. The ability to raise prices should mean that the banking system would consider the loan favorably.

c. Production Effects

No plant closures are anticipated, so that there would be no effluent-control-cost-induced production shifts.

d. Employment Effects

No jobs would be lost through plant closures.

e. Community Effects

There would be no anticipated adverse impact on the community in this case.

6. Aggregate Impact Summary

There are approximately 5,150 facilities in the sand and gravel industry. Of these, about 750 are dry processors and have no effluent discharge, and the remaining 4,400 use water in the processing. It is estimated that 1,088 plants with wet processing are not presently meeting the BPT requirement of total recycle of process water.

Some 978 facilities already have some treatment in place. These plants will incur additional annual costs of less than 0.5% over present annual expenditures, or less than $0.01 per ton. The incremental investment required to meet BPT will be less than 3% of the book value of assets.

For the 110 plants with no treatment in place, the annual effluent control costs could increase current expenditures by as much as 10.7%. The required investment to meet BPT will be high: 18% to 34% of the book value of assets. Although there are several treatment options available, only settling and recycle of process water (Level C) appears economically viable.

The analysis incorporates an estimate must be made as to the numbers of each class of plant falling into each market model. Small firms appear to be located generally in the smaller markets. Also, a small market would not support larger size plants. It has been assumed that 50% of the less than 91,000 metric ton capacity plants are in small markets, and 25% of the 91,000 to 227,000 ton capacity plants are in small markets. Given this size distribution, the national economic impact can be estimated. Table II-27 shows the numbers of plants, production, and employment by the three summary impact groups:

- unimpacted,

- plants that will increase prices but remain open, and

- plants which are expected to close.

The only plants expected to close are the smaller plants that must shift from total discharge to total recycle and also operate in large markets. An estimate is also included for plant closures should all the plants which are marginal candidates for closure remain open. This is a lower limit of the anticipated adverse economic impact. It appears unrealistic to expect operators to remain in business at the lower returns, but there may well be special cases where operation would be continued.

Table II-27 NATIONAL SUMMARY OF ECONOMIC IMPACT SAND AND GRAVEL INDUSTRY

IMPACT CATEGORY Effect	Characterization	Number of Plants	%	Production 10^3 Metric Tons	%	Employ-ment	%
Not Affected	Dry Process or 100% Effluent Recycle	4,063	78.9	563,899	73.6	25,171	73.6
Not Affected	Pass on Cost Increase	1,033	20.0	195,685	25.5	8,720	25.5
Affected	Control Level C	31	0.6	13,635	1.8	616	1.8
Affected	Control Level D	12	0.2	776	0.1	34	0.1
Affected	Control Level G	12	0.2	776	0.1	34	0.1
Range of Plants Subject to Closure	High	55	1.1	6,916	0.9	309	0.9
	Low	26	0.5	1,942	0.3	86	0.3
TOTAL*		5,150	100.0	766,000	100.0	34,200	100.0

*Based on high end of closure range

a. Summary Price Effects

Of the plants expected to increase prices, just under 2% of production would be subject to a price increase of more than 2%. Only 25% of industry output would be subject to any price increase. Because of the local structure of the sand and gravel markets, the price increases would be absorbed within each local market and the impact on national sand and gravel prices would be negligible.

b. Summary Financial Effects

The plants which remain viable economic units in their respective local markets are expected to be able to raise the necessary capital. The total ($7.5 million) capital required (Table II-22) is not a significant share of total national investment, so there is no national financial impact for the sand and gravel effluent guidelines.

c. Summary Production Effects

The anticipated closure of range of 26 to 55 smaller sand and gravel plants nationally would reduce output by 0.3 to 0.9% respectively. However, in each market this lost production is expected to be made up by increased production at other plants. The net impact on total production would be negligible. The economic analysis indicated that if a plant needed to install Level D or G treatments, and was unable to pass the costs on, they could not continue operations due to a negative cash flow. However, if the Level C technology was installed, the cash flow would remain positive although profitability would fall by one-third from present levels. Due to the serious economic impacts predicted for plants requiring technologies D and G, the effluent guideline is based on Level C technology. Because of these factors--the uncertainty of whether or not plants will be able to finance the needed investment, even assuming use of a Level C treatment--it is estimated that up to 26 plants may close. At most, these plants represent 0.3% of present national production.

The additional capital for discharge control for new facilities in the industry should not be a limitation on the future expansion of production. The capital requirements may mean that new facilities will tend to be larger, but plant size appears to be a function of local market size rather than economies of scale. The guidelines should not alter the patterns.

d. Summary Employment Effects

The anticipated plant closures are estimated to reduce employment in the industry by 86 to 309. Even the maximum job loss is negligible in terms of national employment impact.

e. Summary Community Effects

Each affected market area should be able to absorb the job loss due to expected plant closures. No further impact is expected to be felt by other areas which do not experience plant closures, because each market constitutes a closed system.

f. Summary Balance of Trade Effects

The highly local nature of sand and gravel markets because of high transportation costs means that expected price increases would not induce any measurable competition from imports. National balance of trade would be unaffected.

g. Summary Industry Growth Effects

It is not anticipated that industry growth will be significantly affected by these guidelines. Construction sand and gravel facilities will tend to incorporate the land required for settling ponds into future siting specifications.

G. LIMITS OF THE ANALYSIS

In addition to the general limits imposed by the overall method used for the economic analysis, the sand and gravel industry raises some additional limitations.

The structure of the industry requires analysis of local markets and yet only scanty information is available concerning the actual structure of those markets. The impact of the guidelines would be shifted if plants do not exist in the classes of markets that have been assumed. The assumptions used are believed to err on the side of overstatement of the adverse economic impact. In this analysis it has been assumed that a larger share of small plants are in large markets than is likely to be the case, but there is no real way of testing this hypothesis.

A narrow definition of economic viability has been used. Individual operations may be willing to accept lower rates of return because of property values of the site, future potential land values, etc. The sand and gravel plant may be a means of just meeting the holding costs for an appreciating asset. As long as the operation can meet its costs of operation, it will be kept going. This error would again lead to an overstatement of the economic impact of the guidelines. An estimate has been prepared as a low range for plant closures should this acceptance apply to the plants which are potentially marginally profitable. Other than for the small plants in large markets the highest effluent control costs can be either passed on or are sufficient to virtually eliminate profitability. The incremental control costs are sufficiently small that if they were in error by a factor of two or even three, the impact would not be altered.

There are also discharge situations where the cost of zero discharge is effectively infinite. Some pits experience instrusion of water from springs, which means that the water level rises until it naturally runs off into nearby streams. Should zero discharge be rigidly applied to these operations, they would require an ever-increasing pond area to hold the net inflow of ground water. In like manner, hydraulic dredging sand and gravel operators who process on land would eventually have to store all the water they ever took out of the river. Control in these cases is physically impossible. Since these constitute special cases it is expected that they will be handled individually when the permit is written.

While there are limits to the analysis, the basic approach taken has been to make assumptions which would overstate the adverse economic impact. Within this context the expected impact for sand and gravel is of such magnitude that even increased by a factor of ten it would remain negligible.

III. CRUSHED STONE, [SIC-1422, SIC-1423, SIC-1429]

A. PRODUCTS, MARKETS AND SHIPMENTS

1. Product Definition

Stone is an inclusive term that covers products and materials ranging from highly finished exotic marbles, through other finished dimension building stone, dimension slate, stone rubble, and the many varieties of crushed and broken stone. The stone industry is the largest non-fuel, non-metallic mineral industry in the United States from the standpoint of total value of production and is second only to sand and gravel in volume produced. The crushed stone industry, examined by this study, is regionally highly dispersed and produces a low-value commodity product in locations close to urban areas. Because of the latter, the industry has been facing acute land use and environmental problems that have, in certain cases, added considerable cost burdens above normal operating costs. Some urban and suburban quarries are now only permitted to operate within limited daily hours; some have had to file and implement redevelopment plans for depleted quarries.

Crushed stone is a term used to describe a rock that has been reduced in size after mining to meet various consumer requirements. The rock may meet any one of many minerological definitions, such as limestone, granite, or trap rock. Specifications are also numerous because of the diversity of stone types, the variations in physical and chemical characteristics within each type, and the large number of different end uses. The specifications are prepared and established by various organizations, such as the American Society for Testing and Materials and the American Association of State Highway Officials; further specifications exist to control the use and performance of crushed stone in different applications, such as concrete, highway construction, etc. For example, specifications for stone used in highway concrete normally insist that the product be washed.

2. Production Processes

Crushed stone is normally mined from open quarries using surface mining equipment that varies with the type of stone, planned rate of extraction, size and shape of the deposits and other factors. After the stone face is exposed by removing the overburden, holes are drilled for inserting various blasting mixtures (normally ammonium-nitrate/fuel-oil mixtures). Drilling is commonly done with percussion machines that drill 4- to 6-inch holes some 15- to 20-feet deep in a 15-to-20 foot pattern. Drilling rates in limestones are around 35 feet per hour and in the hard stones about 20 feet per hour.

Depending on the size of the fragmented stone, additional (secondary) breakage of up to 10% of the stone is carried out either at the quarry face by further blasting, with mechanical equipment such as drop hammers, or at the crushing plant.

Transportation and conveying equipment used in the quarry includes track-mounted bulldozers and shovels, pneumatic-tire trucks, or conveyor belts at the crushing plant. After the blasting operation, the stone is front-end loaded into 15-to-35 ton capacity off-the-road vehicles that transport the large pieces to crushers for processing. The stationary crushing plants are located both near access roads (so that the finished product may be shipped to consumers) and also at a central location convenient to the quarry faces being worked. Stone is always size-reduced; the plant has at least two crushing stages to get the required size reductions, as well as various screening, conveying, and loading equipment. Primary crushing is usually carried out with jaw crushers, gyratories, or impact crushers; secondary or tertiary crushing uses cone crushers, gyratories, or hammer mills. Rod mills are used where fine grinding is required.

Screening of the crushed stone to separate the product into different size gradations is carried out by a combination of horizontal or inclined vibrating screens; heavy, punched-steel plates are used for large size separations and woven wire screens are used for smaller material.

After crushing and classifying, highway concrete stone is washed and all grade stone is then conveyed to stockpiles close to the crushing plant. Some plants make only two or three finished sizes, while others make up to 20. It is from such stockpiles that trucks, barges, or railcars are loaded for delivery to the customer.

Portable aggregate plants are being used increasingly to supplement stationary plants. Such plants are smaller and more mobile editions of stationary facilities and can be established either by a contractor or a commercial producer. Commercial producers may operate portable plants to extend their operating radius or to expand the capacity of fixed equipment.

Contractors may decide to establish a plant at a deposit local to a specific project to reduce the delivered cost of stone for that project or to ensure a steady supply of material. This situation may occur when a specific construction project is an uneconomical distance from commercial quarries so that transportation costs might be prohibitively high. Also, the demand for crushed stone from such a project might be so great as to strain the operating capacities of commercial quarries in the locale, yet not justify expanding the latter capacities to serve a one-time need. Good examples of such an occurrence might be the construction of a major highway, such as the Interstate Highway System, or of a dam that requires significant volumes of materials for a short time period and would thus justify a contractor's investing in portable equipment and operating a local deposit.

Over the past few years, a number of changes in production technologies have resulted from the desire to make operations more efficient, more cost effective, and more environmentally acceptable. Such changes include: the design and installation of larger units of equipment to increase operating capacities and the introduction of automatic and centralized control systems to produce the optimal product mix and to eliminate many of the labor-intensive tasks in the quarry. Finally, the industry has taken some steps to alleviate environmental problems (involving air and noise pollution, as well as aesthetic considerations) by implementing pollution control measures, new blasting techniques and schedules, land rehabilitation and reuse policies, and even by carrying out a limited amount of underground mining close to urban areas.

3. Shipments

Domestic shipments of crushed stone as reported by the Bureau of Mines increased at an average annual compound rate of 3.3% from 707.7 million metric tons in 1965 to 947.8 million metric tons in 1974 (Table III-1). Mainly because of price inflation, total value of shipments increased at a greater rate of 7.2% annually from 1965 to 1974. In 1974, the value of shipments of crushed stone reached a high of $2.1 billion. Foreign trade in crushed stone is negligible and largely limited by transportation costs. The 1973 exports totalled $10 million (0.5% of domestic production) and imports, $5.5 million. Shipments (value and tonnage) since 1972 have been:

		Quantity	
Year	Value ($10^6$$)	10^6 Short Tons	10^6 Metric Tons
1973	1904	1060	965
1974	2086	1042	948
1975	1900	856	779

TABLE III-1 CRUSHED AND BROKEN STONE SHIPPED OR USED BY PRODUCERS IN THE UNITED STATES 1965-1974

	LIMESTONE & DOLOMITE		GRANITE		TRAPROCK		SANDSTONE, QUARTZ & QUARTZITE		OTHER*		TOTAL	
	QUANTITY (10^5 short tons)	VALUE (10^3\$)	QUANTITY	VALUE	QUANTITY	VALUE	QUANTITY	VALUE	QUANTITY	VALUE	QUANTITY	VALUE
1965	554,204	748,755	59,242	88,012	75,503	120,491	28,701	50,923	60,189	103,415	777,839	1,111,596
1966	568,849	776,009	65,262	94,711	88,586	146,899	27,088	46,934	61,262	106,348	811,047	1,170,901
1967	568,902	783,135	62,443	94,664	68,430	116,301	26,903	50,152	56,904	100,520	783,582	1,144,772
1968	603,136	857,361	69,830	105,236	73,099	124,749	26,698	52,382	44,775	79,741	817,538	1,219,469
1969	628,362	919,923	75,189	116,102	78,901	142,360	27,145	53,293	51,424	94,369	861,021	1,326,047
1970	625,313	946,087	86,133	137,795	77,217	146,391	23,768	48,526	55,197	95,642	867,628	1,374,441
1971	628,035	1,016,088	92,912	156,177	75,303	160,281	30,398	74,521	47,849	93,866	874,497	1,500,933
1972	671,496	1,090,707	106,266	182,930	80,462	170,823	26,817[a]	57,994[a]	37,320	90,115	922,361	1,592,569
1973	774,397	1,321,932	120,606	216,874	83,959	177,671	30,351	69,647	49,228	118,340	1,058,541	1,904,464
1974	751,515	1,428,232	118,558	238,144	96,885	217,897	31,090	77,815	43,579	123,749	1,041,627	2,085,837
Compound Growth Rate	3.4	7.4	8.0	11.7	2.8	6.8	0.9	4.8	-3.5	2.0	3.3	7.2

*Other, includes marble, shell, slate, calcareous marl, and other stone.

a Excludes stone used in manufacture of industrial sand in 1972.

Source: U.S. Department of the Interior, Bureau of Mines; Minerals Yearbook, Volume I (various years)

The sharp drop in 1975 reflected the recessionary impact on the construction industry.

The advance in domestic shipments during the 1965-1974 period was led by a 3.4% increase in the output of limestone and dolomite to 684.3 million metric tons valued at $1.4 billion and a 8.0% rate of increase in the output of granite to 108.2 million metric tons valued at $238 million. Shipments of trap rock increased 2.8% annually over the decade reaching 88.3 million metric tons valued at $218 million in 1974. Offsetting the increased shipments in these kinds of stones was a small decrease in other types of stone--a category which includes marble, shell, calcareous marl, slate, and miscellaneous other stone.

Shipments of sandstone, quartz, and quartzite increased 0.9% from 1965 to 1974 to 28.2 million metric tons while dollar value of shipments increased at a rate of 4.8% to $78 million in 1974. Shipments of other crushed stone declined 3.5% annually, in tonnage terms, mainly because of decreasing output in the calcareous marl and shell subsectors.

In 1972, limestone and dolomite accounted for 73% of total tonnage of crushed stone shipped or used by U.S. producers; granite (12%); trap rock (9%); sandstone, quartz, and quartzite (3%); and other stone (3%) as shown in Table III-2. Data on a regional basis was not available for 1974.

Regionally, shipments vary significantly with the type of stone considered, but because limestone captures such a large percentage of the total, its distribution dominates. All regions contributed to the output of limestone in 1972. The proportion of limestone shipments among regions was consistent with the population breakdown. However, granite shipments were much more concentrated regionally. The South Atlantic region accounted for 75% of total granite tonnage shipped in 1972. Traprock shipments came primarily from the Northeast and Pacific regions. The New England, Middle

TABLE III-2 CRUSHED STONE SHIPPED OR USED BY U.S. PRODUCERS BY REGION, 1972

Region	Limestone & Dolomite Quantity	Limestone & Dolomite % of U.S.	Granite Quantity	Granite % of U.S.	Traprock Quantity	Traprock % of U.S.	Sandstone, Quartz, Quartzite Quantity	Sandstone, Quartz, Quartzite % of U.S.	Other Quantity	Other % of U.S.	Total Quantity	Total % of U.S.
New England												
1000 short tons	2,371	0.4	474	0.4	12,849	16.0	51	0.2	9	--	15,754	1.7
percent	15.1		3.0		81.6		0.3		0.1		100.0	
Middle Atlantic												
1000 short tons	90,833	13.5	2,884	2.7	23,333	29.0	44,279	16.0	1,340	4.0	122,669	13.4
Percent	74.0		2.4		19.0		3.5		1.1		100.0	
East North Central												
1000 short tons	185,323	27.6	1,267	1.2	--	--	2,064	7.7	347	1.0	189,001	20.6
percent	98.1		0.7		--		1.1		0.2		100.0	
West North Central												
1000 short tons	93,824	14.0	--	--	97	0.1	1,162	4.3	25	0.1	95,108	10.4
percent	98.6		--		0.1		1.2		--		100.0	
South Atlantic												
1000 short tons	103,390	15.4	79,562	74.9	4,561	5.7	1,896	7.1	--	--	189,409	20.6
percent	54.6		42.0		2.4		1.0		--		100.0	
East South Central												
1000 short tons	86,743	12.9	--	--	--	--	57	0.2	152	0.5	86,952	9.5
percent	99.8		--		--		0.1		0.2		100.0	
West South Central												
1000 short tons	65,783	9.8	--	--	39	--	6,764	25.2	14,254	42.5	86,840	9.5
percent	75.8		--		--		7.8		17.4		100.0	
Mountain												
1000 short tons	14,630	2.2	1,529	1.4	4,424	5.5	1,420	5.3	864	2.6	22,867	2.5
percent	64.0		6.7		19.3		6.2		3.8		100.0	
Pacific												
1000 short tons	20,385	3.0	6,610	6.2	29,312	36.4	6,396	23.9	5,185	15.5	67,888	7.4
percent	30.0		9.7		43.2		9.4		7.6		100.0	
Undistributed												
1000 short tons	8,214	1.2	13,940	13.1	5,848	7.3	2,728	10.2	11,381	33.9	42,111	4.6
percent	19.5		33.1		13.9		6.5		27.0		100.0	
United States												
1000 short tons	671,496	100.0	106,266	100.0	80,463	100.0	26,817	100.0	33,557	100.0	918,599	100.0
percent	73.1		11.6		8.8		2.9		3.7		100.0	

Source: U.S. Department of the Interior, Bureau of Mines; Minerals Yearbook, Volume I, 1972.

Atlantic, and Pacific regions account for 81% of traprock shipments. All regions ship some sandstone, quartz, and quartzite, but the Pacific and West South Central regions combined account for about 50% of the total.

4. End Uses

The end uses for crushed stone are many and varied, but construction and construction-related applications account for at least 80% of total shipments. Crushed stone is either used directly in its natural state or is shipped for further processing into miscellaneous manufactured products.

In its natural state, stone is an important ingredient for highway and street construction where it can form the road base, be included in the concrete or bituminous pavement as an aggregate or to be used as an anti-skid material for surface treatment. (The Development Document estimates that about 136.5 million metric tons (15%) of the total stone produced is washed for highway concrete use.) As an aggregate in other types of concrete, stone is sold to ready-mix and precast concrete manufacturers as a basic ingredient for structural concrete. Still in its natural state, crushed stone is employed as railroad ballast, as riprap, or for jetty construction. (Riprap is large irregular stone used chiefly in river, lake, and harbor work to inhibit soil erosion and protect highway embankments.)

Crushed stone also finds many applications in manufacturing industries. It is a basic ingredient for cement manufacture, where it is burned in kilns with other materials to form a cement "clinker" which is then fine ground into cement powder. It is also used for a variety of agricultural purposes, including soil conditioners, lime, poultry grit, and mineral food; as a flux stone in steel manufacture; in refractory manufacture; as an ingredient in glass; and as a mineral filler, extender or whiting in rubber, paper, or other products, etc.

Table III-3 shows the quantities of crushed stone shipped or used by U.S. producers in 1974. The major application, accounting for 23.6% of all crushed stone, was as a dense graded road base; concrete aggregates accounted for 13.4%; other construction aggregates and road stones, for 12.4%; and cement manufacture, for 11.1%. (The table identifies only those end uses that accounted for at least 5% of the volume and/or value of shipments for each stone type. It can thus be seen that approximately 24% of total production in 1972 was accounted for by miscellaneous applications that are each insignificant (less than 5%) relative to the total crushed stone production, but which together represent a sizeable proportion. The Bureau of Mines, in its Minerals Yearbook, does identify many of the miscellaneous applications, but the detailed breakdown is considered unnecessary for the purposes of this study.)

Limestone and dolomite, together representing 72.1% of total crushed stone shipments in 1974, found use in a similar pattern to that for all crushed stone. A larger proportion (29.7%) of crushed granite was used as a road base, with less than 3% in non-aggregate applications. Traprock, representing 9.3% of all crushed stone, was similarly distributed but represented the largest proportion of the total (9.1%) going into riprap and jetty stone consumption of all minerological types. The uses for sandstone, quartz, and quartzite are more varied than those of other types of stone and include a large proportion of feedstocks for ferro-silicon, glass, flux, and refractory applications. Finally, miscellaneous stone types, including shell, calcareous marl, crushed marble, etc., represented only 4% of all crushed stones and found diverse applications in end markets.

5. Possibilities of Substitution

Limited substitution of alternative products can and does occur depending on the geographic location of an operation. Sand and gravel, blast furnace slag, and lightweight aggregates can be used interchangeably

TABLE III-3 CRUSHED AND BROKEN STONE SHIPPED OR USED BY U.S. PRODUCERS BY MAJOR USE, 1974

End Use	Limestone and Dolomite		Granite		Traprock		Sandstone, Quartz, and Quartzite		Other		Total	
	1,000 Short Tons	Percent of Total	1,000 Short Tons	Percent of Total	1,000 Short Tons	Percent of Total	1,000 Short Tons	Percent of Total	1,000 Short Tons	Percent of Total	1,000 Short Tons	Percent of Total
Dense Graded Road Base Stone	168,469	22.4	35,137	29.7	22,485	23.2	8,082	26.0	11,392	26.2	245,565	23.6
Cement Manufacture	105,246	14.0							10,158	23.3	115,404	11.1
Concrete Aggregate (coarse)	105,188	14.0	21,518	18.2	8,530	8.8	2,135	6.9	1,922	4.4	139,293	13.4
Unspecified Construction Aggregate & Roadstone	76,563	10.2	16,998	14.3	24,375	25.2	6,178	19.8	4,755	10.9	128,869	12.4
Bituminous Aggregate	62,239	8.3	18,123	15.3	14,598	15.0	3,207	10.3	4,678	10.7	102,845	9.9
Surface Treatment Aggregate	46,603	6.2	5,144	4.3	4,808	5.0			2,137	4.9	58,692	5.6
Agricultural Purposes	34,400	4.6							1,638	3.8	36,038	3.4
Railroad Ballast	9,677	1.3	7,816	6.6	2,155	2.2	1,168	3.8	1,019	2.3	21,835	2.1
Riprap and Jetty Stone	19,382	2.6	2,761	2.3	8,771	9.1	2,481	8.0	1,897	4.4	35,292	3.4
Flux Stone	30,663	4.1					1,126	3.6			31,789	3.0
Mineral Fillers, Extenders and Whiting	2,565	0.3							1,495	3.4	4,060	0.4
Glass	1,714	0.2					1,423	4.6			3,137	0.3
Other Uses--Identifiable	78,687	10.5	8,336	7.0	7,982	8.2	3,547	11.4	1,232	2.8	99,784	9.6
Other Uses--Unidentifiable	10,119	1.3	2,725	2.3	3,181	3.3	1,743	5.6	1,256	2.9	19,024	1.8
TOTAL	751,515	100.0	118,558	100.0	96,885	100.0	31,090	100.0	43,579	100.0	1,041,627	100.0
Percent by Type	72.1		11.4		9.3		3.0		4.2		100.0	

[1]Includes lime manufacture

Source: U.S. Department of the Interior, Bureau of Mines, Mineral Industry Surveys/Stone in 1974.

with crushed stone and many specifications accept or even encourage substitutions. An important criterion considered in making such a decision are the relative distances of available materials sources from the user. Thus, sand and gravel pits may prove to be favored as concrete aggregates if the geology and extraction location shows them to be more economic than stone quarries. Blast furnace slag (readily available where steel mills are located) and gravel can often be an economic source of aggregate, and can also offer distinct performance advantages when used as an anti-skid highway surfacing material. Lightweight aggregates, such as expanded shale or clay, perlite, or vermiculite can result in considerable reductions in concrete density, and thus building load, when substituted for crushed stone, but the economic availability of these aggregates is limited. Oyster shells from the Gulf of Mexico and aragonite from the Bahamas have both substituted effectively and economically for limestone in the manufacture of cement in the southern states from Texas to Georgia.

However, while each of the substitute materials has and will continue to show considerable growth over the remainder of this decade, their total impact on the demand for crushed stone will probably remain small because specifications are changed slowly and the relative economics are unlikely to vary.

6. Future Growth

Historically, crushed stone has been very closely correlated with constant-dollar Gross National Product. For crushed stone, as a function of real GNP, over the 1959-1974 period the $R^2 = .960$. This relationship provided a better fit than constant-dollar expenditures on new construction housing starts, or the Federal Reserve Board Industrial Production index.

Thus, by using GNP forecasts of 2.8% for 1975-1980 and 3.3% for 1980-1985, the following demand forecasts were calculated:

	Crushed Stone	
Year	10^6 Short Tons	10^6 Metric Tons
1974 actual	1042	948.2
1980	1100	1001
1985	1300	1183

With the high correlations to the stated GNP growth,* demand growth for these products should be highest in areas with the best economic growth potentials. Therefore, the high growth areas will be the South and Western states. The Northeast and North Central regions will grow at or below the national average. Within regions, stronger growth is predicted for demand to occur on the fringes of urban areas as the most likely locations for industrial and population growth.

On a yearly basis, 1976 is expected to be a recovery year, with strong growth in real GNP (6%) and housing starts (29%). The year 1977 is expected to show continuing good growth in GNP and housing starts and recovery in non-residential building construction. Another downturn in the business cycle is predicted for the 1978 and 1979 period, which will also be years of declining demand for crushed stone and sand and gravel. Another recovery is expected in 1980, with real growth in GNP then reaching 4.7%.

7. Marketing and Distribution

Although some major multi-location or multi-division companies have significant marketing efforts for the promotion of crushed stone, the typical quarry is a single-location operation serving a restricted geographic market. Its marketing efforts are limited to order-taking and delivery service, with some technical support for quality and specifications control. In such cases, marketing and promotion is frequently the

*Unless otherwise stated, estimates and predictions are by Arthur D. Little, Inc.

responsibility of national trade associations or similar local groups. They maintain contacts with highway and state or local agencies to develop appropriate product requirements and to insure that performance specifications are met.

Some companies, especially the major ones, operate an effective sales force and have good technical support. In fact, salesmen are frequently qualified engineers who are capable of providing a customer with special design assistance (for example, in modifying standard asphalt paving or ready-mix concrete design mixes) and in problem-solving when the need occurs.

In addition, there may also be corporate technical staff assistance to develop new product applications or improve existing ones; to tackle process, geological, or mining problems; or to design special plant equipment. Because of the ready availability of crushed stone close to most metropolitan areas, the transportation and distribution of stone is predominately by truck. As shown in Table III-4, 79% of all shipments were by truck in 1974, with 9% by rail and 8% by waterways. However, a study of transportation methods* indicates that individual quarries ship from 300 to 100,000 rail cars per year and that the distribution mix from individual shipping points ranges from all truck to over 75% rail. Although the volume of aggregates moved by rail has remained almost constant for the last 40 years, the railroads' share of the market shrank from 30% in the 1930's to about 7% in 1970, but then increased to the current 9%. It is possible that further increases will occur as quarries are located further from population centers.

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*Rail Distribution of Construction Aggregates, prepared by A.T. Kearney & Company, Inc., for the Construction Aggregate Rail Shippers Conference, February 1, 1972.

Table III-4 CRUSHED STONE SHIPPED OR USED IN THE UNITED STATES

Method of Transportation	1973 Thousand Short Tons	1973 Percent of Total	1974 Thousand Short Tons	1974 Percent of Total
Truck	830,372	79	828,558	79
Rail	98,771	9	94,439	9
Waterway	77,741	7	80,672	8
Other	31,746	3	28,795	3
Unspecified	19,911	2	9,164	1
TOTAL*	1,058,541	100	1,041,627	100

*Data may not add to totals shown because of independent rounding.

Source: U.S. Department of the Interior, Bureau of Mines, Mineral Industry Surveys, Stone in 1974.

Distribution of crushed stone is direct from quarry to end user with no intermediary involved. Inventories are held almost entirely at the quarry location, because double handling would be prohibitively expensive, and customers maintain only sufficient inventory to insure uniform production rates over a predetermined length of time. Crushed stone production and shipment is a very seasonal business in many northern regions. Northern producers typically operate plants for nine months a year and stockpile sufficient stone to cover greatly reduced shipments during the winter months.

B. INDUSTRY STRUCTURE

1. Types of Firms

The Bureau of the Census does not compile statistics on patterns of ownership in the mining industries as it does for some of the manufacturing sectors of the economy. Thus, it is difficult to precisely characterize the crushed stone industry by type of firm. However, it is possible to draw certain valid conclusions based on industry contacts and past experience.

The crushed stone industry consists primarily of a large number of small, locally owned firms which together account for a significant proportion of national production. In addition, a few larger firms, which are regionally or nationally diversified, individually account for a small percentage of national production. The relationships for plants by size as depicted later in this report is also a reasonable description for the relative distribution of firms in the industry.

In 1967, the Bureau of the Census began to exclude data about establishments without paid employees. In 1972, 911 firms operated the 1573 limestone quarries covered by the Census (of which 199 quarries were associated with manufacturing establishments); 74 firms were active in 155 granite quarries; while 291 firms operated 408 quarries producing other types of stone. Thus, the overall average number of quarries operated by the firms is 1.67. This average would be further reduced by including the firms and establishments not covered by the Census.

Patterns of firm ownership are similar to those in other sectors of the construction-oriented basic materials industries. At one extreme there are small local operations, often operated as proprietorships, where the plant manager and the owner are one and the same person. At the other extreme are plants owned by major public corporations for whom the crushed stone business is but one part of a number of fields of enterprise. Plant managers for the latter firms rarely have an equity interest in the firm for which they work, and are regular employees whose tenure at a particular quarry may be temporary in nature. Some of the larger companies in the industry following this pattern are Vulcan Materials, Martin-Marietta, Lone Star Industries, General Crushed Stone, United States Steel, Kaiser Cement and Gypsum, and Materials Service. Many of these larger firms also operate captive quarries to supply their other manufacturing business--steel mills, lime plants, cement mills, etc. In 1972, the Bureau of the Census estimated that 199 of the 1573 limestone plants were part of manufacturing establishments. About 132 of these were probably associated with cement mills, 41 with lime plants, and the remainder mainly with steel-manufacturing operations.

The larger firms are certainly multi-quarry, are usually in a number of geographic regions, and are diversified into non-aggregates industries. A certain amount of vertical product integration (for example, into ready-mixed concrete, highway construction) also takes place, but not as significantly as does the business diversification. The size and business diversification of the large, public companies frequently puts them in a better position to raise capital at competitive rates of interest than can the smaller and independent operators. However, the latter firms, because crushed stone usually is their primary business, allocate a larger proportion of their total capital to those operations.

Between the two extremes in company size are firms which are less diversified in terms of geography and business, yet which can compete effectively with the larger firms on a regional basis. In such firms, the plant manager is likely to be a professional manager, but also more likely to have a minority equity position in the firm for which he works.

An attempt was made to establish whether or not there has been a historical trend toward greater concentration in the crushed stone industry, at either the quarry and/or the company level. Historical data show that the number of plants and production volumes steadily increased from 1959 to 1973, except for occasional reversals in production volume due to economic conditions. Further analysis of the data in terms of average production per location, and the graphical representation of this ratio in Figure III-1, very definitely shows that the average production per location has been increasing over time, thus leading to greater concentration at the quarry level. (Note: The Bureau of Mines changed its reporting methods in 1968, and now provides data on the number of "quarries", when previously it reported on the number of "plants". Hence, the sudden apparent increase apparent in the number of plants from 1967 to 1968.)

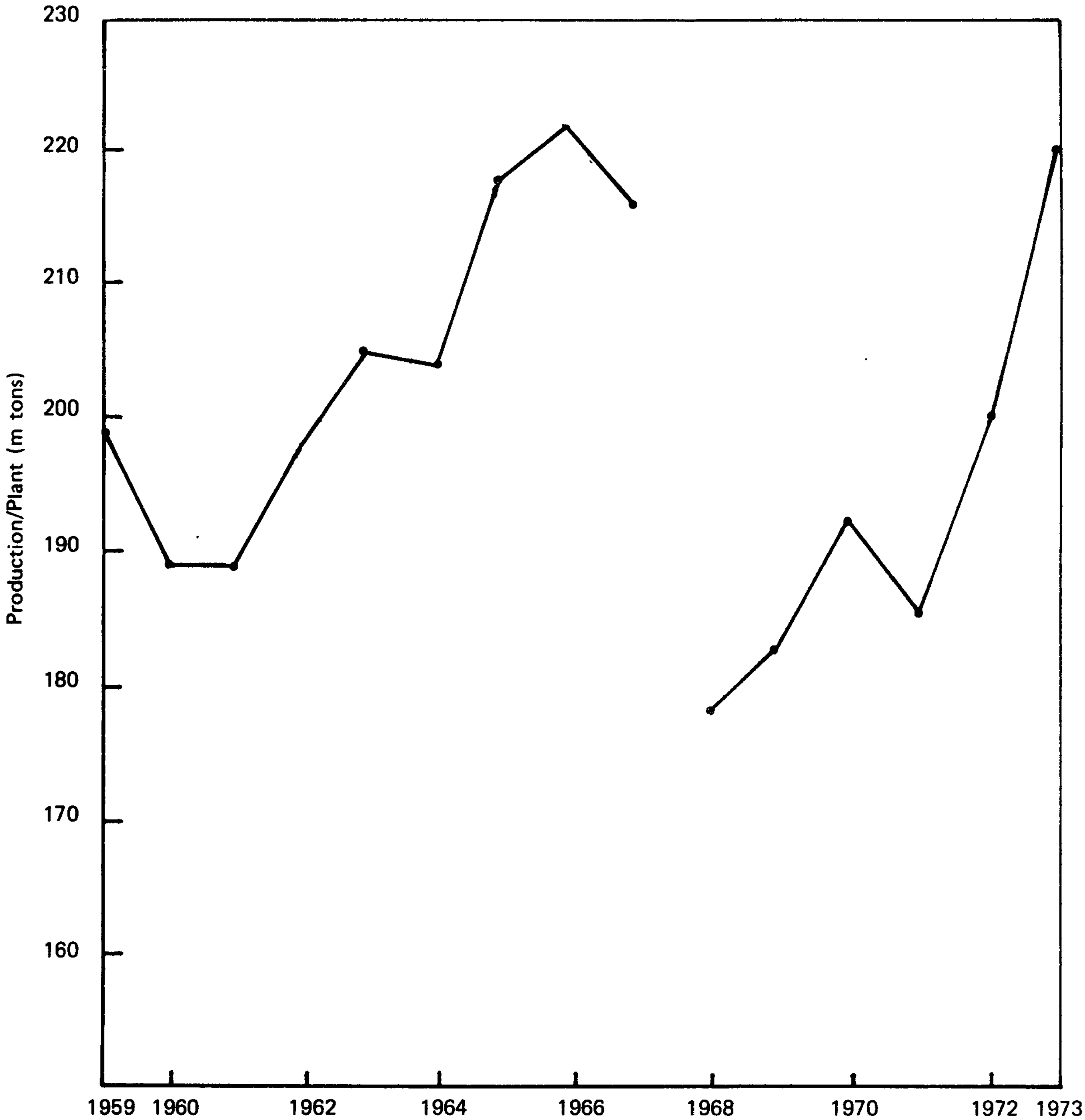
In other words, although production and number of establishments have both been increasing over time, the average output per location has been increasing at a faster rate than either. Exceptions to this general conclusion have occurred in individual years--for example, in 1960/61, 1963/64, 1966/67, and 1970/71--in which the stone industry experienced little or no growth.

All current indications suggest that the industry will continue to be more concentrated at the quarry level and that the average size of new quarries will continue to increase.

Finally, there are the operators of portable plants who sometimes compete effectively against the stationary ones. They include:

- Highway contractor operations (SIC-1611) to supply their own construction needs at or close to the site;

- Independent operators who move their equipment from quarry to quarry and prepare sufficient material to supply a rural county or township for a certain period; and



Source: Bureau of Mines. Data prior to 1968 refer to the number of plants; that since 1968, to the number of quarries.

FIGURE III-1 CRUSHED STONE PRODUCTION PER PLANT 1959-1973

- Local public authorities who operate their own portable plants.

Portable plant operators generally have no landholdings, but either lease mining rights on a royalty basis or hire out their men and equipment for quarrying a landowner's stone. The macro-economic factors affecting a portable plant operator's business are similar to those for a stationary plant operator; his cost structure will be different, but margins and returns on investment are usually better.

2. Plant Characteristics

Typically, crushed stone facilities produce dry, or dry and wet crushed stone product. Wet crushed stone is typically produced by adding a water washing step to the end of a dry crushed stone processing line. Wet crushed stone is typically produced to meet specifications such as for aggregate used in concrete or asphalt paving on a major road building project.

The percentage of total crushed stone output from a plant which is referred to as a wet process crushed stone facility can range from a minor amount up to 100% wet crushed stone. There is no "typical" mix of wet versus dry crushed stone from such a plant in the process sense, since the mix of wet and dry crushed stone is determined by the demands of the market. Therefore, in any year, there would be a broad spectrum of wet versus dry product mix from all of the plants producing wet crushed stone in the United States. Due to market demand variations with time, the mix of wet versus dry crushed stone from any of the individual plants would also change on a year-to-year basis. There are presently insufficient data available to interrelate annual plant production, mix of wet versus dry crushed stone and geographic or market location.

There are currently slightly over 4,800 crushed stone quarries in the United States as reported by the Bureau of Mines. Of these, approximately 2,000 are considered by the Bureau of the Census (SIC's 1422, 1423, and 1429) to be commercial operations primarily concerned with the production of crushed stone. The remaining 2,800 plants consist of quarries operated by federal, state, and local governments; quarries that are part of integrated (cement, lime, etc.) operations, quarries operated on a temporary basis by establishments not concerned primarily with the production of stone (e.g., highway contractors, SIC-1611); and small quarries operated without paid employees, but proprietor-operated. Some of the latter categories enter and re-enter the market. The 4,800 quarries are served by approximately 3,600 plants. The approach used for the impact analysis has been to overstate the adverse economic impact. Therefore, the analysis is based on the assumption that there are 4,800 quarry/plant facilities.

While this study is concerned with all the quarries in operation, for the purposes of characterization it deals with those quarries for which data is available in aggregate form, or those covered by Bureau of the Census records. It also identifies and discusses any significant differences in the characterization derived from the Census records from the industry as a whole.

The basic differences between Bureau of Mines data and that compiled by the Bureau of the Census relates to the purposes of the two organizations. The Bureau of Mines is concerned primarily with measuring production of various minerals to determine policy regarding the availability, extraction, and exploration for mineral products. On the other hand, the Bureau of the Census is concerned with developing data on the industry's contribution to, or demands on, the various components of the U.S. economy. Thus, the primary focus of the latter is on economic factors such as value of shipments, value added, and employment, rather than production on a unit basis.

Included in the Bureau of Mines data (but not in the Census data) are single-unit establishments without paid employees, all stone produced and used in the same establishment, and portable crushing plants. The 1,700 portable plants constitute a good portion of those plants referred to above which are attached to federal, state or local governments, or highway contractors, and which may enter or re-enter the market on an irregular basis. They also service small quarries in rural areas for a short period each year, sufficient to crush and stockpile a community's immediate needs.

While the number of plants not included in the Census statistics is proportionately large, their production in relation to the industry totals is much less so. Table III-5 is a comparison of the Census and Bureau of Mines data for 1972. It indicates that approximately 90% of the total production of the industry is represented by shipments reported to the Bureau of the Census, and that these shipments represent over 85% of the value of the industrywide production.

Of the 1,937 establishments (plant locations) covered by the 1972 Census 1,374 (71%) primarily crush limestone, 155 (8%) crush granite, and 408 (21%) miscellaneous materials such as trap rock, quartzite, sandstone, and volcanic materials. In addition, the Census reports 199 limestone quarries, and 33 producing other stones, that are associated with manufacturing establishments. Table III-6 lists selected characteristics for each of three SIC's for 1972 and preceding Census years. Some highlights of this data include:

- A steady and healthy increase in value added (up 67% from 1963), value of shipments (up 65%), and capital expenditures (up 124%) in all segments of the industry;

Table III-5 1972 BUREAU OF THE CENSUS AND BUREAU OF MINES STATISTICS COMPARED

Product	Bureau of the Census statistics			Bureau of Mines statistics	
	Production[1] (quantity)	Shipments including interplant transfers		Stone sold or used by producers	
		Quantity	Value	Quantity	Value
	(million s. tons)	(million s. tons)	(million dollars)	(million s. tons)	(million dollars)
Dimension stone, total	(X)	(X)	89.0	1.5	90.8
Rough (net)	(NA)	1.9	34.3	.9	23.1
Dressed	(X)	(X)	54.8	.6	67.6
Limestone, total	(X)	(X)	15.7	.4	14.4
Rough (net)	(NA)	.5	7.9	.3	5.2
Dressed	(X)	(X)	7.8	.2	9.2
Granite, total	(X)	(X)	41.1	.6	42.6
Rough (net)	(NA)	.4	13.1	.4	14.1
Dressed	(X)	(X)	28.0	.2	28.6
Stone, n.e.c., total	(X)	(X)	32.1	.4	33.6
Rough (net)	(NA)	.9	13.1	.2	3.8
Dressed	(X)	(X)	19.0	.2	29.8
Crushed and broken stone, total	(NA)	(NA)	(NA)	[2]905.8	[2]1,563.0
Excluding Federal, State, and local government operations	837.2	823.5	1,319.5	(NA)	(NA)
Limestone[3]	602.4	598.0	883.7	671.5	1,090.7
Granite[3]	109.8	107.5	180.4	106.3	182.9
Stone, n.e.c.[3]	125.0	118.0	255.4	[2]128.0	[2]289.4

(X) Not applicable. (NA) Not available.
[1] Represents stone shipments plus stone mined and used in the same establishment in making cement, lime, and other manufactured products.
[2] Excludes shell.
[3] Census figures exclude operations by Federal, State, and local governments. Bureau of Mines figures represent totals for all stone sold or used by commercial, government, and contractor operations.

Table III-6 GENERAL STATISTICS: 1972 AND EARLIER YEARS

Year	Establishments		All Employees		Production, Development and Exploration Workers			Value Added in Mining	Cost of Supplies Etc. and Purchased Machinery Installed	Value of Shipments & Receipts	Capital Expenditures
	Total	With 20 Employees or More	Number	Payroll	Number	Man-Hours	Wages				
	(Number)	(Number)	(1,000)	(Million Dollars)	(1,000)	(Millions)	(Million Dollars)	(Million Dollars)	(Million Dollars)	(Million Dollars)	(Million Dollars)
INDUSTRY 1422. -- CRUSHED AND BROKEN LIMESTONE											
1972........	1,374	476	30.0	278.8	24.3	54.3	209.2	690.4	349.5	905.8	133.1
1967........	1,484	510	30.8	197.5	25.8	58.5	153.6	492.2	253.1	666.6	78.7
1963........	1,612	491	31.1	160.6	26.3	59.4	126.8	408.5	194.0	542.9	59.5
INDUSTRY 1423. -- CRUSHED AND BROKEN GRANITE											
1972........	155	94	4.5	38.5	4.0	9.5	32.5	119.8	82.2	172.1	30.0
1967........	149	80	4.5	27.1	3.9	8.9	22.0	80.1	47.1	114.2	13.0
1963........	150	65	4.1	19.8	3.4	7.9	16.0	61.7	35.2	89.7	7.2
INDUSTRY 1429. -- CRUSHED AND BROKEN STONE, N.E.C.											
1972........	408	99	7.0	70.4	5.4	11.8	49.6	172.0	91.3	240.5	22.8
1967........	400	124	7.7	56.2	6.1	13.3	40.1	132.4	68.2	179.8	17.8
1963........	494	112	8.1	48.7	6.4	13.6	35.0	111.5	66.7	162.2	16.0

Source: 1967 and 1972 Censuses of Mineral Industries, Table 1; U.S. Department of Commerce, Bureau of the Census.

- A decline in both number of establishments (from 2,256 to 1,937) and employment (from 43,300 to 41,500) over the last ten years;

- No significant changes in the relative importance of larger establishments (those with 20 or more employees); and

- Substantial increases in productivity and wages per employee.

Table III-7 lists selected characteristics on a regional basis for the establishments covered by the Census for 1972. It can be seen that the production of crushed limestone is heaviest in the North Central and South regions; crushed granite industry is concentrated in the South; and miscellaneous crushed stone facilities are dispersed fairly evenly geographically. In general, the larger facilities tend to be located in the Northeast and the South. This is also shown in Table III-8, which compares, on a regional basis, the percentage of the national totals for establishments to that for value of shipments for the various products. Figure III-2 demonstrates the distribution of all quarries in the industry by state for 1971, totaling over 4,700.

Table III-9 lists the Bureau of Mines breakdown of quarries by production tonnage, and shows the large number of low-annual-output quarries in existence and the relatively heavy percentage of total shipments accounted for by the small number of larger quarries. In 1973, about 5% of the quarries in operation accounted for 39.5% of production; 33% accounted for only 1.3%. The ten largest quarries in the United States range from 12.74 million metric tons per year (U.S. Steel at Rogers City, Michigan) to 4 million metric tons (Bethlehem Mines at Hanover, Penn).

TABLE III-7. DETAILED STATISTICS BY GEOGRAPHIC AREA (1972)

Industry 1422 (Crushed and Broken Limestone)

Geographic Area	Total Number of Establishments	Total Number of Employees*	Total Number of Production, Development & Exploration Workers*	Value Added by Mining**	Value of Industry Shipments**	Capital Expenditures**
United States	1,374	30.0	24.3	690.4	906.8	133.1
Northeast	200	5.3	3.9	126.6	170.3	24.0
North Central	675	12.7	10.3	294.4	382.2	55.5
South	422	10.4	9.0	236.6	311.0	48.4
West	77	1.5	1.1	33.2	43.2	5.3

Industry 1429 (Crushed and Broken Stone, n.e.c.)

Geographic Area	Total Number of Establishments	Total Number of Employees*	Total Number of Production, Development & Exploration Workers*	Value Added by Mining**	Value of Industry Shipments**	Capital Expenditures**
United States	408	7.0	5.4	172.0	240.5	22.8
Northeast	80	2.0	1.4	57.1	79.0	4.7
North Central	90	1.0	0.6	15.2	23.5	(D)
South	115	2.8	2.4	69.8	95.9	11.9
West	123	1.1	1.0	29.9	42.5	(D)

Industry 1423 (Crushed and Broken Granite)

Geographic Area	Total Number of Establishments	Total Number of Production, Total Number of Employees*	Development & Exploration Workers*	Value Added by Mining**	Value of Industry Shipments**	Capital Expenditures**
United States	155	4.5	4.0	119.8	172.1	30.0
South	112	3.7	3.2	96.3	141.9	30.2

*Thousands.
**Millions of dollars.
(D)Withheld to avoid disclosing figures for individual companies.

SOURCE: 1972 Census of Mineral Industries, Table 3A; U.S. Department of Commerce, Bureau of the Census

Table III-8 PERCENT DISTRIBUTION OF ESTABLISHMENTS AND SHIPMENTS (1972)

Region	Crushed Limestone (1422) Number of Establishments	Crushed Limestone (1422) Value of Shipments	Crushed Granite (1423) Number of Establishments	Crushed Granite (1423) Value of Shipments	Miscellaneous (1429) Number of Establishments	Miscellaneous (1429) Value of Shipments
Northeast	14.6%	18.8%	(D)	(D)	19.6%	32.8%
North Central	49.1	42.1	(D)	(D)	27.1	9.8
South	30.7	34.3	72.3	82.5	28.2	39.9
West	5.6	7.8	(D)	(D)	30.1	17.5
National Total	100.0	100.0	100.0	100.0	100.0	100.0

(D) Withheld to avoid disclosing figures for individual companies

Source: 1972 Census of Mineral Industries; Table 3A, U.S. Department of Commerce, Bureau of the Census

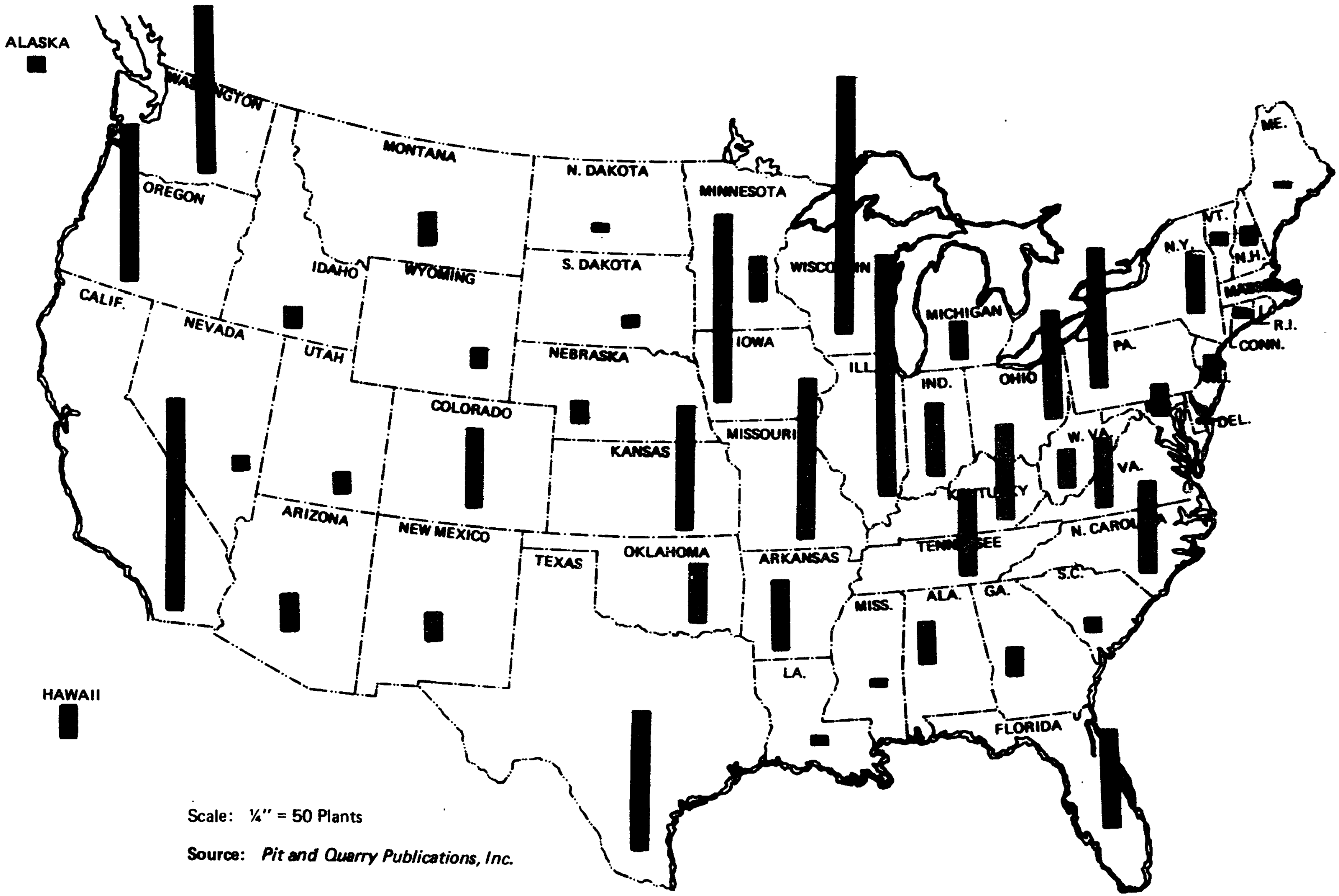


FIGURE III-2 LOCATION OF CRUSHED STONE OPERATIONS, 1971

Table III-9 NUMBER AND PRODUCTION OF CRUSHED-STONE QUARRIES IN THE UNITED STATES BY SIZE OF OPERATION

Annual Production (Short Tons)	1972 Number of Quarries	1972 Production Thousand Short Tons	1972 Production Percent of Total	1973 Number of Quarries	1973 Production Thousand Short Tons	1973 Production Percent of Total
Less than 25,000------	1,756	14,885	1.6	1,600	13,603	1.3
25,000 to 49,999------	521	18,809	2.1	660	24,221	2.3
50,000 to 74,999------	350	21,400	2.3	33	20,485	1.9
75,000 to 99,999------	245	21,316	2.3	253	21,941	2.1
100,000 to 199,999----	536	76,667	8.3	634	90,974	8.6
200,000 to 299,999----	336	82,870	9.0	308	75,868	7.2
300,000 to 399,999----	225	78,252	8.5	233	80,946	7.6
400,000 to 499,999----	160	71,911	7.8	182	80,956	7.7
500,000 to 599,999----	105	57,761	6.3	126	68,903	6.5
600,000 to 699,999----	84	54,051	5.9	98	62,730	5.9
700,000 to 799,999----	55	41,030	4.5	76	56,694	5.4
800,000 to 899,999----	43	36,578	4.0	51	42,718	4.0
900,000 to and over---	211	343,401	37.4	248	418,502	39.5
Total*------------	4,627	918,933	100.0	4,808	1,058,541	100.0

*Data may not add to totals shown because of independent rounding.

SOURCE: U.S. Department of the Interior, Bureau of Mines; Minerals Yearbook, 1973, Volume I

Estimates (summarized in Tables III-10 and III-11 for limestone, and for granite and traprock, respectively) based on unpublished data, provided by the Bureau of Mines in response to a request by the EPA, indicate that portable plants account for about 36% of those operating in limestone quarries and 28% of those in granite and traprock; stationary plants account for 43% and 25%, respectively. The balance of operations are normally not serviced by either. Some 1,974 companies own the 3,051 limestone quarries, while 481 operate the granite and traprock quarries.

Establishments covered by the Bureau of the Census may be distributed by average number of employees as listed in Table III-12. The great majority of plants covered by the Census are open quarries with crushing plants, as opposed to underground quarries with crushing plants, or crushing plants located and operated separately from the quarry supplying the rough stone.

Table III-13 summarizes selected averages for limestone quarries. Average employment ranged from less than 2 to 400 per establishment, and output from 32,800 to 6 million metric tons in 1972. While the average tonnage/employee was 17,000 metric tons in that year, the smaller operations appear to have better productivity because they probably tend to optimize on their use of part-time and/or owner labor.

3. Industry Segmentation

The Development Document examined various factors in categorizing the crushed stone industry and concluded that the principal segmentation should be on the basis of crushing processes. Therefore, the Document categorized the industry into the subcategories:

- Dry,

Table III-10 QUARRY AND PLANT CHARACTERISTICS BY SIZE OF OPERATION

(Limestone and Dolomite, 1973)

Size of Operation (TYP)	Production			Quarries		Type of Plant					
	Short Tons (000's)	Metric Tons (000's)	%	#	%	Stationary #	Stationary %	Portable #	Portable %	Other #	%
Up to 299,999	186,630	169,833	24.1	2,309	75.7	655	21.5	1,093	35.8	561	18.4
300-499,999	119,260	108,523	15.4	305	10.0	273	8.9	-	0	32	1.0
500,000+	468,510	426,344	60.5	437	14.3	391	12.8	-	0	46	1.5
Total	774,400	704,700	100.0	3,051	100.0	1,319	43.2	1,093	35.8	639	20.9

Source: Arthur D. Little, Inc., estimates developed from unpublished Bureau of Mines data.

Table III-11 QUARRY AND PLANT CHARACTERISTICS BY SIZE OF OPERATION

(Traprock and Granite, 1973)

Size of Operation (TPY)	Production: Short Tons (000's)	Production: Metric Tons (000's)	Production: %	Quarries: #	Quarries: %	Type of Plant: Stationary #	Stationary %	Portable #	Portable %	Other #	%
Up to 299,999	42,340	38,530	20.7	908	82.6	105	9.6	312	28.4	491	44.7
300-499,999	25,480	23,190	12.5	65	5.9	56	5.1	-	-	9	0.8
500,000+	136,740	124,430	66.8	126	11.5	113	10.3	-	-	13	1.2
Total	204,560	186,150	100.0	1,099	100.0	274	24.9	312	28.4	513	46.7

Source: Arthur D. Little, Inc., estimates developed from unpublished Bureau of Mines data

Industry 1422 (Crushed and Broken Limestone)

	Number of Establishments	Total Number of Employees*	Value Added In Mining**	Value of Shipments & Receipts**	Capital Expenditures**
Establishments (Total)	1,374	30.0	690.4	906.8	133.1
Establishments With An Average of:					
0 to 9 employees	492	1.7	43.2	58.7	11.3
10 to 19 employees	406	5.7	127.4	167.8	24.8
20 to 49 employees	358	10.8	252.3	317.8	50.4
50 employees or more	118	11.8	267.5	362.5	46.6

Industry 1423 (Crushed and Broken Granite)

<table>
<tr><th></th><th>Number of Establishments</th><th>Total Number of Employees*</th><th>Value Added In Mining**</th><th>Value of Shipments & Receipts**</th><th>Capital Expenditures**</th></tr>
<tr><td>Establishments (Total)</td><td>155</td><td>4.5</td><td>119.8</td><td>172.1</td><td>30.0</td></tr>
<tr><td>Establishments With An Average of:</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>0 to 9 employees</td><td>24</td><td>0.1</td><td>4.9</td><td>4.9</td><td rowspan="2">9.0</td></tr>
<tr><td>10 to 19 employees</td><td>37</td><td>0.5</td><td>11.4</td><td>17.5</td></tr>
<tr><td>20 to 49 employees</td><td>72</td><td>2.2</td><td>62.1</td><td>88.7</td><td>13.2</td></tr>
<tr><td>50 employees or more</td><td>22</td><td>1.7</td><td>41.4</td><td>60.3</td><td>7.8</td></tr>
</table>

Industry 1429 (Crushed and Broken Stone, n.e.c.)

	Number of Establishments	Total Number of Employees*	Value Added In Mining**	Value of Shipments & Receipts**	Capital Expenditures**
Establishments (Total)	408	7.0	172.0	240.5	22.8
Establishments With An Average of:					
0 to 9 employees	209	0.7	15.9	22.5	2.5
10 to 19 employees	100	1.4	35.2	46.3	4.0
20 to 49 employees	71	2.2	56.8	75.7	8.0
50 employees or more	28	2.7	64.1	95.9	8.1

*Thousands
**Millions of dollars

Source: 1972 Census of Mineral Industries; Table 4, U.S. Department of Commerce, Bureau of the Census

TABLE III-13 SELECTED AVERAGES BY ESTABLISHMENT, 1972

Industry 1422 (Crushed and Broken Limestone)

Number of Establishments	Average per Establishment: Employment	Average per Establishment: Value of Shipments ($000's)	Average per Establishment: Equiv. Short Tonnage* (000's)	Metric Tonnage (000's)	Average Short Tonnage/Employee	Average Metric Tonnage/Employee
320	1.6	58	36	33	22,500	20,475
172	7.0	233	144	131	20,500	20,475
406	14.0	413	255	232	18,200	16,562
358	30.2	888	548	499	18,100	16,471
83	68.7	1990	1230	1118	17,900	16,289
32	153.1	5150	3180	2895	20,800	18,928
3	400.0	10,800	6666	6067	16,700	15,197
1374	21.8	660	407	370	18,700	17,017

*at $1.62/short ton, the average for 1972.

Source: Arthur D. Little, Inc., estimates based on Bureau of Mines data

- Wet,

- Flotation, and

- Shell Dredging;

but defined effluent guidelines for only two--wet and flotation processing--that discharge process water. (Shell dredging has no on-land processing.) Other potential factors were considered in the Development Document as possible justifications for industry subcategorization, including type of raw materials, facility age or location, type of pollutants, and size of the facility. However, it was concluded that these other factors do not offer significant differences and were not used in the Document.

Table III-14 summarizes the segmentation of the crushed stone industry based on process and control level required.

The employment characteristics of the industry are confused by the prevalence of portable plants that work either alongside stationary plants in a quarry or move from quarry to quarry with their personnel. Investigations over the past two years suggest that the average output per employee in the crushed stone industry is about 17,000 metric tons, so allocation of employment by segment is carried out on this basis.

The extent of any impact on a specific wet process quarry will depend on a number of factors, including:

- Whether it is competing directly against one or more dry facilities;

- Present competitive advantage and financial performance;

- Ability to raise capital; and

- Size

TABLE III-14. SUMMARY - CRUSHED STONE SEGMENTS

Process	Quarries		Production			Average Production		Employment*	
	#	Percent	Million Short Tons	Million Metric Tons	Percent	Thousand Short Tons/Quarry	Thousand Metric Tons/Quarry	000's	Percent
Dry	3200	66.6	700	637	70	219	199.3	37.4	70
Wet	1600	33.3	300	273	30	188	171	16.0	30
Flotation	8	0.1	0.5	.45	--	63	57.3	0.03	--
INDUSTRY TOTAL	4808	100.0	1000	910	100.0	208	189.3	53.4	100.0

*Note: As a large proportion of the quarries are serviced by portable plants, there is only an indirect relationship between quarries and employment. It is estimated that each employee outputs an average of 18,700 tons per year. The estimated range of tonnage/employee was 16,700 to 20,800 in 1972.

Source: Development Document and Arthur D. Little, Inc. estimates.

The Development Document characterized a representative crushed plant having an output of 182,000 metric tons per year. While this size is representative of the average in the industry and also for all wet processing plants, it tends to overstate the apparent average 91,000 metric tons for wet processing plants that have yet to implement effluent controls. It is believed that the smaller facilities will be the most affected; larger-than-average plants generally enjoy better economies of scale. Consequently, the wet process category is further segmented into two sizes--91,000 and 182,000 metric tons per year. While Bureau of Mines data indicate that 58% of all crushed stone quarries operating in the United States are equal to or smaller than 91,000 metric tons per year, the analysis of this industry suggests that most of the smaller quarries are dry operations operated by portable plants.

C. FINANCIAL PROFILES

1. Industry Performance

The crushed stone industry has had a variable performance record over the past several years, but has remained generally profitable relative to all U.S. firms. Net profit margins for this industry are about 7%, while returns on stockholders' equity are about 8-11%. The industry is capital-intensive and moderately leveraged, with debt representing about one-third of total capitalization. A major portion of the industry's assets is tied up in working capital, primarily inventories and accounts receivables, while depreciation and depletion represent major sources of funds for capital expansion.

2. Representative Plants

Most companies operate only one quarry; those that do are always proprietorships that do not issue financial statements for public examination. Consequently, financial data on the industry are extremely limited and are generally available only for large, diversified companies with multiple quarries and multiple businesses. Consequently, the typical financial profiles for the two representative plants, having 91,000 metric tons and 182,000 metric tons capacities, respectively, have been prepared from an analysis of Bureau of Census data, available financial statements, and proprietary information made available during the course of this study. The profiles are presented in Tables III-15 and III-16. The larger of the two plants corresponds to the representative plant analyzed in the Development Document; the smaller plant is similar in size to the average in the "wet process - partial treatment" segment.

The smaller of the two plants profiles has net revenues, after discounts and freight, of $200,000 and a gross margin of 33%. Its net profits after tax totals $13,000 and is equivalent to 6.5% of net revenues.

Table III-15 FINANCIAL PROFILES - REVENUES FOR CRUSHED STONE OPERATIONS

	SMALL		MEDIUM	
production	100,000 st/yr (91,000 mt/yr)		200,000 st/yr (182,000 mt/yr)	
price/short ton	$2.00		$2.00	
price/metric ton	2.18		2.18	
REVENUES		$200,000		$400,000
Variable Costs				
labor	44,000		90,000	
materials	40,000		80,000	
repair and maintenance	50,000		90,000	
Total		$134,000		$260,000
Fixed Costs				
SG&A	35,000		55,000	
depreciation	8,000		30,000	
depletion	4,000		8,000	
interest	4,000		12,000	
Total		$ 51,000		$105,000
Profit before tax		15,000		35,000
tax		2,000		7,000
net profit		$ 13,000		$ 28,000

Table III-16 FINANCIAL PROFILES - CASH FLOW FOR CRUSHED STONE OPERATIONS

	SMALL	MEDIUM
CASH FLOW		
Cash In		
net profit	$ 13,000	$ 28,000
depreciation	8,000	30,000
depletion	4,000	8,000
debt increase	6,000	14,000
Total	$ 31,000	$ 30,000
Cash Out		
capital expenditures	$ 19,000	$ 56,000
land purchase	4,000	8,000
increase working capital	6,000	12,000
dividends	2,000	4,000
Total	$ 31,000	$ 80,000
Book Value of Assets	$100,000	$250,000

Source: Arthur D. Little, Inc. estimates

A significant proportion of the sources of funds ($12,000) comes from depreciation and depletion allowances; on average, $19,000 of the $31,000 in funds used annually is for capital expenditures both to maintain existing assets and to increase capacity. To finance this, the typical operator increases his long-term debt by an average of $6,000 annually. The salvage value of the facility is about $100,000.

The profile for the 182,000 metric tons per year plant is similar, except that gross margins are slightly less and net profits correspondingly more. While the smaller plant utilizes the equivalent of 15% of its revenues in annual capital and other expenditures, the medium-sized facility expends up to 20%. Both plants would have a ratio of total assets to sales of about 1.25 and a debt-equity ratio of 30%. Return on equity for the small plant is about 7.5%; that for the medium-sized plant, about 8%.

3. Variations by Segments

For individual plants, these figures may vary significantly according to certain parameters, which would include:

- Plant Size: Larger plants may enjoy economies of scale which should enable them to improve labor utilization. Labor as a percentage of revenues may be reduced by 30-40% (to 12-15% of revenues) for modern plants of the 910 metric tons per hour variety.

- Plant Age: Newer plants will have proportionately larger depreciation charges, offset by smaller expenses for repairs and maintenance. With higher investment bases, newer plants will have lower returns on net assets and shareholders' equity.

- Plant Location: Costs will differ between plants in different locations based on the supply/demand relationships for labor and materials. In the Northeast, for example, the costs of materials (primarily fuel) and labor will be higher, relative to other costs than in the South. In addition, the market environment in which a plant operates will determine the realizable revenue for each plant. Plants which are favorably located relative to their competition will realize greater profit margins.

Financial profiles should also vary by firm size (irrespective of plant size or age) but these variations should be minor. Plants owned and operated by larger firms ($100,000 in revenues or more) should have slightly lower unit selling, general, and administrative costs than those owned by smaller firms because they are able to spread such costs over a number of plants. Larger firms should also have lower interest costs (presuming equal debt/equity ratios) because of their ability to tap institutional (banks, insurance companies, etc.) capital markets, but higher tax rates. However, the effects of these differences are not major.

In summary, the smaller and older plants inherently have relatively less capital available for capital expenditures than larger and newer plants. For the older plants, this is true even though their after-tax profit margins should be greater, on average, than larger plants. There should be no regional variation in capital requirements, however, as higher (or lower) regional cost structures should be equal among competing plants and thus lead to higher (or lower) revenues. Also, although some operating cost differences between dry and wet process facilities might exist, these differences can be exceeded when comparing two wet process plants or two dry process plants of identical sizes.

The variations in plant economics are shown on an index basis (revenues equal 100) in Table III-17. Comparisons between groups of data (for example, size vs. age vs. location) should not be made from this table; only comparisons within groups are valid.

Table III-17 VARIATIONS IN PLANT ECONOMICS

	Size (000 short tons/yr)				Age		Location	
	100	200	400	2,000	15 Yrs. Old	New	South	Northeast
Revenues	100	100	100	100	100	100	94	106
Cost of Production	67	65	64	52	66	50	52	64
Depreciation & Depletion	6	9	10	14	6	16	12	12
SG&A	17	14	14	14	12	16	14	14
Interest	2	3	3	5	2	8	4	4
Profit Before Tax	8	8	9	15	14	10	12	12
Sources of Funds (Excluding Debt):								
Net Income	6	7	7	9	8	6	7	7
Depreciation	4	8	8	12	4	14	10	10
Depletion	2	2	2	2	2	2	2	2
	12	17	17	23	14	22	19	19
Use of Funds:								
Capital Expenditures	9	14	14	21	12	19	16	16
Land	2	2	2	2	2	2	2	2
Working Capital	3	3	3	3	3	3	3	3
Dividends	1	1	1	1	1	1	1	1
	15	20	20	27	18	25	22	22
Debt Required	3	3	3	4	14	3	3	3

Source: Arthur D. Little, Inc. estimates, based on public and confidential data

D. PRICES AND PRICE SETTING

1. Historic Prices

For the period 1964-1974, the increase in the wholesale price index for crushed stone (SIC-142) was compared with indexes for all commodities, all construction materials, and all concrete ingredients (Table III-18). The price of crushed stone has increased at a slower rate than any of the other categories. From 1964 to 1974, annual price increases for all construction materials averaged 5.4%; all commodities, 5.4%; concrete ingredients (including sand, gravel, crushed stone, and portland cement), 4.4%; and crushed stone, 3.2%. While current-dollar prices of crushed stone have increased from 1964-1974, the constant-dollar prices, derived by using the All-Commodities Index as a base, have actually declined.

No wholesale price information is available from the Bureau of Labor Statistics at a more detailed product level than crushed stone as a group. Therefore, to approximate the price history of the individual categories, we have used dollar value of shipments per short ton of product. The results, shown in Table III-19, are consistent with the Wholesale Price Index--both show an annual price growth of about 3.0% in current dollars for the combined categories of crushed stone. Limestone and granite price increases were above the average rate; with limestone at 3.2% per year, and granite at 4.2%. Levels of 1973 dollar value of crushed stone at the quarry ranged from $3.04 per metric ton for other stone (which includes High-value specialty-type stone) to $1.88 per metric ton for limestone. The value for all crushed stone averaged $2.04 per metric ton in 1973.

This historic relative price stability (and relative decline in constant dollars) is believed to be partly a result of intra-industry competition at local and regional levels which has resulted in lower profits and returns on investment, and also because the industry has become more efficient in utilizing its equipment and reducing or eliminating labor-intensive activities.

Table III-18 RELATIVE WHOLESALE PRICE INDEXES FOR CRUSHED STONE AND RELATED PRODUCTS, 1964-1974

(1967 = 100)

	All Commodities	All Construction Materials		All Concrete Ingredients		All Crushed Stone (SIC 142)	
		Actual	Relative*	Actual	Relative*	Actual	Relative*
1964	94.7	94.8	100.1	97.0	102.4	97.4	102.9
1965	96.6	95.9	99.3	97.4	100.8	97.5	100.9
1966	99.8	98.8	99.0	98.1	98.3	97.7	97.9
1967	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1968	102.5	105.6	103.2	103.2	100.7	102.9	100.4
1969	106.5	111.9	105.1	106.7	100.2	106.8	100.3
1970	110.4	112.5	101.9	114.6	103.8	112.4	101.8
1971	113.9	119.5	104.9	121.9	107.0	117.7	103.3
1972	119.1	126.6	106.3	126.9	106.6	120.2	100.9
1973	134.7	138.5	102.8	131.2	97.4	122.7	91.1
1974	160.1	160.9	100.5	148.7	92.9	133.0	83.1
Annual Compound Growth Rate 1964-1974	5.4%	5.4%		4.4%			3.2%

*Relative wholesale price index is derived by dividing the "actual" price index by the "all commodities" price index.

Source: U.S. Department of Labor, Bureau of Labor Statistics.

Table III-19 VALUE PER SHORT TON OF CRUSHED STONE SHIPPED, 1964-1973

(in dollars per short ton)

	Limestone & Dolomite	Granite	Traprock	Sandstone Quartz & Quartzite	Other*	Total
1964	1.36	1.45	1.64	1.86	1.61	1.44
1965	1.35	1.49	1.60	1.77	1.72	1.43
1966	1.36	1.45	1.66	1.73	1.74	1.44
1967	1.38	1.52	1.70	1.86	1.77	1.46
1968	1.42	1.51	1.71	1.96	1.78	1.49
1969	1.46	1.54	1.80	1.96	1.84	1.54
1970	1.51	1.60	1.90	2.04	1.73	1.58
1971	1.62	1.68	2.13	2.45	1.96	1.72
1972	1.62	1.72	2.08	2.16	2.41	1.82
1973	1.73	2.17	2.12	2.55	2.79	1.88
Annual Compound Growth Rate 1964-1973	3.2%	4.2%	2.5%	3.2%	5.6%	2.8%

*Includes marble, shell, slate, calcareous marl, and other stone.

Source: Arthur D. Little, Inc., estimates derived from Bureau of Mines, Mineral Yearbook

Data on 1974 average prices are not yet available, but it can be anticipated that significant price increases took place during the year, mainly due to inflation because demand was weaker. (To make comparative relative cost calculations, an average 1974 FOB price of $2.00 per short ton was developed from Table II-1.)

2. Current Prices

Quotations in Engineering News Record for 1-1/2 inch crushed stone as of May 1975, ranged from $7.35 per metric ton in Minneapolis to $1.96 per metric ton in St. Louis. These prices are on an FOB city basis (not allowing for some cash discounts) and are summarized in Table III-20. The average price for the 18 cities shown in the table is $4.58 per metric ton. For 3/4 inch crushed stone, the prices range from $7.57 per metric ton in Pittsburgh to $1.96 per metric ton in St. Louis. The average is $4.64 per metric ton.

These price quotations include transportation costs, which might range from $0.54 to $1.68 per metric ton from the quarry to the city, and vary depending upon distance and whether the transportation is provided by the supplier or customer.

3. Price Elasticity and Pricing Dynamics

On an industry basis, the demand for crushed stone is price inelastic; i.e., when prices increase, even though quantity demand may decline, total revenues increase. As the product is a necessary component of a number of building materials (concrete, asphalt) and products (roads, airport runways, etc.), then demand is based primarily on the demand for those products, irrespective of the end price. The fact that there generally does not exist significant competition from substitution products (discussed earlier), and the price of stone as a percentage of the total price of the materials and products of which it is a component is low (for example, 15%

Table III-20 CRUSHED STONE PRICES FOB CITY

Region/City	Price Range as of May 1975 ($ per short ton) 1-1/2" Stone	3/4" Stone
NEW ENGLAND		
Boston	3.30[a]	3.50[a]
MIDDLE ATLANTIC		
New York	5.10	5.10
Philadelphia	4.15	4.15
Pittsburgh	6.60	6.95
EAST NORTH CENTRAL		
Chicago	4.50	4.50
Cincinnati	2.55	2.55
Cleveland	5.08[b]	5.08[b]
Detroit	2.70	2.80
WEST NORTH CENTRAL		
Kansas City	3.30	3.30
Minneapolis	6.75	6.75
St. Louis	1.80	1.80
SOUTH ATLANTIC		
Atlanta	3.80	4.00
Baltimore	3.15	3.60
EAST SOUTH CENTRAL		
Birmingham	1.90	1.90
WEST SOUTH CENTRAL		
Dallas	2.25	2.50
PACIFIC		
Los Angeles	6.65	6.15
San Francisco	6.20	6.20
Seattle	5.90	5.90

[a]Traprock [b]Trucklots, delivered

Source: Engineering News Record, Pages 58-59, May 8, 1975 of the FOB price of asphalt; less than 1% of the price of a highway for which the asphalt is being supplied), variations in the price of crushed stone do not affect basic demand.

Markets tend to be geographically limited, so plants serving them are generally clustered around one or more population centers. On a plant-by-plant basis within a particular market, competition could be severe or else may tend to be oligopolistic. The crushed stone business is reasonably capital intensive (the ratio of total assets of net revenues is about 1.25) and producers need to maintain production volume to provide for the amortization of their capital investments. A "typical market" will have a number of potential stone suppliers competing for available business and doing so on the basis of a delivered price. These competitors may have a wide range of characteristics, from a small proprietorship to a large public corporation, and from a large to a small plant.

Individual quarries in the typical market establish a desired FOB selling price based on the production costs they experience to achieve a "reasonable" return on investment. What is "reasonable" depends on the type of company; a proprietorship or a private corporation is normally more concerned with cash flow than is a large public company, which is attempting to achieve an acceptable return on investment for its stockholders. However, selling prices that are established by this mechanism are then liable to adjustment based on the perceived competitive environment and transportation costs.

Prices can be quoted on a delivered basis per short ton for a truckload, or on an FOB plant basis with customer pick-up. Both methods are frequently employed, but in both cases the physical transportation is usually carried out by independent truckers working on an on-call or contract basis. Because of price competition, many suppliers to a city will quote a standard FOB city price (a zone price) which will not normally vary between sources or with ultimate destination. Consequently, the customer may sometimes be located close enough to an individual quarry to make it worth his while to arrange pick-up on an FOB plant basis and save on freight equalization.

Thus, the effects of transportation costs on delivered price can be large. Crushed stone is a commodity product that is low in value, and has a high specific gravity. As a result, the pricing of the product for the majority of its applications depends greatly on the distance from the source of supply to the consumer. Transportation costs for the material currently average over 8¢ per metric ton per mile. Given the presumed FOB plant price of $2.18 per metric ton the effective price to the consumer will double at a distance of approximately 30 miles. Alternatively, a plant which is located 10 miles closer to a customer than a competing plant would theoretically be able to realize a price up to 76¢ per metric ton higher than its competitor without a loss of market share. A company with a significantly lower total cost structure will eventually be able to obtain a larger market share, if all other factors (such as transportation costs, etc.) are equal.

However, such situations rarely exist and the actual pricing mechanism is influenced more by such factors as: the rate charged by the independent trucker; access to highways vs. secondary roads; the amount of congestion over the route of travel; and the customer/supplier/trucker relationships.

Delivered costs are not as sensitive to the costs of transportation for higher-value products. These include crushed stone serving refractories, flux, glass, and agricultural markets. There, the customers know in advance what their approximate needs will be over a period of time and what specific product performance standards are required. They will evaluate product offerings from potential suppliers, establish specifications for their purchases, and seek competitive long-term prices on a pre-set delivery schedule. In these situations, stone may be shipped considerable distances if it has certain desirable chemical or physical properties and, in fact, the limited amount of crushed stone imports generally falls into this category. The freight costs are also irrelevant when the stone is being moved only a limited distance from a captive quarry to an integrated, and generally contiguous, operation such as a cement plant.

Delivered prices normally move in small increments in response to the leadership of one or other of the suppliers. In a typical market, such price leadership changes from time to time, as it does in the other basic industries, and no discernable pattern can be apparent. Because price increases are normally relatively small and are tied to changes in costs that are incurred by all producers, it is highly likely that the other competitors will follow the leader's example. If the leader makes a price increase that is considered unnecessary, or if his competitors wish to gain a strategic advantage and larger market share by holding back on similar price increase, the leader may be forced to roll back his increase.

However, there is room in a typical market for a modest spread in FOB prices. Surveys carried out in the past indicate that the spread might be as much as $0.25 without disturbing the supply/demand equilibrium that exists. Another factor that limits the opportunity for the crushed stone industry to make limitless price increases, seemingly in concert, is that crushed stone can also compete against sand and gravel in certain conditions and for specific applications. Interindustry competition depends very much on the geology of the region and the product specifications, but some substitution can take place.

E. POLLUTION CONTROL REQUIREMENTS AND COSTS

1. Effluent Control Levels

Table III-21 presents the EPA regulations for point-source discharge of water effluents from the crushed stone industry. These regulations require no discharge, for either a maximum average for 30 consecutive days or a maximum for any one day, at all three levels: BPCTCA, BATEA, and NSPS. Any effluent originating as mine drainage or pit pumpout is to be limited to a maximum total suspended solids (TSS) of 30 mg/l maximum for any one day.

2. Effluent Control Costs

The effluent control costs for process water from the crushed stone industry are associated totally with the treatment and storage of suspended solids. The recommended level of control is no discharge, which requires the use of settling ponds and the total recycle of clarified process water, which is withdrawn as an overflow from the upper level of the pond. The required ancillary equipment primarily consists of the water handling system (e.g., pump, pipe, etc.). In some specific cases, a flocculating agent might be necessary to enhance the settling rate of the suspended solid particles.

In the six crushed stone facilities that employ the flotation process, the flotation water cannot be directly recycled because of the complex chemical processes involved. Although the wash water can be combined with the flotation water effluent and recycled for the washing process, the flotation process requires fresh water input. The Development Document indicates that flotation water is approximately 5% of the process water, and assumes that the combined effects of percolation and evaporation associated with the settling ponds for wash water treatment would result in the loss of approximately 5% of the total process and flotation water

Table III-21 RECOMMENDED LIMITS AND STANDARDS FOR BPCTA, BATEA, AND NSPS

Crushed Stone Industry

	Concentration in Effluent	
	30-Day Average	24-Hr. Maximum
Process Wastewater	No Discharge	No Discharge
Mine Dewatering		TSS 30 mg/l

Source: Development Document for Interim Final Effluent Limitations Guidelines and New Source Performance Standards, Mineral Mining and Processing Industry: Point Source Category, EPA 440/1-75/059 (Vol. I) and 0596 (Vol. II) effluent, which would permit a totally closed recycle loop to be successfully employed for the flotation operations. This analysis embodies this assumption.

The Development Document presents the fixed capital and operating costs* for four different compliance levels of a typical work process crushed stone facility. The wet process, crushed stone model plant size is 180,000 metric tons per year producing 50% wet product and 50% dry product. The base year for the dollar value used for the development of this compliance cost table was mid-1972.

The following economic impact analysis is based on mid-1974 dollar value. The costs shown in the Development Document have been modified by using a GNP inflator of 16.5%.** Mine dewatering costs are either negligible or are included in the costs presented in the Development Document.

Control costs at all levels were developed for three additional plant sizes to determine the sensitivity of control costs to plant size. The four plant sizes used for the basis of development of control costs are:

- 100,000 short tons per year (91,000 metric tons per year)
- 200,000 short tons per year (182,000 metric tons per year)
- 1,400,000 short tons per year (1,270,000 metric tons per year)
- 2,400,000 short tons per year (2,180,000 metric tons per year)

*See Table 16, page 204, Volume I, of the October 1975 Development Document

**U.S. Department of Commerce Survey of Current Business, Part I, Jan 1975.

Fixed capital costs were varied by the appropriate ratio of annual production costs raised to the 0.9 power, based on the 182,000 metric ton per year model sized plant shown in the Development Document. Operating costs were varied as a direct function of plant capacity.

The basis for the development of the compliance cost for crushed stone operations employing the flotation process was developed from information on page 206 of the Development Document. The assumptions which form the basis for developing the compliance costs are:

- $200,000 total fixed capital (mid-1972 costs) for the six flotation operations with discharge;

- All eight flotation operations of equal size; and

- All other operating costs necessary to reach the equivalent of Level C (no discharge) are equivalent to the wet process crushed stone operations, and were derived from Table III-22 through appropriate use of previously described scaling factors and the GNP inflator.

These control costs are presented in Tables III-22 through III-26. A comparison of the cost per ton for the compliance at any level for the four different plant sizes shows that control cost is very insensitive to plant size.

3. Current Levels of Control

The crushed stone industry in the United States can be divided along process technological lines into three subcategories:

- dry process,

Table III-22 COST OF COMPLIANCE FOR MODEL WET PROCESS

Crushed Stone Facility

Plant Size: 91,000 Total (45,500 wet) Metric Tons Per Year of Product

Plant Age: 40 Years

Plant Location: Rural Location Near Population Center

Base Year: Mid-1974

		Level			
		A (MIN)	B	C	D
Invested Capital Costs:					
Total		0	9,100	12,000	14,200
Annual Capital Recovery		0	1,400	1,800	2,200
Operating and Maintence Costs:					
Annual O & M (excluding power and energy)		0	3,800	3,800	4,300
Annual energy and power		0	600	1,200	1,200
Total Annual Costs		0	5,800	6,800	7,700
Cost/Metric Ton/Wet Process		0	0.128	0.150	0.170
Waste Load Parameters (kg/metric ton of product)	RAW WASTE LOAD				
Suspended Solids	60	60	0.2	0	0

Level Description:
- A - direct discharge
- B - settling pond, discharge
- C - settling pond, recycle
- D - flocculant, settling pond, cycle

Source: Development Document and Arthur D. Little, Inc., estimates

Table III-23 COST OF COMPLIANCE FOR MODEL WET PROCESS

Crushed Stone Facility

Plant Size: 160,000 Total Metric Tons Per Year of Product
(90,000 wet)

Plant Age: 40 Years

Plant Location: Rural Location Near Population Center

Base Year: Mid-1974

	Level A (MIN)	Level B	Level C	Level D
Invested Capital Costs:				
Total	0	16,900	22,100	26,200
Annual Capital Recovery	0	2,800	3,600	4,300
Operating and Maintenance Costs:				
Annual O&M (excluding power and energy)	0	7,500	7,500	8,600
Annual energy and power	0	1,200	2,300	2,300
Total Annual Costs	0	11,500	13,400	15,200
Cost/Metric Ton/Wet Process	0	0.128	0.148	0.168

Waste Load Parameters (kg/metric ton of product)	RAW WASTE LOAD	A	B	C	D
Suspended Solids	60	60	0.2	0	0

Level Description:
A - direct discharge
B - settling pond, discharge
C - settling pond, recycle
D - flocculant, settling pond, recycle

Source: Development Document and Arthur D. Little, Inc. estimates

Table III-24 COST OF COMPLIANCE FOR MODEL WET PROCESS

Crushed Stone Facility

Plant Size: 1,270,000 Total Metric Tons Per Year of Product (635,000 wet)

Plant Location: Rural Location Near Population Center

Plant Age: 40 Years

Base Year: Mid-1974

		Level A (MIN)	Level B	Level C	Level D
Invested Capital Costs:					
Total		0	98,000	128,300	152,000
Annual Capital Recovery		0	19,800	25,400	30,300
Operating and Maintenance Costs:					
Annual O&M (excluding power and energy)		0	52,900	52,900	60,700
Annual energy and power		0	8,500	16,200	16,200
Total Annual Costs		0	81,200	94,500	107,200
Cost/Metric Ton/Wet Process		0	0.128	0.148	0.168
Waste Load Parameters (kg/metric ton of product)	RAW WASTE LOAD				
Suspended Solids	60	60	0.2	0	0

Level Description:
- A - direct discharge
- B - settling pond, discharge
- C - settling pond, recycle
- D - flocculant, settling pond, recycle

Source: Development Document and Arthur D. Little, Inc. estimates

Table III-25 COST OF COMPLIANCE FOR MODEL WET PROCESS

Crushed Stone Facility

Plant Size: 2,130,000 Total Metric Tons Per Year of Product (1,067,500 wet)

Plant Location: Rural Location Near Population Center

Plant Age: 40 Years

Base Year: Mid-1974

		Level			
		A (MIN)	B	C	D
Invested Capital Costs:					
Total		0	159,500	208,600	247,300
Annual Capital Recovery		0	26,400	34,000	40,600
Operating and Maintenance Costs:					
Annual O & M (excluding power and energy)		0	90,800	90,800	104,200
Annual energy and power		0	14,500	27,900	27,900
Total Annual Costs		0	131,700	152,700	172,700
Cost/Metric Ton/Wet Process		0	0.120	0.140	0.158
Waste Load Parameters (kg/metric ton of product)	WET WASTE LOAD				
Suspended Solids	60	60	0.2	0	0

Level Description:
- A - direct discharge
- B - settling pond, discharge
- C - settling pond, recycle
- D - flocculant, settling pond, recycle

Source: Development Document and Arthur D. Little, Inc. estimates

Table III-26 COST OF COMPLIANCE FOR MODEL FLOTATION PROCESS

Crushed Stone Facility

Plant Size: 62,500 Metric Tons Per Year of Product

Base Year: Mid-1974

		Level	
		A (MIN)	B
Invested Capital Costs:			
Total		0	38,800
Annual Capital Recovery		0	6,300
Operating and Maintenance Costs:			
Annual O & M (excluding power and energy)		0	2,200
Annual energy and power		0	700
Total Annual Costs		0	9,200
Cost/Metric Ton/Wet Process		0	0.147
Waste Load Parameters (kg/metric ton of product)	RAW WASTE LOAD		
Suspended Solids	60	60	0

Level Description:
A - direct discharge
B - settling pond, recycle

Source: Development Document and Arthur D. Little, Inc. estimates

- wet process, and

- flotation process.

Figure III-3 shows the distribution of the total 4,808 crushed stone facilities operating in the United States in 1972, and the way in which they are sub-divided into the three main process categories indicated above. The initial subcategorization is based on process technology, and the further subcategorization derives from the nature of the current control levels at which the process categories are currently operating.

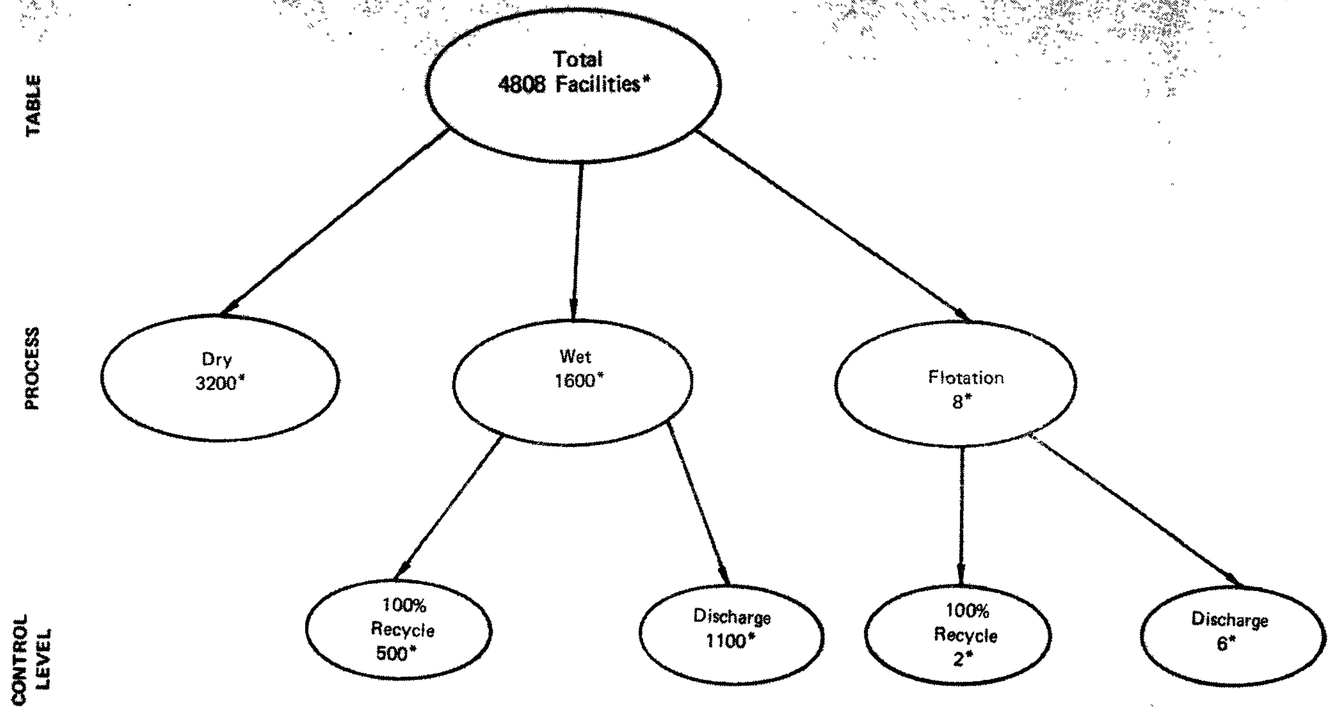
a. Dry Process

Table III-14 showed that in 1972 there were 3,200 dry crushed stone facilities operating in the United States. This represents 66.6% of the total 4,808 crushed stone operations in the United States. There is no process water used in a dry crushed stone operation. The Development Document states that about half of all of the stone quarries which are operated by the crushed stone industry in the United States employ mine dewatering either continuously or periodically to maintain a sufficiently dry quarry to facilitate its operation.

b. Wet Process

In 1972 there were a total of 1,600 wet process crushed stone operations in the United States, representing 33.3% of the total number of plants, producing 30% of the total annual production.

Figure III-3 shows the sub-division of these wet process operations into two main subcategories having the same current effluent control status (i.e., 100% recycle, and discharge). Neither the data presented in the Development Document nor any other information in the available literature indicates the distribution of the 1,100 facilities which are presently



*Number of Facilities.

Source: Development Document

FIGURE III-3 DISTRIBUTION OF CRUSHED STONE FACILITIES BY PROCESSING AND CURRENT CONTROL LEVEL CATEGORIES

discharging, into Control Levels A and B. Undoubtedly, some of these facilities operate with direct discharge with no removal of suspended solids.

Because the available data do not illuminate the distribution of the 1,100 facilities between Level A and Level B, we have considered the case where all 1,100 facilities are at the minimum Level A, which is direct discharge. This maximizes control cost, and represents the limiting case in the economic impact analysis in the following section.

The remaining 500 facilities are reported in the Development Document to be currently operating with 100% recycle, which meets the proposed regulations, and will add no incremental control cost to their present level of operating costs.

c. Flotation Process

There are only eight flotation process crushed stone facilities reported operating in the United States in 1972. Two of these operations are reported by the Development Document to be operating with 100% recycle of the process water, so they comply with the proposed regulations. The remaining six are reported to have some discharge, and will require additional fixed capital and operating costs to comply with the proposed guidelines.

4. Total Control Costs

Table III-27 indicates the number of plants, etc., requiring no, partial, or full effluent treatment. In summary, about 77% of all plants, representing about 90% of production, either require no treatment because they utilize a dry process or have already implemented BPT/BAT by recycling their process water.

TABLE III-27. SUMMARY - CRUSHED STONE SEGMENTS

Process/Treatment Required	Quarries		Production			Average Production		Employment*	
	#	Percent	Million Short Tons	Million Metric Tons	Percent	Thousand Short Tons/Quarry	Thousand Metric Tons/Quarry	000's	Percent
Dry - None	3200	66.6	700	637	70	219	199.3	37.4	70
Wet - None	500	10.4	200	182	20	400	364	10.7	20
Wet - Partial	1100	22.9	100	91	10	91	82.8	5.3	10
SUBTOTAL	1600	33.3	300	273	30	188	171	16.0	30
Flotation - None	2	--	0.1	0.9	--	63	57.3	--	--
Flotation - Partial	6	--	0.4	.36	--	63	57.3	--	--
SUBTOTAL	8	0.1	0.5	.45	--	63	57.3	0.03	--
INDUSTRY TOTAL	4808	100.0	1000	910	100.0	208	189.3	53.4	100.0

*Note: As a large proportion of the quarries are serviced by portable plants, there is only an indirect relationship between quarries and employment. It is estimated that each employee outputs an average of 18,700 tons per year. The estimated range of tonnage/employee was 16,700 to 20,800 in 1972 (see Table).

Source: Development Document and Arthur D. Little, Inc., estimates.

The entire wet process industry will not be subjected to increased costs for effluent control. It is estimated that 500 of the 1,600 facilities in this segment of the industry are already on complete recycle. About 1,100 are currently on various levels of partial discharge. The Development Document indicates that these facilities will be subject to a wide range of discharge control costs, the average of which is about $0.05 per metric ton. There is no precise information available about the numbers of plants requiring control, or the size of plants requiring control. The Development Document indicates that the average capacity for the operations requiring additional discharge control are on average smaller (91,000 metric tons per year) than those already in compliance (400,000 metric tons per year). Thus, for this industry segment, it would not be appropriate to assume industry-wide size distribution for the plants requiring additional expenditures to meet the standards. Instead, it is assumed that 50% of the plants are in the less than 91,000 metric tons per year size class and the other 50% are in the 91,000 to 182,000 ton size class. Within each size class, it has been assumed that 70% of the plants can meet the required standards by an incremental step from Level B to Level C control, while the remaining 30% will have to effectively move from total discharge to total recycle. Of the latter plants, it is assumed the one half will use Level C control procedures and the other will use Level D control. Of the plants requiring incremental control 10% are assumed to require a Level B to Level D control process. These assumptions will probably result in a slight overstatement of the estimated total control costs.

Table III-28 presents the total fixed capital, and the annual costs associated with the additional required control for individual segments of the crushed stone industry. The major fixed capital costs are associated with that segment of the wet processing operations represented by the 1,100 facilities which presently discharge, and are at Control Levels A and B.

The final two columns of Table III-28 show total fixed capital and the annualized cost, in dollars per metric ton of product for each of the

Table III-28 INCREMENTAL CONTROL COSTS FOR CRUSHED STONE FACILITIES, SEGMENTS AND TOTAL INDUSTRY (BPCTCA & BATEA)

Treatment Required	-Process	Current Effluent Control Status	Current Control Level*	Future Control Level	Number of Facilities	Production Thousand Metric Tons	Additional Control Costs Required for Compliance: Total Capital Million $	Additional Control Costs Required for Compliance: Annual Cost $/Metric Ton
NONE	-Dry	No process water	-	-	3,200			
	-Wet	100% effluent re-cycle	C	C	500			
	-Flota-tion	100% effluent re-	C	C	2			
TOTAL					3,702	835,046	0	0
PARTIAL	-Wet	Ponds and discharge	B	C/D	770			
	-Flota-tion	Ponds and discharge	A	B	6			
TOTAL					776	72,375	4.81	0.024
FULL	-wet	No ponds	A	C/D	330			
TOTAL					330	28,000	7.61	0.158
INDUSTRIAL TOTAL					4,808	935,421	12.42	0.007

*Refers to Tables III-22 through III-26.

Source: Development Document and Arthur D. Little, Inc. estimtes aggregated segments of the industry. These costs are developed for each of the process segments in the following Impact Analysis Section.

For the purpose of analyzing economic impact, the industry is segmented on the basis of size and required discharge control process, as shown in Table III-29.

TABLE III-29. CRUSHED STONE INDUSTRY SEGMENTED BY SIZE OF PLANT AND REQUIRED DISCHARGE CONTROL PROCESS. NON-DRY PROCESS ONLY

	Plants Currently at Standard	(B-C) Incremental Control Plants		(B-D) Incremental Control Plants		(A-C) Plants Requiring Type C Control		(A-D) Plants Requiring Type D Control		Total Wet Process	Flotation Process
		91,000	91,000-182,000	91,000	91,000-182,000	91,000	91,000-182,000	91,000	91,000-182,000		
Number	500	345	345	40	40	83	82	83	82	1,600	6
Estimated Annual Production (Wet Process Product x 10^3 Metric Tons)	200,000	18,000	46,600	2,000	5,400	4,000	10,000	4,000	10,000	300,000	375
Employment	10,667	960	2,485	106	2,880	213	533	213	533	16,000	30
Total Control Cost (x 10^3 $)	0	396	973	84	220	598	1,473	677	1,670	6,091	55
Total Capital Requirements (x 10^6 $)	0	1.15	2.66	0.22	0.55	1.05	2.43	1.25	2.88	12.19	0.23
Net Revenue Per Metric Ton	.200	.165	.194	.165	.194	.165	.194	.165	.194	.195	1.940
Annualized Control Cost $/Metric Ton	0.000	0.022	0.020	0.042	0.040	0.150	0.148	0.170	0.168	0.020	0.147
Price Per Metric Ton	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	22.00

F. ANALYSIS OF ECONOMIC IMPACT

The basic result of the implementation of the effluent guidelines on the crushed stone industry will be to increase the cost of operation. The impact on the industry and the general economy will depend on the resulting changes in prices and production in the industry and any secondary impact those primary changes might generate. Table III-30 shows the normal operating costs for the model industry plants and the costs of required levels of discharge control for each of the described industry segments. (These costs have been developed in Sections C and E respectively.)

The variation of both general operating costs and discharge control costs is quite insensitive to plant size. There are few economies of scale in discharge control costs, but there appear to be minor scale effects in normal operating costs. The costs do vary considerably among different operations, but those variations appear to be the result of site-specific costs such as land values or specific mining considerations like depth of overburden, isolation of specific rock strata, the deposit, land rehabilitation costs, etc.

Table III-30 indicates that the additional cost on any operation requiring additional discharge control varies considerably. To analyze the economic impact of the required controls each segment of the discharge control process and the plant size must be analyzed. The portion of the industry that will require some form of discharge control of two very distinct segments would be the wet process and flotation process. Flotation process products are much higher-value products and the control processes are quite distinct. This segment of the crushed stone industry is covered separately from the wet process segment described below.

The table also shows the costs for effluent control for the flotation process segment of the industry, which is discussed below. Most crushed stone--and, indeed, virtually all wet process crushed stone--is used in

TABLE III-30. COST COMPONTENTS FOR CRUSHED STONE INDUSTRY

	Wet Process					Flotation Process
Plant Size (short tons)	100,000	200,000	1,400,000	2,400,000		68,800
Annual Capacity (metric tons)	91,000	182,000	1,270,000	2,180,000		62,500
Price per metric ton	2.20	2.20	2.20	2.20		22.00
Annual Revenues	$200,000	$400,000	$2,800,000	$4,800,000		$1,376,000
Normal Operating Costs:	185,000	365,000	2,520,600	4,255,000		1,255,000
Variable Costs	134,000	260,000	1,795,500	3,031,000		909,000
Labor	44,000	90,000	621,500	1,049,000		298,000
Materials	40,000	80,000	552,500	933,000		271,000
Repair and Maintenance	50,000	90,000	621,500	1,049,000		340,000
Fixed Costs	51,000	105,000	724,100	1,224,000		346,000
SG&A	35,000	55,000	379,300	641,000		237,000
Depreciation	8,000	30,000	206,900	350,000		55,000
Depletion	4,000	8,000	55,200	93,000		27,000
Interest	4,000	12,000	82,700	140,000		27,000
Net Revenues	15,000	35,000	279,400	545,000		121,000
Net Revenues/Metric Ton (pre-tax)	0.165	.194	.220	.250		1.940
Total Discharge to Total Recycle						
Costs of Control						
Process C - Total	6,800	13,400	94,500	152,700	Process B -	9,200
Fixed	1,800	3,600	25,400	34,000		6,300
Variable	5,000	9,800	69,100	118,700		2,900
Net Control Cost/Metric Ton wet process product	.149	.149	.148	.140		.147
Capital Requirements	12,000	22,100	128,300	208,600		38,000
Process D - Total	7,700	15,200	107,200	172,700		
Fixed	2,200	4,300	30,300	40,600		
Variable	5,500	10,900	76,900	132,100		
Net Control Cost/Metric Ton wet process product	.169	.169	.169	.158		
Capital Requirements	14,200	26,200	152,000	247,300		
Partial Recycle to Total Recycle						
Process B to C - Incremental Costs	1,000	1,900	13,300	21,000		
Fixed	400	800	5,600	7,600		
Variable	600	1,100	7,700	13,400		
Net Control Cost/Metric Ton wet process product	.022	.021	.021	.021		
Capital Requirements	1,900	5,200	30,000	49,100		
Process B to D Incremental Costs	1,900	3,700	26,000	41,000		
Fixed	800	1,500	10,500	14,200		
Variable	1,100	2,200	15,500	26,800		
Net Control Cost/Metric Ton wet process product	.042	.041	.041	.038		
Capital Requirements	5,100	9,300	54,000	87,800		

Source: Arthur D. Little, Inc.

construction and some is in direct competition with sand and gravel. Because of the value and transport costs of both these groups of products, there is no national market, but rather a series of local markets. The industry would appear to be very competitive on the basis of national figures from the existence of many small producers.

However, transport costs define limits on the area any producer can serve which means each producer tends to be an oligopolist in a very localized market facing little competition from any other producers 50 to 100 miles from that local market. The highly localized structure of these markets is evidenced by the wide disparity of prices shown in Table III-30. Sand and gravel prices also exhibit these wide variations in inter-market prices. (Sand and Gravel; Table II-15). There is in fact, a general similarity between the relative inter-market prices for crushed stone and construction sand and gravel. The basic market for crushed stone exclusively of feedstocks and agricultural uses will be construction, an activity which is largely concentrated in major population centers, i.e., within metropolitan areas or at the fringes of metropolitan areas.

A model regional market for construction sand and gravel has been constructed for the Baltimore-Washington area separately from the non-existent national market portrayed by examination of national aggregate statistics. This model is useful because sand and gravel is the major competitor of crushed stone. The development and characteristics of this model regional market are presented in Chapter II, Section D.3.

1. Incremental Discharge Control in a Major Metropolitan Market (Case 1)

a. Price Effects

In this case, the plants requiring incremental treatment face a cost increase of \$0.02 to \$0.04 per ton of wet processed product. Some operators in such smaller plants may not distinguish between dry and wet process product in their accounts and may consider their costs to have risen less per total production ton.

Only the smaller plants are expected to be affected by the guidelines. In a large market, the smaller plants would not be able to increase prices, because they would not have a large enough share of the market to function as a price leader. Other plants would hold prices to increase sales. In this case, prices would remain unchanged.

b. Financial Effects

Because the firms requiring additional control would have to absorb the cost increase, net revenues would be reduced. The amount of the reductionfor a particular plant would depend on the mix of wet and dry process product from that plant. The greater the share of wet process, the greater the decline in net revenues. If the total product of the plant was wet process, or if the operator considered each product separately, the reduction of net revenue would be about 25% for those plants requiring the incremental control process from Level B to Level D and half that for Level B to Level C.

The 25% reduction is a substantial change in net revenues, but many of the operations may be much more conscious of cash flow, which would not be so severely affected. (Consideration of depreciation and depletion would almost double net revenues.) After-tax cash flow would be reduced by only 20% under the most expensive increment control process. Operators would probably be willing to absorb that reduction in earnings unless the remaining value of the quarry was insufficient to pay off the required capital investment in effluent control equipment.

The capital requirements for incremental control do not appear to be a major barrier to implementing the control. Cash flows appear to be sufficient to fund the required investment from retained earnings. In this case, a single year of depreciation would more than fund the required effluent control investment.

c. Production Effects

It is not anticipated that plants in this case will close, either because of the deterioration of net revenues or because of difficulties in raising the necessary capital, as developed in the preceeding section on financial effects.

d. Employment Effects

The anticipated non-closure of plants in this case will leave unemployment levels unchanged.

e. Community Effects

The community would face no loss of jobs or income in this case.

2. Small Plants, From Total Discharge to Total Recycle (Case 2)

a. Price Effects

As in Case 1, these plants would not be able to pass on any cost increases. Prices would not be changed by the imposition of guideline effluent controls.

b. Financial Effects

The affected plants would face a substantial reduction in net earnings. The control costs per metric ton are $0.15 to $0.17, while net revenues are only $0.165 per ton for the smallest size model plant and

$0.194 per ton for the next larger size model plant. These plants would not remain economically viable and could be expected to close, or go entirely to dry process operation.

The net effect would be a realignment of wet and dry process production, between the producers who can produce wet process economically and those who would have to bear additional costs to continue in wet process production. (This realignment could conceivably shift some of the production of washed crushed stone to washed gravel produced by the sand and gravel industry.) A plant producing predominantly wet product would face difficulties in shifting markets, but if the option is to go out of business or continue to get a return on already invested capital, etc., the incentives to switch to dry production are powerful. Only if the equipment was old and the site about worked out would the operator be expected to stop producing.

c. Production Effects

It is expected in this case that the plants requiring complete control would switch to dry process product. Total production would be unaffected, although there would be a small realignment of dry and wet production between producers.

d. Employment Effects

No closures are expected, so there would be no loss of employment in this case.

e. Community Effects

The community would face no loss of jobs or incomes in this case.

3. Small Plants, From Total Discharge to Total Recycle in a Small Metropolitan or Rural Market (Case 3)

a. Price Effects

In a small market, small firms would not face much competition and would be able to pass cost increases on to consumers. The cost increase due to the effluent controls is substantial--on the order of 7 to 8% per ton. However, the very low price elasticity of demand for crushed stone would mean that such cost increases could be passed on. Crushed stone and construction sand and gravel each account for only about 1% of total construction costs. Thus, an 8% increase in crushed stone prices would result in an increase of only 0.08% in total construction costs. Prices in this market could be expected to rise to cover the full control cost.

b. Financial Effects

Net revenues are expected to be maintained, through the anticipated price increases. The capital required is substantial for small firms. Using depreciation as a measure of the capital presently used in the model plants, the additional capital required for control is about equal to annual depreciation. While capital requirements appear to be a burden on plant finances, the necessary funds should be available from the local banking system. The largest total capital required even for a moderate sized plant ($26,000) is equivalent to the loan for one moderate single family house. The ability to raise prices should mean that the banking system would consider the loan favorably.

c. Production Effects

No plant closures are anticipated since it is expected that these small plants in a small metropolitan or rural market would be able to pass on the control costs to their customers through the necessary price increase.

Consequently there should be no effluent control cost induced production shifts.

d. Employment Effects

No jobs would be lost through plant closures.

e. Community Effects

There would be no anticipated adverse impact on the community in this case.

4. Aggregate Impact Summary

None of the dry process plants are affected by the guidelines. Therefore this impact summary applies only to plants producing wet process crushed stone. The special flotation process segment is treated in Section 5 following.

The economic impact on the whole nation of the events taking place in isolated local markets will depend on the distribution of the firms among the various classes described above. As mentioned, there is no detailed data on the location of crushed stone plants, so an estimate must be made as to the numbers of each class of plant falling into each market model.

Small firms appear to be located generally in the smaller markets. Also, a small market would not support larger size plants. It has been assumed that 50% of the less than 91,000 metric tons capacity plants are in small markets, and 25% of 91,000 to 180,000 ton capacity plants are in small markets. Given this size distribution, the national economic impact can be estimated. Table III-31 shows the numbers of plants, production, and employment by the four impacted groups: unaffected plants that already meet the guideline standards; plants that face a moderate decline in net revenues; plants that must shift out of wet process production to stay in operation; and plants that can pass on their increased costs of operation. No closures are expected for plants in this industry.

a. Summary Price Effects

Only 412 firms are expected to be in a position to pass on their cost increases.

These firms account for 3.2% of production, so that no significant price impact is expected from the effluent control guidelines.

b. Summary Financial Effects

Some 482 plants are expected to be in a position of having to accept smaller rates of return and net revenues. These plants produce only 4.7% of total product, so impact on overall industry earnings will be insignificant.

c. Summary Production Effects

No plant closures are expected in any of the model markets, so there would be no impact of the guidelines on production levels. Some 206 plants would have to shift to all dry process product to remain in business. These plants produce only 1.7% of total product in the crushed stone industry.

The investment required to meet the guidelines for new or expanded plants in this industry will not be greatly increased. The added capital requirements would probably reduce the viability of new very small operations, but should not hamper the growth capacity of the industry.

Table III-31 NATIONAL SUMMARY OF ECONOMIC IMPACT

Crushed Stone Industry

Impact Category: Effect	Impact Category: Characterization	Number of Plants	%	Production (000 tons)	%	Employment	%
Not Affected	Dry Process	3,200	66.7	700,000	70.0	37,400	70.0
Not Affected	Wet Process Plants at Zero Discharge	500	10.4	200,000	20.0	10,700	20.0
Affected	Absorb Cost Increase	482	10.0	49,000	4.9	2,600	4.9
Affected	Shift to Dry Process	206*	4.3	19,000	1.9	1,000	1.9
Affected	Pass on Cost Increase	412	8.6	32,000	3.2	1,700	3.2
TOTAL		4,800	100.0	1,000,000	100.0	53,400	100.0

* See p III-77 for discussion of this impact category.

It is necessary to place this number of 206 plants into the appropriate context of this analysis. This value has resulted from calculations which have been based on a series of assumptions necessitated by the lack of specific data concerning wet process crushed stone facilities. The first key assumption is presented in the Development Document. This assumption is that of the total 1,600 wet crushed stone facilities, 500 are operating at 100% effluent recycle, with the remaining 1,100 operating with some discharge. There are presently insufficient data available to indicate the level of effluent control presently practiced at these 1,100 discharging facilities. Also, the production size distribution of these facilities is not available. Finally, there is insufficient information concerning the relationship of any of these facilities to specific market categories.

In the absence of these data, and in order to perform this analysis, it has been assumed that 50% of the plants are in the less than 91,000 metric tons per year size class, and the other 50% are in the 91,000 to 182,000 ton size class. Within each of these two size classes, it has been assumed that 70% of the plants can meet the required standards by an incremental step from level B to level C control, while the remaining 30% will have to effectively move from total discharge to total recycle. Of the latter plants, it was assumed that half will use level C control procedures and the other will use level D control. Of the plants requiring incremental control 10% were assumed to require a level B to level D control process.

Finally, it has been assumed that 50% of the small class plants (less than 91,000 metric tons per year) are located in small markets, while 25% of the larger class of plants (91,000-182,000 metric tons per year) serve small markets.

As previously indicated, the mix of wet and dry crushed stone product will vary greatly from plant to plant in the industry, as well as from year to year for any one plant. Finally, the specific market situation for these wet crushed stone producers is also subject to considerable variation with regard to geographic location and time.

Therefore, we believe that many of the plants in this category will be able to produce dry crushed stone only, and still remain economically viable. However, it is not possible to predict, from this data base and analysis how many of the plants in this category cannot successfully make this change.

d. Summary Employment Effects

No plant closures are anticipated, so no loss of employment is associated with the implementation of the effluent control guidelines for the industry.

e. Summary Community Effects

There is no loss of jobs or income anticipated and no adverse community impact is anticipated from implementation of these effluent guidelines.

f. Balance of Trade Effects

The highly local nature of sand and gravel markets because of high transportation costs means that the expected price increases would not induce any measurable competition from imports. National balance of trade would be unaffected.

5. Flotation Process Segment

The flotation process product is a very small proportion of total production and a highly specialized product requiring high purity of color and fineness. It is largely used for a whitening agent in various products. As such, it sells at a much higher price per ton, but also incurs higher production costs. We have assumed that net revenues are the same percentage of gross revenues as in the rest of the industry, so gross revenues per ton are estimated at $22 per metric ton.

The economic impact on the flotation process crushed stone industry is quite separate from the rest of the industry. The specialized nature of the product means that it is traded in a national market, rather than distinct local markets.

a. Price Effects

As an oligopolistic industry, any one of the few sellers would be likely to pass on cost increases through increased prices. These crushed stones are highly specialized products that do not have effective substitutes, so price elasticity of demand is very near zero. The full $0.145 cent per ton effluent control cost for these plants would be only a 0.7% increase in price.

b. Financial Effects

The increased costs would be passed on, so that net revenues and returns on sales or investment would not be reduced.

The required capital for discharge control is small in comparison to normal capital. The total investment in control equipment is only about 60% of one year of depreciation, so the required investment should be capable of being funded from retained earnings.

c. Production Effects

No plant closures are expected, so the implementation of the guidelines should not affect production. The requirement for effluent controls on new or expanded plants will increase the required investment, but not sufficiently to hamper growth of the industry. The ability to enter the industry will continue to depend on the control of the special deposits required for these products.

d. Employment Effects

No plant closures or production loss is expected, so there should be no adverse impact on employment in the industry.

e. Community Effects

The lack of plant closures will mean no adverse community impact.

f. Balance of Trade Effects

The extent of the expected price increase is not considered likely to harm any export potential for these products or to induce any new competition to domestic producers from imports.

G. LIMITS TO THE ANALYSIS

In addition to the general limits imposed by the overall method used for the economic analysis, the crushed stone industry raises some additional limitations.

The structure of the industry requires analysis of local markets, yet there is only scanty information available on the actual structure of those markets. The impact of the guidelines would be shifted if plants do not exist in the classes of markets that have been assumed. The assumptions used have been chosen to err on the side of overstatement of the adverse economic impact. A larger share of small plants has been assumed for large markets than is likely to be the case, but there is no real way of testing that hypothesis.

There is also used a narrow definition of economic viability. Individual operators may be willing to accept lower rates of return because of property values of the site, future potential land values, etc. The crushed stone operation may be a means of just meeting the holding costs for an appreciating asset. As long as the operation can meet the variable costs of operation, it will probably be kept going. This error would again lead to an overstatement of the economic impact of the guidelines.

IV. INDUSTRIAL SAND (SIC-1446)

A. PRODUCTS, MARKETS, AND SHIPMENTS

1. Product Definition

Industrial sands are deposits that have been worked by natural processes into segregated mineral fractions. Such deposits are utilized for their contained quartz (SiO_2). The deposits are found in a broad range of locations and formations, some as loose and visible as dune sand, others as dense and obscure as the hardest of rocks buried under a variety of surface materials, and literally all intermediate types of formations. They may be found as low-lying water bearing sands or as hard faced bluffs and cliffs--as out-cropped escarpments in a level plain or as a massive ridge or mountain face. It is believed that there is only one operating underground mine.

The 1972 Census of Minerals Industries has four subdivisions for this category: glass sand (SIC 14461); molding sand (SIC 14465); and industrial sand, not elsewhere classified (SIC 14469); and not specified by kind (SIC 14460). A more detailed breakdown of the uses of industrial sand is given in the Minerals Yearbook. Table IV-1 is a listing of the uses of the industrial sands and the extent to which they were used in 1974 by quantity and dollar values. From the table it may be seen that glass and molding sand constitute by far the two largest single uses of industrial sand. Dollar-wise they account for 38% and 31% of the market, respectively. These combined totals comprise about 73% of the tonnage of industrial sand sold.

The final use of industrial sand depends chiefly on its grain size and purity. Sand used for the glass, chemical, and silicon industries is required to be mono-mineralic and to possess no staining materials and essentially no iron. Glass sands are also required to be within a specified

Table IV-1 INDUSTRIAL SAND SOLD OR USED BY ALL PRODUCERS IN THE UNITED STATES, 1974

	Quantity		Value
	10^3 MT	(10^3 ST)	(\$$10^3$)
Unground Sand			
Molding	6,939	(7,642)	33,328
Glass	9,116	(10,040)	46,632
Blast	1,939	(2,136)	11,281
Grinding & Polishing	90	(99)	558
Fire or Furnace	362	(399)	1,752
Engine	476	(524)	2,073
Filtration	277	(305)	1,639
Metallurgical	331	(364)	1,286
Oil (hydrofrac)	348	(383)	3,447
Other	1,913	(2,107)	8,824
Total Unground Sand	21,791	(23,820)	110,821
Ground Sand			
Filter	189	(208)	2,865
Chemical	367	(404)	1,719
Abrasive	295	(325)	2,823
Foundry	1,902	(2,095)	8,627
Glass	772	(850)	5,004
Pottery, Porcelain, Tile	123	(136)	1,552
Other	169	(186)	1,944
Total Ground Sand	3,817	(4,204)	24,536
Total Industrial Sand	25,608	(28,024)	135,357

Source: 1975 Annual Advanced Summary, Minerals Industry Surveys, U.S. Department of Interior, Bureau of Mines size range. Foundry sands come in contact with molten metals and as such must have a high degree of refractoriness and be highly permeable. Filtering sand must be pure particles which are well rounded, so that porosity is maximized. Metallurgical pebble employs gravel-sized quartz grains for silicon metal production. Grinding sands are uniform in size and round so that grain fracture is minimized, whereas blasting sand is preferred to have angularity.

2. Production Processes

The Development Document has considered various factors in subcategorizing the industry and has concluded that, with the exception of the manufacturing process employed, no factors are of sufficient significance to justify their use in the segmentation process. As such, the following three subcategories were selected:

- Dry Processes,
- Wet Processes, and
- Flotation Processes.

a. Dry Processing

Dry processing of industrial sand typically involves the scalping or screening of sand grains which have been extracted from a beach deposit or by the crushing of sandstone prior to screening. This type of operation is characterized by the absence of process water for sand classification and beneficiation. Sand obtained from beach deposits, if a specified size, is trucked to the processing facility where it is dried, cooled, screened to remove coarse grains and then stored. By processing beach sand from different shoreline distances it is possible to obtain various grain sizes and ranges, thereby permitting a firm to reach a number of market segments. Facilities that quarry sandstone tend to have a more limited market because of the purity requirements associated with glass sands. However, facilities do exist in which a sandstone is quarried and dry processed to form a product that is suitable for use as a glass sand. As mentioned above, dry processing is characterized by the absence of process water; however, in some facilities wet scrubbers are used for the dust collection system at the dryer to meet air pollution control requirements. Both the fines and the oversize materials are used as landfill.

It is estimated that there are currently 20 plants producing industrial sand by the dry process and that they comprise about 10% of the industry's output.

b. Wet Processing

Wet processing plants are operated on ore obtained by each of the basic extraction methods: mining of sand from open pits, mining of sandstone from quarries, and hydraulic dredging. Water is used as the transport medium in wet processing. An initial screening consisting of a system of scalpers, trammels and/or classifiers is commonly used at most facilities to remove foreign materials such as rocks, wood and clays. The wet process is used for ores containing a lot of debris. Here again, solid wastes are either stockpiled or used as landfill.

Nearly 80% of the plants producing industrial sand do so by the wet process. It is estimated that about 130 plants use this process, and they account for about 75% of the annual industrial sand output.

c. Flotation Processing

In the third subcategory, flotation, three techniques are possible:

- Acid Flotation,

- Alkali Flotation, and

- Hydrofluoric Acid Flotation.

In acid flotation, sand is crushed to appropriate size and washed to remove clays and other impurities. The washed sand is slurried with water and conveyed to the flotation cells. Sulfuric acid, frothers and reagents are added to the slurry to cause separation of the silica and the impurities. The silica settles out, while the iron-bearing impurities are floated and removed through the overflow. The reagents used in this process include sulfamated oils, terpenes and heavy alcohols in amounts of up to 0.5 kg/kkg (1 lb/ton) of product. The purified silica is recovered, dried and stockpiled. All process wash and flotation waste waters are fed to settling lagoons in which mud and other suspended materials are settled out. The water is then recycled to the process.

Alkaline flotation is used to remove aluminates and zirconates. The alkaline flotation process is quite similar to the acid flotation process. Prior to being fed to the flotation cell, the slurried, washed sand is pretreated with acid. In the cell it is treated with an alkaline solution of caustic soda, soda ash, or sodium silicate together with frothers and conditioners. The pH is generally maintained at about 8.5, rather than about 2 in acid flotation. The overflow is fed to settling lagoons in which the impurities are settled out. The water is then recycled or at least partially recycled.

Hydrofluoric acid flotation is used to remove feldspar. This flotation technique consists of feeding the underflow from an acid flotation cell to a second flotation cell in which hydrofluoric acid, terpene oils and conditioning agents are added. The underflow from this cell containing the silica is collected, dewatered and dried. All waste waters are then combined and fed to a thickener to remove suspended materials. The overflow from the thickener is recycled to the process. The underflow, which contains less than 7% of the water and essentially all of the suspended material, is fed to a settling lagoon for removal of suspended solids prior to discharge. Only one plant has been found which uses this process.

It is estimated that there are currently 18 flotation plants in the United States producing industrial sand, and that these plants have a combined output of about 15% of the total tonnage for the industry.

3. Price, Shipments

In 1974, the average price for industrial sand was about $5.30 per metric ton. Filter sand was highest at $15.17 per metric ton, while metallurgical sand was lowest, at $3.89 per metric ton. The large difference in prices between the two types is due to the rather exacting physical property requirements for filter sand (i.e., round, uniform, etc., to allow for maximum porosity), as opposed to the gravel-size quartz grains which constitute metallurgical pebble. Table IV-2 summarizes the average prices for the various types of industrial sand. The prices fall essentially into two ranges.

Table IV-3 summarizes the quantity and value of shipments for the ten-year period 1963-1972. Also included is the average price per metric ton for the same period. During this period, the consumption of industrial sand increased at an average annual rate of 3.5% while the dollar value grew at a rate of 5% per year. As would be expected, this industry closely follows the combined foundry and glass industry, as shown in Figure IV-1. Over the ten-year period, only in 1972 was there any significant deviation, which was due to the "foundry recession" which occurred during 1972 and the first half of 1972 and resulted in a condition of overcapacity in foundry sands. This, together with the supply/demand function, restricted price increases at a time when labor, power and other costs were increasing. Since 1972, the industry has been able to increase prices from an average of $4.20 in 1972 to $5.30 per metric ton in 1974, or about 25%.

Table IV-2 AVERAGE SELLING PRICE FOR VARIOUS TYPES OF INDUSTRIAL SANDS, 1974

Type of Sand	Price Per Metric Ton ($)	Price Category ($/$10^3$ ton)
Glass	5.11	
Molding	4.92	
Fire or Furnace	4.83	\$4 - 6 (\$5.09)
Engine	4.36	
Metallurgical	3.80	
Filter	15.17	
Pottery, Porcelain, Tile	12.26	
Oil (hydrofrac)	9.91	\$6 - 15 (\$7.40)
Abrasives	9.57	
Grinding and Polishing	6.21	

Source: Minerals Industry Surveys, Annual Advanced Summary Report, 1975.

Table IV-3 VALUE OF SHIPMENTS FOR INDUSTRIAL SAND (1963-1972)

	Unground Sand						
	Molding	Glass	Other	Unground Total	Ground Sand	Ground and Unground Total	Avg. Price Per Ton
1963							
Quantity							
M.Tons	6,882	6,541	4,790	18,213	945	19,158	3.58
Sht.Tons	7,579	7,204	5,275	20,058	1,041	21,099	3.25
Value $\$10^6$	20,814	23,626	15,205	59,645	8,921	68,566	
1965							
Quantity							
M.Tons	8,927	7,471	5,172	21,570	1,485	23,055	3.49
Sht.Tons	9,831	8,228	5,696	23,755	1,636	25,391	3.16
Value $\$10^6$	26,319	26,154	16,622	69,105	11,238	80,343	
1967							
Quantity							
M.Tons	8,589	8,115	4,937	21,640	1,353	22,993	3.73
Sht.Tons	9,459	8,937	5,437	23,833	1,490	25,323	3.39
Value $\$10^6$	26,934	28,976	18,962	74,872	10,983	85,855	
1969							
Quantity							
M.Tons	9,629	9,577	5,422	24,628	1,725	26,351	3.87
Sht.Tons	10,605	10,547	5,971	27,123	1,900	29,021	3.52
Value $\$10^6$	30,371	36,398	20,798	87,567	14,460	102,026	
1971							
Quantity							
M.Tons	6,630	8,792	6,595	22,017	1,735	23,754	3.85
Sht.Tons	7,302	9,683	7,263	24,248	1,911	26,161	3.49
Value $\$10^6$	21,763	36,445	20,275	78,483	12,893		
1972							
Quantity							
M.Tons	6,830	9,832	6,055	22,716	4,097	26,813	4.19
Sht.Tons	7,522	10,828	6,668	25,018	4,512	29,530	3.81
Value $\$10^6$	24,827	41,259	24,754	90,840	21,546	112,386	

Source: 1972 Census of Manufactures

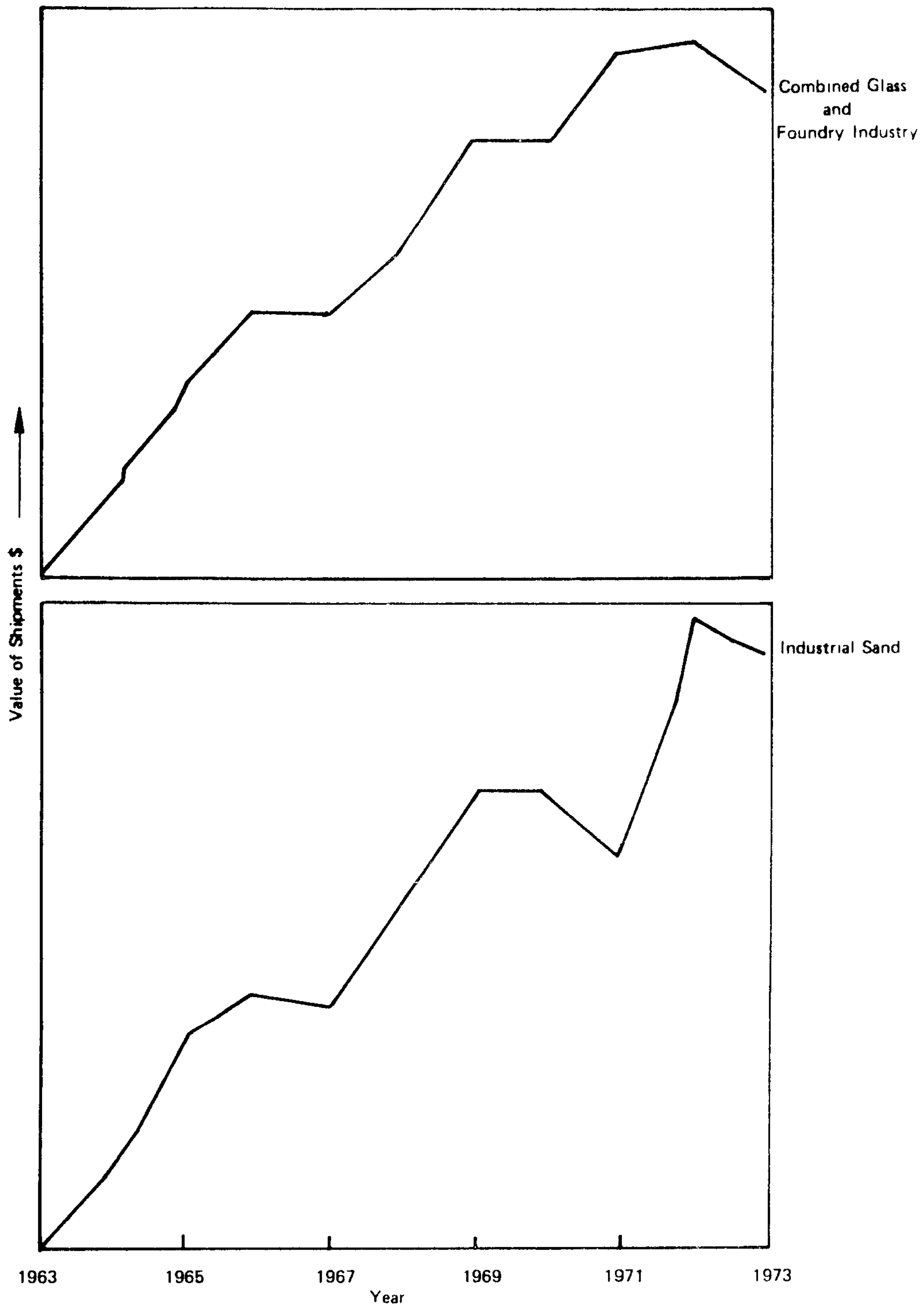


FIGURE IV-1 DEPENDENCE OF INDUSTRIAL SAND ON THE GLASS AND FOUNDRY INDUSTRY

4. End Uses

Industrial sands are used primarily for their refractory properties in the steel and foundry industries, for their chemical properties in the glass industry, and for their physical properties in the oil, filtrating and abrasive industries.

The end uses of industrial sand are essentially those as given in the Minerals Yearbook breakdown given in Table IV-1. Glass sand is used as the principal raw material in the manufacture of glass. The foundry-casting industry makes use of core sand, runner sand, foundery sand, and molding sand. Fire or furnace sand is used for lining and patching open hearth and electric steel furnaces. Oil (hydrofrac) sand is used to increase fluid production in oil wells. Metallurgical pebble is used chiefly as a component in the preparation of silicon alloys or as a flux in phosphorous production. Blasting sand is used to remove rust, paint, or metal in sand-blasting operations. Abrasive sands are used to make abrasive cloths and papers and as a polishing medium.

5. Possibility of Substitutes

In both the foundry and glass industries, industrial sand has essentially no substitute. It is true that in the foundry industry such materials as zircon, olivine, staurolite, and chromite sands are used in special applications, but their costs of five to ten times that of silica prohibit their extensive use. In the glass industry, silica has no substitute, as the other glass-forming oxides do not impart the necessary working and/or durability properties required in glass applications. This is also true in the production of silicon. In the remaining end-use markets, silica enjoys a large price advantage over other possible substitute materials.

6. Future Growth

As mentioned previously, the industrial sand industry closely parallels the combined glass and foundry industries. It is estimated that by 1982 the United States foundry industry will be shipping about 26 million tons of castings, which is about a 3% annual growth rate. Growth projections for the glass industry are similar, hence it is expected that the industrial sand industry will also grow at about a 3% per year rate. It is not expected that any new applications for industrial sands will significantly increase demand for these products. However, the threat of reduced consumption is present, especially for the glass container industry, which competes with metal and plastic containers, particularly if some state legislates to ban non-returnable bottles. Sand reclamation is on the increase in the foundry industry, and although this would tend to indicate lower demand, it is not necessarily the case. Foundries using no-bake resin sand usually add 20-30% new sand to each batch, which is considerably more than the amount of new sand required for each batch of green molding sand.

7. Market and Distribution

Foundry sands are sold mostly by direct salesmen who are located in the vicinity of each firm's largest customer. The salesmen can be considered sales engineers, because they must be capable of carrying on technical discussions with their customers and also be able to help diagnose casting defects. Foundry sands are also sold by jobbers and manufacturers' representatives who sell on a commission basis but also have the same technical capability as do the sand producers' direct salesmen. Sales of glass sands are made largely on a long-term basis. Prices, uniformity, quality product, and supplier reliability are the key to sales of sand into the glass industry.

Transportation of glass sand is by large 100-ton closed, hopper-bottom rail cars and by specially equipped trucks. The competition between rail and truck controls freight charges in the industry. At one time, foundry sands were transported mostly by water. Since most of the sand is dry and free flowing, pressure-truck delivery of 20 tons or more is typically used for customers within a 150-mile radius, except for particularly large customers whereby freight cost dictates rail shipment.

B. INDUSTRY STRUCTURE

1. Types of Firms

The number of firms producing industrial sand in the United States (SIC 1446) has declined by approximately 50% since 1963, when there were 159 firms reported.[1] However, during this same period, the number of plants declined by only about 16% or from 197 plants in 1963 to the present number of 168. The reduction in the number of plants has chiefly been caused by the closing of single-plant firms that were unable to raise the necessary capital to upgrade equipment to produce high-quality products. The drastic reduction in the number of firms has been due to the multiple acquisitions of plants by large corporations and to a lesser degree by large privately held companies, so now the types of firms producing industrial sands vary from the ownership of multiple-plant firms (by either privately held companies or corporations of varying size) to firms having a single plant.

All of the large producers are either owned by corporations or are privately held. Therefore, products and sales volumes are not directly accessible. For instance, the largest producer, Pennsylvania Glass Sand, is owned by ITT. Sales for the production of industrial sand per se are not given in their annual reports but rather is included with other products in their Natural Resources Division. A report was obtained for Ottawa Silica Company, a privately held company that reports annual sales of $16 million. Ottawa Silica Company and Wedron Silica Company (a division of Del Monte Properties Company) are considered to be second and third in size after Pennsylvania Glass Sand. A reasonable estimate of annual sales for Pennsylvania Glass Sand Company then might be about $40 million, as it is believed to have somewhat more than double the volume of Ottawa Silica Sand Company.

[1] 1967 Census of Minerals Industry; Sand and Gravel; U.S. Dept. of Commerce, Bureau of the Census.

The next three largest firms whose annual sales are believed to be in the order of $10 million are Martin-Marietta, Arkhola Sand and Gravel (owned by Ashland Oil), and Whitehead Brothers. Together those six firms comprise about two-thirds of the industrial sand industry.

All the large firms sell to both the glass and foundry industries and have a product range which covers essentially all the markets for industrial sands. The small firms sell very little, if any, to the glass industry because as they are unable to fill the large demands of the glass manufacturers. The smaller firms, of necessity, have a very restricted product line. Primarily they sell to the foundry industry. Table IV-4 lists most of the firms producing industrial sands, and list the market segments they supply.

2. Types of Plants

The 1972 Census data reported that 167 plants produced industrial sand. The present 168 plants reported in the Development Document agree, but there is a rather large discrepancy compared to the number of plants reported in the 1974 Advanced Summary of the Minerals Industry Surveys for Sand and Gravel. The latter publication reports 118 plants producing only industrial sand and gravel, and 101 plants producing some industrial sand and gravel.

The plants producing industrial sand have from 4 to 250 employees. Specific data on production quantities per plant are not available. An estimate of the output for various plant sizes can be estimated from a calculation based on the industry output per employee as determined from Census data. Table IV-5 summarizes the estimates. The calculated output values were obtained by taking the 1972 average selling price of $4.20 per ton and then making the appropriate calculation with the published shipment values and number of plants in each employee category. From the calculation, it is estimated that plant sizes vary from between 20,000 to

Table IV-4 INDUSTRIAL SAND FIRMS

Company	Location
American Gilsonite Co.	Utah
Arkhola Sand & Gravel Co.	Arkansas
Arrowhead Silica Corp.	Indiana
Ayers Mineral Co.	New York
Bay City Sand Co.	Wisconsin
Bellrose Silica Co.	Illinois
G.W. Bryant	New York
C.E. Cast Equipment	Ohio
Central Silica Co.	Ohio
Columbia Silica Sand Co.	S. Carolina
Continental Minerals Processing Co.	Ohio
Crystal Silica Co.	Calif.
CX Products Corp.	Texas
Dawes Silica Mining Co.	Georgia
Delhi Foundry Sand Co.	Ohio
Del Monte Processing Co.	Calif.
Downer Silica Co.	New Jersey
Dresser Industries	Texas
Durez-Stevens Foundry Sand Co.	Michigan
Eastern Rock Products, Inc.	New York
Ellwood Stone Co.	Penna.
Engineering Abrasives Co.	Illinois
Exner Sand & Gravel Corp.	New York
Filtros Plant (Ferro Corp)	New York
Foundry Materials Co.	Michigan
Gopher State Silica Inc.	Minnesota
Great Lakes Foundry Sand Co.	Michigan
Hardy Sand Co.	Indiana
Harris Mining Co.	N. Carolina
Hungerford & Terry Inc.	New Jersey
Illinois Sand & Ballast Co.	Illinois
Independent Gravel Co.	Missouri
Indiana Products Co.	Indiana
Inland Refractories Co.	Ohio
Inversand Co.	New Jersey
Kenner Sand & Clay Co.	Ohio
Kings Mountain Silica Co.	N. Carolina
Klicks Core Co.	Calif.
Lewes Sand Co.	Minnesota
Manufacturers Minerals Co.	Washington
MDC Industries	Penna.
Martin-Marietta	Illinois
Millwood Sand Co.	Ohio
Mississippi Lime Co.	Illinois
Morie, J.S. & Co.	New Jersey
Moulder's Friends, Inc.	Illinois
National Glass Sand Corp.	New Jersey
N.J. Pulverizing Co.	New York
N.J. Silica Sand Co.	New Jersey
Northern Gravel Co.	Iowa
Northwest-International	Washington
Ottawa Silica Sand Co.	Illinois
Peerless Mineral Products Company	Ohio
Penn. Foundry & Supply Co.	Penna.
Penn. Glass Sand Co.	Penna.
Pettinos, G.F.	Penna.
Porter Warner Industries, Inc.	Tennessee
Refractory Sand Co.	Penna.
Ross & White Co.	Illinois
Saginaw Core Sand Co.	Michigan
Sand Products Co.	Michigan
Sargent Sand Co.	Michigan
Silica Products Co.	Arkansas
Southern Processing Div.	Alabama
Southern Products and Silica Co.	N. Carolina
Standard Sand Co., Inc.	Michigan
Standard Silica Co.	Illinois
Unisil Corp.	New York
Wedron Silica Sand Co.	Illinois
Western Filter Co.	Colorado
Whitehead Brothers Co.	New Jersey

Source: Thomas Register; Dun & Bradstreet Million Dollar Directory - Middle Market Directory

Table IV-5 ESTIMATED OUTPUTS FOR VARIOUS SIZE PLANTS

Avg. Employees Per Plant	No. of Plants	Value of Shipments ($10^6)	Average Output* Per Plant (10^3 tons)
0 to 4	35	2.9	20,000
5 to 9	31	6.5	50,000
10 to 19	38	13.6	85,000
20 to 49	46	46.8	240,000
50 to 99	11	30.2	655,000
100 to 249	5	24.8	1,200,000
250 to 499	1	9.3+	2,000,000+

*Based on an average price of $4.20/metric ton

+ADL estimates

Source: 1972 Census of Mineral Industries; ADL estimates

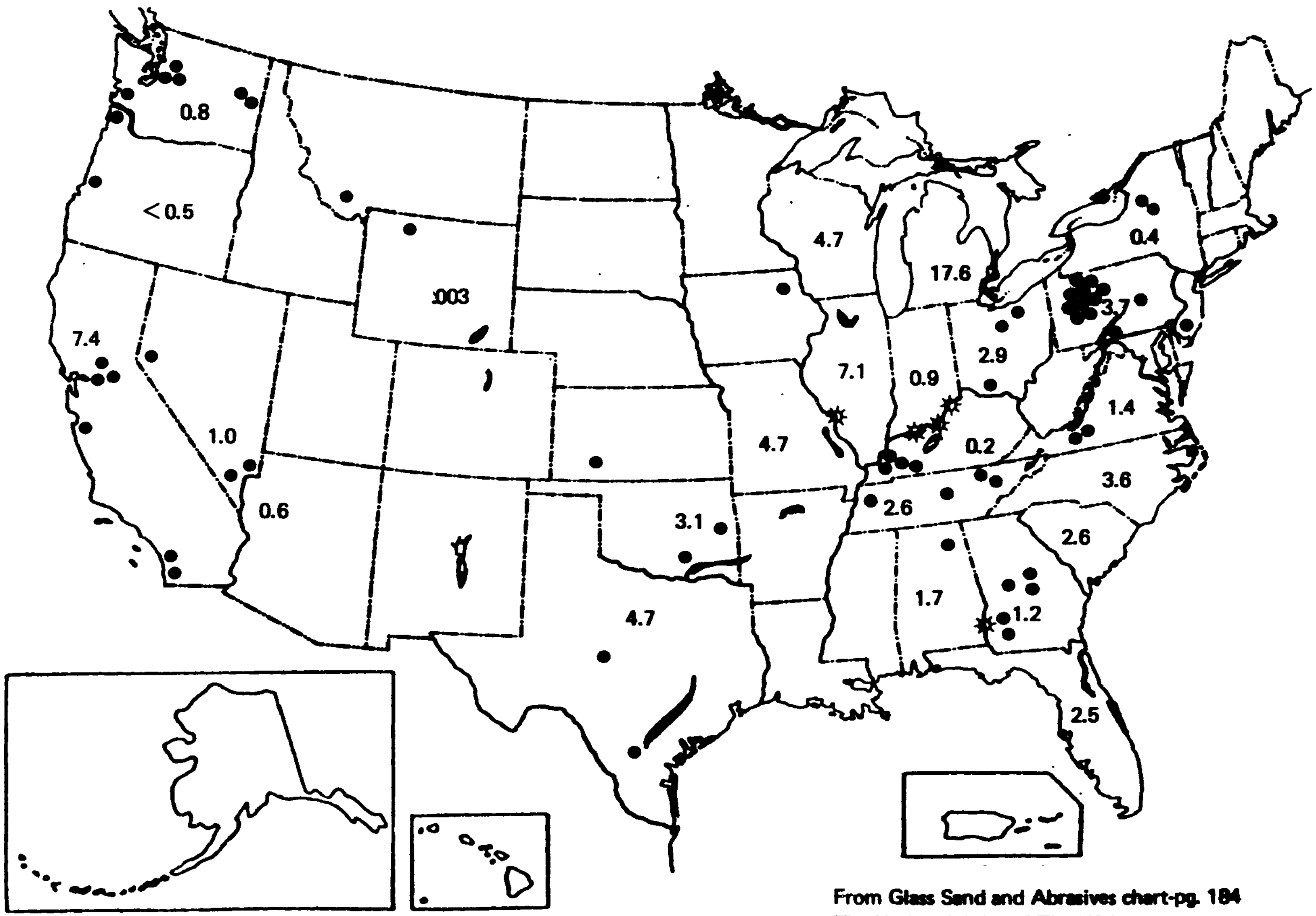
2 million metric tons per year. The Development Document presents a typical plant as producing 180,000 metric tons per year. This value lies between the calculated values of 85,000 and 240,000-ton plants, which accounts for 38 and 46 plants, respectively. These two categories account for about 50% of the industries output and number of plants.

Based on the information in the Development Document, facilities range in age from one year to 60 years.

Plants producing industrial sand are located in 42 of the 50 states. Four industrial producing states account for 43% of 1974 U.S. production, and are Michigan (17.6%), New Jersey (11%), California (7.4%), and Illinois (7.1%). Plant locations are determined by balancing marketing and processing costs, availability of power and fuels, and transporation cost. A measure of the importance of these factors is shown in Figure IV-2, which contains the geographic location of U.S. industrial sand deposits and approximate production for a number of states. Specific data concerning the number of plants in each state are not available; however, data are available about the production per state.

3. Industry Segmentation

There are basically three methods used for processing industrial sands: dry, wet and flotation. Table IV-6 summarizes the magnitude of each of these basic segments. Data on operating costs for the various processing methods are considered proprietary in the industry, so they are not directly available. To obtain some measure of operating costs, an engineering cost estimate was made for each of the processes. A breakdown of the cost estimates is given in Table IV-7 for the model plant size of 180,000 metric tons per year. From the table it is apparent that, at a given output level, operating costs for wet and dry processes are essentially identical, whereas the operating costs for a flotation process are significantly higher. However, because of the interrelation between the processing



From Glass Sand and Abrasives chart-pg. 184
The National Atlas of The USA
USGS-1970

FIGURE IV-2 INDUSTRIAL SAND DEPOSITS

Table IV-6 SUMMARY - INDUSTRIAL SAND SEGMENTS, 1972

Process	Plants Number	Plants %	Production %
Dry	20	11.9	10
Wet	130	77.4	74
Flotation (Acid/Alkali)	17	10.1	15
Flotation (Hydrofluoric Acid)	1	0.6	1
Industry Total	168	100.0	100

Source: Development Document; ADL estimates

Table IV-7 ESTIMATED OPERATING COST FOR INDUSTRIAL SAND PROCESSING PLANTS

Annual Production: 180,000 Metric Tons

	Annual Operating Cost		
	Dry Process	Wet Process	Flotation Process
Variable Cost			
Cost of Labor	$ 84,000	$ 84,000	$207,000
Cost of Maintenance, Repair, etc.	13,000	15,000	31,000
Cost of Fuels and Supplies	263,000	250,000	325,000
Payroll Overhead	13,000	13,000	32,000
	$373,000	$362,000	$595,000
Fixed Cost			
Depreciation	63,000	77,000	154,000
Taxes and Insurance	9,500	11,000	23,000
Plant Overhead	11,000	13,000	26,000
	$ 83,500	$101,000	$203,000
Annual Operating Cost	$456,500	$463,000	$798,000
Manufacturing Cost ($/$10^3$ ton)	2.54	2.57	4.43

Source: ADL Estimates

techniques and mining methods (dry pit, wet pit, and quarry), segmentation of the industry based solely on processing method is not sufficient. Therefore, an engineering cost estimate for each of the three mining methods has also been made for the model size plant.

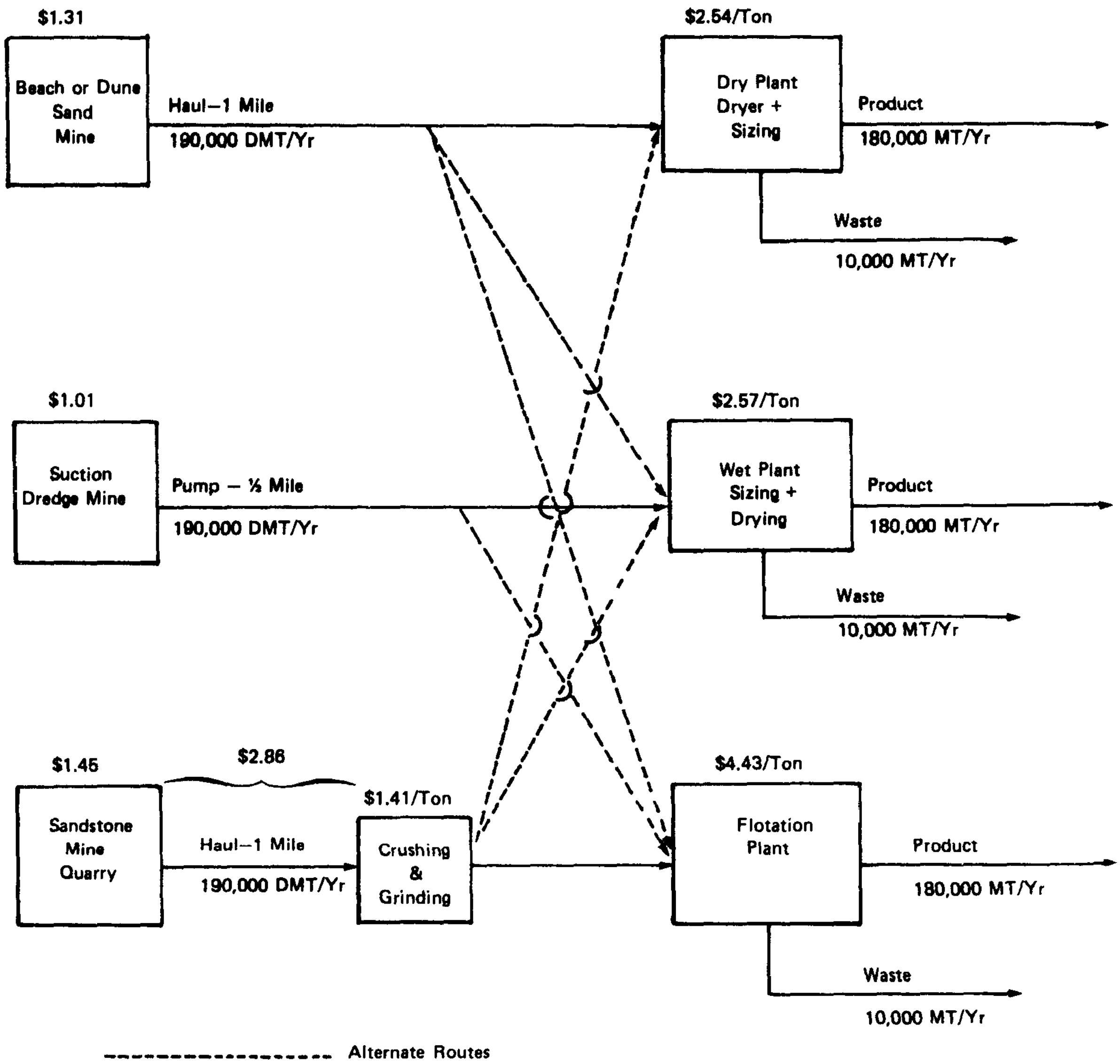
The estimated investment and operating cost associated with each mining method is given in Table IV-8. The various process-mining options are shown graphically in Figure IV-3. A summation of the operating costs for the various mining-processing alternatives suggests a means of greatly reducing the number of segments occurs, as all but one of the alternatives fall into one of two operating cost levels. Table IV-2 showed that--although there are at least ten identifiable market segments, all at different prices, in the industrial sand industry--there were only two distinct price levels or averages. Table IV-9 summarizes the combined data of Tables IV-2, IV-7 and IV-8. Also included in Table IV-9 is an estimate of the operating cost for a high-production (1 million metric tons per year) facility that uses flotation. This size and type of plant has been incorporated in the table because, although the Development Document model size of 180,000 metric tons per year is representative of the industrial sand industry, it is not representative of glass sand producers. The reason for this is that glass manufacturers require such large tonnages that a facility having an output of 180,000 metric tons per year would be unable to meet all of the demands of a glass manufacturer. At such a high output level, facilities employing flotation processes are able to sell sands into the high-volume, lower-price market.

In summary, the industrial sand industry has two segments: one with an operating cost of nearly \$4 per metric ton, that sells into a market of slightly more than \$5 per metric ton that comprises about 80% of the industrial sand industry; and one with an operating cost of about \$5.50 per metric ton, that sells into a market of greater than \$7 per metric ton. The one mining-processing alternative at the model level--quarry-flotation--was not included in the segmentation, because such an

Table IV-8 ESTIMATED INDUSTRIAL SAND MINING COSTS

Type of Mining	Investment	Manufacturing Cost Fixed	Manufacturing Cost Variable	Total
Beach	$264,000	$ 90,000	$146,000	$236,000
		$0.50/Mton	$0.81/Mton	$1.31/Mton
Dredge	$280,000	76,000	106,000	182,000
		0.42	0.59	1.01
Quarry	$314,000	150,000	365,000	515,000
		0.83	2.03	2.86

Source: Arthur D. Little, Inc. estimates



Source: Arthur D. Little, Inc.

FIGURE IV-3 INDUSTRIAL SAND MINING-PROCESSING ALTERNATIVES

Table IV-9 SUMMARY OF SEGMENTATION RATIONALE

Segment Designation	Facility Description	Plant Size (Mtons/Yr)	Investment ($)	Operating Cost ($/Mton)	Average Oper. Cost for Segment ($/Mton)	Market Segment (Price per ton)	Market Share (tons-$)
	Dry Pit - Dry Process	180,000	900,000	3.85			
I_A	Dry Pit - Wet Process	180,000	1,000,000	3.88	3.77		
	Dredge - Wet Process	180,000	1,000,000	3.58			
						$5.09	78%-77%
I_B	Mine - Flotation	1,000,000	5,200,000	4.00	4.00		
	Dry Pit - Flotation	180,000	1,800,000	5.74			
	Dredge - Flotation	180,000	1,800,000	5.44	5.50	$7.40	22%-23%
II	Quarry - Dry Process	180,000	1,900,000	5.40			
	Quarry - Wet Process	180,000	2,000,000	5.43			

The operating costs include depreciation on a 10-year basis for the plants and mining costs on an equipment life of 5 years.

Mining costs include a royalty of 35¢ per M ton of mined sand or stone.

Source: Arthur D. Little, Inc. estimates

operation is believed to exist only at the very high capacity outputs. Therefore, because of economies of scale, its operating cost is low enough to be competitive with the other alternatives.

C. FINANCIAL PROFILE

Based on cost engineering estimates, annual reports, and current understanding of other costs associated with the selling and marketing of industrial sands, three income statements have been prepared to characterize the industry. Table IV-10 represents those types of facilities designated as segment I_A; Table IV-11, segment I_B; and Table IV-12, segment II.

An abbreviated annual cash flow, indicating the level of internal funds available for other uses such as control equipment, is given in Table IV-13 for each of the segments. The tabulation shows that the funds available range from 2.4 to 4.2% of sales. A balance sheet of what may be considered to be an average plant is included as Table IV-14.

Table IV-10 INCOME STATEMENT FOR SEGMENT I_A FACILITIES, 1974

Annual Production: 180,000 Metric Tons Per Year		
Net Sales (based on $5.09 selling price):		$916,000
Less:		
Cost of Labor	$ 84,000	
Cost of Materials, Fuels	256,000	
Cost of Maintenance, Repair, etc.	14,000	
Cost of Mining	218,000	
Payroll Overhead	13,000	
Gross Profit		$331,000
Less:		
Plant Overhead	12,000	
Taxes and Insurance	11,000	
Depreciation	72,000	
Interest	17,000	
Sales, Gen. & Admin.	138,000	
Profit Before Taxes		$ 81,000
Taxes	39,000	
Profit After Taxes		$ 42,000

Source: Arthur D. Little, Inc. estimates

Table IV-11 INCOME STATEMENT FOR SETMENT I_B FACILITIES, 1974

Annual Production: 1,000,000 Metric Tons Per Year		
Net Sales (based on $5.11 glass sand selling price)		$5,110,000
Less:		
Cost of Labor	595,000	
Cost of Fuels	1,820,000	
Cost of Maintenance, Repairs, Etc.	99,000	
Cost of Mining	740,000	
Payroll Overhead	92,000	
Gross Profit		$1,764,000
Less:		
Plant Overhead	85,000	
Taxes and Insurance	75,000	
Depreciation	500,000	
Interest	100,000	
Sales, Gen. & Admin.	500,000	
Profit Before Taxes		$ 504,000
Taxes	242,000	
Profit After Taxes		$ 262,000

Source: Arthur D. Little, Inc. estimates

Table IV-12 INCOME STATEMENT FOR SEGMENT II FACILITIES, 1974

Annual Production: 180,000 Metric Tons Per Year

Net Sales (based on $7.40 selling price)		$1,330,000
Less:		
Cost of Labor	$145,000	
Cost of Materials, Fuel	290,000	
Cost of Maintenance, Repairs, Etc.	22,000	
Cost of Mining	362,000	
Payroll Overhead	23,000	
Gross Profit		$ 488,000
Less:		
Plant Overhead	19,000	
Taxes and Insurance	17,000	
Depreciation	112,000	
Interest	34,000	
Sales, Gen. & Admin.	200,000	
Profit Before Taxes		$ 106,000
Taxes	51,000	
Profit After Taxes		$ 55,000

Source: Arthur D. Little, Inc. estimates

Table IV-13 ANNUAL CASH FLOW FOR THE VARIOUS SEGMENTS, 1974

	Segment Designation		
	I_A	I_B	II
Pretax Profit	81,000	504,000	106,000
Plus Depreciation	72,000	500,000	112,000
Cash Flow Pretax	153,000	1,004,000	218,000
Income Tax	39,000	242,000	51,000
Cash Outlay for Capital Assets	92,000	511,000	133,000
Cash Available for Other Uses	22,000	251,000	34,000
(as % of Sales)	(2.4%)	(4.2%)	(2.6%)

Source: Arthur D. Little, Inc. estimates

Table IV-14 BALANCE SHEET FOR TYPICAL PLANT PRODUCING INDUSTRIAL SAND

Annual Production: 180,000 Metric Tons

Net Sales: $1,000,000

Assets:		
Current Assets		$ 400,000
Fixed Assets	700,000	
Less: Depreciation	20,000	700,000
Other Assets		200,000
Total Assets		$1,300,000
Liabilities and Net Worth:		
Current Liabilities		400,000
Long Term Debt		400,000
Stockholders' Equity		200,000
Retained Earnings		300,000
Total Liabilities		$1,300,000

Source: Arthur D. Little, Inc. estimates

D. PRICING

Prior to 1972, the price per ton of industrial sands increased at a very low rate, and even declined in one year, as shown in Table IV-3. Then in 1972, at a time when labor and energy costs were increasing, a price freeze was invoked. Since the freeze was lifted, the price of industrial sand has increased 26%. This large increase, although it reflects an inflated price, tends to indicate that the industry as a whole is able to pass on increases.

Economies of scale would normally dictate a lower operating cost for larger facilities, thereby reducing profit levels for smaller operations. This condition tends not to occur in this industry, because the small industrial sand operations sell to a very localized market, usually within a 100-mile radius. Because of this they enjoy a price advantage, due to lower unit transporation costs, compared with larger distant competition. In some specific instances, profit levels for some of these small operations are considerably higher than the 9-12% range.

E. POLLUTION CONTROL REQUIREMENTS AND COSTS

1. Effluent Control Levels

The pollution specie present in any water effluent discharged from either a dry or wet process industrial sand operation is small-diameter solid particulate material, consisting primarily of silica and clay particles. The concentration of the fine particulates in effluent water is the key characterizing parameter for such facilities. In flotation processes, an additional pollutant (the acid or alkali specie) is also present and must be neutralized.

Settling ponds are quite effective in reducing the concentration of total suspended solids in processing water discharged from wet processing and flotation processing operations. Given sufficient residence time, the suspended solids settle and consolidate in layers at the bottom of the pond, from which they are periodically removed to maintain sufficient pond depth for proper settling.

Table IV-15 presents the guidelines for point-source discharge of water effluents from the industrial sand industry. These guidelines require no discharge for BPT, BAT, and NSPS for dry, wet and acid/alkali flotation processing facilities. However, the hydrofluoric and flotation category is allowed a specific discharge for BPT. Mine dewatering is to be limited to a maximum total suspended solids (TSS) of 30 mg/l for any one day.

2. Current Levels of Control

The industrial sand industry in the United States can be divided along process technological lines into three subcategories:

Table IV-15 RECOMMENDED LIMITS AND STANDARDS FOR THE INDUSTRIAL SAND INDUSTRY

		Type of Process			
		Dry	Wet	Flotation Acid/Alkali	HF
Process Waste Water	BPT	No discharge	No discharge	No discharge	*
	BAT, NSPS	No discharge	No discharge	No discharge	No discharge
Mine Dewatering (TSS)		30mg/l	30mg/l	30mg/l	30mg/l

* Effluent Characteristics	Effluent Limitation kg/kkg of Product	
	Monthly Average	Daily Maximum
TSS	0.023	0.046
Fluoride	0.003	0.006

Source: Development Document

- Dry Process,
- Wet Process, and
- Flotation Process.

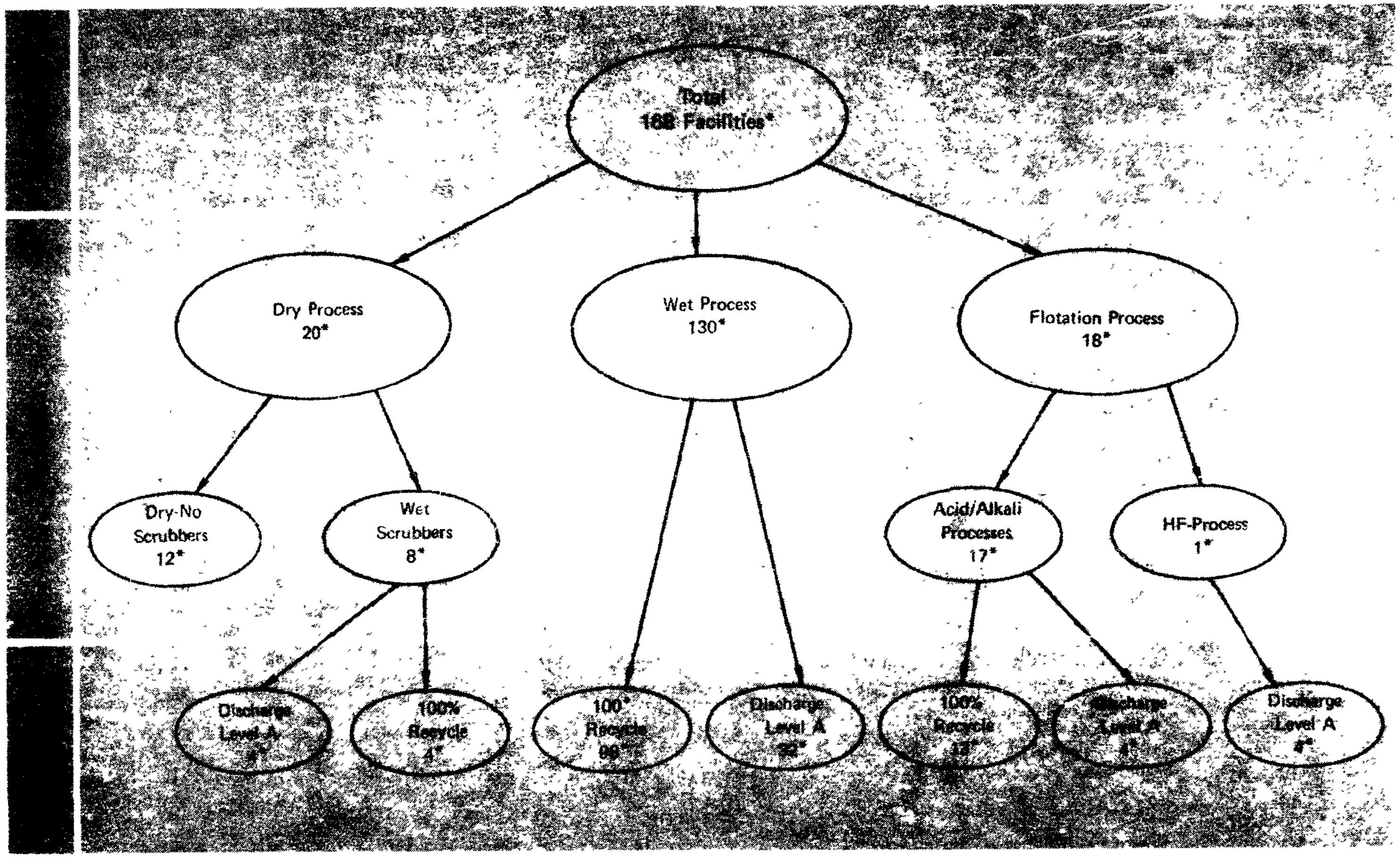
Figure IV-4 shows the distribution of the 168 industrial sand facilities and the degree of effluent control in the industry.

Dry processing plants account for about 10% of the industrial sand plants. The Development Document indicates that of these 20 plants, about 60% use no process water at all, and 40% use water in their scrubbers for dust control. Of the 40%, half are on total recycle of scrubber water, leaving about 4 plants that discharge scrubber water.

The 130 wet processing plants comprise nearly 75% of the industry. The Development Document indicates that apparently 98 of the plants are on total recycle, while about 32 plants discharge after settling.

For the purposes of this analysis, it was assumed that the plants had normal wet pits, like the ones discussed in the Development Document. It is recognized that some pits have water entering from springs. It is expected that such situations will be handled individually when a permit is written. Therefore, they have not been included in this analysis.

Flotation plants account for about 15% of the industry's output. The Development Document indicates that of the 18 plants in this category, about 13 have no discharge, hence no associated control cost. Of the remaining 5 plants, the 4 acid/alkali plants are currently at Level A (neutralize, settle, and discharge). The remaining facility, with HF flocation, is at a level in which 90% of the wastewater is removed in thickeners and recycled to process water. Underflow from the thickener is fed to settling-pond areas for removal of tailings and pH adjustment prior to discharge.



*Number of Facilities.

Source: Development Document, and Arthur D. Little, Inc., Estimates.

FIGURE IV-4 DISTRIBUTION OF INDUSTRIAL SAND FACILITIES BY PROCESSING AND CURRENT CONTROL LEVEL CATEGORIES, 1972

3. Effluent Control Costs

The effluent control costs for process water from industrial sand facilities are associated with the treatment and storage of suspended solids for the affected dry and wet processing facilities. Facilities employing flotation techniques have an additional control cost necessitated by the neutralization of the process water. The recommended level of control is no discharge, which typically requires the use of settling ponds and the total recycle of clarified process water. The ancillary equipment required consists primarily of a water-handling system (e.g., pumps, piping, etc.).

The Development Document presents the fixed capital and operating costs for the different compliance levels for the three types of processes at model plant size. Mid-1972 was the base year for the dollar value used to develop the compliance cost table. A GNP inflator of 16.5% was used to update control consts to mid-1974. Mine dewatering costs are either negligible, or are included in the costs presented in the Development Document.

Control costs were developed for two additional plant sizes--20,000 and 1,000,000 metric tons per year--to determine the sensitivity of control cost to plant size. The costs were calculated using the appropriate ratio (i.e., 0.9 or 0.7 power factor) as indicated in the Development Document for capital-associated costs, while operating costs were varied as a direct function of plant size. These control costs are presented in Tables IV-16 through IV-25 for each of the three processes and plant sizes. A comparison of the cost per metric ton for compliance at any level among the three different plant sizes shows that control cost is only slightly sensitive to plant size.

Table IV-16 COST OF COMPLIANCE FOR MODEL DRY PROCESSING PLANT

Plant Size: 20,000 Metric Tons Per Year of Product

Plant Location: Near Population Center

		Level	
		A (Min)	B
Invested Capital Costs:			
Total		0	$2,400
Annual Capital Recovery		0	400
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy)		0	200
Annual Energy and Power		0	20
Total Annual Costs		0	620
Cost/Metric Ton of Product		0	$0.03
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	135	0.044	0
Fluoride	0.45	0.005	0

Level Description:
A - Settle, discharge
B - Settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-17 COST OF COMPLIANCE FOR MODEL DRY PROCESSING PLANT

Plant Size: 1,000,000 Metric Tons Per Year of Product

Plant Location: Near Population Center

	Level A (Min)	Level B
Invested Capital Costs:		
Total	0	$80,000
Annual Capital Recovery	0	13,200
Operating and Maintenance Costs:		
Annual O&M (excluding power and energy)	0	9,000
Annual Energy and Power	0	1,100
Total Annual Costs	0	23,300
Cost/Metric Ton of Product	0	$0.02

Waste Load Parameters (kg/metric ton of product)	Raw Waste Load	A	B
Suspended Solids	135	0.044	0
Fluoride	0.45	0.0005	0

Level Description:
A - Settle, discharge
B - Settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-18 COST OF COMPLIANCE FOR MODEL DRY PROCESSING PLANT

Plant Size: 180,000 Metric Tons Per Year of Product

Plant Location: Near Population Center

		Level	
		A (Min)	B
Invested Capital Costs:			
Total		0	$17,000
Annual Capital Recovery		0	2,800
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy		0	1,600
Annual Energy and Power		0	200
Total Annual Costs		0	4,600
Cost/Metric Ton Product		0	$0.03
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	135	0	0
Fluoride	0.45	0	0

Level Description:
A - Settle, discharge
B - Settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-19 COST OF COMPLIANCE FOR MODEL WET PROCESSING PLANT

Plant Size: 20,000 Metric Tons Per Year of Product

Plant Age: 10 Years   Plant Location: Near Population Center

Base Year: Mid-1974

		Level A (Min)	Level B
Invested Capital Costs:			
Total		$11,000	$13,000
Annual Capital Recovery		1,300	1,750
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy)		400	400
Annual Energy and Power		150	250
Total Annual Costs		1,850	2,400
Cost/Metric Ton Product		$0.09	$0.12
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	35	0.7	0

Level Description:
A - Settle, discharge
B - Settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-20 COST OF COMPLIANCE FOR MODEL WET PROCESSING PLANT

Plant Size: 180,000 Metric Tons Per Year of Product

Plant Age: 10 Years   Plant Location: Near Population Center

Base Year: Mid-1974

		Level		
		A (Min)	B	C
Invested Capital Costs:				
Total		$80,400	$92,600	$180,600
Annual Capital Recovery		9,300	12,500	29,400
Operating and Maintenance Costs:				
Annual O&M (excluding power and energy)		3,300	3,700	25,500
Annual Power and Energy		1,200	2,300	2,300
Total Annual Costs		13,800	18,500	57,200
Cost/Metric Ton of Product		$0.08	$0.10	$0.32
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load			
Suspended Solids	35	0.7	0	0

Level Description:
- A - Settle, discharge
- B - Settle, recycle
- C - Mechanical thickener with coagulant, overflow is recycled to process. Underflow is passed through a settling basin. Effluent from the settling basin is also recycled to process.

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-21 COST OF COMPLIANCE FOR MODEL WET PROCESSING PLANT

Plant Size: 1,000,000 Metric Tons Per Year of Product

Plant Age: 10 Years Plant Location: Near Population Center

Base Year: Mid-1974

		Level	
		A (Min)	B
Invested Capital Costs:			
Total		$376,000	$433,000
Annual Capital Recovery		43,500	58,500
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy)		18,000	21,000
Annual Energy and Power		7,000	13,000
Total Annual Costs		68,500	92,500
Cost/Metric Ton Product		$0.07	$0.09
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	35	0.7	0

Level Description:
A - Settle, discharge
B - Settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-22 COST OF COMPLIANCE FOR MODEL ACID AND ALKALINE FLOTATION PLANT

Plant Size: 20,000 Metric Tons Per Year of Product

Plant Age: 30 Years Plant Location: Southeastern U.S.

		Level	
		A (Min)	B
Invested Capital Costs:			
Total		$29,000	$34,000
Annual Capital Recovery		4,700	5,500
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy)		2,500	2,800
Annual Energy and Power		150	250
Total Annual Costs		7,350	8,550
Cost/Metric Ton of Product		$0.37	$0.43
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	100	0.4	0

Level Description:
A - Neutralize, settle, discharge
B - Neutralize, settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-23 COST OF COMPLIANCE FOR MODEL ACID AND ALKALINE FLOTATION PLANT

Plant Size: 180,000 Metric Tons Per Year of Product

Plant Age: 30 Years   Plant Location: Southeastern U.S.

		Level	
		A (Min)	B
Invested Capital Costs:			
Total		$134,000	$157,000
Annual Capital Recovery		21,800	25,600
Operating and Maintenane Costs:			
Annual O&M (excluding power and energy)		22,100	24,700
Annual Energy and Power		1,200	2,300
Total Annual Costs		45,100	52,600
Cost/Metric Ton Product		$0.25	$0.29
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	100	0.4	0

Level Description:
A - Neutralize, settle, discharge
B - Neutralize, settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-24 COST OF COMPLIANCE FOR MODEL ACID AND ALKALINE FLOTATION PLANT

Plant Size: 1,000,000 Metric Tons Per Year of Product

Plant Age: 30 Years   Plant Location: Southeastern U.S.

		Level	
		A (Min)	B
Invested Capital Costs:			
Total		$445,000	$521,000
Annual Capital Recovery		72,400	86,000
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy		123,000	137,000
Annual Energy and Power		6,700	13,000
Total Annual Costs		202,100	236,000
Cost/Metric Ton of Product		$0.20	$0.24
Waste Load Parameters (kg/metric ton of product)	Raw Waste Load		
Suspended Solids	100	0.4	0

Level Description:
A - Neutralize, settle, discharge
B - Neutralize, settle, recycle

Source: Development Document and Arthur D. Little, Inc. estimates.

Table IV-25 COST OF COMPLIANCE FOR MODEL HYDROFLUORIC ACID FLOTATION PLANT

Plant Size: 180,000 Metric Tons per Year of Product

Plant Location: [illegible]

	Level A (Min)	Level B
Invested Capital Costs:		
Total	$139,800	$233,000
Annual Capital Recovery	22,700	37,900
Operating and Maintenance Costs:		
Annual O&M (excluding power and energy)	24,900	24,900
Annual Energy and Power	2,300	2,300
Total Annual Costs	49,900	65,100
Cost/Metric Ton Product	$0.28	$0.36

Waste Load Parameters (kg/metric ton of product)	Raw Waste Load	A	B
Suspended Solids (TSS)	135	30 day max.0.023 1 day max.0.046	0
Fluoride	0.45	30 day max.0.003 1 day max.0.006	0

Level Description:

A - 90% of wastewater removed in thickener and recycled to process. Underflow from thickener fed to settling pond for removal of tailings and pH adjustment prior to discharge.

B - Segregate HF wastewater, pond and evaporate; recycle other water after ponding.

Source: Development Document and Arthur D. Little, Inc. estimates.

Control Level C was included in the Development Document for three wet processing facilities which have such limited land available that proper-size settling ponds could not be installed.

4. Total Control Cost

Table IV-26 summarizes the total fixed capital, and the annual costs associated with the additional required control for the three processes in the industrial sand industry.

Table IV-26 INCREMENTAL CONTROL COSTS TO MEET EFFLUENT GUIDELINES FOR INDUSTRIAL SAND FACILITIES

Treatment	Process	Current Effluent Control Status	Current Control Level*	Future Control Level	Number of Plants	Production Thousand Metric Tons	Additional Control Costs Required for Compliance: Capital ($)	Additional Control Costs Required for Compliance: Operating ($/$10^3$ ton)
none	Dry	100% recycle	B	B	16	2,049	0	0.00
partial	Dry	settle & discharge	A	B	4	512	68,000	0.03
none	Wet	100% recycle	B	B	98	14,340	0	0.00
partial	Wet	settle & discharge	A	B	32	4,609	390,400	0.02
none	Flotation A/A	100% recycle	B	B	13	2,817	0	0.0
partial	Flotation A/A	neutralize, settle, discharge	A	B	4	1,024	92,000	0.04
partial	Flotation HF	90% recycle, neutralize	A	B	1	256	93,200	0.08
INDUSTRY TOTAL						25,608		

*Refer to Tables IV-16 through IV-25.

Source: Development Document; Arthur D. Little estimates.

F. ANALYSIS OF ECONOMIC IMPACT

The primary economic effect of the implementation of the effluent guidelines on the industrial sands industry will be to increase the cost of operation. The impact on the industry and the general economy will depend on the resulting changes in prices and production in the industry, and any secondary impact the primary changes might generate. Table IV-27 shows the normal costs of operation for model industry plants, and the costs of required levels of discharge control for each of the described industry segments. Compliance costs range from $0.02 to $0.08 per metric ton, compared with baseline operating costs of $3.80 to $5.50 per metric ton.

1. Price Effects

The nature of the uses of the various specific industrial sands means that their demand is very price inelastic. The cost of industrial sands represents a very minor portion of total product cost for the end products of which they are a part. A very large percentage increase in the price of industrial sand would result in a negligible increase in total cost for glass, foundry products, or products which use sands as either an abrasive or filtration medium in their production process. Either the cost of substitutes for sand is several times the costs of sands, or there are no substitutes available at present or in the foreseeable future.

Thus, a significant general increase in industrial sand prices would probably be passed on to consumers, and demand would not decline in the face of higher prices. The costs of incremental control from Level A to Level B for the flotation process would increase costs by $0.042 per ton, which translates to an increase of only 0.8% of the price of low-cost sands (Segment IA)*, and a smaller increase for higher-cost sands.

*See Table IV-9 for type definition.

TABLE IV-27. COST COMPONENTS FOR INDUSTRIAL SAND INDUSTRY

	Dry Process Plants		Wet Process Plants		Flotation Process Plants		
	Type IA	Type II	Type IA	Type II	Type IB	Type IA	Type II
Plant Size (st) Annual Capacity (mt)	180,000	180,000	180,000	180,000	1,000,000	180,000	180,000
Price per	5.09	7.40	5.09	7.40	5.11	5.09	7.40
Revenues	916,200	1,330,000	916,200	1,330,000	5,110,000	916,200	1,330,000
Normal Operating Costs	855,000	1,250,000	355,000	1,250,000	4,708,000	355,000	1,250,000
Variable Costs	585,000	842,000	585,000	842,000	3,346,000	585,000	842,000
Labor	97,000	168,000	97,000	168,000	687,000	97,000	168,000
Materials	256,000	290,000	256,000	290,000	1,820,000	256,000	290,000
Repair & Maintenance	14,000	22,000	14,000	22,000	99,000	14,000	22,000
Mining	218,000	362,000	218,000	362,000	740,000	218,000	362,000
Fixed Costs	270,000	408,000	270,000	408,000	1,362,000	270,000	408,000
SG&A	140,000	219,000	140,000	219,000	585,000	140,000	219,000
Depreciation	72,000	112,000	72,000	112,000	500,000	72,000	112,000
Interest	17,000	34,000	17,000	34,000	100,000	17,000	34,000
State & Local Taxes & Insurance	11,000	17,000	11,000	17,000	75,000	11,000	17,000
Net Revenues	79,000	106,000	79,000	106,000	5,040,000	790,000	106,000
Net Revenue per Metric Ton	.439	.589	.439	.589	.504	.439	.589

COMPLIANCE COSTS BY LEVEL INCREMENTAL STEP FROM A-B
(Partial Recycle to Complete Recycle)

	Dry Type IA	Dry Type II	Wet Type IA	Wet Type II	Flotation Type IB	Flotation Type IA	Flotation Type II
Total Cost	4,600	4,600	4,700	4,700	136,000	7,500	7,500
Fixed Cost	2,800	2,800	3,200	3,200	203,000	3,800	3,800
Variable Cost	1,800	1,800	1,500	1,500	33,900	3,700	3,700
Cost Per Metric Ton	0.030	0.030	0.026	0.026	0.034	0.042	0.042
Capital Investment	170,000	170,000	12,200	12,000	570,000	15,000	15,000

INCREMENTAL STEP FROM A-C

	Dry Type IA	Dry Type II	Wet Type IA	Wet Type II	Flotation Type IB	Flotation Type IA	Flotation Type II
Total Cost			43,400	43,400			
Fixed Cost			20,100	20,100			
Variable Cost			23,300	23,300			
Cost Per Metric Ton			.241	.241			
Capital Investment			100,600	100,600			

Source: Arthur D. Little, Inc. estimates

About 25% of the nation's industrial sand plants, representing about 25% of annual production, have been identified as requiring additional costs to meet effluent guidelines. The increased costs borne by such incremental control plants are expected to be passed on.

However, some plants may have to make the more costly control procedure of shifting from Level A to Level C. The estimated per ton control cost then is $0.241. There is no specific data available on the actual number of plants that would require this level of discharge control. However, it is believed that the bulk of plants which would require the use of thickeners are already on full recycle. It is assumed that 10% of the plants requiring incremental control would have to move from Level A to Level C (four plants). An upper limit on the number of these plants is expected to be 25% of the total number of plants requiring incremental control (10 plants). (See Table IV-28.) These plants are not believed to be in a market position that will allow them to pass on their much higher cost to consumers. The consumers of sands from such plants would probably not accept a price increase greater than the industry average, but would go to other suppliers of industrial sands. It is anticipated that such plants would only be able to get the $0.04 per ton industry-wide increase. Should any of the plants possess certain characteristics--such as dominance in a local, isolated market, a very-low-operating-cost site, or a very special type of mineral deposit--then they could probably pass on their cost increases.

2. Financial Effects

The rates of return and cash flow position for the bulk of impacted plants would be unaffected, because they would be able to pass on the cost increase. The essentially zero price elasticity of demand would mean that such firms would not suffer a decline of sales in the face of a small price increase. Net revenues would be maintained in the face of a cost increase.

Table IV-28 SUMMARY OF EFFLUENT GUIDELINE IMPACT ON THE INDUSTRIAL SAND INDUSTRY

Impact Category							
Effect	Characterization	# of Plants	%	Production	%	Employment	%
Unaffected		127	75.6	19,400	75.8	3,335	75.8
Unaffected	Case I-Increased Costs	39	23.2	5,480	21.4	942	21.4
Affected	Case I-Potential Closure-lower limit	4	2.4	720	2.8	123	2.8
Unaffected	Case II-Increased Costs	31	18.4	4,400	17.2	756	17.2
Affected	Case II-Potential Closure	10	6.0	1,800	7.0	309	7.0
TOTAL		168	100.0	25,600	100.0	4,400	100.0

Source: Arthur D. Little, Inc. estimates

However, the small number of plants--requiring the significantly higher-cost compliance process--would face a substantial deterioration in net revenues and cash flow position. Out of the total $0.241 per ton compliance cost, only $0.04 per ton could probably be passed on to consumers. The net revenues estimated for the model plant in this segment is about $0.45 per ton. Thus, the absorption of a $0.24 per ton compliance cost (of which only $0.04 could be passed on by a price increase) would reduce the net revenue per ton by almost 50%. However, should any of these plants meet any of the special conditions listed above, their ability to pass on costs would protect their financial position.

Because additional investment is required in the plants that must add effluent controls, not only must net revenues after increased control costs be sufficient, but capital must be made available to fund the required investment. The capital requirements for the control change from Level A to Level B for the model firms appears relatively modest. One measure of current capital employed in such plants is the normal depreciation charge. The total required investment for pollution control is 25% or less of annual depreciation. This relatively small addition to capital stock for the model plants should result in little funding difficulty. The required investment could be funded from retained earnings or as part of normal borrowings.

The plants requiring the more expensive control change from Level A to Level C require almost eight times the control investment of the other plants. This substantially larger capital requirement would be a significant financial barrier for such plants. They are not expected to be able to raise the capital from internal funds, and borrowing is also unlikely because their net revenues, return on sales, and return on capital would be much lower under effluent control.

3. Production Effects

a. Potential Plant Closures

The plants which require the control change from Level A to Level C will probably not continue to be viable economic units. It is estimated that there are only 4 to 10 plants in the country that fall into this category, and they are the only plants that are expected to close. For this reason, the regulation specifies that the guidelines are solely based on Level B technology. The regulations specify the manner in which plants in extraordinary situations may seek relief. Therefore, no actual closures are predicted.

The ability of other plants to pass on increased costs and raise the necessary capital will leave their operations unimpaired. The virtually zero price elasticity of demand for industrial sands means that production levels will not be affected by any measurable change in demand because of any small price increase.

b. Effects on Industry Growth

There is no anticipated impact on industry growth because of the effluent guidelines. Total capital requirements are not significantly altered for new or expanding operations in the industry, and anticipated price increases are not expected to alter demand growth.

Control capital requirements are not expected to alter the ease of entry to the industry or any patterns of competition.

4. Employment Effects

No jobs would be lost through plant closures.

5. Community Impacts

There would be no anticipated adverse impact on any community.

6. Other Impacts

No other impacts are expected to result from the implementation of the effluent control guidelines.

G. LIMITS OF THE ANALYSIS

The industrial sand industry raises some additional limitations for the economic analysis, in addition to the general limits imposed by the overall method used. The economic impact depends on the number of plants falling into a specific industry segment: those plants required to implement control Level C. Yet there is no hard information on the actual number of plants falling into this segment. The analysis also used a narrow definition of economic viability. Individual operations may be willing to accept lower rates of return because of property values of the site, future potential land values, etc. The industrial sand plant may be a means of just meeting the holding costs for an appreciating asset; thus, as long as the operation can meet its costs of operation, it will be kept going. This again leads to an overstatement of the economic impact of the guidelines.

Special cases of economic hardship are expected to be dealt with on an individual basis with specific plants that request variances.

While there are limits to the analysis, an attempt has been made to make assumptions that would overstate the adverse economic impact. The expected impact for industrial sand is of such magnitude that even if it increased severalfold it would remain negligible. These plants are also not expected to be a major employer in their community.

V. PHOSPHATE ROCK (SIC-1475)

A. PRODUCTS MARKETS AND SHIPMENTS

1. Product Definition

"Phosphate rock" is a commercial term for a rock that contains one or more phosphate minerals--usually calcium phosphate--of sufficient grade and suitable composition to permit its use, either directly or after concentration, in manufacturing commercial products. The term "phosphate rock" includes phosphatized limestones, sandstones, shales, and igneous rocks.

Phosphate rock does not have a definite chemical composition. The major phosphorus minerals of most phosphate rock are in the apatite group and can be represented by the formula $Ca_5(PO_4)_3(F,CL,OH)$. The (F,Cl,OH) radical may be all fluorine, chlorine, or hydroxyl ions, or any combination of them.

Marketable phosphate rock is graded according to its equivalent content of tricalcium phosphate, $Ca_3(PO_4)_2$, also known as bone phosphate of lime (BPL). The normal percentage ranges of BPL are: below 60%, 60-66%, 66-68%, 68-70%, 70-72%, 72-74%, 74-75%, and 76-77%.

Phosphate rock occurs as nodular phosphates, residual weathered phosphatic limestones, vein phosphates, and consolidated and unconsolidated phosphatic sediments. Major domestic production is by open pit mining of the nodular phosphates found in Florida.

2. Shipments

a. Reserves

Deposits of phosphate rock are widespread throughout the world, but those of the greatest economic importance are in the United States, North

Africa, and the U.S.S.R. South America's most important deposit is in the Sechura Desert of Peru, and it is currently in the process of being commercially developed. Large deposits have been discovered in Australia and production in Queensland is expected to commence in late 1976. Little information is available to analyze the phosphorus potential of Asia, but the only known workable deposit in Southeast Asia is located in North Vietnam.

A recent U.S. Bureau of Mines estimate of world reserves, taking into account the effect of selling price on the volume of economically recoverable reserves is presented in Table V-1. (U.S. reserves are about 34% of the total.) Estimated world reserves at the $20 per ton level equal 384 times world consumption in 1974.

In the United States, phosphate deposits have been reported in 23 states, but important reserves are known and are being exploited in only a few. The estimated quantities of marketable product recoverable in these states are shown in Table V-2. Because of the higher costs associated with their exploitation, reserves in other states will not be tapped until higher price levels are reached for phosphate rock.

The commercial deposits in Tennessee are expected to be depleted within 10 to 20 years, depending on production expansion. However, low-grade deposits not currently considered as a reserve are also available in the area. To respond to increasing demand, production capacity in Florida was greatly increased in 1971. This accelerated depletion of the state's reserves will likely cause production of Florida phosphate rock to peak in the late 1980's and then decline. This action may shift U.S. production toward the remaining western reserves in the later 1980's and 1990's unless technology is developed for recovering the phosphate content of slime tailings. The known reserves reported for the North Carolina deposits are nearly as large as those in Florida, but are being exploited at a much slower rate.

Table V-1 ESTIMATE OF WORLD MARKETABLE PHOSPHATE ROCK RESERVES
U.S. PRICE PER RECOVERABLE TON

(10^6 Short Tons)

Continent	$8 Per Short Ton	$12 Per Short Ton	$20 Per Short Ton
N. America	1,836	5,350	16,340
S. America	53	290	930
Europe	829	2,050	4,100
Africa	1,770	8,430	20,500
Asia	335	1,186	4,600
Oceania	120	750	1,300
TOTAL	4,943	18,036	47,770

Source: U.S. Bureau of Mines--"Economic Significance of the Florida Phosphate Industry," Information Circular 8653, 1974.

Table V-2 U.S. KNOWN MARKETABLE PHOSPHATE ROCK RESERVES AT TWO PRICE LEVELS

State	10^6 Short Tons Marketable Phosphate Rock Reserves (1973 Price Level)	P content	10^6 Metric Tons Phosphate Rock Resources (2.5 Times 1973 Level)	P content
Florida.........	1,200	168	2,500	349
North Carolina..	380	53	2,400	335
Tennessee.......	30	4	600	84
Idaho...........	200	28	6,000	838
Montana.........	3	(1)	1,200	168
Utah............	200	28	2,300	321
Wyoming.........	1	(1)	440	61
Total.........	2,014		15,450	

Source: U.S. Bureau of Mines--"Economic Significance of the Florida Phosphate Industry," Information Circular 8653, 1974.

Present western phosphate mining operations are open pit. However, most of the western reserve is deep, requiring selective underground mining, which will become economically viable only if future phosphate rock prices are high.

The phosphatic slimes from the washing plants in the Florida land-pebble and Tennessee brown-rock fields (containing 5.5 to 7.5 percent phosphorous) are discharged into waste ponds. If an economic process was to be developed to recover the P content, the phosphorus reserves in Florida and Tennessee would be increased by up to 33%, depending on recovery efficiency. Even without such technological advances, both domestic and worldwide reserves will be adequate through 1990, although production patterns will change.

b. Trends in Domestic Supply

Domestic phosphate rock production capacity has increased sharply in recent years in response to a tight demand situation and rising prices in both domestic and foreign markets. U.S. production capacity will continue to grow in the near future as several projects, already undertaken to increase productive mining capacity, are completed. This is shown in Table V-3, where capacity increases represented by firm expansion projects have been included. As indicated, total domestic capacity should rise from 48.6 million metric tons in 1974 to 74.8 million metric tons in 1980, an average annual increase of about 7.5%.

As shown in Table V-4, the United States has historically been a net exporter of phosphate rock. Only small quantities of rock are imported, chiefly low-fluorine rock for animal feed supplement. In the future, the average grade of rock produced domestically will decline as poorer grades become economically recoverable and high grade reserves are depleted. This trend in rock quality will tend to reduce rock exports and increase exports of phosphorus in higher-valued form (i.e., as concentrated phosphatic fertilizers).

Table V-3 TOTAL U.S. PRODUCTION CAPACITY, 1974-1980

(10^3 of Metric Tons)

Area	1974	1975	1976	1977	1978	1979	1980
Florida	36,000	39,200	42,600	49,400	51,700	52,400	52,400
Tennessee	2,950	2,950	2,950	2,950	2,950	2,950	2,950
North Carolina	2,700	2,700	3,650	3,650	7,250	7,250	7,250
Western	6,950	6,950	6,950	10,800	12,200	12,200	12,200
TOTAL U.S.	48,600	51,800	56,150	66,800	74,100	74,800	74,800

Source: Tennessee Valley Authority

Table V-4 PHOSPHATE ROCK EXPORT/IMPORT BALANCE FOR THE UNITED STATES, 1968-1974

Year	Marketable Production		Imports for Consumption		Exports	
	10^3 Metric Tons	Average Value	10^3 Metric Tons	Average Value	10^3 Metric Tons	Average Value
1968	37,422	$ 6.70	105	$25.45	10,976	$ 6.89
1969	34,244	6.10	127	28.02	10,284	6.05
1970	35,143	5.79	123	30.72	10,649	5.63
1971	35,277	5.78	76	32.52	11,419	5.68
1972	37,041	5.61	50	28.38	12,950	5.82
1973	38,226	6.24	59	21.85	12,587	6.59
1974	41,446	12.10	165	54.51	12,607	15.39

Source: Arthur D. Little, Inc.

3. End Uses

The various end uses of phosphate rock are outlined in Figure V-1. In 1974, about 79% of domestic consumption was ultimately used for production of fertilizers, 7.5% was incorporated in detergents, 5.1% in animal feed supplements, 4.2% in food products, and 4.2% in miscellaneous applications.

4. Possibilities of Substitution

Alternative sources of phosphorus are rather limited, consisting primarily of basic slag from Bessemer or basic open-hearth steel manufacturing, from guano, and from bone meal. Nor is there a substitute for phosphorus in the major end use of phosphate rock--fertilizers. However, phosphorus compounds used in products other than fertilizers--such as synthetic detergents, foods, and fire extinguisher compounds--can be replaced by other materials at increased cost or with a sacrifice of quality. For example, alums may be substituted for monocalcium phosphate monohydrate as a leavening agent in baking powder. Similarly, soda ash, borax, soaps, and other cleaning compounds can be used in place of synthetic phosphate detergents.

5. Future Growth

Over the last few years, the rate of growth in worldwide consumption of phosphate rock has been about 7.5% per year. This growth is shown in Table V-5, along with worldwide production for recent years. The recent record of domestic production and consumption is outlined in Table V-6. In 1972-73, phosphate rock was in short supply on the world market, partly because U.S. phosphoric acid production capacity had been rapidly increased, creating additional demand for phosphate rock.

Following Moroccan price initiatives, the price of phosphate rock rapidly escalated to such high levels that the quantity demanded was

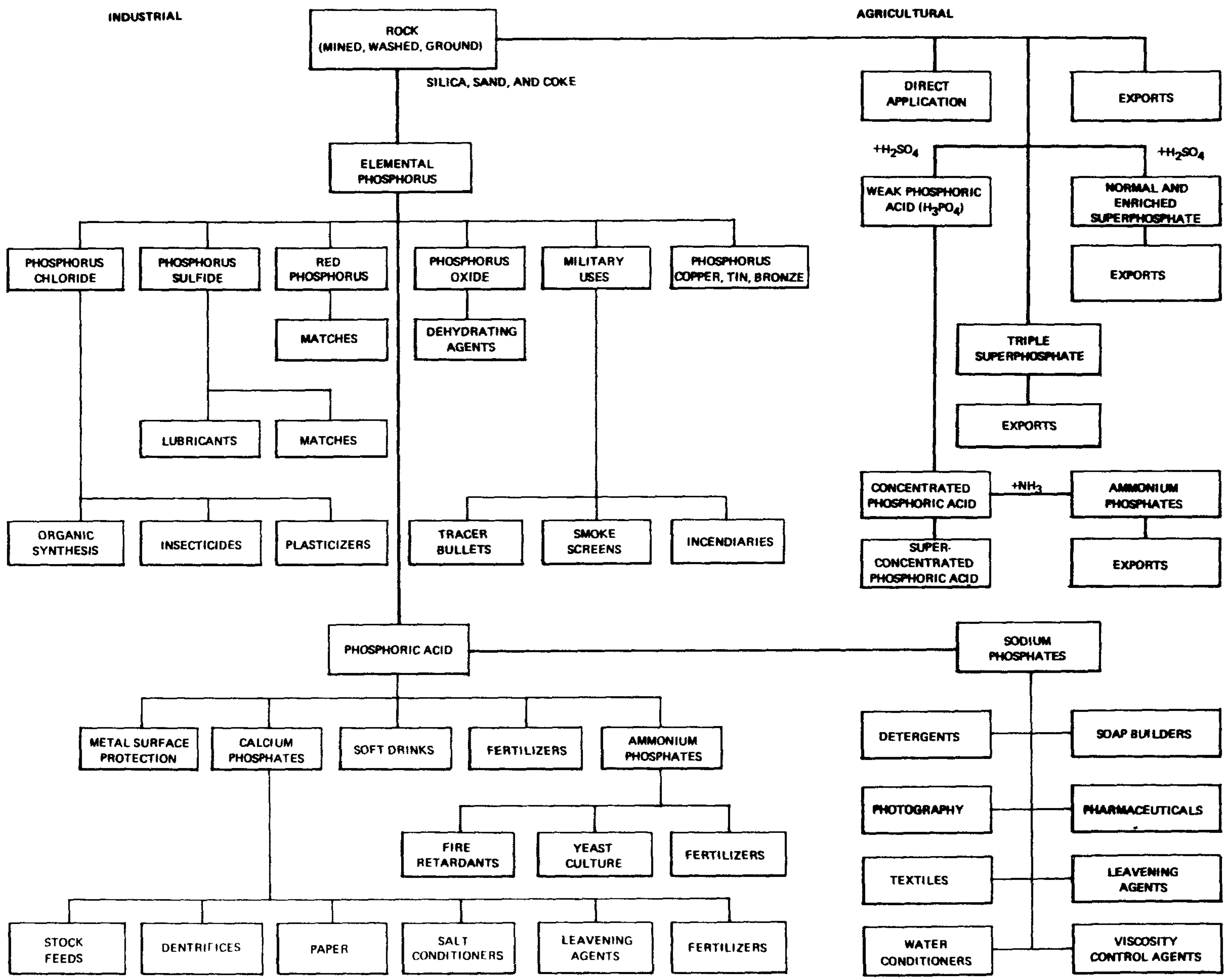


FIGURE IV–1 AGRICULTURAL AND INDUSTRIAL END-USERS OF PHOSPHATE-ROCK

Table V-5 HISTORY OF WORLD PHOSPHATE ROCK PRODUCTION AND CONSUMPTION

(10^6 Metric Tons)

	Production	Consumption
1969	77.1	73.7
1970	81.1	77.9
1971	83.9	85.2
1972	89.0	91.6
1973	97.7	100.5
1974	110.3	112.6

Sources: British Sulfur Corporation
ISMA

Table V-6 HISTORY OF U.S. PHOSPHATE ROCK PRODUCTION AND CONSUMPTION

(10^3 Tons)

Year	Production	Consumption
1968	33,855	22,984
1969	33,321	23,164
1970	35,167	24,642
1971	36,551	25,209
1972	39,694	26,794
1973	40,862	28,334
1974	43,939	31,497

Source: U.S. Bureau of Mines

"Production" here is phosphate rock sold or used by producers.
"Consumption" is apparent consumption as calculated by USBM for the U.S.

reduced, relieving the tight market situation. Although prices have declined recently, it appears they will remain well above the levels that prevailed until 1973; thus, worldwide consumption is expected to grow at a considerably lower rate than in recent years, probably about 5% annually, but certainly no more than 7.5% per year.

B. INDUSTRY STRUCTURE

1. Types of Firms

The Tennessee Valley Authority reports that phosphate rock was produced at 26 locations in the United States in 1974. A list of the 20 firms active at that time is given in Table V-7, which also notes their estimated production capacity, location, and forward integration into fertilizer or other phosphorus products. The producing firms include large diversified corporations; companies involved in many different industries (e.g., U.S. Steel, Borden Chemical); companies involved predominantly in agricultural phosphorus products (Beker Industries); multi-mineral companies (International Minerals and Chemicals); small phosphate rock producers (George Relyea); and a government agency (Tennessee Valley Authority). Some 15 of the 20 firms produce some other phosphorus product. All but two have phosphate rock operations in only one production area. Production capacity for individual firms spans more than three orders of magnitude, from 0.09 to 10.5 million metric tons per year.

Each firm seems unique and dissimilar from the others, an individuality which makes impossible a single-model financial analysis at the corporate level or other generalizations of corporate health, structure, or style.

2. Types of Plants

Phosphate ore is mined by open-pit methods in all four producing areas: Florida, North Carolina, Tennessee, and the Western states. In the Florida land-pebble deposits, the overburden is stripped and the ore mined by large electric dragline excavators equipped with buckets, with capacities up to 37.5 cubic meters. Ore is slurried and pumped to the washing facility, in some instances several miles from the mine. In the Tennessee field, and the open-pit mines in the western field, ore is mined by smaller dragline excavators, scrapers, or shovels and trucked to

Table V-7 U.S. PHOSPHATE ROCK INDUSTRY, 1974

Company	Total Phosphate Rock Capacity[1] (10^3 Tons/Yr)	Location of Mines: Florida	NC	Tenn.	West*	Production Integration (also produces): Phosphorus	Phosphoric Acid	Phosphatic Fertilizer
Agrico	5,500	X					X	X
Beker Industries	2,100				X		X	X
Borden Chemical Co.	900	X					X	X
Brewster Phosphates	3,200	X						X
Cominco-American	200				X		X	X
Gardinier	1,800	X					X	X
W.R. Grace	2,100	X					X	X
Hooker Chemical Co.	700			X				
International Minerals & Chemicals	10,400	X					X	X
Mobil Chemical Co.	4,100	X				X	X	X
Monsanto	1,500			X	X	X	X	
Occidental Ag. Chem.	2,700	X				X	X	X
Presnell Phosphate	600			X				
George Relyea	100				X			
J.R. Simplot	1,800				X		X	X
Stauffer Chemical	2,600			X	X	X	X	X
Swift Chemical Co.	2,700	X						
Tennessee Valley Authority	200			X		X		
Texasgulf	2,700		X				X	X
USS Agrichemicals	2,500	X					X	X
TOTAL U.S.A.	48,600							

[1]Source: Tennessee Valley Authority, 1975

*Includes Idaho, Montana, Wyoming, and Utah facilities. In North Carolina, a 55-cubic-meter dragline is used for stripping, and the ore is then hydraulically transported to the washer.

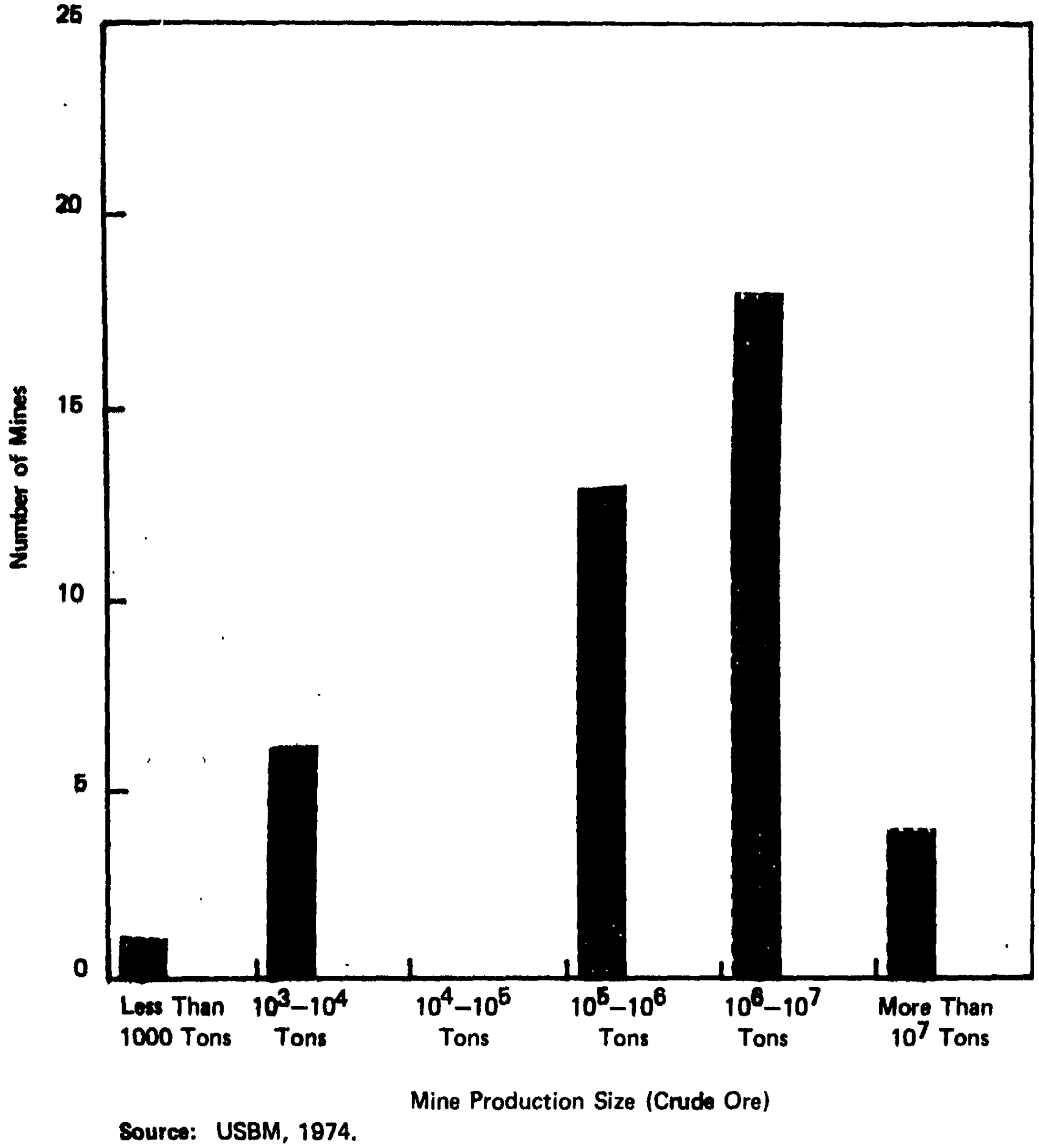
All of the North Carolina (and nearly all Florida and Tennessee) phosphate ore must be treated before it can be used. Washing is accomplished by sizing screens, log washers, various types of classifiers, and mills to disintegrate large clay balls. In the Florida land-pebble field, the plus-14-mesh material is dried and marketed as high-grade rock or sometimes blended with the fine granular material (minus-14, plus-150 mesh) that has been treated in flotation cells, spirals, cones, or tables. Losses of phosphate in washing and flotation operations (up to 40% in some Tennessee areas), occur in the form of slimes containing 4 to 6% solids. The slimes are discharged into holding ponds, where initial settling occurs, and substantial quantities of relatively clear water are returned to the mining and washing operations.

Some of the Western field phosphate rock production is of suitable grade for furnace acid production as it comes from the mine. Siliceous phosphate ore and mixtures of phosphate rock and clay minerals are amenable to beneficiation, and three companies in the Western field are beneficiating part of their production. Two flotation facilities and several washing facilities are in operation.

Most of the producers of phosphate rock sell a beneficiated product of varying grades for processing into elemental phosphorus, phosphoric acid, phosphatic fertilizers, or animal feed. A few mines sell unbeneficiated rock to other producers or processors. In addition, some ore is sold for direct application to the soil.

3. Distribution of Plants and Employees, by Size and Location

The latest statistics available from the U.S. Bureau of Mines indicate the distribution of mine sizes shown in Figure V-2. A rough analysis



Source: USBM, 1974.

FIGURE V-2 DISTRIBUTION OF PHOSPHATE ROCK MINES VERSUS MINE PRODUCTION SIZE, 1973 (Total of 42 Mines)

of this data indicates that over 85% of domestic crude ore production is accounted for by mines over one million tons per year in size; that is, by the upper 50% of the U.S. phosphate rock mines.

On a slightly different basis, the TVA reported phosphate rock production capacity in 1974 at 26 locations in the United States. Capacity varied from 90,000 metric tons annually to more than 11 million metric tons. The distribution of capacity is given in Table V-8 for the different producing regions.

Non-administrative employment in the phosphate rock industry in 1974 was about 4,500 nationally, according to the Bureau of Mines. The U.S. Census provides additional historical data on employment trends, as shown in Figure V-3. If non-administrative employment is distributed among the different regions on the basis of production, then about 3,690 are employed in Florida and North Carolina, 585 in the West, and 225 in Tennessee.

4. Relationship to Total Industry

The quantities produced in the three production regions, from 1968 to 1974, are roughly indicated in Table V-9. Florida and North Carolina dominate domestic production of phosphate rock, accounting for 82% of the national total in 1974. Most of this production comes from the few counties indicated in Figure V-4 as Florida land-pebble districts. (The last Florida hard-rock phosphate mine was shut down in 1965.)* Polk County accounts for 75% of the Florida phosphate industry activity.

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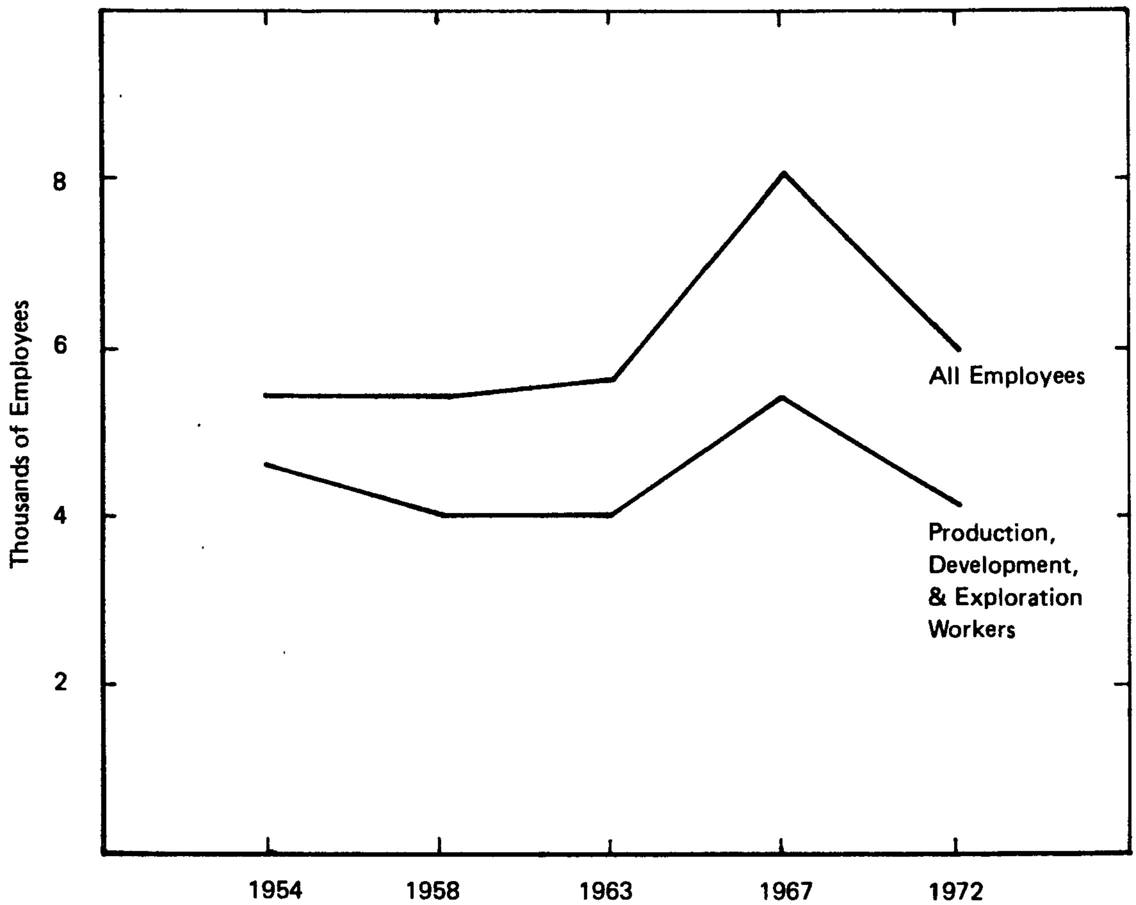
*U.S. Bureau of Mines--"Economic Significance of the Florida Phosphate Industry," Information Circular 8653, 1974.

Table V-8 DISTRIBUTION OF PRODUCTION CAPACITY AT ONE LOCATION, BY REGION, 1974

Production Capacity 10^3 Metric Tons Annually	Number of Production Locations in Region		
	Florida and North Carolina	Western	Tennessee
<100	-	1	-
100-500	-	3	1
500-1,000	1	5	4
1,000-5,000	8	1	-
5,000-10,000	1	-	-
>10,000	1	-	-

Source: Tennessee Valley Authority



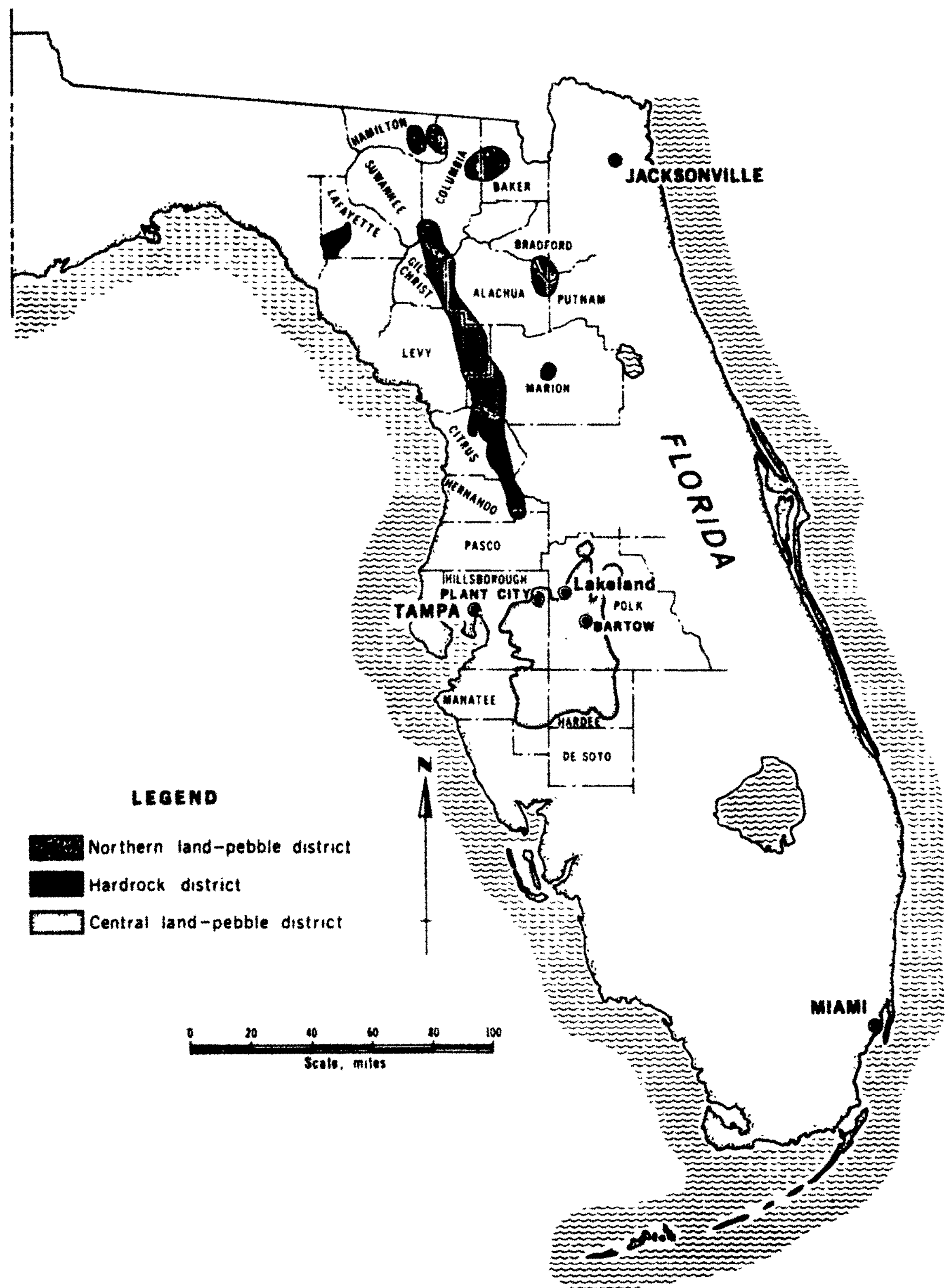
Source: U.S. Bureau of the Census, 1972 Census of the Mineral Industries

FIGURE V-3 PHOSPHATE ROCK INDUSTRY EMPLOYMENT TRENDS

Table V-9 MARKETABLE PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES, 1968-1974

Year	State	Quantity (10^3 tons)	Average Value ($/ton)
1968	Florida and North Carolina	29,966	6.45
	Tennessee	2,857	8.27
	Western States	4,599	7.34
	U.S. Total	37,422	6.70
1969	Florida and North Carolina	27,152	5.92
	Tennessee	2,970	6.36
	Western States	4,101	7.08
	U.S. Total	34,223	6.10
1970	Florida and North Carolina	28,375	5.60
	Tennessee	2,869	5.39
	Western States	3,898	7.39
	U.S. Total	35,142	5.79
1971	Florida and North Carolina	29,167	5.75
	Tennessee	2,332	5.21
	Western States	3,778	6.34
	U.S. Total	35,277	5.78
1972	Florida and North Carolina	30,954	5.62
	Tennessee	1,954	5.49
	Western States	4,132	5.63
	U.S. Total	37,040	5.61
1973	Florida and North Carolina	31,232	6.14
	Tennessee	2,282	5.62
	Western States	4,716	7.25
	U.S. Total	38,230	6.24
1974	Florida and North Carolina	33,548	12.19
	Tennessee	2,187	8.44
	Western States	5,711	12.95
	U.S. Total	41,446	12.10

Source: U.S. Bureau of Mines, 1975



Source: U.S. Bureau of Mines - "Economic Significance of the Florida Phosphate Industry", Information Circular 8653, 1974.

FIGURE V-4 PHOSPHATE DEPOSITS IN FLORIDA

5. Industry Segmentation

As indicated in the preceding sections, phosphate rock production in the United States can be divided into two distinct geographic regions:

- A Western district, including the states of Idaho, Wyoming, Montana, and Utah; and

- An Eastern district, including the major production area in central Florida, and the less significant production areas in North Carolina and Tennessee.

The Western region accounts for only 13% of domestic phosphate rock production. The associated manpower is estimated to bear a similar relationship to total domestic phosphate rock employment. Due to local mineral characteristics and corresponding process practices, and because of the favorable rainfall/evaporation balance existing for the Western facilities, all six producers in this region will soon be operating with no discharge. Therefore, they will experience no incremental costs upon implementation of the proposed effluent guidelines.

Producers in the Eastern district must already comply with effluent guidelines close to those proposed. As stated previously, only four facilities are known to be exceeding the proposed limits, and all four are in Central Florida. As far as is known, the facilities in North Carolina and Tennessee (each state accounting for only about 5% of national production) will not be affected.

There is little competition in phosphate rock between the Western and Eastern districts, because of the large geographical separation, and the large unit freight cost which would be added to a comparatively low unit selling price.

With this background, the U.S. phosphate industry has been segmented into two classes for analysis of economic impact. The Western producers form one segment--which need not be closely studied, because of the absence of incremental control costs and the insignificance of market competition between the Eastern and Western segments.

The Eastern segment can be subdivided into those who will and those who will not experience incremental control costs. The production costs for each group are thought to be similar. Competition in this segment, and the financial and structural characteristics that affect it, will be discussed.

C. FINANCIAL PROFILES

1. Industry Performance

Because of the wide variation in the nature of phosphate rock mining operations, it is quite difficult to generalize regarding production costs for individual producers. Such factors as depth of overburden, phosphate rock matrix thickness and rock quality, age of processing facility, and the location of the facility, can have a material impact on operating costs and investment requirements. The operating costs shown in Table V-10 probably are representative of Western operations and the Eastern facilities in Florida and North Carolina.

The typical Western operation has been defined as producing 1.27 million metric tons per year of acid-grade rock. The typical Eastern operation produces 2.38 million metric tons per year of dry beneficiated phosphate rock, a plant size representative of operations in Florida and North Carolina. For the purposes of cost estimation, each facility was assumed to be producing at full capacity--a reasonable approximation of the 1974 situation. The costs were developed initially on a mid-1975 basis, and have been applied without modification in this report because the variability of costs between producers certainly exceeds the cost changes for each one between mid-1974 and mid-1975. As will be seen, the precise estimation of production costs is not a critical point in the economic impact analysis for phosphate rock.

The costs for Tennessee operations are in the range of $5.83-7.44 per metric ton of dry product. This is very close to the estimated cost for a typical Eastern operation, and thus, within the range of error required for the analysis, production costs can be assumed homogeneous within the Eastern segment.

Table V-10 PRODUCTION COST FOR REPRESENTATIVE EASTERN AND WESTERN PHOSPHATE ROCK FACILITIES

	Eastern	Western
Production Size (10^6 MT/yr)	2.38	1.27
Capital Investment ($$10^6$)		
Mining (incl. royalty & transfer to plant)	10.09	9.02
Beneficiation	14.96	23.45
TOTAL	25.05	32.47
Annual Operating Costs ($$10^6$/yr)		
Mining (incl. transfer to plant)	4.43	10.70
Beneficiation	11.03	7.43
TOTAL	15.46	18.13
Operating Costs ($/Metric Ton of Marketable Rock)	6.50	14.28

Source: Arthur D. Little, Inc. estimates

2. Model Plants

Table V-11 outlines representative financial aspects of a typical Florida phosphate rock mining and beneficiation operation in the Eastern segment. This table has been prepared on the basis of the average domestic 1974 price of $12.10 per metric ton ($11 per short ton). The 1974 price has been used as a long-term ceiling price which is comparable to the discharge control costs generated from the Development Document.

Most phosphate rock and other mineral leases are written so that the producer pays a royalty to the landowner, but retains the right to the depletion allowance. Thus, although a royalty was included in the $6.49 production cost, the financial analysis indicates a depletion allowance of 14% of the sales value.

As stated previously, it is impossible to present "typical" financial data for the corporate health of phosphate rock producers. They form too diverse a group to be represented by one model. A detailed analysis of such factors as ability to raise capital and expected life of the operation must be done on a plant-by-plant basis.

Table V-11 FINANCIAL PROFILE FOR MODEL FLORIDA PHOSPHATE ROCK MINING AND BENEFICIATION OPERATION (per metric ton)

Basis: 2,381,000 tons per year

Price	$12.10
Cost	
Mining	1.86
Beneficiation	4.63
Total	6.49
Gross Margin	5.61
GS&A	1.10
Income Before Taxes	4.51
Depletion Allowance @ 14%	1.69
Taxable Income	2.81
Taxes @ 48%	1.34
After-Tax Profit	1.47
Depreciation	.62
After-Tax Cash Flow	2.09

Source: Arthur D. Little, Inc. estimates

D. PRICES AND PRICE SETTING

1. Present

Until late 1973, the price of phosphate rock from U.S. producers, as well as from such major overseas producers as Morocco, were relatively stable. Sellers were generally not disposed to change prices, because they perceived demand for their own product to be price-elastic in the upward direction and price-inelastic downward.

However, in 1973, the Moroccans, emulating the oil producers, posted a sharp increase in the price of the various grades of rock and followed this with further increases in 1974. Because of the relatively tight supply situation, U.S. producers were able to follow the Moroccans with similar price increases. These are set forth, together with prices for prior years, in Table V-12.

Similar price increases were also taking place during the same period with other fertilizer materials, and the effect of this was to produce a sharp drop in the quantity demanded in 1975. This, coupled with significant expansions in productive capacity in phosphate rock, as well as other fertilizer products, has led to significant overcapacity and continued lag in demand. Hence, prices have dropped markedly from the peak experienced in 1975, and further substantial declines are expected.

Phosphate rock exported from several U.S. producers is handled by a single organization, PHOSROCK (Phosphate Rock Export Association), which publishes a price list for rock exports. This organization has existed since 1973, with exports in prior years having been made by individual producers. Phosphate rock used to manufacture fertilizers in the United States is generally processed by the same companies that produce the rock. No realistic price is available for this material, which moves

Table V-12 EXPORT PRICES OF MOROCCAN AND FLORIDA PHOSPHATE ROCKS

	Morocco 74% BPL ($f.a.s./ Metric Tons)	Florida (U.S.) 74-75% BPL ($f.o.b./ Metric Tons)	Florida (U.S.) 72-70% BPL ($f.o.b./ Metric Tons)
1957	14.00	8.90	7.85
1962	11.25	9.25	8.20
1967	11.75	10.18	9.40
1972	11.75	11.18	10.02
1973	14.17	10.20	11.50
1974 (January)	42.00	27.50	24.00
1974 (July)	63.00	42.00	36.00
1975 (January)	68.00	55.00	48.00
1976 (January)	50.00[1]	47.00	41.00

[1] Approximate

Source: Arthur D. Little, Inc.

between the mine and the processing plant at an arbitrary internal transfer price. That portion of the rock which is sold to other U.S. producers is covered by list prices issued by the various rock producers. For the smaller purchaser, the list probably represents realistic prices paid. However, a significant portion of rock sold to other companies--in particular the larger purchasers--is under individual negotiation contracts, often on a long-term basis, and no price information is generally available. It is known that at least certain of these contracts are written at levels very much below list prices, having been written prior to the sharp increases of 1973 and 1974, but containing excalation provisions governed only by actual increases in mining and beneficiating costs, including such items as power, labor rates, and undoubtedly added costs due to environmental considerations.

2. Projected

The recent shortage was alleviated principally by a drop in the quantities of phosphate fertilizers demanded. The present overcapacity is expected to increase dramatically, as several projects to increase productive mining capacity are underway in various phosphate rock-producing sections of the world. The discussion of domestic supply trends at the beginning of this section predicted that total U.S. capacity would rise from 48.6 million metric tons in 1974 to 74.8 million metric tons in 1980. This represents an average annual increase in excess of 7.5%, which is very much higher than the rate of increase in demand for phosphate fertilizers that can be expected in the United States.

Similar increases in the productive capacity on a global basis are expected, as shown in Table V-13. These figures represent a worldwide rate of increase in rock mining capacity of approximately 9% per year; again, substantially in excess of projected demand growth.

Table V-13 WORLD SUPPLY-DEMAND BALANCE
WORLD DEMAND AT VARIOUS GROWTH RATES, 1974-1980
(Basis: 1974 Demand of 112.6 million metric tons)

	1975	1976	1977	1978	1979	1980
Production Potential	123.9	142.7	155.6	176.0	181.5	191.7
5% Growth	118.1	124.0	130.2	136.7	143.6	150.8
Balance	5.8	18.7	25.4	39.3	37.9	40.9
7.5% Growth	120.9	130.0	139.7	150.2	161.5	173.6
Balance	3.0	12.7	15.9	25.8	20.0	18.1

Source: Arthur D. Little, Inc.

In the same table is shown the demand through 1980 that would develop at two different annual growth rates. It appears likely that the growth will be in the neighborhood of 5% per year, and certainly no higher than the 7.5% per year shown. On both of these bases, significant excess capacity should continue through 1980.

As pointed out elsewhere in this report, the cost of mining phosphate rock is generally well under $10 per ton, even taking into account such increases in cost as have taken place in recent years. Therefore, under the normal actions of competitive marketing, we would expect that the substantial and growing overcapacity in rock that is developing will exert strong downward pressures on prices. It is possible that the rock-producing countries could act together in the manner of OPEC, in maintaining current price levels, but the existence of such a large proportion of the export capacity in the United States, where such collusive action is illegal, suggests that competition will continue and prices will decline, although probably not to levels existing prior to 1973.

E. POLLUTION CONTROL REQUIREMENTS AND COSTS

1. Effluent Control Levels

Table V-14 presents the EPA regulations for point-source discharge of water effluents from the phosphate rock industry. Similar guidelines apply for BPT, BAT, and NSPS. These regulations require effluent discharge to have a total suspended solids (TSS) concentration not exceeding 30 mg/l for a 30-day average, or 60 mg/l maximum average for any one day.

2. Effluent Control Costs

The effluent control costs to process water from the phosphate industry are associated totally with the treatment and storage of suspended solids. There is no specific treatment applied for the removal of fluorides or phosphates, although it is reported that the existing control procedures do affect a reduction in the level of these two pollutants.

Table 18, page 220 of the EPA Development Document, presents the fixed capital and operating costs for three different compliance levels for Eastern phosphate rock producers. The model plant size used to represent both segments of the Florida phosphate rock producers is 2.4 million metric tons per year, and the costs are based on mid-1974 values. These modified control costs are shown in Table V-15.

The change in base year from mid-1972 to mid-1974 was made by using a GNP inflator of 16.5%. The adjustment of fixed capital investment and operating costs was accomplished by appropriately modifying the cost bases for Table 18 of the Development Document. Specifically, the pond area required for the larger model-plant size was assumed to be equal to the original 1,000-acre pond, multiplied by the ratio of new to old plant sizes. Pump and piping costs were adjusted by applying the Development Document recommended exponential factor of 0.9 to the ratio of plant

Table V-14 RECOMMENDED LIMITS AND STANDARDS FOR BPCTA, BATEA, AND NSPS-PHOSPHATE ROCK MINING AND BENEFICIATION*

	CONCENTRATION IN EFFLUENT	
Parameters	30-Day Average	24-Hour Maximum
TSS	30 mg/liter	60 mg/liter

*Flotation unit process and mine drainage other unit processes will have no discharge.

Source: Development Document

Table V-15 COST OF COMPLIANCE FOR MODEL EASTERN PHOSPHATE ROCK MINING AND BENEFICIATING FACILITY

Plant Size: 2,400,000 Metric Tons Per Year of Product

Plant Age: 15 Years   Plant Location: Florida-North-Carolina-Tennessee

Base Year: Mid-1974

	Level A (Min)	Level B	Incremental Cost Level B-A
Invested Capital Costs:			
Total	$11,180,000	$12,090,000	$910,000
Annual Capital Recovery	1,410,000	1,549,000	139,000
Operating and Maintenance Costs:			
Annual O&M (excluding power and energy)	503,000	544,000	41,000
Annual Energy and Power	336,000	420,000	84,000
Total Annual Costs	2,249,000	2,513,000	264,000
Cost/Metric Ton Product	$ 0.94	$ 1.05	$ 0.11

Waste Load Parameters (mg/liter)	RAW WASTE LOAD		
Suspended Solids		3-560	<30
Dissolved Fluoride		2*	2*
Phosphorus (total)		4*	4*

*Estimated average values

Level Description:

A - Pond treatment of slimes and sand tailings
B - A plus improved process water segregation

Source: Development Document and Arthur D. Little, Inc. estimates

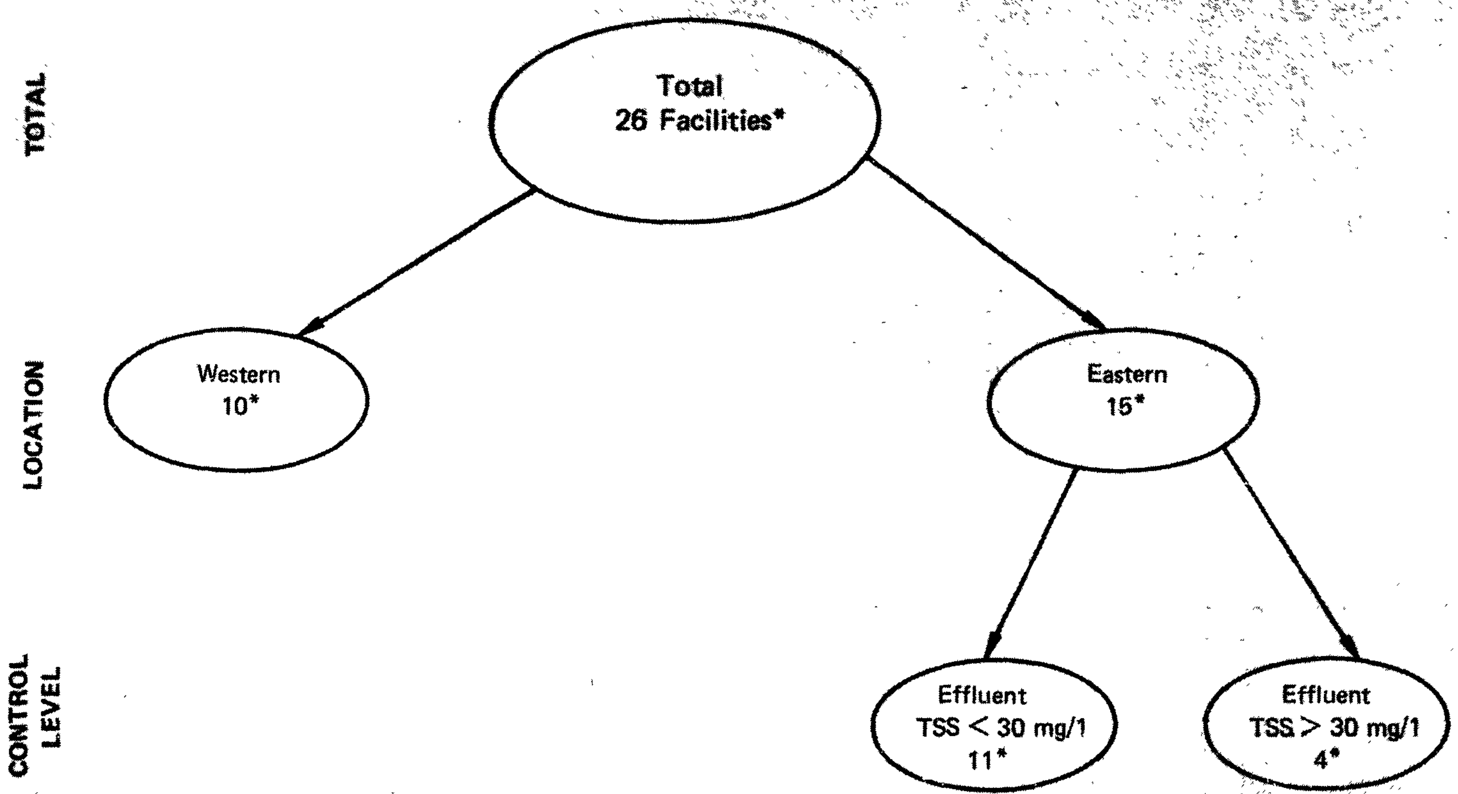
capacities. The annual capital recovery was developed by using an annual interest charge of 10%, plus straight-line depreciationof 20 years for ponds, 10 years for process equipment, and 5 years for materials-handling equipment.

3. Current Levels of Control

As previously stated, the U.S. phosphate industry can be divided into Western and Eastern segments. Figure V-5 shows the segmentation of this industry as it applies to the following economic impact analysis.

Phosphate rock producers must already comply with limits of 30 mg/l TSS (monthly average) and 60 mg/l TSS (maximum one-day average). According to the Development Document, five out of the six Western producers are already operating with no discharge. The other Western producer has evidently agreed to a compliance deadline for achieving zero discharge. Most facilities in the East (Florida, Tennessee, and North Carolina) are reportedly already in compliance. The EPA knows of only four producers who are not already complying with the new effluent levels recommended, and all four are in Florida. No firms in Tennessee or North Carolina are known to be operating in excess of the proposed standard. Thus, the only facilities which will be affected by the new effluent guidelines are assumed to be in Florida, and it is on such facilities that this economic impact study will focus.

It should be noted that the phosphate rock industry is facing a number of other environmental challenges. A long-recognized problem has been the proper treatment of the large volumes of slimes generated during phosphate rock processing in Florida. These slurries of very fine clay and phosphate minerals require years to dewater, and occupy a volume larger than that of the original phosphate rock matrix. Therefore, the slimes are impounded in many large ponds, formed by erecting dikes around mined-out areas. Maintenance of these ponds is a major concern, one closely regulated by



*Number of Facilities.

Source: Development Document.

FIGURE V-5 DISTRIBUTION OF PHOSPHATE ROCK FACILITIES BY GEOGRAPHIC AND CURRENT CONTROL LEVEL CATEGORIES, 1974

state agencies, because dike failures could have enormous environmental impact. Because the Florida land-pebble district is located close to developed and expanding urban areas, the large land areas which must be dedicated for many years to slime-holding ponds pose a significant land-use conflict. Progress is being made in the reclamation of ponds and other mined-out areas for recreational, agricultural, and other uses.

4. Total Control Costs

Table V-16 presents the total fixed capital, and the annual costs associated with the additional control required for the phosphate industry.

Table V-15 INCREMENTAL EFFLUENT CONTROL COSTS FOR MODEL PHOSPHATE ROCK MINING AND BENEFICIATING FACILITY, AND THE TOTAL PHOSPHATE INDUSTRY (BPCTCA, BATEA)

Category	Annual Production Phosphate Rock (10^6 Metric Tons)	Total Costs ($\$10^3$)		$/Ton Phosphate Rock	
		Investment	Annual	Investment	Annual
Model Facility	2.4	910	264	0.38	0.11
Affected Segment	9.6	3,640	1,056	0.38	0.11
TOTAL INDUSTRY	48.6	3,640	1,056	0.7	0.02

Source: Arthur D. Little, Inc. estimates

F. ANALYSIS OF ECONOMIC IMPACT

The basic result on the phosphate rock industry of implementing the effluent guidelines will be to increase the costs of operation. The impact on the industry and the general economy will depend on the resulting changes in prices and production in the industry and any secondary impact those primary changes might generate. Table V-17 shows the normal operating costs for the model industry plant and the costs of required level of discharge control. (These costs have been developed in Sections C and E respectively.)

1. Price Effects

The nature of the uses of phosphate rock means that their demand is very price-inelastic. One of the principal uses of phosphate rock is as fertilizer (79%). As an input for food products the price elasticity of demand is very low. Food products themselves have low price elasticities, so as a small proportion of the total cost of food products, demand for phosphate rock is doubly insensitive to price changes. Phosphates are an essential soil nutrient and there are no economic substitues for phosphate rock as a source of phosphorus. A significant general increase in phosphate rock prices could be passed on to consumers and demand would not decline substantially in the face of higher prices. Much of phosphate rock is produced under long-term contracts which provide for increases in price due to increased costs, so that even under long-term contracts the cost increase due to guideline implementation could be passed on.

Four of the nation's 26 phosphate rock plants, representing about 20% of annual production, have been identified as requiring additional costs to meet the effluent guidelines. The increased costs borne by these incremental control-cost plants is expected to be passed on. The added cost of $0.11 per ton is only a 0.9% increase in the 1974 price.

Table V-17 REVENUES, NORMAL COSTS, AND CONTROL COSTS
PHOSPHATE ROCK INDUSTRY

Production	2,400,000 tons
Price	$ 12.10
Revenues	29,040,000
Normal Operating Costs	23,770,000
Mining	4,646,000
Beneficiation	11,112,000
GS&A	2,640,000
Depreciation	1,488,000
Depletion	4,066,000
Net Revenues (pre-tax)	5,270,000
Net Revenue (per ton)	2,196
Discharge Control Costs	
Incremental Discharge Control A to B	264,000
Fixed Costs	139,000
Variable Costs	125,000
Cost per Ton	0.11
Capital Requirement	$ 910,000

Source: Arthur D. Little, Inc. estimates

In the last two years, phosphate rock prices on the international market have increased about 100%. Demand has fallen, indicating that there is some price elasticity, but demand has fallen remarkably little in face of the large price increases. The present (1976) situation in phosphate production, capacity utilization, and prices would indicate that no cost increase could be passed on. However, the analysis is based on the 1974 price and present prices have already risen many times above the price increase which would have resulted from the passing on of discharge control costs resulting from implementation of the guidelines.

2. Financial Effects

The rates of return and cash flow position for impacted plants would be unaffected, because they could pass on the cost increase. The very low price elasticity of demand would mean that such firms would not suffer decline of sales in the face of the anticipated less-than-1% price increase. Net revenues would be maintained in the face of the cost increase.

Because additional investment is required in the plants that must add effluent controls, not only must net revenues after the increased controls be sufficient, but capital must be made available to fund the required investment. The capital requirements for the required control process for the model firms appears relatively modest. One measure of current capital employed in these plants is the normal depreciation charge. A $910,000 investment is required for the model plant in the industry. This represents a small proportion of the estimate $25 million original cost investment in the plant. This relatively small addition to capital stock for the model plants should result in little funding difficulty, because the plants are part of large corporations where required investment could be funded from retained earnings.

3. Production Effects

No plant closures are anticipated because of implementation of the guidelines, so there would be no alteration of production.

The required investment in discharge control will increase the capital requirements for new or expanded operations. The relative amount of capital required for effluent control is a very small addition to total capital required for the total operation. The effluent control guidelines are not expected to affect future expansion of production by the industry.

The additional capital requirement would also not affect the pattern of competition in the industry. It is already an industry dominated by a few producers and such factors as control of the natural resource are the determining factors in entry to the industry.

4. Employment Effects

Because no plant closures or reduction in production is expected to result from implementation of the guidelines, no adverse impact is expected on employment.

5. Community Effects

Community effects would not be adverse, because no plant closures or employment loss is anticipated.

6. Balance of Trade Effects

Phosphate is a significant material in international trade and the United States is a net exporter. The additional cost due to effluent controls is so slight that it should have no impact on U.S. export volumes.

G. LIMITS OF THE ANALYSIS

In addition to the general limits imposed by the overall method used for the economic analysis, the phosphate rock industry raises some additional limitations.

Recent developments in international markets for phosphates have shown that prices are unstable. This analysis has not considered a dramatic price drop on the international market. The likelihood of international prices falling below 1974 levels is considered to be very remote. However, such a price break could change the economic impact. Domestic producers would then have to absorb the cost increase due to effluent controls. But that is such a small portion of total selling price even at pre-1974 levels that any major impact on the industry because of international price fluctuations should not be ascribed to cost of discharge control. The estimated control costs are so small that even large errors in these estimates would not significantly affect the expected impact.

APPENDIX
ANALYSIS OF SURVEY DATA FROM CRUSHED STONE AND
CONSTRUCTION SAND AND GRAVEL INDUSTRIES

A. SURVEY COVERAGE

Arthur D. Little (ADL) analyzed the results of an industry trade association survey of 199 companies located throughout the United States. The companies were either directly involved in the production of crushed stone (SIC-1422, 1423 and 1429) or in the production of construction sand and gravel (SIC-1442), and were not necessarily solely dependent on the production of non-metallic minerals for their revenues. In fact, many of the actual survey respondents were also in the business of producing other manufactured products, which may or may not be derived from either crushed stone or sand and gravel. Most companies surveyed were members of at least one of the following associations: National Lime Association (NLA), National Lime Institute (NLI), National Crushed Stone Association (NCSA), Portland Cement Association (PCA), and the National Sand and Gravel Association (NSGA).

Table A-1 compares the actual number of companies contacted and associated responses. The survey represents a cross section of companies in the crushed stone industry and the construction and sand and gravel industry for 1974.

The annual production of crushed stone covered by the NLA, NLI/NCSA and PCA sample survey for 1974 was approximately 47.6 million short tons, or about 4.6% of the crushed stone industry. Revenues derived from the sale of this crushed stone also represented about 4.6% of the industry. Tables A-2 and A-3 list the actual tally of information by association and by process used to produce the crushed stone. Of the number of sample respondents who provided information for both production and revenues, PCA members represented almost 50% of the coverage for crushed stone. PCA membership represents about 14 to 15% of the crushed stone industry's

Table A-1 SURVEY COVERAGE BY ASSOCIATION

	Number of Companies Contacted	Number of Company Responses	Number of Quarry or Pit Sites Covered
NLA	12	3	10
NLI/NCSA	78	17	31
PCA	49	28	122
NSGA	60	12	20
TOTAL	199	60	183

Table A-2 ANNUAL PRODUCTION AND SALES COVERED BY SURVEY RESPONSES

	# of Sites	Production (10^3 tons)	Revenue Sales ($\$10^3$)
PCA			
dry processing	23	17,729.6	36,183.6
wet processing	4	7,027.1	15,857.6
NLA			
dry processing	5	4,833.1	9,288.2
NLI/NCSA			
dry processing	22	13,075.3	25,620.9
wet processing	6	4,947.0	8,758.4
NSGA			
wet processing	6	3,308.7	7,246.8
dredging on land processing	8	4,046.8	6,621.8

Table A-3 SAMPLE SURVEY COVERAGE OF CRUSHED STONE INDUSTRY AND SAND AND GRAVEL INDUSTRY, 1974

	Total Industry*		Facilities in Survey		Survey as a % of Industry	
	Production (10^6 tons)	Sales (\$$10^6$)	Production (10^3 tons)	Sales (\$$10^3$)	Production	Sales
Crushed Stone	1,041	2,085	47,612.1	95,708.8	4.6	4.6
Sand and Gravel	949.7	1,312.3	7,355.5	13,868.6	.08	1.1

*Source: U.S. Department of Interior, Bureau of Mines; Minerals Yearbook, Volume I production. PCA companies generally engage in the business of crushed limestone quarrying for the purposes of producing cement. As a result, much of the crushed stone reported by PCA respondents is produced for internal transfer purposes to produce cement. This is unlike the NLA and NLI/NCSA respondents, who sell much of what they produce to the outside world.

The sample coverage of PCA respondents represents about 66% of total crushed stone production that is produced by cement plants. It also turns out that roughly 66% of the quarries owned by cement plants are covered by the survey. This obviously has a strong influence on the sample results.

The sample coverage through the NSGA for the construction sand and gravel industry accounts for about 0.08% of the industry's annual production and 1.1% of the industry's sales. The actual sample coverage of annual production and revenue sales information for construction sand and gravel are presented in Tables A-2 and A-3. The sample only covers two processing techniques for sand and gravel: dredging/on-land processing and wet processing. Responses for dry processing and dredging/on-board processing were insufficient to allow any valid analyses.

In 1974, the Bureau of Mines reported that the construction sand and gravel industry produced 27.4% of its sand and gravel by wet processing on land and approximately 10% by dredging. About 62% of production was by dry processing.

B. SURVEY TABULATIONS

1. Employment, Payroll Characteristics by Site

In tabulating survey site-specific information pertaining to payroll, employment, and production per employee characteristics, Table A-4, PCA responses far outweighed responsed from NLA and NLI/NCSA for the crushed stone industry. There are too few site-specific responses from NSGA. Employment coverage in Table A-4 includes both direct and supervisory employment involved in crushed stone or sand and gravel extraction. The corresponding payroll covers wages and salaries paid to direct and supervisory extraction personnel including the payroll burden. Average wages and tonnageproduction per employee are presented in Table A-4 by association by process. In 1974, average wages for the crushed stone industry as represented by the site-specific responses from PCA, NLA, and NLI/NCSA were approximately $15,924 and for sand and gravel (NSGA) $12,189. The 1974 average production per employee, as represented by the responses, was 32,831 short tons for crushed stone and 28,912 short tons for sand and gravel. For both crushed stone and sand and gravel the survey figures on productivity appear to be higher than the industry figures (estimated from 1972 Bureau of Mines data). Census reports show that 1972 employment in sand and gravel wet processing was 24.2% of total employment and 2.2% of dredging on land.

The Census reports show that in 1972 employment in the crushed stone industry dry processing was 70% of total employment and 30% in wet processing.

2. Cost Structure Characteristics by Site

In analyzing the crushed stone and sand and gravel company data, an attempt was made to ascertain the cost structure of extraction sites by size of operation as measured by production. Total costs of extraction

Table A-4 AVERAGE WAGES AND PRODUCTION PER EMPLOYEE BY ASSOCIATION

	# of Sites	Payroll ($$10^3) Total	Payroll ($$10^3) Average	Employment Total	Employment Average	Average Wages	Production (10^3 tons) Total	Production (10^3 tons) Average	Tons per Employee
NLA									
dry processing	6	3,071	512	316	53	9,718	4,969	828	15,725
NLI/NCSA									
dry processing	26	6,933	267	619	24	11,200	18,976	730	30,656
wet processing	9	4,545	505	266	30	17,086	7,658	851	28,789
PCA									
dry processing	90	33,165	369	1,725	19	19,226	64,699	719	37,507
wet processing	5	3,051	610	262	52	11,645	8,362	1,672	31,916
TOTAL (crushed stone)		50,765		3,188		15,924	104,664		32,831
NSGA									
wet processing	7	1,318	188	91.4	13.1	14,420	2,601	372	28,457
dredging on-land processing	9	2,380	264	212	24	11,226	6,171	686	29,108
TOTAL (sand and gravel)		3,698		303.4		12,189	8,722		28,912

by site were subdivided into fixed, semi-variable, and variable costs. Energy costs, as a subcomponent of variable costs, were also discreetly defined as a piece of extraction cost data. This cost information was attained by site for each company that responded. Extraction cost data was defined as follows:

- Fixed Costs (FC) - For each site, the total annual costs that do not change when extraction levels change. Examples of fixed costs are: depreciation of capitalized items, interest on long-term loans that may have been taken out to cover the equipment and installations, land rents, real estate taxes, and insurance premiums on equipment and installations. Include stone extracted for external sale.

- Semi-Variable Costs (SVC) - For each site, the total annual costs that do not change when extraction levels change, but which can drastically be reduced or eliminated if operations at the site cease. Examples of semi-variable costs are: leases paid for equipment and installations, licenses paid, and expensed exploration and development work. Include stone extracted for external sale.

- Variable Costs (VC) - For each site, the total annual costs that vary with the level of output. Examples of variable costs are: the direct labor payroll; payroll for supervisors and other indirect labor; payroll burden; consumption of fuels, electricity, water, and other such utilities; operating materials and supplies; charges made for the depletion of reserves; net interest payments on loans to finance applicable working capital; and payments of royalties and taxes that vary with extraction levels. Include stone extracted for external sale.

- Total Costs (TC) - Summation of fixed, semi-variable, and variable costs.

The cost information presented in Table A-5 applies to the portion of a company that extracts minerals from a quarry or pit site and produces either crushed stone or sand and gravel at the point of transfer. Point of transfer is that point at which the resource qualifies for inclusion in percentage depletion.

Table A-5 presents average production costs and employment by site production size segments for each of the associations process used. For example, all sites surveyed under each association which produce 400,000 short tons or less have an average employment and an average total cost, variable cost and fixed cost as presented in Table A-5. Table A-6 presents an average implied cost per ton of production based on the information tabulated in Table A-5. Figures A-1 through A-3 chart total, variable, and fixed costs by production size for PCA, NLI/NCSA, and NSGA, respectively. It must be noted here that in deriving Tables A-5, A-6 and Figures A-1 through A-3, disclosure problems were prevalent; therefore, only the information derived from three or more responses are presented.

Energy costs by site as reported by the respondents reveal that energy costs per ton of production of crushed stone averages around $0.14 per ton, and around $0.17 per ton for sand and gravel. Refer to Table A-7 for specific site responses on energy costs.

3. Pricing Characteristics by Site

Actual pricing information was difficult to ascertain. Very few responses listed prices per ton. From these, Arthur D. Little was able to attain an average FOB price per ton by site. However, this price does not necessarily correspond to the actual price that a ton of either crushed stone or sand and gravel was sold for in the marketplace. For companies

Table A-5 AVERAGE PRODUCTION, COSTS, AND EMPLOYMENT WITHIN PRODUCTION SEGMENTS BY ASSOCIATION
(short tons)

	<400,000	400,000 - 1.0 million	>1.0 million
PCA			
# of respondents	14	56	12
dry			
avg. production	216	671	1,458
avg. TC	556	1,186	2,432
avg. VC	422	930	1,753
avg. FC	134	256	679
avg. employees	9	19	28
wet			
# of respondents			3
avg. production			2,455
avg. TC			4,209
avg. VC			2,941
avg. FC			1,268
avg. employees			46
NLA			
dry			
# of respondents	3		
avg. production	238		
avg. TC	764		
avg. VC	534		
avg. FC	230		
avg. employees	23		
NLI/NCSA			
dry			
# of respondents	9	12	5
avg. production	226	655	1,928
avg. TC	451	1,046	2,805
avg. VC	351	819	2,287
avg. FC	100	227	518
avg. employees	9	26	51
wet			
# of respondents		5	3
avg. production		554	1,434
avg. TC		767	2,166
avg. VC		630	1,817
avg. FC		138	349
avg. employees		17	51

Table A-5 (cont) AVERAGE PRODUCTION, COSTS, AND EMPLOYMENT WITHIN PRODUCTION SEGMENTS BY ASSOCIATION*
Production (short tons)

	<400,000	>400,000	<700,000
NSGA			
dredging			
# of respondents	4	4	
avg. production	251	761	
avg. TC	328	1,061	
avg. VC	276	854	
avg. FC	52	207	
avg. employees	9.8	26.3	
wet			
# of respondents			5
avg. production			327
avg. TC			562
avg. VC			404
avg. FC			158
avg. employees			13

*Semi-variable costs from the survey responses were allocated to fixed costs and variable costs: 80% and 20% respectively.

Table A-6 AVERAGE COST PER TON BY SIZE OF PLANT

	Size Plant		
	<400,000	400,000 - 1.0 million	>1.0 million
Association			
NLI/NCSA			
dry processing	1.99	1.60	1.45
wet processing		1.37	1.51
PCA			
dry processing	2.57	1.77	1.67
wet processing			1.71

Size of Plant

NSGA	<700
wet processing	1.72

NSGA	<400,000	>400,000
dredging on land processing	1.31	1.39

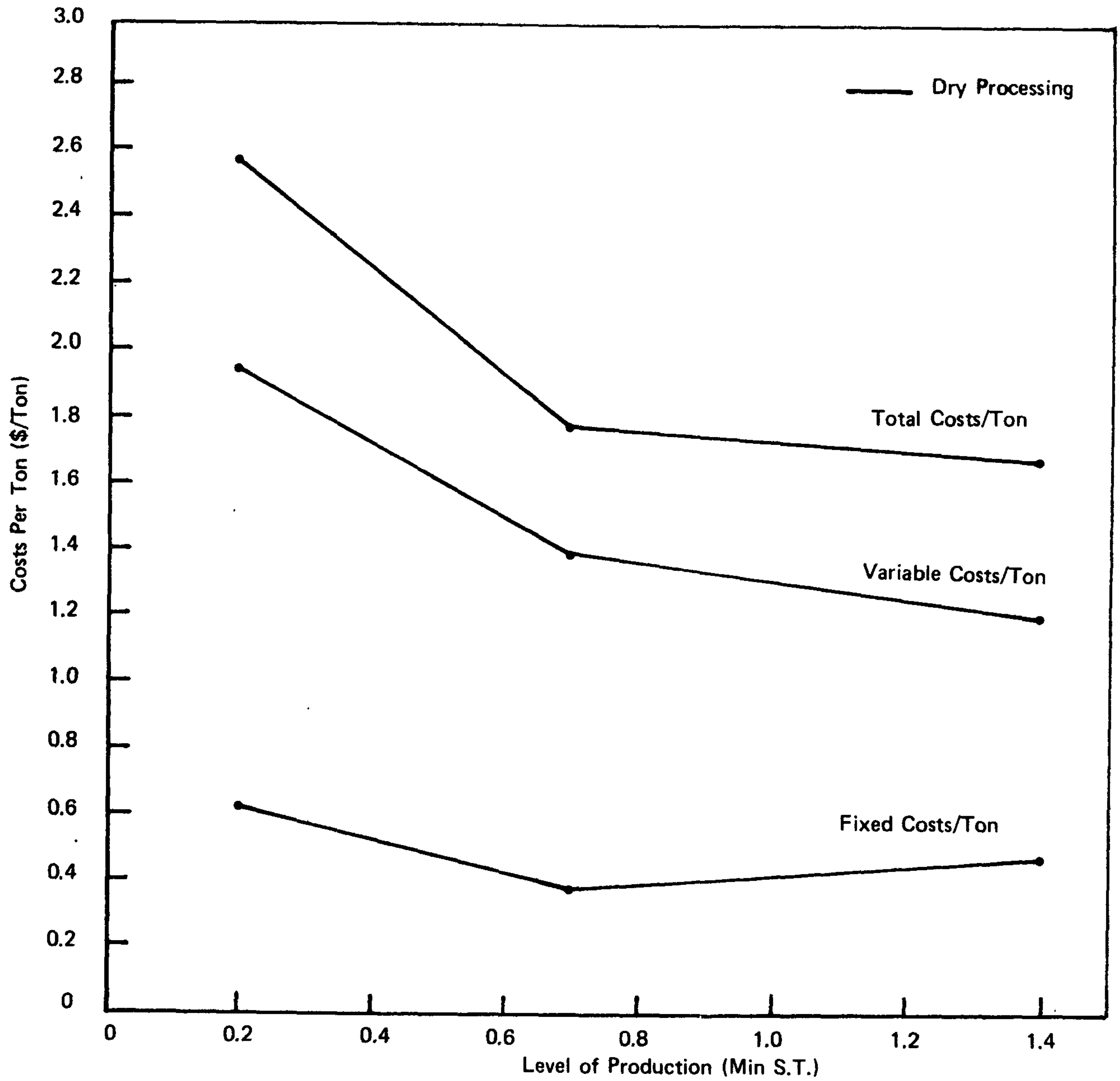


FIGURE A-1 CRUSHED STONE INTEGRATED WITH PORTLAND CEMENT MANUFACTURE COSTS PER TON BY LEVEL OF PLANT PRODUCTION

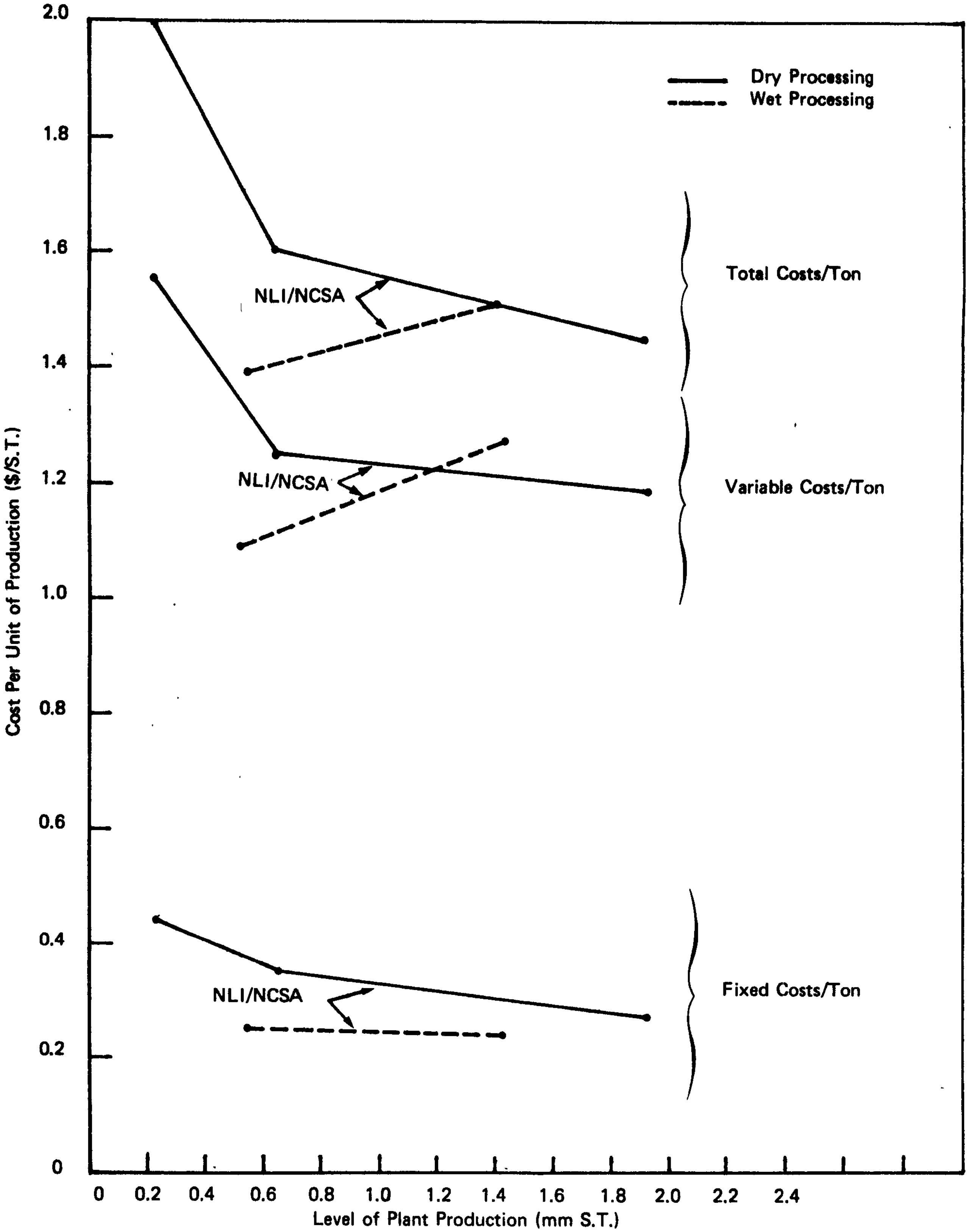


FIGURE A-2 COMPARATIVE UNIT PRODUCTION COSTS FOR CRUSHED STONE, BY LEVEL OF PLANT PRODUCTION

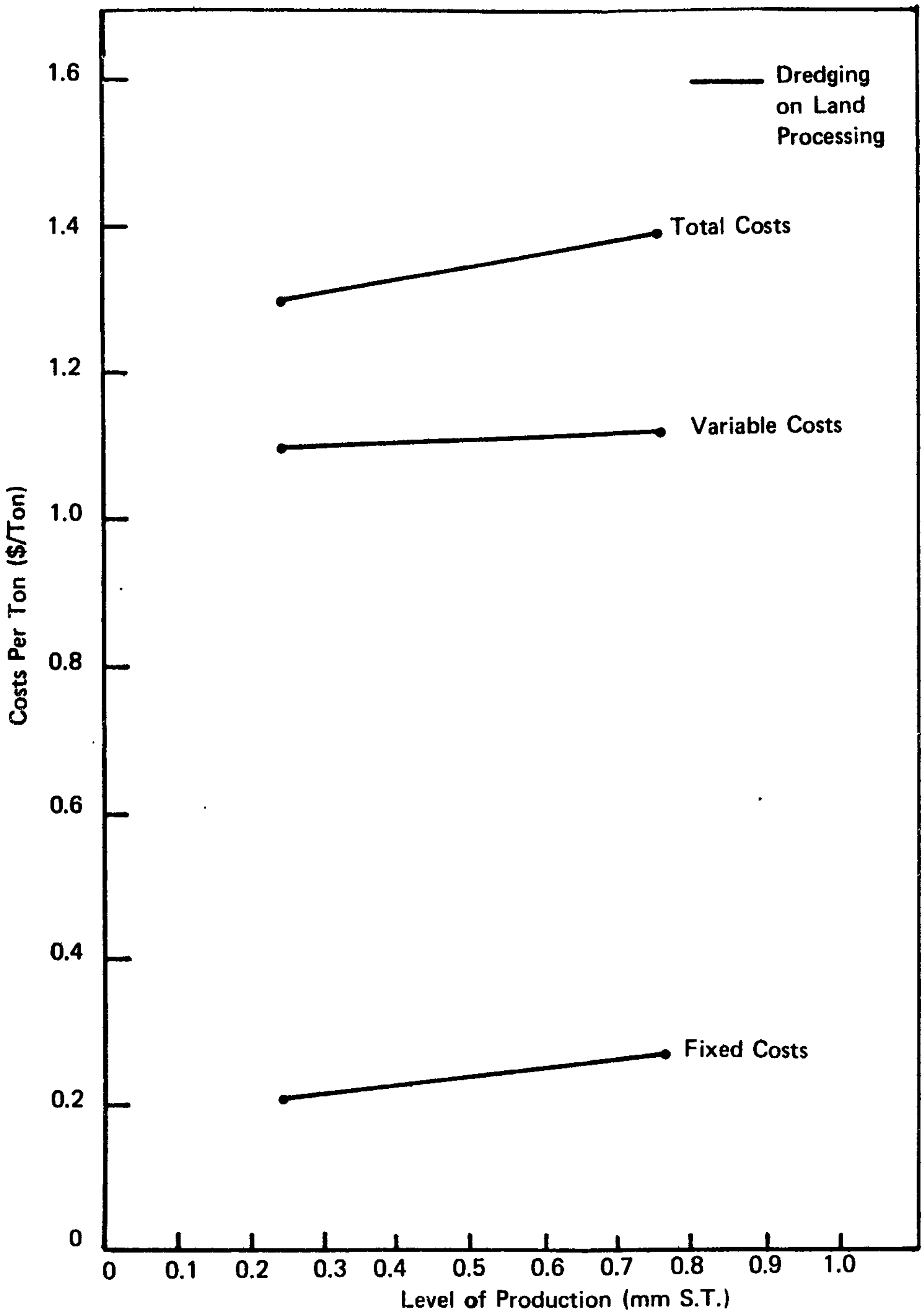


FIGURE A-3 CONSTRUCTION SAND AND GRAVEL COSTS PER TON BY LEVEL OF PLANT PRODUCTION

Table A-7 ENERGY COSTS PER TON OF PRODUCTION

Associations	# of Sites Responses	Production (10^3 tons)	Energy Cost ($\$10^3$)	Energy Cost Per Ton
NLA				
dry processing	6	4,969.3	1,172.7	.24
NLI/NCSA				
dry processing	29	20,521.3	2,460.6	.12
wet processing	9	7,778.9	1,019.0	.13
PCA				
dry processing	87	59,886.5	9,197.0	.15
wet processing	4	8,262.6	717.2	.09
NSGA				
wet processing	4	2,392.7	380.3	.16
dredging on land processing	8	3,046.8	529.3	.17

that own quarries and transfer their product internally to other sections of the company, it was necessary to be able to place a transfer price or value of the crushed stone or sand and gravel which is being internally transferred. Table A-8 shows average FOB price per ton and internal transfer price per ton. Responses were few and there was a considerable range of answers from individual sites.

The crushed stone industry in 1974 valued its crushed stone shipped at approximately $2.00 per ton.* The sand and gravel industry in 1974 valued its sand and gravel shipped at approximately $1.38 per ton.* The sample appears to represent the crushed stone industry better than the construction sand and gravel industry.

4. Potential vs. Actual Operating Capacity by Site

By aggregating site responses on capacity/hour and annual hours operated, it is possible to derive an implied potential operating capacity given that the sites do not increase or decrease numbers of hours operated during the year. This is accomplished by multiplying the total capacity/hour by the number of total hours operated per year. Comparing this potential level of production with actual annual production, it is possible to ascertain an actual operating capacity rate. Refer to Table A-9 for an implied actual operating capacity rate for each of the associations. Of course if the sites increased the number of hours operated during the year, the actual operating capacity rate could be lower given the same level of annual production. We estimate that the crushed stone industry operates at about 75-80% capacity and the sand and gravel industry operates at slightly less than 70-75%. This assumes that the number of annual operation hours and production are not changed.

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*Source: Arthur D. Little, Inc. estimates derived from Bureau of Mines information.

Table A-8 AVERAGE FOB PRICE/TON AND INTERNAL TRANSFER PRICE/TON BY ASSOCIATION

Associations	# of Sites	FOB Price/Ton	# of Companies	Internal Transfer Price/Ton
NLA				
dry processing	7	$1.92		
NLI/NCSA				
dry processing	29	1.99	5	$1.53
wet processing	10	1.88		
PCA				
dry & wet processing	7	1.49	12	1.64
NSGA				
wet processing	9	1.96	2	2.31
dredging on-land processing	6	1.79		

Table A-9 ACTUAL VS. POTENTIAL OPERATING CAPACITY BY ASSOCIATION

	# of Sites	Production (10^3 tons)	Capacity/Hour	Hours Operated Per Year	Potential Operating Capacity (10^3 tons)	Actual Operating Capacity (%)
NLA	8	7,934.4	2,860	21,363	9,136.2	86.9
NLI/NCSA	40	29,380.2	16,410	90,129	32,768.0	89.7
PCA	99	73,758.0	49,978	218,565	114,227.8	64.6
NSGA	15	7,197.7	5,984.3	26,143.5	7,632.7	94.3

5. Expected Life Cycles of Production by Site

Based on the responses from our survey, about 80% of the crushed stone sites covered have an expected life of over 10 years, as shown in Table A-10. Sand and gravel responses show that only 20% of the sites have an expected life of greater than 10 years. As can be seen from Table A-10, the sand and gravel data contained too few responses for much confidence to be associated with this site life-expectancy figure.

One would expect that the pit sites for construction sand and gravel industry would probably not register an expected life cycle as long as the crushed stone industry due possibly to the difference in the nature of the capital equipment requirements and mineral extraction process.

6. Gross Capital Outlays

In comparing annual revenue sales of company respondents with their annual gross capital outlays, it appears that the crushed stone respondents (excluding the PCA respondents) provide approximately 10% of each dollar worth of sales for capital outlays: PCA provides approximately 17%. (See Table A-11.) Based on the sand and gravel responses, it appears that approximately 11% of each dollar's worth of sales goes toward capital outlays. This was based on company financial statements and not site-specific financial statements. As a result, this is by no means a clean number to be directly associated with either the crushed stone or sand and gravel operations. However, it does give some indication of capital outlays associated with companies who are in the business of producing crushed stone and sand and gravel. The cleaner number of capital outlays per dollar sales, of course, would be for crushed stone, excluding cement companies and for sand and gravel. The Bureau of Mines reported that in 1972 the sand and gravel industry's capital outlays were 14% of their shipments.

Table A-10 ANNUAL PRODUCTION SEGMENTED INTO EXPECTED SITE LIFE BY ASSOCIATION

	<5 Years		5-10 Years		>10 Years	
	# of Sites	Production	# of Sites	Production	# of Sites	Production
NLA						
Dry Processing	0	-			5	4,525
NLI/NCSA						
Dry Processing			4	1,441	19	14,953
Wet Processing			3	3,449	6	4,210
PCA						
Dry Processing	4	3,256	12	6,033	63	42,444
Wet Processing	0	-	0	-	5	8,362
NSGA						
Dredging On-Land Processing and Wet Processing	3	819	9	3,971	3	2,344

TABLE A-11. ANNUAL NET CASH FLOW PER CAPITAL OUTLAY DOLLAR AND CAPITAL OUTLAYS PER DOLLAR SALES

	# of Company Responses	Annual Sales (10^6)	Annual Gross Capital Outlays (10^6)	Annual Before Tax Profits (10^6)	Annual Depreciation	Net Cash Flow Per $ Capital Outlay*	Capital Outlay Per $ Sales
NLA NLI/NSCA	19	1143.6	116.5	97.9	60.8	.9426	.1018
PCA	26	3396.9	586.2	273.4	129.7	.4773	.1720
NSGA	6	22.1	2.5	1.7	2.8	1.5267	.1118

*Net Cash Flow = (Before tax profits * tax rate) + depreciation: tax rate is assumed to be .50

In comparing net cash flow per dollar of gross annual capital outlays, crushed stone (excluding PCA respondents) produce $0.94 of net cash flow for every dollar spent on capital, and the sand and gravel industry produces $1.52 in net cash flow for every dollar spent on capital. (See Table A-11.) Net cash flow should include depletion allowances; however, it was not possible to quantify this information, so net cash flow is assumed to be equal to before tax profits multiplied by a tax rate of 0.50 plus depreciation.

7. Company Financial Statements

Table A-12 presents a summation of 1974 company financial statements by association grouping. Only the companies that responded to all the balance sheet information presented in Table A-12 were included in this summation. These financial statement profiles for each association are composed of all business dealings that the respondent companies are engaging. For example: a PCA company that receives sales revenues from limestone quarrying and cement manufacturing will have reported revenues as a sum of both business involvements. The same concept would apply to the remaining financial statement entries tabulated and present in Table A-12; however, respondents from NLA, NLI/NCSA, and NSGA appear to be more in the business of crushed stone and sand and gravel.

Table A-13 attempts to gain some indication of how profits, assets, liabilities, and net worth relate to revenue sales as they were reported by the same companies presented in Table A-12. For instance, pre-tax profits for companies grouped into NLA and NLI/NCSA, as represented by the sample, are slightly less than 13% of revenues. If one assumes a tax rate of 0.5, and applies this rate to before-tax profits, after-tax profits for NLA, NLI/NCSA are approximately 6% of sales revenues. The crushed stone industry profits average around 7% of sales. Repeating this analysis with PCA and NSGA data groupings, PCA respondents show that after-tax

TABLE A-12. AGGREGATE COMPANY FINANCIAL STATEMENTS BY ASSOCIATION

	Association		
	NLA & NLI/NCSA	PCA	NSGA
# of Company responses	19	25	8
Revenues (millions $)	697.4	3308.3	26.1
Pre-tax Profits (millions $)	89.2	266.6	1.8
After tax Profits (millions $)*	44.3	133.3	.9
Current Assets (millions $)	474.7	1168.9	12.9
Fixed Assets (millions $)	370.0	2100.5	20.5
Current Liabilities (millions $)	92.0	508.2	6.5
Long Term Liabilities (millions $)	130.4	806.7	4.1
Net Worth (millions $)	1067.7	2142.0	19.8
Production (million tons)	103.1	82.9	5.7

*Assumes tax rate of 0.5

TABLE A-13. AGGREGATE COMPANY FINANCIAL STATEMENTS BY ASSOCIATION
(Revenues Index = 100)

	Association		
	NLA & NLI/NCSA	PCA	NSGA
# of Companies	19	25	8
Revenues	100.0	100.0	100.0
Pre-Tax Profits	12.9	8.0	1.8
Current Assets	68.1	35.3	12.5
Fixed Assets	53.1	63.4	20.5
Current Liabilities	13.2	15.3	6.5
Long Term Liabilities	18.7	24.3	4.1
Net Worth	153.1	67.7	19.8
After Tax Profits*	6.4	4.0	3.5

*Assumes tax rate of 0.5

profits are about 4% of sales and NSGA respondents are slightly lower at 3.5% of sales.

In comparing sand and gravel company responses (NSGA) to crushed stone respondents (NLA, NLI/NCSA, PCA), the current value of fixed assets relative to current revenues for sand and gravel is substantially lower than for crushed stone. Given that most sand and gravel company respondents deal mainly in the sand and gravel business, this suggests that the value of equipment (i.e., front-end loaders, etc.) for sand and gravel is much less than for the equipment required in rock quarry pits to produce crushed stone.

The crushed stone respondents (NLA, NLI/NCSA) show that the ratio of total assets to sales is approximately 1.21. The crushed stone industry shows that for a 200,000-ton plant this ratio is approximately 1.25.

Sand and gravel respondents (NSGA) show that the ratio of total assets to sales is approximately 1.28. The sand and gravel industry shows that for a small and medium size plant the ratio is approximately 1.3.