COST FOR TREATING MINERAL MINING DISCHARGES

Originating from Mine and Process Area Runoff

Contract No. 68-01-3273

FINAL REPORT

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SECTION I

SUMMARY AND CONCLUSIONS

The costs to control and treat the contaminated storm runoff from the mineral mining and processing industry have been estimated to assess the economic impact. During the course of this study, it was found that there are many industry sites for which state regulations have already imposed comparable runoff control and which therefore would have no additional cost impact due to EPA proposed regulations.

No single industry segment cost estimate has been made solely on the basis of industry-supplied data. The cost estimates furnished herein are based on a general runoff control model applied to each segment with regard to the distribution of affected area sizes, soil absorbencies, and the need for treatment chemicals. In addition, comparisons with such industry-supplied estimates as were available have been made.

Sixteen of the thirty-eight segments of this industry were found to have runoff control problems and to operate in unregulated states. The preponderance of the control costs were found to be concentrated in only five industry segments - sand and gravel, industrial sand, crushed stone, common clay and shale, and kaolin. Twenty-two industry segments have runoff problems whether or not they operate in regulated states.

A summary of costs by commodity is given in Table 1.

Table 1. Costs to Control Runoff from the 10-Year Event

Commodity	Capital, millions of dollars			Annual Operating, millions of dollars		
	Regulated States	Unregulated States	Total	Regulated States	Unregulated States	Total
Dimension Stone	5.1	1.9	7.0	2.55	0.95	3.5
Crushed Stone	193.7	22.5	216.2	59.6	8.2	67.8
Sand and Gravel (including industrial sand)	307.6	102	409.6	88.9	29.8	118.7
Gypsum	3.66	0.64	4.3	1	0.2	1.2
Asbestos and Wollastonie	0.226	0.034	0.26	0.09	0.02	0.11
Mica and Sericite	0.1	0.41	0.51	0.171	0.029	0.2
Rock Salt			*(2.9)			*(0.15)
Phosphate Rock	0.032	0.073	0.105	0.014	0.021	0.035
Bentonite	0.295	0.425	0.72	0.169	0.221	0.39
Fire Clay	16.024	0.176	16.2	6.108	0.092	6.2
Fuller's Earth	1.128	0.132	1.26	0.613	0.057	0.67
Common Clay and Shale	40.618	3.182	43.8	18.185	1.415	19.6
Kaolin	30.203	0.097	30.3	8.018	0.032	8.05
Ball Clay	2.82	0.28	3.1	1.36	0.14	1.5
Feldspar	0.679	0.021	0.7	0.189	0.011	0.2
Talc, Soapstone, Steatite and Pyrophyilite	0.513	0.087	0.6	0.253	0.087	0.34
Lithium Minerals	0.18	0	0.18	0.048	0	0.048
Vermiculite	1.3	0	1.3	0.382	0	0.382
Barite	1.6	0	1.6	0.44	0	0.44
Aplite	0.57	0	0.57	0.12	0	0.12
Kyanite	0.18	0	0.18	0.056	0	0.056
Mineral Pigments	0.014	0	0.014	0.018	0	0.018
Total	606.742	131.957	738.699	188.329	41.275	229.604

*Not included in total; these are costs for covering storage piles rather than diversion.

SECTION II

INTRODUCTION

1.0 GENERAL DESCRIPTION OF INDUSTRY

There are 38 commodity categories in mineral mining and processing industries which were studied for this report. These categories and corresponding SIC codes are listed in Table 2.

Of these categories, several are in areas where runoff does not present a problem, some are mined under ground and have no runoff, and several are in states with current sedimentation and erosion control laws. Mine sites in regulated states have already experienced a cost obligation for runoff control. Commodities mined only in regulated states include lithium minerals, vermiculite, barite, aplite, kyanite and mineral pigments. These along with the remaining 16 categories listed below that have runoff problems are those for which costs of runoff control and treatment are assessed:

Dimension Stone
Crushed Stone
Construction Sand and Gravel
  and Industrial Sand
Gypsum
Asbestos and Wollastonite
Mica and Sericite
Rock Shale
Phosphate Rock
Bentonite
Fireclay
Fuller's Earth
Shale and Common Clay
Kaolin
Ball Clay
Feldspar
Talc, Steatite, Soapsonte,
  Pyrophyllite

Table 2. Industry Categories and SIC Codes

Categories	SIC Codes
Dimension Stone	1411
Crushed Stone	1422, 1423, 1429, 1499
Construction Sand and Gravel	1442
Industrial Sand	1446
Gypsum	1492
Asphaltic Minerals	1499
Asbestos and Wollastonite	1499
Lightweight Aggregates	1499
Mica and Sericite	1499
Barite	1472, 3295
Fluorspar	1473, 3295
Salines from Brine Lakes	various
Borax	1474
Potash	1474
Sodium Sulfate	1474
Trona	1474
Rock Salt	1476
Phosphate Rock	1475
Frasch Sulfur	1477
Mineral Pigments	1479
Lithium Minerals	1479
Bentonite	1452
Magnesite	1459
Diatomite	1499
Jade	1499
Novaculite	1499
Fireclay	1453
Fuller's Earth	1454
Kyanite	1459
Shale and Common Clay	1459
Aplite	1499
Tripoli	1499
Kaolin	1455
Ball Clay	1455
Feldspar	1459
Talc, Steatite, Soapstone, Pyrophyllite	1496
Garnet	1499
Graphite	1499

2.0 GENERAL DISCUSSION OF CURRENT STATE LEGISLATION

During the initial phase of this study it became apparent that many States had enacted legislation within the past five years that regulated surface mining, reclamation procedures, erosion and sedimentation control, and related objectives. Several of the trade associations confirmed that applications, drainage, plans mining and reclamation schedules, performance bonds, and other regulatory information from both new and existing surface mining operations are required by a number of states. A survey of applicable state legislation is summarized in Table 3 and in Figure 1. The summary shows that 38 states have current legislation controlling runoff, erosion, or siltation, 2 states are preparing or enacting similar legislation, and 10 states either have no legislation or have not responded to the request for information.

An analysis of these laws shows that many have similar, if not identical, language relating to the control of runoff from disturbed or affected areas. Almost all require permits to initiate or continue surface mining. These permit applications usually stipulate that the operator must present a satisfactory erosion and sedimentation control plan. In a majority of cases, the water discharged is required to meet the applicable state water quality regulations.

Eleven states belong to the Interstate Mining Compact which requires effective programs for control of surface disturbance. These states are Illinois, Indiana, Kentucky, Maryland, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas and West Virginia.

The following excerpts of pertinent sections of selected State Laws will illustrate the widespread applicability of these laws and regulations to the control and treatment of runcff from disturbed areas.

Table 3. State Legislation

State	Surface Mining	Water	Dam
Alabama	X		
Alaska	X		
Arizona		X	X
Arkansas	X	X	
California	X	X	X
Colorado	X		X
Connecticut	No Law		
Delaware	No Law		
Florida	X	X	X
Georgia	X	X	
Hawaii	No Law		
Idaho	X		
Illinois	X	X	
Indiana	X	X	
Iowa	X	X	
Kansas	X	X	
Kentucky	X	X	X
Louisiana	No Law		
Maine	X		
Maryland	X (coal)	X	
Massachusetts	X		
Michigan	X		X
Minnesota	(drafting)	X	X
Mississippi	(drafting)	X	
Missouri	X	X	
Montana	X		
Nebraska	Partial Law		
Nevada		X	
New Hampshire	X		
New Jersey	No Law	X	X
New Mexico	X (coal)		
New York	X	X	X
North Carolina	X		X
North Dakota	X		
Ohio	X	X	X
Oklahoma	X	X	
Oregon	X	X	
Pennsylvania	X		X
Rhode Island			
South Carolina	X		
South Dakota	X	X	
Tennessee	X		
Texas	X		
Utah	X		X
Vermont	X		X
Virginia	X	X	
Washington	X		
West Virginia	X	X	X
Wisconsin	No Law	X	X
Wyoming	X	X	

Alabama "Alabama Surface Mining Act of 1969", Section VII, 4.

4. Divert water from the mining operation in a manner designed to reduce siltation, erosion, or other damage to streams and natural water courses.

Arkansas "Arkansas Open Cut Land Reclamation Act, Reclamation Plan Procedures, Act 236 of 1971", Section 3. (h).

(h) "Affected land" means the area of land from which overburden has been removed for open cut mining or upon which overburden or refuse has been deposited, or both; on or after the effective date of this Act.

Section 6. (l)

(l) All refuse shall be disposed of in a manner designed to control siltation, erosion or other damage to streams and natural water courses, as best allowed by the soil condition of the location involved.

Colorado "Colorado Open Mining Land Reclamation Act of 1973", 92-13-6, (1)(f).

(f) All refuse shall be disposed of in a manner that will control stream pollution, unsightliness, or deleterious effects from such refuse, and water from the mining operation shall be diverted in a manner designed to control siltation, erosion, or other damage to streams and natural watercourses.

Georgia "Georgia Surface Mining Act of 1968", "Mined Land Use Plan" (Subsection 6(a) amended by Act No. 75(S.B. No. 3) approved March 29, 1971).

(b) to submit, with the application for a license, a Mined Land Use Plan which shall be consistent with the land use in the area of the mine and shall provide for reclamation of the affected land. Once approved the operator will be responsible for completion of the plan. Once a Mined Land Use Plan has been approved for a specified area to be mined, it shall not have to be submitted annually with the application for a license renewal. However,

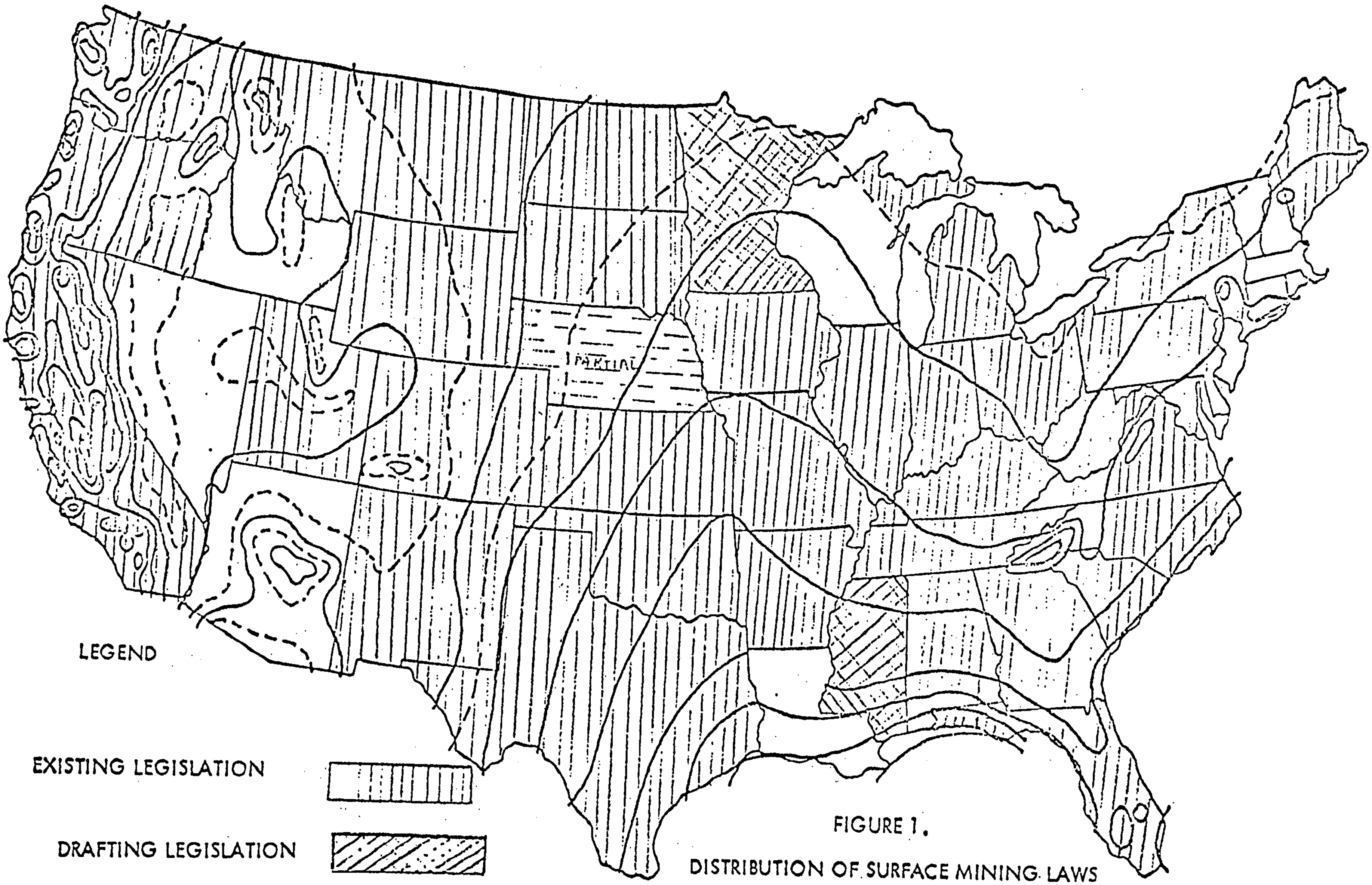

FIGURE 1.
DISTRIBUTION OF SURFACE MINING LAWS

any new area to be affected or any change in an approved plant must be submitted to the Board for approval as an amendment to an operator's Mined Land Use Plan.

(c) to file a bond with the Board written by surety approved by the Board and authorized to transact business in this State. The bond shall be fixed by the Board in an amount not less than $100 nor more than $500 per acre, or fraction thereof, of the area of affected land. The bond shall be payable to the Governor and conditioned upon the faithful performance of the requirements set forth in this Act and the rules and regulations of the Board. Any operator who has fulfilled all of his obligations in accordance with his Mined Land Use Plan for three years may be relieved of the future bonding requirements imposed by this Act, at the discretion of the Board. However, any operator who violates any of the provisions of this Act or the rules and regulations of the Board, or who defaults on his obligations under a present Mined Land Use Plan or any Mined Land Use Plan filed by him in the future, after being relieved of the bonding requirements imposed by this Act, may be required by the Board to post a new bond for such period of time as the Board may determine. Operators shall have the option of posting bond, government securities, cash or any combination thereof, on each mined area. In determining the amount of bond, government securities or cash within the above limits, the Board shall take into consideration the character and nature of the overburden, the future suitable use of the land involved and the cost of reclamation to be required. The bond, government securities or cash shall be held by the Board until the affected land or any portion thereof is satisfactorily reclaimed, in the opinion of the Board, at which time the bond, government securities or cash or portion thereof shall be terminated or returned to the operator. An operator, upon approval of an amended Mined Land Use Plan, shall file with the Board the appropriate bond, government securities or cash to cover the plan as amended, unless otherwise exempted from bonding under provisions of this Act. (Subsection 6(c) amended by Act No. 75 (S.B. No. 3) approved March 19, 1971).

Kentucky "Department for Natural Resources and Environmental Protection, Title XXVIII, Chapter 350, Strip Mining, 1966", 350.090 (2)(d)

(d) Impound, drain or treat all runoff water so as to reduce soil erosion, damage to agricultural lands and pollution of streams and other waters;

Regulation II — Water Quality, (2) Drainage.

(a) Water which might drain into the stripping pit shall be intercepted above the highwall by diversion ditches and conveyed by stable channels (designed so they will not erode) or other means to natural or prepared water-courses unless the Division finds these ditches unnecessary. Such ditches shall be built of sufficient size and grade to handle the runoff resulting from a once in ten (10) year storm event as a minimum.

(e) All drainage originating on the area of land affected must meet the specifications in paragraph 1(c) herein or exit through treatment facilities in accordance with paragraph 1.

Michigan "Mine Reclamation Acts — Act No. 92 of the Public Acts of 1970, as amended by Act No. 123 of the Public Acts of 1972", Section 3. (a).

(a) The sloping, terracing or other practical treatment of stockpiles and tailings basins where erosion is occurring or is likely to occur which results or may result in injury or damage to fish and wildlife, the pollution of public waters, or which is causing or might cause injury to the property or person of others.

Illinois "Surface-Mined Land Conservation and Reclamation Act, P.A. 77-1568", effective Sept. 17, 1971. Rule 1105 - Water Impoundments

All runoff water shall be impounded, drained, or treated so as to reduce soil erosion, damage to unmined lands and the pollution of streams and other waters. The operator shall construct in accordance with Chapter 15 of these Rules and Regulations earth dams, where lakes may be formed, in accordance with sound engineering practices if necessary to impound waters, provided the formation of the lakes or ponds will not interfere with underground or other mining operations; other subsequent uses of the area approved by the Department, or damage adjoining property. Such water impoundments shall be approved by the Department based on the expected ability of the lakes or ponds to support desirable aquatic life and shall have minimum depths in accordance with standards for fish stocking in the various areas of the State recommended by the Department.

North Carolina "The Mining Act of 1971", 74.48 Purposes; 74.51 Denial of Permit.

74.48. Purposes.—The purposes of this Article are to provide:

(1) That the usefulness, productivity, and scenic values of all lands and waters involved in mining within the State will receive the greatest practical degree of protection and restoration.

(2) That from June 11, 1971, no mining shall be carried on in the State unless plans for such mining include reasonable provisions for protection of the surrounding environment and for reclamation of the area of land affected by mining. (1971, c. 545, s. 3.).

74.51. Denial of Permit

(2) That the operation will have unduly adverse effects on wildlife or fresh water, estuarine, or marine fisheries;

(3) That the operation will violate standards of air quality, surface water quality, or ground water quality which have been promulgated by the Department of Water and Air Resources;

(6) That previous experience with similar operations indicates a substantial possibility that the operation will result in substantial deposits of sediment in stream beds or lakes, landslides, or acid water pollution;

Oklahoma "The Mining Lands Reclamation Act, 1971", Rules and Regulations, Page 11, (c).

(c) Impound, drain or treat all runoff water so as to reduce soil erosion, damage to grazing and agricultural lands, and pollution of subsurface waters;

Pennsylvania "Surface Mining Conservation and Reclamation Act, Nov. 1971", Section 1, Purpose; Section 4, (2) (k).

.Section 1. Purpose of Act — This act shall be deemed to be an exercise of the police powers of the Commonwealth for the general welfare of the people of the Commonwealth, by providing for the conservation and improvement of areas of land affected in the surface mining of bituminous and anthracite coal and metallic and nonmetallic minerals, to aid thereby in the protection of birds and wild life, to enhance the value of such land for taxation, to decrease soil erosion, to aid in the prevention of the pollution of rivers and streams, to prevent and eliminate hazards to health and safety, to prevent combustion of unmined coal, and generally to improve the use and enjoyment of said lands. (Amended November 30, 1971, Act No. 147.)

Section 4. (2) K. The application shall also set forth the manner in which the operator plans to divert surface water from draining into the pit and the manner in which he plans to prevent water from accumulating in the pit. No approval shall be granted unless the plan provides for a practicable method of avoiding acid mine drainage and preventing avoidable siltation or other stream pollution. Failure to prevent water from draining into or accumulating in the pit, or to prevent stream pollution, during surface mining or thereafter, shall render the operator liable to the sanctions and penalties provided in this act and in "The Clean Streams Law," and shall be cause for revocation of any approval, license or permit issued by the department of the operator.

Subchapter E. Surface Non-Coal Mining Operations, 77.101. Requirements.

(c) Water Quality Criteria

(14) The permittee shall take all necessary measures to prevent the discharge of avoidable silt, clay or other fines associated with the operation into the receiving stream. These precautions may include planting or vegetation, construction of settling ponds, and treatment, if necessary to meet the current erosion and sediment control regulations of the Department.

(15) Any discharges emanating from the surface mine operation shall be in compliance with the requirements of the Act of June 22, 1937 as amended, P.L. 1987, "The Clean Streams Law" and Department regulations applicable to water quality criteria and water pollution control.

(d) Drainage

(16) All surface water which might drain into the surface mine pit, shall be intercepted by diversion ditches and conveyed to natural watercourses outside the surface mining operation. Such conveyance shall be built of sufficient size and grade to prevent overflow into any mine workings. Alternate surface water control measures will be approved on their own merit.

(17) In the process of surface mining, the permittee shall be responsible for all impoundments of water encountered and shall take necessary action to prevent discharge of water not meeting discharge standards.

(18) After mining has been completed, the permittee shall promptly complete the mine closure procedures set forth in the approved reclamation plan.

(19) All water shall be directed through a collection basin for each point of discharge, constructed of sufficient size for settling prior to discharge, unless water quality indicates otherwise.

(e) Treatment

(20) All discharges from processing plants, which are integrated with and part of an operation, shall meet minimum discharge standards and be covered by a permit.

(21) Discharges from processing plants which are not integrated with or part of a permitted operation and are therefore not covered by a permit, shall apply for and receive an Industrial Waste Permit from the Department prior to operation.

(22) When treatment facilities are a part of the approved plan of drainage, such facilities shall be constructed, inspected and approved by the Department and ready for operation prior to the initiation of mining.

(23) Where a treatment facility is required, it shall be maintained in proper working condition and operated according to the approved design so that it performs the functions for which it was intended.

(24) The permittee shall conduct such tests and/or shall install such equipment for continuous monitoring as are reasonably necessary to assure continuous satisfactory operation of the treatment facilities.

(25) The permittee shall employ personnel who are qualified by training and/or experience to operate and maintain the treatment facilities.

(26) Treatment works shall be designed and constructed to the satisfaction of a qualified professional engineer or registered surveyor. Construction shall be in accordance with the approved plans, designs, and other data and plans as approved, and the conditions of the permit.

(27) During construction of treatment facilities, no changes shall be made from the approved plans, designs, and other data unless the permittee shall first receive written approval for each such revision from the Department.

(28) Monthly operation reports of the treatment facilities having a discharge to a stream shall be submitted to the Department if required by the Department. Such reports shall be submitted promptly after the end of each month on forms provided by the Department.

<u>South Carolina</u> "The South Carolina Mining Act, 1973", Section 6.

The Department shall deny such permit upon finding:

(c) That the operation will violate standards of air quality, surface water quality, or ground water quality which have been promulgated by the South Carolina Pollution Control Authority;

(f) That previous experience with similar operations indicates a substantial possibility that the operation will result in substantial deposits of sediment in stream beds or lakes, landslides, or acid water pollution;

Tennessee "Surface Mining Law, 1972", Regulations. 11.14 - Water Control

The water flow from the mine area and haul roads shall be controlled to minimize soil erosion damage to other lands and pollution of streams or other waters. This may include construction of checks, impoundments, silt-trap dams, and water bars in conjunction with other control measures as required. All sediment control structures shall be constructed according to criteria contained in the Drainage Handbook for Surface Mining published by the Department of Conservation.

Utah "Utah Mined Land Reclamation Act, 1975", Section 15.

(b) To minimize or prevent present and future on-site or off-site environmental degradation caused by mining operations to the ecologic and hydrologic regimes and to meet other pertinent state and federal regarding air and water quality standards and health and safety criteria.

West Virginia "Surface Mining Reclamation Law, 1972", Regulations, Section 7.

7.01 Drainage Plan - There shall be submitted with the application for surface mining a drainage plan which will show the proposed method of drainage on and away from the area of land to be disturbed. Said plan shall indicate the directional flow of water, constructed drainways, natural waterways used for drainage, streams or tributaries receiving or to receive this discharge, location of sediment dams and other silt retarding structures, location of all water test sites, treatment and all other data as may be required.

7B.01 Sediment Control - Embankment type sediment dams or excavated sediment ponds will be constructed in appropriate locations in order to control sedimentation. All such impoundments shall have a minimum capacity to store .125 acre-ft /acre of disturbed area in the watershed. This disturbed area will include all land affected by previous operations that is not presently stabilized and all land that will be affected throughout the life of the permit. Design criteria and construction specifications for embankment type sediment dams, excavated sediment ponds and other water retarding structures will be found in the "Drainage Handbook for Surface Mining."

7C.01 Water Quality Control - All reasonable measures shall be taken to intercept all surface water by the use of diversions, culverts and drainage ditches or other methods to prevent water from entering the pit area. All water accumulation into the pit shall be removed as rapidly as possible with due recognition to water quality requirements. All water discharged from the permit area is to be monitored daily by the operator and a written record of the testing dates and analytical data shall be kept current and made available for inspection. A monthly compilation of the foregoing information will be submitted monthly to the Chief of the Reclamation Division. Any treatment works necessary to meet "adequate treatment" shall be approved by the Division of Water Resources. The water leaving the permit area will not lower the water quality of the river, stream or drainway into which it is discharged below the water quality standards established for such river, stream or drainway. In general, the following values or conditions are the minimum accepted standards for water leaving the permit area:

1. pH - 5.5 to 9.0;
2. Iron - 10 milligrams per liter or less;
3. Turbidity - not more than 1,000 Jackson Units (J.U.) of turbidity four hours following a major precipitation event and not more than 200 J.U. after 24 hours. (Major precipitation event - one-half inch of rainfall in 30 minutes.)

Water tests shall be taken before surface mining operations begin and the results of these tests will be shown on the "drainage plan" map. The location for these preliminary tests will be:

1. On natural drainways above proposed surface mining operations;
2. On natural drainways below proposed surface mining operation at or near the affected drainage area boundary;

3. On natural drainways upstream from the mouth of a natural drainway affected by surface mining.

The fourteen state laws quoted above provide a spectrum of typical legislation. Sections regarding enforcement have not been quoted, but tend to rely on periodic reports, inspections, and fines for violations. In almost all cases, performance bonds are required to assure completion of the approved plans.

As a result of this widespread trend to enact State legislation controlling erosion and runoff from mining operations, a substantial percentage of all non-metallic mineral processors have already completed or initiated programs for diverting, controlling, collecting, and treating runoff from areas disturbed by mining and covered with overburden. In some categories in the mineral mining industry, all meaningful production is from regulated states. In all categories, a substantial percentage of production is from such states. It is therefore evident that the economic impact of federal standards will only be felt by producers in non-regulated states. In most categories these producers will represent a relatively modest percentage of the total category, and the economic impact on each such category will therefore be proportional to such percentage. However, costs were developed for production of commodities in all states except those which for climatic reasons or mining methods used have no runoff problems. A range of costs are given from the percentage in unregulated states to the total for regulated and unregulated states.

Appendix A is a summary of state surface mining and mined land reclamation laws prepared by the Bureau of Mines.

3.0 COST DEVELOPMENT METHODOLOGY

The purpose of this report is to present engineering cost estimates for diversion, total containment or treatment of rainfall runoff for sediment control in the mineral mining and processing industries. The estimates were based on data accumulated from industry, engineering sources and various reports by the EPA, the Soil Conservation Service and the National Weather Bureau. Other sources of useful information were the individual state mining laws, sedimentation and erosion control laws where they existed, dam construction specifications and water rights laws where applicable. More than 40 site visits were made to gather first-hand information on the types of problems associated with runoff control at specific mine sites.

Cost analysis was based on estimates from a uniform runoff control and treatment model that took into account the variety of rainfall intensities, disturbed area sizes, and local geological features. Where available, these were compared to estimates furnished by industry for specific mine sites. The generalized model includes: the disturbed area which encompasses the active mine site*, future working site, ore storage piles, and overburden and tailings piles, rainfall events for specific sites; and the soil types which determine the amount of rainfall absorbed and the amount which runs off. It is recognized that this model cannot account for some exceptions in these mining industries. However, it does serves as a conservative guideline to assess costs at a majority of the mines sites. Exceptions, such as salt and phosphate rock are assessed individually in the report.

Both capital and annual operating cost ranges were developed for disturbed areas ranging from 2 to 200 hectares (5 to 500 acres), for rainfall events ranging grom 5 to 30.5 cm (2 to 12 in), and for soil types and saturation conditions with runoff factors ranging from less than 10 to 90 percent. The following discussion includes the cost elements, assumptions and rationale which served as the bases for computing costs which were then interpolated to specific regions and commodities.

*For high wall quarries, where the pit area contains direct rainfall (which becomes mine discharge), the active mine area is reduced by the pit area.

A conservative model runoff control and treatment system was designed to develop capital and operating costs for the subcategories for which site-by-site costs were not available or reasonable to estimate. This model was generalized in the sense that it was designed to apply to a wide range of disturbed areas, severity of rainfall*, and soil absorbency** - ground cover situations. The basic elements of the model consisted of:

— exclusion and diversion of all run-in of uncontaminated water at the affected area perimeter by means of ditches and dikes,

— collection of all runoff within the disturbed area

— segregation of runoff from mine (pit) water

— conduction of the collected runoff via ditches through small stilling basins to reduce sediment load to a settling lagoon system, capable of flocculation treatment, if necessary.

The sedimentation lagoon system discussed below is based on an earthen impoundment for runoff of the 10- and 25-year, 24-hour event. It is further a system to control and treat all other storm runoff that is smaller in amount than the 10- or 25-year event runoff. Beside providing for this impoundment, the principal lagoon also contains at all times a relatively small amount of water that is the normal week-by-week runoff and direct precipitation that is being retained for at least 24 hours prior to discharge. The volume of pond allocated for this function was sized conservatively as equal to the volume of runoff from a one-year, 24-hour event. This lagoon must be maintained with a freeboard that will accommodate the runoff from the 10- and 25-year event, collected from the "disturbed area," plus direct pond infall. The lagoon design volume consisted of these two volumes plus safety factor freeboard plus an upstream pretreatment pond or basin.

The principal lagoon is designed to not overflow its spillway except when rainfall occurs that is in excess of the 10- and 25-year event. Discharge of the treated runoff up to

*See Appendix B.
**As characterized by USDA-SCS. See paragraph below.

the amounts of these events are by batch release when the proper degree of clarification has been attained.

Included in the "disturbed area" are the disturbed land adjacent to the mine or pit, the overburden piles, grout piles and temporary ore storage piles that are contiguous to the mine, as well as the diversion ditches and dikes for runoff control. The general characteristics of the model control system are shown in the sketch of Figure 2.

A significant conservative element of this runoff model is the perimeter exclusion and diversion of uncontaminated run-in water. Although this is only one of several ways of dealing with runoff water that originates outside the "disturbed area" of the mine and hence is "uncontaminated" prior to entry into the disturbed area, this control method allows the model costs to be developed relatively independent of the topography of the territory surrounding the mine site. Thus, a mine site which might normally experience the overflow of the runoff of a large watershed would, in this model, be affected only by the direct rainfall within the affected mine area because of the segregation.

3.1 Design Elements

The design of the runoff control and treatment elements, the ditches, dikes, and lagoons were then related principally to two important remaining variables:

- the size of the included disturbed area
- the amount of runoff to be accommodated.

The size of the disturbed area affects not only the amount of runoff water generated but also the length of the exclusion and collection dikes and ditches. The amount of runoff collected is further affected in major ways by both the intensity of the local rainfall and the absorbency of the soil in the affected area. For the purposes of this study, the size of the treatment system was based on the 10- or 25-year, 24-hour rainfall event rather than normal rainfall. The lagoon system was designed to collect and treat by sedimentation for a minimum of

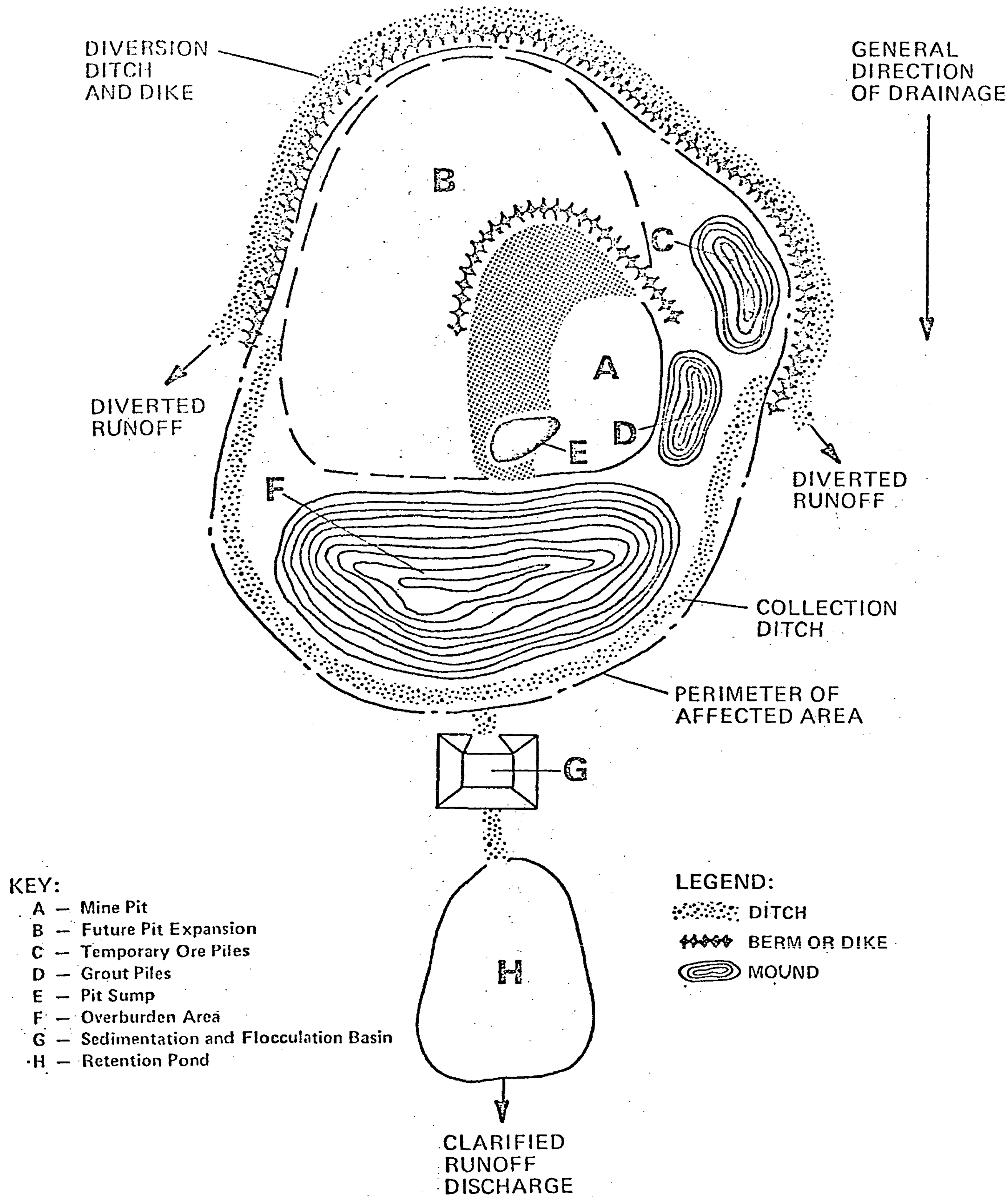

Figure 2. GENERALIZED MINE SITE RUNOFF CONTROL MODEL

24 hours retention time rainfall normally experienced by the locality, and further, to have freeboard capable of impounding the 24-hour event rainfall for sedimentation treatment prior to discharge. The treatment consisted of a minimum 24-hour lagoon retention with or without addition of flocculants, prior to discharge. Water in excess of the 24-hour event overflows the lagoon without treatment.

A single level of flocculant treatment was included in the model for those mine sites situations in which the runoff is believed to contain significant amounts of colloidal or otherwise difficult-to-settle materials.

3.2 Soil Absorbency

Differences in absorbency of the disturbed areas were allowed for in the model by providing for four absorbency conditions related to the four hydrologic soil groups of the Soil Conservation Service (USDA). These USDA hydrologic soil groups, according to their infiltration and transmission rates, are:

Group A (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted. These consist chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission in that water readily passes through them.

Group B Soils having moderate infiltration rates when thoroughly wetted. These consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C Soils having slow infiltration rates when thoroughly wetted. These consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The soil, its cover, and its hydrologic condition, in most cases, affect the volume of runoff more than any other single factor. The hydrologic condition of the soil is determined by its moisture content at the time of the storm, its humus and organic content, its temperature, and whether or not it is frozen. The soil cover condition for the disturbed area was assumed to be equivalent to a combination of cultivated land with conservation treatment plus roads in order to relate soil group to runoff potential. The assumed relation between intensity of rainfall, soil condition, and resultant runoff is shown in Figure 3. Soil conditions A, B, C and D refer to the A to D hydrologic soil groups with the soil cover condition as stated above.

3.3 Cost Elements

Cost information contained in this report was assembled directly from industry, engineering firms, government sources, and published literature. Where possible, unit costs are based on data from actual installations in this industry.

3.3.1 Interest Costs and Equity Financing Charges

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

3.3.2 Time Basis for Costs

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

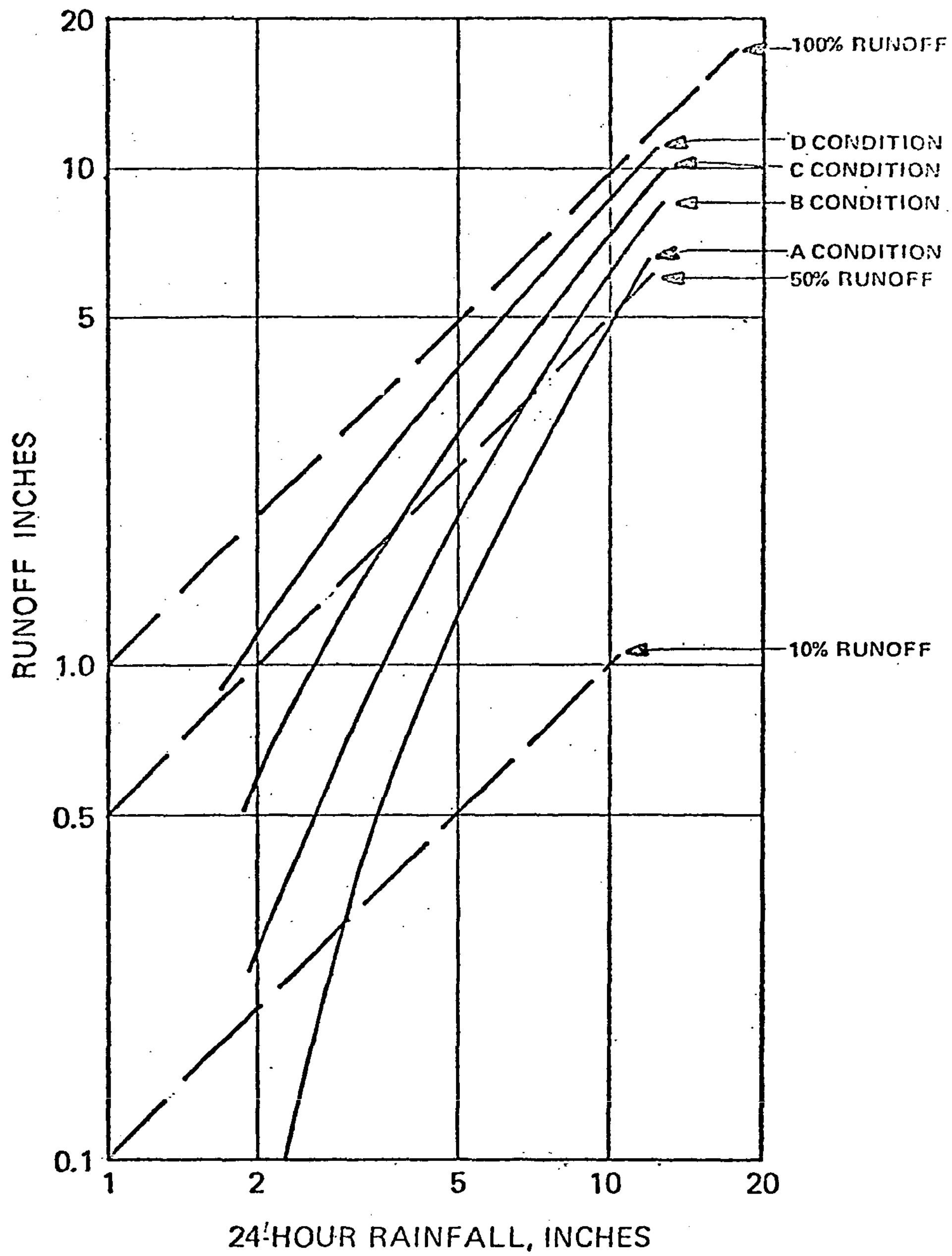

Figure 3. RELATION BETWEEN 24-HOUR RAINFALL AND RESULTING RUNOFF

3.3.3 Useful Service Life

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

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

chemical treatment equipment	10 years
ponds, lined and unlined	20 years

3.3.4 Depreciation

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

3.3.5 Capital Costs

Capital costs are defined as all front-end,out-of-pocket expenditures for providing runoff treatment and control facilities. These costs include equipment, construction and installation, buildings and services. No extra costs for contingencies were included in the capital estimates.

3.3.6 Annual Capital Costs

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

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

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

For lagoons, which are assumed to have a 20-year useful life, the UAD is 11.8 percent and for chemical treatment equipment, with an assumed useful life of 10 years, it is 16.3 percent.

3.3.7 Land Costs

Land used for runoff collection, diversion or treatment facilities requires removal of the land from other economic use. This was taken into account by assuming 10 percent interest on land used for runoff treatment and control. It was also assumed that the full value of the land is recoverable. Land was costed at $1,750/ha ($700/ac). This land consists in the main of the land occupied by the diversion and collection ditches and dikes and by the sedimentation lagoon system.

3.3.8 Operating Expenses

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

3.3.9 Operating Cost Basis

The three parameters which affect operating as well as capital costs are disturbed area, soil type, and rainfall. The disturbed areas were assumed to range from 2 to 200 ha (5 to 500 ac) and the rainfall events were assumed to range from 0.8 to 30 cm

(2 to 12 inches). The annual operating costs include the following elements:

- — cost of capital
- — cost of land
- — cost of operating labor
- — cost of pond dredging
- — cost of flocculant

The annual capital is the Uniform Annual Disbursement (UAD) of the capital cost.

The cost of land was derived by assuming 10 percent interest on invested capital in land occupied both by treatment ponds and by diversion ditches and dikes. Land costs were assumed to be $1,750/ha ($700/ac). The pond acreage was calculated by determining the appropriate lagoon volume and dividing by an assumed depth of 3 meters (10 feet). The acreage used in diversion ditches and dikes was a product of the length determined by the model times a width of 12 meters (40 feet). The sum of these gives the total area tied up in the collection and treatment of runoff. The total land cost is 0.10 times $1,750 ha ($700/ac) times the area involved in the treatment system.

The cost of pond dredging depends on the amount of sediment accumulated and the storage capacity of the pond. To determine this cost, we made the following assumptions:

- — frequency of dredging is once per year, as a minimum
- — a cost of $0.66 per cu m ($0.50 per cu yd) of dredged material is based on excavation values furnished by industry
- — the amount of material settled is 1,000 ppm
- — the proportionality factor between the annual rainfall and the 24-hour event runoff is 7.5

— the average annual rainfall has 20 percent runoff

— the average 24-hour event has 50 percent runoff

Therefore, the cost of pond dredging equals the cost per cubic meter (cubic yard) of dredged material times the pond volume times the concentration of suspended solids times the proportionality factor times the ratio of annual rainfall runoff to 24-hour event runoff.

In cases where chemical treatment is necessary to facilitate settling, the cost of flocculant is added to the annual operating costs. These costs are assumed to be $0.085 per 1,000 liters ($0.32 per 1,000 gallons) of water treated.

The cost of labor includes the cost to monitor the quality of the effluent and the cost to adjust and maintain the runoff control ponds. The monitoring was assumed to require 4 hours per week for collecting a composite sample and 2 hours per week for miscellaneous work. This amounts to 312 hours per year. For maintenance, one man-day per week, amounting to 416 man-hours per year was assumed. The costs were calculated by assuming $10 per hour as an effective labor rate including overhead, fringes and supervision. The cost to analyze samples was assumed to be $10 per sample and this cost was added to give a total fixed cost of labor.

Additional labor costs are incurred when flocculation is required. The labor required for the chemical addition was assumed to be porportional to the amount of normal runoff. It was further assumed that this was normal runoff was proportional to the 24-hour event runoff. The effective labor rate is the same as above, $10 per hour including fringes, overhead and supervision. The labor necessary was assumed to be 2 man-hours per month for a 0.5 cm (0.2 in) runoff, and proportionally more for greater amounts of runoff.

In summary, the total annual operating costs are a sum of the cost of capital, the cost of land, the cost of operating labor and the cost of pond dredging. Where flocculant is added, the additional capital costs, additional labor costs and the cost of the flocculant were included. These estimates gave annual operating costs per site ranging from $8,700 to $362,000 without flocculation. Cost curves derived from the cost model as described above are given in Appendix C.

3.4 Sensitivity of the Model Costs to Lagoon Retention Time

Since the model lagoon system is an impoundment for the 10- or 25-year event runoff, it has the capability of retaining for an indefinite period of time the runoff from any event up to and including the 10- to 25-year event. This is normally true because the probability of any substantial additional rainfall occurring within a period of time equal to the desired retention time after a 10- or 25-year event is extremely low. The simple criterion of 24-hour retention of any runoff up to the 10- or 25-year event was assumed in this study. The probability of attaining this retention time with the model lagoon system under the operating conditions prescribed is very high. Since the principal lagoon is in fact a conservatively designed impoundment, it is not necessary to operate with continuous discharge under any conditions except those exceeding the 10- or 25-year event. Proper attention to periodic pump down or batch release of the normal runoff should insure that any reasonable retention time can be maintained without affecting costs.

3.5 Sensitivity of the Model Costs to the Design Rainfall Event

The construction cost of the impoundment lagoons (ponds) is a major fraction of the total capital cost for this modelled control and treatment system, ranging from 15 to 75 percent across the range of runoff capacities considered in the model. Pond construction cost is fixed in the model by pond volume. In turn, pond volume is determined principally by the amount of runoff from the 24-hour event selected for limitations. Strictly speaking the model was designed to be valid in the 10- and 25-year event range because of the assumed proportionalities in rainfall amounts. The 25-year event on the average is approximately

20 percent larger than the 10-year event, and the corresponding runoff 30 to 35 percent larger, depending on soil conditions. Therefore, the corresponding pond system would be also approximately 30 to 35 percent larger, but the cost to construct only about 23 percent higher on the average.

If it were desired to limit runoff only up to the one-year, 24-hour event, the model would have to be altered. The one-year, 24-hour event is approximately 55 per cent as large as the 10-year event on the average. (See Figure 4.) The corresponding runoff would be 25 to 35 per cent as large as the 10-year event runoff, depending on soil conditions. Altering the model so that the freeboard in excess of normal operation is adequate to contain only the one-year event runoff before overflow would result in a sedimentation pond system volume that is about 50 per cent of the 10-year event pond system volume. The corresponding construction cost would be approximately 60 per cent of that sized to contain the 10-year event. The differences in pond construction cost affect total capital and operating costs derived from the runoff cost model. The following summarizes the approximate range of effects of this cost variance and that of the 25-year event relative to the costs of 10-year, 24-hour event-sized systems:

to impound:	change in capital cost	change in operating cost
25-year, 24-hour event	+3 to +17%	+0.6 to +15%
1-year, 24-hour event	-6 to -30%	-1.5 to -25%

3.6 Sensitivity of the Model Costs to Sediment Load

Sediment is picked up by runoff water moving across disturbed land, and the greater the slope, the more sediment pickup would be expected. The major effects of topography were excluded from the model by the use of diversion ditches to prevent run-in from surrounding watershed. An initial assumption was made that a sediment load of

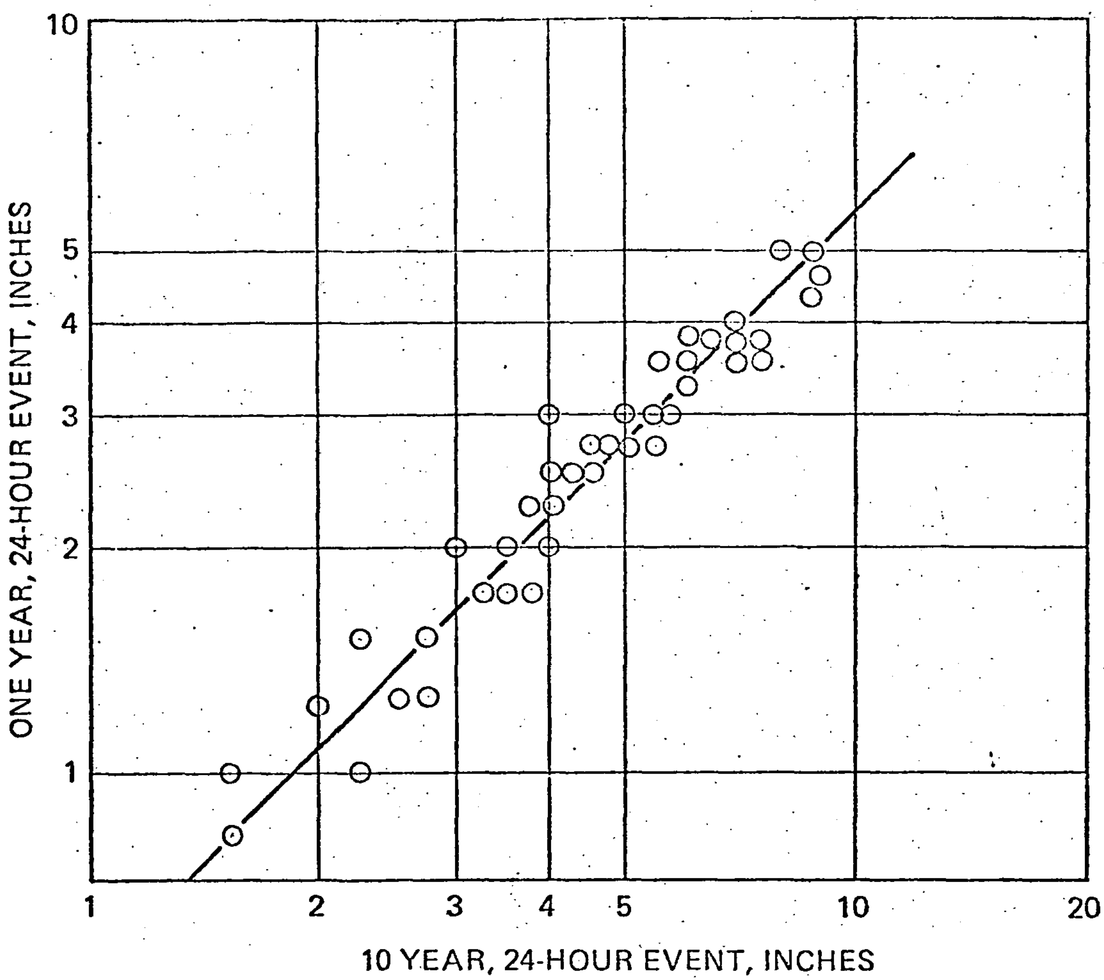

Figure 4. RELATIONSHIP BETWEEN THE ONE YEAR AND TEN YEAR RAINFALL EVENTS AT VARIOUS U.S. SITES

1,000 ppm was removed in the lagoon from the runoff water collected on the disturbed mining and processing area. The costs of dredging this sediment load ranged from 0.002 to 0.4 per cent of the annual operating costs. This is a very minor cost fraction and further refinement of the model by including a slope factor would have had inconsequential effects on the costs. This is one of the advantages for the purpose of cost estimation of the conservative design feature of perimeter exclusion of outside runoff to minimize topographic effects.

Mining area runoff follows existing slopes and where areas have been freshly disturbed, the runoff velocity must be minimized by terracing, berms and other surface featuring to form low slope drain ways. Numerous small stilling basins are included in the model drainage system for sediment traps to further minimize the sediment load carried to the final impoundment. These small catch basins are constructed and in turn consumed in subsequent mining. They are, therefore, temporary structures for erosion control.

3.7 Verification of Model Costs

In developing the estimated industry-wide costs, the generalized runoff control cost model was used in all but a very few instances because of an almost complete lack of in-place control and treatment systems from which actual cost data could be obtained. Further, the estimates of costs of hypothetical systems from industry sources that were solicited for the purposes of this program were not forthcoming early enough or complete enough to use the specific designs embodied in these estimates for total subcategory costs. However, industry-furnished cost estimates have been used for comparison on a site-by-site basis with the cost model to establish the validity and range of possible variance of the modeled costs. Comparable model costs were estimated for certain specific sites for which industry cost estimates had been received and the results are plotted against the industry estimates in Figure 5.

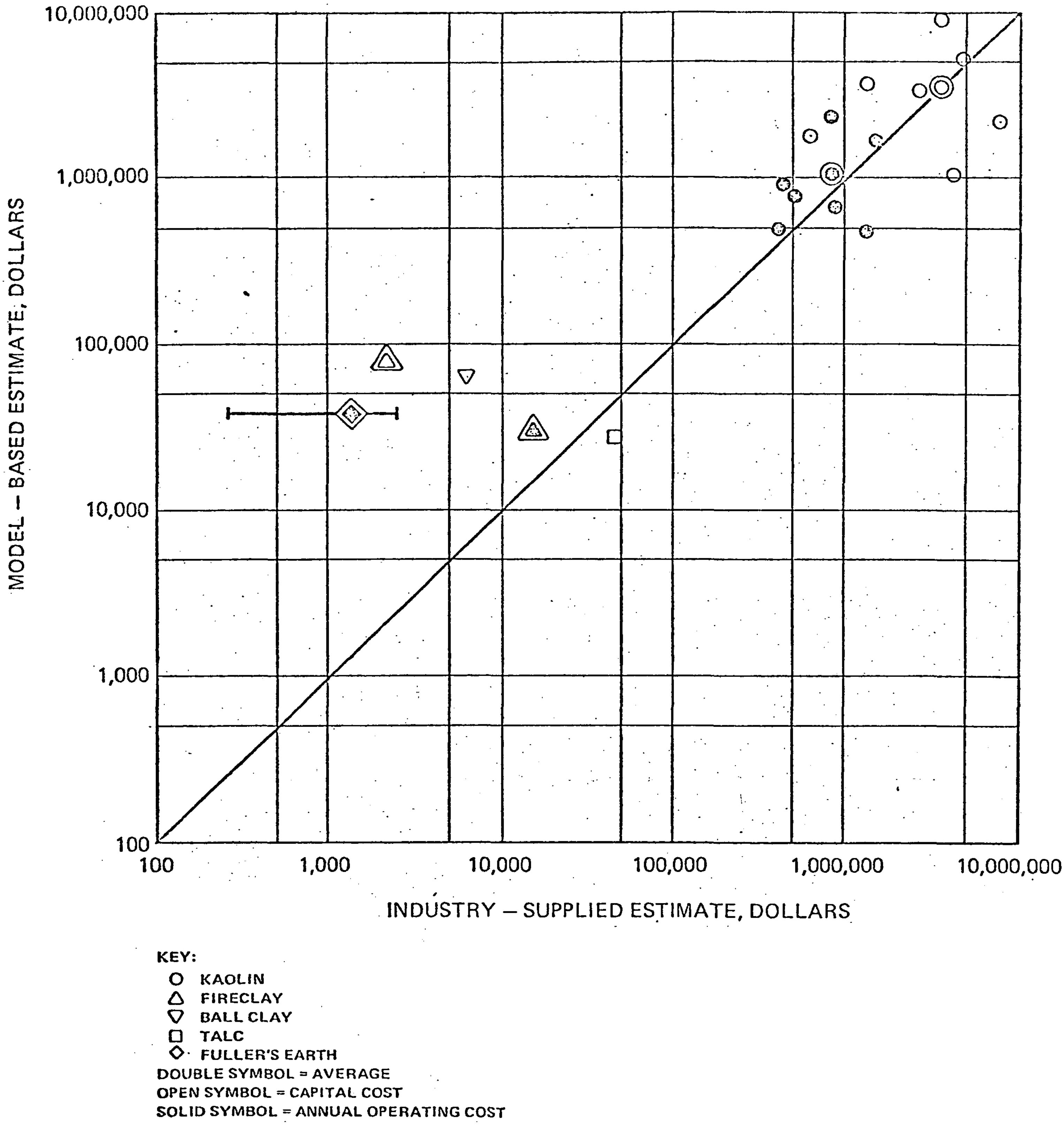

Figure 5. COMPARISON OF COSTS DERIVED FROM THE GENERAL COST MODEL WITH INDUSTRY-SUPPLIED ESTIMATES

The most extensive set of detailed cost estimates was received from kaolin producers, and the cost model very accurately predicted the average of the capital and operating costs from these sites, although individual values varied considerably. The average values of capital and operating cost received from fireclay industry as well as the average operating cost from fuller's earth producers were lower to a significant extent that the model-based estimates, but the dollars involved are relatively small per mine site, unlike the kaolin producers. The model was designed to produce annual operating costs limited on the low side to about $8,000 so long as a control and treatment system was in place, since this was felt to be the minimum annual cost that any control system could incur, if costs were fully attributed. Thus when industry estimates of operating costs as low as $250 per year are made, it is inevitable that the comparable model costs would be significantly higher.

Crushed Stone Cost Data

Industry-supplied cost estimates for control and treatment of runoff were also obtained through a Portland Cement Association survey from 36 companies operating limestone, limerock, or shale mining operations that supply raw materials to cement plants. For the most part these estimates did not contain sufficient detail with respect to disturbed area to allow a comparison cost model estimate to be made. In all instances there was insufficient detail of the cost elements to form an independent judgment of the comparability.

However, for some of the data furnished by eight companies, a comparable model based estimate could be made because the size of disturbed area and rainfall data were given. The comparison of these is given in Figures 6 and 7. It should be noted that some of these plant-furnished costs had to be substantially altered to make a comparison. One company with 17 sites had calculated their costs based on ponds lined by material costing $.50 per sq. ft., which amounted to a very large part of their estimated capital costs. The cost model does not allow for pond liner, nor is it believed to be necessary for runoff water, which is usually contaminated only with suspended solids and otherwise is similar to the local ground water. Therefore the cost estimates of this one company were reduced by the costs involved in installing and depreciating the pond liner, and these reduced costs plotted in Figures 6 and 7 (circles).

Apparently good correspondence of costs overall were found in this industry segment between the model estimates and the industry estimates when allowances are made for idiosyncracies of estimation, such as the cost year used and the lining of impoundments, as discussed above. In general, the model appears to fulfill the requirements expected of it, which were to predict with reasonable accuracy the overall total capital and operating costs for the industry segments, and to estimate conservatively for small facilities, where the cost impact can be especially serious.

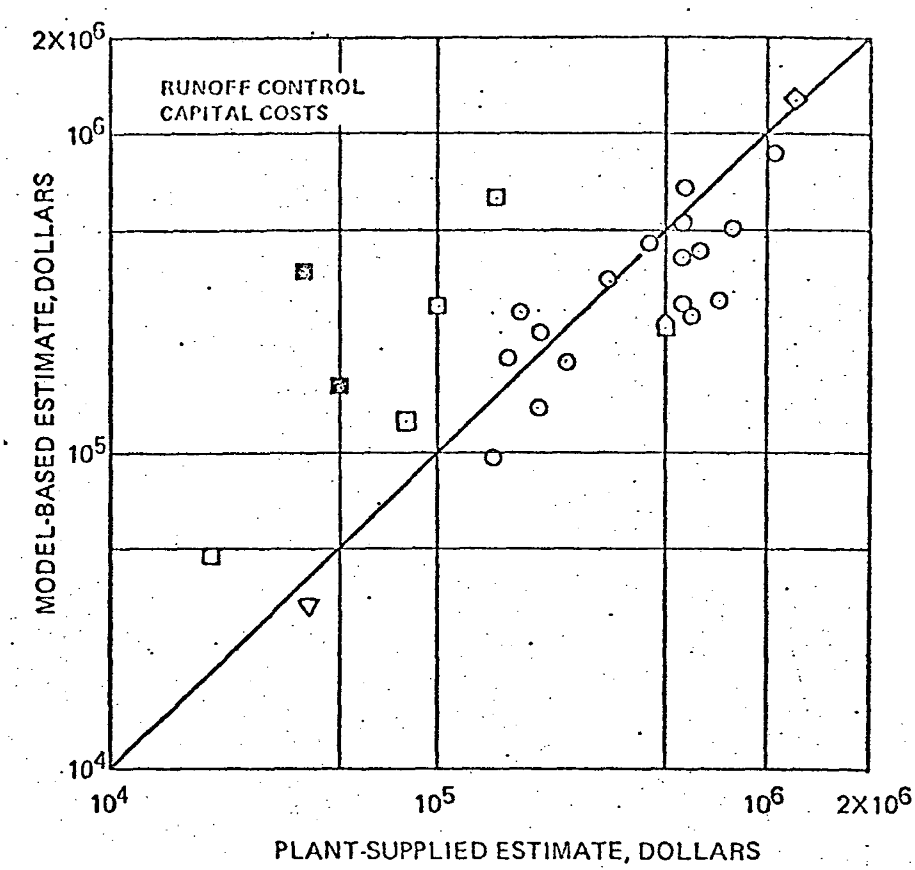

Figure 6. COMPARISON OF ESTIMATED CAPITAL COSTS FOR CRUSHED STONE SITES

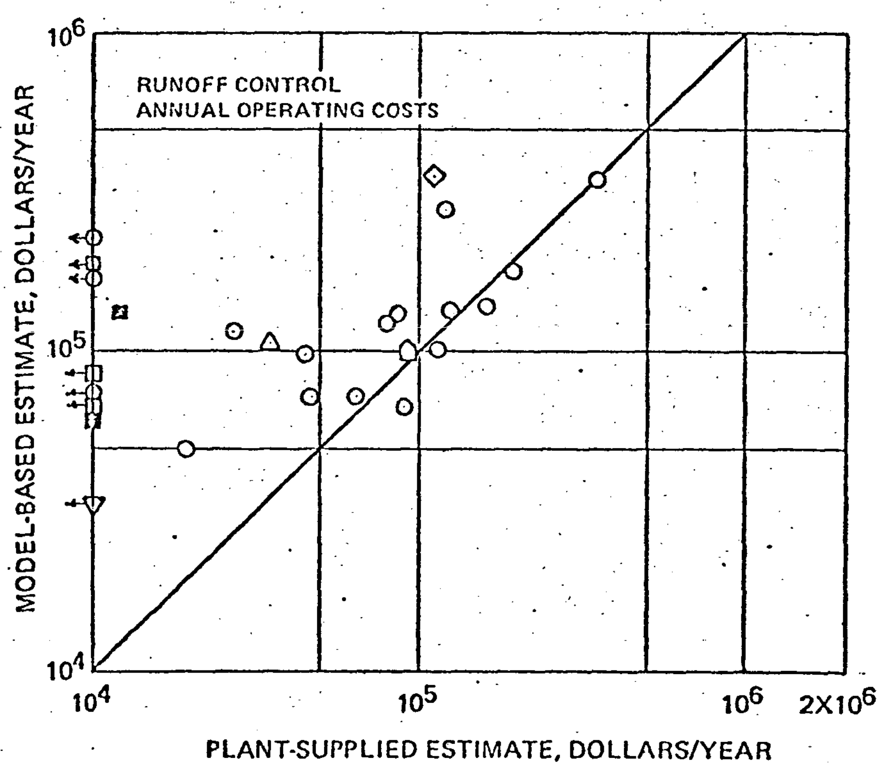

Figure 7. COMPARISON OF ESTIMATED OPERATING COSTS FOR CRUSHED STONE SITES

SECTION III

INDUSTRY CATEGORIZATION

It is felt that certain mineral mining industry segments do not have runoff problems requiring further consideration. This was based either on the fact that certain minerals are mined where storm runoff has not been found to be a problem because of aridity, or that certain minerals are mined underground and have no contaminated storm runoff. The rationale is given in the following sections for each commodity not considered further.

1.0 DRY CATEGORIES

Several categories of the mineral mining industry do not have problems associated with contaminated rainwater runoff, collection and treatment. These operations are free of such problems for a variety of reasons discussed below.

1.1 Bentonite, Western Operations

These operations consist of open pits in arid areas (chiefly Wyoming, South Dakota, and Montana). Data provided by one operation in this region shows that plants are normally built close to the mining sites and that any runoff is generally collected, when available, for use as scrubber makeup water at the plants due to the scarcity of water in the area. Product is stored inside. The ore is a good adsorbent so that runoff problems are virtually non-existent.

1.2 Borax

Borax ores are dry mined at Mojave Desert locations. The products are stored inside and all wastes are sent to evaporation ponds. Runoff is not a problem because of extremely low rainfall conditions.

1.3 Oil Impregnated Diatomite

This product is produced at only one location in a semi-arid area of California. Diatomite, which is an adsorbent, is stored inside. The deposit consists mostly of non-oil bearing material with a seam of oil-bearing strata also present. Since the soil-free material is an adsorbent, it is expected that most rainfall would be held by exposed deposit areas and hence, runoff problems are minimal. Pure diatomite producers in the same area have encountered no runoff problems in larger operations.

1.4 Feldspar, Dry Process

This product is produced in arid and semi-arid regions (Arizona, California, Colorado, South Dakota and Wyoming) and processed inside. Information from producers in South Dakota (the area of highest rainfall and largest production) reveal that runoff from disturbed areas has never been encountered at the sites. In addition, all of these states have regulations controlling pollution from surface runoff.

1.5 Gilsonite

This mineral is produced at one underground mine near Vernal, Utah, where all plant and mine waters are collected and used locally for irrigation purposes in lieu of discharge. The control method is unique to the needs of the local area.

1.6 Graphite

Natural graphite is produced at only one site in Texas. Local topography controls the situation. All mine drainage and process waters are combined for treatment prior to discharge and covered by the recommended process wastewater guidelines.

1.7 Jade

The bulk of the U.S. production of this commodity comes from one mine in Wyoming which is operated on an intermittent basis. The disturbed area is mininal. Due to the arid location and limited disturbed area, contaminated runoff problems are nonexistent.

1.8 Lithium Minerals - Silver Peak, Nevada

Underground brine mining is used at this location. All wastewater is fed to evaporation ponds and there are no runoff problems.

1.9 Magnesite

Magnesite is dry mined underground at only one site in Nevada. There is no disturbed surface area of any consequence and the product is stored inside.

1.10 Novaculite

Novaculite is produced at one underground mine in Arkansas and the product is stored inside. There is no disturbed surface area of any consequence and no runoff problems are encountered.

1.11 Perlite

Perlite is surface mined in an arid region of western New Mexico. No runoff problems have been encountered in this category.

1.12 Potash

This mineral is either solution or dry mined from underground sources in arid areas. The products are stored indoors and, in both cases, all wastes are disposed of in evaporation ponds. No contaminated rainfall is generated other than direct precipitation on the ponds.

1.13 Pumice

Pumice is surface mined in several western states (Oregon, California, Nevada, Idaho, Arizona, and Hawaii). In the arid locations, due to climatic conditions, there are no runoff problems. At other locations (Northern California and Hawaii), the high porosity of the exposed deposits prevents runoff problems. Contacts with producers in northern California (annual rainfall of about 60 inches) have revealed that the porosities of the exposed deposits are apparently sufficient to prevent runoff even under these high rainfall conditions.

1.14 Salines from Brine Lakes

1.14.1 Searles Lake Operations

A varity of saline products are recovered by underground brine mining at Searles Lake, California, in the Mojave Desert. All spent brines and process water are returned to the brine sources to maintain the operations and the products are stored under cover. No runoff problems are present.

1.14.2 Great Salt Lake Operations

These facilities recover a number of saline products from the Great Salt Lake in Utah by evaporation processes. All spent brines and wash waters are returned to the lake and the products are stored inside. The only exposed areas are the evaporation ponds and any rainfall picked up in these areas will be evaporated along with the brines.

1.15 Sodium Sulfate, West Texas Brine Wells

The product is solution mined from underground deposits in arid areas. The recovered product is stored under cover and all wastes are fed to evaporation ponds. There is no discharge of any process or runoff waters from any of these operations.

1.16 Frasch Sulfur

This material is produced in three areas:

1) From anhydrite deposits in arid regions of West Texas. All process water losses are to the underground deposits and the product is stored in heated tanks prior to shipment. No exposed mining areas are involved.

2) From offshore deposits. Product is also stored in heated vessels prior to shipment and there are no contaminated runoff problems.

3) From onshore deposits in Louisiana and East Texas. Product is stored in enclosed heated vessels and the only exposed areas are the wastewater treatment facilities. Any rainfall entering these areas will be treated along with process water prior to release.

1.17 Trona Ore (Natural Soda Ash)

Trona ore is mined underground in Sweetwater County, Wyoming, an arid region. Process area runoff and stockpile runoff goes to the process or process wastewater stream, and wastewater is sent to evaporation ponds from which there is normally no discharge.

1.18 Vermiculite - Montana Operations

Vermiculite is mined from open pits at one site in western Montana. All runoff from the mining areas drains into the process water ponds by design and serves as makeup water. Because of the semi-arid location, the process water is totally recycled from the ponds and there is no discharge.

1.19 Fluorspar

Fluorspar is produced intwo geographical areas:

1) southern Illinois and Kentucky, and

2) three southwestern states.

The bulk of the production is in the first area. Three underground mines are involved and, due to topography, waste piles located at the adjacent plants drain into the process wastewater treatment ponds. No surface mining areas are present at any of these sites.

The southwestern operations all involve small production acreage and are located in arid areas far removed from any streams or rivers. Runoff at these sites generally evaporates.

1.20 Tripoli

Tripoli is produced from underground mines in Arkansas, Illinois and Pennsylvania. There are no significant amounts of disturbed surface areas involved and the product is stored inside. No runoff problems are encountered in this segment of the industry.

1.21 Garnet

This mineral is produced at two U.S. locations. At the first, in upstate New York, topography is the dominant factor. All runoff from the disturbed areas drains into the process water ponds, where it is treated prior to discharge. At the second location, in northern Idaho, placer mining in streams is used. These operations are currently under state regulation and do not have runoff problems.

1.22 Bituminous Limestone

This material is produced without runoff problems at two locations in west Texas, which is an arid area. The few small operations in southern Missouri which also once produced this material are no longer in operation.

1.23 Diatomite

Diatomite is produced at open pit mines in Nevada, Arizona and southern California. The first two locations are in desert areas and no runoff problems are encountered at these sites.

The southern California operations are all located at Lompoc, about 10 miles south of the Oil Impregnated Diatomite production site discussed earlier. The largest producer states that runoff problems are minimal because of the absorbent nature of the deposits and because these sites generally have small impoundments to collect any runoff for plant use. This area of southern California has low rainfall.

2.0 PREVIOUSLY REGULATED CATEGORIES

In addition to the minerals which were excluded from further consideration due to either methods of mining employed or locations involved, there are six categories in which all mining of the commodity occurs in states where land reclamation and rainwater runoff from disturbed areas are already regulated by state laws. These include lithium mined at eastern locations, vermiculite, barite, aplite, kyanite and mineral pigments. These six categories are further discussed and cost estimates for runoff control and treatment presented in Section IV.

SECTION IV

APPLICATION OF RUNOFF MODEL BY SUBCATEGORY

In this section, the subcategory costs for treatment and control of runoff derived from the cost model are presented.

1.0 DIMENSION STONE

1.1 General Description of the Industry

Dimension stone is rock which has been specially cut or shaped for use in buildings, monuments, memorial and gravestones, curbing, or other construction or special uses. The principal dimension stones are granite, marble, limestone, slate, and sandstone.

Many of the continental United States contain dimension stone operations of one kind or other, however, the significant producing states are Minnesota, Georgia, Vermont, Massachusetts, South Dakota, Indiana, Wisconsin, New York, and Pennsylvania. There are approximately 300 dimension stone mining activities in the U.S.

Dimension stone is usually mined in deep open pit, high wall quarries; very little is mined from underground mines. A total of 277 dimension stone quarries was included in the modeled costs for this mineral commodity. This includes states which have regulations for both surface mining site reclamation and runoff control from disturbed areas, and states without legislation.

1.2 Runoff and Rainfall Data

The volume of runoff is determined by the rainfall event, the infiltration rate of the soil, and the acreage of the affected area. Most of the acreage involved in dimension stone is taken up by the quarry itself. Since runoff into the quarry becomes pit pumpout water, which is presently regulated, no additional costs will be incurred for this volume of water. Therefore, only the area immediately surrounding the quarry was considered the affected area. This usually included haul roads, stockpiles, overburden areas, and stone cutting and finishing areas. Because dimension stone quarries are deep open pits and there is normally no crushing or screening of the stone, the disturbed area surrounding the quarry is relatively small when compared to crushed stone plants. All dimension stone quarries, except dimension limestone, were assumed to occupy 2 ha (5 ac) of disturbed area per quarry outside of the pit; dimensional limestone quarries (60 operations) were assumed to occupy 4 ha (10 ac) of disturbed area per quarry outside of the pit. These assumptions are based on actual site visits to dimension granite and limestone quarries. The larger acreage for limestone is due to the larger stockpiles that occur with the quarrying and finishing of this softer rock.

Each of the 277 dimension stone quarries was categorized according to soil type and rainfall event. (See Appendix B for the soil map and the rainfall Atlas.) The following table describes this categorization:

10-Yr/24-Hr Rainfall Event

Soil Type	0-5.1 cm (0-2 in)	5.1-12.7 cm (2-5 in)	12.7-25.4 cm (5-10 in)	25.4-30.5 cm (10-12 in)
A	0	0	0	0
B	0	39	66	0
C	3	137	6	0
D	1	25	0	0

25-Yr/24-Hr Rainfall Event

Soil Type	0-7.6 cm (0-3 in)	7.6-15.2 cm (4-7 in)	15.2-30.5 cm (8-12 in)	30.5-35.6 cm (12-14 in)
A	0	0	0	0
B	0	93	12	0
C	4	142	0	0
D	1	25	0	0

1.3 Runoff Control and Treatment Costs

The following table lists the modeled capital and operating costs to control and treat runoff from 277 dimension stone quarries. Flocculants are usually not needed to settle limestone, granite, or sandstone solids and therefore are not part of the modeled costs.

10-yr/24-hr Rainfall Event

Category	Costs (in thousand $) Capital	Annual Operating
Soil B, 12.7 cm (5 in) rainfall, 2 ha (5 ac) (39 quarries)	741.0	429.0
Soil B, 25.4 cm (10 in) rainfall, 2 ha (5 ac) (66 quarries)	1,914.0	924.0
Soil C, 5.08 cm (2 in) rainfall, 2 ha (5 ac) (3 quarries)	36.0	30.0
Soil C, 12.7 cm (5 in) rainfall, 2 ha (5 ac) (77 quarries)	1,617.0	924.0
Soil C, 12.7 cm (5 in) rainfall, 4 ha (10 ac) (60 quarries)	1,920.0	840.0
Soil C, 25.4 cm (10 in) rainfall, 2 ha (5 ac) (6 quarries)	180.0	90.0
Soil D, 5.08 cm (2 in) rainfall, 2 ha (5 ac) (1 quarry)	15.0	10.0
Soil D, 12.7 cm (5 in) rainfall, 2 ha (5 ac) (25 quarries)	600.0	300.0
Total	7,023.0	3,547.0

25-yr/24-hr Rainfall Event

Category	Costs (in thousand $) Capital	Annual Operating
Soil B, 15.24 cm (6 in) rainfall, 2 ha (5 ac) (93 quarries)	2,046.0	1,116.0
Soil B, 30.48 cm (12 in) rainfall, 2 ha (5 ac) (12 quarries)	660.0	192.0
Soil C, 7.62 cm (3 in) rainfall, 2 ha (5 ac) (4 quarries)	60.0	44.0
Soil C, 15.24 cm (6 in) rainfall, 2 ha (5 ac) (82 quarries)	1,886.0	1,066.0
Soil C, 15.24 cm (6 in) rainfall, 4 ha (10 ac) (60 quarries)	2,280.0	900.0
Soil D, 7.62 cm (3 in) rainfall, 2 ha (5 ac) (1 quarry)	18.0	11.0
Soil D, 15.24 cm (6 in) rainfall, 2 ha (5 ac) (25 quarries)	675.0	350.0
Total	7,625.0	3,679.0

Total capital cost for treating a 10-year, 24-hour event is 7.0 million dollars; capital cost for a 25-year, 24-hour event is 7.6 million dollars. The annual operating costs for a 10-year and 25-year event are 3.5 and 3.7 million dollars, respectively.

Capital cost impact for unregulated states versus total industry cost for both the 10- and 25-year rainfall events are given below.

	Capital Cost, dollars 10-year event	25-year event
Unregulated states	1,936,000	2,321,000
Total industry	7,000,000	7,600,000

2.0 CRUSHED STONE

2.1 General Description of the Industry

The crushed stone industry is widespread and varied in size of facilities and types of material produced. Facility capacities range from less than 22,700 to 13.6 million kkg/yr (25,000 to 15 million tons/yr). Facility production rate is roughly related to the acreage disturbed; i.e. the larger capacity plants have the largest quarries. (Figure 8.)

Most crushed stone is mined from open pit quarries; very little is mined from underground mines. A total of 4,286 crushed stone quarries was considered as part of the runoff cost model. Although most states have regulations for both surface mining site reclamation and runoff central from disturbed areas, modelled costs include all of the 4,286 crushed stone quarries.

Crushed stone quarries are generally deep open pits with steep high walls or working faces. Very little crushed stone is mined by surface stripping.

2.2 Runoff and Rainfall Data

The volume of runoff is determined by the rainfall event, the infiltration rate of the soil, and the acreage of the affected area. Large crushed stone quarries can use over 160 ha (400 ac) of land for the total quarrying operation. Most of the acreage, however, is taken up by the open pit itself. Since runoff into the pit is classified as pit pump-out water and is presently regulated, no additional costs will be incurred for this volume of water. Runoff from adjacent areas outside of the quarry (e.g. stockpiles, overburden areas, crushing/screening areas, etc.) will, however, have to be treated and is therefore included in the cost estimates.

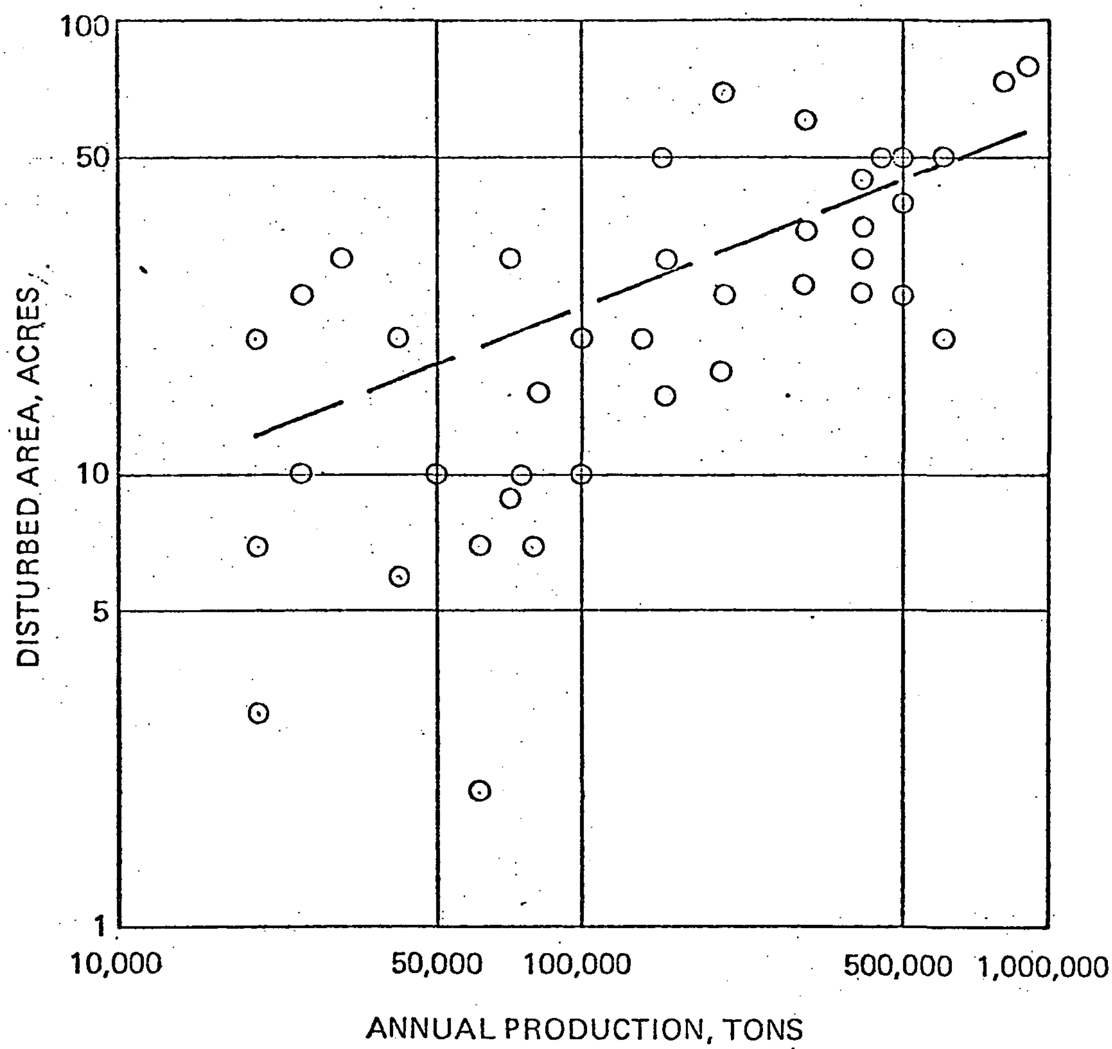

Figure 8. TOTAL DISTURBED AREA VERSUS PRODUCTION OF CRUSHED STONE

Since the size of the affected area is roughly proportional to the production of crushed stone, each of the 4,286 quarries was grouped into one of four size categories based on the annual production tonnage of crushed stone. (Figure 8.) Disturbed acreage ranged from 4 to 30 ha (10 to 75 ac).

Each of the 4,286 stone quarries was further categorized according to soil type and the rainfall event. (See Appendix B for Soil Map and Rainfall Atlas.) Because of the large number of quarries, categorization was done on a state by state basis, by averaging the soil type and rainfall event within each state. The following table describes this categorization.

	10-year, 24-hour Rainfall Event			
Soil Type	0-7.6 cm (0-3 in)	10.2-17.8 cm (4-7 in)	20.3-27.9 cm (8-11 in)	>27.9cm (>11 in)
A	0	0	0	0
B	0	1,242	320	0
C	198	1,965	81	0
D	185	295	0	0

	25-year, 24-hour Rainfall Event			
	0-7.6 cm (0-3 in)	10.2-17.8 cm (4-7 in)	20.3-27.9 cm (8-11 in)	>27.9 cm (>11 in)
A	0	0	0	0
B	0	1,242	320	0
C	198	1,965	81	0
D	73	407	0	0

2.3 Runoff Control and Treatment Costs

The following table lists the modelled capital and operating costs to control and treat runoff from 4,286 crushed stone quarries. Flocculants are usually not needed to settle granite or limestone solids and therefore these costs do not include flocculation.

10-year, 24-hour Rainfall Event

Category	Costs (in million $) Capital	Annual Operating
Soil B, 10.2-17.8 cm (4-7 in) rainfall (1,242 quarries)	54.3	19.2
Soil B, 20.3-27.9 cm (8-11 in) rainfall (320 quarries)	25.7	7.3
Soil C, 0-7.6 cm (0-3 in) rainfall (198 quarries)	4.9	2.3
Soil C, 10.2-17.8 cm (4-7 in) rainfall (1,965 quarries)	98.0	28.3
Soil C, 20.3-27.9 cm (8-11 in) rainfall (81 quarries)	7.3	2.1
Soil D, 0-7.6 cm (0-3 in) rainfall (185 quarries)	5.9	2.4
Soil D, 10.2-17.8 cm (4-7 in) rainfall (295 quarries)	20.1	6.2
Total	216.2	67.8

25-year, 24-hour Rainfall Event

Category	Costs (in million $) Capital	Annual Operating
Soil B, 10.2-17.8 cm (4-7 in) rainfall (1,242 quarries)	54.3	19.2
Soil B, 20.3-27.9 cm (8-11 in) rainfall (320 quarries)	25.7	7.3
Soil C, 0-7.6 cm (0-3 in) rainfall (198 quarries)	4.9	2.3
Soil C, 10.2-17.8 cm (4-7 in) rainfall (1,965 quarries)	98.0	28.3
Soil C, 20.3-27.9 cm (8-11 in) rainfall (81 quarries)	7.3	2.1
Soil D, 0-7.6 cm (0-3 in) rainfall (73 quarries)	2.4	1.0
Soil D, 10.2-17.8 cm (4-7 in) rainfall (407 quarries)	24.3	7.6
Total	216.9	67.8

Total capital cost for treating a 10-year, 24-hour event is 216.2 million dollars; capital cost for a 25-year, 24-hour event is 216.9 million dollars. The annual operating costs for a 10-year and 25-year event are 67.8 million dollars and 67.8 million dollars, respectively.

Actual installed costs for treating area runoff were not available from industry. At this time, the few (~5) crushed stone plants that have implemented runoff control and whose costs were examined tend to be approximately the same as the corresponding modeled costs.

Capital cost impact for unregulated states versus total industry cost for both the 10- and 25-year rainfall events are given below:

	Capital Costs, dollars 10-year event	25-year event
Unregulated states	22,500,000	23,000,000
Total industry	216,200,000	216,900,000

A nationwide survey of cement rock (limestone) quarries was conducted through the Portland Cement Association. Each member company was asked to provide Versar cost information on treating and controlling surface runoff at each of their quarries. The survey form used contained a description of the Versar runoff model in order that industry supplied costs could be compared with Versar modeled costs. Discussion of these costs was given earlier in Section II.

3.0 SAND AND GRAVEL AND INDUSTRIAL SAND

3.1 General Description of the Industry

The sand and gravel industry, on the basis of physical volume, is the largest non-fuel mineral industry. Because of its widespread occurrence and the necessity for producing sand and gravel near the point of use, there are more than 5,000 firms engaged in commercial sand and gravel output. Facility sizes range from very small producers of pit-run material to highly automated permanent installations capable of supplying as much as 3.6 million kkg (4 million tons) yearly of closely graded and processed sand and gravel products. The average commercial facility capacity is about 108,000 kkg/yr (120,000 tons/yr). Facility size is usually directly proportional to the acreage disturbed; i.e., the larger capacity plants have the largest stripping or working areas.

Geographically the sand and gravel industry is concentrated in the large rapidly expanding urban areas and on a transitory basis, in areas where highways, dams, and other large-scale public and private works are under construction.

Industrial sands include those types of silica raw materials that have been segregated and refined by natural processes into nearly monomineralic deposits and hence have become the sources of commodities having special and somewhat restricted commercial use. Uses of industrial sand include glassmaking, molding, grinding and polishing, and blasting. Since the mining of industrial sand is similar in physical dimensions as that of sand and gravel, industrial sands are included in this model along with sand and gravel.

Most sand and gravel is mined or extracted from shallow surface excavations, sometimes called strip mines or open pits. Sand and gravel operations are not, however, deep open pit quarries characteristic of crushed stone, nor are they large surface strip mines characteristic of coal mining operations.

A total of 5,867 sand and gravel and industrial sand operations was considered as part of the runoff cost model. Although most states have regulations for both surface mining site reclamation and runoff control from disturbed areas, modeled costs include all of the 5,867 operations. Sand and gravel extracted by dredging, however, is not part of the model.

3.2 Runoff and Rainfall Data

The volume of runoff is determined by the rainfall event, the infiltration rate of the soil, and the acreage of the disturbed area. Large sand and gravel operations can use over 40 ha (100 ac) of land which is not usually confined to one large pit or quarry as in crushed stone. Most sand and gravel operations do not de-water their pits since they are shallow and are excavated at a much faster pace. Therefore, runoff control from a typical sand and gravel operation normally involves more acreage than a crushed stone quarry. In addition to treating runoff from the working pit area, it must also be treated from adjacent areas including stockpiles, overburden areas, and crushing or screening areas.

Since the size of the affected area is roughly related to the production of sand and gravel and industrial sand, each of the 5,867 pits was grouped into one of four size categories based on the annual production tonnage of sand and gravel and industrial sand. Affected acreage ranged from 8 to 40 ha (20 to 100 ac). The relationship of disturbed acreage to production is illustrated in Figure 9.

Each of the 5,867 pits was further categorized according to soil type and the rainfall event. (See Appendix B for Soil Map and Rainfall Atlas.) Because of the large number of operations, categorization was done on a state by state basis, by averaging the

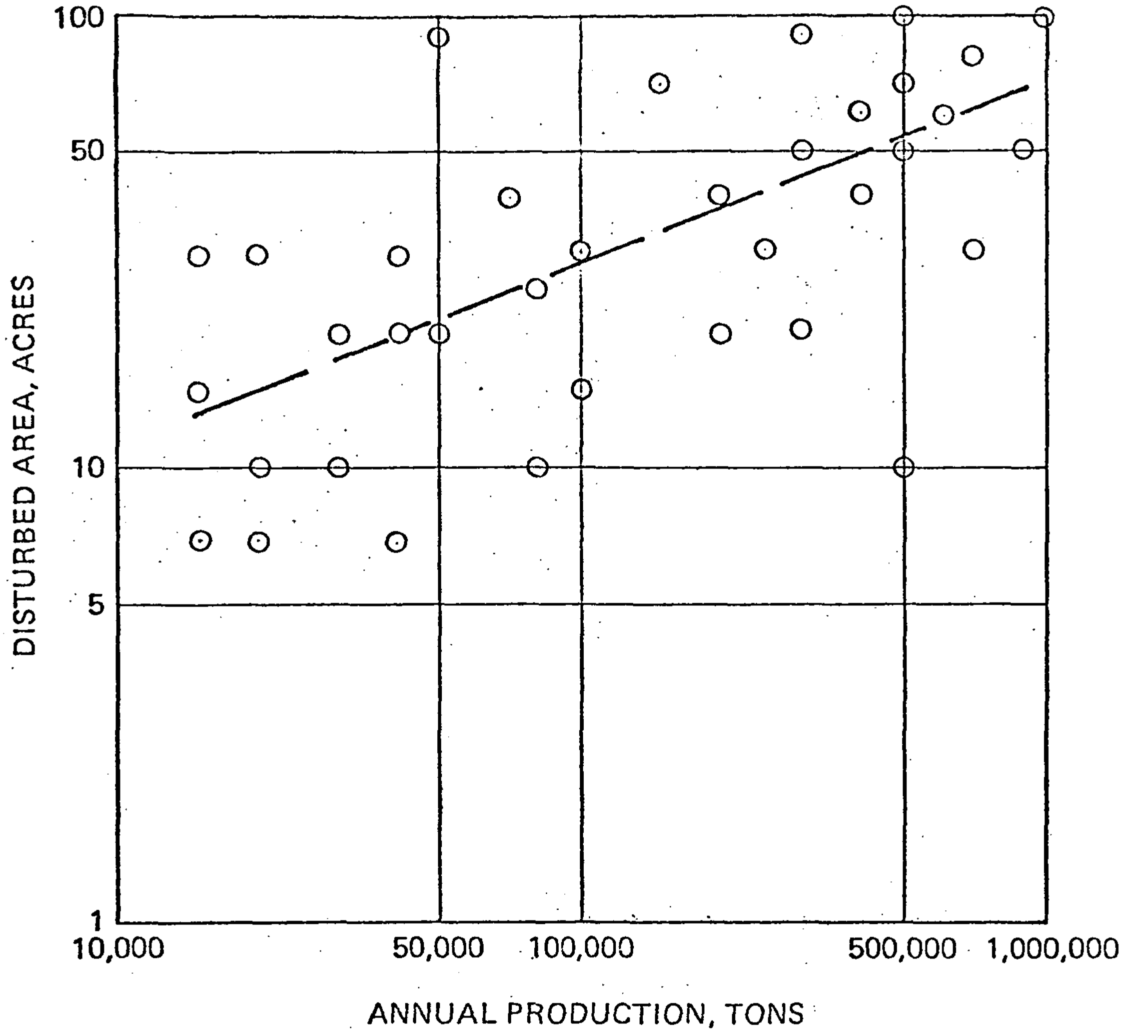

Figure 9. TOTAL DISTURBED AREA VERSUS PRODUCTION OF SAND AND GRAVEL

soil type and rainfall event within each state. The following table describes this categorization:

Soil type	0-7.6 cm (0-3 in)	10.2-17.8 cm (4-7 in)	20.3-27.9 cm (8-11 in)	>27.9 cm (>11 in)
	10-year/24-hour rainfall event			
A	0	0	0	0
B	0	1,040	436	0
C	473	3,225	59	0
D	461	173	0	0
	25-year/24-hour rainfall event			
A	0	0	0	0
B	0	1,040	436	0
C	473	3,225	59	0
D	216	418	0	0

3.3 Runoff Control and Treatment Costs

The following table lists the modeled capital and operating costs to control and treat runoff from 5,867 sand and gravel and industrial sand operations. Flocculants are usually not needed to settle silica solids and therefore these costs do not include flocculation.

10-year/24-hour rainfall event

Category	Costs (in million $)	
	Capital	Annual Operating
Soil B, 10.2-17.8 cm (4-7 in) rainfall (1,040)	63.1	19.2
Soil B, 20.2-27.9 cm (8-11 in) rainfall (436)	52.1	12.6
Soil C, 0-7.6 cm (0-3 in) rainfall (473)	16.0	6.2
Soil C, 10.2-17.8 cm (4-7 in) rainfall (3,225)	235.2	67.7
Soil C, 20.3-27.9 cm (8-11 in) rainfall (59)	7.9	2.0
Soil D, 0-7.6 cm (0-3 in) rainfall (461)	20.3	6.9
Soil D, 10.2-17.8 cm (4-7 in) rainfall (173)	15.0	4.1
Total	409.6	118.7

25-yr/24-hour Rainfall Event

Category (with the number of operations)	Costs (in million $) Capital	Annual Operating
Soil B, 10.2-17.8 cm (4-7 in) rainfall (1,040)	63.1	19.2
Soil B, 20.3-27.9 cm (8-11 in) rainfall (436)	52.0	12.6
Soil C, 0-7.6 cm (0-3 in) rainfall (473)	16.0	6.2
Soil C, 10.2-17.8 cm (4-7 in) rainfall (3,225)	235.2	67.7
Soil C, 20.3-27.9 cm (8-11 in) rainfall (59)	7.8	2.0
Soil D, 0-7.6 cm (0-3 in) rainfall (216)	9.5	3.2
Soil D, 10.2-17.8 cm (4-7 in) rainfall (418)	36.0	9.7
Total	419.6	120.6

Total capital cost for treating a 10-year, 24-hour event is 409.6 million dollars; capital costs for a 25-year, 24-hour event is 419.6 million dollars. The annual operating costs for a 10-year and 25-year event are 118.7 and 120.6 million dollars, respectively.

Actual costs incurred for treating area runoff were not available from industry since very few sand and gravel plants were identified as having implemented runoff control plans. In the one operation where runoff control has been implemented, the incurred costs are similar to Versar modeled costs. Plant 1555 has spent $180,000 (capital) to control runoff from a 40 ha (100 ac) area which drains into a surface stream. Versar modeled capital costs for the same rainfall, soil type and disturbed acreage are $160,000.

Capital cost impact for unregulated states versus total industry cost for both the 10- and 25-year rainfall events are given below.

	Capital Costs, dollars 10-year event	25-year event
Unregulated states	102,000,000	104,500,000
Total industry	409,600,000	419,600,000

4.0 GYPSUM

4.1 General Description of the Industry

Gypsum deposits are found in over 30 states with the leading producers being California, Iowa, Nevada, New York, Texas, and Michigan, and lesser amounts being produced in Colorado and Oklahoma. In 1972 there were approximately 80 gypsum operations; 53 surface mines and 27 underground mines. Only the surface mines were considered in this study.

Most of the 53 surface mines are characterized by the typical open pit quarry. The stripping of overburden is usually accomplished with drag lines or with tractor equipment. Gypsum quarries in the upper midwest (Iowa, Indiana, Michigan, Ohio) are deep open pit quarries with relatively steep high walls. Quarries in Oklahoma, Kansas, and the Northwest are more characteristic of surface strip mines.

Although most of the states with gypsum surface mines have some regulations for both surface mining site reclamation and runoff control from disturbed areas, all 53 surface mines were included in the modeled costs.

4.2 Runoff and Rainfall Data

The volume of runoff is determined by the rainfall event, the infiltration rate of the soil, and the size of the disturbed area. Large gypsum quarries can utilize over 122 ha (300 acres) of land for the total quarrying operation. Most of this acreage, however, is taken up by the open pit itself. Since runoff into the pit is classified as pit pumpout water and is considered to be regulated, no additional costs will be incurred for this volume. Runoff from adjacent areas outside of the quarry (e.g., stockpiles, overburden piles, crushing and grinding areas, etc.) will, however, have to be treated and are therefore included in the cost estimate.

The size of the affected area (outside of the pit) is proportional to the size or production of the gypsum operation. The larger producers require greater areas for stockpiles and overburden deposition. The 53 gypsum quarries in this model were placed into one of three size categories: 10 ha (25 ac), 20 ha (50 ac), and 30 ha (75 ac), based on production. (Figure 10.)

Each of the 53 quarries was further categorized according to soil type and the rainfall event. The following table describes the categorization by soil type and rainfall event.

10-yr/24-hr Rainfall Event

Soil Type	0-7.6 cm (0-3 in)	10.2-17.8 cm (4-7 in)	20.3 - 27.9 cm (8-11 in)	>27.9 cm (>11 in)
A	0	0	0	0
B	7	4	0	0
C	5	16	8	0
D	4	9	0	0

25-yr/24-hr Rainfall Event

Soil Type	0-7.6 cm (0-3 in)	10.2-17.8 cm (4-7 in)	20.3-27.9 cm (8-11 in)	>27.9 cm (>11 in)
A	0	0	0	0
B	4	5	2	0
C	3	12	13	1
D	2	10	1	0

4.3 Runoff Control and Treatment Costs

The following table lists the modeled capital and operating costs to control

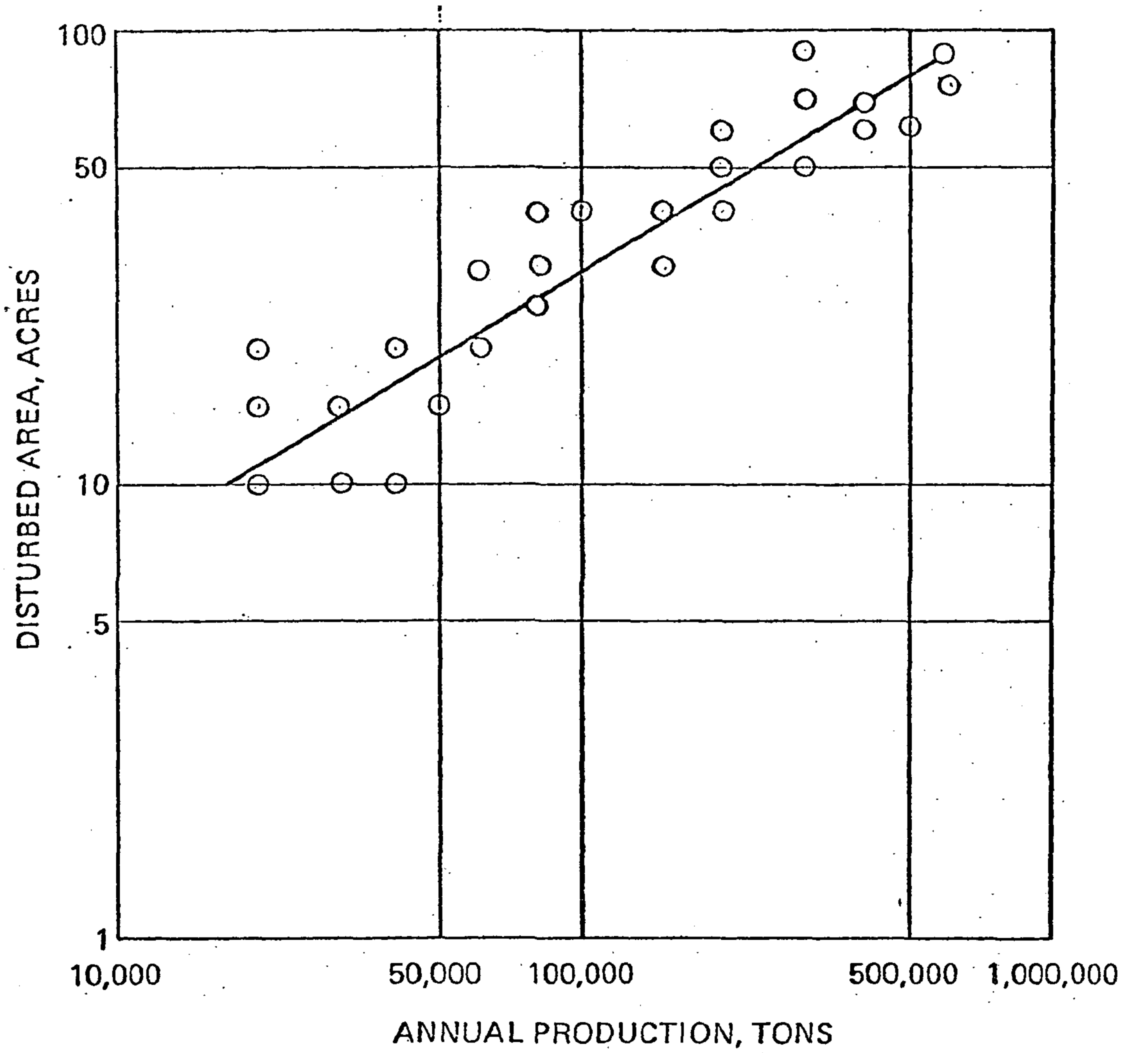

Figure 10. TOTAL DISTURBED AREA VERSUS PRODUCTION OF GYPSUM

and treat runoff from 53 gypsum quarries. No flocculants are needed to settle gypsum solids and most quarries do not contain high amounts of clay material in the overburden, therefore, these costs do not include flocculation.

10-yr/24-hr Rainfall Event

Category	Costs (in thousand $) Capital	Annual Operating
Soil B, 0 - 7.6 cm (0-3 in) rainfall		
5 quarries at 10 ha (25 ac)	110.0	55.0
1 quarry at 20 ha (50 ac)	34.0	13.0
1 quarry at 30 ha (75 ac)	44.0	14.0
Soil B, 10.2 - 17.8 cm (4-7 in) rainfall		
2 quarries at 10 ha (25 ac)	108.0	34.0
1 quarry at 20 ha (50 ac)	85.0	23.0
1 quarry at 30 ha (75 ac)	115.0	28.0
Soil C, 0-7.6 cm (0-3 in) rainfall		
3 quarries at 10 ha (25 ac)	90.0	36.0
1 quarry at 20 ha (50 ac)	48.0	15.0
1 quarry at 30 ha (75 ac)	60.0	18.0
Soil C, 10.2 - 17.8 cm (4-7 in) rainfall		
11 quarries at 10 ha (25 ac)	715.0	198.0
2 quarries at 20 ha (50 ac)	220.0	52.0
3 quarries at 30 ha (75 ac)	420.0	93.0
Soil C, 20.3 - 27.9 cm (8-11 in) rainfall		
6 quarries at 10 ha (25 ac)	690.0	180.0
1 quarry at 20 ha (50 ac)	200.0	44.0
1 quarry at 30 ha (75 ac)	260.0	58.0
Soil D, 0-7.6 cm (0-3 in) rainfall		
2 quarries at 10 ha (25 ac)	80.0	28.0
1 quarry at 20 ha (50 ac)	65.0	18.0
1 quarry at 30 ha (75 ac)	80.0	22.0

10-yr/24-hr Rainfall Event (continued)

Category	Costs (in thousand $) Capital	Annual Operating
Soil D, 10.2 - 17.8 cm (4-7 in) rainfall		
6 quarries at 10 ha (25 ac)	450.0	132.0
2 quarries at 20 ha (50 ac)	260.0	60.0
1 quarry at 30 ha (75 ac)	170.0	38.0
Total	4,304.0	1,159.0

25-yr/24-hr Rainfall Event

Category	Costs (in thousand $) Capital	Annual Operating
Soil B, 0 - 7.6 cm (0-3 in) rainfall		
2 quarries at 10 ha (25 ac)	44.0	22.0
1 quarry at 20 ha (50 ac)	34.0	13.0
1 quarry at 30 ha (75 ac)	44.0	14.0
Soil B, 10.2- 17.8 cm (4-7 in) rainfall		
3 quarries at 10 ha (25 ac)	162.0	51.0
1 quarry at 20 ha (50 ac)	85.0	23.0
1 quarry at 30 ha (75 ac)	115.0	28.0
Soil B, 20.3 - 27.9 cm (8-11 in) rainfall		
1 quarry at 10 ha (25 ac)	105.0	27.0
1 quarry at 20 ha (50 ac)	170.0	38.0
Soil C, 0-7.6 cm (0-3 in) rainfall		
1 quarry at 10 ha (25 ac)	30.0	12.0
1 quarry at 20 ha (50 ac)	48.0	15.0
1 quarry at 30 ha (75 ac)	60.0	18.0
Soil C, 10.2 - 17.8 cm (4-7 in) rainfall		
9 quarries at 10 ha (25 ac)	585.0	162.0
2 quarries at 20 ha (50 ac)	220.0	52.0
1 quarry at 30 ha (75 ac)	140.0	31.0
Soil C, 20.3 - 27.9 cm (8-11 in) rainfall		
9 quarries at 10 ha (25 ac)	1,035.0	270.0
2 quarries at 20 ha (50 ac)	400.0	88.0
2 quarries at 30 ha (75 ac)	520.0	116.0

Category	Costs (in thousand $) Capital	Annual Operating
Soil C, >27.9 cm (>12 in) rainfall		
1 quarry at 10 ha (25 ac)	175.0	40.0
Soil D, 0-7.6 cm (0-3 in) rainfall		
1 quarry at 10 ha (25 ac)	40.0	14.0
1 quarry at 20 ha (50 ac)	65.0	18.0
Soil D, 10.2 - 17.8 cm (4-7 in) rainfall		
7 quarries at 10 ha (25 ac)	525.0	154.0
2 quarries at 20 ha (50 ac)	260.0	60.0
1 quarry at 30 ha (75 ac)	170.0	38.0
Soil D, 20.3 - 27.9 cm (8-11 in) rainfall		
1 quarry at 10 ha (25 ac)	130.0	32.0
Total	5,162.0	1,336.0

Total modeled capital and annual operating costs for treating a 10-year, 24-hour event are $4,304,000 and $1,159,000 respectively. Capital and annual operating costs for a 25-year, 24-hour event are $5,162,000 and $1,336,000., respectively.

Capital cost impact for unregulated states versus total industry cost for both the 10- and 25-year rainfall events are given below.

	Capital Cost, dollars 10-year event	25-year event
Unregulated states	640,000	890,000
Total industry	4,304,000	5,162,000

5.0 ASBESTOS AND WOLLASTONITE

5.1 General Description of the Industry

Asbestos is produced at seven sites in three states:

State	Surface Mine Law in Effect	No. of Sites	Disturbed Areas ha (ac)
California	Yes	3	8 (20)
		1	2.4 (6)
North Carolina	Yes	2	4 (10)
Vermont	No	1	1.6 (4)
		1	2.4 (6)

5.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events and soil conditions for the sites are: below.

Location	10-year Event cm (in)	25-year Event cm (in)	Soil Condition
California	10.2 (4)	12.7 (5)	C (all sites)
North Carolina	12.7 (5)	15.2 (6)	C (all sites)
Vermont	8.9 (3.5)	10.2 (4)	C (all sites)

5.3 Runoff Control and Treatment Costs

The capital costs for handling the 10- and 25-year events are given below along with the operating costs for both the 10- and 25-year events.

Location	Capital Costs 10-Year	Capital Costs 25-Year	Annual Operating Costs 10-Year	Annual Operating Costs 25-Year
California	159,000	188,500	58,600	64,500
North Carolina	68,000	78,000	27,300	30,000
Vermont	34,000	35,500	20,000	22,000
Totals	$261,000	$302,000	$105,900	$116,500

Flocculants are not required in this case.

Capital cost impact on this industry ranges from $34,000 in unregulated states to an industry total of $261,000 for a 10-year event and from $35,500 to $302,000 for a 25-year event.

6.0 MICA AND SERICITE

6.1 General Description of the Industry

Mica is produced by surface mining operations at 15 sites in 9 states. Below is given a breakdown of locations and the disturbed acreages.

Location	Surface Mine Law in Effect	No. of Sites	Disturbed Acreage ha (ac)	
Alabama	Yes	1	2	(5)
Arizona	No	1	1.2	(3)
Connecticut	No	1	2	(5)
Georgia	Yes	1	2	(5)
New Mexico	No	1	1.2	(3)
Pennsylvania	Yes	1	2	(5)
South Dakota	Yes	1	1.2	(3)
South Carolina	Yes	1	4	(10)
North Carolina	Yes	4	4	(10)
		3	12	(30)

6.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events and soil type for all of the sites are listed below:

Location	10-Year Event cm (in)	25-Year Event cm (in)	Soil Condition
Alabama	15.2 (6)	17.8 (7)	C
Arizona	7.6 (3)	8.9 (3.5)	C
Connecticut	12.7 (5)	13.9 (5.5)	C
Georgia	15.2 (6)	17.8 (7)	C
New Mexico	7.6 (3)	8.9 (3.5)	C
Pennsylvania	10.2 (4)	12.7 (5)	C
South Carolina	15.2 (6)	17.8 (7)	C
South Dakota	7.6 (3)	8.9 (3.5)	C
North Carolina	12.7 (5)	15.2 (6)	C

6.3 Runoff Control and Treatment Costs

Below are given the capital costs involved in treatment of the 10- and 25-year events and operating costs involved for the 10- and 25-year events.

Location	Capital Costs 10-Year	Capital Costs 25-Year	Annual Operating Costs 10-Year	Annual Operating Costs 25-Year
Alabama	23,000	25,000	11,400	12,500
Arizona	10,000	11,000	8,600	9,500
Connecticut	21,000	22,500	10,900	12,000
Georgia	23,000	25,000	11,800	13,000
New Mexico	10,000	11,000	9,100	10,000
Pennsylvania	18,000	21,000	10,500	11,500
South Dakota	10,000	11,000	9,100	10,000
South Carolina	38,000	42,000	14,500	16,000
North Carolina	355,000	407,000	117,300	129,000
Totals	$508,000	$575,500	$202,900	$223,500

Flocculants are not needed in this case.

Capital cost impact ranges from $41,000 in unregulated states to an industry total of $508,000 for a 10-year event. Capital costs for a 25-year event range from $44,500 to $575,500.

7.0 ROCK SALT

7.1 General Description of the Industry

Rock salt is mined underground in Kansas, Texas, Louisiana, Ohio, Michigan, and New York. While all but two of these states have mining reclamation laws, there are no runoff problems with the mining sites, but there is runoff from stored piles of product or waste materials at exposed locations. The areas occupied by these piles are generally one acre or less.

7.2 Runoff and Rainfall Data

Due to the widespread nature of the runoff problem from these piles, all types of soil conditions except type D are involved. In Kansas salt piles are generally kept in enclosed areas to prevent loss due to wind. Open stockpiles are found at sites in all of the other involved states. Ten-year rainfall events for these locations are about 22.9 cm (9 in) for Texas and Louisiana and about 8.9 cm (3.5 in) for the Michigan, Ohio, and New York sites. Twenty-five year events range from 10.2 cm (4 in) for the northern sites to 27.9 cm (11 in) for the Gulf Coast plants. Most salt piles are stored adjacent to the processing plants in essentially flat areas.

7.3 Runoff Control Treatment Costs

Flocculation is not needed to treat runoff from salt piles. These are three possible approaches to containing runoff:

1) storage of the salt in enclosed areas,

2) use of portable covers for the piles, and

3) impoundment of runoff from piles stored outside.

All three approaches have been used by the industry.

The plants are in five states, New York, Ohio, Michigan, Louisiana, and Texas. In Ohio and Michigan, only one plant in each state is not currently covering the storage piles. There are two facilities each in New York and Texas with uncovered piles. Because of terrain problems, the Louisiana facilities generally store their salt in the mine and ship the crushed product as produced. Consequently, there are no outdoor, above ground,storage facilities at the Louisiana plants. Thus, there are 6 facilities with outdoor storage of salt. For each of these plants, costs of warehouse facilities with 100,000 ton storage capacities would be $478,000 each based on recent construction costs for such a facility in Kansas, which included loading equipment.

The total cost to the industry using this approach would be $2,868,000. The impoundment approach is usable only in cases where evaporation exceeds rainfall, which does not occur in any of these areas.

Total annual operating costs for this subcategory are estimated at $150,000. These costs involve general maintenance of the storage buildings and electricity.

The costs presented above are based entirely on those supplied by plants recently installing storage facilities with capacities similar to those required by the involved production locations. Actual costs for the sites involved may vary slightly due to small regional differences in labor rates.

8.0 PHOSPHATE ROCK

This material is mined by surface operations in Florida, North Carolina, Tennessee, Utah, Montana, Wyoming and Idaho. In the latter four states all mining is conducted in arid areas and rainwater drains into the process ponds, where it is captured for plant use. There is typically no discharge of either process water, pit pumpout waters or runoff from the western operations. One plant contacted in Wyoming, Plant 4023, does not have any runoff to surface waters. All precipitation is adsorbed or evaporated. This plant has an average 10-year rainfall (25-year) event of 2 inches (2.5) inches). The soil was described as Type C. There is approximately 100 acres of disturbed area. Calculated costs of controlling runoff are summarized below using the appropriate curves in Appendix C:

Area	Soil	10-year Event (in)	25-year Event (in)	10-year Event Capital Costs	10-year Event Annual Operating Costs	25-year Event Capital Costs	25-year Event Annual Operating Costs
100 acres	Type C	2	2.5	$73,000	$21,000	$80,000	$24,000

The eastern sites (Tennessee, Florida, and North Carolina) are all currently under state regulations governing both land reclamation of surface mining sites and runoff from disturbed areas. Costs were solicited from the Florida and Tennessee producers but no useful data were supplied. Florida and North Carolina phosphate plants consider all precipitation to be process water. It drains into the process ditches and ponds and becomes process water.

Plant 4008 in Tennessee supplied data on average disturbed area for their mine sites. The average disturbed area was 9.69 acres per mine and the five-year average number of mines was 21.8. Calculated costs of controlling runoff are summarized below using the appropriate curves in Appendix C:

Area	Soil	10-year Event (in)	25-year Event (in)	10-year Event Capital Costs	10-year Event Annual Operating Costs	25-year Event Capital Costs	25-year Event Annual Operating Costs
10 acres	Type B	5.5	6	$32,000	$13,500	$34,000	$14,100

Thus the aggregate capital costs for 22 sites are $704,000 (10-year) and $748,000 (25-year) and corresponding operating costs are $297,000 (10-year) and $310,000 (25-year) per year.

9.0 BENTONITE

9.1 General Description of the Industry

In an earlier section, we discussed dry western bentonite operations. The other operations in high rainfall areas are in Missouri, Texas, and Mississippi. The disturbed areas of these latter are:

Area	No. of Sites	Disturbed Area ha (ac)	Surface Law Law in Effect
Missouri	1	2.4 (6)	Yes
Texas	1	8 (20)	Yes
	4	2.4 (6)	
Mississippi	3	8 (20)	No
	5	2.4 (6)	

9.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events for these sites are:

Location	10-year Event cm (in)	25-year Event cm (in)
Missouri	12.7 (5)	15.2 (6)
Texas	17.8 (7)	20.3 (8)
Mississippi	15.2 (6)	17.8 (7)

All of the locations have type C soil condition.

9.3 Runoff Control and Treatment Costs

The capital and operating costs derived from the cost model using flocculation are:

State	Capital Costs 10-year Event	Capital Costs 25-year Event	Annual Operating Costs 10-year Event	Annual Operating Costs 25-year Event
Missouri	36,000	41,000	21,800	24,000
Texas	259,000	275,000	147,300	162,000
Mississippi	425,000	475,000	221,000	243,000
Totals	$720,000	$791,000	$390,100	$439,000

Capital costs for the 10-year event range from $425,000 in the unregulated state to a total of $720,000 for the industry. Corresponding capital costs for the 25-year event range from $475,000 to $791,000.

Flocculant costs were supplied for a plant of similar size using these materials in the clay industry. These were estimated to be $300,000 but this cost also included installation of metering equipment, pond redesign, etc. No real or projected costs were obtained for these Mississippi operations.

It should be noted that there may be some variation in costs with site location. Contacts with several clay operations in Mississippi have revealed a considerable variation in depths and acreages involved per ton of product for open pit mines. Thus, mines in the northern portion of the state tend to be more shallow and involve greater acreage per unit of production. Pits in the central portion tend to involve less acreage and to be considerably deeper. At these latter locations, much of the rainwater may become pit pumpout due to the topography of the operations involved.

10.0 FIRECLAY

10.1 General Description of the Industry

Fireclay (including plastic clay, flint clay, and bauxitic clay) is mined in 20 states with an aggregate annual tonnage of 3.80 x 10^6 kkg (4.14 x 10^6 tons) in 1974. This

State	No. of Mines	Not Costed Due to Climatic Conditions	Annual Production kkg x 10^3	(tons x 10^3)	% of Total Produced	Surface Mine Law In Effect
Alabama	10		290	316	7.6	yes
Calif.	6		144	157	3.8	yes
Color.	14		49	53	1.3	yes
Georgia	5		N.D.[a]			yes
Idaho	1	X	N.D.			no
Illinois	5		95	103	2.5	yes
Indiana	3		24	26	.6	yes
Kentucky	12		107	117	2.8	yes
Missouri	81		848	924	22.3	yes
Montana	1	X				yes
Nevada	1		N.D.			yes
N.J.	4		34	37	1.0	no
N.M.	2	X	N.D.			no
Ohio	32		1,031	1,124	27.1	yes
Penn.	36		821	894	21.6	yes
Texas	4		38	41	1.0	yes
Utah	2	X	N.D.	N.D.		yes
Wash.	4		N.D.	N.D.		yes
W.Va.	2		N.D.	N.D.		yes
Undistributed[b]			320	349	8.4	
Total	226		3,801	4,141	100	

[a]Not disclosed
[b]Total of undisclosed tonnage

The bulk of the fireclay is mined in three states: Missouri, Ohio and Pennsylvania, which account for 71 percent of the total produced. Alabama, California, Kentucky, and Illinois account for another 19 percent of the total. Thus, seven states account for nearly 90 percent of the total fireclay production.

Missouri fireclay mines are small (1 to 3 acres) open pit operations. The "average" Missouri fireclay mine produces 10,500 kkg/yr (11,400 TPY). Fireclay mines in Ohio and Pennsylvania are strip-mine operations, similar in many respects to stop coal mining operations. Fireclay seams in these states are closely associated with coal seams. Acid mine drainage is usually a problem and continuous lime treatment is required before mine water can be discharged. In at least some of these mines, surface runoff commingles with acid mine drainage, requiring lime treatment of the entire combined stream before discharge. In these situations the lime treatment ponds also act as settling ponds for sediment in the mine surface runoff. Fireclay mines in Ohio and Pennsylvania are appreciably larger than Missouri mines with the "average" mine producing 27,000 kkkg/yr (30,000 TPY). Of the twenty states producing fireclay, 6 states (with a total of 8 mines) have been eliminated from surface runoff considerations due to the arid climate.

10.2 Fireclay Surface Runoff Model Baseline Data

There was only limited data available on fireclay mine total disturbed area. These data were plotted versus annual raw fireclay production in Figure 11. There appears to be a direct relationship between fireclay production rate and total disturbed area. This curve was then used to approximate the disturbed area of the fireclay mines in the states under consideration, i.e., an "average" value for mine production in each state was derived by dividing total production by the number of mines. The "average" total

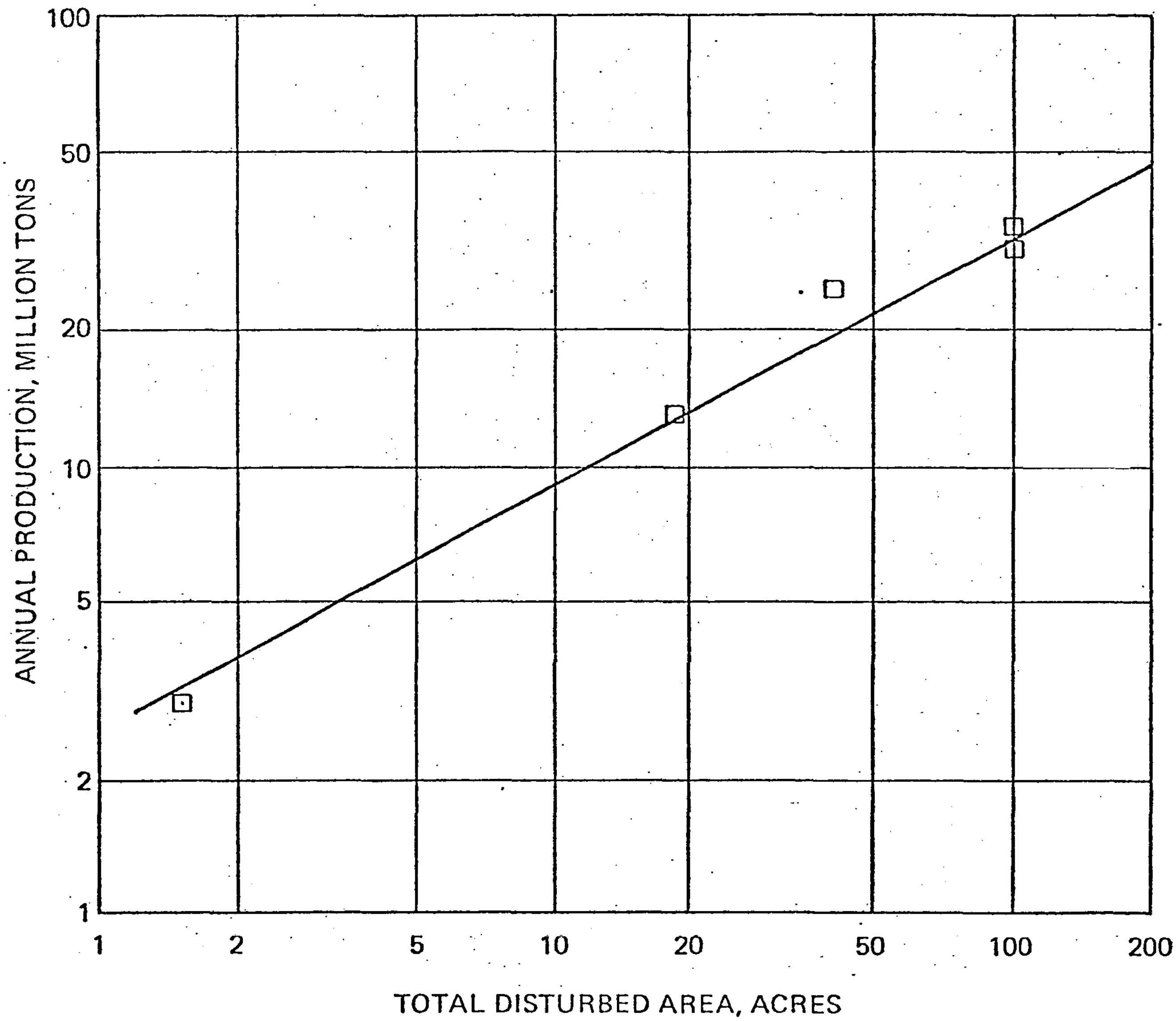

Figure 11. PRODUCTION OF FIRECLAY VERSUS TOTAL DISTURBED AREA

disturbed area for this mine was then obtained from the curve. These data together with the appropriate S.C.S. soil condition and average 10-year and 25-year rainfall events for the states under consideration are given in Table 4.

10.3 Runoff Control and Treatment Costs

For the purposes of the runoff model, all surface runoff in a fireclay mine is assumed to be collected in a holding and treatment pond using appropriate ditching and diking. Any acid mine drainage or pit pumpout is not considered in this model. It is also assumed that a "standard" amount of flocculant will be added to precipitate colloidal clay in the collection pond to an acceptable TSS level in the pond discharge. None of the fireclay mines visited had any associated process plants adjacent to the mine. Based on this observation, it is assumed that no process wastewater commingles with surface runoff at the modeled mines.

Using the derived data, the assumptions made above, and cost curves for surface runoff control in Appendix C, capital and annual operating costs were developed for the 10-year and 25-year rainfall events at the "average" fireclay mines for the states under consideration. These costs are tabulated in Table 5. Total capital and annual operating costs for all of the mines in these states are also presented below.

The total capital costs and annual operating cost for the 25-year rainfall event are $18,500,000 and $6,800,000., respectively.

Capital cost impact for unregulated states versus that for the total industry for both the 10- and 25-year event is given below.

	Capital Costs, dollars	
	10-year event	25-year event
Unregulated states	176,000	192,000
Total industry	16,206,000	18,528,000

Table 4. Fireclay Rainfall and Runoff Data

	No. of Mines	Average Mine Production		Average Mine Total Disturbed Area		Soil Condition	Average State Rainfall Data			
		kkg x 10^3	(TPY x 10^3)	Hectares	(Acres)		10-year Event cm	(in)	25-year Event cm	(in)
Alabama	10	29	32	25.1	62	C	16.5	6.5	19.0	7.5
California	6	24	26	19.4	48	C	7.6	3	10.2	4
Colorado	14	4	4	10.1	25	C	6.4	2.5	7.6	3
Georgia	5	18	20	13.0	32	C	15.2	6	17.8	7
Illinois	5	19	21	14.2	35	C	11.4	4.5	12.7	5
Indiana	3	8	9	3.6	9	C	12.0	4.7	12.4	4.9
Kentucky	12	9	10	5.0	12	C	11.2	4	11.9	4.7
Missouri	81	10	11	5.5	13.5	C	14.0	5.5	15.2	6
New Jersey	4	8	9	3.6	9	C	13.2	5.2	14.7	5.8
Ohio	32	32	35	30.8	76	C	9.7	3.8	10.7	4.2
Pennsylvania	36	23	25	18.2	45	C	10.2	4	11.9	4.7
Texas	4	9	10	4.5	11	C	15.2	6	17.8	7
Washington	4	18	20	13.0	32	D	7.6	3	10.2	4
West Virginia	2	18	20	13.0	32	C	10.2	4	11.4	4.5
TOTALS	218									

Table 5. Capital and Annual Operating Costs for Fireclay Mines

Surface Runoff Collection and Treatment

State	No. of Mines	Capital Costs, dollars				Annual Operating Costs, dollars			
		Per Mine		Total		Per Mine		Total	
		10-year	25-year	10-year	25-year	10-year	25-year	10-year	25-year
Alabama	10	160,000	190,000	1,600,000	1,900,000	56,000	65,000	560,000	650,000
California	6	70,000	90,000	420,000	540,000	23,000	30,000	138,000	180,000
Colorado	14	44,000	50,000	616,000	700,000	18,000	20,000	252,000	280,000
Georgia	5	100,000	120,000	500,000	600,000	34,000	40,000	170,000	200,000
Illinois	5	85,000	95,000	425,000	475,000	29,000	31,000	145,000	155,000
Indiana	3	41,000	41,500	123,000	124,500	21,000	22,000	63,000	66,000
Kentucky	12	41,000	48,000	492,000	576,000	19,000	23,000	228,000	276,000
Missouri	81	58,000	65,000	4,698,000	5,265,000	26,000	27,000	2,106,000	2,187,000
New Jersey	4	44,000	48,000	176,000	192,000	23,000	25,000	92,000	100,000
Ohio	32	110,000	120,000	3,520,000	3,840,000	34,000	38,000	1,088,000	1,216,000
Pennsylvania	36	85,000	100,000	3,060,000	3,600,000	30,000	34,000	1,080,000	1,224,000
Texas	4	52,000	54,000	208,000	216,000	26,000	28,000	104,000	112,000
Washington	4	72,000	85,000	288,000	340,000	26,000	32,000	104,000	128,000
West Virginia	2	70,000	80,000	140,000	160,000	27,000	30,000	54,000	60,000
TOTALS	218	1,032,000	1,186,000	16,206,000	18,528,000	392,000	445,000	6,184,000	6,834,000
Overall Average Costs/Mine				74,000	85,000			28,000	31,000

11.0 FULLER's EARTH

11.1 General Description of the Industry

Fuller's earth (including attapulgite and montmorillonite) is mined in eleven states with an aggregate annual production of 12.25×10^5 kkg (11.98×10^5 tons) in 1974. This production is distributed as follows:

State	No. of Mines	Annual Production kkg x 10^3	(tons x 10^3)	% of Total Produced	Not Costed Due to Climatic Conditions	Surface Mining Laws In Effect
California	3	N.D.[a]				Yes
Florida	5	379	413	33.7		Yes
Georgia	8	449	489	40.0		Yes
Illinois	1	N.D.				Yes
Mississippi	3	N.D.				No
Missouri	1	N.D.				Yes
Nevada	1	0.07	0.08	0.0	X	Yes
South Carolina	1	N.D.				Yes
Tennessee	1	N.D.				Yes
Texas	1	N.D.				Yes
Utah	1	1.8	2	0.2	X	Yes
Undistributed[b]	—	295	321	26.2		
Total	26	1,198	1,225	10.0		

[a] N.D. = not disclosed.
[b] Total of undisclosed tonnage.

Fuller's Earth mines in two states (Nevada and Utah) were not costed due to arid climate conditions.

The bulk of the Fuller's Earth is mined in two states, Florida and Georgia, which account for about 70 percent of the total produced. The "average" Fuller's Earth mine in these two states produces about 63,000 kkg/yr (70,000 TPY).

11.2 Runoff and Rainfall Data

The limited data available on total disturbed area in Fuller's Earth mines was plotted versus annual production rate in Figure 12. A direct relationship is indicated though the data does show some scatter. This correlation was used to derive an "average" Fuller's Earth mine total disturbed area for each state by dividing the total annual production by the number of mines in the respective state to obtain an "average" annual Fuller's Earth production rate per state. Figure 12 was then used to obtain the respective average total disturbed area. The total disturbed area in a Fuller's Earth mine is about 4 to 8 ha (10 to 20 ac).

Soil Condition D (with the highest runoff potential) was used for the entire Fuller's Earth cost estimate based on observation of several mines.

Table 6 presents the "average" Fuller's Earth mine total disturbed area, and an average 10-year and 25-year rainfall event for the states involved.

11.3 Runoff Control and Treatment Costs

For the purposes of the cost model, all surface runoff in a Fuller's Earth mine is assumed to be collected in a holding and treatment pond prior to discharge, using appropriate ditching and diking. Fuller's Earth can either be the attapulgite type (a fast-settling clay) or the montmorillonite type (a colloidal, difficult to settle clay), depending on locality. A conservative approach in deriving the costs is to assume the need in all cases to use a "standard" amount of flocculant which would reduce the TSS level in the pond discharge to an acceptable level. None of the Fuller's Earth mines visited in the previous effluent guidelines study had associated process plants immediately adjacent to the mines. It is, therefore, assumed that no process wastewater commingles with surface runoff.

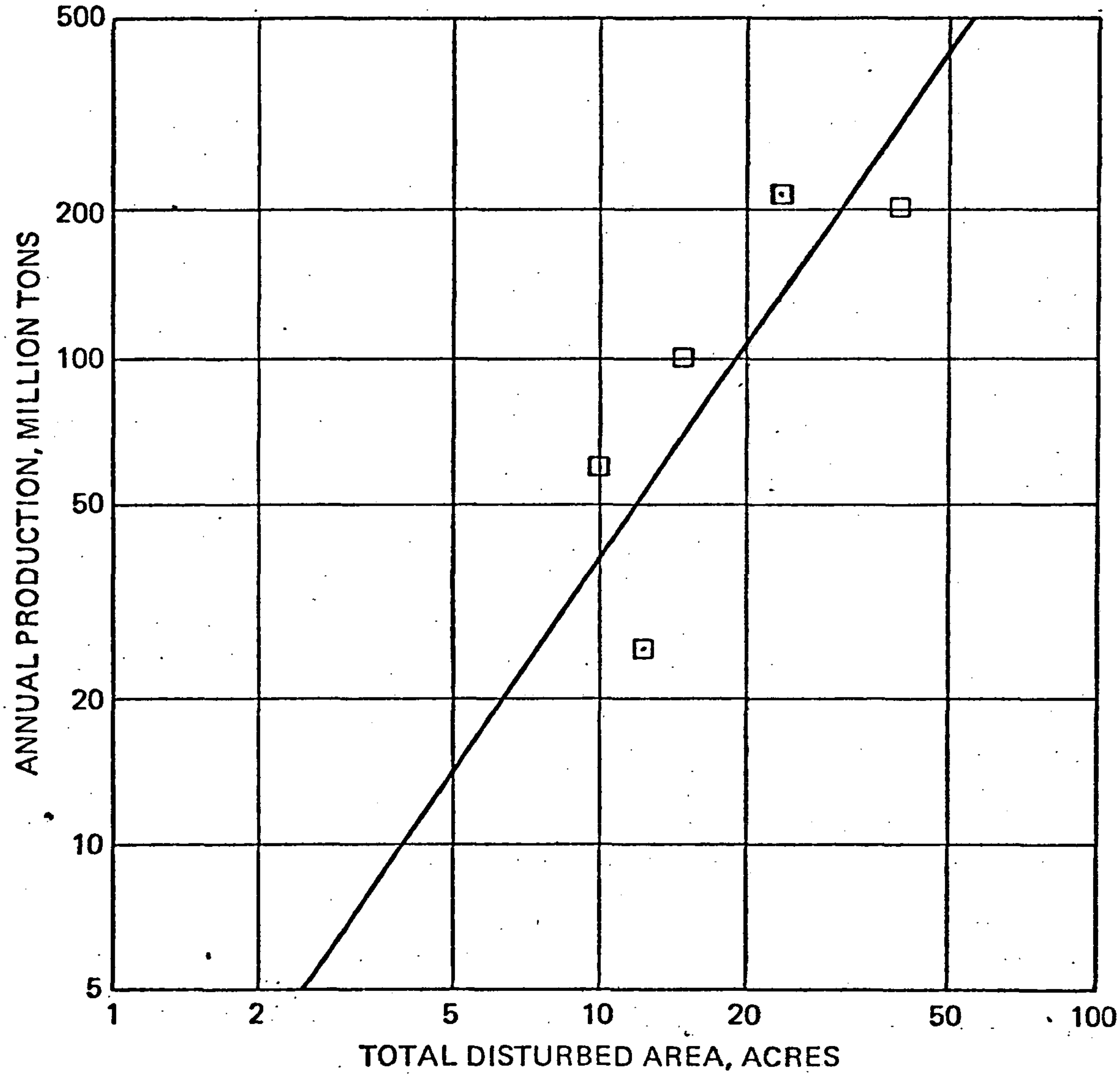

Figure 12. PRODUCTION OF FULLER'S EARTH VERSUS TOTAL DISTURBED AREA

Table 6. Rainfall and Runoff for Fuller's Earth

State	No. of Mines	Average Mine Production, kkg/yr x 10^3 (TPY x 10^3)	Average Total Disturbed Mine Area, ha (ac)	Soil Condition	Average Rainfall Event, cm (in) 10-yr. Event	25-yr. Event
California	3	27 (29[a])	2.23 (5.5)	D	7.6 (3)	10.2 (4)
Florida	5	76 (83)	5.27 (13)	D	19.0 (7.5)	21.6 (8.5)
Georgia	8	56 (61)	4.05 (10)	D	15.2 (6)	17.8 (7)
Illinois	1	27 (29[a])	2.23 (5.5)	D	11.4 (4.5)	12.7 (5)
Mississippi	3	27 (29[a])	2.23 (5.5)	D	16.1 (6.5)	17.8 (7)
Missouri	1	27 (29[a])	2.23 (5.5)	D	13.5 (5.3)	15.2 (6)
South Carolina	1	27 (29[a])	2.23 (5.5)	D	15.2 (6)	17.8 (7)
Tennessee	1	27 (29[a])	2.23 (5.5)	D	12.7 (5)	14.0 (5.5)
Texas	1	27 (29[a])	2.23 (5.5)	D	15.2 (6)	17.8 (7)
Total	26					

[a] These values derived by dividing total undistributed tonnage in the first table by the number of mines involved in these states to obtain an approximation of the actual average value.

Using the data and the assumptions presented above and the model cost curves, capital and annual operating costs were developed for the 10- and 25-year rainfall events requiring surface runoff collection at the 26 mines under consideration. These costs are given in Table 7.

The total capital cost and annual operating costs for the 25-year rainfall event are $1,300,000 and $780,000, respectively.

Capital cost impact in terms of unregulated states costs versus total industry costs for both the 10- and 25-year events is given below.

	Capital Costs, dollars	
	10-Year Event	25-Year Event
Unregulated states	132,000	135,000
Total industry	1,255,000	1,334,000

Table 7. Capital and Annual Operating Costs For Surface Runoff Collection and Treatment at Fuller's Earth Mines

State	No. of	Capital Costs, dollars				Annual Operating Costs, dollars per year			
State		Per Mine		Total		Per Mine		Total	
State	Mines	10-yr Event	25-yr Event	10-yr Event	25-yr Event	10-yr Event	25-yr Event	10-yr Event	25-yr Event
California	3	34,000	36,000	102,000	108,000	18,000	21,000	54,000	63,000
Florida	5	74,000	80,000	375,000	400,000	38,000	44,000	190,000	220,000
Georgia	8	56,000	60,000	448,000	480,000	30,000	34,0000	240,000	272,000
Illinois	1	35,000	39,000	35,000	39,000	23,000	24,000	23,000	24,000
Mississippi	3	44,000	45,000	132,000	135,000	28,000	29,000	57,000	87,000
Missouri	1	40,000	42,000	40,000	42,000	25,000	27,000	25,000	27,000
South Carolina	1	42,000	45,000	42,000	45,000	27,000	29,000	27,000	29,000
Tennessee	1	39,000	40,000	39,000	40,000	24,000	26,000	24,000	26,000
Texas	1	42,000	45,000	42,000	45,000	27,000	29,000	27,000	29,000
TOTALS	26	407,000	432,000	1,255,000	1,334,000	240,000	263,000	667,000	779,000
Average Costs/Mine				48,000	51,000			26,000	30,000

12.0 COMMON CLAY AND SHALE

12.1 General Description of the Industry[a]

Clay and shale are mined in 47 states and in Puerto Rico; there is no known clay or shale production in Alaska, Rhode Island, Vermont and the District of Columbia. A total of 41.1 x 10^6 kkg (45.2 x 10^6 tons) of clay and shale was mined in 839 mines, including 3 mines in Puerto Rico in 1974. The average production per mine was about 44.5 x 10^3 kkg/yr (49 x 10^3 TPY).

Common clay and shale production in 1974 was distributed among states as shown in Table 8.

Production of common clay and shale is widely distributed among the states with the largest production being in Texas (~11% of the total).

For the most part, common clay and shale mines are captive to the same companies which manufacture products based on these raw materials. Only about 10 percent of mine output is sold. The typical brick or tile manufacturing company is a one or two plant operation, with one to three mining locations. The typical common clay or shale mining operation which serves the portland cement industry, is owned by a large company which operates a number of plants and mines. With respect to the entire industry, there is no "typical" situation: there are both large and small companies involved.

12.2 Runoff and Rainfall Data

Forty-six of the 48 continental states have common clay and shale mines. Therefore nearly every type of surface soil, topography and rainfall will be encountered in this industry.

[a]All statistical values quoted are from Bureau of Mines, 1974 data (See Appendix D).

Table 8. Production of Common Clay and Shale in the United States in 1974

State	Total No. of Mines	Annual Production kkg x 10^3	Annual Production tons x 10^3	Per Cent of Total Produced	Mines Not Costed Due to Climatic Conditions	Surface Mining Law In Effect
Alabama	26	2,150	2,342	5.2		Yes
Arizona	6	151	164	.4	X	No
Arkansas	16	830	904	2.0		Yes
California	52	2,055	2,239	5.0	5(c)	Yes
Colorado	35	549	598	1.3	7(c)	Yes
Connecticut	5	143	156	0.3		No
Delaware	1	13	14	0.0		No
Florida	4	339	369	0.8		Yes
Georgia	24	2,241	2,441	5.4		Yes
Hawaii	1	N.D. (a)				No
Idaho	4	8	9	0.0	X	No
Illinois	16	1,362	1,484	0.3		Yes
Indiana	26	979	1,066	2.4		Yes
Iowa	17	881	960	2.1		Yes
Kansas	25	1,203	1,311	2.9	2(c)	Yes
Kentucky	13	671	731	1.6		Yes
Louisiana	15	707	770	1.7		Yes
Maine	6	134	146	0.3		No
Maryland	10	812	884	1.9		Yes
Massachusetts	3	200	218	0.5		Yes
Michigan	11	1.984	2,161	4.8		Yes
Minnesota	2	N.D.				No
Mississippi	22	1,370	1,492	3.3		No
Missouri	21	1,416	1,542	3.4		Yes
Montana	10	54	59	0.1	9(c)	Yes
Nebraska	6	167	182	0.4		Yes
Nevada	1	N.D.			X	No
New Hampshire	3	31	34	0.1		No
New Jersey	2	62	67	0.1		No
New Mexico	7	50	55	0.1	X	No
New York	15	1,332	1,451	3.2		Yes
North Carolina	48	3,141	3,422	7.6		Yes
North Dakota	5	N.D.			X	Yes
Ohio	82	2,939	3,202	7.1		Yes
Oklahoma	17	1,183	1,289	2.8	2(c)	Yes
Oregon	13	128	139	0.3	9(c)	Yes
Pennsylvania	45	1,687	1,838	4.1		Yes
Puerto Rico	3	267	291	0.6		Yes
South Carolina	37	1,402	1,527	3.4		Yes
South Dakota	4	174	190	0.4	X	Yes
Tennessee	21	1,045	1,138	2.5		Yes
Texas	93	4,632	5,046	11.2	3(c)	Yes
Utah	9	185	201	0.4	X	Yes
Virginia	33	1,797	1,957	4.3		Yes
Washington	15	247	269	0.6		Yes
West Virginia	4	311	339	0.7		Yes
Wisconsin	1	2	2	0.0		Yes
Wyoming	4	198	216	0.5	X	No
Undistributed (b)		265	289	0.6		
Total	839			100.0		

(a) N.D. not disclosed
(b) Total of undisclosed production
(c) These mines in counties where climatic conditions eliminate runoff consideration

From a geographic standpoint common clay and shale deposits are concentrated in three semi-distinct zones, as shown below:

1. Gulf-Atlantic Coastal Zone - including:

Texas	South Carolina
Louisiana	North Carolina
Mississippi	Virginia
Alabama	Maryland
Tennessee	Pennsylvania
Georgia	New York

2. Central Interior Zone - including:

Ohio	Missiouri
Michigan	Arkansas
Indiana	Kansas
Illinois	Oklahoma
Iowa	Nebraska

3. West Coast - including:

California	Oregon

The Gulf-Atlantic coastal zone, as identified above, can be further characterized as having Type B and C soils primarily, and as being subject to 25-year, 24-hour rainfall events of about 12.7 to 25 cm (5 to 10 in.).

The Central Interior zone is not completely defined with respect to shale or clay. New York, Pennsylvania, and Iowa deposits are believed to be primarily shale. The 25-year, 24-hour rainfall events are moderate and lie for the most part within a small rainfall range of 10-15 cm (4-6 in). Topography does vary, with mountainous to hilly areas in Pennsylvania, New York, and Arkansas. The remaining area is relatively flat or rolling. Type C soils predominate.

The Pacific Coast area is quite variable with respect to rainfall events and soil conditions (the area has Type B, C, and D soils).

Referring to Table 8, those mines in states which have entirely arid climates or in counties with arid climates, were eliminated.

In addition, only mines in the continental U.S. were considered in the cost estimate.

Since it was not possible to get extensive data on the respective disturbed areas for the common clay and shale mines in the various states under consideration, a correlation of annual production versus total disturbed area was developed based on limited data obtained for shale mines in Pennsylvania. These data are plotted in Figure 13. A direct relationship is indicated between disturbed area and production rate. As an approximation to the actual total disturbed area for the mines under consideration, each state total production of common clay and shale was divided by the total number of active mines to derive an "average" production rate per mine. Using Figure 13, the "average" area per mine was determined for each of the states under consideration. Table 9 tabulates these derived values, together with the soil condition to be used in calculations and the average 10-year and 25-year, 24-hour rainfall events for the respective state under consideration.

While common clay contributes more TSS to runoff than shale, it was conservatively assumed that a "standard" amount of flocculant would be used in the model for all of the common clay and shale mines under consideration. It is also assumed that there is no commingling of surface runoff with process wastewater in the vast majority of the mines under consideration.

12.3 Runoff Control and Treatment Costs

For the purpose of the cost model, all runoff from the common clay or shale mine is assumed to be collected in a holding and treatment pond system using appropriate ditching and diking. Using the data developed in the previous section, together with the cost curves for the appropriate soil condition, capital and annual operating costs were developed for the 10-year and 25-year rainfall events for the various states under

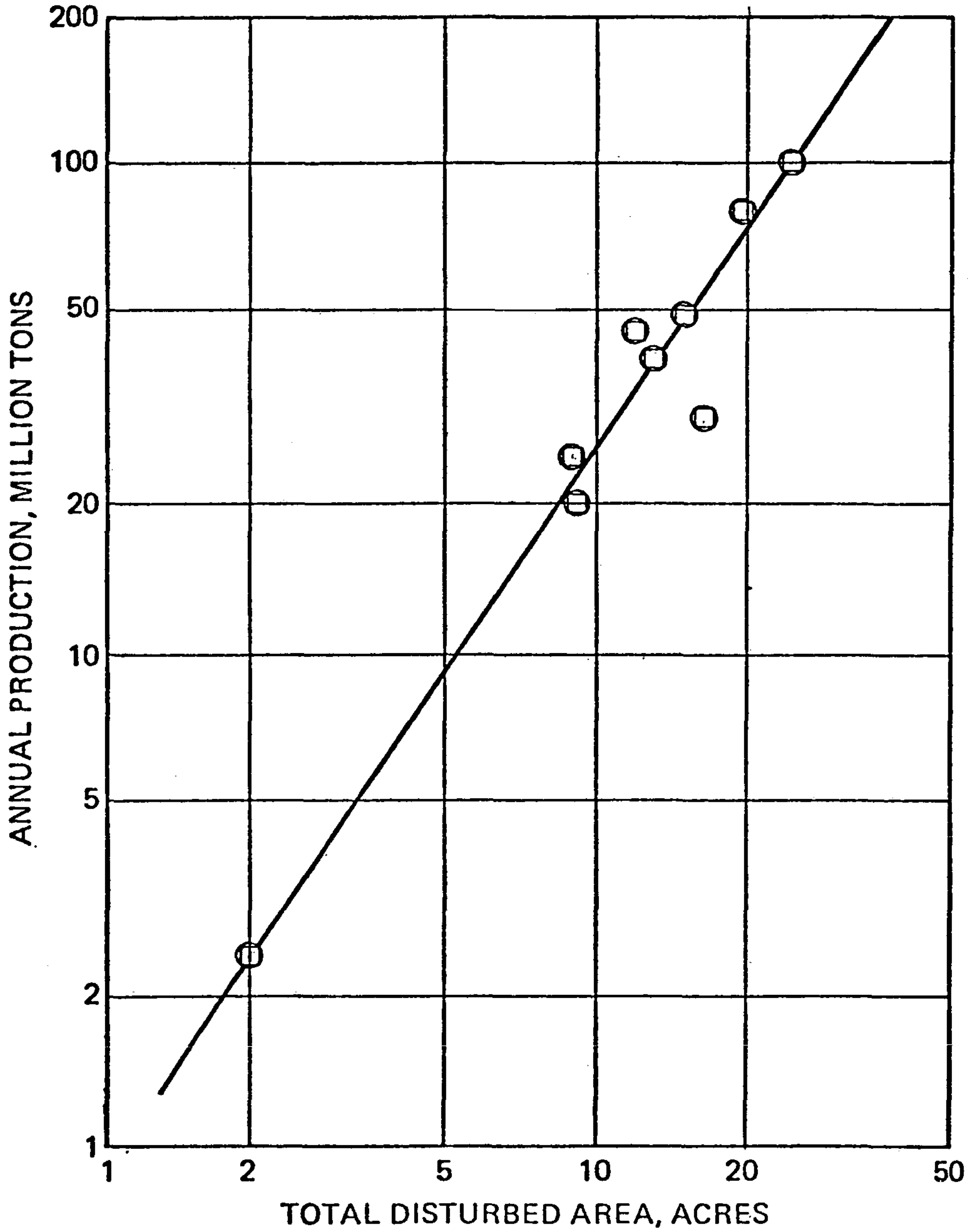

Figure 13. PRODUCTION OF SHALE VERSUS TOTAL DISTURBED AREA

Table 9. Rainfall and Runoff Data for Common Clay and Shale

State	No. of Mines	Average Production Per mine kkg/yr (TPY)	Average Mine Area ha (acre)	Soil Condition	Rainfall, cm (in) 10-yr. Event	25-yr. Event
Alabama	26	83,000 (90,000)	9.3 (23)	C	16.5 (6.5)	19.0 (7.5)
Arkansas	16	52,000 (56,000)	7.0 (17)	C	15.8 (6.2)	17.8 (7)
California	47	40,000 (43,000)	5.7 (14)	C	7.6 (3)	10.2 (4)
Colorado	28	16,000 (17,000)	3.0 (7.4)	D	6.4 (2.5)	7.6 (3)
Connecticut	5	29,000 (31,000)	4.5 (11)	C	12.1 (4.8)	14.6 (5.8)
Delaware	1	13,000 (14,000)	2.6 (6.4)	C	14.0 (5.5)	15.2 (6)
Florida	4	85,000 (92,000)	9.3 (23)	C	19.0 (7.5)	21.6 (8.5)
Georgia	24	93,000 (102,000)	10.1 (25)	C	15.2 (6)	17.8 (7)
Illinois	16	85,000 (93,000)	9.3 (23)	C	11.4 (4.5)	12.7 (5)
Indiana	26	38,000 (41,000)	5.3 (13)	C	11.9 (4.7)	12.4 (4.9)
Iowa	17	52,000 (56,000)	6.5 (16)	C	11.4 (4.5)	14.0 (5.5)
Kansas	23	48,000 (52,000)	6.5 (16)	C	11.4 (4.5)	14.0 (5.5)
Kentucky	13	52,000 (56,000)	6.5 (16)	C	10.2 (4)	12.0 (4.7)
Louisiana	15	47,000 (51,000)	6.5 (16)	C	19.0 (7.5)	22.2 (8.8)
Maine	6	22,000 (24,000)	3.6 (9)	C	10.2 (4)	11.4 (4.5)
Maryland	10	81,000 (88,000)	8.9 (22)	C	12.7 (5)	14.0 (5.5)
Massachusetts	3	67,000 (73,000)	8.1 (20)	C	11.4 (4.5)	13.3 (5.2)
Michigan	11	180,000 (196,000)	18.2 (45)	C	8.9 (3.5)	10.2 (4.0)
Mississippi	22	62,000 (68,000)	7.3 (18)	C	16.5 (6.5)	17.8 (7)
Missouri	21	67,000 (73,000)	8.1 (20)	C	14.0 (5.5)	15.2 (6)
Montana	1	5,000 (6,000)	6.9 (17)	C	6.4 (2.5)	7.6 (3)
Nebraska	6	28,000 (30,000)	4.5 (11)	C	8.3 (3.2)	11.4 (4.5)
New Hampshire	3	10,000 (11,000)	2.2 (5.4)	C	10.2 (4)	12.7 (5)
New Jersey	2	3,000 (3,000)	1.0 (2.5)	C	13.2 (5.2)	14.7 (5.8)
New York	15	89,000 (97,000)	9.7 (24)	C	10.2 (4)	11.4 (4.5)
No. Carolina	48	65,000 (71,000)	7.7 (19)	C	11.0 (5.5)	16.5 (6.5)
Ohio	82	35,000 (39,000)	1.1 (2.8)	C	9.6 (3.8)	10.7 (4.2)
Oklahoma	15	70,000 (76,000)	8.1 (20)	C	14.0 (5.5)	16.5 (6.5)
Oregon	9	10,000 (11,000)	2.1 (5.2)	D	5.1 (2)	12.9 (3)
Pennsylvania	45	37,000 (41,000)	5.3 (13)	C	10.2 (4)	11.9 (4.7)
So. Carolina	37	38,000 (41,000)	5.3 (13)	C	15.2 (6)	17.8 (7)
Tennessee	21	50,000 (54,000)	6.5 (16)	C	12.7 (5)	11.0 (5.5)
Texas	90	50,000 (54,000)	6.5 (16)	C	15.2 (6)	17.8 (7)
Virginia	33	54,000 (59,000)	6.9 (17)	C	13.9 (5.5)	15.2 (6)
Washington	15	16,000 (18,000)	3.0 (7.3)	D	7.6 (3)	10.2 (4)
West Virginia	4	78,000 (85,000)	8.1 (20)	C	10.2 (4)	12.1 (4.8)
Wisconsin	1	2,000 (2,000)	.7 (1.8)	C	10.2 (4)	11.4 (4.5)

consideration. The developed costs are given in Table 10. The total 25-year event capital and annual operating costs are $48,600,000 and $21,700,000., respectively.

Capital cost impact in terms of unregulated states costs versus total industry cost for both the 10- and 25-year events is given below.

	Capital Costs, dollars	
	10-Year Event	25-Year Event
Unregulated states	3,182,000	3,466,000
Total industry	43,845,000	48,591,000

Table 10. Capital and Annual Operating Costs for Surface Runoff Collection and Treatment in Common Clay and Shale Mines

State	No. of Mines	Capital Cost: Per Mine 10-yr.	Capital Cost: Per Mine 25-yr.	Capital Cost: Total 10-yr.	Capital Cost: Total 25-yr.	Annual Operating Costs, dollars per year: Per Mine 10-yr.	Annual Operating Costs, dollars per year: Per Mine 25-yr.	Annual Operating Costs, dollars per year: Total 10-yr.	Annual Operating Costs, dollars per year: Total 25-yr.
Alabama	26	85,000	95,000	2,210,000	2,470,000	34,000	40,000	884,000	1,040,000
Arkansas	16	70,000	75,000	1,120,000	1,200,000	30,000	33,000	480,000	528,000
California	47	38,000	46,000	1,786,000	2,162,000	17,000	20,000	799,000	940,000
Colorado	28	36,000	38,000	1,000,000	1,064,000	17,000	19,000	476,000	532,000
Connecticut	5	46,000	53,000	230,000	265,000	22,000	25,000	110,000	125,000
Delaware	1	38,000	42,000	38,000	42,000	22,000	23,000	22,000	23,000
Florida	4	85,000	97,000	340,000	388,000	38,000	44,000	152,000	176,000
Georgia	24	87,000	110,000	2,088,000	2,640,000	34,000	38,000	816,000	912,000
Illinois	16	65,000	72,000	1,040,000	1,152,000	25,000	28,000	400,000	448,000
Indiana	26	48,000	50,000	1,248,000	1,300,000	23,000	24,000	598,000	624,000
Iowa	17	54,000	62,000	918,000	1,054,000	23,000	27,000	391,000	459,000
Kansas	23	54,000	62,000	1,242,000	1,426,000	23,000	27,000	52,900	621,000
Kentucky	13	48,000	55,000	624,000	715,000	22,000	24,000	286,000	312,000
Louisiana	15	77,000	85,000	1,155,000	1,275,000	35,000	40,000	525,000	600,000
Maine	6	36,000	40,000	216,000	240,000	19,000	21,000	114,000	126,000
Maryland	10	70,000	75,000	700,000	750,000	28,000	30,000	280,000	300,000
Massachusetts	3	61,000	70,000	183,000	210,000	25,000	28,000	75,000	84,000
Michigan	11	75,000	85,000	825,000	935,000	27,000	30,000	297,000	330,000
Mississippi	22	74,000	80,000	1,628,000	1,760,000	32,000	34,000	704,000	748,000
Missouri	21	71,000	75,000	1,491,000	1,575,000	29,000	31,000	609,000	651,000
Montana	1	38,000	50,000	38,000	50,000	17,000	18,000	17,000	18,000
Nebraska	6	38,000	44,000	228,000	264,000	17,000	22,000	102,000	132,000
New Hampshire	3	30,000	34,000	90,000	102,000	18,000	21,000	54,000	63,000
New Jersey	2	25,000	26,000	50,000	52,000	18,000	20,000	36,000	40,000
New York	15	62,000	67,000	930,000	1,005,000	25,000	27,000	375,000	405,000
North Carolina	48	67,000	76,000	3,216,000	3,648,000	29,000	32,000	1,392,000	1,536,000
Ohio	82	24,000	25,000	1,968,000	2,050,000	17,000	18,000	1,394,000	1,476,000
Oklahoma	15	70,000	80,000	1,050,000	1,200,000	29,000	32,000	435,000	480,000
Oregon	9	31,000	33,000	279,000	297,000	15,000	17,000	135,000	153,000
So. Carolina	37	58,000	65,000	2,146,000	2,405,000	27,000	30,000	999,000	1,035,000
Tennessee	21	60,000	62,000	1,260,000	1,302,000	26,000	27,000	546,000	567,000
Texas	90	65,000	71,000	5,850,000	6,390,000	29,000	32,000	2,610,000	288,000
Virginia	33	64,000	67,000	2,112,000	2,211,000	28,000	29,000	924,000	957,000
Washington	15	36,000	40,000	540,000	680,000	19,000	22,000	285,000	330,000
West Virginia	4	56,000	62,000	224,000	248,000	24,000	26,000	96,000	104,000
Wisconsin	1	22,000	23,000	22,000	23,000	17,000	18,000	12,000	18,000
Totals	761	2,118,000	2,316,000	43,845,000	48,591,000	932,000	1,036,000	19,600,000	21,704,000
Average Cost/Mine				58,000	64,000			26,000	28,000

13.0 THE KAOLIN MINING INDUSTRY

13.1 General Description of the Industry

Kaolin is mined in 14 states with an aggregate annual tonnage of 5.87×10^6 kkg (6.39×10^6 tons) in 1974. This tonnage is distributed as follows:

State	No. of Mines	Annual Production kkg x 10^3 (tons x 10^3)	% of Total Production	Not Costed Due to Climatic Conditions	Surface Mining Laws In Effect
Alabama	6	309 (337)	5.3		yes
Arkansas	4	73 (80)	1.3		yes
California	6	39 (43)	0.7		yes
Colorado	1	7 (8)	0.1		yes
Florida	3	25 (27)	0.4		yes
Georgia	59	4,372 (4,762)	74.5		yes
Minnesota	1	N.D. (a)			no
Missouri	10	91 (99)	1.5		yes
Nevada	1	1.8 (2)	0.03	X	no
No. Carolina	2	N.D.			yes
Pennsylvania	2	N.D.			yes
So. Carolina	21	707 (770)	12.0		yes
Texas	2	N.D.			yes
Utah	2	N.D.		X	yes
Undistributed (b)		242 (264)	4.1		
Totals	120	5,867 (6,392)	100.0		

(a) N.D. - not disclosed
(b) Total of undistributed tonnage

The bulk of kaolin products occurs in just two states, Georgia and South Carolina. These states produce ~87% of the total amount of kaolin mined.

Since Georgia is the primary producing state for kaolin, both its government agencies and producers have been solicited for surface runoff information. The Georgia DMR states that "generally speaking, kaolin mining contributes substantially to the siltation of adjacent watersheds. Highly turbid waters resulting primarily from surface runoff frequently affect low-lying areas. Soils involved are sandy and highly erodable, especially during surface mining. General topography of kaolin mining areas is rolling to low hills." [(a)] It should be noted that Georgia has surface mining and water quality laws in effect. However, the Georgia DMR has indicated that the mineral mining producers, including kaolin producers, have largely ignored or circumvented these laws with respect to surface runoff control. [(b)]

Seven of the largest Georgia kaolin producers have furnished projected capital cost and annual operating cost data for control of surface runoff. This data is discussed in Section 13.3 below.

Two states with kaolin mines have not been considered in the surface runoff cost estimate due to arid climate considerations.

13.2 Runoff and Rainfall Data

Available data on total disturbed area versus kaolin production has been plotted in Figure 14. A direct relationship is indicated although there is some scattering of data. This curve was used to approximate the disturbed area of the kaolin mines in all the states under consideration except Georgia [(c)], i.e., an "average" value for mine production in each state was derived by dividing total production by the number of mines. The "average" total disturbed area for this mine was then obtained from Figure 14. This data together with the appropriate soil condition and average 10-year and 25-year rainfall events for the states under consideration, are given in the table below:

(a) Personal Communication, Surface Mined Land Reclamation Program," Georgia DMR, Feb 4, 1976.

(b) Personal Communication, Surface Mined Land Reclamation Program, Georgia DMR, Feb 6, 1976.

(c) Enough cost data were obtained from Georgia kaolin producers to fairly approximate the entire state cost of surface runoff control. Data presented in Section 13.3

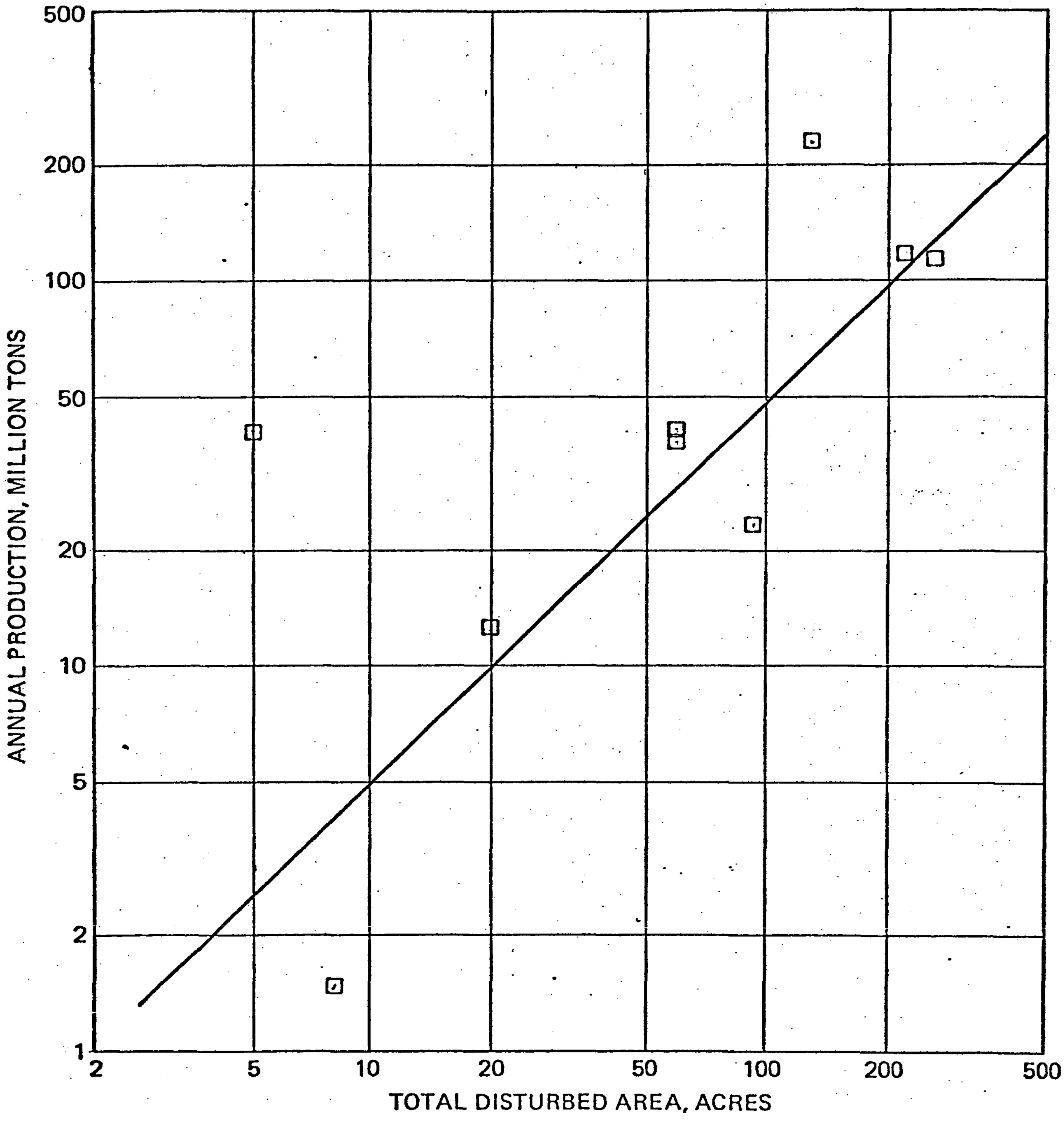

Figure 14. PRODUCTION OF KAOLIN VERSUS TOTAL DISTURBED AREA

State	No. of Mines	Average Mine Production kkg/yr x 10^3 (TPY x 10^3)	Total Disturbed Average Mine Area ha (acres)	SDS Soil Condition	Average State Rainfall Event 10-yr. cm (in)	25-yr. cm (in)
Alabama	6	51 (56)	41.5 (100)	C	16.5 (6.5)	19.0 (7.5)
Arkansas	4	18 (20)	13.3 (32)	C	15.7 (6.2)	17.8 (7)
California	6	6 (7)	7.3 (17.5)	C	7.6 (3)	10.2 (4)
Colorado	1	7 (8)	7.7 (18.5)	D	6.4 (2.5)	7.6 (3)
Florida	3	8 (9)	8.3 (20)	C	19.0 (7.5)	21.6 (8.5)
Minnesota	1	27 (29) (a)	18.3 (44)	C	9.7 (3.8)	11.4 (4.5)
Missouri	10	9 (10)	8.7 (21)	C	13.5 (5.3)	15.2 (6)
No. Carolina	2	27 (29) (a)	18.3 (44)	C	14.0 (5.5)	16.5 (6.5)
Pennsylvania	2	27 (29) (a)	18.3 (44)	C	10.2 (4)	17.8 (7)
So. Carolina	21	34 (37)	23.2 (56)	C	15.2 (6)	17.8 (7)
Texas	2	27 (29) (a)	18.3 (44)	C	15.2 (6)	17.8 (7)
Total	58					

(a) This value was derived by dividing total undisclosed state production by the respective number of mines.

13.3 Runoff Control and Treatment Costs

• For the purpose of the cost model, all runoff in a kaolin mine is assumed to be collected in a holding and treatment pond using appropriate ditching and diking. It is also assumed that a "standard" amount of flocculant will be added to precipitate colloidal kaolin in the collection pond to an acceptable level of TSS in the pond discharge. As far as is known, the vast majority of kaolin mines do not have process plants adjacent to the mine. It is therefore assumed that no process wastewater commingles with surface runoff at the modeled mines.

Using the derived data presented in the table above, the assumptions made above and the cost curves for surface runoff in Appendix C, capital costs and annual operating costs were developed for the 10-year and 25-year rainfall event for the "average" kaolin mine in the states under consideration as shown in Table 11, except for the state of Georgia. Total capital and annual operating costs for all of the mines in these states are also shown. Projected runoff cost and other data presented by seven Georgia kaolin producers are shown in Table 12. Based on the kaolin produced by these seven major producers, approximately 3.39×10^6 kkg (3.74×10^6 tons) in 1975 out of a total of approximately 3.43×10^6 kkg (3.78×10^6 tons)[a] produced in the state, the total 25-year, 24-hour rainfall event surface runoff costs are $24,750,000 capital and $5,800,000 annual operating cost for Georgia. The total capital and annual operating costs for all of the states under consideration, for the 25-year, 24-hour rainfall event are $33,360,000 and $8,860,000,respectively.

Capital cost impacts in terms of unregulated state costs versus total industry costs for both the 10- and 25-year events are given below.

	Capital Costs, dollars	
	10-Year Event	25-Year Event
Unregulated states	97,000	120,000
Total industry	30,330,000	33,360,000

[a] Private communication, John Hetrich, Georgia DMR, Jan. 22, 1976

Table 11. Capital Costs and Annual Operating Costs for Surface Runoff Collection and Treatment - Kaolin Mining

State	No. of Mines	Capital Costs, dollars: Per Mine, 10-year Event	Capital Costs, dollars: Per Mine, 25-year Event	Capital Costs, dollars: Total, 10-year Event	Capital Costs, dollars: Total, 25-year Event	Annual Operating Costs, dollars: Per Mine, 10-year Event	Annual Operating Costs, dollars: Per Mine, 25-year Event	Annual Operating Costs, dollars: Total, 10-year Event	Annual Operating Costs, dollars: Total, 25-year Event
Alabama	6	250,000	280,000	1,500,000	1,680,000	70,000	80,000	420,000	560,000
Arkansas	4	120,000	130,000	480,000	520,000	40,000	48,000	160,000	192,000
California	6	40,000	48,000	240,000	288,000	18,000	21,000	108,000	126,000
Colorado	1	48,000	52,000	48,000	52,000	20,000	22,000	20,000	22,000
Florida	3	85,000	95,000	225,000	285,000	38,000	42,000	114,000	126,000
Minnesota	1	97,000	120,000	97,000	120,000	32,000	37,000	32,000	37,000
Missouri	10	72,000	75,000	720,000	750,000	29,000	32,000	290,000	320,000
North Carolina	2	140,000	160,000	280,000	320,000	45,000	54,000	90,000	108,000
Pennsylvania	2	100,000	130,000	200,000	260,000	34,000	42,000	68,000	84,000
South Carolina	21	170,000	190,000	3,570,000	3,990,000	56,000	65,000	1,176,000	1,365,000
Texas	2	150,000	170,000	130,000	340,000	48,000	58,000	96,000	116,000
Total	120	1,272,000	1,450,000	7,360,000	8,605,000	430,000	501,000	2,574,000	3,056,000

Table 12. Production and Projected Runoff Cost Data - Major Georgia Kaolin Producers

Producer (a)	No. of Active Mines (1975)	Total Disturbed Mine Area (1975) ha (acres)	Total Raw Kaolin Production x 10^3 (b) kkg/yr (TPY)	For 25-yr., 24-hr. Rainfall Event Projected Surface Runoff Costs (c) Capital x 10^6	Annual Operating x 10^6
5003	13	105 (260)	157 (173)	4.04 (d)	1.28 (d)
3024	13	308 (760)	466 (514)	3.43 (e)	0.79 (e)
5001	4	212 (522)	816 (900)	7.56 (f)	0.86 (f)
5002	12	284 (700)	422 (465)	2.72 (g)	0.42 (g)
3025	4	365 (900)	420 (463)	0.59	0.41
5009	6	612 (1,512)	620 (684)	1.29 (h)	0.49 (h)
5010	23	891 (2,202)	490 (540)	4.86	1.49
Totals	75		3,391 (3,739)	24.49	5.74

(a) Versar Code No.
(b) Where finished kaolin production data were obtained, these were converted to raw ore production by dividing by 0.70.
(c) All in 1972 dollars. Reclamation costs presented by these producers have been deleted.
(d) For a total disturbed area of 113 ha (280 acres)
(e) For a total watershed of 3,240 ha (8,000 acres)
(f) For a total disturbed area of 381 ha (939 acres)
(g) For a total disturbed area of 850 ha (2,100 acres)
(h) For a total disturbed area of 689 ha (1,700 acres)

14.0 BALL CLAY

14.1 General Description of the Industry

Ball clay, an impure form of kaolin, is mined and processed in eight states, with an aggregate annual production of 7.43×10^5 kkg (8.17×10^5 tons) in 1974. This production[a] is distributed as follows:

State	No. of Mines	Annual Production kkg x 10^3	(tons x 10^3)	% of Total Produced	Surface Mining Law in Effect
Arizona	1	N.D. (b)			Yes
California	1	N.D.			Yes
Kentucky	4	N.D.			Yes
Maryland	1	N.D.			Yes
Mississippi	4	N.D.			No
New York	1	N.D.			Yes
Tennessee	33	455	(500)	61.2	Yes
Texas	7	37	(41)	5.0	Yes
Undistributed (c)	--	251	(276)	33.8	
	52	743	(817)	100.0	

(a) Bureau of Mines Statistics
(b) Not disclosed
(c) Total of undisclosed production

The bulk of ball clay is produced in Tennessee (~ 61%) with Kentucky probably accounting for most of the remainder (no specific mine production figures are available for Kentucky). Ball clay is mined in open pit operations, where, following the removal of overburden, front end loaders or drag lines excavate the raw material from the pit and load it into trucks for transportation to the processing plant. Mining operations are weather-dependent as ball clay is extremely difficult to handle when wet.

Due to climatic considerations the one ball clay mine in Arizona has been excluded from the runoff control cost estimate for this commodity, leaving 51 mines in seven states which are included in the cost estimates.

14.2 Runoff and Rainfall Data

Plant 5684 currently operates 18 active mines in Kentucky and Tennessee, with a total annual production of 275 x 10^3 kkg/yr (258 x 10^3 TPY) of ball clay. The approximate total disturbed area of the above sites is 91 hectares (225 acres). For the purposes of the surface runoff model calculation, each of the 51 ball clay mines total disturbed area is assumed to be the same value as the average of the above data, i.e., 53 hectares (13 acres). It is also assumed that the bulk of the disturbed area at each site has a clayey base with the highest runoff potential (soil condition D) pertaining.

The average 10-year and 25-year events for the various states are listed below.

State	Average 10-year Event, cm (in.)		Average 25-year Event, cm (in.)	
California	7.6	(3)	10.2	(4)
Kentucky	10.2	(4)	11.9	(4.7)
Maryland	12.7	(5)	14.0	(5.5)
Mississippi	16.5	(6.5)	17.8	(7)
New York	10.2	(4)	11.4	(4.5)
Tennessee	12.7	(5)	14.0	(5.5)
Texas	15.2	(6)	17.8	(7)

Because of the colloidal nature of ball clay, it is assumed that a "standard" amount of flocculant will be added to precipitate colloidal clay in the surface runoff collection pond to an acceptable TSS level in the pond discharge. None of the ball clay mines visited for either the effluent guidelines study or this study had associated process plants immediately adjacent to the pit. Based on this observation, it is assumed that surface runoff does not commingle with process wastewater in the model.

14.3 Runoff Control and Treatment Costs

For the purpose of the cost model, all surface runoff from the ball clay mine is assumed to be collected in a holding and treatment pond system using appropriate ditching and diking. Using the data developed in the previous section, together with the cost curves for Soil Condition D (Appendix C), capital and annual operating costs were developed for the 10-year and 25-year rainfall events for the various states under consideration:

State	No. of Mines	Capital Cost Per Mine		Total Capital Cost	
		10-Yr. Event	25-Yr. Event	10-Year Event	25-Year Event
California	1	$44,000	$54,000	$44,000	$54,000
Kentucky	4	54,000	57,000	216,000	228,000
Maryland	1	60,000	63,000	60,000	63,000
Mississippi	4	70,000	74,000	280,000	296,000
New York	1	54,000	56,000	54,000	56,000
Tennessee	33	60,000	63,000	1,980,000	2,079,000
Texas	7	66,000	74,000	462,000	518,000
Total	51	$408,000	$441,000	$3,096,000	$3,294,000
Overall Avg/Mine				61,000	65,000

State	No. of Mines	Annual Operating Cost per Mine		Total Annual Operating Cost	
		10-Yr. Event	25-Yr. Event	10-Year Event	25-Year Event
California	1	$21,000	$25,000	$21,000	$25,000
Kentucky	4	25,000	28,000	100,000	112,000
Maryland	1	29,000	31,000	29,000	31,000
Mississippi	4	35,000	36,000	140,000	144,000
New York	1	25,000	27,000	25,000	27,000
Tennessee	33	29,000	31,000	957,000	1,023,000
Texas	7	33,000	36,000	231,000	252,000
Total	51	$197,000	$214,000	$1,503,000	$1,614,000
Overall Avg/Mine				30,000	32,000

In the most conservative situation (the 25-year rainfall event), the total capital and annual operating costs for surface runoff collection and treatment for the entire ball clay mining industry as calculated from the model are $3,300,000 and $1,600,000., respectively.

The capital cost impacts for a 10-year event range from $280,000 for unregulated states to an industry total of $1,503,000. Similar cost impacts for a 25-year event range from $144,000 to $1,614,000.

15.0 FELDSPAR

15.1 General Description of the Industry

As discussed earlier, the western feldspar operations have no area runoff and are not included in this cost estimate. The remaining operations are in North Carolina, Georgia and Connecticut:

Location	Number of Sites	Disturbed Area per site, hectares (acres)	Surface Mine Law in Effect
North Carolina	6	12 (30)	Yes
	2	20 (50)	
Georgia	1	2 (5)	Yes
Connecticut	1	2 (5)	No

15.2 Runoff and Rainfall Data

All of the North Carolina sites are in the same area. The 10- and 25-year rainfall events are 13 and 15 cm (5 and 6 in.),respectively. For the Georgia site, the 10- and 25-year events are 15 and 18 cm (6 and 7 in.). For the Connecticut location, the 10- and 25-year events are 13 and 14 cm (5 and 5.5 in.). The soil in each of these locations is assumed to be in the C condition

15.3 Runoff Control and Treatment Costs

The estimated capital and operating costs for the 10- and 25-year events are:

State	Capital Costs, dollars		Operating Costs, dollars/yr	
	10 Yr. Event	25-Yr. Event	10-Yr. Event	25-Yr. Event
North Carolina	660,000	772,000	180,000	198,000
Georgia	23,500	26,000	12,000	13,000
Connecticut	21,000	22,000	11,000	12,000
Total	704,500	820,000	203,000	223,000

Flocculants are not required for runoff treatment in this category.

Capital cost impact ranges for both the 10- and 25-year event in unregulated states versus the total industry are:

	Capital Costs, dollars	
	10-Yr. Event	25-Yr. Event
Unregulated states	21,000	22,000
Total industry	704,500	820,000

16.0 TALC, STEATITE, SOAPSTONE, PYROPHYLLITE

16.1 General Description of the Industry

Talc is produced at 53 sites in 14 states. Many of the sites have not been attributed any control cost based on their locations in extremely arid areas. These are 17 sites in the Mohave Desert of southern California, one in an adjoining arid area of southern Nevada, and 6 sites in Culberson and Hudspeth counties of west Texas. All of these 24 sites are located at least 20 miles from any rivers or streams. The remaining 29 sites are distributed as follows:

State	Surface Mine Law in Effect	Type of Mine	Disturbed Area, hectares (acres)
Alabama	Yes	1 pit	2 (5)
Arkansas	Yes	1 underground mine	0.4 (1) tailings area
Georgia	Yes	5 underground mines	0.4 (1) tailings areas
Maryland	No	1 pit	1.2 (3)
Montana	Yes	2 underground mines	0.4 (1) tailings areas
New York	No	1 open pit, 2 underground mines	2.8 (7) 3-0.4 (1) tailings areas
North Carolina	Yes	3 pits, 3 pits, 1 underground mine	12 (30) each 4 (10) each 0.4 (1) tailings area
Oregon	Yes	1 underground mine	0.4 (1) tailings area
Vermont	No	1 pit, 3 underground mines	2.8 (7) 4-0.4 (1) tailings areas
Virginia	Yes	1 pit	0.4 (1)
Washington	Yes	2 pits	2 (5)

16.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events for the 29 sites are listed below, along with the local soil condition.

State	Rainfall Event, cm (in.) 10-Year	25-Year	Soil Condition
Alabama	15.2 (6)	17.8 (7)	B
Arkansas	15.2 (6)	17.8 (7)	B
Georgia	15.2 (6)	17.8 (7)	B
Maryland	12.7 (5)	15.2 (6)	B
Montana	5 (2)	6.4 (2.5)	C
New York	8.9 (3.5)	10.2 (4)	C
North Carolina	12.7 (5)	15.2 (6)	C
Oregon	8.9 (3.5)	10.2 (4)	C
Vermont	8.9 (3.5)	10.2 (4)	C
Virginia	12.7 (5)	15.2 (6)	C
Washington	12.7 (5)	15.2 (6)	C

16.3 Runoff Treatment and Control Costs

For most cases, there is no special area runoff treatment required. However, a special situation exists for the New York sites, where the talc deposits lie adjacent to pyrite and zinc ore bodies. This leads to some pickup of sulfides and zinc in the runoff which may require additional treatment.

The following table presents capital and operating costs for impoundment and diversion for the 10- and 25-year rainfall events for all talc operations. These costs are exclusive of lime treatment facilities required at the N.Y. sites, which are presented separately.

State	Capital Costs, dollars 10-Yr. Event	25-Yr. Event	Annual Operating Costs, dollars/yr 10-Yr. Event	25-Yr. Event
Alabama	21,000	25,000	11,000	12,000
Arkansas	7,000	8,000	8,000	9,000
Georgia	35,000	40,000	41,000	45,000
Maryland	13,000	14,000	9,000	10,000
Montana	10,000	11,000	16,000	18,000
New York	33,000	36,500	35,000	38,500
North Carolina	363,500	432,000	132,000	145,500
Oregon	5,000	5,500	7,000	8,000
Vermont	41,000	45,000	43,000	47,500
Virginia	6,000	7,000	9,000	10,000
Washington	42,000	46,000	23,000	25,000
Subtotals	576,500	670,000	334,000	368,500
Neutralization Costs (N.Y. sites)	20,000 (est.)	22,000 (est.)	4,000 (est.)	4,000
Totals	596,500	692,000	338,000	372,000

Capital cost impact ranges for both the 10- and 25-year event in unregulated states versus the total industry cost are:

	Capital Costs, dollars	
	10-Yr. Event	25-Yr. Event
Unregulated states	87,000	95,500
Total industry	596,500	692,000

17.0 PREVIOUSLY REGULATED CATEGORIES

17.1 Lithium Minerals (Eastern Operations)

17.1.1 General Description of the Industry

These materials are mined in two geographic areas; North Carolina and Nevada. The latter location has been excluded from further consideration because of a combination of mining methods and climatic conditions. In North Carolina, there are two sites with cost impact. These areas considered are 20 and 12 ha (50 and 30 ac).

17.1.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events for the involved locations are 12.7 and 15.2 cm (5 and 6 in.), respectively. Both North Carolina sites have type C soil condition.

17.1.3 Runoff Control and Treatment Costs

The capital costs for treatment of the 10- and 25-year events are $178,000 and $210,000, respectively. The annual operating costs for the 10- and 25-year cases are $48,000 and $53,000, respectively. Flocculants are not required for lithium minerals runoff water.

17.2 Vermiculite

17.2.1 General Description of the Industry

This product is produced in two areas - western Montana and South Carolina. The former sites have been excluded from this phase of the study due to mining practices used. The latter location involved about 20 discrete sites, each having about 8.1 ha (20 ac) of disturbed area.

17.2.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events for the South Carolina locations are 15.2 and 17.8 cm (6 and 7 in.), respectively. These sites have type C soil condition.

17.2.3 Runoff Control and Treatment Costs

Capital costs for treatment of the 10- and 25-year events are $1,300,000 and $1,500,000, respectively. The 10- and 25-year annual operating costs are estimated at $382,000 and $420,000. Flocculants are not required for this category.

17.3 Barite

17.3.1 General Description of the Industry

Barite is mined by open pit methods in seven states. The locations of the pits and disturbed areas are:

Location	Number of Sites	Disturbed Area, hectares (acres)	
Alaska	1	40	(100)
Arkansas	2	28	(70)
California	1	16	(40)
Georgia	1	8	(20)
	2	4	(10)
Missouri	5	20	(50)
Nevada	4	20	(50)
Tennessee	3	4	(10)

17.3.2 Runoff and Rainfall Data

Below are presented the 10- and 25-year rainfall events and soil condition for the locations.

Site	10-Year Event, cm (in.)		25-Year Event, cm (in.)		Soil Condition
Alaska	15.2	(6)	17.8	(7)	D
Arkansas	15.2	(6)	17.8	(7)	C
California	15.2	(6)	20.3	(8)	C
Georgia	15.2	(6)	17.8	(7)	C
Missouri	12.7	(5)	15.2	(6)	C
Nevada	3.8	(1.5)	5	(2)	C
Tennessee	12.7	(5)	15.2	(6)	C

17.3 Runoff Control and Treatment Costs

Below are given the capital costs for diversion, collection and treatment of the 10- and 25-year rainfall events and the annual operating costs for both rainfall events. Flocculants are not needed for this category.

Location	Capital Costs, dollars 10-Yr. Event	25-Yr. Event	Annual Operating Costs, dollars/yr. 10-Yr. Event	25-Yr. Event
Alaska	240,000	280,000	50,000	55,000
Arkansas	320,000	360,000	73,000	80,000
California	110,000	140,000	29,000	32,000
Georgia	141,000	159,000	48,000	53,000
Missouri	550,000	625,000	136,000	150,000
Nevada	160,000	168,000	62,000	68,000
Tennessee	102,000	114,000	44,000	48,000
Totals	1,623,000	1,846,000	442,000	486,000

17.4 Aplite

17.4.1 General Description of the Industry

The aplite mining industry is located entirely in Virginia with two companies each operating an active mine. Data on these two mines is:

Plant	Mine Production Rate kkg/yr	(TPY)	Total Disturbed Area ha	(acres)
3020	54,000	(60,000)	27	(66)
3016	136,000	(150,000)	128	(315)
Total	190,000	(210,000)		

The aplite mine (plant 3016) produces a relatively soft ore which can be mined with a bulldozer, elevating scrapers and a grader without resort to blasting. The aplite mine (plant 3020) produces a sufficiently rocklike ore which requires blasting to loosen the ore. A power shovel than collects the broken stone and loads it into trucks for transport to the nearby plant.

17.4.2 Runoff and Rainfall Data

The 10- and 25-year rainfall events for these two mines are:

Plant	10-Yr. Event		25-Yr. Event	
	cm	(in.)	cm	(in.)
3020	15.2	(6)	19	(7.5)
3016	14.3	(5.6)	15.2	(6)

Soil Condition C is assumed to be pertinent to these mines.

17.4.3 Runoff Control and Treatment Costs

For the purpose of the runoff model, all surface runoff in each of the two aplite mines under consideration is assumed to be collected in a holding and treatment pond using appropriate ditching and diking. No flocculant is needed for acceptable pond performance. It is also assumed that no process wastewater from the associated processing plant commingles with surface runoff at the modelled mines.

Estimated capital and annual operating costs for the two aplite mines are:

Plant No.	10-Yr. Event		25-Yr. Event	
	Capital Costs	Annual Operating Costs	Capital Costs	Annual Operating Costs
3020	150,000	33,000	75,000	38,000
3016	420,000	85,000	450,000	90,000
Total	570,000	118,000	625,000	128,000

The total 25-year, 24-hour event capital and annual operating costs for the two aplite mines are $630,000 and $130,000, respectively.

Mine 3016 has installed three surface runoff collection ponds at a total cost of $90,000. These ponds were installed to collect surface runoff for process use for the associated aplite process plants. This cost is about 0.2 of the model cost. Annual operating cost for these ponds is about $7,500 per year (less than 10 percent of the 25-year event model-derived cost).

17.5 Kyanite

17.5.1 General Description of the Industry

Kyanite is produced in two states, Virginia and Georgia, two mines being located in Virginia and one in Georgia:

Plant No.	Raw Ore Production		Total Disturbed Area	
	kkg/yr	(TPY)	ha	(acres)
3028	341,000	(375,000)	14.6	(36)[c]
3015	114,000	(125,000)[a]	4.9	(12)
5011	16,400	(18,000)[b]	4.9	(12)

(a) Including 69,000 kkg/yr (75,000 TPY) of by-product quartz sand.
(b) Finished kyanite.
(c) Versar estimate.

The kyanite mining operation consists of blasting the ore loose in the quarry and loading the broken rock with a power shovel into trucks for transportation to the plant.

17.5.2 Runoff and Rainfall Data

The 10-year and 25-year rainfall events for the three mines under consideration.

Plant No.	10-Yr. Event		25-Yr. Event	
	cm	(in.)	cm	(in.)
3028	14.5	(5.7)	16.7	(6.6)
3051	15.2	(6)	19.0	(7.5)
5011	15.2	(6)	19.0	(7.5)

Soil Condition C was assumed for the surface runoff model.

17.5.3 Runoff Treatment and Costs

For the purposes of the runoff model, all surface runoff in a kyanite mine is assumed to be collected in a holding and treatment pond using appropriate ditching and diking. It is assumed that no flocculant will be needed to achieve an acceptable TSS level in the pond discharge. It is further assumed that no process wastewater commingles with surface runoff at the modelled mines.

Capital costs and annual operating costs for the 10-year and 25-year events are tabluated below for the three mines under consideration.

Plant No.	Capital Costs, dollars		Annual Operating Costs	
	10-Yr. Event	25-Yr. Event	10-Yr. Event	25-Yr. Event
3028	95,000	100,000	24,000	26,000
3051	44,000	49,000	16,000	18,000
5011	44,000	49,000	16,000	18,000
Total	183,000	198,000	56,000	62,000

The total 25-year event capital and annual operating costs are $198,000 and $62,000, respectively. There are no industry costs for surface runoff control available for comparison.

17.6 Mineral Pigments

17.6.1 General Description of the Industry

Natural iron oxide pigments are produced at five sites in the U.S. At two sites (one each in Minnesota and Michigan), the ore is mined primarily for iron production. At another site in Pennsylvania, these materials are recovered as a minor co-product of coal mining. These three sites are outside of the scope of this study.

The remaining two sites, one each in Virginia and Georgia, each involve about 0.4 ha (1 ac) of disturbed area.

17.6.2 Runoff and Rainfall Data

The conditions of soil and 10- and 25-year rainfall events for the two sites are as follows:

Site	10-Yr. Event, cm (in.)	25-Yr. Event, cm (in.)	Soil Condition
Virginia	15.2 (6)	17.8 (7)	C
Georgia	15.2 (6)	17.8 (7)	C

17.6.3 Runoff Control and Treatment Costs

Capital costs for the 10- and 25-year events and annual operating costs for both events are presented below.

Site	Capital Costs, dollars		Annual Operating Costs, dollars/yr.	
	10-Yr. Event	25-Yr. Event	10-Yr. Event	25-Yr. Event
Virginia	7,000	7,500	9,100	10,000
Georgia	7,000	7,500	9,100	10,000
Total	14,000	15,000	18,200	20,000

No special treatment such as flocculation is required.

APPENDIX A

Summary of State Surface Mining and Mined Land Reclamation Laws

APPENDIX A

SUMMARY OF STATE SURFACE MINING AND MINED LAND RECLAMATION LAWS

STATE	TITLE OR CODE CITATION	MINERALS COVERED	LICENSE AND/OR PERMIT REQUIREMENTS: APPLICATION	LICENSE AND/OR PERMIT REQUIREMENTS: FEE	LICENSE AND/OR PERMIT REQUIREMENTS: PENALTY	BOND REQUIREMENTS	RECLAMATION REQUIREMENTS	PENALTY FOR FAILURE TO RECLAIM: FORFEITURE OF BOND	PENALTY FOR FAILURE TO RECLAIM: DENIAL OF NEW PERMIT	REMARKS
ALABAMA	The Alabama Surface Mining Act of 1969. Title 26, Alabama State Code, effective October 1, 1970.	All minerals except lime-stone, marble and dolemite.	Permit applications must be filed with the Department of Industrial Relations and be accompanied by a plan of recla-mation.	Filing fee-$250. $50 fee for amended permit.	Mining without a permit-not less than $500 nor more than $5000 and a re-quirement that the affected land be reclaim-ed. Willful misrepresenta-tion of facts on permit appli-cation-not less than $100 nor more than $500 for each offense.	$150 for each acre covered by the permit.	Reduce peaks and ridges to a width of 15 feet at the top; cover face of toxic material; divert water to reduce silta-tion, erosion or damage to streams and natural water courses; plant trees or direct-seed the affected land; revegetate haulage roads and land used to dispose of refuse; and construct fire lanes or access roads in areas to be reforested. Reclamation to be completed within 3 yrs. of expiration of permit period.	Yes	Yes	
ARKANSAS	The Arkansas Open Cut Land Reclamation Act of 1971, Arkansas Statutes Annotated, Title 52, Chapter 9, effective July 1, 1971.	All Minerals	Permit applications must be filed with Arkansas Pollution Control Commission and be accompanied by a reclamation plan.	$25 to $500 de-pending upon the number of acres to be mined.	Surface Mining without a permit-a fine of not less than $500 nor more than $1000 for each day the violation contin-ues.	$500 for each acre or portion to be affected.	Grade peaks and ridges to a rolling topogra-phy; construct earth dams; in areas to be reforested, construct fire lanes or access roads at least 10 feet wide; strike peaks and ridges to a minimum of 20 feet at the top on all land to be seeded for pasture; cover exposed acid forming material; and dispose of refuse so as to control erosion or damage to streams or natural water courses. Reclamation to be completed prior to the expiration of 2 yrs. after termina-tion of permit.	Yes	No	
COLORADO	The Colorado Open Cut Land Reclamation Act of 1969 as amended. Colorado Revised Statutes, Chapter 92, Article 32, effective July 1, 1972.	Coal	Permit applications must be filed with the Land Reclamation Board. A reclamation plan is required.	$50 plus $15 for each acre to be affected.	The Act provides no penalties but contain adminis-trative procedures for dealing with violations.	The bond penalty shall be in such amount as is deemed necessary to insure the operator's per-formance.	Grade ridges and peaks to a width of 15 ft. at the top; where practial, construct earth dams in final cuts to impound water; cover acid forming material to protect drainage system from pollution; and dispose of all refuse so as to control stream pollution, and divert water to control siltation, erosion, or other damage to streams and natural water courses. The Act further contains specific requirements for reclaim-ing disturbed areas for various uses in-cluding forest, range, agricultural or horticultural crops, homesites, recreation-al and industrial.	Yes	Yes	
	Chapter 92, Article 32, Colorado Revised Statutes, as amended, effective July 1, 1969.	Minerals other than Coal	----------------	--------	Forfeiture of performance bond.	The Commissioner of Mines may require an oper-ator to post a performance bond conditioned upon the faithful per-formance of stabi-lization work.	The Commissioner of Mines is empowered to examine all ore mills, sampling works, smelters, metallurgical plants, rock and stone quarries, clay pits, tunnels, sand and gravel pit excavations and plant and mines, except coal mines, to determine the method of surface stabilization used including vegetation to prevent landslides, floods or erosion. Whenever possible, the type of reclamation to be perfuimed is determined through agreement between the Commissionet and the operator.	Yes	---	
FLORIDA	Chapter 71-105, Florida Statutes. Effective July 1, 1971.	Solid Minerals	------------------	--------	-------------	----------------	The Act imposes a severence tax on the extraction of certain solid minerals. A mine operater may obtain a refund of up to 60 percent of the tax imposed by the Act for developing and instituting a reclamation and restoration program.			Solid minerals which are ex-tracted by the owner of the site of severe-ance for the improvement of such site, or solid minerals upon which a sales tax is paid to the State or sold to governmental agencies in the State, including cities and counties, shall be exempt from the subject tax.

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GEORGIA	Georgia Surface Mining Act of 1968, Code of Georgia Annotated, Title 43, Chapter 14. Effective January 1, 1969.	All Minerals	A license must be obtained from the Surface Mined Land Use Board. A mined land use plan is required.	$100 to $500 annually depending upon the number of mining employees employed.	The Act provides Administrative remedies (restraining orders, temporary and permanent injunctions) for violation of its provisions.	Not less than $100 nor more than $500 per acre of land affected.	Grade and backfill peaks, ridges, and valleys to a rolling topography; cover exposed toxic ores or mineral solids with a minimum of 2 feet of soil capable of supporting a permanent plant cover; and establish permanent ground cover on affected lands the first growing season following grading.	Yes	Yes
IDAHO	The Idaho Surface Mining Act. Idaho Code, Title 47, Chapter 15. Effective May 31, 1971.	All minerals	No permit is required, but persons desiring to conduct exploration and surface mining operations must submit and have approved, by the Board of Land Commissioners, a plan of reclamation.		Any violation of the reclamation plan subjects the operator to a civil penalty, the amount of which is not specified.	Not to exceed $500 for any acre of land affected.	Level ridges of overburden to a minimum of 10 feet at the top; level peaks of overburden to a minimum of 15 feet at the top; prepare overburden piles to control erosion; minimize siltation of lakes and streams as a result of water run-off from affected lands; cross-ditch abandoned roads to avoid erosion gullies; plug exploration drill holes; when possible, top affected land with overburden conducive to erosion control and establishment of vegetative growth; prepare tailings ponds so as not to constitute a hazard to human or animal life; and complete reclamation within 1 year after surface mining operations permanently cease or are abandoned.	Yes	Yes
	The Idaho Dredge and Placer Mining Protection Act, Idaho Code, Title 47, Chapter 13. Effective May 31,1971.	Minerals recovered with the use of dredge boat, sluice washing or other method capable of removing more than two (2) cubic yards of material per hour.	Permit application must be filed with the Board of Land Commissioners.	$50 for each 10 acres involved in the application.	Termination of permit, enjoinment from operating dredge or mine placer.	$10,000 for the 10-acre tract or less than 10 acres.	Every person conducting dredging or placer mining operations in the State is required to level and smooth the affected area comparable with the natural contour of the ground prior to the disturbance, and to a condition conducive to the growth of verdure. Whenever such operations result in substantive removal of topsoil, the operator shall be required to restore the land to its original condition by adding topsoil and planting grass, trees, and other vegetation.	Yes	Yes
ILLINOIS	The Illinois Surface-Mined Land Conservation Act. Illinois Annotated Statutes, Chapter 93-201 Mines and Miners. Effective July 1, 1975.	All Minerals	Applications for permits must be filed with the Department of Mines and Minerals for all operations exceeding 10 feet in depth or affecting more than 10 acres during the permit year. A reclamation plan is required.	$50 plus $25 for every acre to be affected.	Surface mining without a permit-not less than $50 nor more than $1000. Each day's violation is deemed a separate offense.	$600 to $5000 for each acre to be affected including slurry and gob disposal areas.	Grade affected land to a rolling topography with slopes having no more than a 15% grade, except land reclaimed for forest plantation, recreational or wildlife, the final cut spoil, the box-cut spoil, and the outside slopes of all overburden deposition areas, the grade shall not exceed 30%; return land to be used for row crop to approximate original grade and, when available, segregate and replace at least 18 inches of topsoil; impound runoff water to reduce soil erosion, damage to unmined lands, and pollution of streams and waters; cover exposed acid forming material with not less than 4 feet of water or other materials capable of supporting plant and animal life; confine slurry in depressed or mined areas; remove and grade all haulage roads and drainage ditches; and plant trees, shrubs, grasses and legumes. All reclamation except slurry and gob areas in active use shall be completed prior to the expiration of 3 years after termination of the permit year.	Yes	Yes
INDIANA*	Indiana Code 1971, 13-4, 6. Effective February 2, 1976.	Coal, clay and shale	Applications for permits must be filed with the Department of Natural Resources. A reclamation plan is required.	$50 plus $30 for each acre to be affected.	Not less than $1000 nor more than $5000.	The greater of $5000 or $600 multiplied by the number of acres for which the permit is issued.	Grading to reduce peaks and ridges to a rolling, sloping or terraced topography; construct earth dams in final cuts to impound water; bury all metal, lumber, or other debris or refuse resulting from mining; and revegetate affected areas as soon as practicable after initiation of mining operations.	Yes	Yes
IOWA	Iowa Surface Mining Law, Title V, Chapter 83A. Effective January 1, 1968, amended August 15, 1973.	All Minerals	Permit applications must be filed with the Department of Soil Conservation.	License-$50, $10 renewal.	$50 to $500 or imprisonment not to exceed 30 days or both.	An amount equal to the estimated cost of rehabilitating each site affected.	Grade spoil banks to slopes having a maximum of 1-foot vertical rise for each 3-feet horizontal distance, except where the original topography exceeds these stipulations, and spoil bank shall be graded to blend with surrounding terrain; construct an earth dam where a lake or pond may be formed to properly control the drainage of acid water from the site; and cover acid forming material with at least 2 feet of earth or spoil material. Operators shall rehabilitate affected areas within 24 months after mining is completed.	Yes	Yes

KANSAS	The Kansas Mined-Land Conservation and Reclamation Act. Kansas Statutes Annotated, Article 4, Chapter 49-409. Effective January 1, 1975.	Coal	Permit applications must be filed with the Mined Land Conservation and Reclamation Board. A reclamation plan is required.	$50 plus $25 per acre.	Not to exceed $250. Each day violation continues, constitutes a separate offense.	Not less than $200 nor more than $500 per acre with a $2000 minimum.	Grade each pit to a flat surface with a width equal to at least 60% of the original pit; cover the face of coal or other minerals with non-acid bearing and non-toxic materials to a distance of at least 2 feet above the seam being mined, or by a permanent water impoundment; control flow of all runoff water to reduce soil erosion, damage to agricultural lands, and pollution of streams and waters; and grade overburden to provide suitable vegetative cover. Reclamation must be pursued as soon as possible after mining begins and completed within 12 months after the permit has expired.	Yes	Yes
KENTUCKY*	Kentucky Strip Mining Law, Kentucky Revised Statutes, Title 28, Chapter 350 as amended by Chapter 3, Laws of 1972. Effective January 1, 1973.	All Minerals	Permit applications must be filed with the Division of Reclamation. A reclamation Plan is required.	$150 plus $35 per acre.	$100 to $1000 for each violation plus an additional $100 to $1000 for each day violation continues. Willful violation-not less than $500 nor more than $5000 for each day violation continues.	Operations in existence before June 23, 1974-$500 per acre or $5000, whichever is greater. Operations started on or after June 23, 1974-$1000 per acre or $5000, whichever is greater.	Complete backfilling not to exceed the original contour with no depressions to accumulate water is required of all land affected by area mining. All highwalls resulting from contour strip mining shall be reduced or backfilled, the steepest slope of the reduced or backfilled highwall and the outer slope of the fill bench being no greater than 45 degrees from the horizontal. The table portion to be terraced with a slope not greater than 10 degrees. The restored area to have a minimum depth of 4 feet of fill over the pit floor. Revegetation shall include planting trees, shrubs, grasses legumes. Reclamation to begin as soon as possible after strip mining begins and completed within 12 months after the permit has expired.	Yes	Yes
MAINE	Conservation and Rehabilitation of Land, Maine revised Statutes, Annotated, Part 5A, Chapter 451. Effective June 1, 1971.	All Minerals except sand, gravel and borrow operations.	Permission to conduct surface mining is contingent upon approval of the operators mining plan.	$50 plus $25 for each acre to be affected not to exceed a total of $500.	Not more than $100 for each day a violation continues.	An amount to be determined by the Mining Commission of not less than $100 nor more than $1500 for each acre to be affected.	Varied-depending on planned future use of reclaimed land. The intent of the Commission is to insure that an approved permanent vegetative cover is established where possible on affected land, and that the condition in which the land is left is not conducive to erosion or pollution.	Yes	No
MARYLAND*	Maryland Strip Mining Law. Annotated Code of Maryland, Natural Resources Article, Title 7, Subtitle 5, Strip Mining. Effective July 1, 1971.	Coal	A license and permit must be obtained from the bureau of Mines. A reclamation plan is required.	License-$100 plus $10 for each renewal.	Failure to obtain a license-not less than $5000 nor more than $10,000 or imprisonment not to exceed 6 months, or both. Failure to obtain a permit-not less than $500 nor more than $5000. Failure to backfill prospected areas-not less than $200 nor more than $500.	$400 per acre with a $3000 minimum. A special reclamation fee of $30 per acre of land affected and a revegetation bond of not less than $50 nor more than $125 per acre are also required.	Grade spoil banks to reduce depressions between peaks of spoil to a surface which restores the terrain to a condition prescribed by the Director, bureau of Mines; if overburden deposits are composed of materials which are suitable for supporting vegetative growth, it shall be graded so as to cover the final pit; and seal-off, with a fill, underground mining operations at the base of the final cut.	Yes	Yes
MICHIGAN	Reclamation of Mining Lands. Michigan Statutes Annotated, Act No. 92 of the Public Acts of 1970, as amended by Act No. 123 of the Public Acts of 1972. Effective March 29, 1973.	All Minerals except Clay, gravel, marl, peat or sand.	--------------	-------	--------------	If there is doubt as to the operator's financial ability to comply with the rules of the Act, he may be required to post a performanance bond or other security.	The Act authorizes the Chief of the Geological Survey to conduct a comprehensive study and survey to determine the type of regulation needed to protect the public interest. Upon completion of the survey, rules may be promulgated governing: Sloping, terracing or treatment of stockpiles and tailings to prevent damage to fish and wildlife, pollution of waters or injury to persons or property; vegetation or treatment of tailings basins and stockpiles where natural vegetation is not expected within 5 years and where research reveals vegetation can be accomplished within practical limitations; and stabilization of the surface overburden banks of open pits in rocks and the entire bank of open pits in unconsolidated material.	---	---

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MINNESOTA	Reclamation of Lands, Minnesota Statutes Annotated, Title 8, Chapter 94, effective August 1, 1973.	Metallic Minerals	A permit to mine must be obtained from the Commissioner of Natural Resources. A reclamation plan is required.	-------	Failure to comply with the provisions of the Act-not more than $1000 for each day such failure continues.	The Commissioner determines whether or not a bond may be required.	The Commissioner of Natural Resources shall conduct a comprehensive study and survey to determine the extent to which regulation is needed to protect the public interest giving due consideration to the environment, future land utilization, protection of other natural resources and the future economic effects of such regulations on mine operators and landowners, the surrounding communities and the State of Minnesota.	---	---	Public liability insurance in an adequate amount to provide personal injury and property damage protection is also required.
MISSOURI	Reclamation of Mining Lands. Vernons Annotated Missouri Statutes, Vol. 23, Section 444.500, effective September 28, 1971.	Coal and barite.	Permit applications must be filed with the Land Reclamation Commission. A reclamation plan is required.	$50 plus $17.50 for each acre to be affected.	Mining without a permit-$1000 per day for each day the violation continues.	Not less than $300 for coal and $200 for barite nor more than $700 for coal and $500 for barite for each acre of land affected, with a $2000 minimum.	Grade peaks and ridges of overburden, except where lakes are to be formed, to a rolling topography traversable by farm machinery. The slopes need not be reduced to less than the original grade prior to mining, and the slope of overburden ridge resulting from a box cut need not be reduced to less than 25 degrees from the horizontal. Dispose of all debris, material or substance removed from the surface prior to mining.	Yes	Yes	
	The Land Reclamation Act, Vernons Annotated Missouri Statutes, Vol. 23, Section 444.760, effective September 28, 1971.	Clay, limestone, sand and Gravel.	Permit applications must be filed with the Land Reclamation Commission. A reclamation plan is required.	$50 plus $17.50 for each acre to be affected.	Mining without a permit-not less than $50 nor more than $1000. Each day violation continues is deemed a separate offense.	$500 for each acre to be affected.	Grade peaks and ridges to a rolling topography traversable by machines; construct fire lanes or access roads through areas to be reforested; strike peaks and ridges of overburden to a minimum of 25 feet at the top on all land to be reforested; on land to be used for crops, grade peaks and ridges of overburden so that the area can be traversed by farm machinery; construct lakes from mined pits and dams in final cuts; cover exposed face of mineral seam with not less than 4 feet of earth that will support plant life; and sow, set out or plant upon the affected land plants, cuttings of trees, shrubs, grasses or legumes appropriate to the designated type of reclamation.	Yes	Yes	
MONTANA	The Montana Strip Mining and Reclamation Act, Revised Code of Montana, Replacement Volume 3, Part 2, Title 50, Chapter 10, effective March 16, 1973.	Coal and uranium.	Permit applications must be filed with the Department of State Lands. A reclamation plan is required.	$50 for mining permit. $100 for prospecting permit.	Violation of provisions-fine of not less than $100 nor more than $1000. Willful violation-not less than $500 nor more than $5000. Each day violation occurs constitutes a separate offense.	Not less than $200 nor more than $2500 per acre with a $2000 minimum.	Bury under adequate fill all toxic materials; seal off breakthrough of water creating a hazard; impound, drain or treat runoff water so as to reduce soil erosion, damage to grazing and agricultural lands, and pollution of surface and subsurface waters; and remove and bury all refuse resulting from the operation. Segregate, preserve, and replace topsoil. All highwalls must be reduced, the steepest slope of which shall be no greater than 20 degrees from the horizontal. Backfilled, graded and topsoiled areas shall be prepared and planted with legumes, grasses, shrubs, and trees. Reclamation to begin as soon as possible after beginning strip mining.	Yes	Yes	
	Reclamation of Mining Lands. Chapter 12, effective September 15, 1971.	Any ore, rock or substance other than oil, gas, bentonite, clay, coal, sand, gravel, phosphate rock or uranium.	Exploration license and Development permit must be obtained from the Department of State Lands. A reclamation plan is required.	Exploration License-$5.00. Development permit-$25.00.	Not less than $100 nor more than $1000 with an additional $100 to $1000 for each day violation continues.	Not less than $200 nor more than $2500.	Reclamation of the affected land must be performed in accordance with the approved reclamation plan which contains measures for: surface gradient restoration suitable for proposed land use; revegetation or other surface treatment; public health and safety; disposal of mining debris; diverting water to prevent pollutin or erosion; reclamation of stream channels and banks to control erosion, siltation, and pollution.	Yes	Yes	
	Strip Mined Coal Conservation Act, Chapter 14, effective March 8, 1973.	Coal	-------	-------	Mining without an approved strip mining plan-not less than $100 nor more than $1000 and an additional $100 to $1000 for each day violation continues.	-------	The Act provides for the conservation of strippable and marketable coal by requiring each operator wishing to conduct strip coal mining within the State to submit, for approval of the Department of State Lands, a strip mining plan which outlines the planned course of conduct of a strip mining operation including plans for the removal and utilization of strippable and marketable coal located within the area planned to be mined.	---	---	
	The Open Cut Mining Act, Chapter 15, effective March 16, 1973.	Bentonite, clay, scoria, phosphate rock, sand and gravel.	Applications for contracts must be made to the Board of Land Commissioners if the planned operation involves removing 10,000 cubic yards or more of product or overburden. A reclamation plan is required.	$50	Mining without a contract-not less than $500 nor more than $1000. Each day's violation is considered a separate offense.	Not less than $200 nor more than $1000 per acre.	Reclamation must be carried out in accordance with the approved reclamation plan which requires that the land be reclaimed for specified uses including forest, pasture, orchards, cropland, residence, recreation, industry, or wildlife habitat. Reclamation requirements include: establishment of vegetative cover; control water drainage; grading; removal or burial of metal or waste; and revegetation of affected area.	Yes	Yes	

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MONTANA (cont.)	The Strip Mine Siting Act, Chapter 16, effective January 1, 1974.	Coal and uranium.	A minesite location permit must be obtained from the Department of State Lands before preparatory work (construction of buildings, railroads, storage and train load-out facilities, transmission lines, etc.) begins.	$50	Not less than $100 nor more than $1000 for the violation, plus an additional $100 to $1000 for each day violation continues. Willful violation-$500 to $5000. Each day's violation constitutes a separate offense.	Not less than $200 nor more than $10,000 per acre with a $5000 minimum.	The type of reclamation is determined by future suitable use of the land including removing or burying facilities, backfilling, grading, and topsoiling.	Yes	Yes	
NEW MEXICO	Coal Surface Mining Act. New Mexico Statutes Annotated, Replacement Vol. 9, Part 1, Article 34, effective February 29, 1972.	Coal	Application for permit must be filed with the Coal Surface Mining Commission. Mining plans must accompany permit applications.	$50 application fee. $10 initial acreage fee. Annual fee of $20 per acre for each acre affected during the preceding year.	$1000 for each day violation continues.	The Surface Coal Mining Commission may require an operator to file a bond in an amount sufficient to insure compliance.	Grade to produce a gently undulating topography or such other topography as is consistent with planned end use of the land. Grading shall be done in such a manner as to control erosion and siltation of the affected area and surrounding property and water courses. Revegetation of the affected area must be accomplished in accordance with the previously approved mining plan.	---	---	
NEW YORK	The New York State Mined Land Reclamation Law, McKinney's Consolidated Laws of New York, Environmental Conservation Law, Title 27, effective April 1, 1975.	All Minerals	A permit is required for any operator mining 1000 tons or more in 12 successive months. A reclamation plan is required	$100 annually or $200 for 3 years.	Suspension or revocation of permit.	The amount of bond is to be determined by the administering agency.	Reclamation to be accomplished in accordance with the approved reclamation plan which shall indicate specifics covering revegetation, disposal of debris, refuse, tailings, waste, and spoil grading. Reclamation to be completed within a 2-year period after mining ceases.	Yes	Yes	
NORTH CAROLINA*	The Mining Act of 1971. General Statutes of North Carolina, Chapter 74, Article 7, Amended 1973, effective July 1, 1974.	All Minerals	Application for a permit must be filed with the Department of Conservation and Development. A reclamation plan is required.	No fee is required. Permit will be granted if the reclamation plan is approved.	Willful violation $100 to $1000 fine. Each day constitutes a separate violation.	$2,500 to $25,000 depending upon the number of acres to be affected.	Reclamation must be performed in accordance with approved reclamation plan which must meet the following standards: The final slopes in all excavations in soil, sand, gravel, and other unconsolidated materials shall be at such an angle as to minimize the possibility of slides and be consistent with the future use of the land. Provisions for safety to persons and to adjoining property must be provided in all excavations in rock. In open cast mining operations, all overburden and spoil shall be in a configuration which is in accordance with accepted conservation practices and which is suitable for the proposed subsequent use of the land. Suitable drainage ditches or conduits shall be constructed to prevent collection of small pools of water that are noxious, odious, or foul. The type of vegetative cover and method of its establishment shall conform to accepted agronomic and reforestation practices.	Yes	Yes	
NORTH DAKOTA	Reclamation of Strip Mined Lands, Title 38, Chapter 38-14, effective July 1, 1973.	All Minerals	Applications for permits must be filed with the Public Service Commission for all planned operations exceeding 10 feet in depth. A reclamation plan is required.	Up to ten acres-$25 plus $10 times the number of acres to be affected between two and ten; eleven to fifty acres-$100 plus $10 times the number of acres between eleven and fifty. More than fifty acres-$275 plus $10 times the number of acres in excess of fifty acres.	Mining without a permit-fine of not less than $50 nor more than $1000. Each day violation continues constitutes a separate offense.	$500 for each acre to be affected.	Regrade affected area to approximate original contour, or rolling topography or topography for higher end use; spread topsoil or other suitable soil material over the regraded area to a depth of two feet; impound or treat runoff water to reduce soil erosion, damage to agricultural lands and pollution of streams; back-slope final cuts and end walls to an angle not to exceed 35 degrees from the horizontal (operator may propose alternative to backfilling if consistent with the Act); remove or bury all debris; and sow, set-out, or plant cuttings of trees, shrubs, grasses, or legumes. All reclamation shall be carried to completion prior to the expiration of three years after termination of the permit term.	Yes	Yes	

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OHIO	Ohio Reclamation Law. Ohio Revised Code Annotated, Title 15, Chapter 1513, effective April 10, 1972.	Coal	Applications for licenses must be filed with the Division of Reclamation. A reclamation plan is required.	$100 plus $30 for each acre to be mined.	Mining without a permit-$5000 plus $1000 per acre of land affected. Exceed limits of license-$1000 per acre of land affected that is not under license. Willful misrepresentation-$100 to $1000 or 6 months. Violation of any other provision-$100 to $5000 or 6 months in prison, or both	Sufficient to cover the cost of reclamation but not less than $5000.	Cover all acid producing materials with nontoxic material; construct and maintain access roads; prevent the pollution of waters, erosion, landslides, flooding and the accumulation or discharge of acid water; contour the affected area unless the mining and reclamation plan provides for terracing or other uses; and replace segregated topsoil and grow vegetative covering.	Yes	Yes	The Act levies a severance tax on the following minerals for the purpose of reclaiming land affected by strip mining: (a) four cents per ton of coal; (b) four cents per ton of salt; (c) one cent per ton of limestone and dolomite; (d) one cent per ton of sand and gravel; (e) three cents per barrel of oil; (f) one cent per thousand cubic feet of natural gas.
	(Ohio Revised Code Annotated, Title 15, Chapter 1514, effective September 27, 1974.)	All minerals except coal.	Application for permit must be filed with the Division of Reclamation. A reclamation plan is required.	$150 plus $30 for each acre to be affected but not to exceed $1000 per	Mining without a permit-$5000 plus $1000 per acre of land affected. Exceeding limits of permit-$1000 per acre of land affected. Willful misrepresentation-$100 to $1000 or 6 months, or both. Violation of any other provision-$100 to $5000 or 6 months, or both	$500 per acre of land to be affected.	Grade, contour, or terrace final slope; teeoil affected land with topsoil or suitable subsoil; establish diverse vegetative cover of grass, legumes, or trees; remove or bury refuse resulting from mining; insure prevention of contaminating underground water supply; and control drainage to prevent floods or landslides.	Yes	Yes	Public Liability Insurance: $100,000 to $200,000 for bodily injury and $100,000 to $300,000 for property damage.
OKLAHOMA*	The Mining Lands Reclamation Act, Oklahoma Statutes Annotated, Title 45, Chapter 8A, effective June 12, 1971, amended April 17, 1972.	All Minerals	Application for permits must be filed with the Department of Mines and Mining. A reclamation plan is required.	$50	Mining without a permit-not less than $50 nor more $1000. Each day constitutes a separate offense.	Not less than $350 nor more than $650 for each acre to be affected. For coal and copper mining the minimum bond shall be $5000. For all other mining the minimum bond shall be $1000. Sand and gravel operators who sell less than $1000 per year may be exempt.	Grade peaks and ridges of overburden to a rolling topography, but the slopes need not be reduced to less than the original grade prior to mining, and the slope of ridge resulting from the box cut need not be reduced to less than 25 degrees from the horizontal; construct earth dams to form lakes in pits resulting from surface mining operations; cover exposed faces of mineral seams with not less than 3 feet of earth to support plant life or with a permanent water impoundment; and revegrtate affected land, except that which is to be covered with water or used for homesites or industrial purposes, by planting trees, shrubs or other plantings appropriate to future use of the land.	Yes	Yes	
OREGON	An Act Relating to mining. Oregon Revised Statutes, Title 43, Mines and Minerals, effective July 1, 1972.	All Minerals	Permits must be obtained for all operation exceeding 10,000 cubic yards of material extracted or at least 2 acres of land affected within a period of 12 consecutive calendar months. A reclamation plan is required.	Basic fee-$150. Annual renewal fee-$50.	Mining without a permit-a fine not exceeding $1000. Violation of any rules or regulations is punishable by a fine of not less than $25 nor more than $250, or imprisonment for not more than 60 days, or both.	Not to exceed $300 per acre to be surface mined.	Reclamation of the affected land must be performed in accordance with the approved reclamation plan which must contain: measures to be undertaken by the operator in protecting the natural resources of adjacent lands; measures for the rehabilitation of the surface-mined lands and the procedures to be applied; procedures to be applied in the surface mining operation to control the discharge of contaminants and the disposal of surface mining refuse; procedures to be applied in the rehabilitation of affected stream channels and stream banks to a condition minimizing erosion, sedimentation and other factors of pollution; such maps and other documents as may be requested by the Department of Geology and Mineral Industries; and a proposed time schedule for the completion of reclamation operations.	Yes	Yes	

PENNSYLVANIA*	Surface Mining Conservation and Reclamation Act, Pennsylvania Statutes Annotated, Title 52, Chapter 1396, approved May 31, 1945, amended by Public Acts of 1963 and 1968; Public Act No. 147, November 30, 1971, effective January 1, 1972; Public Act 355, approved December 28, 1972; Public Act No. 941, approved October 18, 1974.	All Minerals	Application for permits must be filed with the Department of Environmental Resources. A reclamation plan is required.	$50 for persons mining 2000 tons or less of marketable minerals other than coal per year, and $300 for mining coal or more than 2000 tons of other marketable minerals per year. Annual renewal-$50 for mining 2000 tons or less of marketable minerals other than coal and $300 in the case of all other minerals.	Mining without a permit-$5000 or an amount of not less than the total profits derived from unlawful activities, together with the cost of restoring the land to its original condition or 1 year imprisonment, or both.	An amount sufficient to insure completion of the reclamation plan, but not less than $5000, except in the case of minerals other than anthracite and bituminous coal where it is determined that the amount of marketable minerals to be extracted does not exceed 2000 tons, no bond shall be required. Liability under the bond shall be for the duration of the operation and for 5 years thereafter.	Backfill all pits within 6 months after completion of mining. Such backfilling shall be terraced or sloped to an angle not to exceed the original contour. Plant grasses and trees or grasses and shrubs upon affected land within 1 year after backfilling.	Yes	Yes	Operators mining minerals other than anthracite and bituminous coal, the amount of which does not exceed 2000 tons, shall be exempt from obtaining the required $100,000 certificate of public liability insurance and posting the required bond.
SOUTH CAROLINA*	The South Carolina Mining Act. Code of Laws of South Carolina, Title 63, Chapter 5, effective July 1, 1974.	All Minerals	Applications for permits must be filed with the Land Resources Conservation Commission. A reclamation plan is required.	--------	Willful violation of the Act or misrepresentation of facts or giving false information on permit applications-not less than $100 nor more than $1000 fine for each day the violation continues.	$2,500 to $25,000 or a greater amount depending upon the number of acres to be affected.	Reclamation to be performed in accordance with the approved reclamation plan which must meet the following standards: The final slopes in all excavations shall be at such an angle so as to minimize the possibility of slides; provide safety of persons and of adjoining property; in open cut mining, overburden and spoil shall be left in a configuration suitable for subsequent use of the land; and construct suitable drainage to prevent the collection of small pools of water that are noxious or likely to become noxious, odious, or foul. The type of vegetative cover and method of its establishment shall conform to accepted recommended agronomic and reforestation practices. The plan must further provide that reclamation activities be completed within 2 years after completion or termination of mining on each segment of the area for which a permit is issued unless a longer period is specifically authorized.	Yes	Yes	
SOUTH DAKOTA	Surface Mining Land Reclamation Act., South Dakota Compiled Laws of 1967, Title 45, Chapter 45-6A, effective July 1, 1971.	All Minerals	Permit applications must be filed with the State Conservation Commission. A reclamation plan is required.	$50 - $25 for each renewal.	Violation of the Act's provisions-a fine of not less than $1000 for each day the violation continues.	An amount sufficient to cover the cost of reclamation.	Isolate all toxic or other material that have a damaging effect upon ground and surface waters, fish and wildlife, public health and the environment; reclaim surface mined areas to control erosion, provide vegetation, and eliminate safety hazards; replace topsoil evenly over reclaimed areas; revegetate in accordance with agronomic and forestry recommendations; and upon completion of operations, remove all structures, machinery, equipment, tools and materials from the site of operation.	Yes	Yes	
TENNESSEE*	The Tennessee Surface Mining Law, Tennessee Code Annotated, Chapter 15, effective March 23, 1972, amended by House Bill 630, approved March 20, 1974.	All minerals except limestone, marble, and dimension stone.	Applications for permits must be filed with the Commissioner, Department of Conservation. A reclamation plan is required.	$250 plus $25 for each acre to be mined. The total amount not to exceed $7,500.	Violation of the Act-fine of not less than $100 nor more $5,000 for each day violation continues. Willfull violation-not less than $1000 nor more than $5000 or imprisonment not to exceed 1 year, or both.	Not less than $600 for minerals other than coal and not less than $600 for coal for each estimated acre to be affected.	Coal: cover all acid producing material; seal off any breakthrough in mine or pit walls which creates a hazard; control drainage to prevent damage to adjacent lands, soil erosion and pollution of streams and waters; remove all refuse except vegetation resulting from the operation; provide adequate access roads to remote areas; on steep slopes, regrade area to approximate original contour or rolling topography and eliminate highwalls, spoil piles and water-collecting depressions. (Grading and other soil preparation to accomodate vegetation shall be completed within 6 months following initiation of soil disturbance.) Revegetate the affected area with grasses or legumes to prevent soil erosion. Minerals other than coal: regrade the area to approximately the original or rolling topography, and eliminate all highwalls, spoil piles, and water collecting depressions; control drainage to prevent soil erosion, damage to adjacent lands, and pollution of streams and other waters; and revegetate with trees, grasses, or legumes.	Yes	Yes	

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VIRGINIA	Chapter 17, Title 45.1, Code of Virginia (1950), as amended. Effective April 10, 1972.	Coal	Permit applications must be filed with the Department of Conservation and Economic Development. A reclamation plan is required.	Prospecting permit-$10 per acre. Surface mining permit-$12 per acre. Annual fee-$6 per acre.	Violation of the Act-Fine of not more than $1000 or imprisonment for not more than 1 year or both. Each day violation continues constitutes a separate offense.	Prospecting-$300 per acre. Surface mining bond-not less than $200 or more than $1000 per acre to be mined. Minimum bond-$2500, except when the operation involves less than 5 acres, the bond shall not be less than $1000.	Remove all debris resulting from mining operations; regrade the area in a manner established by rules and regulations; grade overburden to reduce peaks and depressions between peaks to produce a gently rolling topography; preserve existent access roads; and plant trees, shrubs, grasses or other vegetation upon areas where revegetation is practicable.	Yes	Yes	
	Title 45.1, Chapter 16, Code of Virginia, 1950 as amended. Effective June 27, 1966.	Other minerals	Permit applications must be filed with the Department of Conservation and Economic Development. A reclamation plan is required.	$6 for each acre to be affected, not to exceed a total of $150.	Violation of the Act-maximum fine of $1000 or 1 year in jail, or both.	$50 per acre based upon the number of acres to be disturbed. The minimum amount of bond furnished shall be $1000.	Same as for coal, except that in the case of dimensional stone and quarry operations, special consideration is given to the peculiar nature of the excavated cavity.	Yes	Yes	
WASHINGTON	Surface-Mined Land Reclamation Act, Revised Code of Washington Annotated, Title 78, Mines and Minerals, Chapter 78.44, effective January 1, 1971.	All Minerals	Permit applications must be filed with the Department of Natural Resources. A reclamation plan is required.	$25 per permit year for each location plus $5 per acre for all acreage exceeding 10 acres which was disturbed during the previous permit year.	Mining without a permit-misdemeanor. An operator can be enjoined or otherwise stopped. Each day's violation constitutes a separate offense.	Not less than $100 nor more than $1000 per acre.	In reclaiming excavations for use as lakes, all banks shall be sloped to 2 feet below the groundwater line at a slope no steeper than 1½ feet horizontal to 1 foot vertical. In all other excavations, the side slopes shall be no steeper than 1½ feet horizontal to 1 foot vertical for their entire length. All strip pits and open pits shall be no steeper than 1 foot horizontal to 1 foot vertical. The slopes of quarry walls shall have no prescribed slopes, except where a hazardous condition is created the quarry shall be graded or backfilled to a slope of 1 foot horizontal to 1 foot vertical. In strip mining, peaks and depressions of spoil banks shall be constructed to a gently rolling topography. Suitable drainage shall be constructed to prevent the collection of stagnant water. All grading and backfilling shall be made with non-noxious, non-flammable, noncombustible solids. All acid-forming materials shall be covered with at least 2 feet of clean fill. Vegetative cover shall be required and all surface mining that disturbs streams must comply with State fisheries laws.	Yes	Yes	
WEST VIRGINIA*	West Virginia Surface Mining Act, West Virginia Code, Vol. 8, 1970 Replacement Volume, Chapter 20, effective March 13, 1971.	All Minerals	Applications for permits must be filed with the Department of Natural Resources.	Prospecting-$300. Surface mining-$500. Annual renewal-$100. Personal injury and property damage insurance of $100,000 and $300,000 respectively are also required.	Violation of the law's provisions-$100 to $1000 fine or 6 months imprisonment, or both. Deliberate violation-$1000 to $10,000 fine or 6 months imprisonment, or both.	Not less than $600 per acre nor more than $1000 per acre with a $10,000 minimum. A special reclamation tax of $60 per acre is also required.	Cover the face of coal and disturbed area with material suitable to support vegetative cover; bury acid-forming materials, toxic material, or materials constituting fire hazard; impound water. Bury all debris. The law also contains requirements for regrading surface mined areas where benches result specifying the maximum bench width allowed. On land where benches do not result complete backfilling is required but shall not exceed the original contour of the land. The backfilling shall eliminate all highwalls and spoil peaks. Planting is required.	Yes	Yes	An operator who causes damage to property of others shall be liable to them in an amount not in excess of three times the provable amount of such damage. A $10,000 certificate of insurance must be filed to cover such damage.
WYOMING	The Wyoming Environmental Quality Act, Wyoming Statutes, Title 35, Article A, Land Quality, effective July 1, 1973.	All Minerals	Applications for permits must be filed with the Administrator, Division of Land Quality. A reclamation plan is required.	Surface mining fee-$100 plus $10 for each acre to be affected with a $2000 maximum. Amended permit-$200 plus $10 per acre with a $2000 maximum. License fee for mineral exploration-$25.	The Act imposes fines ranging from $10,000 to $50,000 per day depending upon the violation involved. Criminal penalties are also prescribed for certain violations ranging from 6 months to 2 years imprisonment.	Not less than $10,000 except for scoria or jade and sand and gravel, in which case the bond shall not be less than $200 per acre.	Protect the removed and segregated topsoil from wind and water erosion and from acid or toxic materials; cover, bury, impound or otherwise contain radioactive material; conduct contouring operation to achieve planned use; backfill, grade, and replace topsoil or approved subsoil; replace vegetation; prevent pollution of surface and subsurface waters; and reclaim affected land as mining progresses in conformity with the approved reclamation plan.	Yes	Yes	

*-MEMBER OF THE INTERSTATE MINING COMPACT

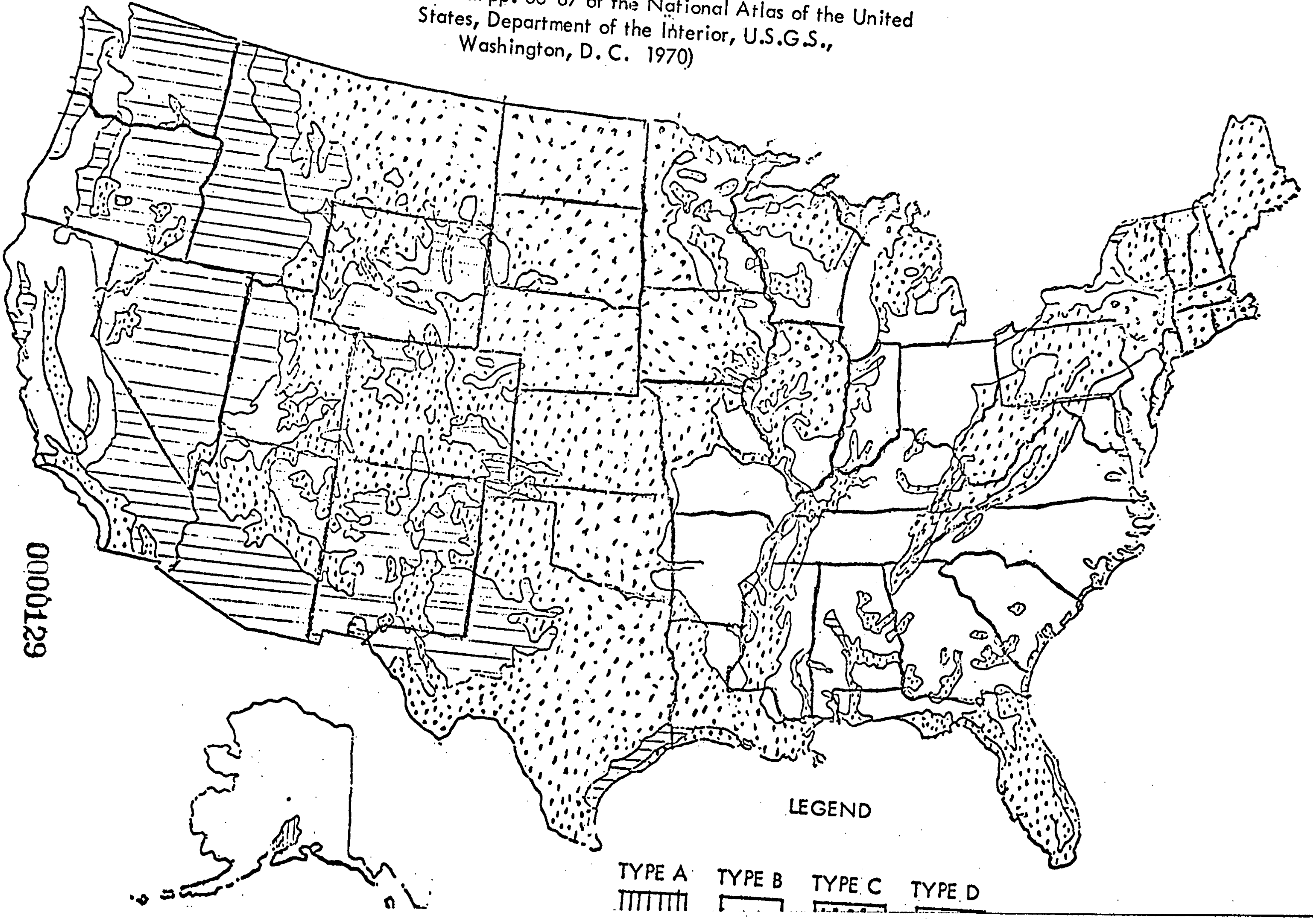
U.S. Bureau of Mines
Mining - Environment
April 1, 1975

APPENDIX B

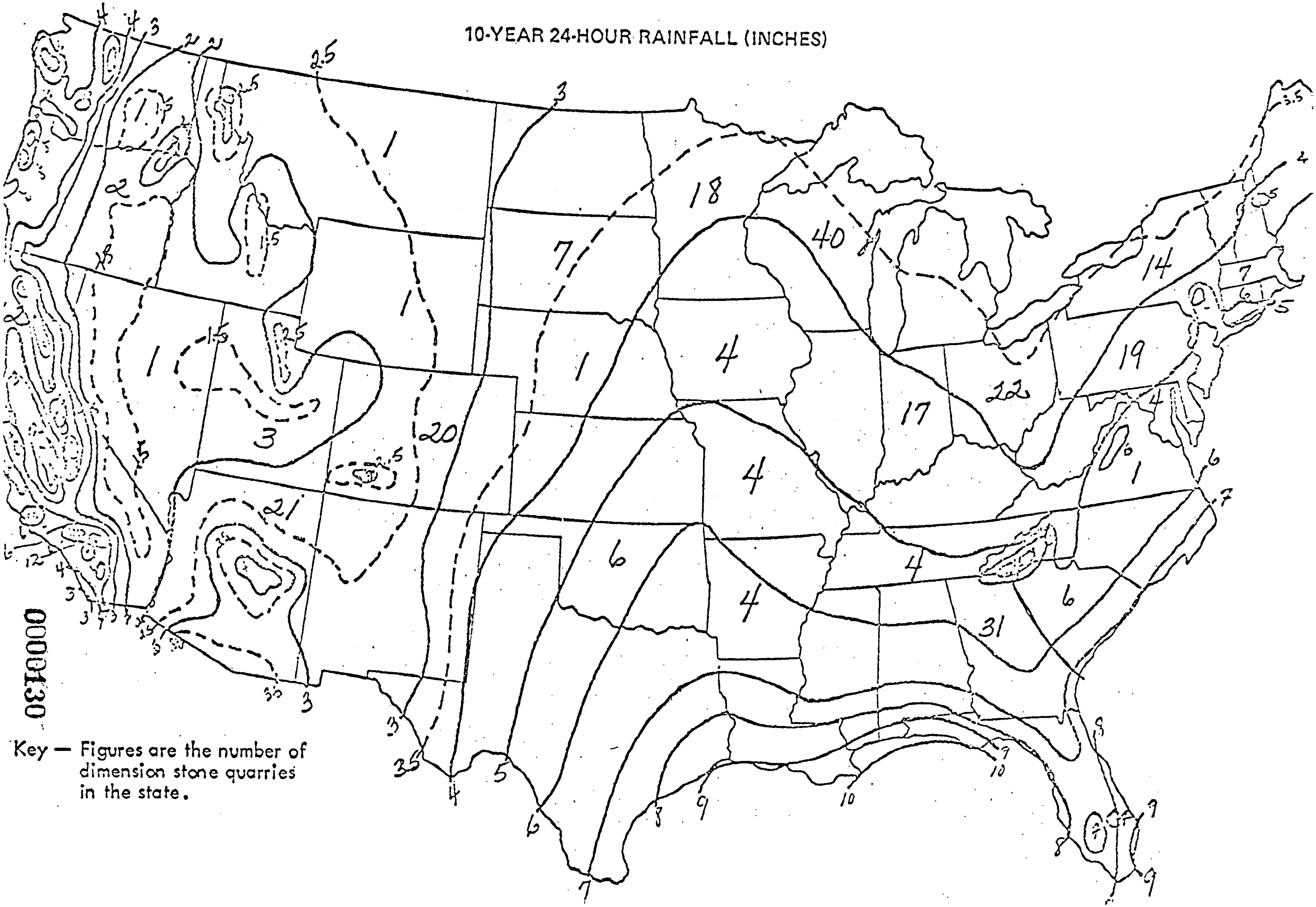
Rainfall Maps and Mining Site Locations

Distribution of Soil Absorbancy Conditions Assumed for Mine Runoff

(Derived from pp. 86-87 of the National Atlas of the United States, Department of the Interior, U.S.G.S., Washington, D.C. 1970)

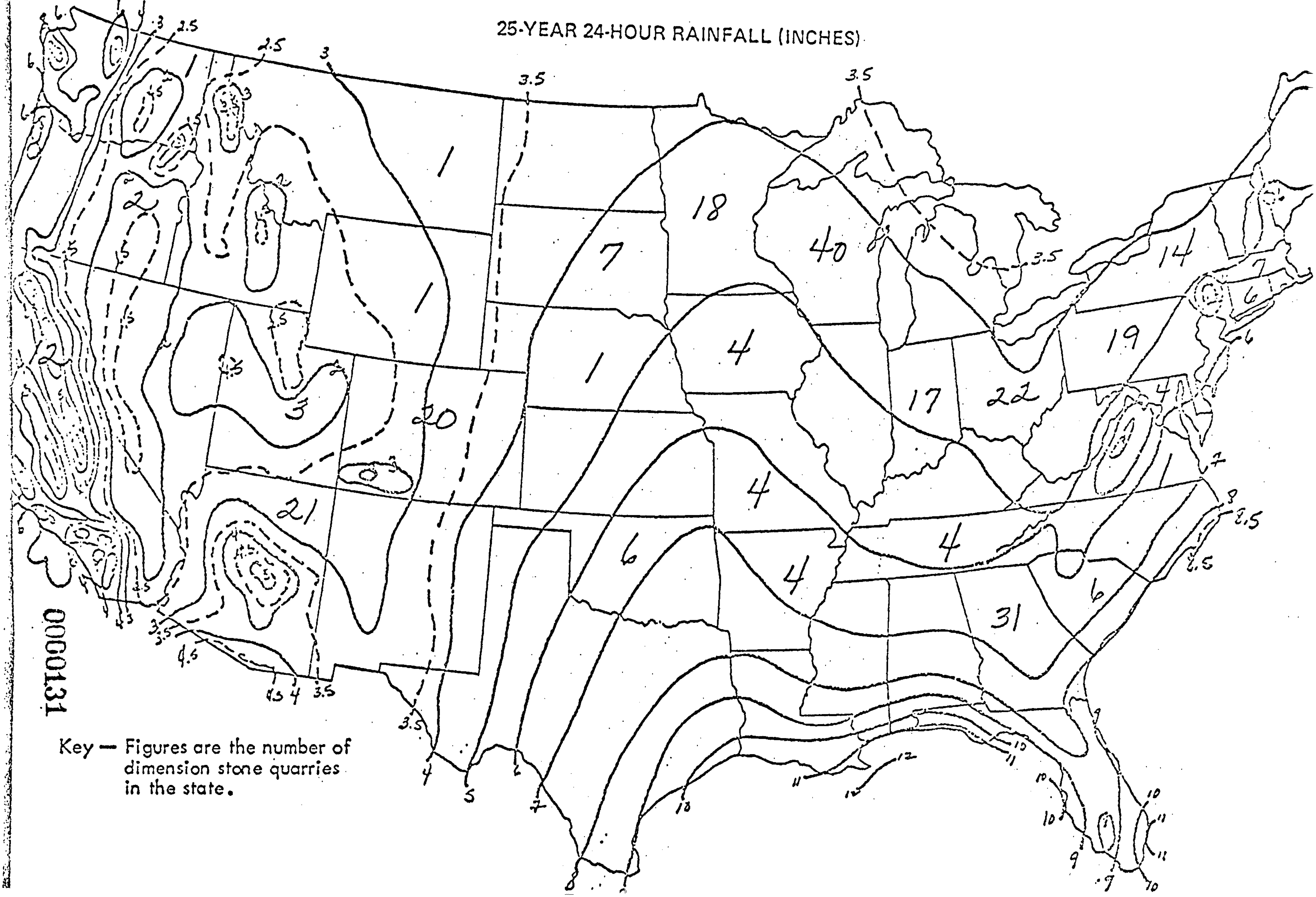


10-YEAR 24-HOUR RAINFALL (INCHES)

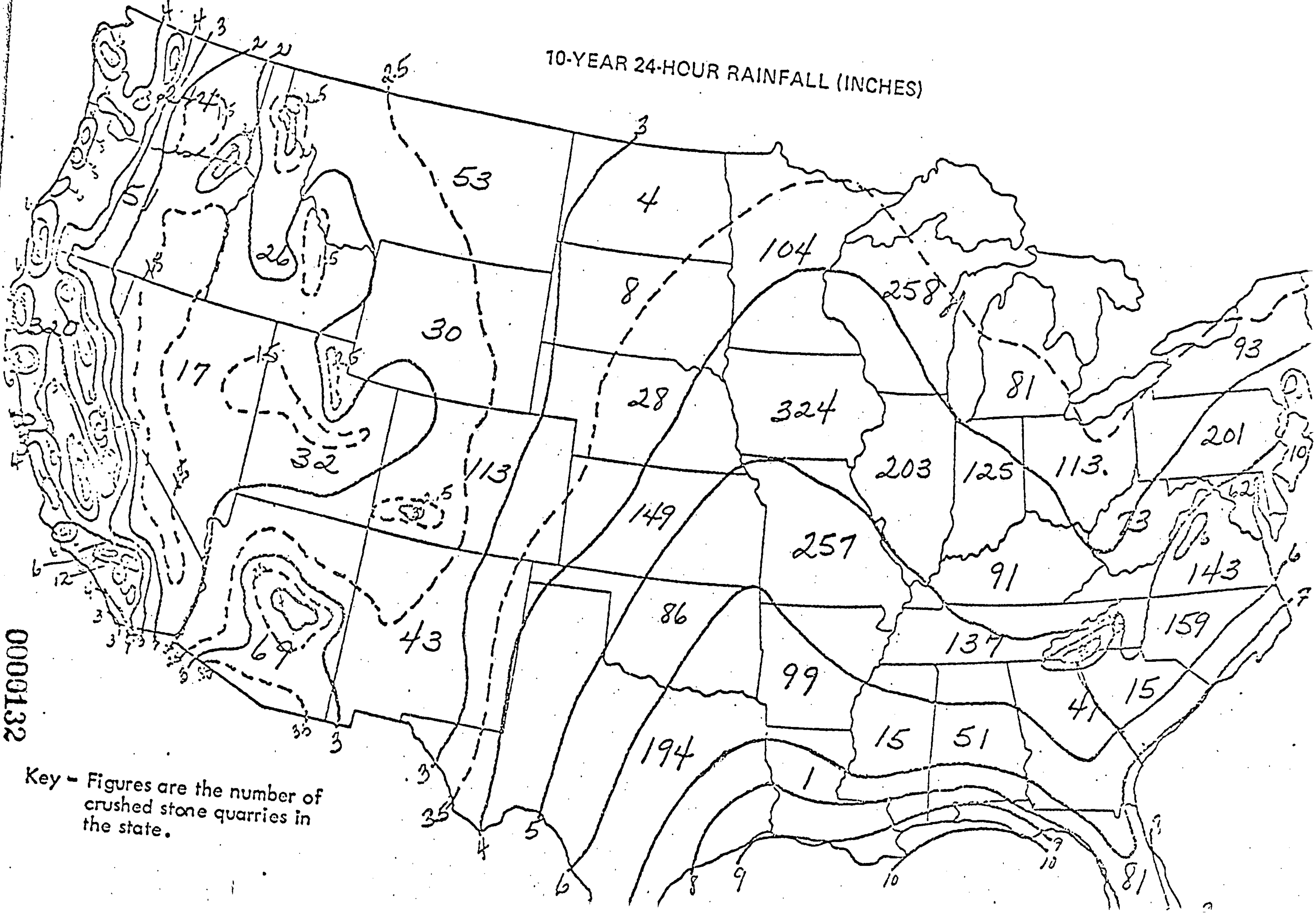


Key — Figures are the number of dimension stone quarries in the state.

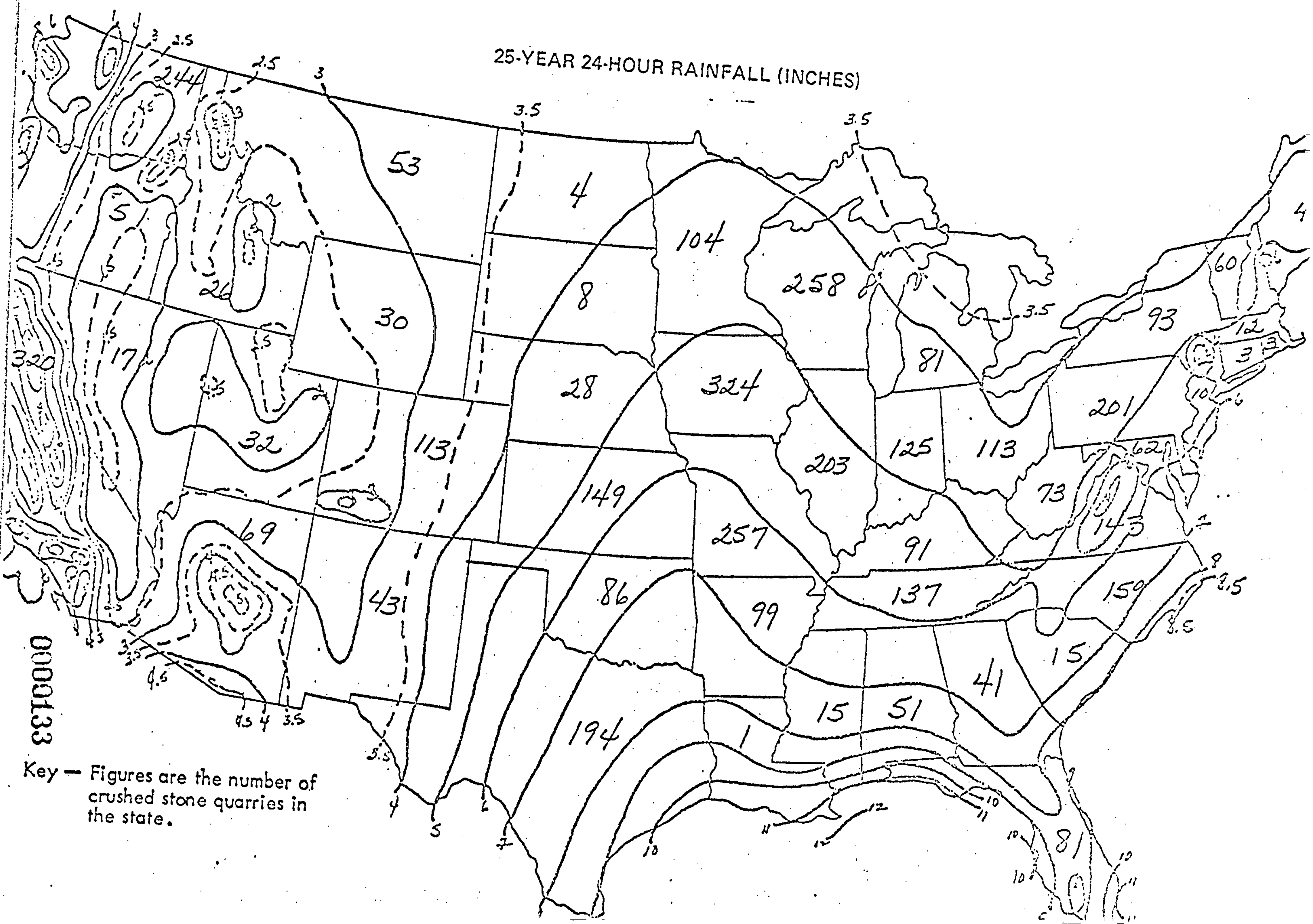
25-YEAR 24-HOUR RAINFALL (INCHES)



Key — Figures are the number of dimension stone quarries in the state.



Key – Figures are the number of crushed stone quarries in the state.



Key — Figures are the number of crushed stone quarries in the state.

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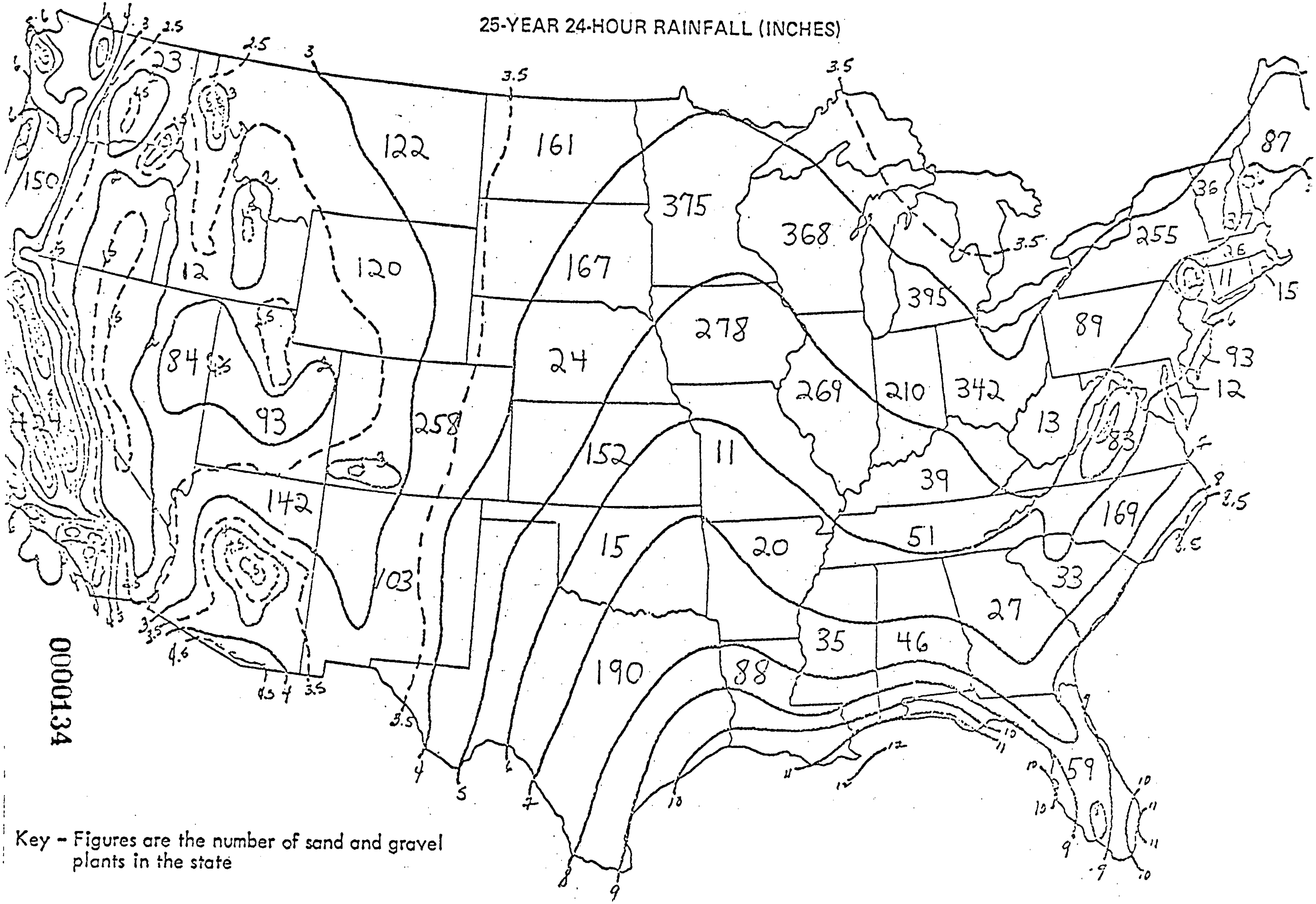
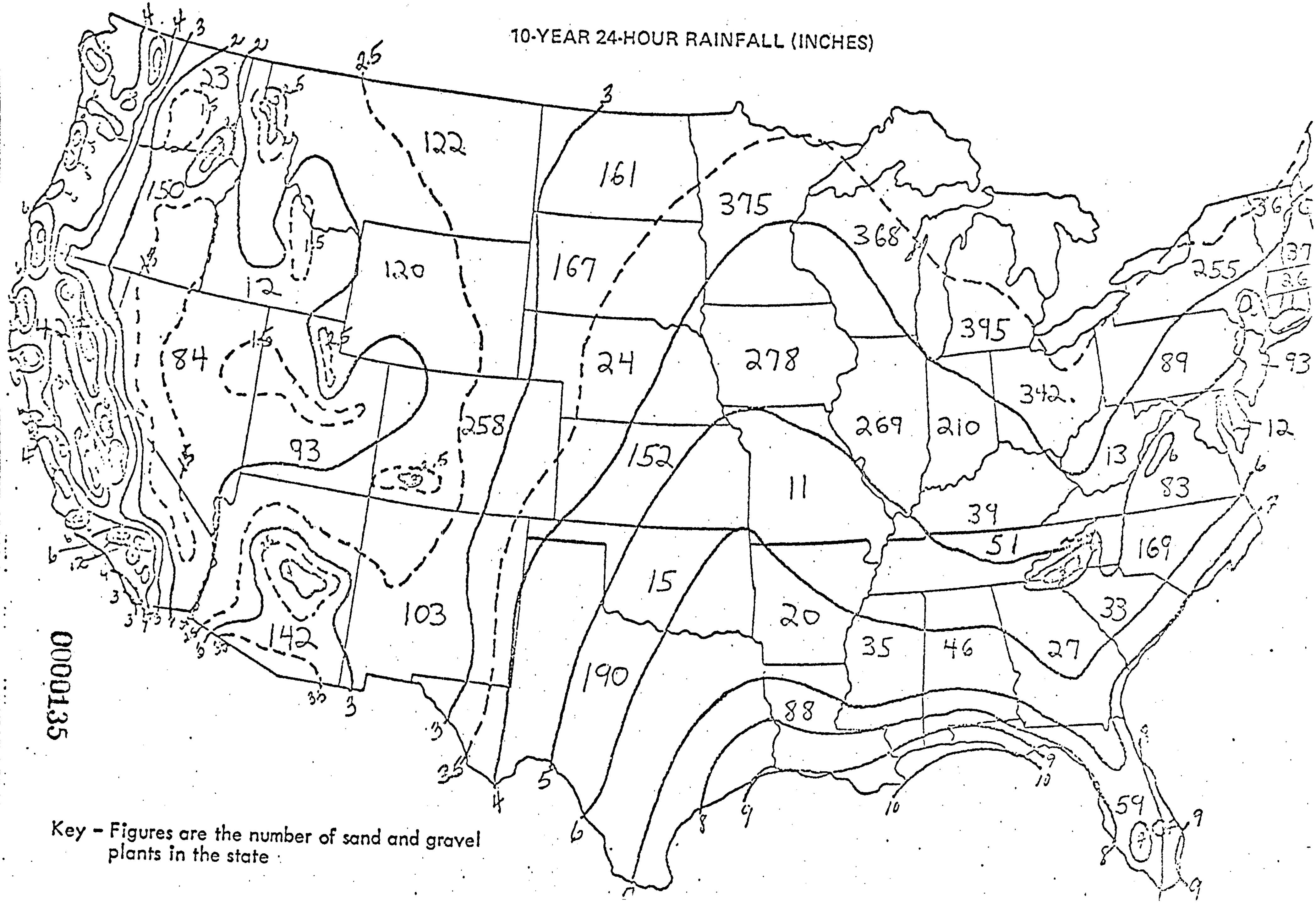
25-YEAR 24-HOUR RAINFALL (INCHES)



Key – Figures are the number of sand and gravel plants in the state

10-YEAR 24-HOUR RAINFALL (INCHES)



Key – Figures are the number of sand and gravel plants in the state

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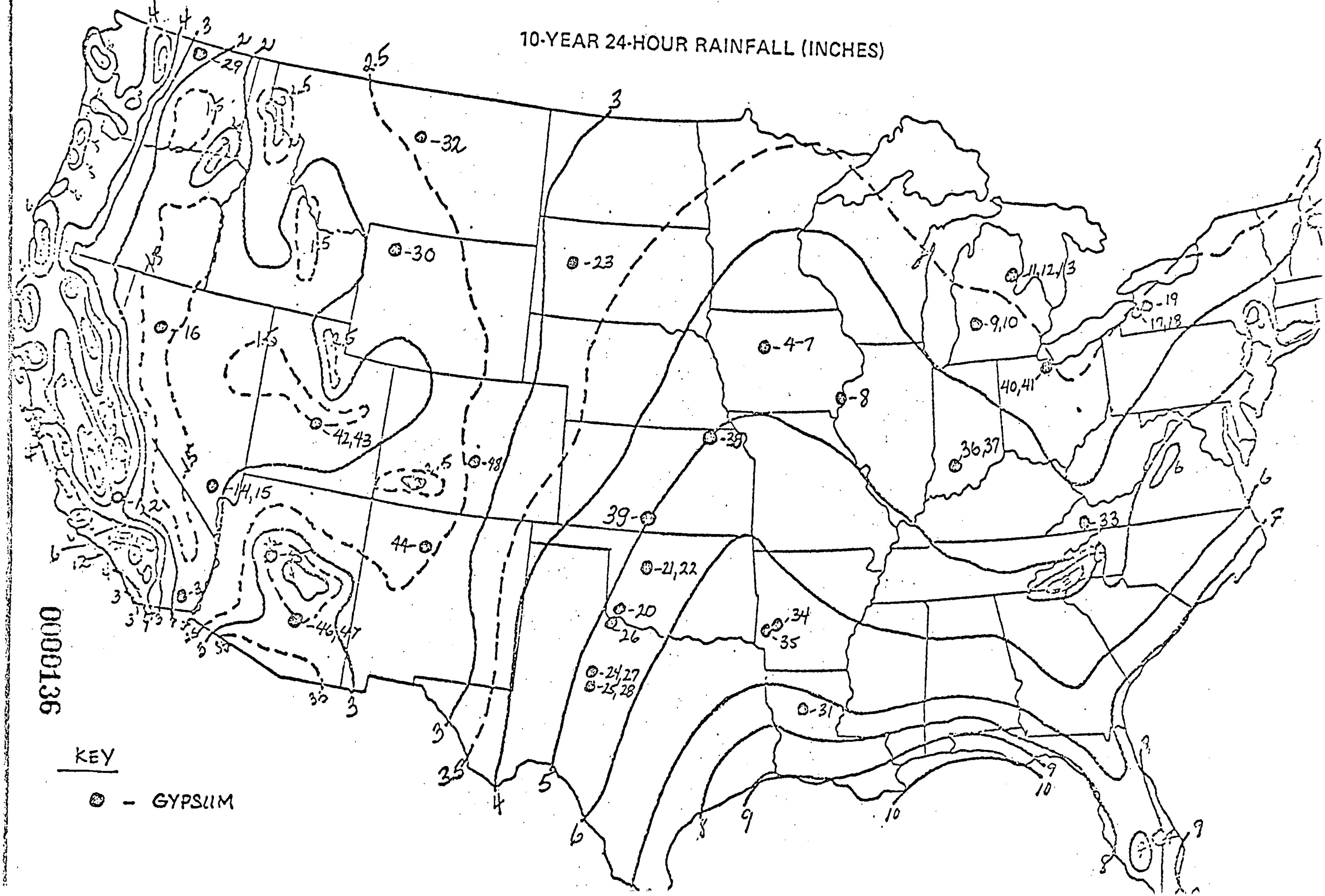
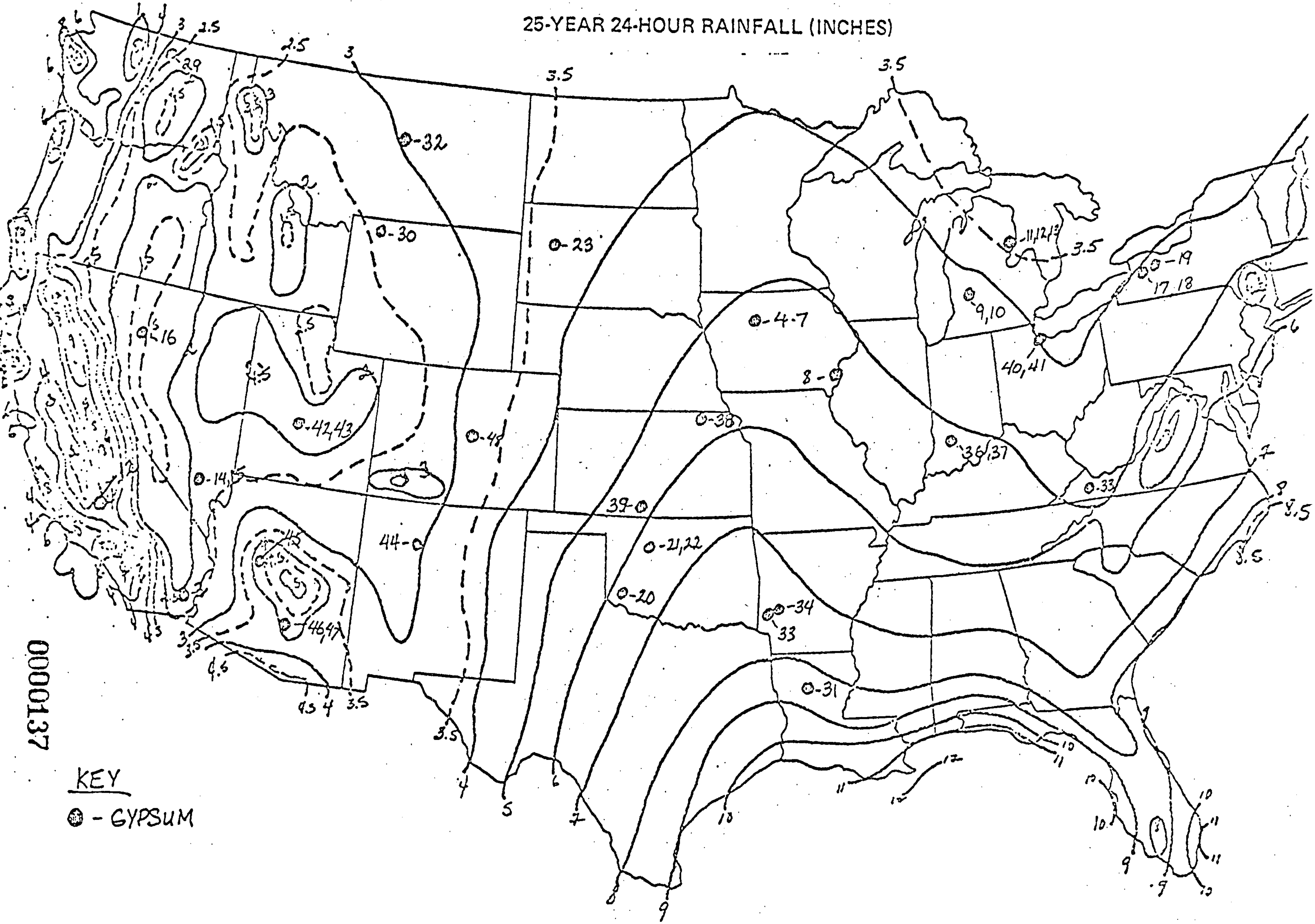
10-YEAR 24-HOUR RAINFALL (INCHES)



25-YEAR 24-HOUR RAINFALL (INCHES)

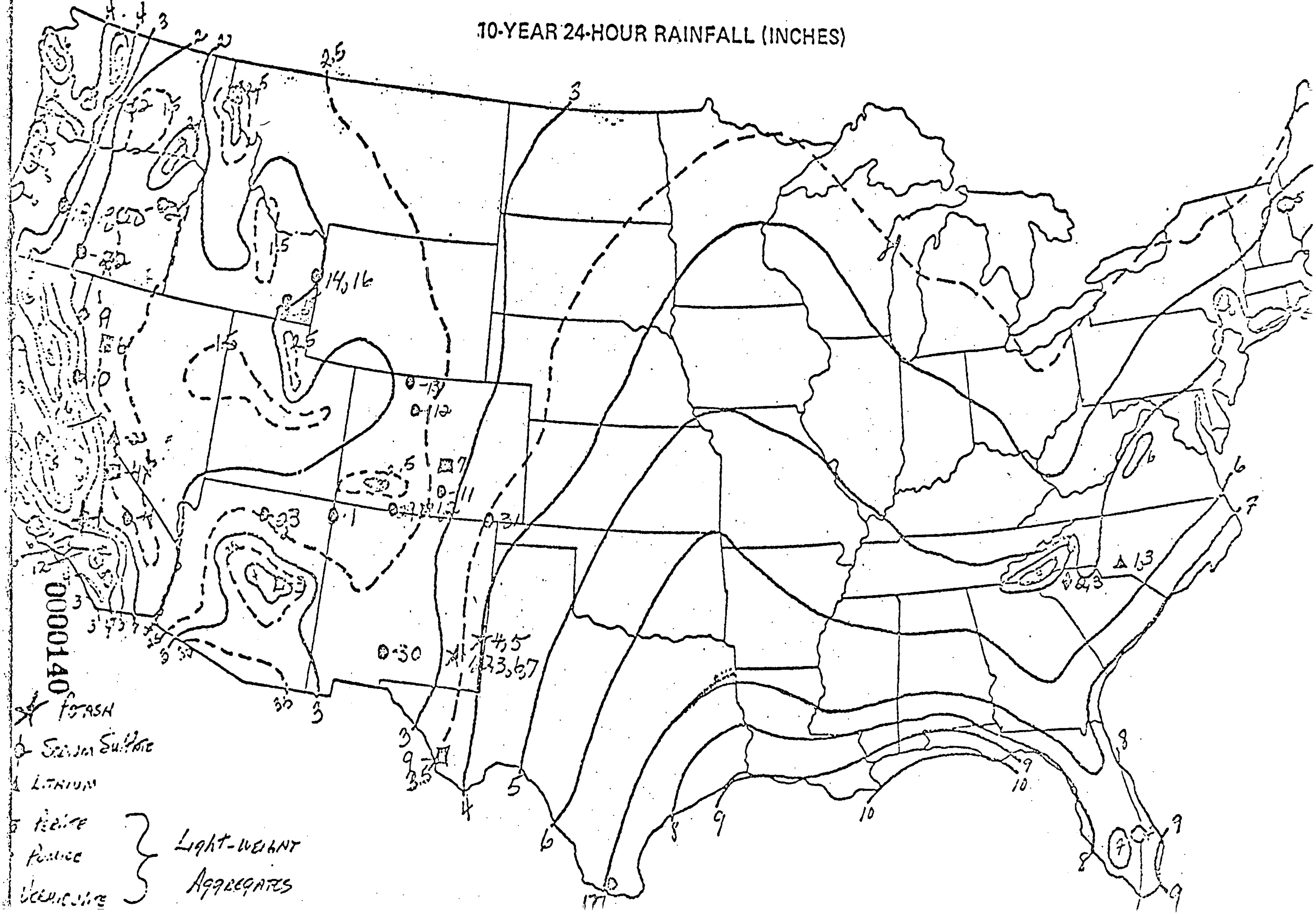


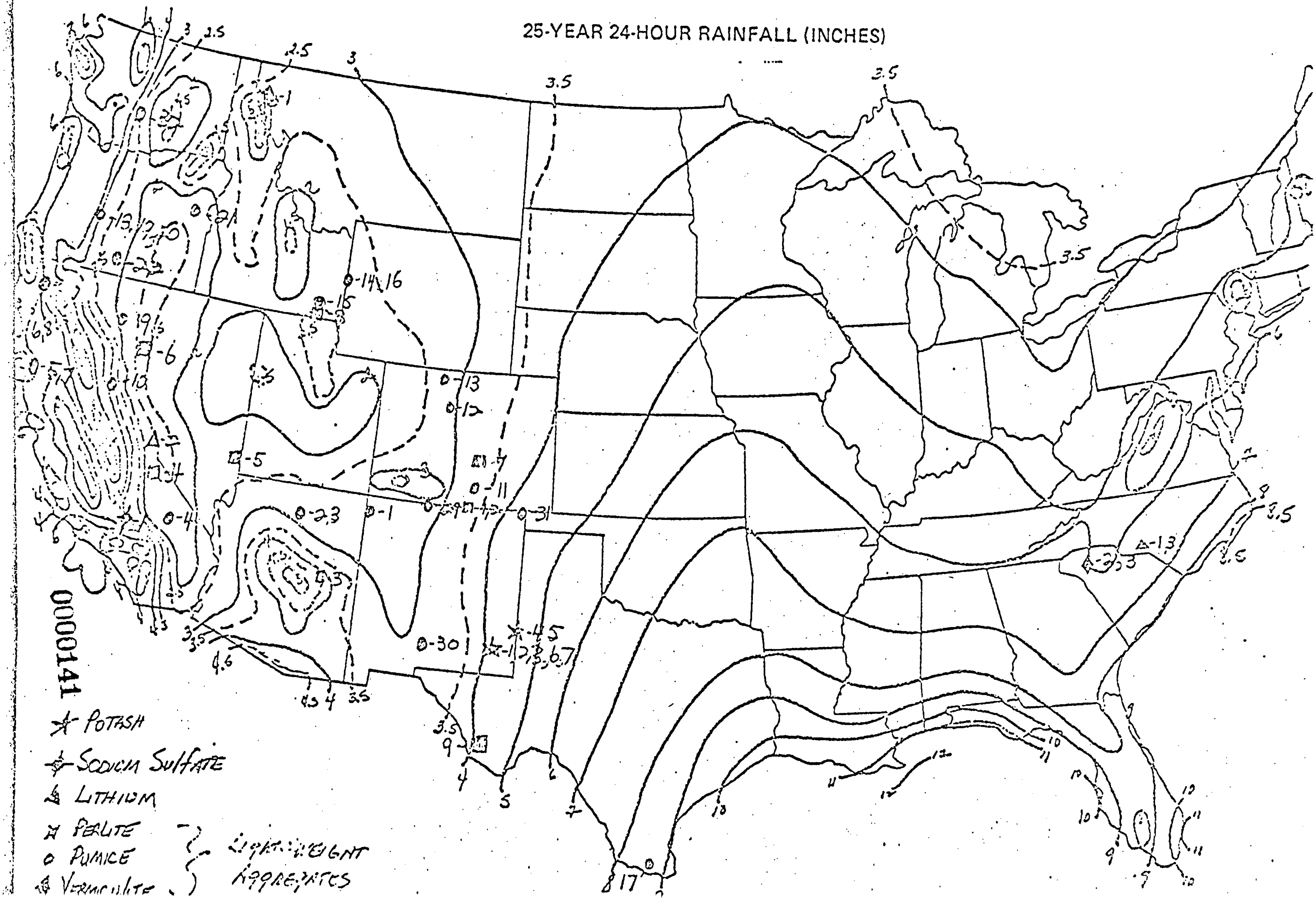
0000137

Gypsum

1.	H. M. Holloway, Inc.	Kern County, Calif.
2.	Temblor Gypsum Co.	Kern County, Calif.
3.	U. S. Gypsum	Imperial County, Calif.
4.	Celotex Corp.	Webster County, Iowa
5.	Ga-Pac Corp, Gypsum Div.	Webster County, Iowa
6.	National Gypsum Co.	Webster County, Iowa
7.	U. S. Gypsum	Webster County, Iowa
8.	U. S. Gypsum	Des Moines County, Iowa
9.	Ga-Pac Corp, Gypsum Div.	Kent County, Mich.
10.	Grand Rapids Gypsum Co.	Kent County, Mich.
11.	Michigan Gypsum Co.	Iosco County, Mich.
12.	National Gypsum Co.	Iosco County, Mich.
13.	U. S. Gypsum Co.	Iosco County, Mich.
14.	Flintkote Co.	Clark Co., Nev.
15.	Johns-Manville Products Corp.	Clark Co., Nev.
16.	U.S. Gypsum Co.	Pershing Co., Nev.
17.	Ga-Pac Corp., Gypsum Div.	Erie County, N. Y.
18.	National Gypsum Co.	Erie County, N. Y.
19.	U. S. Gypsum Co.	Genesee County, N. Y.
20.	Republic Gypsum Co.	Jackson County, Okla.
21.	U.S. Gypsum Co.	Blaine County, Okla.
22.	Univ. Atlas Cement, Div. of U.S. Steel	Blaine County, Okla.
23.	S.D. Cement Commission	Meade County, S. D.
24.	Celotex Corp.	Fisher County, Texas

25. Flintkote County	Nolan County, Texas
26. Ga-Pac Corp.	Hardeman County, Texas
27. National Gypsum Co.	Fisher County, Texas
28. U. S. Gypsum Co.	Nolan County, Texas
29. Agro Minerals Inc.	Okanogan County, Wash.
30. Big Horn Gypsum Co.	Park County, Wyo.
31. Winn Rock, Inc.	Winn County, La.
32. U.S. Gypsum Co.	Fergus County, Montana
33. U.S. Gypsum Co.	Washington County, Va.
34. Dulin Bauxite Co., Inc.	Pike County, Ark.
35. Weyerhaeuser Co.	Howard County, Ark.
36. National Gypsum Co.	Martin County, Ind.
37. U.S. Gypsum Co.	Martin County, Ind.
38. Ga-Pac Corp.	Marshall County, Kansas
39. National Gypsum Co.	Barber County, Kansas
40. Celotex Corp.	Ottawa County, Ohio
41. U.S. Gypsum Co.	Ottawa County, Ohio
42. Ga-Pac Corp.	Sevier County, Utah
43. U.S. Gypsum Co.	Sevier County, Utah
44. White Mesa Cypsum Co.	Sandoval County, N. M.
45. Superior County, Verde Div.	Yavapai County, Ariz.
46. Superior County, Winkelman Div.	Pinal County, Ariz.
47. National Gypsum Co.	Pinal County, Ariz.
48. Johns-Manville Products, Corp.	Fremont County, Colorado


10-YEAR 24-HOUR RAINFALL (INCHES)
Potash
Sodium Sulfate
Lithium
Perlite
Pumice
Vermiculite
LIGHT-WEIGHT AGGREGATES


25-YEAR 24-HOUR RAINFALL (INCHES)
POTASH
SODIUM SULFATE
LITHIUM
PERLITE
PUMICE
VERMICULITE
LIGHTWEIGHT AGGREGATES

Potash

1.	AMAX Chemical Corp.	Eddy County, New Mexico
2.	Duval Corporation	Eddy County, New Mexico
3.	IMC Corporation	Eddy County, New Mexico
4.	Kerr-McGee Corp.	Lea County, New Mexico
5.	National Potash Co.	Lea County, New Mexico
6.	Potash Co. of America, Div. of Ideal Basic Industries, Inc.	Eddy County, New Mexico
7.	Teledyne Potash	Eddy County, New Mexico

Brine processing

1.	Great Salt Lake Minerals & Chem. Corp.	Ogden, Utah
2.	Kaiser Aluminum & Chemical Corp.	Toole County, Utah
3.	Kerr-McGee Corp.	California

Solution Mining

1.	Texas Gulf, Inc.	Potash, Utah

Sodium Sulfate

1.	U.S. Borax & Chemical Corp.	Boron, California

Others are brine processing

Lithium

1.	Foote Mineral Co.	Kings Mountain, North Carolina
2.	Foote Mineral Co.	Silver Peak, Nevada
3.	Lithium Corporation of America	Bessemer City, North Carolina

Perlite

1.	Grefco, Inc., Dicalite Div.	Taos County, New Mexico
2.	Johns-Manville Perlite Corp.	Taos County, New Mexico
3.	Filters International, Inc.	Gila County, Arizona
4.	American Perlite Co.	Inyo County, California
5.	Delamar Perlite	Lincoln County, Nevada
6.	U.S. Gypsum Co.	Pershing County, Nevada
7.	Persolite Products, Inc.	Custer County, Colorado
8.	Oneida Perlite Corp.	Oneida County, Idaho
9.	Texas American Sulphur Co.	Presidio County, Texas

Pumice

1.	Apache Co., Hwy. Dept.	Apache County, Arizona
2.	Atchison Topeka & Santa Fe Railway	Coconino County, Arizona
3.	Superlite Builders Supply, Inc.	Coconino County, Arizona
4.	Aiken Builders Products	San Bernardino, California
5.	Cinder Products Co.	Lake County, California
6.	Glass Mountain Block, Inc.	Siskiyou County, California
7.	Red Lava Products of California	Lake County, California
8.	Shastalite Cinder Co.	Siskiyou County, California
9.	Rilite Aggregate Co.	Washoe County, Nevada
10.	Savage Construction Co., Inc.	Carson City County, Nevada
11.	Colorado Aggregate Co., Inc.	Costilla County, Colorado
12.	Dotsero Block Co., Inc.	Eagle County, Colorado
13.	McCoy Aggregate Co.	Routt County, Colorado
14.	AmCor, Inc.	Bonneville County, Idaho
15.	Hess Pumice Products	Oneida County, Idaho
16.	Producers Pumice	Bonneville County, Idaho
17.	Rio Clay Products	Starr County, Texas
18.	Central Oregon Pumice Co.	Deschutes County, Oregon
19.	Graystone Corp	Deschutes County, Oregon
20.	Chester Hiatt	Deschutes County, Oregon
21.	Oregon Portland Cement Co.	Baker County, Oregon
22.	Jed Wilson & Son	Lake County, Oregon

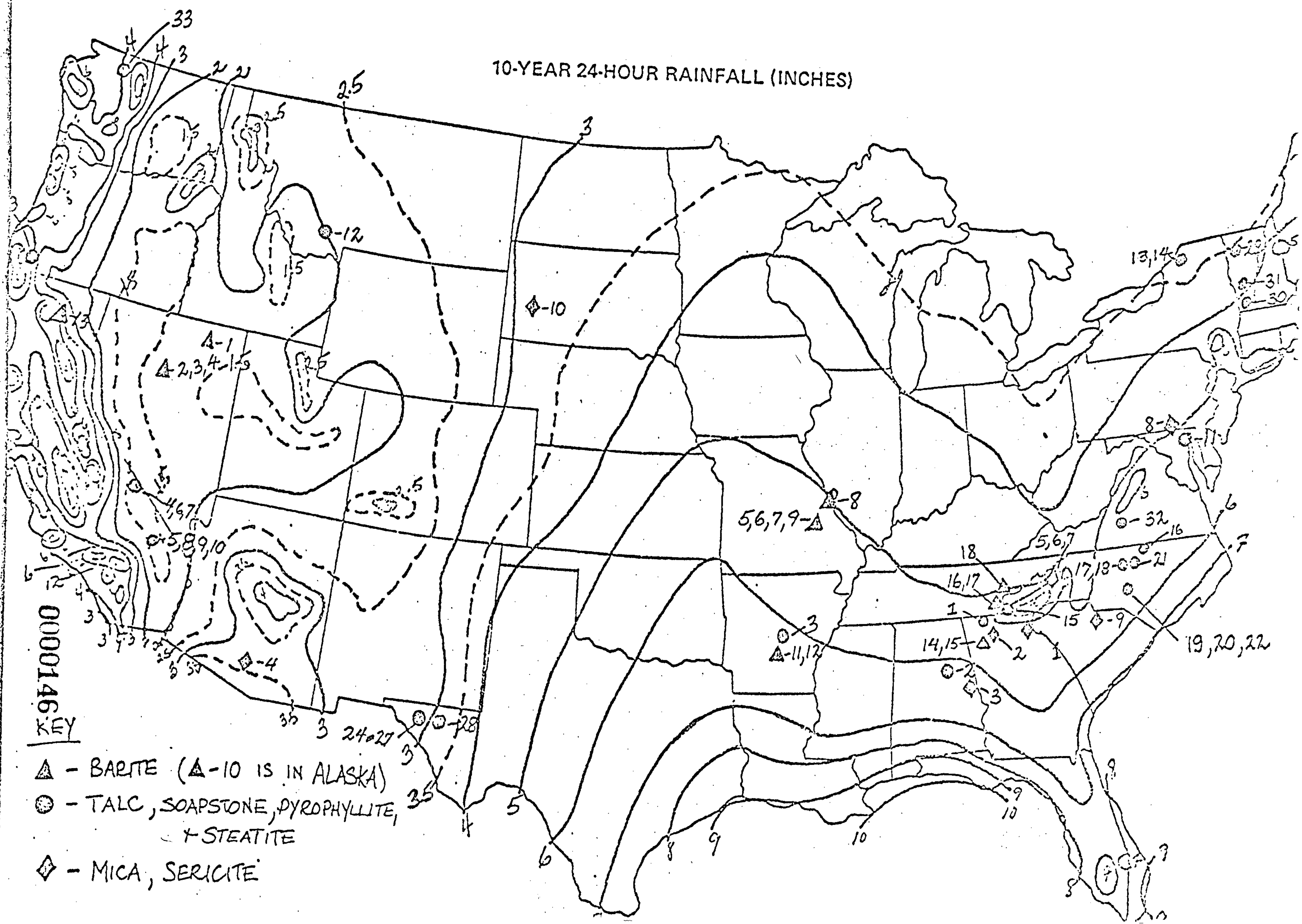
Pumice (continued)

23.	Fong Construction Co., Ltd.	Maui Island
24.	H C & D, Ltd.	Molokai Island
25.	James Kuwana	Hawaii
26.	Hilo Coast Processing Co.	Hawaii Island
27.	Lopahoehoe Sugar Co.	Hawaii Island
28.	Volcanite, Ltd.	Hawaii Island
29.	General Pumice Corp.	Rio Arriba County, New Mexico
30.	Morton Bros.	Dona Ana County, New Mexico
31.	Twin Mountain Rock Co.	Union County, New Mexico
32.	W. L. Marenakos County	Kittitas County, Washington

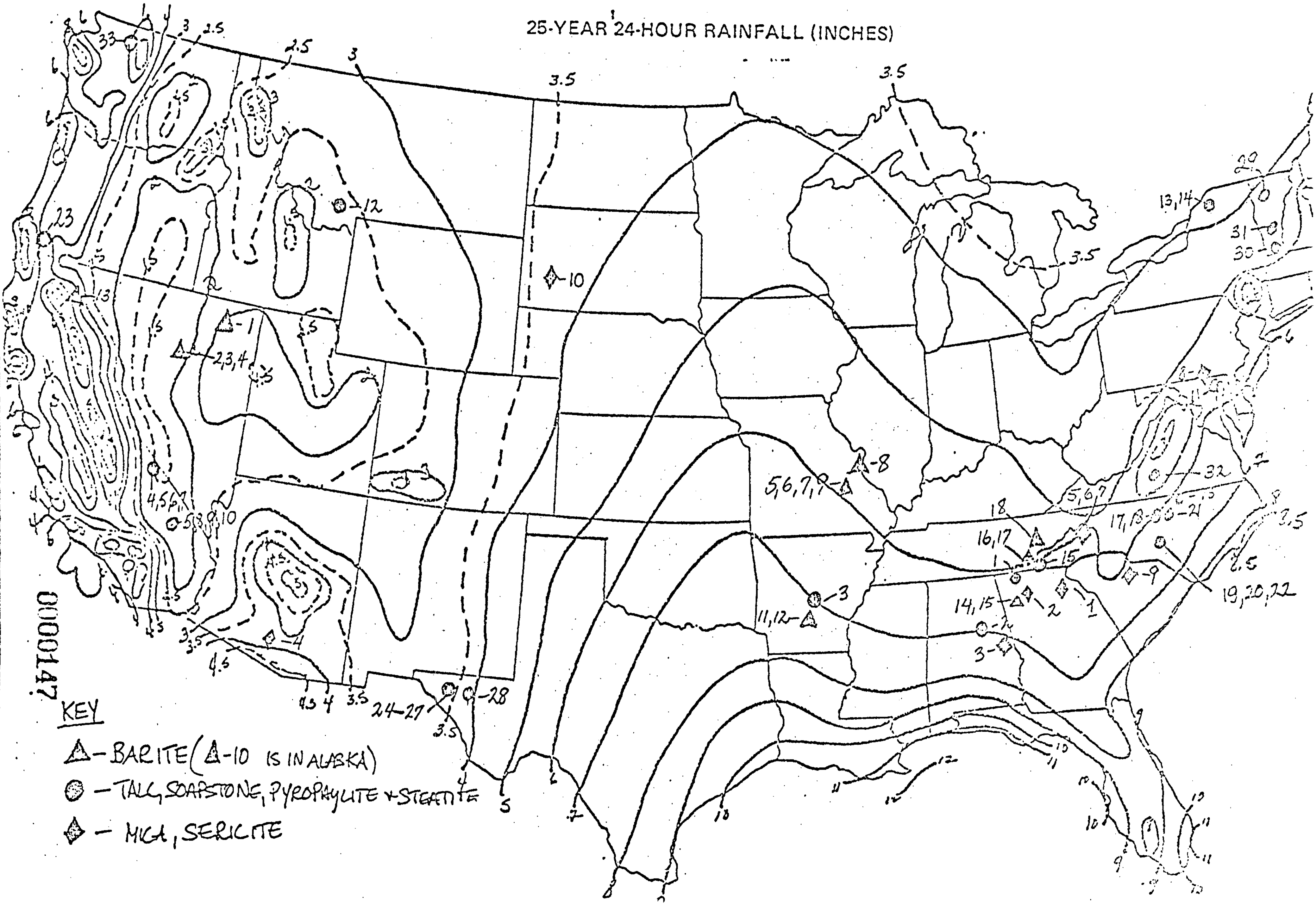
Vermiculite

1.	W. R. Grace & Co.	Libby, Montana
2.	W. R. Grace & Co.	Enoree, South Carolina
3.	Patterson Vermiculite Co.	Lanford, South Carolina

10-YEAR 24-HOUR RAINFALL (INCHES)



25-YEAR 24-HOUR RAINFALL (INCHES)



Barite

1.	Baroid Div., N.L. Industries Inc.	Elko County, Nev.
2.	Dresser Mineral Div., Dresser Industries Inc.	Lander County, Nev.
3.	FMC Corporation	Lander County, Nev.
4.	Milchem, Inc., Mineral Div.	Lander County, Nev.
5.	Dresser Minerals Div.	Washington County, Mo.
6.	Milchem, Inc.	Washington County, Mo.
7.	N.L. Industries Inc., Baroid Div.	Washington County, Mo.
8.	N.L. Industries Inc., DeLore Div.	St. Louis County, Mo.
9.	Pfizer & Co.	Washington County, Mo.
10.	Alaska Barite Co.	Southeastern Alaska
11.	Dresser Minerals	Hot Springs County, Ark.
12.	N. L. Industries, Inc.	Hot Springs County, Ark.
13.	Industrial Minerals Co.	Shasta County, Calif.
14.	New Riverside Ochre Co.	Cartersville, Ga.
15.	Paga Mining Co., Div. Thompson-Weirman & Co.	Cartersville, Ga.
16. & 17.	N. L. Industries Inc., Baroid Div.	Monroe County, Tenn.
18.	B. C. Wood	Louden County, Tenn.

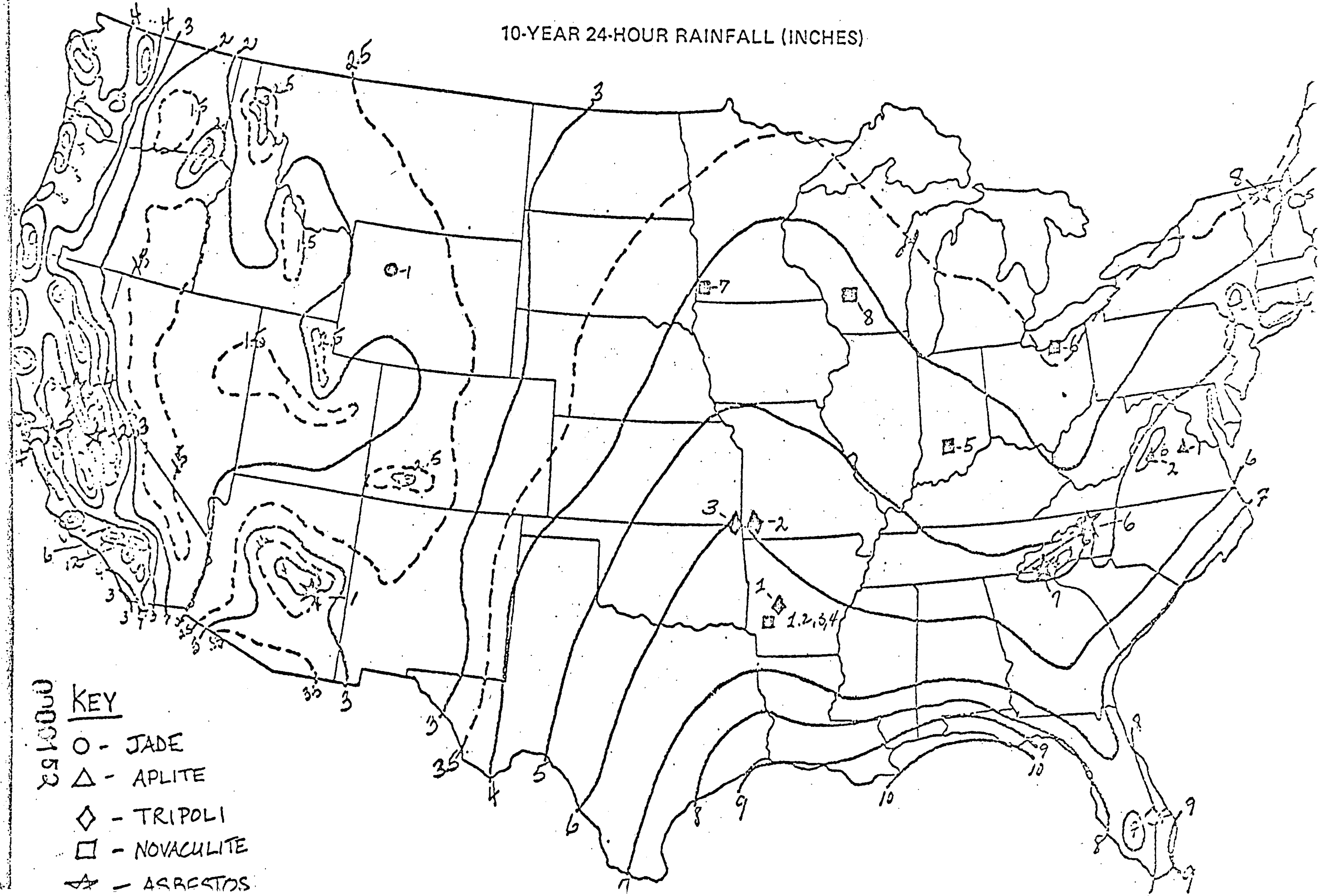
Talc, Pyrophyllite, Soapstone, Steatite

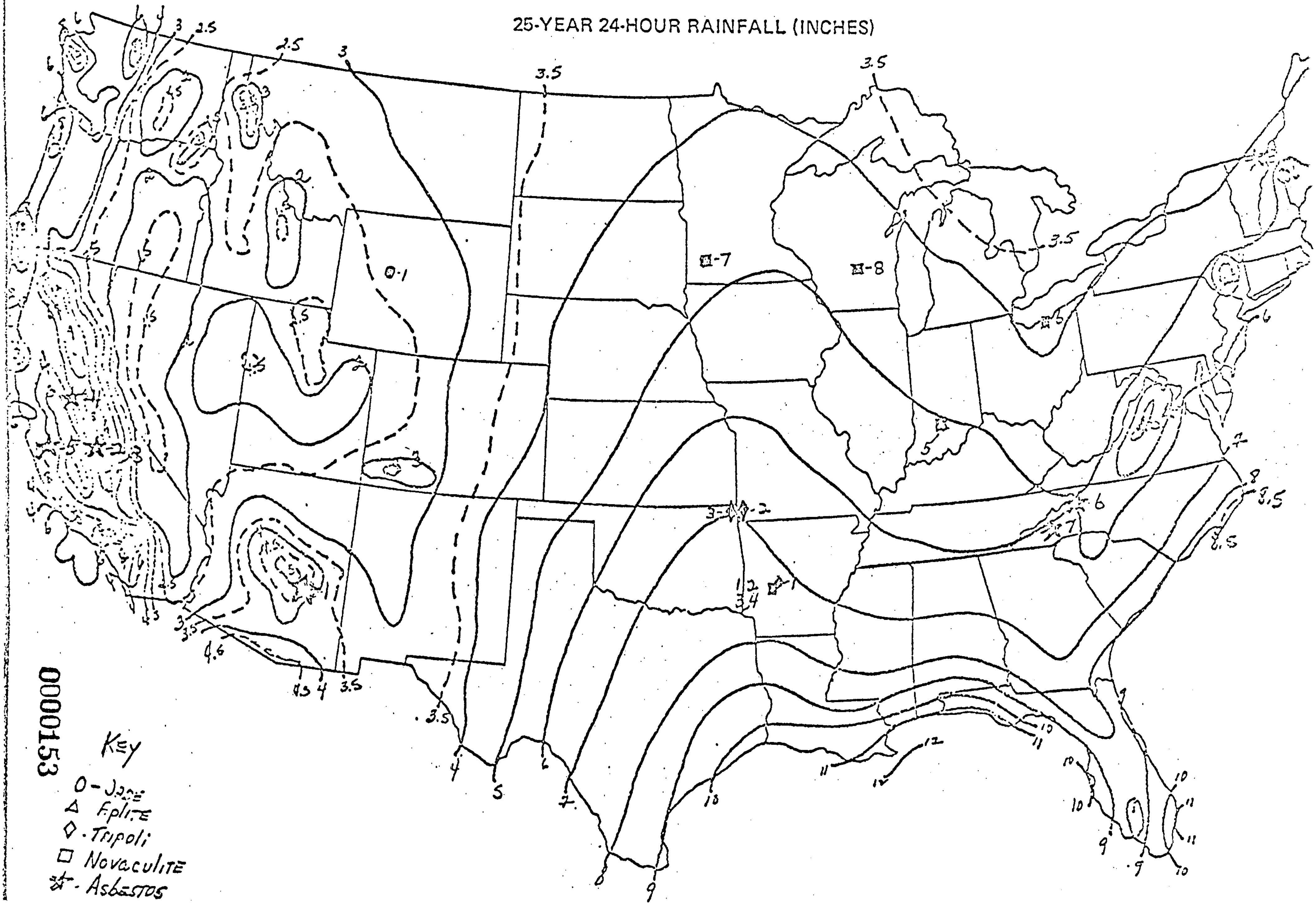
1.	Southern Talc Co.	Murray County, Ga.
2.	American Talc Co.	Alpine, Ala.
3.	The Milwhite Co., Inc.	Saline County, Ark.
4.	Cyprus Mines Corp.	Inyo County, Calif.
5.	Cyprus Mines Corp.	San Bernardino County, Calif.
6.	L.Grantham Corp.	Inyo County, Calif.
7.	Minerals, Pigments & Metals Div., Pfizer, Inc.	Inyo County, Calif.
8.	Minerals, Pigments & Metals Div., Pfizer, Inc.	San Bernardino County, Calif.
9.	Pomona Tile Mfg., Co. (Div. of America Olean)	San Bernardino County, Calif.
10.	Western Talc Co.	San Bernardino County, Calif.
11.	Harford Talc Co.	Harford County, Md.
12.	Pfizer, Inc.	Madison County, Montana
13.	Governeur Tacl Co. Inc.	St. Lawrence County, N. Y.
14.	International Talc Co. Inc.	St. Lawrence County, N. Y.
15.	Hitchcock Corp.	Cherokee County, N. C.
16.	Boren & Harvey Inc.	Granville County, N. C.
17. & 18	Glendon Pyrophyllite	Alamance County, N. C.
19. & 20	Glendon Pyrophyllite	Moore County, N. C.
21	Piedmont Minerals Co. Inc.	Orange County, N. C.

22.	Standard Minerals Co., Inc.	Moore County, N. C.
23.	John H. Pugh	Josephine County, Oregon
24.	Pioneer Talc Co. Inc.	Hudspeth County, Texas
25.	Southern Clay Products Inc.	Hudspeth County, Texas
26.	Texas Talc Co.	Hudspeth County, Texas
27.	U.S. Sierra Div., Cyprus Mines Corp.	Hudspeth County, Texas
28.	Westex Talc Co.	Hudspeth County, Texas
29.	Eastern Magnesia Talc Co.	LaMoille County, Vt.
30.	Vermont Talc Co.	Windham County, Vt.
31.	Windsor Materials Inc.	Windsor County, Vt.
32.	Blue Ridge Talc Co. Inc.	Franklin County, Va.
33.	Western Minerals Inc.	Skagit County, Wash.

Mica & Sericite

1.	Franklin Mineral Products Co.	Hart County, Ga.
2.	Thompson-Weirman & Co.	Cherokee County, Ga.
3.	U. S. Gypsum Co.	Randolph County, Ala.
4.	San Antonio Mica Co.	Pina County, Arizona
5.	Deneen Mica Co. Inc.	Yancey County, N. C.
6. & 7.	Harris Mining Co.	Mitchell County, N. C.
8.	Micalith Mining Co. Inc.	York County, Penna.
9.	The Mineral Mining Corp.	Lancaster County, S. C.
10.	L. W. Judson	Pennington County, S. D.


10-YEAR 24-HOUR RAINFALL (INCHES)
KEY
O - JADE
△ - APLITE
◇ - TRIPOLI
□ - NOVACULITE
☆ - ASBESTOS



25-YEAR 24-HOUR RAINFALL (INCHES)

Jade

1.	Majestic Jade Company	Riverton, Wyoming

Aplite

1.	Feldspar Corp.	Montpelier, Virginia
2.	IMC Corp.	Piney River, Virginia

Tripoli

1.	Malvern Minerals Co.	Garland County, Arkansas
2.	Carborundum Company	Newton County, Missouri
3.	Carborundum Company	Ottawa County, Oklahoma

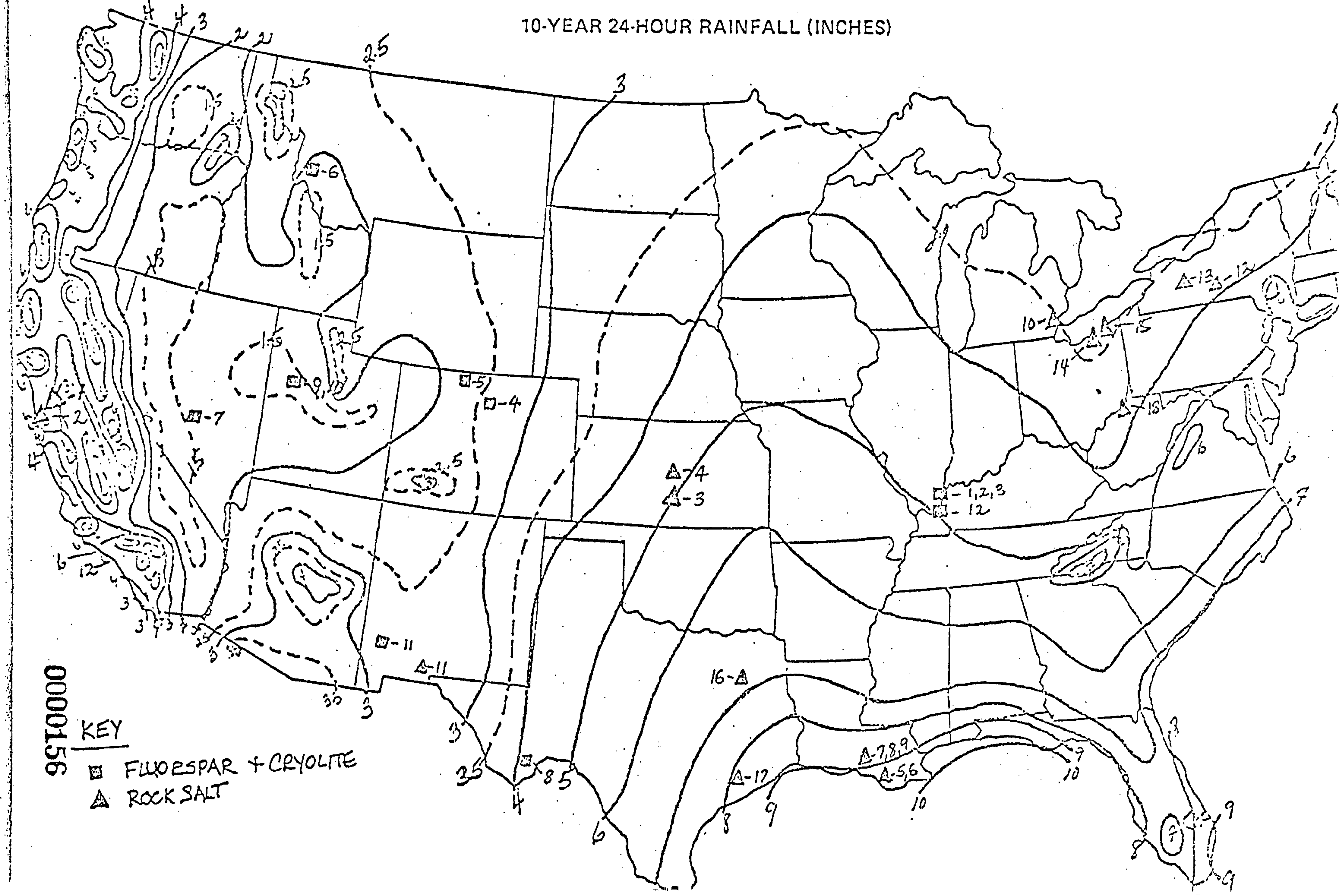
Novaculite

1.	Arkansas Abrasives, Inc.	Garland County, Arkansas
2.	Arkansas Oilstones Co., Inc.	Garland County, Arkansas
3.	John O. Glassford, Cleve Milroy, M.V. Smith, Hiram A. Smith Whetstone Co.	Garland County, Arkansas
4.	Norton Pike Division	Garland County, Arkansas
5.	Hindostan Whetstone Co.	Orleans, Indiana
6.	Cleveland Quarries Co.	Amherst, Ohio
7.	Jasper Stone Co.	Jasper, Minnesota
8.	Baraboo Quartzite Co., Inc.	Souk County, Wisconsin

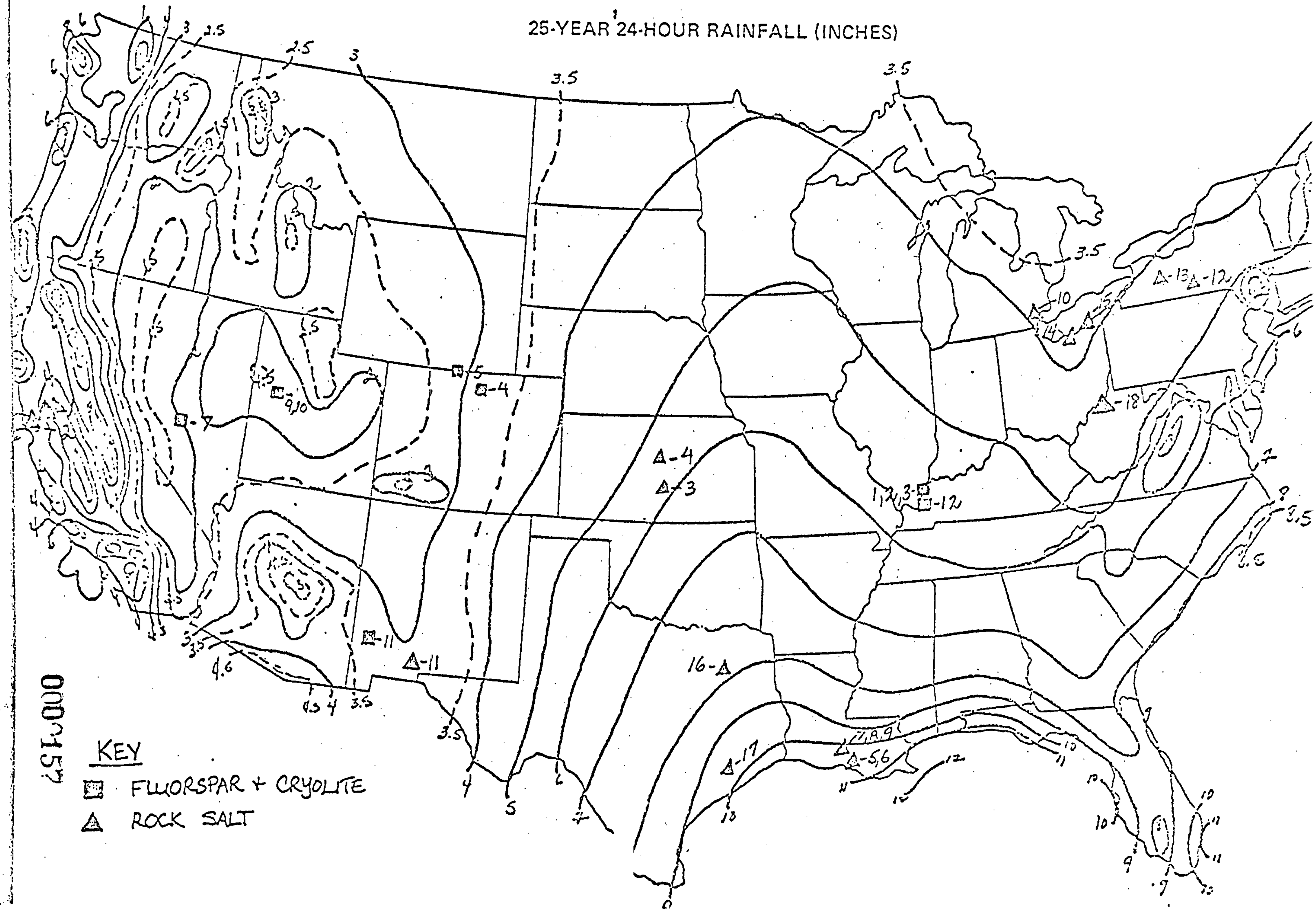
Asbestos (Wollastonite)

1.	Jaquays Mining Corp.	Gila County, Arizona
2.	Atlas Asbestos Corp.	Fresno County, California
3.	Coalinga Asbestos Co., Inc.	Fresno County, California
4.	Pacific Asbestos Corp.	Calaveras County, California
5.	Union Carbide Corp.	San Benito County, California
6.	Powhatan Mining Co.	Yancey County, North Carolina
7.	Powhatan Mining Co.	Jackson County, North Carolina
8.	Vermont Asbestos Group, Inc. formerly GAF	Orleans County, Vermont

10-YEAR 24-HOUR RAINFALL (INCHES)



25-YEAR 24-HOUR RAINFALL (INCHES)



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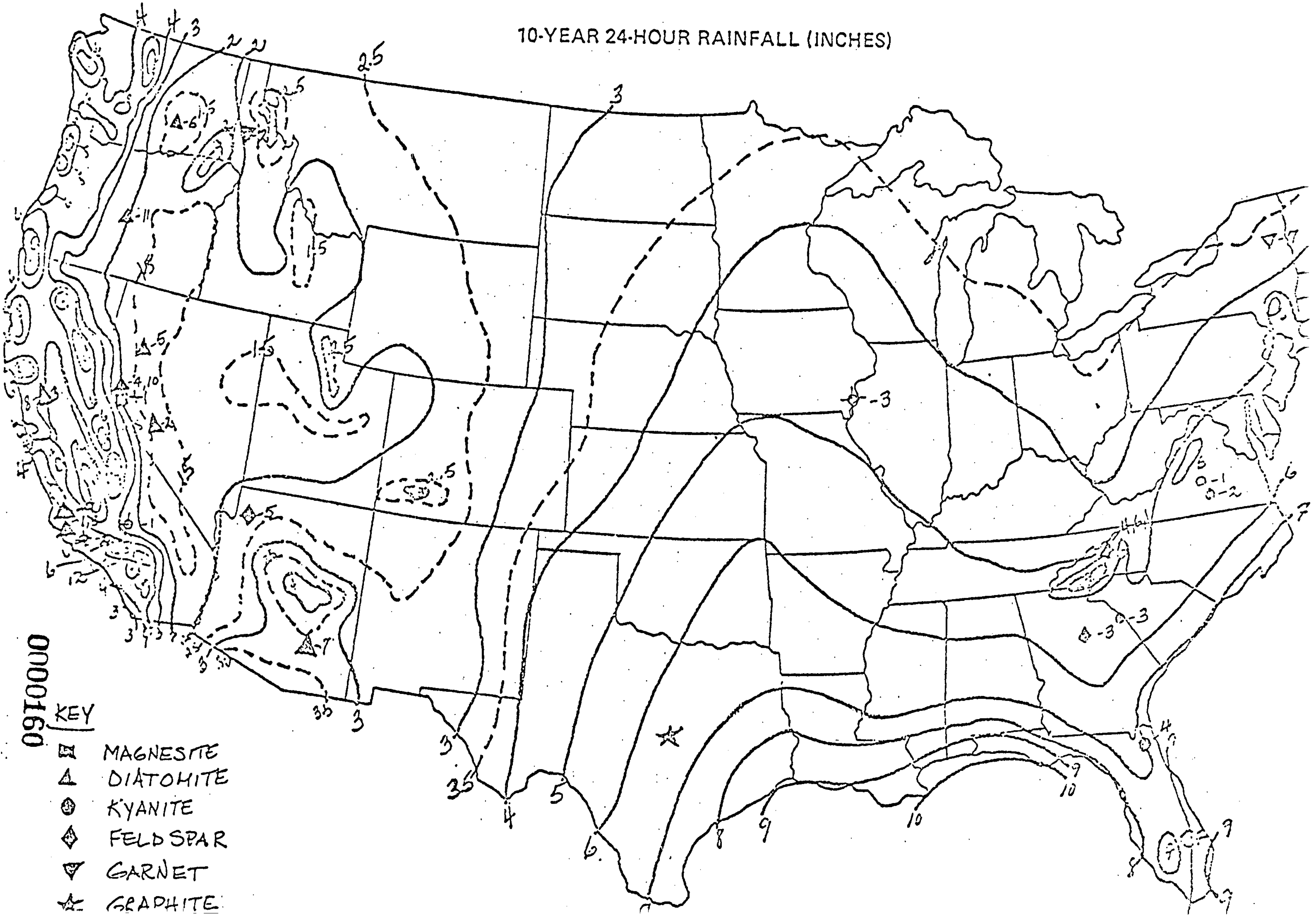
Fluorspar and Cryolite

1.	Minerva Co., Mining Div. Minerva Oil Co., Crystal Group	Hardin County, Ill.
2.	Minerva Oil Co., Minerva No. 1	Hardin County, Ill.
3.	Ozark-Mahoning Co.	Hardin County, Ill.
4.	Allied Chemical Corp., Industrial Chemicals Div.	Boulder County, Col.
5.	Ozark-Mahoning Co.	Jackson County, Col.
6.	Roberts Mining Co.	Ravalli County, Montana
7.	J. Irving Crowell, Jr.	Nye County, Nev.
8.	D & F Minerals Co.	Brewster County, Texas
9.	Spor Brothers	Juab County, Utah
10.	Wilden Fluorspar Co.	Juab County, Utah
11.	Southwest Fluorspar Co.	Grant County, N. M.
12.	Calvert City Chemical Co.	Crittenden County & Livingston County, Ky.

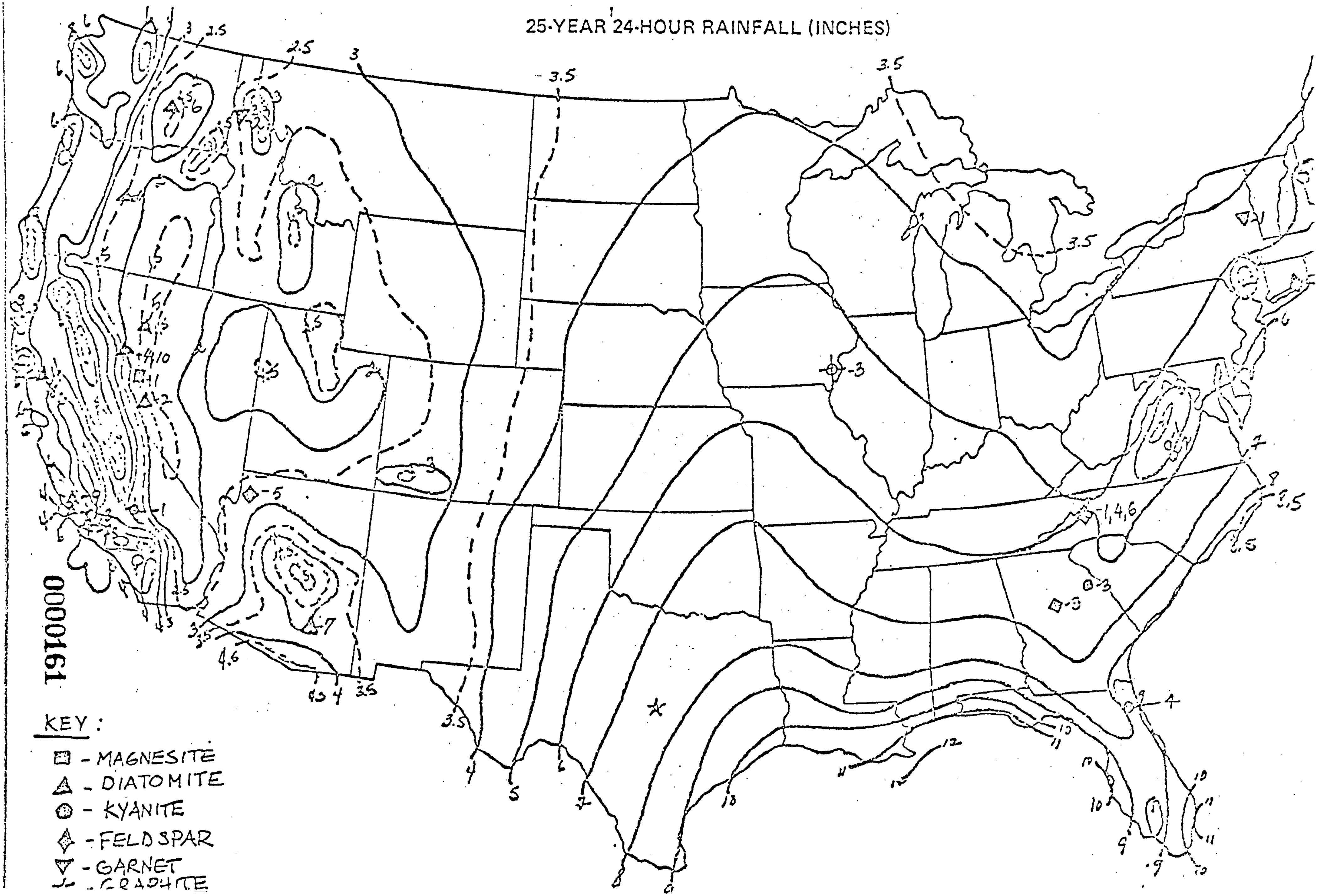
Rock Salt

1.	Leslie Salt Co.	Alameda County, Calif.
2.	Leslie Salt Co.	San Mateo County, Calif.
3.	Carey Salt Co.	Reno County, Kansas
4.	Independent Salt Co.	Ellsworth County, Kansas
5.	Carey Salt Co.	St. Mary County, La.
6.	Cargill, Inc.	St. Mary County, La.
7.	Diamond Crystal Salt Co. Jefferson Island Div.	Iberia County, La.
8.	International Salt Co., Avery Mine & Refinery	Iberia County, La.
9.	Morton Salt Co.	Iberia County, La.
10.	International Salt Co., Inc.	Wayne County, Mich.
11.	Morton Brothers	Dona Ana County, N. M.
12.	Cayuga Rock Salt Co. Inc.	Tompkins County, N. Y.
13.	International Salt Co.	Livingston County, N. Y.
14.	International Salt Co.	Cuyahoga County, Ohio
15.	Morton Salt Co.	Lake County, Ohio
16.	Morton Salt Co.	Van Zandt County, Texas
17.	United Salt Corp.	Fort Bend County, Texas
18.	Inorganic Chemical Div., FMC Corp.	Tyler County, W. Va.

10-YEAR 24-HOUR RAINFALL (INCHES)



25-YEAR 24-HOUR RAINFALL (INCHES)



Magnesite

1.	Basic Inc.	Gabbs, Nev.

Diatomite

1.	Johns-Manville Products	Lompoc, Calif.
2.	Grefco Inc.,	Mina, Nev.
3.	Grefco Inc.	Lompoc, Calif.
4.	Eagle-Picher Industries Inc.	Sparks, Nev.
5.	Eagle-Picher Industries Inc.	Lovelock, Nev.
6.	Kenite Corp., Div. of Whitco Chemical Corp.	Quincy, Wash.
7.	Superior Co.	San Manuel, Ariz.
8.	Basalt Rock Co.	Napa, Calif.
9.	Airox, Inc.	Santa Maria, Calif.
10.	United Sierra Div., Cyprus Mines Corp.	Fernley, Nev.
11.	A.M. Matlock	Christmas Valley, Ore.

Kyanite

1.	Kyanite Mining Corp.	Buckingham County, Va.
2.	Kyanite Mining Corp.	Prince Edward County, Va.
3.	C-E Minerals	Lincoln County, Ga.
4.	E.I. duPont de Nemours & Co. Inc.	Clay County, Fla.

Feldspar

1.	Feldspar Corp.	Mitchell County, N. C.
2.	Feldspar Corp.	Middlesex County, Conn.
3.	Feldspar Corp.	Jasper County, Ga.
4.	I.M.C. Corp.	Mitchell County, N. C.
5.	I.M.C. Corp.	Mohave County, Ariz.
6.	Lawson-United Feldspar & Minerals	Mitchell County, N. C.

Garnet

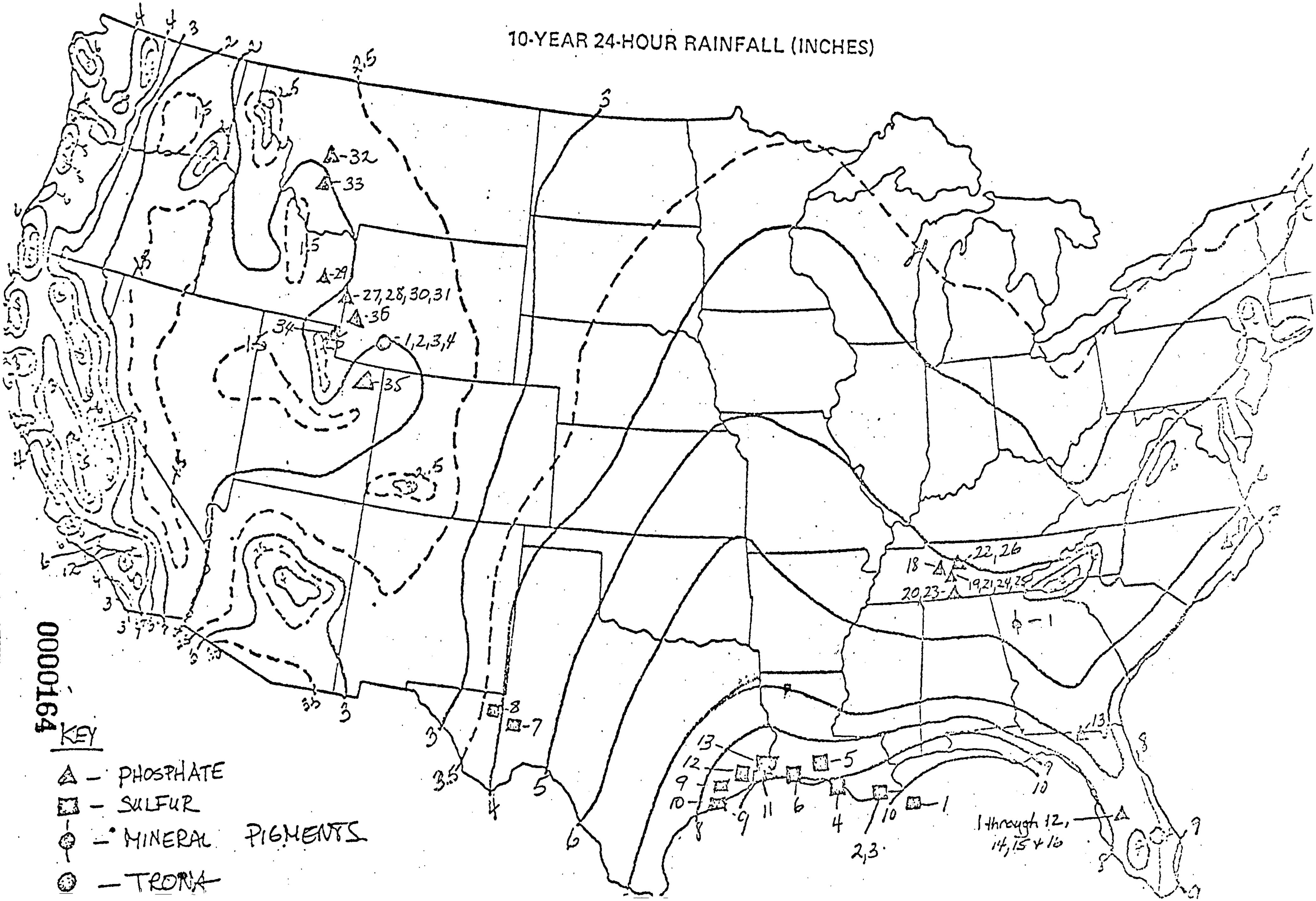
1.	Barton Mines	Warren County, N. Y.
2.	Idaho Garnet Abrasives	Benewah County, Idaho

Graphite

1.	Southwestern Graphite	Burnet, Texas

Borax

1.	U.S. Borax & Chemical Corp.	Boron, Kern City, Calif.
2.	U.S. Borax & Chemical Corp.	Wilmington, Calif.
3.	U.S. Borax & Chemical Corp.	Burlington, Iowa


10-YEAR 24-HOUR RAINFALL (INCHES)
KEY
PHOSPHATE
SULFUR
MINERAL PIGMENTS
TRONA
32
33
29
27,28,30,31
36
34
1,2,3,4
35
18
22,26
19,21,24,25
20,23
13
5
12
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11
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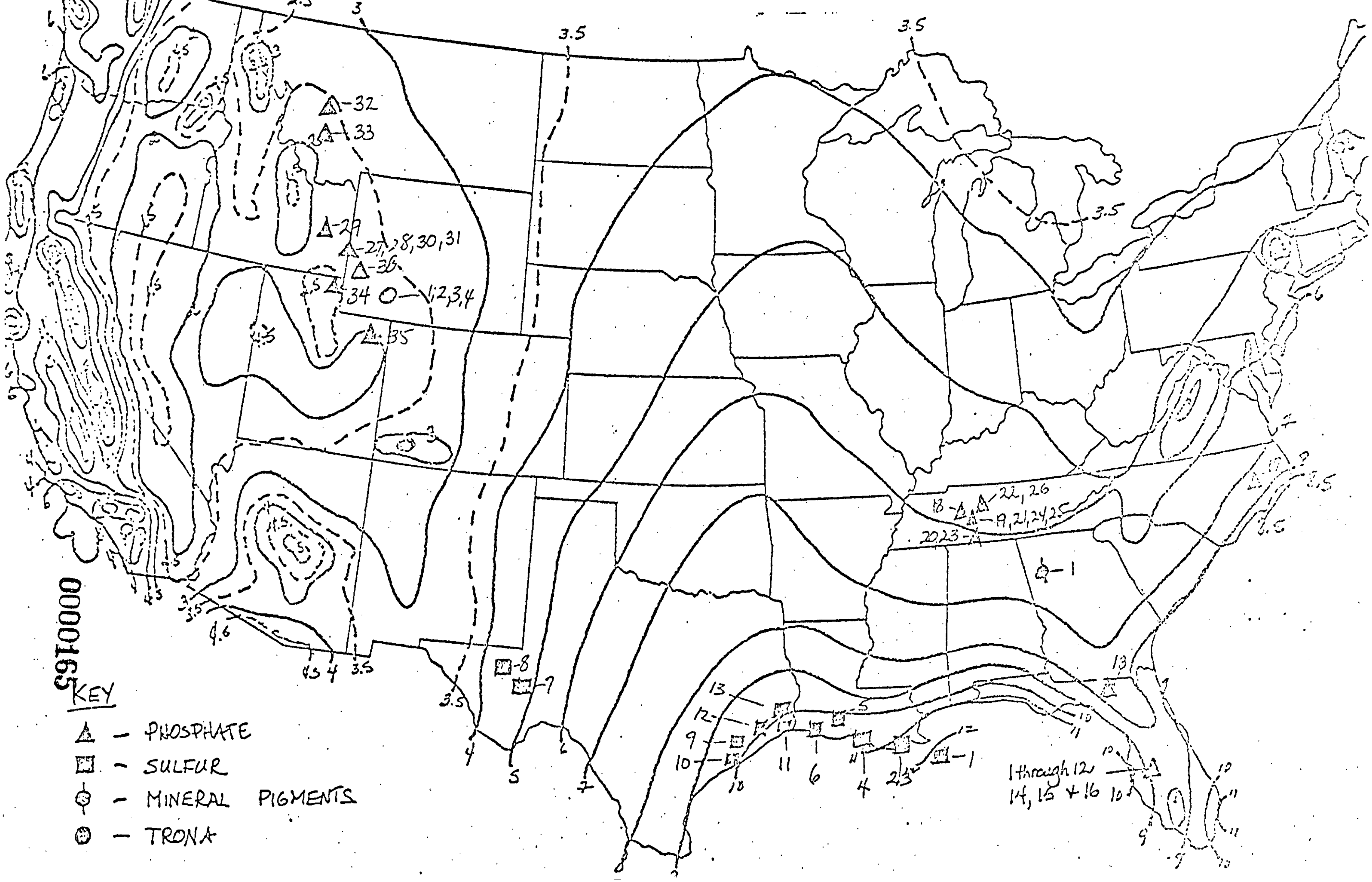
4
2,3
1
8
7
1 through 12, 14,15 & 16

25-YEAR 24-HOUR RAINFALL (INCHES)



Phosphate Rock

1.	Agrico Chemical Company	Polk County, Florida
2.	Agrico Chemical Company	Polk County, Florida
3.	Agrico Chemical Co.	Polk County, Florida
4.	Borden, Inc.	Polk County, Florida
5.	Brewster Phosphates	Polk County, Florida
6.	Cities Service Co.	Polk County, Florida
7.	W. R. Grace & Co.	Polk County, Florida
8.	IMC Corp.	Polk County, Florida
9.	IMC Corp.	Polk County, Florida
10.	IMC Corp.	Polk County, Florida
11.	Mobil Oil Corp., Chemical Div.	Polk County, Florida
12.	Mobil Oil Corp., Chemical Div.	Polk County, Florida
13.	Occidental Petroleum Corp.	Hamilton County, Florida
14.	Swift Agri. Chem. Corp.	Polk County, Florida
15.	Swift Agri. Chem. Corp.	Polk County, Florida
16.	U.S.S. Agri-Chemicals, Inc.	Polk County, Florida
17.	Texas Gulf, Inc.	Beaufort, N.C.
18.	Hooker Chem. Corp.	Hickman County, Tennessee
19.	Hooker Chem. Corp.	Maury County, Tennessee
20.	Monsanto Co.	Giles County, Tennessee
21.	Monsanto Co.	Maury County, Tennessee
22.	Monsanto Co.	Williamson County, Tennessee

Phosphate Rock (continued)

23. Stauffer Chemical Co.	Giles County, Tennessee
24. Stauffer Chemical Co.	Maury County, Tennessee
25. Tennessee Valley Authority	Maury County, Tennessee
26. Tennessee Valley Authority	Maury County, Tennessee
27. Agri. Products Corp.	Caribou, Idaho
28. Monsanto Co.	Caribou, Idaho
29. J.R. Simplot Co.	Bingham County, Idaho
30. J.R. Simplot Co.	Caribou, Idaho
31. Stauffer Chemical Co.	Caribou, Idaho
32. Cominco American, Inc.	Powell County, Montana
33. Stauffer Chem. Co.	Silver Bow County, Montana
34. Stauffer Chem. Co.	Rich County, Utah
35. Stauffer Chem. Co.	Vintah County, Utah
36. Stauffer Chem. Co.	Lincoln County, Wyoming

Sulfur

1.	Freeport Minerals Co.	Garden Island Bay, Louisiana
2.	Freeport Minerals Co.	Grande Isle, Louisiana
3.	Freeport Minerals Co.	Grande Ecaille, Louisiana
4.	Freeport Minerals Co.	Lake Pelto, Louisiana
5.	Jefferson Lake Sulfur Co.	Lake Hermitage, Louisiana
6.	Texas Gulf	Bully Camp, Louisiana
7.	Atlantic Richfield Co.	Ft. Stockton, Texas
8.	Duval Corp.	Pecos, Texas
9.	Jefferson Lake Sulfur Co.	Needville, Texas
10.	Texas Gulf	New Gulf, Texas
11.	Texas Gulf	Fannett Dome, Texas
12.	Texas Gulf	Liberty County, Texas
13.	Texas Gulf	Spindletop Dome, Texas

Minerals Pigments

1.	New Riverside Ochre Co.	Cartersville, Georgia

Trona

1.	Allied Chemical Co.	Green River, Wyoming
2.	FMC	Green River, Wyoming
3.	Stauffer	Green River, Wyoming
4.	Texas Gulf	Green River, Wyoming

APPENDIX C

Model-Derived Capital and Annual Operating Costs

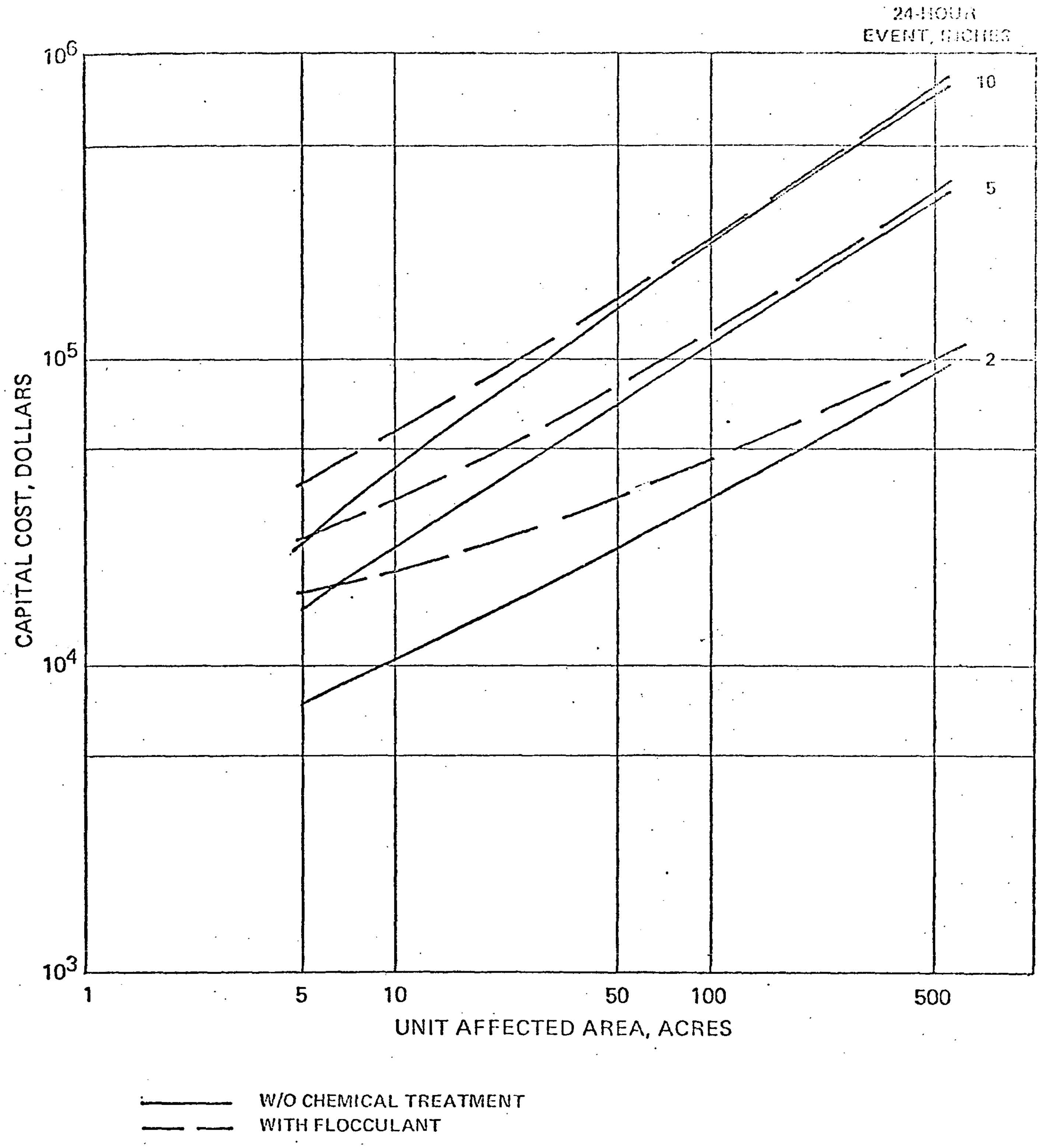


Figure C-1. CAPITAL COST, TYPE A SOIL CONDITIONS

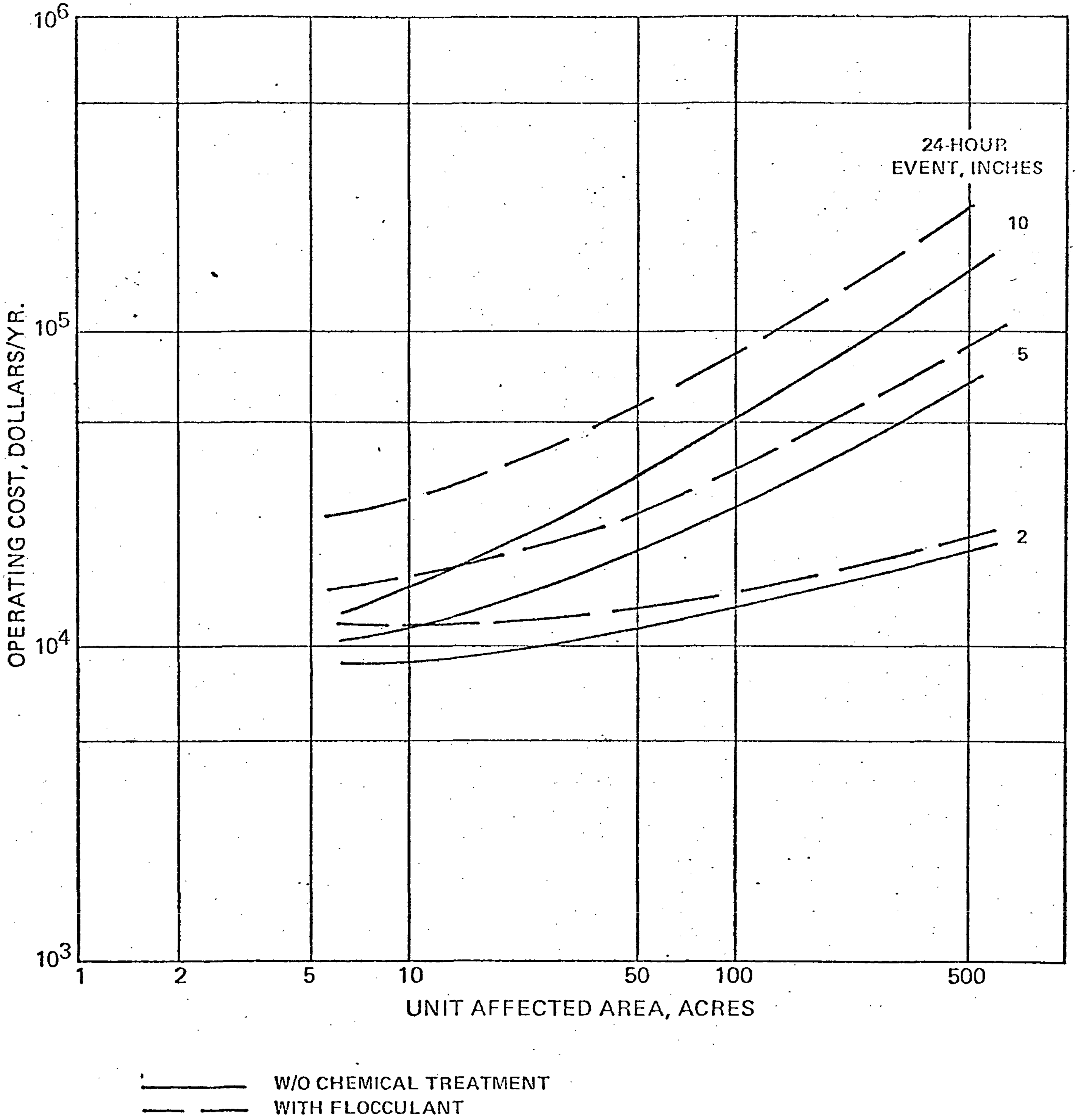


Figure C-2. ANNUAL OPERATING COSTS, TYPE A SOIL CONDITIONS

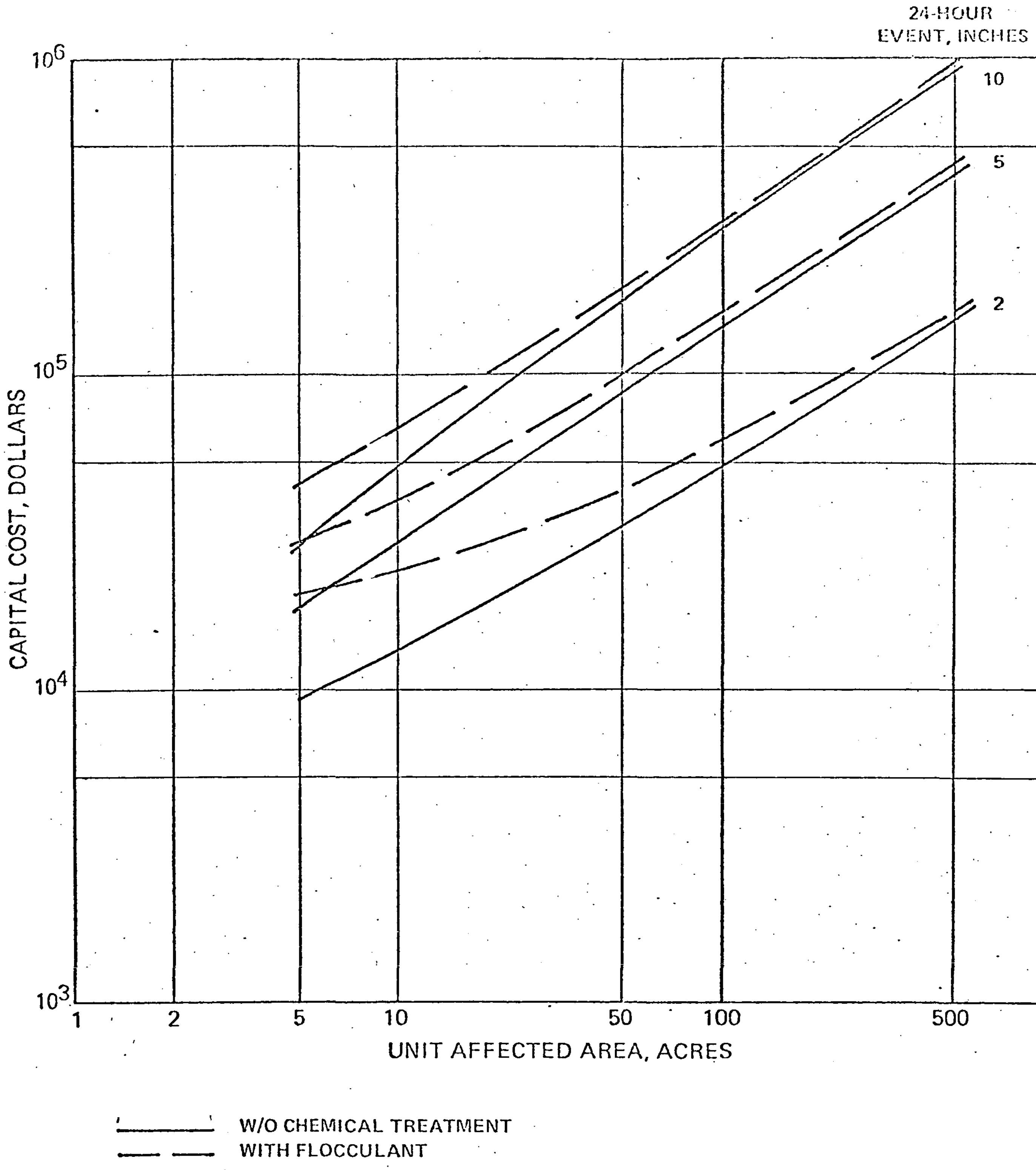


Figure C-3. CAPITAL COST, TYPE B SOIL CONDITIONS

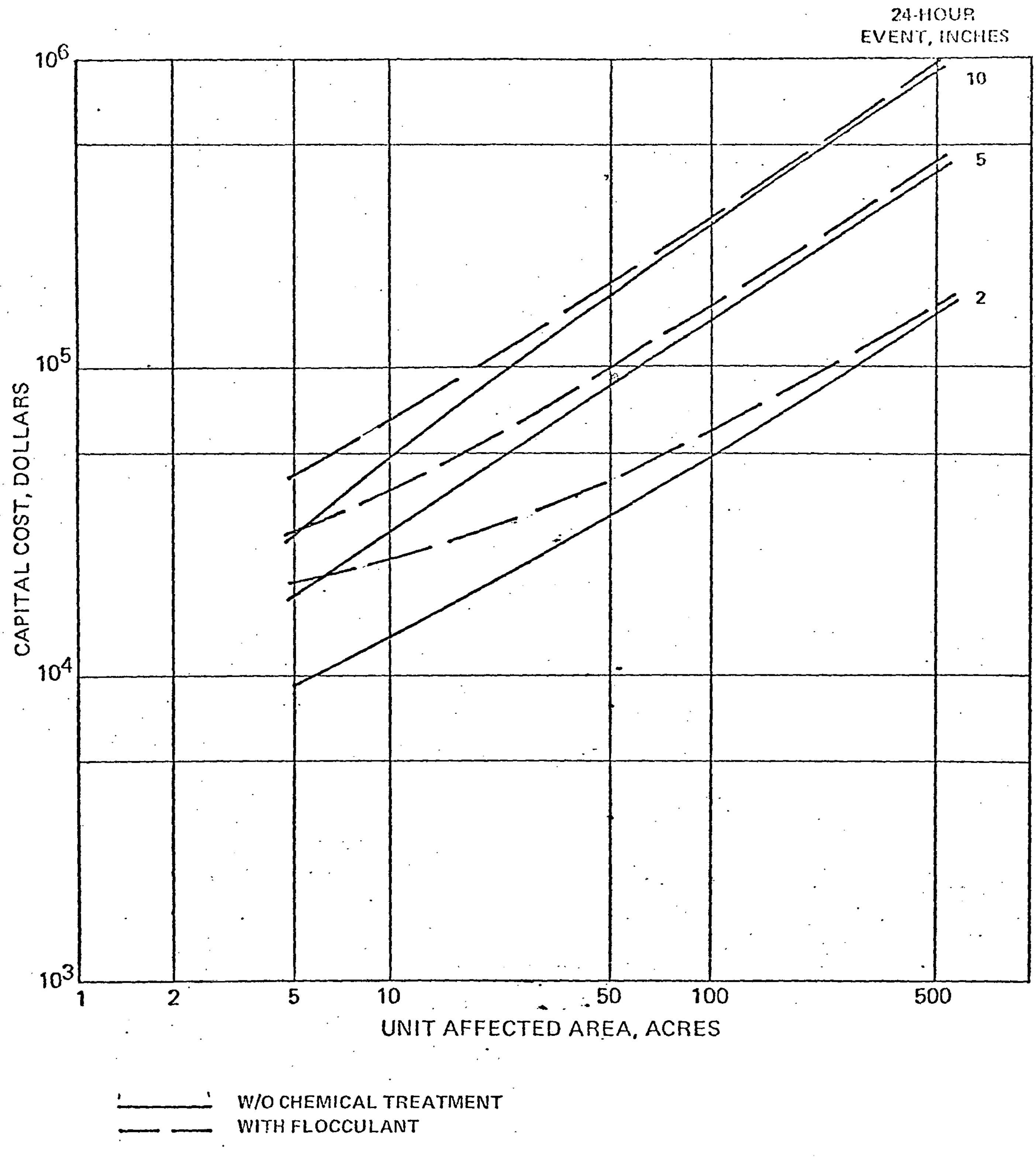


Figure C-3. CAPITAL COST, TYPE B SOIL CONDITIONS

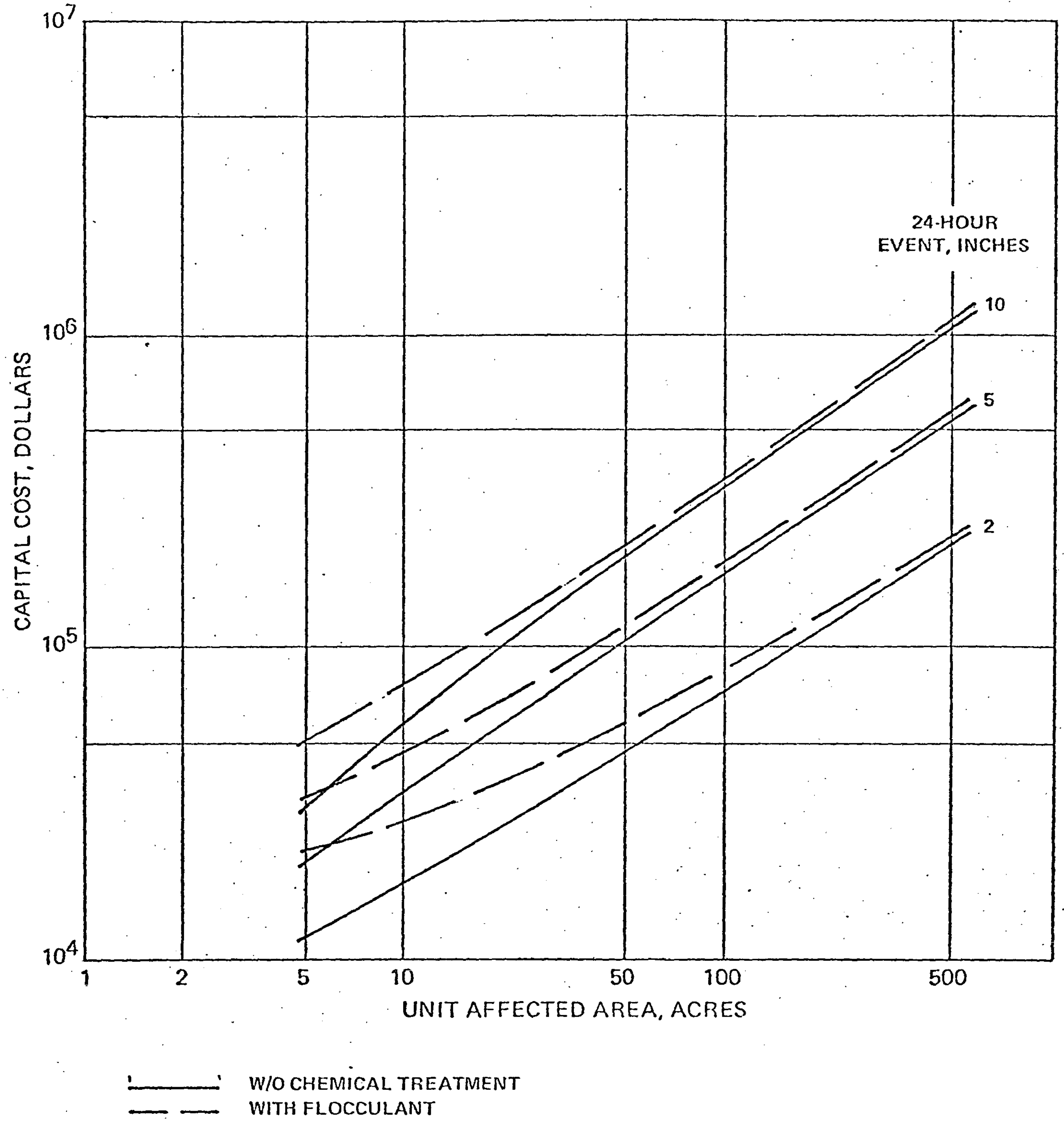


Figure C-5. CAPITAL COST, TYPE C SOIL CONDITIONS

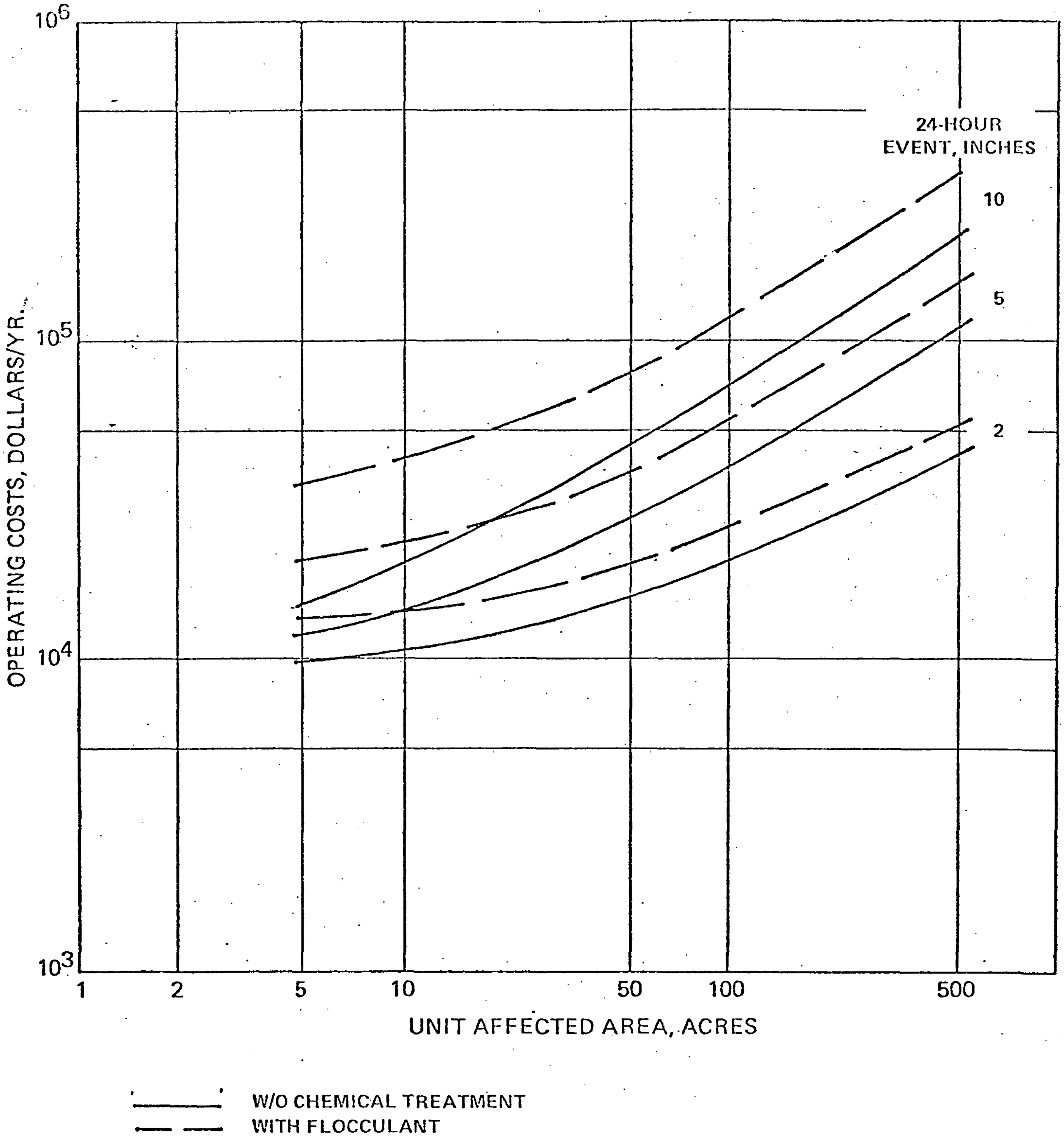


Figure C-6. ANNUAL OPERATING COSTS, TYPE C SOIL CONDITIONS

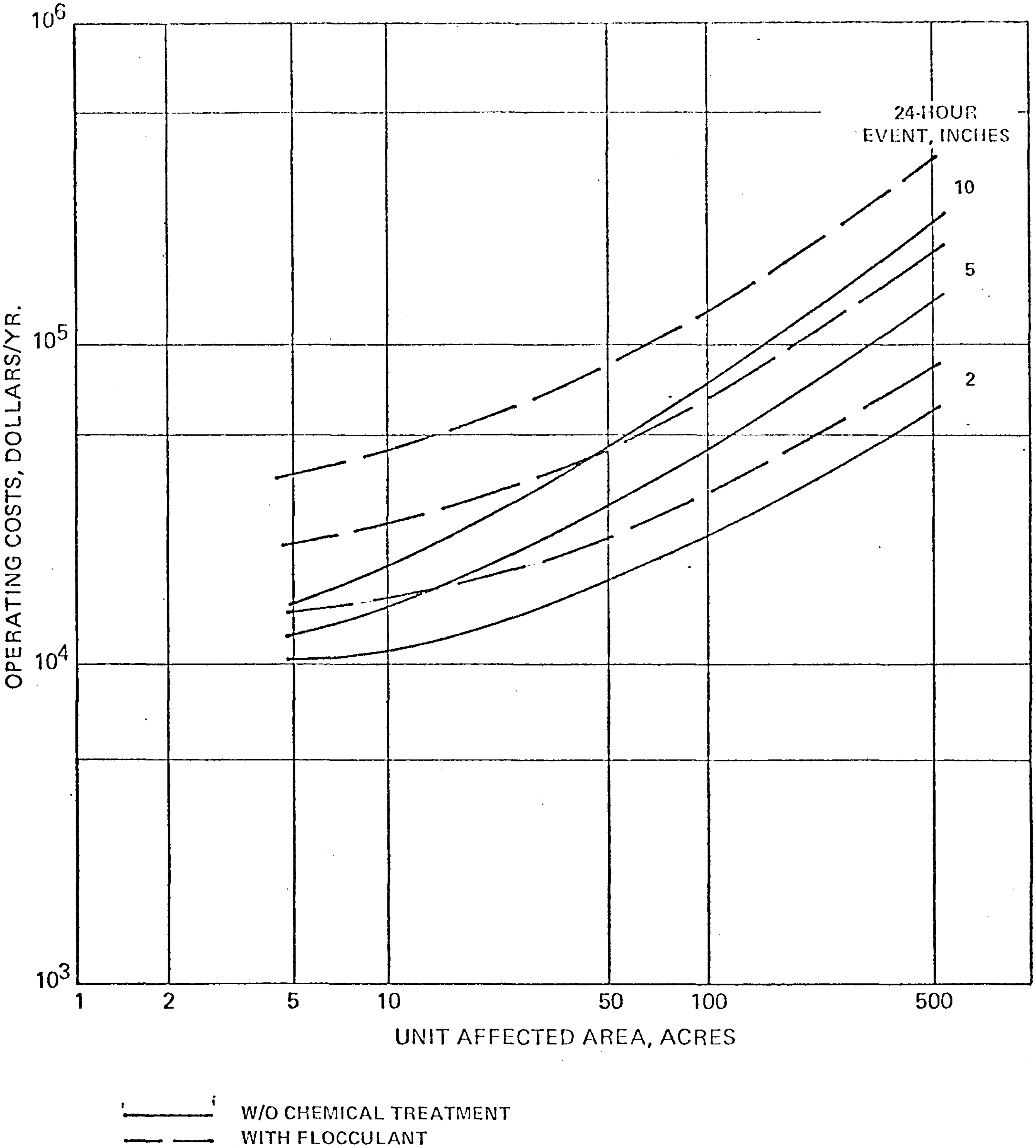


Figure C-7. CAPITAL COST, TYPE D SOIL CONDITIONS

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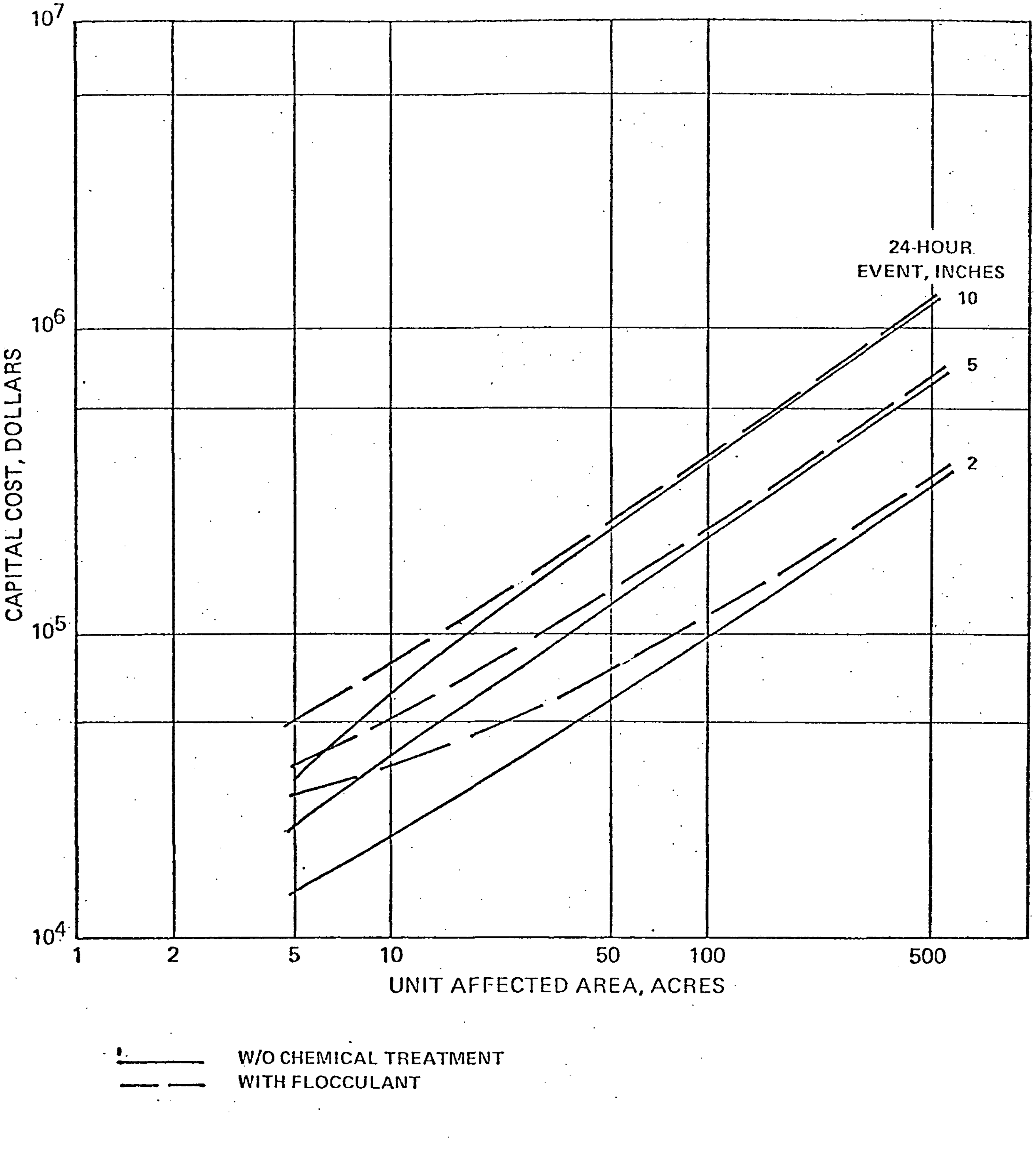

Figure C-8. ANNUAL OPERATING COSTS, TYPE D SOIL CONDITIONS

APPENDIX D

Bureau of Mines Clay Mining and Production Statistics, 1974

Table .--Number of mines from which producers sold or used clay in the United States in 1974, by States

State	Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Common clay & shale	Total 1/
Alabama	6	--	10	4	--	26	46
Arizona	--	1	1	3	--	6	11
Arkansas	4	--	--	--	--	16	20
California	6	1	6	10	3	52	74
Colorado	1	--	14	3	--	35	53
Connecticut	--	--	--	--	--	5	5
Delaware	--	--	--	--	--	1	1
Florida	3	--	--	--	5	4	12
Georgia	59	--	5	--	8	24	89
Hawaii	--	--	--	--	--	1	1
Idaho	--	--	1	--	--	4	5
Illinois	--	--	5	--	1	16	22
Indiana	--	--	3	--	--	26	27
Iowa	--	--	--	--	--	17	17
Kansas	--	--	--	--	--	25	25
Kentucky	--	4	12	--	--	13	29
Louisiana	--	--	--	--	--	15	15
Maine	--	--	--	--	--	6	6
Maryland	--	1	--	--	--	10	11
Massachusetts	--	--	--	--	--	3	3
Michigan	--	--	--	--	--	11	11
Minnesota	1	--	--	--	--	2	3
Mississippi	--	4	--	5	3	22	34
Missouri	10	--	81	1	1	21	113
Montana	--	--	1	10	--	10	21
Nebraska	--	--	--	--	--	6	6
Nevada	1	--	1	4	1	1	8
New Hampshire	--	--	--	--	--	3	3
New Jersey	--	--	4	--	--	2	6
New Mexico	--	--	2	--	--	7	9
New York	--	1	--	--	--	15	16
North Carolina	2	--	--	--	--	48	50
North Dakota	--	--	--	--	--	5	5
Ohio	--	--	32	--	--	82	108
Oklahoma	--	--	--	--	--	17	17
Oregon	--	--	--	4	--	13	17
Pennsylvania	2	--	36	--	--	45	74
Puerto Rico	--	--	--	--	--	3	3
South Carolina	21	--	--	--	1	37	58
South Dakota	--	--	--	2	--	4	6
Tennessee	--	33	--	--	1	21	51
Texas	2	7	4	14	1	93	115
Utah	2	--	2	3	1	9	17
Virginia	--	--	--	--	--	33	33
Washington	--	--	4	--	--	15	16
West Virginia	--	--	2	--	--	4	6
Wisconsin	--	--	--	--	--	1	1
Wyoming	--	--	--	435	--	4	439
Total	120	52	226	498	26	839	1,718

1/ Data may not add to totals shown because of mines having more than one kind of clay.

Table 2.--Clays sold or used by producers in the United States in 1974, by State 1/
(Short tons)

State	Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Common clay and shale	Total	Total value
Alabama	337,471	--	316,401	W	--	2,341,508	2/2,995,360	2/13,298,240
Arizona	--	W	W	32,803	--	163,816	198,672	621,737
Arkansas	80,386	--	--	--	--	903,711	984,097	1,597,397
California	42,707	W	157,125	56,427	W	2,239,161	2,497,241	7,626,341
Colorado	7,950	--	53,263	4,124	--	597,943	663,280	1,583,214
Connecticut	--	--	--	--	--	155,579	155,579	363,446
Delaware	--	--	--	--	--	14,049	14,049	8,429
Florida	27,270	--	--	--	412,523	368,556	808,349	3/14,261,463
Georgia	4,762,000	--	W	--	489,204	2,440,755	4/7,691,959	4/203,936,262
Hawaii	--	--	--	--	--	W	W	W
Idaho	--	--	W	--	--	9,295	4/9,295	4/10,348
Illinois	--	--	102,585	--	W	1,484,461	5/1,587,046	5/3,744,447
Indiana	--	--	26,236	--	--	1,065,897	1,092,133	1,946,636
Iowa	--	--	--	--	--	960,221	960,221	1,969,045
Kansas	--	--	--	--	--	1,310,576	1,310,576	1,785,130
Kentucky	--	W	116,787	--	--	731,423	6/848,210	6/1,476,562
Louisiana	--	--	--	--	--	770,254	770,254	1,425,260
Maine	--	--	--	--	--	146,333	146,333	182,716
Maryland	--	W	--	--	--	884,189	6/884,189	6/2,065,548
Massachusetts	--	--	--	--	--	217,685	217,685	378,780
Michigan	--	--	--	--	--	2,160,928	2,160,928	4,073,629
Minnesota	W	--	--	--	--	W	W	W
Mississippi	--	W	--	333,533	W	1,492,249	2,012,888	10,468,010
Missouri	99,000	--	924,197	W	W	1,541,656	2/5/2,564,853	3/5/13,151,317
Montana	--	--	W	239,290	--	58,624	4/297,914	4/2,189,373
Nebraska	--	--	--	--	--	182,394	182,394	413,878
Nevada	2,406	--	104	W	80	W	38,570	218,126
New Hampshire	--	--	--	--	--	33,827	33,827	55,325
New Jersey	--	--	36,849	--	--	66,827	103,676	524,210
New Mexico	--	--	W	--	--	55,336	4/55,336	4/316,628
New York	--	W	--	--	--	1,450,564	6/1,450,564	6/2,348,006
North Carolina	W	--	--	---	--	3,421,825	3/3,421,825	3/4,648,355
North Dakota	--	--	--	--	--	W	W	W
Ohio	--	--	1,123,506	--	--	3,201,636	4,325,142	13,488,248
Oklahoma	--	--	--	--	--	1,288,938	1,288,938	2,105,382
Oregon	--	--	--	1,119	--	138,649	139,768	242,609
Pennsylvania	W	--	894,458	--	--	1,837,522	3/2,731,980	3/16,495,699
Puerto Rico	--	--	--	--	--	291,007	291,007	332,481
South Carolina	769,709	--	--	--	W	1,527,252	5/2,296,961	5/13,765,142
South Dakota	--	--	--	W	--	189,592	2/189,592	2/201,654
Tennessee	--	500,323	--	--	W	1,137,603	5/1,637,926	5/9,776,204
Texas	W	40,731	40,754	68,575	W	5,045,922	5,314,770	12,677,250
Utah	W	--	W	3,153	2,174	201,201	231,880	952,946
Virginia	--	--	--	--	--	1,956,746	1,556,746	2,613,820
Washington	--	--	W	--	--	269,425	4/269,425	4/698,235
West Virginia	--	--	W	--	--	338,817	4/338,817	4/520,315
Wisconsin	--	--	--	--	--	2,385	2,385	4,393
Wyoming	--	--	--	2,295,248	--	215,903	2,511,151	29,338,785
Undistributed	263,927	276,122	348,576	276,228	320,659	239,104	7/1,403,116	7/22,068,294
Total	6,392,826	817,176	4,140,841	3,310,500	1,224,640	45,201,344	61,087,327	422,874,315

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
1/ Includes Puerto Rico.
2/ Excludes bentonite.
3/ Excludes kaolin.
4/ Excludes fire clay.
5/ Excludes fuller's earth.
6/ Excludes ball clay.
7/ Incomplete total; remainder included in State totals.

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Table 19.--Clays sold or used by producers in the United States in 1974, by kind and use, including Puerto Rico
(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed 1/	Total
Adhesives	2/	2/	--	--	1,525	65,059	725	65,309
Alum (aluminum sulfate) and other chemicals	--	2/	--	2/	2/	323,250	10,616	333,866
Animal feed	2/	175,706	72	--	2/	14,878	555	191,211
Asphalt emulsion and tiles	2/	2/	--	--	--	--	21,128	21,128
Building brick:								
Common	2/	2/	3,191,514	--	--	--	755	3,192,269
Face	13,000	2,922	17,283,521	105,257	--	425,328	--	17,830,028
Catalysts (oil refining)	2/	4,819	--	--	2/	69,936	16,171	90,926
Caulking, putty, sealers, glue	--	--	--	5	--	5,016	--	5,021
Cement, portland	--	459	11,966,555	--	19,690	134,275	--	12,120,979
Ceramic--hobby	--	--	--	--	--	647	--	647
China/dinnerware	43,291	--	--	--	--	21,555	--	64,846
Crockery and other earthenware	1,137	--	6,893	2/	2/	68,464	23,670	100,164
Drilling mud	4,663	599,688	1,428	--	75,976	--	--	681,755
Electrical porcelain	45,132	--	--	--	--	15,433	--	60,565
Fertilizers	--	6,490	8,443	--	54,516	88,087	--	157,536
Fiberglass	--	--	128	--	--	127,984	--	128,112
Filtering, clarifying, and decolorizing:								
Animal oils	--	68,271	--	--	--	--	--	68,271
Mineral oils and greases	--	23,533	--	--	31,128	3/	--	4/54,661
Vegetable oils	--	71,290	--	--	--	--	--	71,290
Firebrick, block, and shapes	27,411	3/	--	2,462,589	--	449,248	--	4/2,939,248
Flower pots	--	--	47,365	--	--	--	--	47,366
Flue linings	--	--	99,789	57,141	--	3/	--	4/156,930
Foundry sand	--	738,055	--	229,395	--	5,372	--	972,822
Glazes, glass, and enamels	1,959	209	--	50,658	--	5,240	--	58,106
Grogs and crudes, refractory	3/	--	--	142,754	--	277,362	--	4/420,115
Gypsum products	--	506	--	--	--	4,822	--	5,328
High alumina (minimum 50% Al_2O_3) refractories	22,019	--	--	348,540	--	60,501	--	431,060
Ink	--	--	--	--	--	14,162	--	14,162
Kiln furniture	9,349	--	--	250	--	2,245	--	11,844
Lightweight aggregate:								
Concrete block	--	--	5,989,303	--	--	--	--	5,989,303
Structural concrete	--	--	2,967,029	--	--	--	--	2,967,029
Highway surfacing	--	--	975,497	--	--	--	--	975,497
Other	--	--	98,929	--	--	--	--	98,929
Medical, pharmaceutical, cosmetic	2	14,878	--	--	16	1,986	--	16,882
Mortar and cement, refractory	2/	--	--	432,761	2/	1,855	72,235	506,851
Oil and grease absorbents	--	14,860	--	--	409,734	--	--	424,594
Paint	--	4,915	--	--	1,662	261,362	--	267,939
Paper coating	2/	2/	--	--	71	1,313,406	2,282	1,315,759
Paper filling	2/	2/	--	--	--	1,012,129	13,760	1,025,889
Pelletizing (iron ore)	--	870,464	--	--	--	--	--	870,464
Pelletizing (other)	--	--	--	18,000	--	--	--	18,000
Pesticides and related products	3/	23,853	--	--	179,579	28,511	--	4/231,943
Pet absorbent	--	6,319	--	--	357,993	--	--	364,312
Plastics	--	--	--	--	3/	54,275	--	4/54,275
Plug, tap, and wad	--	--	--	9,592	--	--	--	9,592
Pottery	170,212	307	36,973	20,460	--	42,059	--	270,011
Rubber	400	--	100	--	--	378,602	--	379,102
Sanitary ware	174,701	3/	--	--	--	82,774	--	4/257,475
Sewer pipe, vitrified	--	100	1,502,508	105,102	--	--	--	1,608,710
Tamping dummies	--	--	7,680	--	--	--	--	7,680
Tile:								
Drain	--	--	434,413	--	--	--	--	434,413
Floor and wall, ceramic	83,474	--	142,769	65,998	--	17,082	--	314,323
Quarry	1,142	--	156,891	--	--	--	--	158,033
Roofing	--	13,129	83,534	--	--	--	--	96,663
Structural	--	--	64,591	--	--	--	--	64,591
Terra cotta	--	--	52,025	1,000	--	--	--	53,025
Waterproofing and sealing	2/	86,295	--	--	2/	3,554	6,230	96,079
Water treatment and filtering	--	--	11,651	--	--	--	--	11,651
Miscellaneous 5/	4,298	50,192	8,756	7,888	5,286	40,037	--	116,457
Undistributed	127,189	10,037	--	25,698	5,203	--	--	--
Exports	82,737	523,143	62,986	55,723	82,261	975,330	--	1,751,239
Total	817,176	3,310,500	45,201,344	4,140,841	1,224,640	6,392,826	6/	61,087,327

1/ Total of clays indicated by footnote 2/.
2/ Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
3/ Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
4/ Incomplete figure; remainder included with "Miscellaneous."
5/ Includes abrasives; graphite anodes; linoleum; mineral wool and insulation; roofing granules; textiles; unknown uses; and data indicated by footnote 3/.
6/ "Undistributed" total included with total for each specific use.

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Table 20.--Shipments of principal structural clay products in the United States

Products	1970 Quantity	1970 Value	1971 Quantity	1971 Value	1972 Quantity	1972 Value	1973 Quantity	1973 Value	1974 Quantity	1974 Value
Unglazed common and face brick (M̄ standard brick, M dollars)	6,496	288 r	7,570	346	8,402	404	8,674 r	451 r	6,673	376
Unglazed structural tile (M short tons, M̄ dollars)	181	6	157 r	4	101	3	94	4	100	4
Vitrified clay and sewer pipe fittings (M short tons, M̄ dollars)	1,622	119	1,721	133	1,718	143	1,647 r	138 r	1,454	134
Unglazed, salt glazed, and ceramic glazed structural facing tile, including glazed brick (M equivalent, M̄ dollars)	169	16	153	15	131	13	122 r	13 r	97	13
Clay floor and wall tile, including quarry tile (M square feet, M̄ dollars)	250 r	126	276 r	143	308 r	159	301 r	168	273	168
Total (M̄ dollars)	xxx	555	xxx	641	xxx	722	xxx	774 r	xxx	695

r Revised. M Thousand M̄ Million.

Table 21.--Common clay and shale used in building brick production in the United States in 1974, by State

State	Short tons	Value	State	Short tons	Value
Alabama	1,133,882	$1,725,994	New Hampshire	33,827	$ 55,256
Arizona and Hawaii	83,700	94,900	New Jersey	66,827	292,068
Arkansas	535,487	515,028	New Mexico and North Dakota	87,722	110,846
California	403,371	746,877	New York	274,241	521,968
Colorado	358,744	920,636	North Carolina	2,584,605	3,490,979
Connecticut	146,879	346,133	Ohio	1,538,834	3,150,950
Delaware	14,049	8,429	Oklahoma	602,148	1,001,041
Florida	30,000	44,040	Oregon	33,610	52,331
Georgia	2,208,446	4,313,507	Pennsylvania	1,413,094	4,296,416
Idaho	9,295	10,348	South Carolina	1,112,805	2,004,739
Illinois	459,407	1,192,425	South Dakota	14,000	17,080
Indiana	444,414	702,027	Tennessee	579,972	730,786
Iowa	243,120	381,041	Texas	1,392,325	2,858,266
Kansas	502,146	649,904	Utah and West Virginia	245,445	465,345
Kentucky	319,518	355,264	Virginia	1,103,716	1,547,640
Louisiana	199,539	294,984	Washington	142,239	300,898
Maine and Maryland	418,799	1,280,387	Wisconsin	2,385	4,368
Massachusetts and Michigan	207,476	316,153	Wyoming	61,181	202,727
Minnesota and Montana	56,512	90,338			
Mississippi	1,146,018	1,600,611			
Missouri	170,495	435,738	Total	20,475,035	37,391,728
Nebraska	94,762	263,240			

Table 22.--Clay and shale used in lightweight aggregate production in the United States in 1974, by State and kind

State	Short tons					Total value
	Concrete block	Structural concrete	Highway surfacing	Other	Total	
Alabama and South Dakota	766,885	60,038	7,000	--	833,923	$999,135
Arkansas and Virginia	624,550	178,000	15,000	--	817,550	991,500
California	363,245	358,035	--	--	721,280	1,844,472
Colorado, Nebraska, and Utah	268,801	121,601	--	78	390,480	712,382
Florida, Maryland, and Massachusetts	512,190	89,200	--	--	601,390	1,036,713
Illinois, Indiana, and Iowa	763,251	450,262	--	--	1,213,513	2,231,739
Kansas, Louisiana, and Missouri	383,448	68,659	71,974	36,348	560,429	892,327
Kentucky, Michigan, and Minnesota	256,097	49,725	--	40,243	346,065	487,272
Mississippi	287,372	24,236	34,623	--	346,231	446,638
Montana, North Dakota, and Washington	55,609	--	--	--	55,609	89,720
New York	272,508	466,352	--	--	738,860	1,269,495
North Carolina, Ohio, and Pennsylvania	437,200	365,800	--	--	803,000	1,116,081
Oklahoma	131,619	87,745	--	--	219,364	361,900
Oregon	29,773	6,236	--	--	36,009	90,023
Tennessee	164,436	134,400	--	--	298,836	371,700
Texas	672,319	506,740	846,900	22,260	2,048,219	2,830,169
Total	5,989,303	2,967,029	975,497	98,929	10,030,758	15,771,266