IDEAL

Ideal Basic Industries

Cement Division

INDIVIDUAL EXEMPTION PETITION
TO
WASHINGTON STATE
FOR
CEMENT KILN DUST
SOLID WASTE DESIGNATION

◆

NOVEMBER, 1984

Ideal Basic Industries
Cement Division

Ideal Plaza—950 17th Street
P.O. Box 8789
Denver, Colorado 80201

303 623 5661

IDEAL

2 November, 1984

Mr. Donald W. Moos, Director
Washington State Department of Ecology
Mail Stop PV-11
Olympia, WA 98504

Dear Mr. Moos:

Enclosed herewith is the Ideal Basic Industries petition to exempt cement-kiln dust generated at the Seattle Cement Manufacturing Plant from Washington State Dangerous Waste Regulations WAC 173-303.

Information in this exemption petition document presents evidence that even though cement-kiln dust is captured as a dangerous waste because of its alkalinity, it does not pose a threat to public health or the environment under Ideal's current management and disposal practices.

As such, we respectfully request your approval of the petition so that the substance may regain its solid waste classification by which it will fall once again under the regulatory authority of the King County Department of Public Health.

Sincerely,

Fred Bauer

Fred Bauer
Senior Vice President and
General Manager, Pacific
Region

PORTLAND CEMENT ASSOCIATION
Suite 730, 1100 Fifteenth St., N.W., Washington, D.C. 20005, Telephone 202/293-4260

October 24, 1984

Mr. Donald Moos
Director, Department of Ecology
State of Washington
Mail Stop PVII
Olympia, Washington 98504

Re: Characteristics of Waste Cement Kiln Dust

Dear Mr. Moos:

Introduction

Cement companies in the State of Washington are developing individual petitions to exempt their cement kiln dust from the state's Dangerous Waste Regulations (Chapter 173-303 WAC). The purpose of this letter is to provide general information on cement kiln dust (CKD) in support of these petitions, including experiences at the federal level and in other states.

The Portland Cement Association is the promotional, research, and governmental affairs arm of the U. S. cement industry, representing about 75% of domestic production capacity. Accordingly, in this letter we can speak from the perspective of the industry across the country. Our discussion will touch on regulatory approaches used elsewhere, characteristics of CKD both as a waste and as a useful product, and results of some studies involving the substance.

Federal Regulation

Regulatory action at the federal level has consistently acknowledged the low potential for any hazard associated with CKD, and the need to avoid sweeping CKD into regulatory schemes designed for the truly "problem" or dangerous wastes.

When the Environmental Protection Agency originally proposed its comprehensive rules on hazardous waste on December 18, 1978, it put CKD in a particular category of "high-volume relatively low-risk waste" (43 FR 58946, 58991-58992, 59015). By being declared such a "special waste", CKD was exempted from most of the treatment, storage, and disposal standards in the proposed regulations, pending the results of further study.

While EPA was developing its regulations, the U.S. Congress took even stronger action to recognize the apparent non-hazardous character of the dust as well as the need for more information. That action occurred during the reauthorization of the Resource Conservation and Recovery Act (P.L. 94-580). In 1980, both houses of Congress approved an amendment completely exempting CKD from the comprehensive hazardous waste regulations, which were promulgated finally in May, 1980. The measure, originally sponsored in the House by Representative Tom Bevill (D-Alabama), was signed by the President on October 21, 1980. The amendment stipulated that within a three year period there should be an EPA study of kiln dust and a report to Congress.

Bevill Amendment Study

Based on all available information, EPA evidently put CKD in a lower priority for study as compared with other wastes it was required to examine. The Agency was given no additional money for the various studies mandated by Congress, and elected, naturally, to concentrate its main energies on those wastes where it perceived the highest potential for health or environmental risk. Also, it gave preference to wastes disposed of in higher volumes than CKD.

Over the past several months EPA has been conducting an exhaustive survey of information on kiln dust as a waste and as a recycled material. The major work has been performed by a private contractor, SCS Engineers, of Reston, Virginia.

As we understand it, the contractor has contacted the relevant control officials in all 50 states as to experiences with CKD, and has visited a number of states to confer with local and EPA regional authorities. While the results of the fact-gathering have been transmitted to EPA, the writing of the final report has not been completed yet. Consequently, the report will not be signed off on at EPA and available to interested parties for another month or so.

Nevertheless, according to our information, the picture emerging from the study is clear. The survey of all 50 states, as a general statement, disclosed no indication that CKD is a problem to health or the environment.

There is one special situation, however, which had come to our attention, which the survey found as well. A waste site in the State of Utah was formerly used by the Portland Cement Company of Utah to dispose of a number of wastes, including CKD. That site has been nominated for the National Priorities List, which means that there will be a systematic program supervised by the EPA to determine whether there is a release of contaminants at the location and, if so, what to do about it. The responsible cement company also is analyzing the site.

The current status is that the facts are equivocal and uncertain, but will be ascertained in the near future. Since other materials were disposed of at the site, it is presently unclear to what extent any problem is traceable to CKD. Also, there are indications that the waste characteristics are unique to that location. In any event, that site stands as the only caveat in a finding of essentially no information in the United States suggesting environmental harm from CKD.

Bureau of Mines Study

Another federal research effort of major significance is the study of CKD performed by the Bureau of Mines, U.S. Department of Interior. (Characterization of U.S. Cement Kiln Dust, Benjamin W. Haynes and Gary W. Kramer, Bureau of Mines Information Circular 8885, 1982.) Recognizing the relative scarcity of data and the considerable resource potential for CKD, the Bureau of Mines on its own initiative undertook in 1978 a study of waste CKD from across the United States. Its purpose was to characterize the mineralogical and chemical composition, and determine whether CKD has any hazardous waste potential.

Among other things, the Bureau of Mines performed EPA's extraction procedure toxicity test on 113 CKD samples from all regions of the nation. All of the samples passed the EP test except one which slightly exceeded the criterion for lead. That sample evidently represented a particular situation at one site, reflecting perhaps an extraordinary lead presence in the raw materials.

The Bureau of Mines drew the following conclusion from its investigation:

> Cement kiln dust is a large-volume material and a potential resource as a substitue for lime. Any environmental considerations are minor, as the results of this extensive survey show that U.S. CKD is not a hazardous waste as defined by current regulations established under RCRA. (Characterization of U.S. Cement Kiln Dust p. 19).

State Regulation

Cement companies have facilities in the great majority of states. Our inquiries have disclosed no state other than Washington which has sought to regulate CKD as hazardous or dangerous. And, as the petitions will say, there are crucial questions as to whether the particular Washington state regulation is realistic or sound public policy as regards CKD. Dust from plants in Washington state has been tested extensively and has passed all of the criteria under the Dangerous Waste Regulations, except the fish biossay test. That test deals with the effect of pH levels on juvenile trout resulting from high concentrations of CKD (1000 ppm).

Two points need to be made: first, the test results demonstrated an absence of any inherent toxicity in the CKD, such as heavy metal levels and the like. Secondly, it may not be a reasonable measure of danger since many common products, not thought of as hazardous, could not pass the test as well. An example is agricultural lime. Further, the biossay test does not replicate realistic conditions surrounding the actual disposal of CKD, which would not be placed in a position to harm juvenile trout.

Disposal Conditions

Obviously, regulations should be predicated on how the waste, in fact, will be disposed of or beneficially reused, and the characteristics of the substance under real-life circumstances. Normally, CKD at the disposal location solidifies and hardens under exposure to the elements.

This process reduces the potential for the leaching of any trace substances to the environment. This sealing quality has been demonstrated both by inspections of waste piles and by laboratory experiments.

Further, CKD has for years been used for a variety of commercial purposes without an indication of problems to health or the environment. The dust has been employed extensively for agricultural liming, fertilizer, soil stabilization, soil cement, and filler in roofing shingles and asphalt products, among other uses.

Indeed, recent meetings between DOE officials and the petitioners in this matter have brought out that CKD in the State of Washington is being used for mined land reclamation and as a compacting medium at municipal trash dumps. In addition, large quantities of CKD are being used as a liming agent at the seed farms in the eastern part of the state, where it is generally considered as superior to competitive substances.

Conclusion

Rational regulation, of course, means targeting on the exact problem, and fashioning rules which guard against a specific and well-delineated risk. Clearly, it is wasteful of both public and private resources to regulate beyond the demonstrated need.

CKD should not be swept into a regulatory apparatus which does not bear a reasonable relationship to actual disposal practices. Also, overreaching requirements could preclude or limit a number of the reuses of CKD which have beneficial consequences for the environment or are in the public interest.

Certainly there is a continuing obligation by disposers to be aware of the exact constituents of their particular wastes, and to act accordingly. CKD in the State of Washington has been studied intensively, and the facts are reasonably clear. We believe that a compelling case has been made to support the individual company exclusions and a broader class exclusion for CKD as a category of waste.

Sincerely,

A. Cleve Schneeberger
Vice President for Public Affairs

ACS/sk

IDEAL BASIC INDUSTRIES
CEMENT DIVISION
SEATTLE CEMENT-MANUFACTURING PLANT

INDIVIDUAL EXEMPTION PETITION TO WASHINGTON STATE DEPARTMENT OF ECOLOGY FOR CEMENT-KILN DUST SOLID WASTE DESIGNATION

NOVEMBER, 1984

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IDEAL
Ideal Basic Industries
Cement Division

SCALE:
DATE: 1983
FIGURE 1
DRAWN BY
REVISED

IDEAL BASIC INDUSTRIES, SEATTLE PLANT

IDEAL
Ideal Basic Industries
Cement Division

SCALE
DATE: 1983
FIGURE 2
DRAWN BY
REVISED

IDEAL BASIC INDUSTRIES, CEMENT KILN

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WAC 173-303-910(1) GENERAL PETITIONS

IDEAL BASIC INDUSTRIES, CEMENT DIVISION, INDIVIDUAL EXEMPTION PETITION TO WASHINGTON STATE DEPARTMENT OF ECOLOGY FOR CEMENT-KILN DUST SOLID WASTE DESIGNATION

WAC 173-303-910(1)(b)(i) PETITIONER'S NAME AND ADDRESS

IDEAL BASIC INDUSTRIES, CEMENT DIVISION
SEATTLE CEMENT MANUFACTURING PLANT
5400 WEST MARGINAL WAY, S.W.
SEATTLE, WASHINGTON 98106

WAC 173-303-910(1)(b)(ii)

STATEMENT OF PETITIONER'S INTEREST IN PROPOSED ACTION

INTRODUCTION

Manufacture of portland cement is accompanied by generation of large quantities of dust. Grinding and conveying raw materials, heating them in a rotary kiln, and grinding the resulting clinker are all dust-producing operations and the dust escaping from these operations must be collected to prevent air pollution. Dust collected in raw material processing operations can be returned to the process, and dust from clinker grinding can be sold as cement. Since the manufacturer has economic incentive to collect and reuse these dusts, their disposal is seldom a problem (Davis, 1975).

Dust generated in the rotary kiln is difficult to collect because it is entrained in large volumes of hot exhaust gases. Moreover, it often contains unacceptably high concentrations of alkalies (sodium and potassium) which make it unsuitable for return to the cement-making process because of government specifications limiting the amount of these alkalies in the final cement product. The EPA and the U.S. Bureau of Mines initiated studies to assess the problems associated with cement-kiln dust (CKD) disposal, and to find and evaluate possible solutions to these problems with an emphasis on utilization of CKD, rather than development and maintenance of expensive and wasteful disposal systems (Davis, 1975).

The exhaust gases from portland cement kilns carry away an average of 12 percent of the kiln feed. To reduce particulate emissions, CKD is removed from the exhaust gases by dust collectors. Since the CKD has a value approaching $18. per ton, it is returned to the kiln whenever possible. In the U.S., cement manufacturers produce 18 to 20 million tons of fresh CKD annually. Of this, 8 to 10 million tons are recycled internally. The remainder is discarded. To date, over 100 million tons have been deposited at various waste sites in the U.S.

While the U.S. has the lowest rate of cement-kiln dust utilization in the industrialized world, interest is growing in marketing opportunities for the product. Increasingly, the public is becoming aware that, as a nation, we have a responsibility to reclaim resources whenever possible, especially if doing so saves energy. Members of government and industry are becoming aware of new applications for CKD such as substitution for agricultural lime and for hydrated lime in lime/flyash/aggregate road-base systems (Nicholson, 1983).

The markets for agricultural lime and potash fertilizer materials are large enough to consume all of the cement-kiln dust that is currently being discarded in the U.S. Moreover, on the basis of numerous studies, the chemical composition of kiln dust appears suitable for its application to acidic soils and to soils that require additional potassium. However, only small amounts of CKD are being used for this purpose in the U.S. Other uses for CKD include lining and daily cover sources for sanitary landfills, mine reclamation, soil stabilization, neutralization of acidic wastes from coal mines and metal plating operations, absorption of SO_2 from stack gases, water treatment, glass making, and production of light-weight aggregate (Davis, 1975).

CKD has been generated at the Seattle Plant of Ideal Basic Industries (Figures 1 and 2) since operations commenced in 1967. Because complete process recycling and/or market development of all CKD production has not been accomplished, a considerable portion, of necessity, has become a waste material. At the present time, 30 to 35 percent of all generated CKD is wasted. Improvements in CKD plant recycling engineering and increases in agricultural lime markets have substantially reduced the quantities of dust put to waste, from 87,394 tons in 1982 to 29,167 tons to date in 1984. Due to the seasonal nature of the agricultural lime market, the largest consumer of Ideal's CKD, and the inherent variablity of the cement market, which directly influences the amount of cement and CKD produced, it is unlikely that Ideal will be able to market all the CKD it produces through time. A state-approved disposal site is, therefore, essential.

This document includes a description of the current CKD disposal site at the Dale Strip Pit Reclamation Site near Ravensdale, Washington, and presents evidence that it is the most ecologically and economically viable disposal site available to Ideal. In addition, the document presents evidence in conformance with the results of the U.S. Bureau of Mines study of CKD samples from 70 percent of the U.S. cement industry (Appendix A-1) that, "any environmental considerations are minor, as the results of this extensive survey shows that U.S. cement-kiln dust is not a hazardous waste as defined by current regulations established under the Resource Conservation and Recovery Act".

BACKGROUND REGULATORY INFORMATION

On October 21, 1976, Public Law 94-580, the Resource Conservation and Recovery Act (RCRA) went into effect. In 1978, the Environmental Protection Agency proposed comprehensive regulations applying to all wastes. This could have involved large-volume, low risk wastes such as cement-kiln dust in an expensive federal regulatory program designed for truly hazardous substances. The situation was complicated by a scarcity of information on possible environmental effects posed by CKD. Because the greatest concern at that time was for possible heavy-metal leaching at disposal sites, the U.S. Bureau of Mines initiated a study of heavy-metal content of CKD from 113 cement plants representing 70 percent of the total U.S. cement-manufacturing industry. The Bureau also investigated the possible recovery of valuable elements present in the dust. Their conclusion was that CKD is not a hazardous waste, as defined by the EPA.

During the same period, the Portland Cement Association (PCA) was working intensively with the EPA, the U.S. Office of Management and Budget and, ultimately, with the U.S. Congress, in stressing a "degree of hazard" approach to waste substances by which any particular waste would be regulated only to the extent of a "demonstrated risk." Those efforts resulted in designation of CKD as a "Special Waste" in the EPA'S 1978 Hazardous Waste Guidelines and Regulations, 110 CFR, Part 250, pending more information on the composition, characteristics and degree of hazard posed by this waste material.

Subsequently, PCA'S work with Congress led to the Bevill Amendment, sponsored by Tom Bevill (D-Alabama), and signed into Public Law 94-482 by President Carter on October 21, 1980, as part of the Solid Waste Disposal Act Amendments [Section 7, Subsection (b)(3) of Section 3001]. This amendment, included in Appendix A-2, removed the "Special Waste" category and amended the hazardous waste regulations under Subtitle C of RCRA, pending completion of certain studies and certain rulemaking by the EPA. Subsequent to implementation of the Bevill Amendment, the EPA was forced to make changes in its regulations to bring them into conformance with the portion of the hazardous waste regulations that contained the Bevill Amendment. The ensuing EPA regulation (Appendix A-2) amended the hazardous waste regulations [40 CFR 261.4(b)(7)], to specifically excempt cement-kiln dust. The EPA was directed, through legislation, to study the health and environmental effects of CKD and report the findings to Congress by October, 1983.

In Tom Bevill's words, "the amendment is in no way intended to limit EPA's appropiate attention to hazardous waste disposal practices which have been shown to threaten our communities and environment, but to clarify the intent of Congress that the EPA not digress from issues deserving immediate attention. Detailed and comprehensive studies will assure that the regulatory decisions made by EPA on the basis of these studies are valid and in the public interest.

Conversation with Mr. Dexter Hinckley of the EPA'S Office of Solid Waste on October 4, 1984, provided the following update on the status of the EPA'S research into the matter of cement-kiln dust disposal. The congressionally-mandated study of CKD included investigation of other solid wastes derived from the extraction, beneficiation and processing of ores and minerals (including coal), including phosphate rock and overburden from the mining of uranium ore, all substances excluded from regulation under Subtitle C of RCRA. This included drilling muds and brines associated with oil-and gas-wells.

Because of limited funding, the EPA essentially took no action on CKD characterization, but devoted most of their research to the most hazardous of the excluded wastes, phosphates and oil and gas drilling muds and brines.

In regard to CKD, the EPA focused on the subcategories of RCRA's Section 8002, which requires an inventory of incidences of environmental contamination, and documented cases in which damage to human health and the environment have been proven. The only incident studied to date involved a disposal site in Utah where CKD was mixed with other, chromium-bearing wastes; environmental water problems developed as a result of the chromium, which was not attributable to the accompanying CKD.

A contract has been let with an independent contractor, SES Engineering, Reston, Virginia, to complete this portion of EPA'S study. The report is in the final preparatory phase and will be reviewed by the EPA by the end of 1984. While advance information could not be released, Mr. Hinckley stated that very little evidence of environmental or health problems had been found in association with disposal of CKD. Results of the study will not reach Congress until 1985, at the earliest, two years past the congressionally-mandated deadline. Should EPA management deem it worthwhile, they may follow through with a study of management practices, costs, and beneficial uses of the mineral byproduct.

Washington State's Dangerous Waste Regulations (Washington Administrative Code, Title 173, chapter 303) were promulgated on March 12, 1982. The original regulations included WAC 173-303-071, Excluded Categories of Waste, which said:

> Certain categories of waste have been excluded because they generally are not hazardous, are regulated under other state or federal programs, or are recycled in ways which do not threaten public health or the environment.

WAC 173-303-071(4), Temporary Exclusions, states:

> The following wastes are excluded from the requirements of Chapter 173-303 WAC, except for WAC 173-303-050 (DOE cleanup authority), until January 1, 1984. WAC 173-303-071(4)(c) Cement-kiln dust waste. The department will study data provided by industry on each of the wastes listed in WAC 173-303-071(4) to assess the need for permanent exclusions. Any waste that has not been permanently excluded [by addition to WAC 173-303-071(3) above] by January 1, 1984, shall became subject to the requirements of chapter 173-303 WAC.

Recognizing the need to provide the Washington State DOE with sufficient information to adequately "assess the need for permanent exclusions" in a timely fashion, representatives of Ideal Basic Industries initiated an informational meeting with the DOE on March 29, 1983. April 4, 1983, correspondence from the DOE to Ideal in response to the March meeting is included in Appendix A-3. This correspondence included information as to: 1) the various methods by which Ideal could exclude their CKD as an individual generator, or as part of a class of generators; 2) how to apply for a certificate of non-designation; 3) how to develop a waste-sampling plan; and, 4) the type of tests required to designate their CKD waste.

Ideal responded on May 3, 1983, by proposing a sampling plan, a description of the cement-manufacturing process and the dust-collection system, and a description of raw materials. On May 27, 1983, the DOE approved Ideal's sampling plan and on September 28, 1983, samples of CKD were delivered to an independent testing laboratory (Biomed Laboratories, Seattle) for determination of the degree of hazard demonstrated by the waste. Test results were reported over the period from October 25 to November 16. 1983; results demonstrated that Ideal's CKD is not dangerous as per WAC 173-303-090, <u>Dangerous Waste Characteristics</u>. It was; however, captured as a dangerous waste under WAC 173-303-101, <u>Toxic Dangerous Wastes</u>, subcategory (5) <u>Designation From Bioassy Data, via the Static Acute Fish Toxicity Test</u>, a test peculiar to Washington State. Based on information that these results negated issuance of a Certificate of Non-Designation by the DOE, Ideal submitted a <u>Petition for Exemption of Waste CKD from their Seattle, Washington, Cement Manufacturing Plant</u> (Appendix A-4).

The DOE did not act on this petition in a time frame that allowed its inclusion in the Washington State Amended Dangerous Waste Regulations, effective May 17, 1984. As such, CKD is absent from WAC 173-303, Section 071, Excluded Categories of Waste. Repeated efforts to elicit guidance from the DOE were unsuccessful until September 19, 1984, when the agency responded to Ideal's petition with a "completeness review" (Appendix A-5). In the interim, Ideal has submitted a Notification of Dangerous Waste Activities, Form 2 (Appendix A-6). Submission of this form represents timely compliance within the six-month interim period following amendment of the May 17, 1984, Amended Dangerous Waste Regulations.

REFERENCES

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WAC 173-303-910(1)(b)(iii)

DESCRIPTION OF PROPOSED ACTION

Ideal Basic Industries is requesting exemption of its waste cement-kiln dust (CKD) from the amended Washington State Dangerous Waste Regulations, WAC 173-303, effective May 17, 1984. The result of this exemption will be to re-establish the exclusionary status provided by the EPA for cement-kiln dust in 1980, as well as the exclusion provided by the original Washington State Dangerous Waste Regulations promulgated on March 10, 1982. It will also re-establish CKD as a solid waste under the regulatory jurisdiction of the King County Public Health Department, whereupon Ideal's Seattle Cement-Manufacturing Plant will be able to renew transportation of their cement dust to the Industrial Mineral Products (I.M.P.) Silica Sand Mine property near Ravensdale, Washington, as it has done for the last five years. At that property, the cement-kiln dust will be placed in the Dale Strip Pit for reclamation purposes.

WAC 173-303-910(1)(b)(iv)

STATEMENT OF NEED AND JUSTIFICATION FOR PROPOSED ACTION

WAC 173-303-910(1)(b)(iv)(aa)

STATEMENT OF NEED

The cement industry has been a leader among extractive and industrial process industries in improving environmental quality. In the 10 years before passage of the Clean Air Act Amendments of 1970, U.S. cement companies had invested more that $210 million in capital equipment for all pollution control. They have invested an additional $450 to $500 million to meet the highly stringent standards promulgated by the Environmental Protection Agency.

The economic cost of regulations governing water quality, land use, and safety and health is affecting the cement industry's ability to carry forward urgently-needed energy conservation programs, plant modernization, and capacity expansion. The cement industry's position is that the extent and character of government regulation - as desirable as it may sometimes be - must be examined and assessed in light of the impact on the economy, employment levels, and the public good.

Ideal Basic Industries began producing cement at its Seattle Plant on West Marginal Way in 1967. They immediately began to produce a mineral by-product, cement-kiln dust, resulting from the use of a highly efficient electrostatic precipitator for cleaning exhaust gases from kiln burning operations. The first choice of any cement company is to re-introduce this kiln dust to the production cycle because it represents 10 to 20 percent of the raw materials used for cement manufacture, and because as much as $18. per ton is tied up in the substance during its production.

The concentration of potassium and sodium alkalies in CKD is elevated above their concentration in finished cement. This is because their volatility encourages their exhaust, along with hot combustion gases, from the kiln. They are then entrained on fine dust particles in the stack. Rigid government specifications limit the amount of these alkalies in finished cement because of their potential adverse reaction with aggregates, and resultant weakening of concrete structures. These specifications have become more severe than they possibly need to be. Their relaxation could do a great deal to mitigate the problems posed by CKD disposal, because more CKD could be introduced back into the production cycle if alkali build-up were not of such concern. Because they are very soluble, these alkalies can be leached out of CKD, and the leached sludge can be re-introduced to the production cycle. The problem associated with leaching centers around disposal of the alkaline leachate.

For several years, Ideal provided the fill resource for a private, local excavation and trucking company that built up Seattle parkland and tidelands surrounding the Ideal Plant. This was performed through a contractual agreement with Ideal whereby the trucking company provided dumping sites, acquired all necessary permits, and strove to prevent contamination of the Duwamish River or storm sewers. The improved real estate was used for development of home sites and industrial facilities along West Marginal Way and the South Park area.

When these projects were complete, however, Ideal required another disposal site. From the start of production, Ideal had promoted use of their CKD as a soil amendment, and had shipped large quantities of the liming agent into northwest Washington counties via established fertilizer dealers. The fertilizer market is, by its very nature, a seasonal one. Several months out of the year, CKD cannot be sold for this purpose because it must be applied before crops are sown.

In 1979, with the endorsement of the King County Public Health Department, Ideal started trucking its CKD to the Industrial Mineral Products (I.M.P.) Silica Sand Mine Reclamation Project near Ravensdale, Washington, a town 35 miles southeast of Seattle in the flanks of the Cascade Range. The Health Department was concerned that Ideal's CKD be placed in an environment away from population centers, in a repository that was designed to prevent alkaline leachate from polluting waterways, and where monitoring could be performed routinely.

Examination of the enclosed Environmental Checklist pertaining to the Dale Strip Pit Reclamation Project demonstrates that it represents an unusually clean landfill with a natural monitoring system that is more effective than any specially-designed monitoring system could have been. Nothing in the records that have been maintained for five years on this site and the surrounding terrain demonstrates that the environment has been impacted as a result of I.M.P.'s management practices.

The site has solved the practical disposal and reclamation needs of two major basic industries in the Seattle area, in an economic fashion that has allowed their continued operation and contribution to the local employment and tax base. In doing so, the Dale Strip Pit Reclamation Project has had the full support of the local solid-waste regulatory authority, the King County Public Health Department, as evidenced by their letter to the Washington Department of Ecology in Appendix C-13. King County recognizes the need for special waste disposal sites within economical transportation distance~~s~~ of the industries that support the local economy, and have often expressed faith in how this material is being handled at Ravensdale.

Washington State has done a commendable job in their efforts to keep the environment free of hazardous substances that can pollute air, soil and water. Certainly hazardous wastes need to be inventoried and disposed of in the safest possible manner. However, at the same time, Washington State has failed to provide the means by which industry can reasonably afford to dispose of its wastes. It has not recognized industry's need for an in-state dangerous-waste disposal site and has done little to encourage recycling of industrial wastes. Many wastes could be combined to render one another harmless, e.g., CKD and pickling liquors.

The state has also failed to distinguish between substances that are truly hazardous, and those that are not. It is ludicrous that a waste substance should be labeled dangerous when the same substance, without going through any physical or chemical alternation of its properties, has been used without harm to public health in the treatment of public water supplies and in the direct fertilization of food crops. Application of a dangerous waste label to a substance whose major market involves direct application to crop-producing soils, will greatly impede its use for this purpose because of press-inspired public paranoia over these labels. The state has done nothing to educate the public as to the "Degree of Hazard" posed by substances captured by their dangerous-waste regulations. This labeling, and the market inhibition inherent in their use, is in direct contradiction to the fundamental purpose of the Resource Conservation and Recovery Act, which is to save the nation's resources, especially when doing so saves energy.

Cement manufacture has been identified by the Department of Commerce as one of the six most energy-intensive industries, as ranked by the energy required to produce a ton of product. Energy consumption represents nearly one-third of the manufacturing cost of cement. The cement industry uses all major forms of energy: coal, oil, natural gas and electric power. In addition to measures for conserving oil and natural gas by greater reliance on coal, the cement industry has made significant progress in overall energy conservation. In the period 1972 to 1982, energy consumption per ton of production was reduced from 6.7 million BTU to 5.4 million BTU, a 20 percent increase in energy efficiency. Encouragement of CKD recycling could only contribute in a positive way to increased energy savings.

Ideal Basic Industies cannot continue to compete in the cement-manufacturing industry with CKD disposal fees of $104. per ton, twice the amount per ton they receive for their finished cement. This is the amount assessed by Chemical Security Systems, Arlington, Oregon, for trucking to, and tipping fees at the only state-sanctioned dangerous-waste disposal site. This amount is especially difficult to accept when it is generally understood that the Arlington disposal site will use Ideal's CKD material to stabilize acidic wastes from other industries who are also charged for acceptance of their wastes.

The economic impact of refusal of this exemption petition is discussed fully in the Justification Section of this document. Suffice it to say ~~here~~ that, if Ideal is forced to haul their CKD to Arlington, Oregon, while operating at full capacity, the cost to them would by $3.6 million per year.

Obviously, Ideal Basic Industries needs a relaxation of the regulations that have been applied to their waste since January 1, 1984, so that their CKD can be restored to the solid-waste classification that would allow its continued monitoring-management by the local public health authority. To refuse the exemption from regulation of a substance considered safe by even the U. S. Environmental Protection Agency, as well as by every other public and private agency nationwide that has studied its properties, would be punitive. It would be especially punitive for a corporation recognized in the WDOE records for its responsibility in dealing with environmental concerns and its good managment practices. It would also draw Washington State's attention and pollution-abatement resources away from those substances of real hazard.

The mechanism for exempting Ideal's CKD is in place in the existing Dangerous Waste Regulations, WAC 173-303, in the provisions that allow for exemption of substances that are captured, but that can be proven to otherwise not pose a hazard to the environment or public health. The state needs to make a decision based on the degree of real, practical, demonstrated hazard, based on the method by which a "dangerous waste" substance is managed. Examination of the following document establishes, without question, that no better disposal site is available to Ideal than the existing Dale Reclamation Site at Ravensdale.

WAC 173-303-910(1)(b)(iv)(bb)

JUSTIFICATION FOR PROPOSED ACTION

There are many reasons for which Ideal Basic Industries feels justified in requesting exemption of their cement-kiln dust from Washington's Dangerous Waste Regulations, but only the five major reasons are discussed in this document. These justifications are:

1. The commonness of cement and concrete in the environment throughout the history of human civilization, including its extensive use in bodies of water containing aquatic life.

2. The widespread uses for cement-kiln dust in a variety of industries and environments. This section documents Ideal's progress in cutting back the production of their CKD and in establishing markets for the CKD they will inevitably produce if they continue to make cement clinker. With all the documented use of CKD in situations where it is utilized to stabilize other wastes, and where it comes into direct contact with public water supplies and food-crop soils, it is difficult to see how the substance can be considered

hazardous to human health or the environment. Evidence supports Ideal's claim that CKD is a low-risk substance.

3. The inapplicability of the Static Acute Fish Bioassay for characterization of this substance, when it can be proven that the only property of CKD that kills fish is its alkalinity. When CKD test solutions are pH-controlled, fish do not die, demonstrating that the components of CKD are not, of themselves, toxic to aquatic life. This pH-related fish mortality is documented by duplicate bioassay tests using distilled water that was artificially elevated to the pH at which the CKD solution killed fish. This points out the necessity of testing wastes in the environment in which they actually exist. Additionally, this section points out that the only property by which CKD is captured, its high pH, diminishes through time, such that it ultimately poses no hazard, even to aquatic life.

4. The suitability of the existing disposal site for Ideal's CKD at Ravensdale, Washington. Evidence is developed that demonstrates this is the most viable geohydrologic repository for CKD, and other low-risk industrial wastes, within economically feasible trucking distances of Seattle. The suitability of the site was borne out by a 1972 METRO

study of its potential use as a repository for Seattle's sewage sludge.

5. The punitive economic impact to Ideal's Seattle Plant and its suppliers, as well as to the employment and tax base of King County and Washington State, should this exemption petition be denied.

WAC 173-303-910(1)(b)(iv)(bb.1)

COMMONNESS OF CEMENT AND CONCRETE IN THE ENVIRONMENT

Cementitious substances have been used by man since the earliest civilizations. The Egyptians used impure gypsum plaster as mortar in pyramid construction. Slaked lime was used by the Greeks, and the Romans probably learned its utility from them. Both civilizations made a pozzolanic mortar by mixing finely-ground volcanic ash with lime, sand and water. Pozzolana hardens by reacting chemically with the free lime in cement.

Pozzolan is defined as an artificial, or natural, fine silicious and aluminous compound which will form cementitious compounds upon combination with water and calcium hydroxide (slaked lime). During hydration of portland cement, calcium hydroxide is produced. It does not add any cementitious properties to the concrete and is readily leached, resulting in porous, permeable concrete. By addition of a pozzolanic substance to cement, excess lime will enter into the chemical reaction, after the portland cement reaction is complete, to add more strength and impermeability to concrete. Pozzolan such as utility flyash is commonly added to concrete, especially in large concrete construction projects, but this is a fairly new process. Leaching of lime from concrete is, therefore, very common. Obviously, if concern for CKD results from the action of its lime content, concern would have to be expressed over the environmental impact of the lime that leaches in untold quantities from every concrete structure that has been built, in every conceivable environment, including bodies of water that support aquatic life.

Cement is used in nearly every type of construction. In the U.S., the annual tonnage of concrete made with portland cement greatly exceeds the combined tonnage of all other construction materials. Concrete is used in residential, farm and public building construction, in pavement, dams, bridges, silos, piping, tanks, reservoirs, revetments, swimming pools, ornamentation, and so on. Washington State's Grand Coulee Dam is the largest concrete structure on Earth.

Throughout the world, concrete structures are the most common because they are cheaper to build, more durable, and can be constructed from locally-available raw materials. Concrete structures occur in every environment.

The annual production of portland cement in the U.S. is between 75 and 80 million tons. The domestic industry consists of 42 companies operating 133 clinker-producing plants in 38 states. Portland cement is a chemical combination of calcium (usually in the form of limestone), silica, alumina, iron ore, and small amounts of other materials. Most construction cements are hydraulic cement; i.e., ones that are not only mixed with water but will set and harden under water. They are composed of the commoner oxides of the Earth's crust and depend for their hydraulic property on chemical compounds of lime that react with water.

Figure 3 is a chemical analysis of Ideal's cement-kiln dust. Figure 4 is a chemical analysis of the I.M.P. silica sand, one of the major components of Ideal's portalnd cement. CKD represents 10 to 20 percent of the raw material used in cement manufacture. Examination of Figure 5, the common chemical elements of the Earth's crust, demonstrates that the oxides that compose Ideal's CKD are the most common compounds in nature. They are the common components of every major rock-type and nothing about their occurrence in CKD is unusual in any way, either in composition or in quantity.

Limestone, from which portland cement is largely derived, occurs in most parts of the world. It represents 20

CEMENT KILN DUST

SiO_2	12.5
TiO_2	0.1
Al_2O_3	2.9
Fe_2O_3	1.9
MgO	0.7
CaO	49.7
Na_2O	0.7
K_2O	1.4
SO_3	4.8
LOI	24.8

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CEMENT KILN DUST COMPOSITION		
		FIGURE 3

INDUSTRIAL MINERAL PRODUCTS, INC.

CRUDE SILICA SAND

SiO_2	79.96
TiO_2	0.29
Al_2O_3	12.47
Fe_2O_3	1.24
MgO	0.14
CaO	0.15
Na_2O	0.54
K_2O	2.42
LOI	3.46
	100.67%

Quartz	54.8
Anorthite	1.4
Albite	4.6
Orthoclase	14.3
Clay	24.7
	100.2%

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COMPOSITION OF I.M.P. CRUDE SILICA SAND

FIGURE 4

ACCELERATION DUE TO GRAVITY AND LENGTH OF THE SECONDS PENDULUM

For Sea Level at Various Latitudes

Based on the formula of the U. S. Coast and Geodetic Survey. The length of the simple pendulum whose period is two seconds, that is which beats seconds, is computed in each case from the corresponding value of the acceleration.

Latitude	Acceleration due to gravity		Length of seconds pendulum	
°	cm/sec.^{2}	ft./sec.^{2}	cm	in.
0	978.039	32.0878	99.0961	39.0141
5	978.078	32.0891	99.1000	39.0157
10	978.195	32.0929	99.1119	39.0204
15	978.384	32.0991	99.1310	39.0279
20	978.641	32.1076	99.1571	39.0382
25	978.960	32.1180	99.1894	39.0509
30	979.329	32.1302	99.2268	39.0656
31	979.407	32.1327		
32	979.487	32.1353		
33	979.569	32.1380		
34	979.652	32.1407		
35	979.737	32.1435	99.2681	39.0819
36	979.822	32.1463		
37	979.908	32.1491		
38	979.995	32.1520		
39	980.083	32.1549		
40	980.171	32.1578	99.3121	39.0992
41	980.261	32.1607		
42	980.350	32.1636		
43	980.440	32.1666		
44	980.531	32.1696		
45	980.621	32.1725	99.3577	39.1171
46	980.711	32.1755		
47	980.802	32.1785		
48	980.892	32.1814		
49	980.981	32.1844		
50	981.071	32.1873	99.4033	39.1351
51	981.159	32.1902		
52	981.247	32.1931		
53	981.336	32.1960		
54	981.422	32.1988		
55	981.507	32.2016	99.4475	39.1525
56	981.592	32.2044		
57	981.675	32.2071		
58	981.757	32.2098		
59	981.839	32.2125		
60	981.918	32.2151	99.4891	39.1689
65	982.288	32.2272	99.5266	39.1836
70	982.608	32.2377	99.5590	39.1964
75	982.868	32.2463	99.5854	39.2068
80	983.059	32.2525	99.6047	39.2144
85	983.178	32.2564	99.6168	39.2191
90	983.217	32.2577	99.6207	39.2207

Free Air Correction for Altitude

−0.0003086 cm/sec.^{2}/m for altitude in meters.
−0.000003086 ft./sec.^{2}/ft. for altitude in feet.

Altitude meters	Correction cm/sec.^{2}	Altitude feet	Correction ft./sec.^{2}
200	−0.0617	200	−0.000617
300	.0926	300	.000926
400	.1234	400	.001234
500	.1543	500	.001543
600	.1852	600	.001852
700	.2160	700	.002160
800	.2469	800	.002469
900	.2777	900	.002777

DATA IN REGARD TO THE EARTH

Equatorial radius, 6,378,390 meters, 3,963.34 miles.
Polar radius, 6,356,910 meters, 3,949.99 miles.
Radius of sphere having same volume, 6,371,220 meters, 3,958.89 miles.
Quadrant of the equator, 10,019,150 meters, 6,225.60 miles.
Quadrant of the meridian, 10,002,290 meters, 6,215.12 miles.
1° latitude at the equator = 69.41 miles
1° latitude at the pole = 68.70 miles.
Mean density of the earth, 5.522 g/cm^3, 344.7 lb./ft.^{3}
Mass of the earth, 5.983 × 10^{24} kg, 6.595 × 10^{21} tons.
Mean surface density of the continents, 2.67 g/cm^3, 166.7 lb./ft.^{3}
Mean linear velocity of the earth in its orbit, 29.77 km/sec., 18.50 mi./sec.
Mean linear velocity of rotation of the surface at the equator, 0.465 km/sec., 0.289 mi./sec.

DATA IN REGARD TO THE EARTH (Continued)

Land area, 148.847 × 10^6 km^2, 57.470 × 10^6 sq. mi.
Ocean area, 361.254 × 10^6 km^2, 139.480 × 10^6 sq. mi.
Highest mountain, Everest, 8840 meters, 29,003 ft.
Greatest sea depth, 10,430 meters, 34,219 ft.
Thermal gradient of the earth, higher at increasing depths, 30° C per km, 48° C per mi. (uncertain).
Mean distance to the sun, 149,500,000 km or 92,900,000 mi.
Mean distance to the moon, 384,393 km or 238,854 mi.

THE COMMONER CHEMICAL ELEMENTS IN THE EARTH'S CRUST

Reprinted from "Principles of Geochemistry" (1952) with the permission of Brian Mason, author, and John Wiley and Sons, publishers.
The "Earth's Crust" refers to the rocks only and does not include atmosphere or the oceans. The atom percent column is obtained by dividing the weight percent by the atomic weights and reducing to 100%. The radius is the ionic radius. The volume percent is the atomic percent multiplied by $\frac{4}{3}\pi r^3$ and reducing to 100%.

Element	Weight %	Atom %	Ion Radius (Å)	Volume %
O	46.60	62.55	1.32	91.97
Si	27.72	21.22	0.39	0.80
Al	8.13	6.47	0.57	0.77
Fe	5.00	1.92	0.82	0.68
Mg	2.09	1.84	0.78	0.56
Ca	3.63	1.94	1.06	1.48
Na	2.83	2.64	0.98	1.60
K	2.59	1.42	1.33	2.14

THE AVERAGE AMOUNTS OF THE ELEMENTS IN EARTH'S CRUST IN GRAMS PER METRIC TON OR PARTS PER MILLION

Reprinted from "Principles of Geochemistry" (1952) with the permission of Brian Mason, author, and John Wiley and Sons, publishers.

O	466,000	N	46	Br	1.6
Si	277,200	Ce	46	Ho	1.2
Al	81,300	Sn	40	Eu	1.1
Fe	50,000	Y	28	Sb	1?
Ca	36,300	Nd	24	Tb	0.9
Na	28,300	Nb	24	Lu	0.8
K	25,900	Co	23	Tl	0.6
Mg	20,900	La	18	Hg	0.5
Ti	4,400	Pb	16	I	0.3
H	1,400	Ga	15	Bi	0.2
P	1,180	Mo	15	Tm	0.2
Mn	1,000	Th	12	Cd	0.15
S	520	Cs	7	Ag	0.1
C	320	Ge	7	In	0.1
Cl	314	Sm	6.5	Se	0.09
Rb	310	Gd	6.4	A	0.04
F	300	Be	6	Pd	0.01
Sr	300	Pr	5.5	Pt	0.005
Ba	250	Sc	5	Au	0.005
Zr	220	As	5	He	0.003
Cr	200	Hf	4.5	Te	0.002?
V	150	Dy	4.5	Rh	0.001
Zn	132	U	4	Re	0.001
Ni	80	B	3	Ir	0.001
Cu	70	Yb	2.7	Os	0.001?
W	69	Er	2.5	Ru	0.001?
Li	65	Ta	2.1		

CHEMICAL COMPOSITION OF ROCKS

Reprinted from "Sedimentary Rocks" (1948) with the permission of F. J. Pettijohn, author, and Harper Brothers, publishers.

Element	Average igneous rock	Average shale	Average sandstone	Average limestone	Average sediment
SiO_2	59.14	58.10	78.33	5.19	57.95
TiO_2	1.05	0.65	0.25	0.06	0.57
Al_2O_3	15.34	15.40	4.77	0.81	13.39
Fe_2O_3	3.08	4.02	1.07	0.54	3.47
FeO	3.80	2.45	0.30		2.08
MgO	3.49	2.44	1.16	7.89	2.65
CaO	5.08	3.11	5.50	42.57	5.89
Na_2O	3.84	1.30	0.45	0.05	1.13
K_2O	3.13	3.24	1.31	0.33	2.86
H_2O	1.15	5.00	1.63	0.77	3.23
P_2O_5	0.30	0.17	0.08	0.04	0.13
CO_2	0.10	2.63	5.03	41.54	5.38
SO_3		0.64	0.07	0.05	0.54
BaO	0.06	0.05	0.05		
C		0.80			0.66
	99 56	100.00	100.00	99.84	99.96

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Cement Division

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DATE:
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FIGURE 5
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COMMON ELEMENTS IN THE EARTH'S CRUST
DRAWING NUMBER

percent of all sedimentary rocks. In many states it is the common bedrock and natural waters in these states are influenced by this carbonate environment, as evidenced by elevated pH and calcium-induced water hardness. Aquatic life thrives in limestone terrains where water pH is often in the high 8's and low 9's.

WAC 173-303-910(1)(b)(iv)(bb.2)

WIDESPREAD USES FOR CKD IN A VARIETY OF INDUSTRIES AND ENVIRONMENTS

The United States has the worst record of any industrialized nation for recycling and marketing its cement-kiln dust. This inertia is partly due to the failure of government agencies to see the value of domestic wastes and provide incentives for their recovery and use, and partly due to the public's resistance to change and recognition that our natural resources are exhaustible. The cement industry is also to blame, in that it has been so preoccupied with the manufacture of cement, it hasn't taken the time to assess and correct the problems developing around disposal of its CKD waste. CKD is a substance the cement industry has traditionally regarded as a costly waste, not a viable, marketable mineral resource with sales value. Now that CKD has become subject to stringent waste-disposal regulation at both the federal and state level, incentive has been provided to focus attention on market development for this valuable substance. The institutional barriers to recovery and reuse of CKD are still in place. Strong political input will be necessary to gain acceptance of CKD as a replacement for other substances, such as lime, in traditional applications, and for its use in completely new, untried areas.

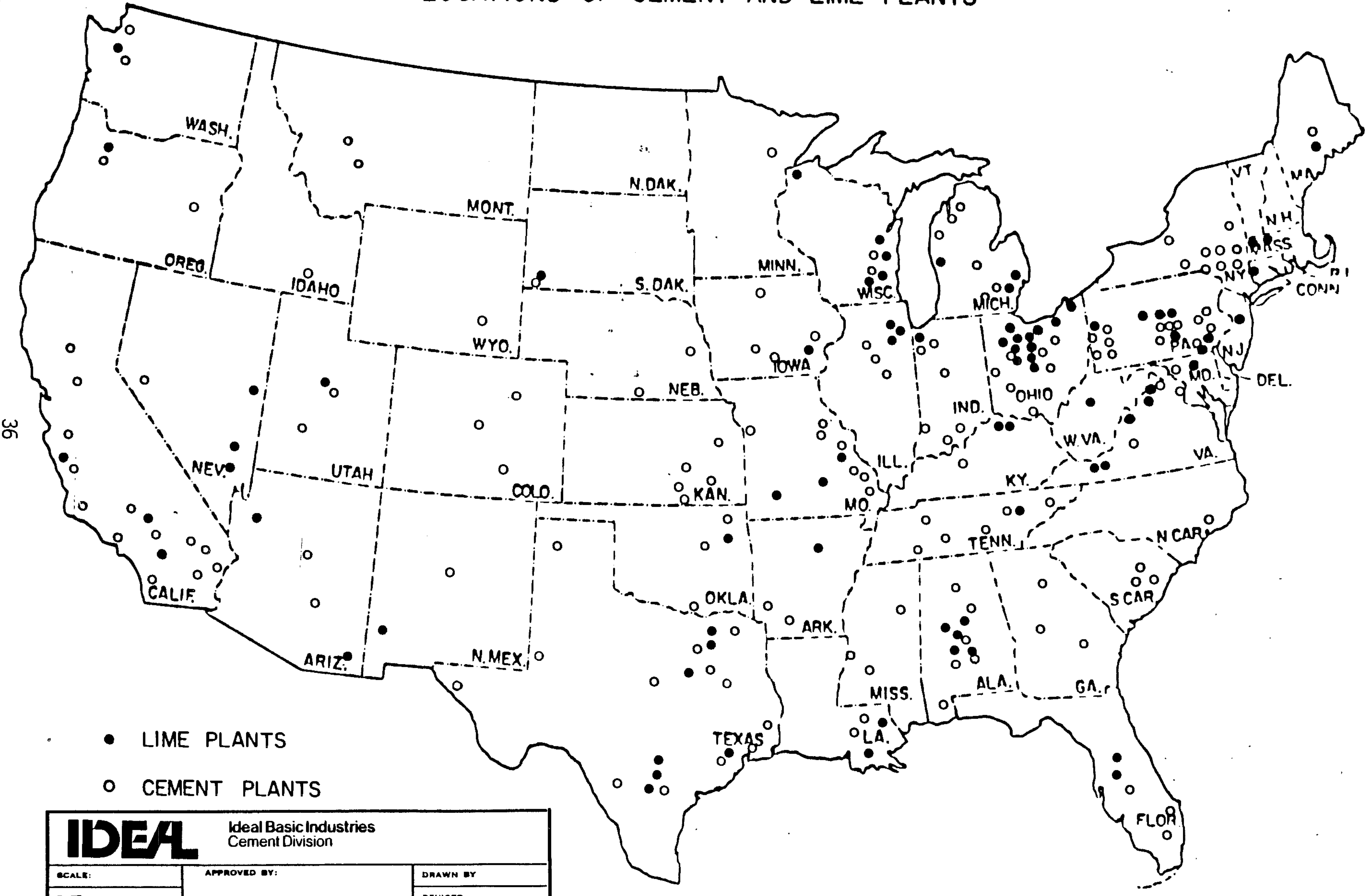
Once considered an unserviceable by-product of the cement-manufacturing process, CKD is now gaining recognition as a viable mineral resource whose use can reduce energy consumption and lower operating costs for the cement companies. These savings will be passed on to the consumer.

Ideal's Seattle Plant spends $12. per ton to dispose of its CKD, in addition to the $18. per ton it costs to produce it. Sales, therefore, result in a turnaround of $30. per ton. With current supply, a reasonable marketing effort, and this sales incentive, Ideal is making progress in establishing markets for all the CKD they produce. Appendix B-1 is a marketing program solicitation from N-Viro Energy System to Ideal Basic Industries. N-Viro is the largest marketing company in the U.S. devoted to developing uses for CKD. These CKD specialists hold patents on processes they have developed to utilize CKD in road-base systems.

One of the most difficult aspects of the Washington State Dangerous Waste Regulations for the generator of a low-risk waste to comprehend, is designation of a substance simply because it is a waste, when the identical substance is not subject to regulation as a product. This is certainly true for Ideal's cement-kiln dust, which like cement dust from all U.S. sources, has been used in a wide variety of product applications, most especially as a food-crop soil amendment. The annual production of portland cement in the U.S. is between 75 and 80 million tons. There are presently 133 operating cement plants in 38 states (Figure 6). At this time, it is estimated that 18-to-20 million tons of CKD are produced annually. Previous estimates indicate that 6-to-10 million tons per year of CKD are recycled or utilized in some way, resulting in approximately 8-to-12 million tons per year of CKD put to waste. In addition to freshly-produced kiln dust, there are many large stockpiles of kiln dust throughout the country. Accumulations in these stockpiles have been estimated to be well in excess of 100 million tons (Collins and Emery, 1983). The longer they sit, the less value these stockpiles have because the aging or weathering process results in contamination and diminished reactivity, further decreasing the potential for recycling them. If they have been mixed with other wastes, their usefulness is also diminished; however, lower grade applications such as use in agriculture are possible. Once again, pressures applied by waste regulations may make recovery economically feasible.

Although substantial quantities of cement-kiln dust must be disposed of every year, there is a wide range of current and potential uses for these materials. The ideal use, of

LOCATIONS OF CEMENT AND LIME PLANTS



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LOCATION OF CEMENT & LIME PLANTS IN U.S.

FIGURE 6

course, is to recycle the kiln dust back into the production cycle, whenever alkali levels permit, because the amount of dust generated represents from 10-to-20 percent of the raw material used in cement manufacture. The savings in energy alone from recycling CKD is immense.

A recent Bureau of Mines report (1982), Characterization of U.S. Cement-Kiln Dust, concludes that "CKD is a large-volume material and potential resource as a substitute for lime. Any environmental considerations are minor, as the results of this extensive survey show that U.S. CKD is not a hazardous waste as defined by current regulations established under RCRA."

The original purpose of the Resource Conservation and Recovery Act (RCRA), from which waste regulations derive, is exactly what its title states, the use of waste materials whenever reasonable, especially when their use conserves energy. The act mandates such use in federal programs, and in particular, highway programs. The EPA was directed by Congress to develop guidelines to encourage waste utilization. Today, however, EPA is clearly in non-compliance with RCRA by its failure to act on the RCRA waste-utilization guidelines.

Regulatory agencies at the state level should direct their focus to encouragement of waste recovery and recycling, and development of markets that will put mineral by-products such as CKD directly back into the industrial resource mainstream, with resultant conservation of exhaustable natural resources and fossil fuels. With this spirit of conservation and recovery, state and industry can pool their resources to eliminate generation of costly, pollution-forming wastes. The entire purpose of this Exemption Petition is to demonstrate that Ideal's CKD is a low-risk waste and that market development is Ideal's principal aim in dealing with their by-products, as evidenced by the steadily-decreasing tonnages they transport to the Dale Strip Pit Reclamation Site. The following letters from Ideal's Seattle Plant and the information presented in Table 20 and Figure 64 in Section WAC 173-303-910(3)(c)(vi), document Ideal's progress in reducing the amount of CKD put to waste, as well as their incentives for, and progress in, developing markets for all CKD they produce.

Every effort should be made at the state level to recognize and encourage Ideal's effort through relaxation of regulations. These regulations should, instead, be aimed directly at waste substances of real hazard to the environment and public health, not those wastes that are so innocuous they can be used as food crop-fertilizers.

A comprehensive review of the disposal and utilization of CKD was conducted by Davis and Hooks (1974), attached as

Ideal Basic Industries
Cement Division

Seattle Plant
5400 West Marginal Way S.W.
Seattle, Washington 98106
206 937 8025

IDEAL

October 4, 1984

Glennda McLucas
Consulting Geologist
P.O. Box 5352
Lacey, WA 98503

Re: Waste Recycling

Glennda:

Over the years several methods of recycling our waste dust have been developed.

We always have had the capabilities to insufflate our dust. This is nothing more than blowing the collected waste dust back into the front of the kiln to be reburned into clinker. This method of recycling is advantageous in that we can build up coating and control the burning zone temperatures. We generally insufflate 4 to 9 tons per hour.

Another method used in the early days and up to about 1974 was a method called "classification". Using this method, dust was mixed with water (called "pugging") and added to a large settling basin. A coagulating agent such as "Separan" was added. This caused the dust particles to coagulate and sink to the bottom.

Rakes moved the dust out to a pump that transferred the wet "dust slurry" to the kiln.

The clear water left was neutralized with acid and then overflowed to the Metro sewer. This method is no longer used and all equipment has been removed.

The newest method we are using is called "briquetting". The collected dust is fed to a roll press at the rate of 10-15 tons per hour. The rolls are hydraulically operated and, under 2000 pounds pressure, press or "briquette" the dust into pieces about 2" to 3" long and cigar shaped. These pieces drop from the rolls into a screw which takes them up an elevator over a shaker screen and into the kiln.

Waste Recycling

This piece of equipment is the only one of its kind being used in our industry, and extensive testing and rebuilding was necessary for us to be where we are today.

We are investigating other ways to utilize the dust in areas outside of our plant.

These include its use as a fertilizer, a soil stabilizer and soil conditioner. We are in contact with U.C. Berkeley where a program is under way for finding other uses for our dust. Other people have shown interest as a stabilizer for waste dumps of wet sludges.

These methods of dust utilization are exciting and show promise, but we feel the key is to recycle all waste dust at the plant and drastically reduce the production of dust in the first place.

We are currently undergoing test runs at various inputs to see just where our optimum production point is for zero or near zero dust generation.

Sincerely,

L Darby

L. Darby

LD:dp

cc: R. Wallis
R. Bergman
E. Owens

Appendix B-2. The range of potential and actual markets for cement-kiln dust includes:

1) Agricultural Uses.
2) Landfill, Mine Reclamation and Soil Stabilization.
3) Waste Stabilization.
4) Highway Construction.
5) Filler Materials.
6) Ceramics Manufacture.

In Washington State, CKD has been used principally as a soil liming agent and as a mine backfill for compliance with Washington's surface-mining reclamation laws. CKD has also been used as an acid-waste stabilizer by Chemical Security Systems at their Arlington, Oregon, Hazardous Waste Disposal Facility. In addition, it has been considered for use by the City of Spokane Wastewater Treatment Plant as a substitute for lime in stabilization of sewage sludge, as a filler for asphaltic concrete, as a liner and daily cover source for King County sanitary landfills, and as a neutralization/stabilization agent for pickling liquors by two metal finishing/plating companies. Kaiser Aluminum in Spokane has used small quantities as a baghouse pre-coating agent to tie up sulfates and nitrates generated by their process, then exhausted through the baghouse system.

Because agricultural and mine reclamation uses have consumed most of Ideal's CKD markets in the last five years, those uses will be discussed first, followed by short summaries of potential uses. Publications describing potential uses for CKD in Washington are attached as appendices to this section.

WAC 173-303-910(1)(b)(iv)(bb.2)

AGRICULTURAL USES

In the past five years, Ideal's Seattle Plant has generated 894,199 tons of CKD, of which 499,566 tons (55.8 percent of production) have been sold, predominantly as a liming agent; 247,663 tons (27.6 percent of production) have been transported to the I.M.P. Silica Sand Mine as a reclamation backfill. In 1981, the tonnages sold as a liming agent were 27.6 percent of the amount transported to Ravensdale; by 1983, the amount sold was 72.7 percent of the amount hauled; and by 1984, the amount sold was 224 percent of the amount hauled to the mine. These figures show that Ideal's aim is to market their kiln dust, not to waste it.

Ideal's CKD has been formally registered as a fertilizer and agricultural lime (Cottrell lime) in Washingon State. The Wahington State Certificates of Registration and Product Data Sheets for Ideal's soil amendment product are attached in Appendix B-3. This lime registration guarantees a calcium carbonate equivalent not less than 80 percent. Calcium-carbonate equivalent means the sum of the calcium and magnesium oxide content of a substance used as a liming material, when both are expressed as their equivalent in calcium carbonate; it is expressed as a percentage, with pure limestone at 100 percent. Ideal pays the Washington State Department of Agriculture 14 to 17 cents per ton of CKD sold to guarantee their analysis.

Liming refers to the addition to the soil of any product consisting of calcium or calcium and magnesium carbonates, oxides, or hydroxides, in sufficient quantity to neutralize soil acidity, such as burned lime, hydrated lime, ground or pulverized limestone, limestone screenings, and aglime. The most commonly-used product is pulverized limestone (Shideler, 1971). Liming agents are used to:

1) Supply calcium, or calcium and magnesium, to growing plants.

2) Neutralize soil acidity and create the best condition for availability of minor elements.

3) Increase the activity of nitrogen and phosphorus for plant growth.

4) Counteract acid-forming sources of nitrogen, such as ammonia in fertilizers.

5) Reduce the uptake of strontium 90.

6) Provide calcium, which is of vital importance for the health of humans and other animals, much of which comes through products of the soil.

7) Bring soil pH to the range of 5.5 to 7, where almost all crops and plants have greatest yields.

Ideal's agricultural liming agent has been marketed since 1968 through Wolfkill Feed and Fertilizer Company in Mt. Vernon, Lynden and Monroe, and through Northern Lime Company, Burlington, Washington. The following letter from the owner of Northern Lime Company outlines the history, current operations and forecasts of future markets for Ideal's CKD in western Washington's agricultural markets. Figures 7 and 8 show the equipment and application method used by Northern Lime to spread Ideal's CKD on Skagit County cropland.

Use of CKD in western Washington has greater potential than in the dryer, eastern counties (with some notable exceptions) because the heavy rainfall on the west side has leached out many of the elemental nutrients available in CKD, and has created more acidic soil conditions. Washington State's cropland lime application need is 262,500 tons per year. Records of the National Limestone Institute (Appendix B-4) for 1977 and 1978, show that 83,356 and 70,753 tons of lime were applied, respectively. From this information, it is obvious that Washington agriculture could absorb three times the lime that is currently being applied. At a replacement ratio of 2:1 (CKD/aglime), 525,000 tons of CKD could be used

NORTHERN
LIME
CO.

1718 PEASE ROAD, BURLINGTON, WA 98233

Sept 26, 1984

SEP 28 1984

Glenda B. McLucas
Industrial Mineral Products, Inc.
PO Box 95
Ravensdale, WA 98051

Dear Glenda;

In response to your request, the following information is a brief description of our involvement with agricultural kiln dust (AKD), produced at the Ideal cement plant in Seattle.

We began hauling AKD in 1974 providing transportation for Wolfkill Feed & Fertilizer in Mt. Vernon and later in Lynden and Monroe. Our family has been actively involved in agriculture and dairy operations since the Skagit Valley area was settled and because we specialize in bulk pneumatic tanker operations, it was a natural extension for us to become involved with the application of the material as well as the transportation.

In 1982 we saw three problem areas that we felt needed to be addressed, if AKD was to continue as a major source of agricultural lime. These areas were; 1) Service, 2) Application, and 3) Supply.

To solve the first two areas, service and application, we purchased a 4-wheeled, high flotation, fertilizer and lime spreader, and modified it to our specifications. And in early 1983, we entered into a sales agreement with Agri-Chem, Inc. of Burlington and began operations as Northern Lime Co.

With our success in the spring of 83, we decided to then address the remaining problem of supply. Ideal Cement produces approximately 50,000 tons of kiln dust annually. However, only a small portion of that material is available in the spring and fall when there is a market demand for agricultural lime. In the past, we have not been able to obtain enough kiln dust during the application season. Therefore, we built a flat storage warehouse and bulk load out facility, capable of storing and handling 5,000 tons of AKD. We then purchased another, identical, spreader. Utilizing the storage facility, AKD received directly from Ideal, and the two spreaders, we experienced a 100% growth from 1983 to 1984.

Burlington: 424-1230
Toll Free: 1-800-742-1230

Since we began operations, Northern Lime Co. has shown excellent growth and the potential exists for further growth and expansion. In 1983 we applied 5,043 tons of AKD and in 1984, we have currently applied 10,693 tons and we anticipate the total to exceed 12,000 tons.

As you can see, we have invested heavily and are fully committed to expanding the market and application of agricultural kiln dust. In the future we would like to move into other geographical areas where we could put our equipment and specialized talents to best use, especially during the slack months of winter.

Sincerely,

Brian Youngquist

Brian Youngquist

cc:Ron Wallace
Ed Owens

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NORTHERN LIME CO., CKD LIME SPREADER

MOUNT VERNON, WASHINGTON FIGURE 7

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CKD USED AS LIMING AGENT ON CROPLAND

SKAGIT COUNTY, NORTHERN LIME FIGURE 8

annually. This amount exceeds the annual production of both CKD generators in Washington.

CKD is an excellent soil conditioner, containing many essential nutrients. It has been used in agriculture since the turn of this century, the world over. Because it is significantly finer and provides quicker reactivity, kiln dust can replace aglime in some instances, at a common rate of two tons CKD for one ton of aglime. CKD is particularly valuable in sandy soils where traditional liming materials can leach out in a short period of time. Kiln dust pH is usually 11 to 12, while limestone pH is usually 8 to 10. CKD typically contains 50 percent calcium carbonate, 25 percent reactive calcined calcium, and 25 percent silica, alumina, iron and alkalies of sodium and potassium. It provides other valuable components to the soil such as potassium and sulfur. While the calcium carbonate equivalent of CKD is lower than quality aglime, it is available at one-third to one-fifth the price (Nicholson, 1983).

In agricultural applications, CKD can be used in the dry, powdered form, in a pelleted form, or as a slurry. Material already stockpiled can be recovered for agricultural uses as well. The seasonal nature of agricultural uses can be a problem in guaranteeing CKD availability in sufficient quantities for this use. Peak CKD production occurs in summer months. Peak agriculture use is in spring and autumn. This problem can be surmounted by construction of storage silos, the approach taken by Northern Lime Company in Burlington. The seasonal consumption by agricultural users also creates a supply problem during spring and fall months for other CKD markets.

Shideler (1971) provides a literature review of CKD as a fertilizer and soil conditioner, included in Appendix B-5. The paper concludes that if most CKD is applied at four tons per acre, it will supply three times the magnesium, six times the sulfur, 0.9 times the potassium, and sixteen times the calcium removed in a typical five-year crop rotation.

Other uses for CKD in the agricultural realm include its use for stabilizing and neutralizing cattle feed-lot runoff. Its use as a cattle-feed finishing supplement has been researched as well; however, to date nothing conclusive has been drawn from this research regarding the benefit of this application. Some attention has also been given to its use as a substitute for ground limestone for poultry grit. A Hungarian study indicated that, in addition to its stimulation of plant growth, CKD has potential as an insecticide. Most insects are covered with a waxy substance that retains body moisture. Abrasive, fine substances such as CKD can find their way through openings in this layer, to desiccate and ultimately kill the insect. Research into the use of CKD as a carrier for insecticides and herbicides seems in order.

Study Performed on the Effects of Cement-Kiln Dust on the Chemical and Biological Properties of Soils

The following information represents the results of a study performed for Ideal Basic Industries on the Effects of Cement-Kiln Dust on the Chemical and Biological Properties of Soils, by Dr. J.C. Smith of the Department of Plant and Soil Biology at the University of California, Berkeley. While this study principally investigates the use of Ideal's CKD as a soil amendment for agriculture and its use as a landfill liner and cover source, it also contains summary information on the use of CKD as a stack-gas sulfur scrubber, as a pH control and phosphate removal agent in sewage treatment plants, and as an acid-water treatment aid. These subjects are discussed in greater detail, especially as they apply to potential markets in Washington State, in following sections of this document.

Introduction

Cement-kiln dust (CKD) is a by-product of the cement-manufacturing process. In the late 1970's this by-product was accumulating at the rate of 4 to 12 million tons per year in the United States (Kearney, 1979; Federal Register, 1978).

This rate of accumulation of a "Waste" product caused enough concern that the Environmental Protection Agency gave CKD a "Special Waste" designation. This designation resulted from a lack of information about CKD characteristics and its potential hazard. Since the EPA had reason to believe that CKD may be a hazardous waste, they were obligated to place CKD in a "Special Waste" category (Federal Register, 1978). CKD was removed from this category in 1980; however, the agency continued to monitor new information concerning CKD. According to the U.S. Bureau of Mines (Haynes and Kramer, 1982), the EPA's major concern was the heavy-metal content of CKD. They astutely point out that the possible heavy-metal problem cited by the EPA came from only two studies, both of which analyzed a single CKD sample from Blaubeuren, West Germany.

The Bureau of Mines has produced two studies of characteristics and hazardous waste potential of CKD (Haynes and others, 1981; Haynes and Kramer, 1982).From these studies is is clearly evident that CKD is not a hazardous waste according to federal guidelines (Federal Register, 1980). Haynes and Kramer (1982) concluded that, "cement-kiln dust is a large-volume material and a potential resource as a substitute for lime." Their study of 113 CKD samples identifed the major constituents of CKD to be calcite ($CaCO_3$) and lime (CaO).

In the 1970's, interest increased in the use of lime for such industrial processes as water purification, phosphate removal from sewage, pH control in sewage plants and stack-gas scrubbing for atmospheric pollution control. These new and developing markets have grown rapidly in recent years, putting an increased demand on limestone and limestone producers.

Major requirements of these new lime uses are the fineness, reactivity and cost of the lime material. After reviewing these lime-utilizing technologies, it becomes apparent that CKD should be a much preferred material for these uses over limestone rock, which requires expensive grinding before use.

Stack-Gas Sulfur-Scrubbing and Sludge Stabilization

In recent years alarm has increased over pollution in developing countries. In the United States, the strengthening of pollution-control regulations has forced many marginally-profitable plants in a variety of industries to close. In the early 1970's, 10 lime plants closed down rather than meet the costly air-pollution control requirements (Smith and others, 1974). However, in the next few years there was to be a dramatic increase in lime production to be used for controlling air pollution by electric utilities. By 1984, the use of the limestone wet-scrubbing process for SO_2 control had reached 5.5 million tons annually (Daugherty, 1984). In the next five years this use of limestone is expected to reach 8 million tons annually.

The use of limestone and lime products for trapping SO_2 from coal and oil-burning power plants has been studied since the early 1970's. It was first believed that the majority of new power plants would be equipped with SO_2 scrubbers and that by 1980, 75 percent of total power output would come from plants equipped with SO_2 removal systems (Malhotra and Major, 1975). The utilization of this pollution-control process has not grown as rapidly as predicted; however, it remains the leading technology to date. There is still controversy surrounding the use of lime materials in stack scrubbing because of the varied efficiency between scrubbing methods and differences in reactivity between lime material types. In addition, there is concern about the waste sludge from the scrubbing process, and its suitability for land disposal.

The different methods and types of materials used for SO_2 scrubbing center around the physical and chemical properties of the lime material. Some companies use finely ground limestone,some 95 percent use burned lime (CaO), and others use waste lime from other industries (Malhotra and Major, 1974). The impurities inherent in lime materials have not been found to change the reactivity of the material. It has been found that the reactivity of the material increases with decreasing particle size. A particle size of 325-mesh is considered the ideal size for the scrubbing process. A major drawback of using limestone for the reactive material is the cost of grinding the stone to 325-mesh.

The post-combustion method of wet-scrubbing flue gases produces large amounts of waste sludge consisting mainly of calcium sulfate ($CaSO_4$), calcium carbonate ($CaCO_3$), and calcium hydroxide ($Ca(OH)_2$). This waste sludge generally has poor physical properties and potentially unsafe levels of toxic elements. To improve the properties of scrubber sludge for eventual land disposal, several materials have been mixed with the sludge including flyash, slag, lime, cement and combinations of these materials (Chu and others, 1978). In the Chu study, the conclusion was that scrubber sludge was physically stabilized by the addition of lime and fly ash. The strength of the stabilized material was compared to over-consolidated clays. It was also determined that additions of lime and fly ash to sludge reduced the mobility of several potentially-toxic elements by chemical fixation and decreased sludge permeability.

The use of post-combustion methods to control atmospheric pollution is now being pushed to its limit with mounting concern over acid rain. New technologies are being developed for the elimination of SO_2 and NO_X by mixing lime with coal before combustion (Bernabo, 1984).

Wastewater Treatment and Sludge Stabilization

In wastewater treatment, the removal of phosphorus is a major objective. Until the late 1960's the major precipitating chemicals used to remove phosphorus were iron and aluminum salts (Mennell et al,. 1974). The precipitates are then gravity settled, which tends to be a slow process. Using lime as the phosphorus-precipitation agent has the advantage of being less costly and the material may be recovered for re-use. In addition, lime may reduce the ammonia nitrogen in the wastewater along with a significant reduction in soluble solids and biochemical oxygen demand (BOD). An important criteria for the effectiveness of lime in this process is its reactivity, which can be related to its particle size (Mennell et al, 1974). In the waste-treatment process, lime has also been found to be useful as a clarifying agent (Minton and Carlson, 1976), and a stabilizing agent for sewage sludges.

Baker and others, (1975), compared CKD and hydrated lime for vacuum filtering sewage sludge. Their publication is attached to this document. They found that CKD was equal to hydrated lime for use in this process. CKD was more effective than lime in water removal from sewage sludge; however, CKD would have to be used at a rate of 1.3 times that of lime to maintain a filter cake pH of 11 to 12. Maintaining this pH level is important in the vacuum filtration process. However, with the use of more CKD, the removal of phosphorus and heavy metals should be enhanced. Again, the economic advantage of using CKD in this type of process include inexpensive and finely-ground material availability.

The Baker study goes on to say:

> "The additional potassium and magnesium in the kiln dust/sewage sludge filter cake were used as sources of nutrients for crop production. The economic advantages and conservation of energy resulting from the use of kiln dust instead of hydrated lime are obvious. Kiln dust delivered to the treatment plant would be worth 75 percent as much as the hydrated lime with no value applied to the beneficial effect of potassium and magnesium contained in the kiln dust if the filtered sewage sludge and the filtrate were used on cropland."

Treatment of Acid-Mining Drainages and Industrial Acid Wastes

The treatment of acidic and heavy-metal-laden water from mines and industrial sources has created another growing market for lime material. Considerable effort has been put into the development of methods for neutralization of acidic waste from mine drainage. Crushed limestone is the cheapest material for this purpose; however, lime and powdered limestone are more reactive, and thus more efficient per unit area (Pearson an McConnell, 1975). The dissolution and reaction of crushed limestone is dependent upon continuous purging of the reaction system of CO_2, which can pose logistical problems with large volumes of waste.

Removal of trace metals from wastewater by the use of ground, discarded automobile tires as a filter was enhanced by the addition of lime (Netzer and others, 1974). In this study, it was shown that 99 percent of 12 trace metals were removed with a lime/discarded tire system.

Use of CKD as a Landfill Liner and Cover

Continued discovery of hazardous and toxic waste dumps in the United States is focusing attention on hazardous waste disposal. Most attention is being given to chemical solidification (Pojasek, 1979; Maugh, 1979). In the solidification process, wastes are bound into a solid mass that can be buried with reduced fear of toxic-materials leaching into groundwater supplies. An advantage of this technique is that following hazardous waste solidification, they become nonhazardous.

Two of these processes are silicate/cement-based and lime-based solidification. In the first process, cement and flyash are mixed with the waste to produce a rock-like product. The high-pH mixture insures containment of heavy metals in the insoluble hydroxide form.

The lime-based solidification process depends on the reaction of fine siliceous material, lime and water which creates pozzolanic concrete. The most common materials used for this process are fly ash and cement-kiln dust (CKD). The principal advantage of this method over the cement-based method involves the wide availability of the very inexpensive fly ash and CKD byproducts.

Continued interest in use of lime and lime materials in various industries for control and possible elimination of specific pollution problems is likely. Pollution control costs have been a major obstacle for industry and regulatory agencies, resulting in a partial-control tradeoff. With the advent of cheaper pollution- control methods and recycling of usable wastes, more stringent pollution standards could be met. The potential market for CKD in industries in need of atmospheric pollution control, wastewater treatment or solid waste disposal could be substantial. These CKD uses would be augmented by its use as an agricultural liming material.

The potential uses for CKD are numerous; however, in each use, the end result involves its placement in landfills or use as a soil amendment. As previously shown (Haynes and Kramer, 1982), CKD is not a hazardous material; however, being a highly reactive material, CKD may cause temporary negative effects on natural biotic systems (i.e, soil microflora). The purpose of this study is to investigate chemical and physical properties of CKD and its effect on the chemical and biological properties of soils.

Chemical and Physical Properties of CKD

When considering CKD as an agricultural amendment, or for land disposal, it is important that the material not alter the chemical or physical properties of soil in a negative manner. Table 1 shows the major constituents of CKD and a typical soil. The major constituents of soil are SiO_2 and Al_2O_3, whereas CKD typically is made up of CaO. This table shows that CKD would not substantially alter the composition of soil elements and would add calcium, a beneficial additive to base saturation and physical properties of soils.

Table 2 provides comparison of CKD and soils for trace elements that may cause toxicity problems in agriculture. The CKD sample from Ideal Basic Industries' Seattle Plant was tested using the EP Extraction Procedure and are, therefore, not total values; however, under the acidic conditions of the extraction procedure, a majority of the metal species would be in solution. The average values from Haynes and Kramer (1982) represent means from 113 samples. Some of these samples are very high in trace metals, which thus raises the mean. For example, the Cd mean was 21 ppm, but the median was 7.3 ppm. The average values reported in Table 2 are higher

Table 1 Comparison of major constituents of kiln dust and an average soil.

Constituents	Kiln Dust[+]	Avg. Values[++]	Typical Soil[+++]
		%	
SiO	12.5	17.0	70.5
Al_2O_3	2.9	3.2	13.7
Fe_2O_3	1.9	1.7	3.8
CaO	49.7	65.8	2.0
MgO	0.7	0.6	0.8
SO_3	4.8	2.3	0.2
Na_2O	0.5	0.1	1.5
K_2O	1.4	0.2	2.2

[+] Ideal cement sample

[++] Average values from Haynes and Kramer (1982)

[+++] From C. F. Marbot (1935) and W. Linsey (1979)

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COMPARISON OF MAJOR CONSTITUENTS OF CKD AND AN AVERAGE SOIL

TABLE 1

Table 2 Comparison of minor trace elements of kiln dust and an average soil.

Constituents	Kiln Dust[+]	Avg. Values[++]	Typical Soil[+++]
	---------ppm---------		
Ag	0.1	5.4	0.1
As	1.0	24.0	5.0
Ba	50.0	55.0	430.0
Cd	0.1	21.0	0.1
Cr	0.5	41.0	100.0
Hg	0.1	0.1	0.1
Pb	1.0	253.0	10.0

[+] Ideal cement sample, values from EPA test

[++] Average values of total analysis, Haynes and Kramer (1982)

[+++] From N. C. Brady (1974) and W. L. Lindsay (1979)

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COMPARISON OF MINOR TRACE ELEMENTS OF
CKD AND AN AVERAGE SOIL TABLE 2

than soil values for all trace metals except Ba and Cr on a μg-metal/g soil or dust basis. This would appear to be a problem in applying CKD to agricultural soils; however, the amounts applied to soils for liming purposes would not increase the trace metal content of the soils significantly. In addition, increased soil pH would tend to keep the metals in insoluble hydroxide form. Thus, from a total element analysis standpoint, CKD is similar to other soil liming materials.

In the use of any material as a liming agent, it is conventional to express its liming power as a calcium-carbonate equivalent. This is simply the standard oxide analysis of Ca and Mg, converted to calcium carbonate on a weight percent basis. For the CKD sample in Table 1, the calcium carbonate equivalent would be 91 percent. There are several ways of expressing the acid neutralizing power of different materials, but these values give the capacity of the material to react, not the rate of reaction. The rate at which a material reacts is related to its particle size, chemical composition and physical nature. A liming material should completely react with the soil within 2 to 3 years. To achieve this dissolution rate, the material must be finely ground, a process that significantly adds to the cost.

The following reactions occur when lime materials are applied to soils:

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

$$Ca(OH)_2 + 2H_2CO_3 \longrightarrow Ca(HCO_3)_2 + 2H_2O$$

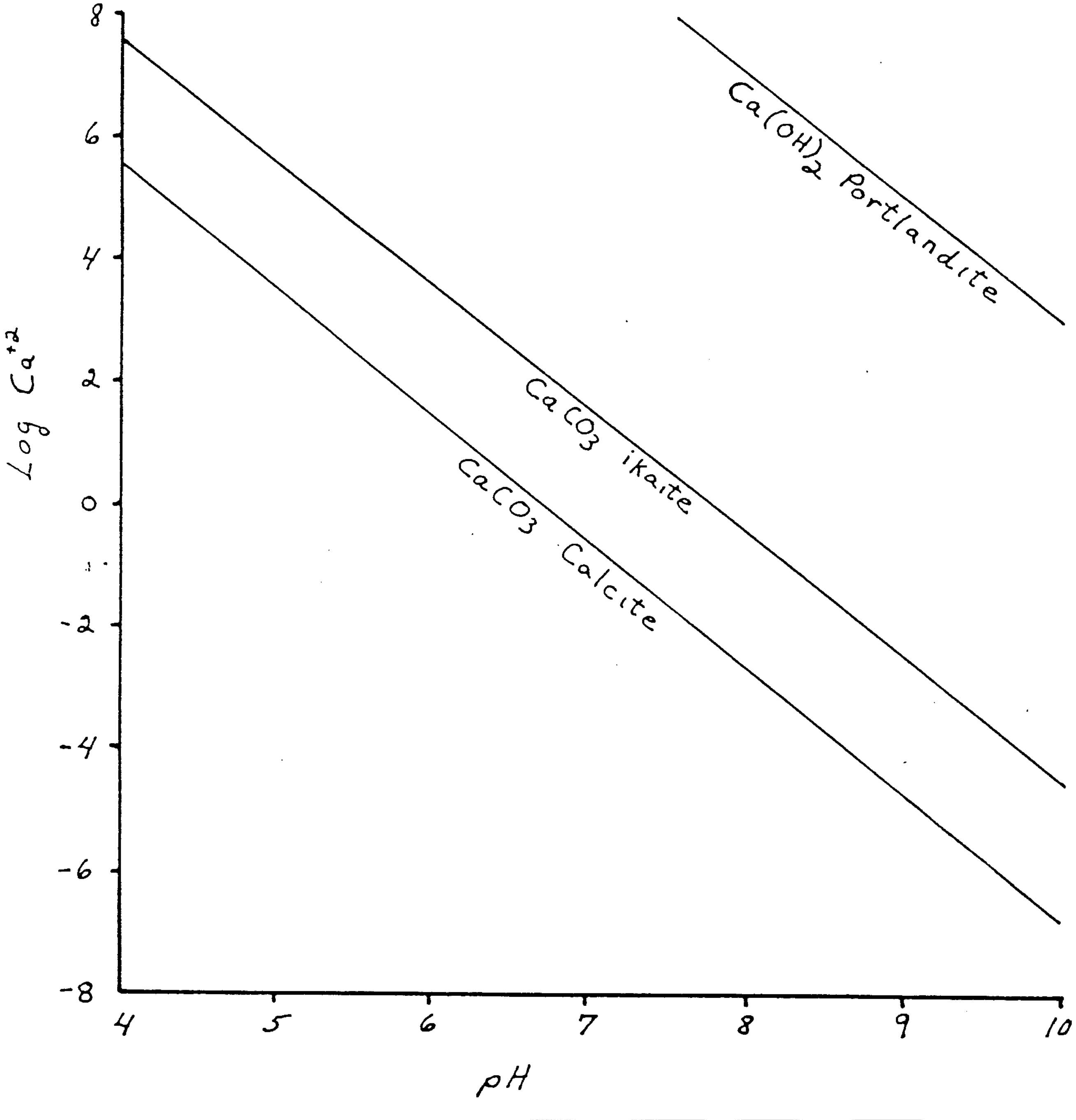
$$CaCO_3 + 2H^+ \longrightarrow Ca^{+2} + CO_{2(g)} + H_2O$$

Reaction 1 and 3 are the dissolution reactions when either material is present in soil; reaction 2 describes the continuing reaction of $Ca(OH)_2$ when abundant carbonic acid is present. Generally, the carbon dioxide level in soils is substantially higher than atmospheric concentrations, which will permit reaction 2 to occur; thus, the system will buffer to a pH of approximately 6 or 7. Calcium oxide is much too soluble to persist in soils; when added to soils, it hydrates to $Ca(OH)_2$ (portlandite). On the other hand, $CaCO_3$ (calcite), is only slightly soluble and increased levels of $CO_{2(g)}$ suppresses the solubility as shown by reaction 3. Since $CaCO_3$ is a slightly-soluble salt of a moderately strong base and weak acid, its reaction with soil acidity will be initially less pronounced than portlandite since this material acts as a strong base. The stability of these materials in soils is shown in Figure 9. Portlandite is much more soluble than calcite or ikaite and maintains a comparatively higher level of Ca^{++} in soils and a high pH according to the following reaction:

$$Ca(OH)_2 + 2H^+ \longrightarrow Ca^{+2} + 2H_2O$$

These solubility relationships and the soluble components of CKD are important when considering it for use in soil systems. First, the ratio of CaO to $CaCO_3$ in CKD will indicate the rate of dissolution of the CKD. This can be important when using CKD for wastewater treatment or agricultural liming when at least relative rates of dissolution are important. Secondly, it has been previously shown that CKD is a caustic material and when added to a fish tank at the rate of 1000 mg/1 the test fish die (personal communication, E.J. Owens, Ideal Cement Co.). The fish do not survive this test due to the increased pH of the system caused by CKD. The actual chemical compounds involved in the pH increase may or may not be important in CKD application to soil.

Figure 9. Solubility diagram for calcite, portlandite and ikaite.



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SOLUBILITY DIAGRAM FOR CALCITE,		
PORTLANDITE AND IKAITE		FIGURE 9

To determine the carbonate content of CKD, a 0.01 g sample was placed in a glass vial, which was stoppered with a septum. Two mls of HCl were injected by syringe into the vial. Vial pressure was equilibrated to atmospheric conditions, then samples from the vial headspace were injected into a gas chromatograph for CO_2 analysis.

Carbonate content, by weight, is shown in Table 3, a mean of 6 replications. The 32.7% value corresponds to 24% CO_2 by weight, which was the percentage listed as "loss" in the total elemental analysis provided by Ideal Basic Industries. Thus, a large percentage of CKD is composed of carbonate compounds.

To determine the soluble cation species, 10g of CKD was mixed with 30 mls water. Upon slurry settlement, it was filtered through a 0.4m millipore filter. The solution was analyzed for major cations and minor metal constituents by atomic absorption spectroscopy. An aliquot sample was titrated with 0.10 N HCl to produce a titration curve.

Extracted cation concentrations are listed in Table 3 as soluble species. Total concentrations are also shown. Total sulfur content is listed to compare the cation concentrations with the major anion species, CO_3^{-2} and SO_4^{-2}. This

Table 3 Carbonate, Soluble, and Total Chemical Composition components of CKD.

Component	CO_3^{-2}	OH^-	SO_4^{-2}	Ca^{+2}	Mg^{+2}	Na^+	K^+
Soluble							
µg/g CKD	-	4,573	-	2,044	0	3,000	11,120
meq/g CKD	-	0.27	-	0.10	0	0.13	0.28
Total							
µg/g CKD	327,000	4,573	57,000	355,000	4,200	3,700	11,600
meq/g CKD	10.9	.27	1.2	17.8	3.46	0.16	0.29
% Soluble	-	100	-	0.6	-	81.0	96.0

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CARBONATE, SOLUBLE, AND TOTAL CHEMICAL
COMPOSITION OF CKD

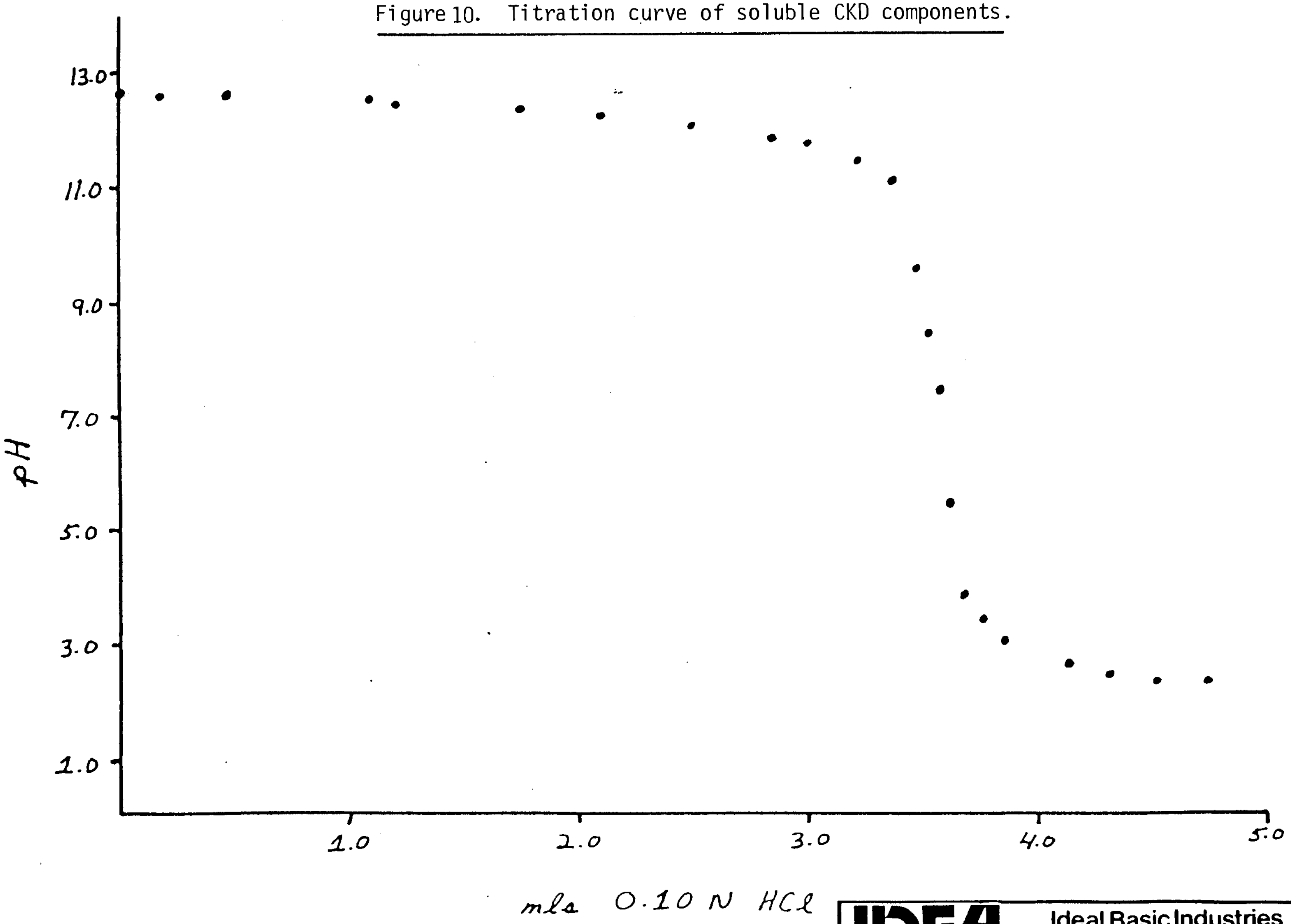
TABLE 3

comparison indicates the compounds that are present in the soluble and insoluble phases.

Figure 10 shows the titration curve of the soluble extract from CKD. This is a typical strong base (pH 13) titration curve, with the equivalence point at 3.59 ml of 0.10 N HCl. By calculation, the soluble extract is 0.09N and contains 0.27 meq base per gram CKD (Table 3). The base in solution accounts for 53 percent of the milliequivalents in solution, the rest probably comprising CO_3^{-2} and SO_4^{-2} compounds. A substantial amount of both Na^+ and K^+ dissolved on contact with water. These compounds probably are in the oxide form in CKD. In contrast, there was no Mg^{+2} dissolution and very little soluble Ca^{+2} compounds, indicating a carbonate or perhaps sulfate form of these compounds. Other anions are also present, as can be deduced from the total milliequivalent balance. There were no minor metal constituents in the soluble extract, indicating they were in the insoluble hydroxide form.

From the solution analysis it is evident that the calcium and magnesium compounds are of the slightly soluble type, which makes CKD similar to limestone or perhaps dolomite in its rate of dissolution. This rate is important if the soil liming objective is to maintain a specific pH. A

Figure 10. Titration curve of soluble CKD components.



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TITRATION CURVE OF SOLUBLE CKD COMPONENTS

FIGURE 10

very soluble material (i.e., portlandite, Figure 9) may only raise the soil pH for a very short time. The fact that 96 percent of the potassium is solubilized may be beneficial when liming K^+ different soils. The sodium also becomes immediately available, which could harm some plants. However, at the low sodium concentration of CKD compared to soil (Lindsay, 1979), this should not be a problem.

The second consideration of this soluble extract is its high pH which, as explained earlier, has a detrimental effect on fish when added to a tank at the rate of 1000 mg/l. It would appear that the high pH of the soluble extract is due to the hydration of Na_2O and K_2O, and to some extent CaO. The sodium reaction would thus be:

$$Na_2O + H_2O \longrightarrow 2NaOH$$

With the formation of sodium hydroxide as the end product, it is quite reasonable that the pH should rise and become toxic to biological organisms. In light of this formation of sodium hydroxide, it becomes of interest what will happen when CKD is added to soil. In comparison, the soil is buffered by numerous inorganic and organic acids and bases. In addition, the exchange complex of clays adds a further buffering effect; however, in water there are no buffering mechanisms when small amounts of acids or bases are added. Once the hydroxide compounds are neutralized in the soil, the $CaCO_3$ compounds will begin dissolving, thereby raising soil pH to a buffered area between 6.5 and 7.5. At normal liming rates, the addition of compunds that form hydroxide compounds should pose no problems to natural soils.

Table 4 shows the effects of CKD on the pH and electrical conductivity (EC) values of various soils. The loading rates were from 0-to-150 tons/acre, both the EC and pH values are from 1:1 (W:W) (water:soil) extracts. The Holland soils are from a forested area, formed from granitic material. The Holland soils all have a high base saturation, although they differ in organic matter content. The designation of clearcut, 60-year, growth and old growth refers to the stage of current tree growth. The Oxford soil is a low-base saturated soil with moderate-to-low organic matter content. The Alderwood soil came from the Dale Strip Pit site in the Seattle area (Ravensdale) of Washington State.

The Holland series responded to additions of CKD with moderate increases in pH. Even at the rate of 150 tons/acre, a totally unacceptable liming rate, the pH of the Holland soil only increased 3 pH units for the clearcut and 2 for the

Table 4 The effect of CKD on the pH and electrical conductivity values of various soils.

Soil		CKD Additions				
		T/Ac				
		0	25	50	100	150
Holland, clearcut	pH	5.4	6.8	7.2	8.1	8.4
	EC	0.1	2.7	3.8	6.2	8.0
Holland, 60 yr growth	pH	6.0	6.8	7.1	7.5	8.0
	EC	0.3	2.6	4.1	6.3	8.7
Holland, old growth	pH	6.2	7.0	7.9	7.8	8.1
	EC	0.3	2.4	3.5	6.0	6.6
Oxford	pH	7.2	8.8	9.6	11.0	11.8
	EC	0.8	3.2	4.5	6.3	8.8
Alderwood	pH	6.2	7.2	8.0	8.8	9.4
	EC	0.2	2.9	4.5	6.5	8.3

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EFFECT OF CKD ON pH AND ELECTRICAL CONDUCTIVITY VALUES OF SOILS

TABLE 4

higher organic matter soils. The Oxford soil pH increased by 4 pH units at the highest rate, due to its low buffering capacity. The Alderwood behaved in similar fashion to the Holland old-growth soil until CKD additions of 100 or 150 tons/acre. This indicates that the soil-buffering capacity was becoming depleted.

The electric-conductivity values for all soils increased dramatically from the 0-to-150 tons/acre addition. However, even at the 50 tons/acre rate, all soils would be classified as nonsaline normal soils, based on the EC values (Black, 1968). If at the higher rates of CKD application, the EC values in the field soils remained this high, there would probably be detrimental effects on crop growth. However, it is very unlikely that these EC values could persist very long in soils from a single application of CKD. The high EC is due to the rapid hydration of calcium, sodium and potassium oxides. These compounds would not be expected to remain in the soil solution for any length of time.

Cement-kiln dust appears to have good liming characteristics, even on soils with high buffering capacities. The increase in osmotic potential of the soil solution due to the high EC would not pose any soil problems even at the 50 tons/acre addition rates.

As previously discussed in the introduction, the fineness of CKD and its basic nature may make it a suitable material for reclaiming acid leachates, and for cleaning up wastewater from industrial sources. It has been hypothesized that CKD could be used as a liner for landfill waste sites, to remove hazardous substances from leaching water. This particular use would eliminate the collection and water treatment now necessary for landfill sites.

To investigate the usefulness of CKD to reclaim leaching wastewater from landfill sites, we obtained samples of wastewater from the Cedar Hills landfill site near Seattle, Washington. The chemical analysis of the leachates, from different places on the same site, are shown in Table 5. These samples were particularly low in concentration of heavy metals except for zinc and iron which we used as indicators of the fate of heavy metals when leached through soil and the soil/CKD combination. The pH of the leachates tends toward neutral, with abundant NH_4^+ and NO_3^- , indicating that the system is operating under anaerobic conditions.

Two soils were used: the Alderwood soil from the Ravensdale Dale Strip Pit landfill site and a Winter Cap soil used in covering the site. Soil columns containing 50 g

Table 5. Chemical analysis of landfill wastewater leachate.

Sample	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	NH_4^{+}	Zn^{+2}	Fe^{+2}	pH
	ppm							
North reservoir	23	65	47	38	36	2.4	13.6	6.7
South reservoir	451	206	344	303	110	6.8	21.0	6.0
Lagoon	140	106	158	61	80	1.7	9.4	7.2

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CHEMICAL ANALYSIS OF LANDFILL WASTEWATER LEACHATE

TABLE 5

Table 6. Chemical analysis of landfill leachate after percolation through columns of Winter Cap Soil or Winter Cap Soil plus CKD.

Treatment	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	NH_4^{+}	Zn^{+2}	Fe^{+2}	pH	E.C.
	ppm								mhos/cm
North Leachate									
Soil	40	47	0	0	0	1.4	10.3	6.5	1.5
Soil + 10g CKD	285	227	575	N.D.	0	0.1	2.6	6.1	7.2
Soil + 20g CKD	318	301	1890	1582	7	0.1	2.0	5.0	20.5
South Leachate									
Soil	631	265	242	0	3	3.1	14.6	5.4	6.4
Soil + 10g CKD	909	291	779	0	10	0.2	3.4	5.6	12.1
Soil + 20g CKD	371	298	1928	2588	64	0.1	2.1	5.4	25.1
Lagoon									
Soil	165	109	0	0	0	0.9	3.4	6.4	2.5
Soil + 10g CKD	347	245	470	0	0	0.1	1.6	6.0	6.7
Soil + 20g CKD	260	296	1808	1816	21	0.1	0.9	5.0	22.2

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CHEMICAL ANALYSIS OF LANDFILL LEACHATE AFTER PERCOLATION THROUGH COLUMNS OF WINTER CAP SOILS PLUS CKD

TABLE 6

soil and 50 g soil with 10 or 20 g CKD packed on top were set up for the leaching study. The columns were leached with 50 ml of leachate, the column leachate was collected and analyzed for major constituents.

The results from leaching of the Winter Cap soil is presented in Table 6. It is evident that soluble cations come into solution when wetted and are leached through. As previously shown, the concentration of soluble cations is quite high for Ca, Na, and K when CKD is wetted. It is interesting that a good deal of Mg was leached from the system, whereas in the soluble analysis there was none.

Both the soil and the soil-plus-CKD removed NH_4^+ from the leaching solution. In all cases the soil-plus-20g-CKD appears to be less efficient in this removal. However, the high pH (12.3) of the leachate right after it has gone through the CKD layer, has probably caused some soluble organic nitrogen compounds to become hydrolized, releasing inorganic NH_4^+. It is apparent that soil-plus-CKD removes a significantly greater amount of heavy metals than does soil alone. In addition, column leachate pH is in the range of 6, showing that only a small amount of soil is needed to neutralize the initially high pH of a CKD solution.

Table 7 shows the results of leaching through the Alderwood soil. Again, there was significant leaching of soluble cations from CKD through the soil. The NH_4^+ analysis showed similar trends as the Winter Cap. The Zn and Fe removal was about the same as the Winter Cap even though the leachate was somewhat more acidic.

The leachates were not analyzed for organics or suspended solids; however, some turbidity measurements were made on selective leachates which indicated that soil columns- plus CKD removed a greater proportion of turbidity than did the soil columns above.

Since a major benefit of using CKD for wastewater cleanup would be for heavy metals removed, we leached two 50 ml volumes of a metal solution through three columns consisting of 50 g Alderwood soil and 10 g CKD. The metals were Pb, Cu, Zn, Mn, Fe at concentrations of 100 mg/l; thus leaching was through a total of 5 mg of each metal-per-leach, or 10 mg total.

Results are shown in Table 8. The values represent concentrations of metals in solution after leaching. It is readily observed that a significant proportion of the metals applied to the system were retained, probably as the

Table 7. Chemical analysis of landfill leachate after percolation through columns of Alderwood Soil or Alderwood Soil plus CKD.

Treatment	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	NH_4^{+}	Zn^{+2}	Fe^{+2}	pH	E.C.
	ppm								mmhos/cm
North Leachate									
Soil	21	47	0	0	0	2.4	9.4	5.8	1.3
Soil + 10g CKD	613	227	752	1830	13	0.1	1.2	5.5	15.4
Soil + 20g CKD	368	301	1424	3484	18	0.1	1.0	6.7	21.9
South Leachate									
Soil	400	278	239	161	40	2.4	12.6	5.3	5.9
Soil + 10g CKD	533	291	1148	3070	68	0.8	2.6	5.5	18.5
Soil + 20g CKD	417	301	1568	3622	80	0.6	2.4	5.5	23.6
Lagoon									
Soil	87	111	0	0	5	1.0	4.8	5.4	1.9
Soil + 10g CKD	439	303	1136	2657	28	0.4	2.1	6.6	18.1
Soil + 20g CKD	377	309	1832	3415	40	0.3	1.0	7.2	24.4

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CHEMICAL ANALYSIS OF LANDFILL LEACHATE AFTER PERCOLATION THROUGH COLUMNS OF ALDERWOOD SOILS PLUS CKD
TABLE 7

Table 8. Heavy metal concentrations in solution after leaching through soil plus CKD.

Soil	Leach	Pb	Zn	Cu	Fe	Mn
		ppm				
Alderwood	1	7.9	40.4	15.0	7.5	25.8
+ 10g CKD	2	6.2	2.8	11.8	8.2	21.6

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HEAVY METAL CONCENTRATIONS IN SOLUTION AFTER LEACHING THROUGH SOIL PLUS CKD
TABLE 8

insoluble hydroxide. The second leaching tended to retain more of the metals than the first leaching; it is unclear why this occurred. The removal of heavy metals at the potentially toxic levels as applied in this experiment, demonstrates the usefulness of CKD in wastewater and leachate treatment.

An important consideration, when applying CKD to landfill sites or to other sites where compaction is likely, is the effect of CKD on the physical properties of soils. In a compacted layer over soil, CKD will alter water-infiltration rates. For a landfill situation, or a similar application, a compacted layer of CKD that would decrease water (leachate) infiltration would provide two benefits. First, the water would be restricted and could be channeled to holding ponds for treatment. Second, if it was beneficial for leachates to pass through CKD for heavy metal removal, the decreased permeability of the CKD would permit longer reaction times between the leachate and CKD.

We investigated the effect of CKD in layers to decrease the hydraulic conductivities of soil columns. In this experiment, we layered CKD on the top, middle and bottom of a soil column. The saturated hydraulic conductivity was measured by saturating the columns, then maintaining a constant hydraulic head while measuring with time the water flux through the column. The hydraulic conductivities are reported in Table 9 and are in units of cm/sec.

The time indicates when the measurement was taken after the column was saturated. For example, 0 time is a measurement right after column saturation. Time 72 represents the column after 3 days, resaturating and measuring the saturated hydraulic conductivity again.

It is apparent that there are significant differences in conductivities when CKD is layered on or in soil. These differences become more pronounced over time. This is due to the hardening of the CKD layer as it sits in a moist but unsaturated state. From this data, it can be seen that the saturated water flow is reduced by one-half after 2 to 3 days. This is a significant amount of water-flow reduction and could be quite beneficial in waste-water holding ponds.

It is quite obvious from the data presented on the chemical and physical properties of CKD, that this material will be quite useful to both the industrial and agricultural communities. The only possible concern of disposal or utilization of CKD on soil involves the movement of a high-pH solution into ground water or runoff; however, we have shown

Table 9. Saturated hydraulic conductivity values for soil columns and soil columns layered with CKD.

Treatment[+]	time[++]	ks	ks Control
	h	cm/s	cm/s
CKD on top of soil, or control	0	3.5×10^{-4}	4.0×10^{-4}
	6	3.3×10^{-4}	4.1×10^{-4}
	72	1.9×10^{-4}	4.3×10^{-4}
	78	1.8×10^{-4}	4.3×10^{-4}
	96	1.7×10^{-4}	4.5×10^{-4}
CKD layered in middle of soil column or control	0	3.1×10^{-4}	4.4×10^{-4}
	24	2.2×10^{-4}	4.5×10^{-4}
CKD on bottom of soil column, or control	0	3.3×10^{-4}	4.5×10^{-4}
	72	1.6×10^{-4}	4.4×10^{-4}

[+] all columns packed with 50 g soil (1.25 g/cm^3 bulk density) and 10 g CKD (1.00 g/cm^3 bulk density)

[++] time of measurement after 1st H_2O addition (see text)

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SATURATED HYDRAULIC CONDUCTIVITY VALUES		
FOR SOIL COLUMNS AND CKD		TABLE 9

that it takes only a small amount of soil to neutralize any alkaline solution resulting from the wetting up of CKD.

Effects of CKD on the Biological Properties of Soils

When considering any material for disposal or use on agricultural land, or in landfills, it becomes necessary to evaluate the effects the material may have on the native biota. Soils contain a wide variety of microflora and microfauna which make up the biologically-active fraction in most terrestrial systems. The soil microflora is quite sensitive to perturbations that occur in the environment; thus, their ecophysiological functioning is a good indicator of the biological health of the soil. It is these normal properties of the total soil population that have to be measured to determine if damage has occurred from toxic material additions. Soil respiration is one such normal property which is indicative of the activity of the soil microbial population, but is somewhat poorly correlated with the quantity of soil population. Other indicators of soil microbial "health" are the net nitrogen mineralized, and actual determination of microbial biomass which recently has been applied to soil systems (Smith, and others, 1984a).

It is the purpose of the following biological experiments to determine if CKD, when mixed with soil, will effect the native microflora in a negative fashion.

Generally, well-worked agricultural soils are aerobic throughout the plow layer for most of the year. However, they can become anaerobic or partially anaerobic during periods of heavy rains or flooding. Even when soils are only moist, anaerobiosis can occur from the rapid decomposition of soluble substrates, which can lower the partial pressure of oxygen substantially. This type of anaerobic condition can occur in landfill waste dumps where drainage may be impeded.

In recent years, an anaerobic incubation method has become popular for use in describing the potentially mineralizable nitrogen in soils (Smith, and others, 1981). The method involves incubating a sample of soil for 7 days and subsequently measuring inorganic-N. This method has been modified to include the measurement of CO_2 evolution which indicates the anaerobic activity. In addition, the method allows the use of ^{14}C-straw with its degradation being related to substrate utilization.

For the experiments using CKD additions to soil that were incubated anaerobically, we used the Alderwood soil and the Holland clear-cut soil. The method utilizes 5 g of soil and CKD additions equivalent to 0-to-150 tons/acre. Fifteen mg of leached straw was added to the mixture, containing approximately 45 percent carbon. The specific activity of the straw was 195,298 dpm/mg-C. The 5 g mixtures were then placed in test tubes, waterlogged, flushed with N_2 gas to remove O_2, then stoppered with rubber septums. The tubes were incubated at 35°C for 7 days. At the end of incubation, the CO_2 in the headspace and in the solution of each tube was measured, as was the $^{14}CO_2$. Both NH_4^+ and pH were also determined for each tube.

Table 10 shows the results of this experiment. In each soil the total CO_2 production peaked at the 25 tons/acre CKD rate; however, in the Holland soil the 50 tons/acre treatment was not significantly different from the 25 tons/acre treatment. It appears that the 100-to-150 tons/acre additions are significantly affecting normal functioning of the anaerobic population.

The $^{14}CO_2$-C evolved is somewhat variable, especially for the Holland soil; however, both sets of data show less utilization of added straw at the 100 and 150 tons/acre additions. As with the total CO_2, the $^{14}CO_2$ peaked around the 25-to-50 tons/acre addition rate. The amount of $^{14}CO_2$, compared to the total CO_2 evolved, is an interesting parameter (also shown in Table 9). In the Alderwood soil, the base percentage (control) of $^{14}CO_2$ is 25 percent of the

Table 10. CO_2 evolved, inorganic-N and straw decomposition from a 7-day anaerobic incubation.

Soil	CKD Rate	Total CO_2 evolved	$^{14}CO_2$-evolved	$\frac{^{14}CO_2 \times 100}{\text{Total } CO_2}$	Inorganic-N	% Straw Decomposition
		µg CO_2-C/g soil	µg $^{14}CO_2$-^{14}C/g soil		µg N/g soil	
Alderwood	0	108	27	25	56	2
	25	140	83	59	68	6
	50	84	53	63	78	4
	100	38	12	32	102	1
	150	27	4	15	68	
Holland	0	63	16	25	17	1
	25	112	18	16	40	1
	50	92	28	30	42	2
	100	50	13	26	33	1
	150	35	11	31	20	1

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7-DAY ANAEROBIC INCUBATION RESULTS		
		TABLE 10

total, increasing to 60 percent in the 25-to-50 tons/acre range, then declining to one-half and one-quarter of that peak percentage in the 100-to-150 tons/acre treatments, respectively. It is possible that at low rates of CKD additions, the environment is more suited for anaerobic activity, and that the CKD is solubilizing some of the straw, making it more available for degradation. At higher rates, this solubilizing effect is offset by the suppression of respiratory activities. This is evident in the 100 tons/acre treatment where the total CO_2 is suppressed; however, more CO_2 came from the straw in this treatment than in the control. The phenomena is not clearly evident for the Holland soil where the ^{14}C percentage remained around 25 percent. Because the Holland is a forest soil it generally shows low rates of straw degradation since straw is not a native substrate for the soil microorganisms in these soils. Even if solubilization had occurred in the Holland soil, it is unlikely that straw degradation would be stimulated.

The inorganic nitrogen production increased over control in all treatments except the 150 tons/acre Holland treatment. The fact that it does not parallel the CO_2 evolution data is not surprising. Addition of inorganic salts to soils generally increases inorganic nitrogen production, but does not appear to increase microbial respiration (Agarwal and others, 1971; Smith and others, 1982). The reason for this is unclear; however, it may be due to solubilization of complex organic nitrogen compounds which then can be degraded by microorganisms, thereby producing inorganic nitrogen. This effect has not been investigated in anaerobic systems.

The last column of Table 9 gives the percent straw decomposition of the added straw. These percentages may seem to be low; however, they are similar to numerous agricultural and forest soils we have tested using this anaerobic ^{14}C-straw technique.

The pH of the solution in each tube, measured after 7 days, showed an increase in pH from the 0-to-150 tons/acre treatments, ranging from pH 6 to pH 8 (data not shown). This range in pH is typical for soils under anaerobic conditions since the microbial products tend to buffer the system toward neutrality.

This experiment suggests that CKD would stimulate cellulose and hemicellulose degradation under anaerobic conditions. It also suggests that there is a stimulating effect on the anaerobic microbial population, evidenced by the increased CO_2 evolved.

As previously discussed, agricultural soils are generally aerobic systems and must be so to be productive. The functioning of soil microbial populations under aerobic conditions is physiologically quite different than under anaerobic conditions. The efficiency of aerobic organisms is generally 5-to-6 times greater than anaerobic organisms. There is a greater diversity of aerobic organisms in soils to anaerobic organisms, thereby providing a more sensitive test when determining the effects of potentially toxic substances on soil microbial populations.

An eighteen-day aerobic incubation to assess the effects of CKD on microbial processes was initiated using the Alderwood soil and CKD amendments of 0-to-150 tons/acre. Ten grams of Alderwood soil was placed in each of 200, 50 ml flasks. The CKD additions were made and the flasks brought to a moisture content of 20 percent by weight. Six flasks from each treatment were stoppered with septums to facilitate daily CO_2 measurements. All flasks were incubated at 22^{0} C for the entire experiment, and were aerated every two days to maintain aerobic conditions.

Periodically, 7 flasks from each treatment were removed from the incubator. Duplicate flasks were analyzed for pH and inorganic-N and triplicate flasks analyzed for microbial biomass. The measurement of microbial biomass is accomplished by adding a glucose and nutrient-broth solution to the sample, and measuring the respiratory response which is related to the microbial biomass carbon (Smith and others, 1984a).

The results of this incubation are presented in Table 11. It can be seen by the cumulative CO data that there was a substantial effect on the soil respiration from addition of CKD. In the first three days, there was a complete inhibitory effect of respiration at the 100-to-150 tons/acre rate. It could have been possible that the basic nature of the soil solution with the addition of CKD would be acting as a CO_2 adsorber at these high rates of addition. On a calculated basis, if the total soluble base equivalent of the CKD was adsorbing CO_2, the adsorbed CO_2 could total no more than 160 to 240 g C/g soil (100 and 150 tons/acre, respectively) still below the three day cumulative values for the other three rates. In addition, $^{14}CO_2$ evolution was tested from straw additions in the initial stages of a separate incubation to confirm the observed inhibitory effect of CKD additions at high rate. Indeed, for the firstfew days there was no $^{14}CO_2$ evolved from the higher rates,in contrast to sizable CO_2 activity in the 0-to-50 tons/acre treatments. For the 0-to-50 tons/acre treatments, a stimulatory effect

Table 11. Trends over time for cumulative CO_2, inorganic-N, microbial biomass-C, and pH for an 18 day incubation of Alderwood soil amended with CKD.

Rate of CKD addition	Days of Incubation					Days of Incubation				
	1	3	8	14	18	1	3	8	14	18
T/Ac	Comm. CO_2 evolved (µg^{-C}/g soil)					Inorganic-N (µg/g soil)				
0	90	250	583	890	1101	1	1	5	3	3
25	168	486	1308	2249	2951	2	1	5	6	3
50	12	268	1181	2367	3228	3	1	5	5	3
100	-	7	655	1896	2794	4	3	5	5	7
150	-	-	89	1158	2012	4	4	7	19	44

	Days of Incubation					Days of Incubation				
	1	3	8	14	18	1	3	8	14	18
	microbial biomass-C (µg/g soil)					pH				
0	265	347	265	286	275	5.4	6.0	4.5	5.0	5.6
25	531	735	735	898	1021	5.4	7.9	7.2	6.6	6.8
50	33	899	1082	1409	1409	6.5	8.3	7.3	6.9	7.0
100	-	408	817	1307	1205	6.6	8.2	7.4	7.4	7.4
150	-	-	633	1389	1225	7.6	8.1	7.6	7.7	7.7

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TRENDS OVER TIME FOR INCUBATED ALDERWOOD
SOIL AMENDED WITH CKD
TABLE 11

of CKD around the 25 tons/acre range was observed. As the incubation proceeded, there was a significant increase in CO_2 production from all CKD treatments compared to the control.

Figure 11 shows the actual rates of CO_2 production over the incubation period. The log period of the higher treatments, along with the dramatic increase, is quite evident. In contrast, the control treatment CO_2 production rate remained relatively constant from day 7 to day 18.

Figure 12 shows graphically the cumulative CO_2 production for the 18-day incubation. Again, it is evident that there is some stimulatory effect on microbial respiration when CKD is applied to soils. Toward the end of incubation, the rates of CO_2 production were similar for all CKD treatments (Figure 11 and slope of curves Figure 12), which suggests that any initial inhibitory or toxicity problem has disappeared.

The staggering increase in CO_2 production could be due to the solubilization of native organic matter and/or stimulation of the microbial population. Decomposition generally proceeds faster under neutral-to-slightly alkaline conditions. Liming materials added to soils can shift the

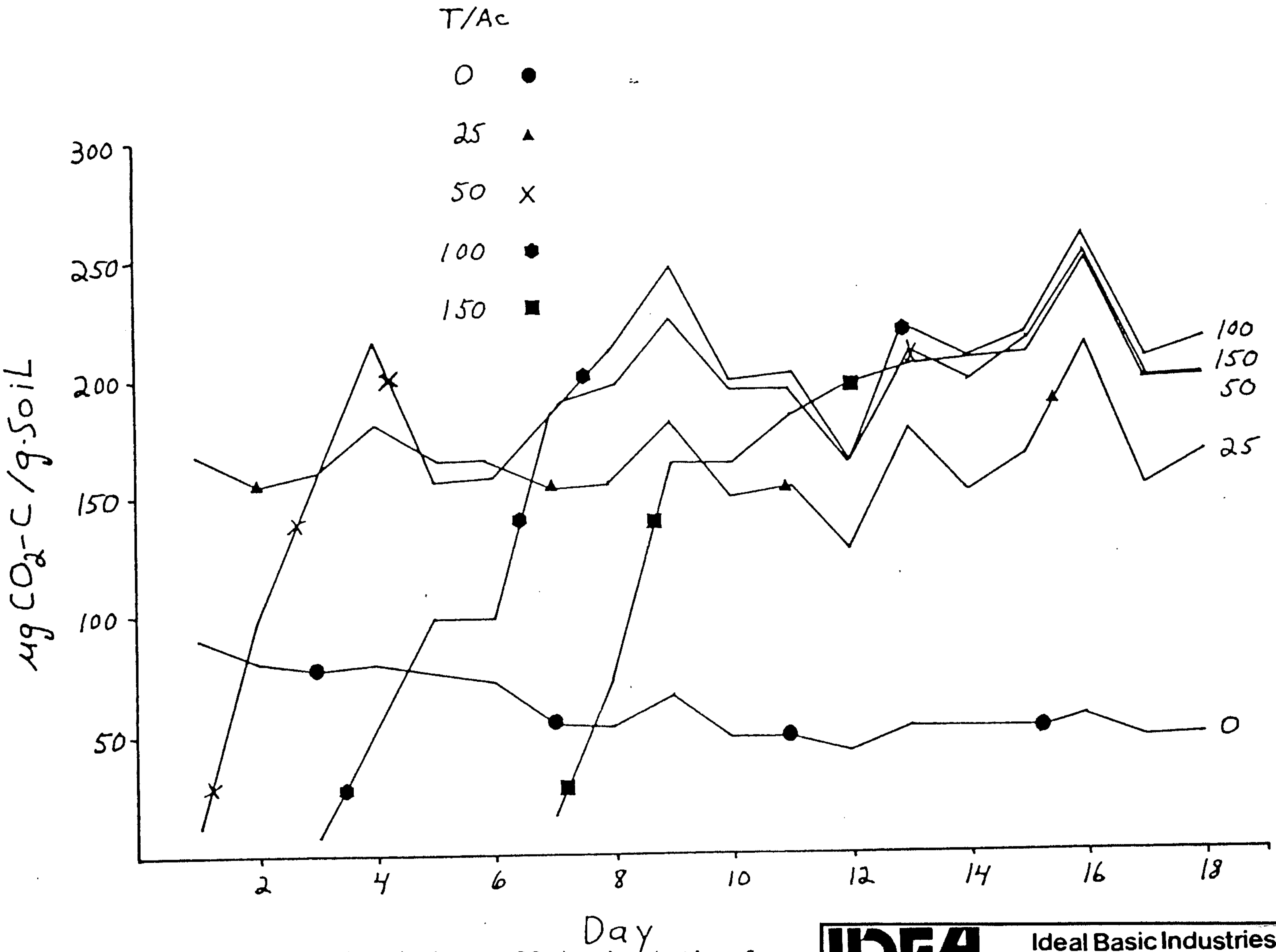

Figure 11 Rates of CO_2 production during an 18-day incubation for the Alderwood Soil amended with different rates of CKD.

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CO_2 PRODUCTION RATES DURING INCUBATION
OF ALDERWOOD SOIL & CKD
FIGURE 11

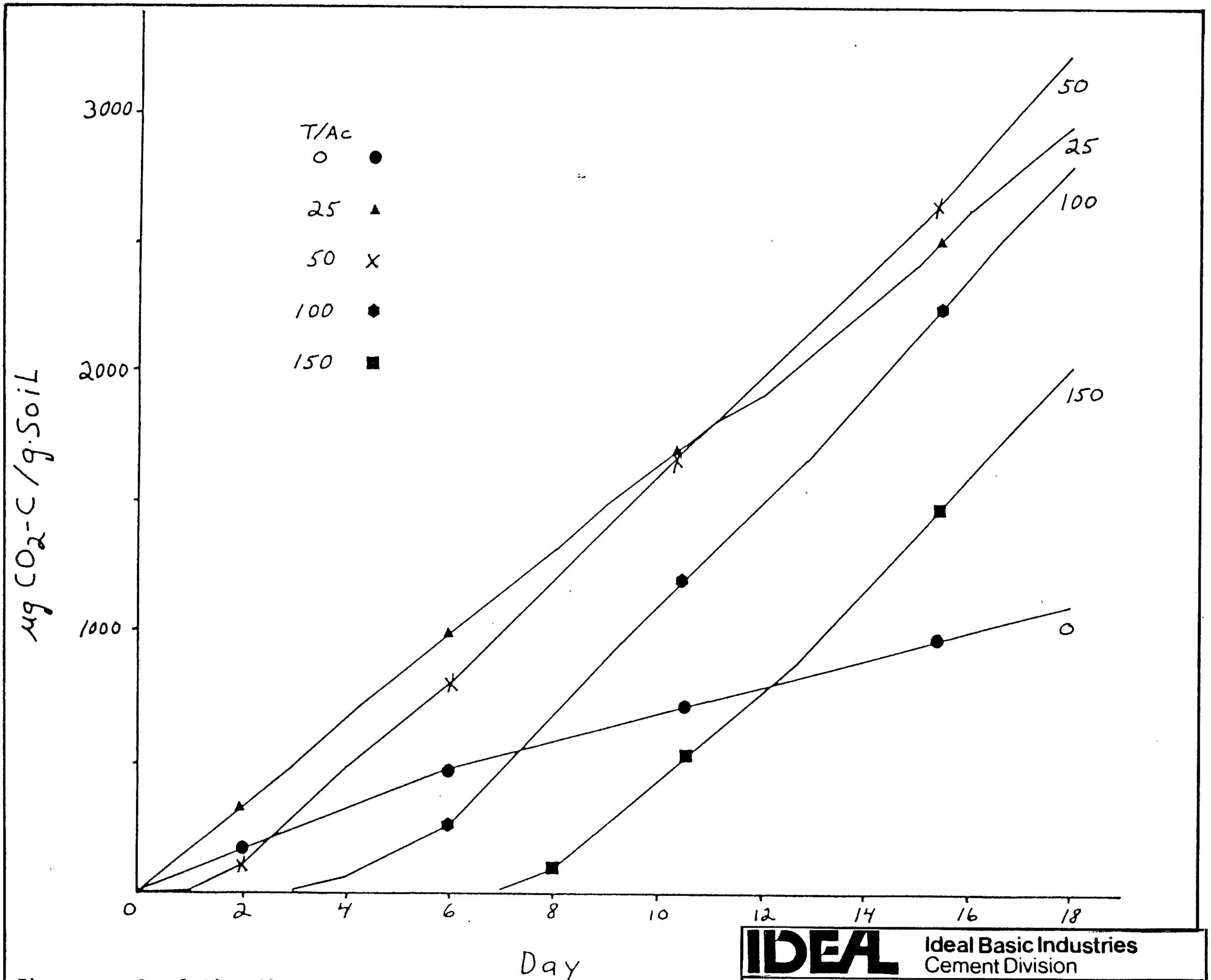

Figure 12. Cumulative CO_2 evolved during 18-day aerobic incubation.

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CUMULATIVE CO_2 EVOLVED DURING 18-DAY AEROBIC INCUBATION

FIGURE 12

composition of active microorganisms to favor cellulolytic decomposition (Alexander, 1961). If this shift were substantial enough, a doubling or tripling of CO_2 production would not be unusual. It is also possible that a substantial amount of CO_2 is coming from the dissolution of $CaCO_3$. Our limited $^{14}CO_2$ study indicated sizable microbial activity; however, the relative contribution to total CO_2 production cannot absolutely be determined.

The microbial biomass measurements from the incubation are shown in the third section of Table 11. These values show a trend similar to the CO_2 production values. For the first few days, the higher treatments could not be induced to respire with substrates. However, in these cases, it is likely that there is a very low population of active microbial biomass, rather than none at all. The control treatment biomass peaked at day three, then declined to a rather constant population. This early peak and biomass population is consistent with previous studies using agricultural soils (Smith and others, 1984b). In the CKD-amended soils, the microbial biomass seemed to peak at the 14-day period (100-to-150 tons/acre) or at least plateau (25-to-50 tons/acre). These large increases in microbial biomass parallel the CO_2 evolution data and indicate a large pool of available substrate in the system.

The inorganic nitrogen production pattern was quite normal for the 0 ton/acre treatment, while for the first few days, inorganic nitrogen was low due to the incorporation of available N into the newly-forming microbial biomass. By day 8, the population was declining and releasing nitrogen back into the inorganic pool. For the 25-and-50 tons/acre treatments, day 3 showed immobilization of nitrogen, although the high rate of carbon mineralization thereafter kept the inorganic-N level at 5 ppm. The high rates of addition maintained higher levels of inorganic-N with the 150 tons/acre application rate, showing some possible salt-induced mineralization, as discussed under anaerobic incubation above. Since the 150 tons/acre, treatment had the highest rate of CO_2 evolution during the last 5 days of incubation, and a declining population, it may be possible to accumulate this amount of inorganic-N.

The pH values over the course of incubation followed the normal slowly-declining trends (Smith and others, 1982). Values are well within the range conducive to microbial growth. CKD treatments were 1-to-2 pH units higher than the control treatment, which could possibly account for the increased activity of the microbial population, as explained earlier in relation to CO_2 production.

Conclusions

From reviewing the experiments and data contained within this report, it is quite evident that cement-kiln dust (CKD) is not a hazardous material when applied to normal soils which are not otherwise contaminated or unstable. From the chemical analysis it was concluded that the subject CKD is similar in composition and reaction to agricultral lime. It has also been shown that CKD would not significantly alter the heavy-metal content of soil. From previous studies (Hayne's and Kramer, 1982), it was shown that CKD did not exceed the EPA limits for extractable toxic compounds.

In this study, the nature of the strong basic properties of CKD solutions were shown to be caused by hydration of minor alkali metal oxides. The pH of this solution should be quite toxic to biological life by itself; however, as the leaching experiment indicated, it would take very little soil to neutralize and buffer most CKD additions.

A significant CKD property is its ability to precipitate heavy metals from solution. Because CKD is very fine material with slow permeability when set up, it is a useful material for liming waste-water holding ponds and landfill sites.

The major consideration in determining the potential hazard or potential toxic nature of CKD is not entirely its chemical makeup or its physical properties, but the effect its use would have on a biological system. Land disposal of CKD will gain greater acceptability after its use as an SO_2 scrubber material, a waste-water cleaning material and, obviously as a soil-liming material, have etablished its usefulness and nonhazardous nature. It would be imperative that CKD not be toxic to the soil microbial population.

In this study, we initiated two biological experiments to determine whether CKD has a toxic effect on soil microbial populations. Under both aerobic and anaerobic conditions, there seemed to be a somewhat stimulating effect from levels of CKD when considering parameters that indicate microbial activity. At higher rates, suppression of activity occurred; however, in each case (aerobic incubation) the population recovered after a few days. It should also be pointed out that laboratory incubations are static systems and, thereby, are not subjected to dynamic environmental forces. Such forces may dilute the effect of CKD even at the higher rate of addition.

In both biological experiments, it appeared that the initial solubilization of organic substrates would be responsible for much of the increased activity and increase in microbial biomass in the aerobic incubation. The pH during both types of incubations was not a factor, demonstrating that the soil and its microflora are quite capable of handling CKD.

In these biological experiments, it was found that CKD had litle effect on the biological component of soil. This points out the need to test the toxicity of a material on the system to which it is to be applied, rather than relying on standardized tests to characterize all materials.

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LANDFILL, MINE RECLAMATION, AND SOIL STABILIZATION

The largest single use for waste CKD in the U.S. is for land fill. This use not only provides a repository for the dust, but increases the value of the land it is used on, which generally is marshy or unproductive in some other way. CKD from Ideal's Seattle Plant provided the fill resource for two reclamation projects adjacent to their plant in the early 1970's. The land fills, along West Marginal Way near Puget Park and at South Park, were operated by Duwamish Excavating and Trucking Company under permit by the King County Engineering and Building and Land Development Departments (Grading Permit File Nos. 1174 and 1849). Maps of the fill locations are attached as Appendix B-6. These landfills increased the value of the land raised by the CKD, which now supports expensive real estate. No significant problems were generated by the fills, which were operated with full knowledge of the Washington Department of Ecology.

The value of Ideal's CKD as mine backfill is discussed thoroughly in Section 910(1)(b)(iv)(bb.4), <u>Environmental</u>

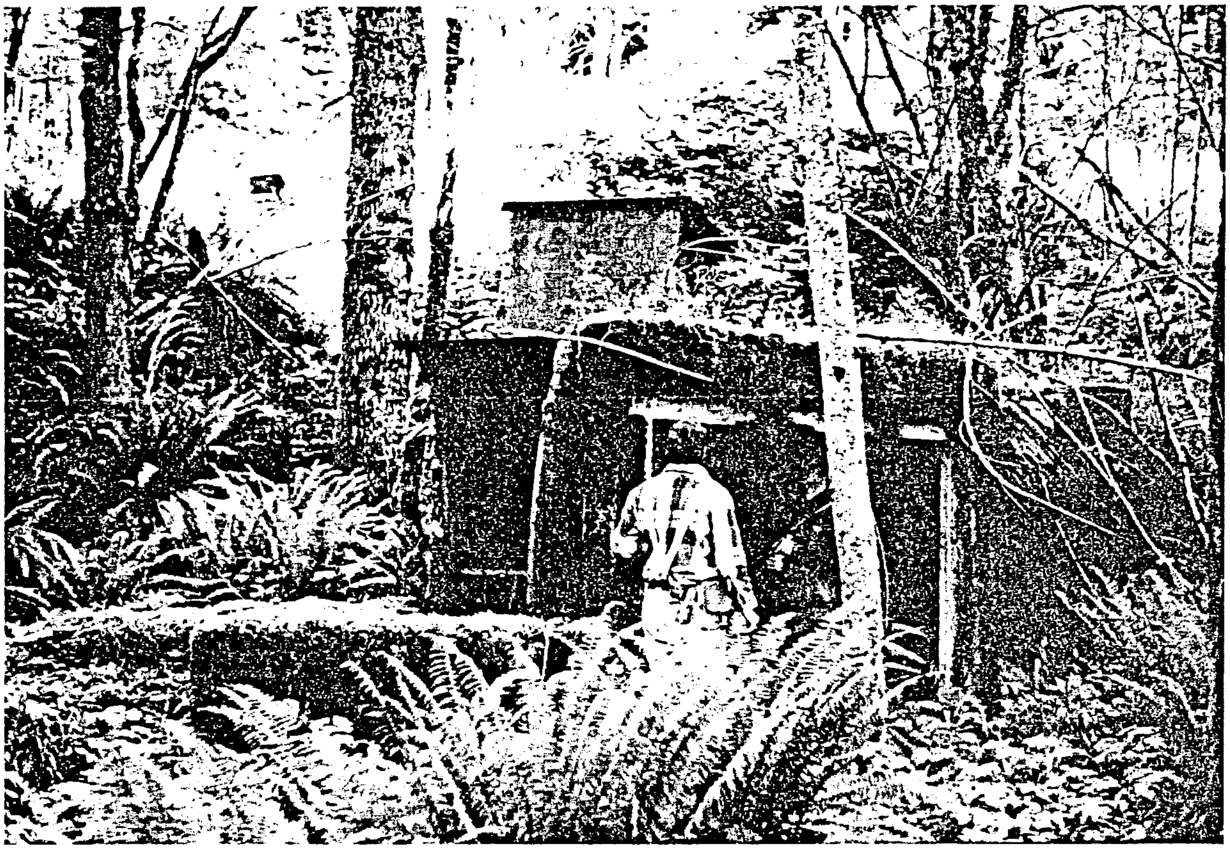
<u>Checklist for the Dale Strip Pit Reclamation Project</u>, and will, therefore, not be repeated here. This use has consumed 247,663 tons of Ideal's CKD over the last five years and assured Industrial Mineral Products' compliance with surface mined-land reclamation laws.

In the last two years, a joint federal/state project involving reclamation of Washington's abandoned coal mines has created a potential large-volume use for Ideal's CKD that could materialize within a year. In the way of explanation of the project's scope, the following report, prepared in July, 1974, by geologists from the Washington Department of Geology and Earth Resources, is reprinted in its entirety.

ABANDONED COAL MINE INVENTORY

by

Timothy J. Walsh and Frank V. La Salata *



Taylor coal mine in King County. Geologists in the foreground are inspecting the shaft which was the main entry.

In 1977, Congress passed the Surface Mining Control and Reclamation Act (SMCRA) to ameliorate adverse effects of past coal mining and to regulate subsequent coal mining. SMCRA provided for a tax on current coal mines at a rate of 35 cents/ton for surface mines, 15 cents/ton for underground mines (or 10 percent of the value at the mine), and 10 cents/ton for lignite mines (or 2 percent of the value at the mine). The revenue from this tax is deposited in the Abandoned Mine Reclamation Fund. SMCRA also created the Office of Surface Mining (OSM) to administer the provisions of the act. OSM oversees state regulatory agencies which administer the act, or as in the case of Washington, directly regulates the coal mining industry of a state. In addition, OSM performs reclamation and provides technical assistance to state reclamation agencies. Washington has no reclamation agency, so reclamation here is performed directly by OSM. The Abandoned Mine Reclamation Fund provides revenue for these functions, and also provides for direct payments to state regulatory and reclamation agencies. The act provided that at least 50 percent of the proceeds should be used for these purposes in the state of origin when there is sufficient need for reclamation. As of the end of fiscal year 1983, more than $9 million had been collected from the Washington Irrigation and Development Company (WIDCO), and Palmer Coking Coal Company, operators of Washington's two active mines.

To determine the reclamation needs of the states, OSM contracted for a national inventory of abandoned mines. The inventory for the State of Washington identified 10 problem areas, four of which are in the vicinity of Roslyn and Cle Elum in central Washington. The other

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* Division of Geology and Earth Resources Geologists.

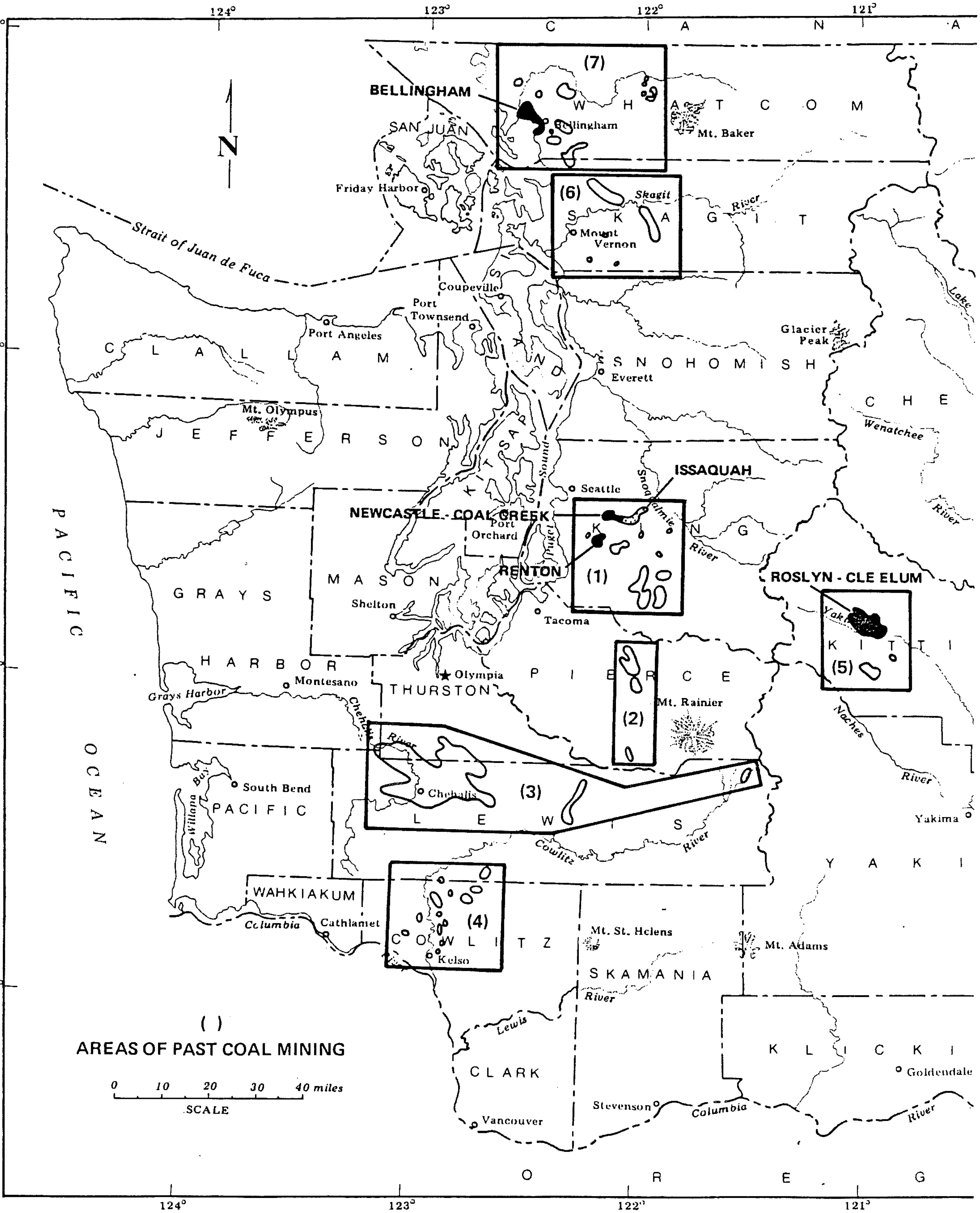

Figure 1. — Study areas for abandoned coal mine inventory in western and central Washington (from Beikman and others, 1961).

six problem areas were located near Centralia (two areas), Bellingham, Black Diamond, Newcastle, and Wilkeson.

By the end of fiscal year 1983, OSM had undertaken 11 emergency reclamation projects in Washington, only one of which was in an area included on the national inventory (these emergency projects cost OSM less than $150,000). Reference to figure 1 shows that the inventory was inadequate for dealing with the potential mine problems because the extent of coal mining in western and central Washington far exceeded that recognized in the inventory. One result of the sparseness of the inventory was that OSM transferred more than $3 million from Washington's 50 percent share of the coal production tax to other parts of the country, citing insufficient reclamation needs for the funds here.

In January of 1984 a cooperative agreement was signed between the Department of Natural Resources, Division of Geology and Earth Resources (DGER), and OSM. This agreement was the culmination of efforts by the Department of Natural Resources to rectify the inadequacies of the original inventory. The agreement called for the State of Washington to conduct an inventory of all abandoned coal mine lands within the state, and provide OSM with a final report along with site-specific descriptions and maps of the areas investigated. The final report will summarize the results of the inventory, by county, quadrangle, and severity of hazard.

Seven broad regions of interest, based on past coal mining activities, were defined for the study. These were (1) King County (Black Diamond, Issaquah, Renton, and the Green River coal mining area), (2) Pierce County (Wilkeson, Carbonado, Fairfax, and Ashford), (3) Lewis County (Centralia, Chehalis, Toledo, Morton, and Packwood), (4) Cowlitz County (Kelso and Castle Rock), (5) Kittitas County (Roslyn, Cle Elum, and Manastash), (6) Skagit County (Hamilton and Cokedale), and (7) Whatcom County (Bellingham, Glen Echo, Van Zandt, Blue Canyon, and Glacier) (fig. 1). An average of 3 weeks was allotted for each of these broad study areas.

The study had three objectives: First, to inventory abandoned-coal-mine-related problems affecting the health, safety, and general welfare of the public at large. Second, to categorize these problems by severity, accessibility, and proximity to population. Finally, to recommend to OSM the priority in which these problems should be corrected (based on their detriment to the general public). To date DGER has identified 76 problem areas.

In addition, five areas within the seven broad regions were targeted for more detailed inventories. These areas were Roslyn-Cle Elum, Issaquah, Newcastle-Coal Creek, Renton, and Bellingham. Each of these areas was selected because of the intensity of previous coal mining activities, the lack of detailed descriptions of the problems as they currently exist, and the presence of extensive residential or recreational development. Each of these areas was selected by OSM in conjunction with DGER. The Office of Surface Mining (OSM) awarded contracts to consulting companies for the detailed inventories.

These contracted inventories proceed from office compilation of mine map data held by the Division of Geology and Earth Resources (Schasse and others, 1983) and all available historical data, to field location of hazardous mines, followed by surveying and title searches of properties requiring reclamation. If necessary, drilling may be done to verify the existence of underground workings as shown on mine maps or to probe for mine voids in areas lacking mine maps. Finally the contractors will make recommendations for reclamation and will rank the severity of problem areas in consultation with OSM.

The contractors retained by OSM are listed below:

(1) Roslyn-Cle Elum: George Maddox and Associates, Spokane, Washington. OSM budgeted $75,000 in fiscal year 1983 for the Roslyn area inventory (fig. 1) which is nearly completed. At least 26 mines were operated in this area (Schasse and others, 1983), and more than 80 mine openings and subsidence areas have been located; 12 have been targeted for reclamation, and OSM anticipates design and construction expenditures of approximately $150,000.

(2) Issaquah: Goodson and Associates, Denver, Colorado. OSM has budgeted $75,000 for the Issaquah area inventory which consists of lands east of state highway 900 and south of interstate highway 90. At least five mines have been operated in this area. Field work to date has shown that most of the surface expressions of mine openings and subsidence have been modified by urban development. Investigations are continuing.

(3) Newcastle-Coal Creek: Skelly and Loy, Lexington, Kentucky. Field investigations have not yet begun in the Newcastle-Coal Creek area but at least 19 mines have been operated in the area (Walsh, 1983) and extensive areas are still known to be open. OSM reclaimed entries to the old Newcastle mine in 1983.

(4) Renton: Morrison-Knudsen, Boise, Idaho. At least 18 mines have been operated in Renton (Livingston, 1971). Investigations to date have uncovered at least three areas of probable mine subsidence. OSM has already reclaimed one area of subsidence in Renton as an emergency problem. Field investigations are continuing as of this writing.

(5) Bellingham: Tetra Tech, Englewood, Colorado. Two large mines and several smaller ones have been operated in Bellingham. Subsidence is known to have occurred

and one entry is reported to be at least partially open. Field investigations have just begun and are expected to be completed soon.

When completed, DGER will combine the information produced by contractors with our own data and produce an overall inventory that we estimate will include virtually all of the potential abandoned-mine-land-problem areas in the state. Reclamation priorities will be recommended to OSM and the report will be made available to the public as a DGER open-file-report. An appendix containing 2 inch by 2 inch photographic color slides of all the sites inventoried by DGER will be on file in the DGER library. The target date for completion of the report is October 1984. While we intend this report to be used principally for establishing reclamation needs and priorities, it is also expected to be used for planning in the affected communities. It may be useful for historical purposes as well.

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New county park digs up Coal Creek's mining days

By Ed Penhale
P-I Reporter

NEWCASTLE — At first glance, it seems a very understated way to start King County's grandest park acquisition.

The roar of trucks hauling rubble to a nearby landfill frequently drowns out the sound of birdsong along Coal Creek below.

At the west end of this 100-acre wooded corridor that the county has purchased for $528,000 is a gravel pit that was in use until last April.

And at the eastern end, an old concrete slab rests in a field of grass that is brown at the onset of autumn.

Mind's eye

But step onto a path that follows the creek into the wooded corridor and remnants of a coal mining era gone by come to life in the mind's eye.

Rotting timbers of a trestle and the firm but overgrown flat surface of an old railroad bed are evidence that the Seattle-Walla Walla Railroad ran up the Coal Creek Valley a hundred years ago to the rich coal mines on the western flanks of Cougar Mountain, near Issaquah.

Called the "Coal Creek Extension," the 100 acres recently purchased by the county represents the first major acquisition of what county officials hope will one day become a 2,000-acre "wilderness" park on Cougar Mountain.

Largest park

It would be the county's largest park, increasing the size of county parkland holdings by one-third.

It's hard to imagine that 3,000 to 4,000 people lived and worked in the Coal Creek Valley from the late 1800s until the market for coal fuel fell away in the 1930s.

The railroad that was to be built to Walla Walla never made it past the Newcastle coal mines. The towns that sprung up around them were moved away by their former residents.

And that old slab of concrete, the foundation of a boiler room, is all that's left of the Newcastle Hotel. It stood where Lakemont Boulevard now turns into the Coal Creek-Newcastle Road, and that's where the trail down the creek begins.

Tom Eksten of the King County Parks Department ties a marker in front of an old mine shaft at Coal Creek

Not far away, the top of the 22-foot-high concrete arch to the Muldoon Seam on the Ford Slope is still visible. Now mostly plugged with dirt and rocky rubble, it was the entrance to a 1,740-foot tunnel that dropped 850 vertical feet to mines where 11 electric locomotives delivered coal-filled cars that then were pulled to the surface by a steam hoist.

Keeping lore alive

Tom Eksten, the King County Parks Department's Cougar Mountain project administrator, knows by heart a lot of the lore that's been kept alive by the local historians, Harvey Manning of the Issaquah Alps Trails Club and Jean Bacon of the Newcastle Historical District.

And like Manning or Bacon, he can point to woods where Red Town, a coal company town where all the houses were painted red, once existed. In the other direction was Rainbow Town, where privately owned homes were painted every other color but red.

The County Council recently authorized County Executive Randy Revelle to spend $1.9 million to acquire 320 acres of land, including the Coal Creek Extension, that make up the key access points to the proposed park.

Among the parcels targeted for early acquisition, however, is a six-acre panoramic view property adjacent to the existing upper Cougar Mountain Park that's been dubbed the "million dollar view" by observers who don't have to negotiate the purchase price. Parks employees joke that they've been told to call it the "$1.50 view."

The land value of the huge woodland park has been estimated at $16 million. Revelle will make known later this month how the county plans to finance further property acquisitions at the park site.

Eksten said the Coal Creek Extension became the first major purchase because it provides a connection between the existing, undeveloped Coal Creek Park to the west and the future Cougar Mountain park.

But even if park plans for the mountain fall apart, the 100-acre site will stand by itself as a valuable park because of its historical interest and because it's a logical extension of Coal Creek Park, he said.

The trail down Coal Creek is an easy one that mostly follows the old bed of the railroad that used to carry coal out of the Newcastle mines. The creek meanders, cutting a deep ravine. It dries up with a dry summer like last one, but is full most of the year. The stream is fed at one point along the trail by a small waterfall.

The Issaquah Alps Club members have walked along the railroad bed for years. And they've placed numerous signs on trees that point out where a railroad station once stood, the location of a steam power plant that vanished after Puget Sound Power and Light Co. came to town in 1922 and the site where locomotives changed direction on a roundtable.

'Interpretive signs'

Eksten envisions a more elaborate system of "interpretive" trail signs that tell the history of the place with weatherproof photographs of buildings and other mining-related structures that once stood alongside the railroad bed.

There are, however, serious hazards on the new park land. Mine and air shaft openings that drop hundreds of feet into the earth dot the area. While many appear plugged with rock, dirt and timber, cave-ins easily could occur, said Eksten.

For that reason, parks officials will not encourage public use of the site until mine shaft safety measures are in place, Eksten said.

But the valley trail will not be closed, he added.

Eksten noted that the federal Office of Surface Mining soon will be installing temporary fencing around the worst hazards.

In western Washington, the Office of Surface Mining has targeted abandoned coal mines in the Coal Creek area near Bellevue as representing the most hazard to public safety. One subsidence pit in the area is 40 feet deep and 30 feet in diameter. Mine entries 15 feet in diameter and 700-plus feet deep have been found. King County has recently acquired 100 acres near Newcastle of what will eventually be a 2,000-acre "wilderness park" on Cougar Mountain. The new "Coal Creek Extension Park" does contain some serious hazards, as outlined on the attached Seattle Post Intelligencer news clipping which says in part: "Mine and air shafts dot the area. While many appear plugged with rock, dirt and timber, cave-ins could easily occur".

OSM is considering the use of spoils generated by excavation of the I-90 Mt. Baker Ridge Tunnel as fill for these mine hazards, if the two projects can be coordinated to fulfill their individual time constraints. Correspondence with the OSM on October 2, 1984 (Appendix B-7), by an Ideal representative, introduced OSM to the existence and availability of Ideal's CKD for such a project. The subject is under discussion between OSM and Ideal and information has been passed onto the contractors responsible for the Coal

Creek reclamation project, Skelly and Loy of Lexington, Virginia.

The technology is available for such a project, as CKD has been used for this purpose in the past, and is widely known for its value as a grout and water-treatment agent (e.g., neutalization and iron precipitation). The ability of CKD to harden after exposure to moisture makes it useful for soil stabilization.Appendix B-8 represents results of a study on the use of CKD as a soil stabilizer. In combination with the Mt. Baker Ridge Tunnel excavation spoils, it could provide an excellent, stable fill in the abandoned coal mines at Coal Creek. Its availability within reasonable trucking distance of the project would make it economically feasible to use CKD for this purpose,

Use of Ideal's CKD as a liner and daily cover source for local sanitary landfills was described in the foregoing section on agricultural uses (Smith, 1984). The King County Solid Waste Division has been made aware of this study and the availability of Ideal's CKD for this application. Discussions are underway between King County Engineers and Ideal personnel as to the feasibility of a pilot landfill project using CKD at the Cedar Hills facility.

WASTE STABILIZATION

In the Agricultural Uses Section above, the paper by Smith, Effects of CKD on the Chemical and Biological Properties of Soils, discussed stack-gas sulfur scrubbing techniques using CKD, along with methods by which other sludges and acid wastes can be stabilized by CKD. The following information is provided in addition to Smith's research summaries.

The use of Ideal's CKD to stabilize hazardous and non-hazardous sludges has real potential in Washington State. CKD is very absorptive so that dewatering is achieved before chemical and physical stabilization. Characteristics of CKD such as high pH, calcium oxide content, and fineness allow lime replacement in waste water treatment and acid neutralization. In these areas and others, there are opportunities for CKD to replace caustic soda, soda ash, and other high-alkaline or alkali materials (Nicholson, 1983).

Sewage Sludge Stabilization

Over 100 million tons of waste-water treatment sludge are generated annually in the U.S. (Nicholson, 1983). Handling of sewage sludge involves problems with odor, heavy-metal migration and disease-causing pathogens. Municipalities, including Seattle, have several alternatives in dealing with the difficulties facing them over disposal of their sewage sludges, all of which have problems: 1) incineration at a cost of $40. per wet ton; 2) landfill disposal; 3) land application to crops; 4) sea disposal; or 5) composting. Use of CKD in conjunction with sewage sludge has many benefits, including sludge dewatering which produces a granular substance that is easier to handle, store and spread. CKD also raises sludge pH to as much as 12 for two hours, which is important in demobilization of heavy metals and destruction of pathogens. CKD also eliminates sludge odor. Because of the presence of calcium oxide in CKD, it acts as a phosphate-and nitrogen-compound suppressant chemical in sewage sludge effluent waters. Appendix B-9 is results of a study using CKD in vacuum-filter processing of sewage sludge. As a fertilizer, the CKD/sewage sludge combination provides soil nutrients that would be absent with use of just one of these waste substances. Repeated use of nitrogen-rich soil amendments such as sewage sludge ultimately reduces soil pH to the point that problems from its use out-weigh benefits. CKD provides a lime effect that counteracts this nitrogen-induced soil acidity problem.

Seattle's METRO applies its sewage sludge on forest land in western Washington. It has chosen to avoid food-crop uses for the fertilizer because of public resistance to this application. The City of Spokane Wastewater Treatment Plant has applied its sewage sludge to barley cropland near Deer Park, however, with great success. Spokane has experimented with combining their sewage sludge with a mineral by-product from Chewelah, Wahington, that has properties very similar to CKD. The technology is available to combine CKD and sewage sludge in western Washington. It remains for governmental agencies and Ideal to work out arrangements for such projects, using the two valuable waste materials in combination. Certainly, CKD would made a good addition to the sewage sludge that is currently being composted with sawdust in the Seattle area.

The coal strip mine at Centralia, Washington (Widco) uses sewage sludge to reclaim its mined land. Encouraging Widco to use CKD in conjunction with sludge in their ground-injection fertilizer system is another option for Ideal in their marketing efforts.

Sulfur-Scrubbing Sludge Stabilization

CKD technology has also been applied in the field of sulfur scrubbing sludge stabilization, an application area thought by some to offer the greatest growth opportunity for recycled CKD in the coming decade (Nicholson, 1983).

In the absorption of SO_2 from stack-gases by wet scrubber slurry, CKD was found to be better than limestone and almost as good as lime. Surprisingly, problems of scaling in the scrubber system were less severe with CKD than with lime in the slurry (Davis and Hooks, 1975).

This use for CKD could have potential in Washington for coal-powered power plant exhausts, as well as for sulfur emissions from paper mills and the sulfide ore smelter in Tacoma (ASARCO).

Northwestern States Portland Cement Company of Mason City, Iowa, studied CKD in 1972 to determine the value of the waste material as a replacement for ground limestone, dolomite or comparable materials to suppress sulfur oxide emissions from coal-fired steam power plants. The rationale for this project included the facts that, as this study stated:

"1) Kiln dust approached limestone in available calcium oxide content;

2) Kiln dust has gone through thermal treatment, partially calcining it, and air stream classification to present an ultrafine particle size with very high specific surface; therefore rate of reaction should be high;

3) Kiln dust contains significant quantities of ultrafine inorganic oxides which might advantageously promote adsorption and reaction;

4) The material is a waste product available in quantities sufficient to handle a significant fraction of sulfur oxide emissions from stack-gases;

5) Particle size is in the same order of magnitude as flyash and, therefore, can be collected in conventional air pollution control equipment."

Three procedures were considered:

1) Using kiln dust in slurry form as a scrubbing agent with the exhaust gases passing through a reactor for liquid contact reaction between the calcium materials and the sulfur oxides. Laboratory results were encouraging. This procedure might be applicable to sulfur emissions from paper mills and sulfide ore smelters in addition to coal-burning steam generating plants.

2) Passing of the sulfur oxide-laden gases through a fluidized bed of kiln dust. This was most successful at ambient temperatures. As the temperature of the gases increased above 100 degrees Fahrenheit, sulfur oxide removal efficiencies dropped.

3) A laboratory dry-scrubbing procedure comparable to introducing the dust with the coal firing area in the boiler. Laboratory test results indicated that up to 90 percent of SO_2 could be removed from stack gases at 930 degrees Fahrenheit, utilizing stoichiometric quantities of the kiln dust. This level is unapproachable by conventional dry injection scrubbing processes."

Water Treatment

In Oregon, CKD has been successfully substituted for lime in coagulation processes involving preparation of alum flock for removal of turbidity from water. The dust neutralized the water and, in addition, improved flocculation, apparently because the small residual insoluble dust particles provided dense nucleation sites for the alum flock.

Acid Mine Drainage Neutralization

While many papers have been written on the successful use of CKD and lime wastes as a neutralization agent for acid mine drainage, this is not a use to which CKD is likely to be put in Washington. The bacterial breakdown of pyrite is responsible for acid mine drainages in eastern states where pH often reaches 2.5 and 3.0. Coal mine drainages in Washington are not generally acidic because its coal measures are low in sulfur and pyrite. The range of coal mine drainage pH in Washington is 5.8 to 8.2. Results of two studies on the use of CKD and waste lime as coal mine backfill and as treatment of acid coal mine water are attached as Appendices B-10 and B-11.

Stabilization of Industrial Waste Acids

In the steel and metal finishing and plating industries, large volumes of sulfuric acid and other heavy-metal laden pickling liquors are generated. Their disposal is a serious problem. Limestone is the most widely-used substance for acid stabilization. Limestone cannot in many cases neutralize a strong acid beyond a pH of 7, which is necessary when a waste stream must be over-neutralized to precipitate metals, and to comply with environmental standards (Nicholson, 1983). The insoluble constituents of limestone also produce a larger volume of sludge, which raises disposal costs (Spinola, 1971). CKD requres a larger neutralizing base system and longer reactivity time than lime, but CKD is more cost effective.

Bethlehem Steel, Boeing and Hytek Finishers, all of whom produce pickle liquors in the Seattle area, have expressed an interest in Ideal's CKD in the last three years. Unfortunately, the present regulatory environment has done nothing to encourage this problem-solving approach to neutralization of wastes at opposite ends of the pH spectrum. Chemical Security Systems of Arlington, Oregon, have used Ideal's CKD in the last two months to stabilize waste acids and chemically-polluted soils at the Western Processing plant cleanup project in Kent, Washington, and routinely use alkaline substances such as CKD at Arlington proper to stabilize acid wastes.

Georgia Pacific has used Ideal's CKD at their Bellingham Plant to neutralize and stabilize acids developed in their paper process so that they could be transported to Arlington, Oregon.

In July, 1982, I.M.P. was approached by the King County Department of Public Health to accept 5,000 cubic feet of waste lignin sulfonate from Monsanto Industrial Chemicals Company, Seattle, at the original CKD reclamation site. Correspondence from Monsanto is attached as Appendix B-12.

Lignin sulfonate is used by Monsanto as the source of vanillin, or vanilla extract. Through time, solids had collected at the bottom of their storage tanks and required removal. The lignin waste was quite acidic (pH 4.9).

At the same time, I.M.P. was looking for a substance to control dust on its mine haul roads. Lignin sulfonate is used routinely by the U.S. Forest Service and private logging companies to control dust on logging roads.

As such, arrangements were made, with full DOE approval, to combine Monsanto's wastes with Ideal's CKD, to neutralize and stabilize the acids. Some of the lignin sulfonate was spread on the silica sand mine roads as well. Road dust was substantially reduced through the summer mining season as a result.

HIGHWAY CONSTRUCTION

Perhaps the greatest potential use for CKD, and one that would not be as seasonal in its demand as agricultural markets, is its use as a substitute for hydrated lime in lime/flyash/aggregate road base systems. In 1983, the Federal Highway Administration released a report entitled Kiln Dust-Fly Ash Systems for Highway Bases and Sub-Bases (Collins and Emery, 1983). It is their intention to undertake some road construction projects using this system soon, in those states already familiar with the concept and its engineering design.

A Toledo, Ohio, company, N-Viro Energy Systems Ltd., has developed a product called N-Viro Crete, a pozzolanic concrete pavement that uses coarse and fine aggregate with a stabilizing mechanism involving cementitious and pozzolanic reactions between CKD and flyash from coal-fired power plants. The concrete is said to be a viable product because it costs less, raw materials are abundant, and fine aggregates can be used in the mix design.

Kiln dusts, replacing hydrated lime in these compositions, can provide equal or better durability, as well as volume stability characteristics. Tests and field performances have shown that such mixes gain strength, with time, to compressive ratings of 2,000 to 3,000 psi, even when cured under ambient temperature conditions. In nearly all cases, the kiln dust/flyash/aggregate mixes exhibit greater ultimate strengths than comparable lime/flyash/aggregate mixes. In addition to higher strengths, the pozzolanic pavement has autogenous healing capability. Any cracking, if allowed to rest, will eventually re-cement with only little strength loss (Nicholson, 1983).

Recent escalation in the cost of fuel and asphalt construction, along with changing business conditions, have presented promoters of CKD for road base construction with fresh marketing opportunities. Today, binder costs of $2.25 per ton or less make the product significantly less expensive than asphaltic concrete. Building a two-lane, 9-inch deep mile of pavement will result in recycling of 3 million pounds of kiln dust and flyash material, save 100,000 gallons of oil, and save at least $30,000 per mile (Nicholson, 1983).

In the road base arena, there are 70 million tons of bituminous base consumed annually in the U.S. The asphalt going into road bases either should be reserved for fuel, or saved for surfacing which is a very important need. In addition to a tremendous cost savings to consumers, aggregates, that are scarce in some areas, can be extended with use of the CKD system (Stearn, 1979).

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FILLER MATERIAL

CKD has been used a mineral filler for bituminous paving materials and asphaltic roofing materials. It has also been suggested as a filler for plastics and for asphaltic products such as insulating board, concrete expansion strips, and sound-deadening material.

WAc 173-303-910(1)(b)(iv)(bb.2)

CERAMIC MANUFACTURE

In the manufacture of glass, large amounts of soda are used. Researchers have found that cement-kiln dust could be used beneficially as a partial replacement for soda in making green glass because it increases the rate of decomposition of sulfates, which is the main cause of foaming in glass baths. Other research reports similar success in the use of kiln dust to make glass where color and high chemical stability are not essential considerations (Davis and Hooks, 1975).

CKD is also being studied as a raw material for light-weight aggregate production. Large pellets have been made from a blend of CKD and other chemically-reactive materials. The heat required is less than that generally required for sintering (Stearn, 1979).

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WAC 173-303-910(1)(b)(iv)(bb.3)

INAPPLICABILITY OF THE STATIC ACUTE FISH BIOASSAY TEST AS A DANGEROUS WASTE CATEGORIZATION TEST FOR CEMENT-KILN DUST THROUGH DEMONSTRATION THAT FISH MORTALITY IS ATTRIBUTABLE SOLELY TO ELEVATED PH

The following report was prepared by Dr. Peter Chapman of E.V.S. Consultants of Vancouver, B.C., to demonstrate that Ideal's CKD was captured as a dangerous waste solely because of effects related to its elevated pH in solutions containing rainbow trout. The study demonstrates that leaching of CKD into groundwater will not pose an acute lethal hazard to aquatic life.

E.V.S. Consultants
Biological and Chemical Services
for the Environment

1014 Yale Avenue N.
Seattle, WA.
U.S.A. 98109
Tel: (206) 623-3074

Our File: 220-1

October 26, 1984

Mr. Larry Darby
Ideal Basic Industries
(Cement Division)
5400 W. Marginal Way S.W.
Seattle, Washington

Dear Mr. Darby:

Re: <u>Biological Testing and Provision of Expert Counsel re Waste Cement Kiln Dust Disposal</u>

We have completed all work on the above, following our work-outline dated October 12, 1984. You have been kept informed of our progress through telephone communications.

Attached please find a draft of our letter report in fulfillment of Task 3 of our work outline. This letter report is presented as a draft for review by yourselves and Industrial Mineral Products prior to finalization. When we have your comments, we will provide you with a final copy, to be submitted to WDOE by Ideal Basic Industries. For this final submission, we would ask that you provide us with a more readily reproducible copy of Biomed's bioassay data sheet than we present have available.

If you have any questions please do not hesitate to call. We trust that the letter report completes our present assignment to your satisfaction.

Yours truly,

E.V.S. CONSULTANTS

Peter Chapman

Peter M. Chapman, Ph.D.,
Vice-President

PMC:mkm

cc: D. Skeie, Industrial Mineral Products, Inc.

VANCOUVER • SEATTLE • VICTORIA • CALGARY

E.V.S. Consultants
Biological and Chemical Services
for the Environment

195 Pemberton Avenue
North Vancouver, B.C.
Canada V7P 2R4
Tel: (604) 986-4331
986-1516

Our File: 220-1
W.O.: 84 - 181

October 24, 1984

Mr. Larry Darby
Ideal Basic Industries
(Cement Division)
5400 W. Marginal Way S.W.
Seattle, Washington

Dear Mr. Darby:

Re: Acute Toxicity Test on Waste Cement Kiln Dust

We have completed three (3) static acute fish toxicity test on Waste Cement Kiln Dust received October 09, 1984.

The following results indicate that cement kiln dust toxicity may be attributed to high pH upon mixing with neutral dilutent water. No toxicity was evident upon exposure of fish to pH-neutralized cement kiln dust and water. Similarly, pH elevated diluent water showed toxic effects identical to pH-unadjusted kiln dust at 1000 ppm.

Standard bioassay procedures were followed in accordance with the Washington State Department of Ecology guidelines for the Static Acute Fish Toxicity Test (1981).

The results, summarized below for your convenience are based on data from the following pages.

Summary of Results:

Sample	Concentration (mg/L)	No Deaths/Total Fish Exposed	Washington D.O.E. Classification*	Initial pH
Cement Kiln Dust (pH unadjusted)	1000 100	30/30 0/30	DW	10.6 9.1
Cement Kiln Dust (pH neutralized)	1000 100	3/30 0/30	no classification	7.2 7.3
Control diluent water (pH elevated)	-	30/30	no classification	10.6

..../2

* EHW = Extremely hazardous waste (no. deaths 10/30 in 100 mg/L sample concentration)
DW = Dangerous waste (no. deaths 11/30 in 1000 mg/L sample concentration).

Yours truly,

E.V.S. CONSULTANTS LTD.

Craig T. Barlow, B.Sc.,
Bioassay Supervisor

CTB:mkm

E.V.S. Consultants
Biological and Chemical Services
for the Environment

1014 Yale Avenue N.
Seattle, WA.
U.S.A. 98109
Tel: (206) 623-3074

Our File: 220-1

October 26, 1984

Mr. Larry Darby
Ideal Basic Industries
(Cement Division)
5400 W. Marginal Way S.W.
Seattle, Washington

Dear Mr. Darby:

Re: Aquatic Toxicity Testing on Waste Cement Kiln Dust (CKD)

At your request, we have conducted two WDOE Hazardous Waste Fish Bioassays with a sample of your waste cement kiln dust. Bioassay data sheets are provided in Attachment A and the results are summarized below.

In the first test, using the sample as provided, the waste was classified as a Dangerous Waste (DW). All 30 of the fish in the 1,000 mg/L concentration died compared to no deaths in the 100 mg/L concentration. The waste initially raised the pH levels in the test containers to 10.6 at 1,000 mg/L and 9.1 at 100 mg/L.

In the second test, the dilution water plus waste was neutralized using HCl. Otherwise, all procedures followed those used in the first test. Measured pH values ranged from 7.2 - 7.3, and the waste was not classified as dangerous.

The results of this testing indicate that elevated pH is the reason for observed toxicity. Similar results had been previously determined in independent testing by Biomed Laboratories (Attachment B).

In order to determine whether elevated pH values alone would kill fish, a third test was done. Clean dilutent water was pH-adjusted with NaOH to the pH recorded at the 1,000 mg/L test concentrations for unadjusted dilutent water plus waste. High pH values in fish bioassays with CKD has been shown to be due to NaOH (Smith, 1984). All of the fish died within hours (Attachment A).

..../2

ATTACHMENT B

Results of Biomed Fish Bioassay Tests With CKD From Ideal Basic Industries

BIOMED
RESEARCH LABORATORIES, INC.

October 25, 1983

Ideal Basic Industries
Cement Division
Ideal Plaza
950 17th Street
P.O. Box 8789
Denver, Colorado 80201

ATTENTION: Harlan W. Powledge

SUBJECT: Static acute fish bioassay testing on juvenile rainbow trout, *Salmo gairdneri*.

Acute oral rat toxicity on male albino white rats.

SAMPLE ID: Lab #10041 Waste cement kiln dust

PROCEDURE: The above sample was tested on fish at the 1000 ppm level, then retested at the 100 ppm level. The sample was tested on fish a third time at the 1000 ppm level under pH controled conditions. The procedure followed is outlined in the State of Washington's General Procedure for Static Acute Fish Bioassay Testing.

RESULTS: Thirty (30/30) of the fish tested with BioMed sample #10041 at the 1000 ppm level died within 2 hours of adding the toxicant to the water.

None (0/30) of the fish tested at the 100 ppm level died throughout the four day test period.

None (0/30) of the fish tested at the 1000 ppm, pH adjusted to approximately 7.0 level died throughout the four day test period.

None (0/90) of the control fish tested died throughout the test period.

None (0/10) of the rats gavaged with BioMed sample #10041 died throughout the 14 day test period.

1115 East Pike Street, Seattle, Washington 98122 (206) 324-0380

None (0/10) of the control rats died throughout the same test period.

CONCLUSIONS: Ideal sample of waste cement kilm dust, BioMed #10041 was found to be toxic to juvenile rainbow trout at the 1000 ppm level, and is therefore to be considered a dangerous waste material under Washington State Guidelines. (Note: "A waste material would be designated a dangerous waste if greater than 11 cumulative deaths out of 30 test organisms occurred within 96 hours at a concentration of 1000 ppm." I hope that the rest of the information contained in this report and the findings of the Chemistry Department will be of value to you in determining the exact toxic nature of this substance.

Respectfully submitted,

Kevin Casey

Kevin Casey,
Fisheries Biologist

Department of Ecology

DATA SHEET FOR STATIC BASIC ACUTE FISH TOXICITY TEST*

Laboratory: Biological Research Lab
Analyst: Kevin Casey

Industry/Toxicant: [illegible] Industries - Cement Division
Address: [illegible] P.O. Box 37 [illegible] 98201
Collector: [illegible]
Date Sample Collected: [illegible]

Beginning: Date 10/4/83 Time 12:00 AM
Ending: Date 10/16/83 Time 12:00 AM
Test Organism: Salmo gairdneri (Rainbow Trout)
Required Test Temperature Range: 11.5 - 12.5

Laboratory Reference Number	Test Container No.	Conc (mg/l)	Number of Cumulative Deaths					Dissolved Oxygen (mg/l)					pH 25 C					Temperature (C)					Total Hardness (mg/l as CaCO$_3$)		Total Alkalinity (mg/l as CaCO$_3$)		Cond uMH
			0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96	0	96	0
[illegible]	[illegible]	—	0	0	0	0	0	11	10	8	7	6	[illegible]	—	—	→	6.4	12	12	12	12	12	26.5	[illegible]	24.0	27.0	[illegible]
[illegible]	2	-	0	0	0	0	0	11	10	9	7	6	6.4	—	—	→	6.2	12	12	12	12	12	26.0	25.7	25.0	29.0	7[illegible]
[illegible]	3	-	0	0	0	0	0	11	10	8	7	6	6.4	—	—	→	6.4	12	12	12	12	12	25.4	25.4	23.0	27.0	[illegible]
[illegible]																											
[illegible]	4	[illegible]	10	)				11	10	8	7	6	11+	—	—	—	→	12	12	12	12	12	103.[illegible]	—	95.5	—	4[illegible]
[illegible]	5	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	11	10	8	7	6	11+	—	—	—	→	12	12	12	12	12	91.1	—	95.0	—	[illegible]
[illegible]	6	[illegible]	10	)				11	10	8	7	6	11+	—	—	—	→	12	12	12	12	12	105.[illegible]	—	106.5	—	[illegible]
[illegible]	[illegible]	[illegible]	0	0	0	0	0	11	10	8	7	6	9.2	—	—	→	6.4	12	12	12	12	12	312.	67.4	33.5	57.0	11[illegible]
	[illegible]	[illegible]	0	0	0	0	0	11	10	8	7	6	9.0	—	—	→	6.4	12	12	12	12	12	71.7	69.2	34.5	57.0	[illegible]
[illegible]	9	[illegible]	0	0	0	0	0	11	10	9	7	6	9.2	—	—	→	6.4	12	12	12	12	12	61.9	67.2	34.5	60.0	[illegible]
[illegible]	[illegible]	[illegible]	0	0	0	0	0	11	10	8	7	6	8.0	—	—	→	6.6	12	12	12	12	12	562	256	17.1	40.1	[illegible]
[illegible]		[illegible]	0	0	0	0	0	11	10	8	7	6	7.4	—	—	→	6.4	12	12	12	12	12	560	253	72	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	0	0	0	0	0	11	10	8	7	6	7.4	—	—	→	6.4	12	12	12	12	12	560	257	41.5	46.5	[illegible]
[illegible]	[illegible]	370																									

Sample Description: [illegible] Cement Kiln Dust - semi-dissolvable in water.
Average Weight: [illegible] Mean Length: 6.5 cm Longest: 8.0 cm Shortest: 6.5 cm Ratio (long/short): 1.26
Number of organisms per chamber: [illegible] Ratio of flesh to water: 1.83 gms/L. Comments: [illegible]
[illegible]
[illegible]

* Method on file with the Department of Ecology
GENERAL PROCEDURE FOR STATIC BASIC ACUTE FISH TOXICITY TEST

DATA VERIFIED BY Kevin Casey DATE 10/21/83

EHW > 10/30
DW > [illegible]

ECY 030-1-48

We feel that the above testing provides convincing evidence that fish mortalities observed in WDOE fish bioassays with waste cement kiln dust are due to pH effects alone. We understand that chemical testing of the waste indicates that it does not contain chemical contaminants at levels that would be of concern (Haynes and Kramer, 1982; D. Skeie, Industrial Mineral Products, Inc., personal communication). This being so, the major aquatic toxicity concern related to use of this waste as landfill would be an elevation of pH in the groundwater.

We are informed that the mine drainage water has been monitored at the lanfill site since 1982. Measurements to date indicate a pH range of 6.67 - 7.08 ($\bar{x}$ = 6.81, S.D. = 0.14, n = 11) in the drainage water (D. Skeie, Industrial Mineral Products, Inc., personal communication). These data are in accord with theoretical and laboratory determinations of pH effects of CKD in natural soils by Smith (1984). This author noted that, although CKD combined with water resulted in high pH levels due to NaOH formation, the buffering capacity of natural soils would maintain pH levels of groundwater leachates at between 6.5 and 7.5.

The bioassay data indicate that CKD is acutely toxic in fish bioassays due to pH effects. Based on the non-classified aquatic toxicity of neutralized CKD, and the proven buffering capacity of natural soils, it is concluded that leaching of this material into groundwater will not pose an acute lethal hazard to aquatic life.

References

Haynes, B.W and G.W. Kramer. 1982. Characterization of U.S. cement kiln dust. Bureau of Mines IC 8885.

Smith, J.L. 1984. The effects of cement kiln dust on the chemical and biological properties of soils. Unpublished report prepared by the Dept. of Plant and Soil Biology, U.C. Berkeley. 42 pp.

We trust that this letter report completes our present assignment to your satisfaction. If you have any questions or concerns, please do not hesitate to contact us.

Yours truly,

E.V.S. CONSULTANTS

Peter Chapman

Peter M. Chapman, Ph.D.,
Vice-President

PMC:mkm

cc: D. Skeie, Industrial Mineral Products, Inc.

ATTACHMENT A

Results of E.V.S. Fish Bioassay Tests With CKD From Ideal Basic Industries

E.V.S. CONSULTANTS
ACUTE LETHALITY BIOASSAY RECORD

Client- Ideal
E.V.S. Project #- 220-1
Work Order #- 84-181

E.V.S. Analyst(s)- H. Villette
C. Barlow

SAMPLE

Identification- adjusted control water
Amount Received- to pH 10.6
Date Collected- —
Date Received- —
pH- 10.6
Dissolved Oxygen (mg/l)- 10.4
Conductivity (umhos/cm)- —
Other-

Bioassay Type- 96h WDOE
Test Initiation Date- 19/10/84

DILUTION AND CONTROL MEDIUM

Fresh Water (dechlorinated)- ✓
Salt Water (Burrard Inlet)-
pH 5.7
Dissolved Oxygen (mg/l)- 11.4
Conductivity (umhos/cm)- 10.0
Hardness (mg/l as $CaCO_3$)- 5.0
Alkalinity (mg/l as $CaCO_3$)- 4.5
Salinity ($^o/_{oo}$)-
Other-

TEST SPECIES

Rainbow Trout- ✓
Threespine Stickleback-
Daphnia (*D. magna*)-
Amphipod (*R. abronius*)-
Other-

TEST CONDITIONS

Temperature (°C)- 12 ± 0.5°C
pH Range- 5.3 - 10.6
Dissolved Oxygen Range- 8.5 - 11.4
Conductivity Range- —
Aeration (7.5 cc/min./l)- —
Photoperiod (L:D-in hours)- 14:10
No. Fish/Test Volume- 10/15 l
Fish Loading Density (g/l)- 0.53
Other-

Bioassay Results- 96 h test on pH elevated control water resulted in 100% mortality.

Certified By- E.V.S. Consultants Ltd.

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

E.V.S. PROJECT NO. 220-1

WORK ORDER NO. 84-481

SAMPLE Control water pH elevated

DATE COLLECTED n/a

LAB NO.	TEST DATE & TIME	NO. FISH/ VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours)									DISSOLVED OXYGEN (mg/L)					TEMPERATURE (°C)					pH					CONDUCTIVITY (umhos/cm)	
				1	2	4	8	18	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96
	19/10/84	10/15l	pH 11 ③	*	0				0	—	—	—	11.4	10.2	—	—	—	11.5	12.0	—	—	—	10.6	10.6	—	—	—		
			〃 ②	*	0				0	—	—	—	11.4	9.8	—	—	—	11.5	12.0	—	—	—	10.6	10.6	—	—	—		
			〃 ①	*	0				0	—	—	—	11.4	9.2	—	—	—	11.5	12.0	—	—	—	10.6	10.6	—	—	—		
			control						100	100	100	100	11.4	8.5	9.1	9.1	9.2	11.5	12.0	11.5	11.5	12.0	5.7	5.5	5.4	5.3	5.4		

SAMPLE DESCRIPTION

COMMENTS *fish stressing w/in 30 seconds of exposure
- lost of equilibrium,

MEAN FISH LENGTH ± (mm) 42.2 RANGE 36-46

MEAN FISH WEIGHT ± (g) 0.816 RANGE 0.41-1.13

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE 25/10/84

E.V.S. CONSULTANTS
ACUTE LETHALITY BIOASSAY RECORD

Client- Ideal Basic Ind.
E.V.S. Project #- 220-1
Work Order #- 84-181

E.V.S. Analyst(s)- C. Barlow
A. Villette

SAMPLE

Identification- Cement Kiln dust
Amount Received- 5Kg
Date Collected- N/A
Date Received- 9/10/84.
pH- 11.3
Dissolved Oxygen (mg/l)- –
Conductivity (umhos/cm)- –
Other- pH adjusted to 7.2 (1000 ppm) AND 7.3 (100 ppm)

Bioassay Type- WDOE Hazardous Waste Toxicity Test.
Test Initiation Date- 15/10/84

DILUTION AND CONTROL MEDIUM

Fresh Water (dechlorinated)- ✓
Salt Water (Burrard Inlet)- –
pH 5.5
Dissolved Oxygen (mg/l)- 11.0
Conductivity (umhos/cm)- 10.0
Hardness (mg/l as $CaCO_3$)- 5.0
Alkalinity (mg/l as $CaCO_3$)- 4.5
Salinity ($^0/_{00}$)- –
Other-

TEST SPECIES

Rainbow Trout- ✓
Threespine Stickleback-
Daphnia (D. magna)-
Amphipod (R. abronius)-
Other-

TEST CONDITIONS

Temperature (°C)- 12 ± 0.5
pH Range- 5.5 - 9.9
Dissolved Oxygen Range- 8.0 - 11.8
Conductivity Range- –
Aeration (7.5 cc/min./l)- –
Photoperiod (L:D-in hours)- 14:10
No. Fish/Test Volume- 10/15ℓ
Fish Loading Density (g/l)- .53
Other-

Bioassay Results- 96h WDOE Hazardous waste toxicity test = no classification = no mortality @ 100 ppm, 3/30 Mortalities at 1000 ppm

Certified By- E.V.S. Consultants Ltd.

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

SAMPLE cement Kiln dust pH adjusted

DATE COLLECTED N/A

E.V.S. PROJECT NO. 220-1

WORK ORDER NO. 84-181

LAB NO.	TEST DATE & TIME	NO. FISH/ VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours)									DISSOLVED OXYGEN (mg/L)					TEMPERATURE (°C)					pH					CONDUCTIVITY (umhos/cm)	
				1	2	4	8	18	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96
	15/10/84	10/25ℓ	1000 ③					70	70	70	70	70	11.2	8.1	8.2	8.5	8.3	12.5	14	12	12.5	12	7.2	9.9	9.4	9.4	8.9		
			1000 ②					100	100	100	100	100	11.2	8.0	9.1	8.6	8.3	12.5	14	12	12.5	12	7.2	9.5	9.2	9.2	5.6		
			1000 ①					100	100	100	100	100	11.2	7.2	8.3	8.6	8.3	12.5	14	12	12.5	12	7.2	9.3	8.5	8.5	7.7		
			100 ③					100	100	100	100	100	11.8	8.3	8.5	8.2	8.2	12.5	14	13	12.5	12	7.3	7.2	7.0	6.9	6.8		
			100 ②					100	100	100	100	100	11.8	8.3	8.8	8.5	8.2	12.5	14	13	12.5	12	7.3	6.9	6.9	6.9	7.2		
			100 ①					100	100	100	100	100	11.4	8.0	8.5	8.6	8.2	12.5	14	13	12.5	12	7.3	6.9	6.9	7.1	7.0		
			control					100	100	100	100	100	11.0	8.5	9.2	8.6	8.4	12.5	14	13	12.5	12	5.5	5.6	5.8	5.5	5.7		

SAMPLE DESCRIPTION

COMMENTS

MEAN FISH LENGTH ± (mm) 42.2 RANGE 36-46

MEAN FISH WEIGHT ± (g) 0.80 RANGE 0.91-1.13

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE 25/10/84

E.V.S. CONSULTANTS
ACUTE LETHALITY BIOASSAY RECORD

Client- Ideal Basic Ind.
E.V.S. Project #- 220-1
Work Order #- 84-181

E.V.S. Analyst(s)- H. Willette
C Barlow

SAMPLE

Identification- Cement Kiln dust
Amount Received- 5Kg
Date Collected- N/A
Date Received- 9/10/84
pH- –
Dissolved Oxygen (mg/l)- –
Conductivity (umhos/cm)- –
Other-

Bioassay Type- WDOE Hazar.
Test Initiation Date- 15/10/84

DILUTION AND CONTROL MEDIUM

Fresh Water (dechlorinated)- ✓
Salt Water (Burrard Inlet)-
pH 5.5
Dissolved Oxygen (mg/l)- 11.0
Conductivity (umhos/cm)- 10.0
Hardness (mg/l as $CaCO_3$)- 5.0
Alkalinity (mg/l as $CaCO_3$)- 4.5
Salinity ($^{o}/_{oo}$)- –
Other-

TEST SPECIES

Rainbow Trout- ✓
Threespine Stickleback-
Daphnia (D. magna)-
Amphipod (R. abronius)-
Other-

TEST CONDITIONS

Temperature (°C)- 12 ± 0.5°c
pH Range- 5.5 - 10.6
Dissolved Oxygen Range- 8.2 - 11.0
Conductivity Range- –
Aeration (7.5 cc/min./l)- –
Photoperiod (L:D-in hours)- 14:10
No. Fish/Test Volume- 10/15 l
Fish Loading Density (g/l)- .53
Other-

Bioassay Results- 96 h WDOE Hazardous waste test = D.W.
(100% mortality at 1000 ppm concentration)

Certified By- E.V.S. Consultants Ltd.

E.V.S. CONSULTANTS

ACUTE LETHALITY BIOASSAY DATA

SAMPLE cement

DATE COLLECTED N/A

E.V.S. PROJECT NO. 220-1

WORK ORDER NO. 84-181

LAB NO.	TEST DATE & TIME	NO. FISH/ VOL.	CONC.	PERCENT SURVIVAL (1 to 96 hours)									DISSOLVED OXYGEN (mg/L)					TEMPERATURE (°C)					pH					CONDUCTIVITY (umhos/cm)	
				1	2	4	8	18	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	24	48	72	96	0	96
	15/10/84	10/15L	1000ppm ③	1*	0								10.8					12.5					10.6						
	11:57		1000 ②	1*	0								10.8					12.5					10.6						
			1000 ①	1*	2* 50	0							10.8					12.5					10.6						
			100 ③		100			100	100	100	100	100	10.8	7.8	8.3	8.4	8.2	12.5	14	13	12.5	12	9.1	9.1	7.9	7.2	7.4		
			100 ②		100			100	100	100	100	100	10.8	8.1	8.9	8.5	8.8	12.5	14	13	12.5	12	9.1	9.1	8.0	7.3	7.2		
			100 ①		100			100	100	100	100	100	10.8	8.1	9.3	8.5	8.6	12.5	14	13	12.5	12	9.1	8.9	8.2	7.2	7.2		
			control		100			100	100	100	100	100	11.0	8.5	9.2	8.6	8.4	12.5	14	13	12.5	12	6.5	5.6	5.8	5.5	5.7		

SAMPLE DESCRIPTION

COMMENTS 1* fish stressing after 15 mins exposure
2* remaining fish severely stressed

MEAN FISH LENGTH ± (mm) 47.2 RANGE 36-46

MEAN FISH WEIGHT ± (g) 0.80 RANGE 0.41-1.13

DATA VERIFIED BY E.V.S. CONSULTANTS

DATE 25/10/84

WAC 173-303-910(1)(b)(iv)(bb.4)

SUITABILITY OF THE DALE COAL STRIP PIT RECLAMATION PROJECT, RAVENSDALE, WASHINGTON, AS A GEOLOGIC REPOSITORY FOR IDEAL'S CEMENT-KILN DUST

The following is an environmental checklist prepared for the Dale Coal Strip Pit Cement-Kiln Dust Reclamation Project, Ravensdale, Washington. The detailed information provided on the surrounding environment and the design aspects of this site, demonstrate over-whelmingly that impacts to public health and the environment posed by acceptance of CKD in this locale are negligible. This evidence makes it obvious that the only practical course of action for the Washington State Department of Ecology is to allow continued acceptance of Ideal's CKD in the only environmentally and economically viable repository within reasonable trucking distance of Ideal's Seattle Plant. The following printed checklist form is followed by detailed explanations of those checklist categories that required more information than could fit on the checklist form.

STATE OF WASHINGTON
DEPARTMENT OF NATURAL RESOURCES
BRIAN J. BOYLE, COMMISSIONER OF PUBLIC LANDS

ENVIRONMENTAL CHECKLIST

Application No. ____________________

Project Title DALE COAL STRIP PIT CKD RECLAMATION PROJECT

Area RAVENSDALE, WASHINGTON

District/County KING

Legal Subdivision EASTERN HALF NW¼

Sec. 1 T. 21 North R. 6 East, W.M.

I. BACKGROUND

1. Name of Proponent: IDEAL BASIC INDUSTRIES, SEATTLE CEMENT PLANT
2. Address and Phone Number of Proponent:
5400 WEST MARGINAL WAY, S. W.
SEATTLE, WA 98106
3. Date Checklist Submitted: ____________________
4. Agency Requiring Checklist: WASHINGTON STATE DEPARTMENT OF ECOLOGY
5. Name of Proposal, if applicable:
DALE COAL STRIP PIT CEMENT-KILN DUST RECLAMATION PROJECT, RAVENSDALE, WA.
6. Nature and Brief Description of the Proposal (including but not limited to its size, general design elements, and other factors that will give an accurate understanding of its scope and nature):
SEE ATTACHED INFORMATION
7. Location of Proposal (describe the physical setting of the proposal, as well as the extent of the land area affected by any environmental impacts, including any other information needed to give an accurate understanding of the environmental setting of the proposal):
SEE ATTACHED INFORMATION
8. Estimated Date for Completion of the Proposal:
SEE ATTACHED INFORMATION
9. List of all Permit, Licenses or Government Approvals Required for the Proposal (federal, state and local -- including rezones):
KING COUNTY BUILDING AND LAND DEVELOPMENT DIVISION, GRADING PERMIT NO. 1122-58;
KING COUNTY DEPARTMENT OF PUBLIC HEALTH SOLID WASTE DISPOSAL SITE PERMIT NO. 17101
WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES SURFACE MINING PERMIT NO. 10346
10. Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain:
NO
11. Do you know of any plans by others which may affect the property covered by your proposal? If yes, explain:
NO
12. Attach any other application form that has been completed regarding the proposal; if none has been completed, but is expected to be filed at some future date, describe the nature of such application form:
SEE THE APPENDIX FOR THIS SECTION OF THE EXEMPTION PETITION DOCUMENT FOR THE KING COUNTY PUBLIC HEALTH DEPARTMENT APPLICATION FOR DISPOSAL SITE PERMIT FOR THE DALE STRIP PIT RECLAMATION PROJECT, DATED AUGUST 25, 1984.

RES 30-1802(REV)(4-81)

II. ENVIRONMENTAL IMPACTS
(Explanation of all "yes" and "maybe" answers are required)

	Yes	Maybe	No
(1) Earth. Will the proposal result in:			
(a) Unstable earth conditions or in changes in geologic substructures?			X
(b) Disruptions, displacements, compaction or overcovering of the soil?			X
(c) Change in topography or ground surface relief features?	X		
(d) The destruction, covering or modification of any unique geologic or physical features?			X
(e) Any increase in wind or water erosion of soils, either on or off the site?			X
(f) Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion which may modify the channel of a river or stream or the bed of the ocean or any bay, inlet or lake?			X

Explanation: SEE ATTACHED EXPLANATION

	Yes	Maybe	No
(2) Air. Will the proposal result in:			
(a) Air emissions or deterioration of ambient air quality?			X
(b) The creation of objectionable odors?			X
(c) Alteration of air movement, moisture or temperature, or any change in climate, either locally or regionally?			X

Explanation: SEE ATTACHED EXPLANATION

	Yes	Maybe	No
(3) Water. Will the proposal result in:			
(a) Changes in currents, or the course of direction of water movements, in either marine or fresh waters?			X
(b) Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X
(c) Alterations to the course or flow of flood waters?			X
(d) Change in the amount of surface water in any water body?			X
(e) Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen or turbidity?			X
(f) Alteration of the direction or rate of flow of ground waters?			X

	Yes	Maybe	No
(g) Change in the quantity of ground waters, either through direct additions or withdrawals, or through interceptions of an aquifer by cuts or excavations?			X
(h) Deterioration in ground water quality, either through direct injection, or through the seepage of leachate, phosphates, detergents, waterborne virus or bacteria, or other substances into the ground waters?			X
(i) Reduction in the amount of water otherwise available for public water supplies?			X

Explanation: SEE ATTACHED EXPLANATION

(4) Flora. Will the proposal result in:

	Yes	Maybe	No
(a) Change in the diversity of species, or numbers of any species of flora (including trees, shrubs, grass, crops, microflora and aquatic plants)?			X
(b) Reduction of the numbers of any unique, rare or endangered species of flora?			X
(c) Introduction of new species of flora into an area, or in a barrier to the normal replenishment of existing species?			X
(d) Reduction in acreage of any agricultural crop?			X

Explanation: SEE ATTACHED EXPLANATION

(5) Fauna. Will the proposal result in:

	Yes	Maybe	No
(a) Changes in the diversity of species, or numbers of any species of fauna (birds, land animals including reptiles, fish and shellfish, benthic organisms, insects or microfauna)?			X
(b) Reduction of the numbers of any unique, rare, or endangered species of fauna?			X
(c) Introduction of new species of fauna into an area, or result in a barrier to the migration or movement of fauna?			X
(d) Deterioration to existing fish or wildlife habitat?			X

Explanation: SEE ATTACHED EXPLANATION

	Yes	Maybe	No
(6) Noise. Will the proposal increase existing noise levels?			X

Explanation: SEE ATTACHED EXPLANATION

		Yes	Maybe	No
(7)	Light and Glare. Will the proposal produce new light or glare?			X
	Explanation: SEE ATTACHED EXPLANATION			
(8)	Land Use. Will the proposal result in the alteration of the present or planned land use of an area?			X
	Explanation: SEE ATTACHED EXPLANATION			
(9)	Natural Resources. Will the proposal result in:			
	(a) Increase in the rate of use of any natural resources?			X
	(b) Depletion of any nonrenewable natural resource?			X
	Explanation: SEE ATTACHED EXPLANATION			
(10)	Risk of Upset. Does the proposal involve a risk of an explosion or the release of hazardous substances (including, but not limited to oil, pesticides, chemicals or radiation) in the event of an accident or upset conditions?			X
	Explanation: SEE ATTACHED EXPLANATION			
(11)	Population. Will the proposal alter the location, distribution, density, or growth rate of the human population of an area?			X
	Explanation:			
(12)	Housing. Will the proposal affect existing housing, or create a demand for additional housing?			X
	Explanation:			
(13)	Transportation/Circulation. Will the proposal result in:			
	(a) Generation of additional vehicular movement?			X
	(b) Effects on existing parking facilities, or demand for new parking?			X
	(c) Impact upon existing transportation systems?			X
	(d) Alterations to present patterns of circulation or movement of people and/or goods?			X
	(e) Alterations to waterborne, rail or air traffic?			X
	(f) Increase in traffic hazards to motor vehicles, bicyclists or pedestrians?			X
	Explanation: SEE ATTACHED EXPLANATION			

	Yes	Maybe	No
(14) Public Services. Will the proposal have an effect upon, or result in a need for new or altered governmental services in any of the following areas:			
(a) Fire protection?			X
(b) Police protection?			X
(c) Schools?			X
(d) Parks or other recreational facilities?			X
(e) Maintenance of public facilities, including roads?			X
(f) Other governmental services?			X

Explanation: RECENT EFFORTS TO LIMIT ACCESS TO THE PROPERTY, INCLUDING METAL GATES, POSTING AND BERM CONSTRUCTION ACROSS ROADS, HAVE REDUCED THE NEED FOR POLICE SURVEILLANCE OF THE PROPERTY, A SITE OF REPEATED VANDALISM, THEFT AND GENERAL PROPERTY ABUSE BY THE PUBLIC.

	Yes	Maybe	No
(15) Energy. Will the proposal result in:			
(a) Use of substantial amounts of fuel or energy?			X
(b) Demand upon existing sources of energy, or require the development of new sources of energy?			X

Explanation:

	Yes	Maybe	No
(16) Utilities. Will the proposal result in a need for new systems, or alterations to the following utilities:			
(a) Power or natural gas?			X
(b) Communications systems?			X
(c) Water?			X
(d) Sewer or septic tanks?			X
(e) Storm water drainage?			X
(f) Solid waste and disposal?			X

Explanation:

	Yes	Maybe	No
(17) Human Health. Will the proposal result in the creation of any health hazard or potential health hazard (excluding mental health)?			X

Explanation: SEE ATTACHED EXPLANATION

	Yes	Maybe	No
(18) Aesthetics. Will the proposal result in the obstruction of any scenic vista or view open to the public, or will the proposal result in the creation of an aesthetically offensive site open to the public view?			X

Explanation: SEE ATTACHED EXPLANATION

	Yes	Maybe	No
(19) Recreation. Will the proposal result in an impact upon the quality or quantity of existing recreational opportunities?			X

Explanation: SEE ATTACHED EXPLANATION

	Yes	Maybe	No
(20) Archaeological/Historical. Will the proposal result in an alteration of a significant archaeological or historical site, structure, object or building?			X

Explanation:

III. SIGNATURE

I, the undersigned, state that to the best of my knowledge the above information is true and complete. It is understood that the lead agency may withdraw any declaration of nonsignificance that it might issue in reliance upon this checklist should there be any willful misrepresentation or willful lack of full disclosure on my part.

Proponent:

Title: Senior Vice President and General Manager, Pacific Region

Date: 1 November, 1984

Approved by: GLENNDA B. MC LUCAS

Title: MINE GEOLOGIST

Date: 13 OCTOBER, 1984

REGISTERED PROFESSIONAL GEOLOGIST
OREGON
GLENNDA B. McLUCAS
No. G 834

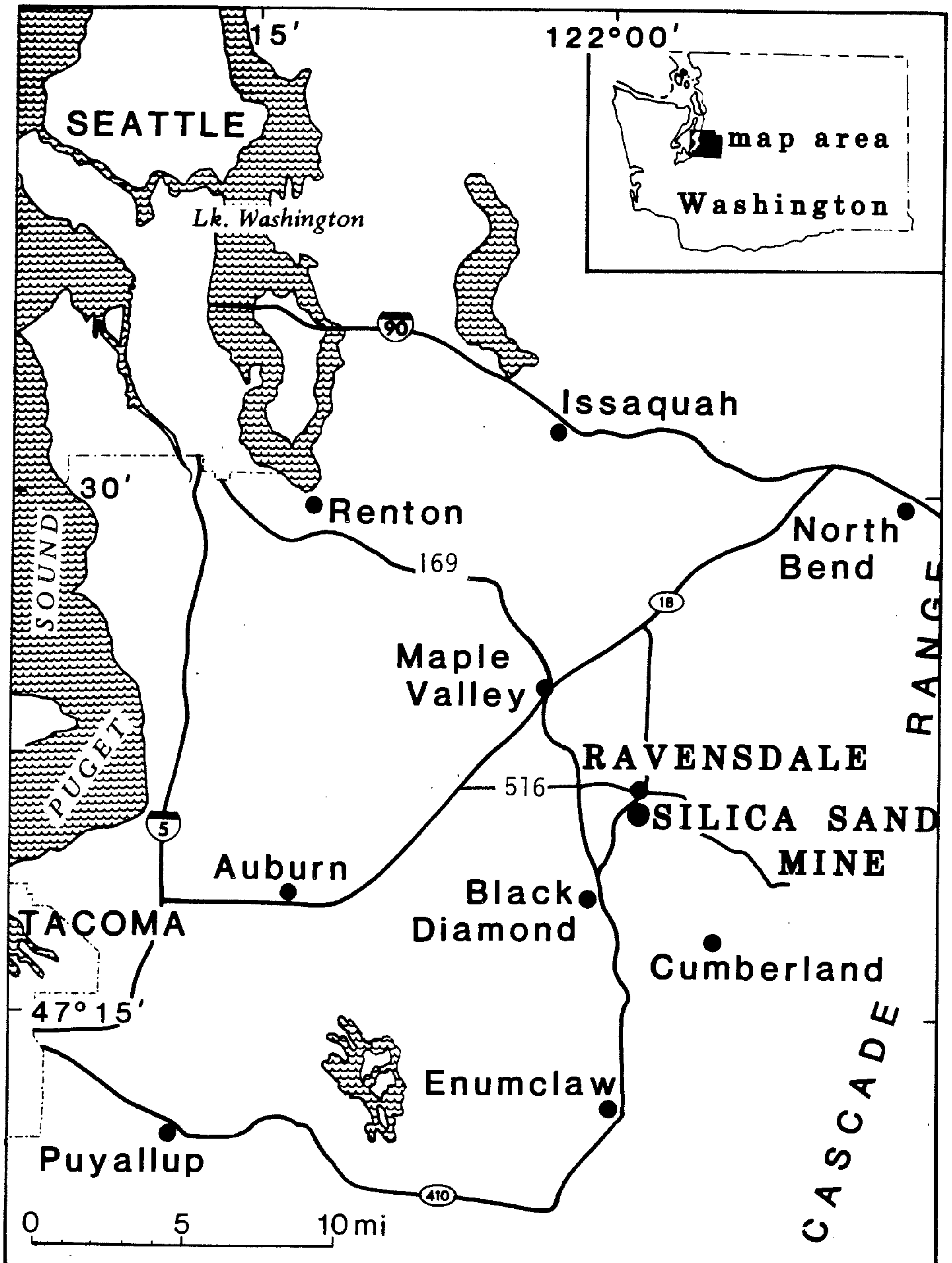
RES 30-1802(REV)(4-81)

WAC 173-303-910(1)(b)(iv)(bb.4)

I. (6). Nature and Brief Description of the Proposal.

Background Mining and Regulatory Information for the Ravensdale Silica Sand Mine

Industrial Mineral Products, Inc. (I.M.P.), operates a surface mine at Ravensdale, King County, Wahington, 12 miles east of Kent (Figure 13, Vicinity Map, and Figure 14, Aerial View). The mine occupies a portion of a 250-acre leasehold (Figure 15) held in fee title (surface and mineral) by Burlington Northern Railroad and leased to I.M.P. since 1968. Silica sand is extracted from this property and sold for use in the bottle glass, fiberglass insulation, and cement-manufacturing industries. Quartz sandstone occurs in three near-vertical beds, 100-to-200 feet wide, on the north flank of a synclinal fold (Figure 17). These units are stripped to a depth of 50-to-100 feet, at which point it is no longer economically feasible to continue excavation. I.M.P.'s mining plan involves side-hill excavation of the western flank of Ravensdale Hill (Figure 18) which allows for excavation of these three sandstone units from lowest to



IDEAL

Ideal Basic Industries
Cement Division

SCALE:

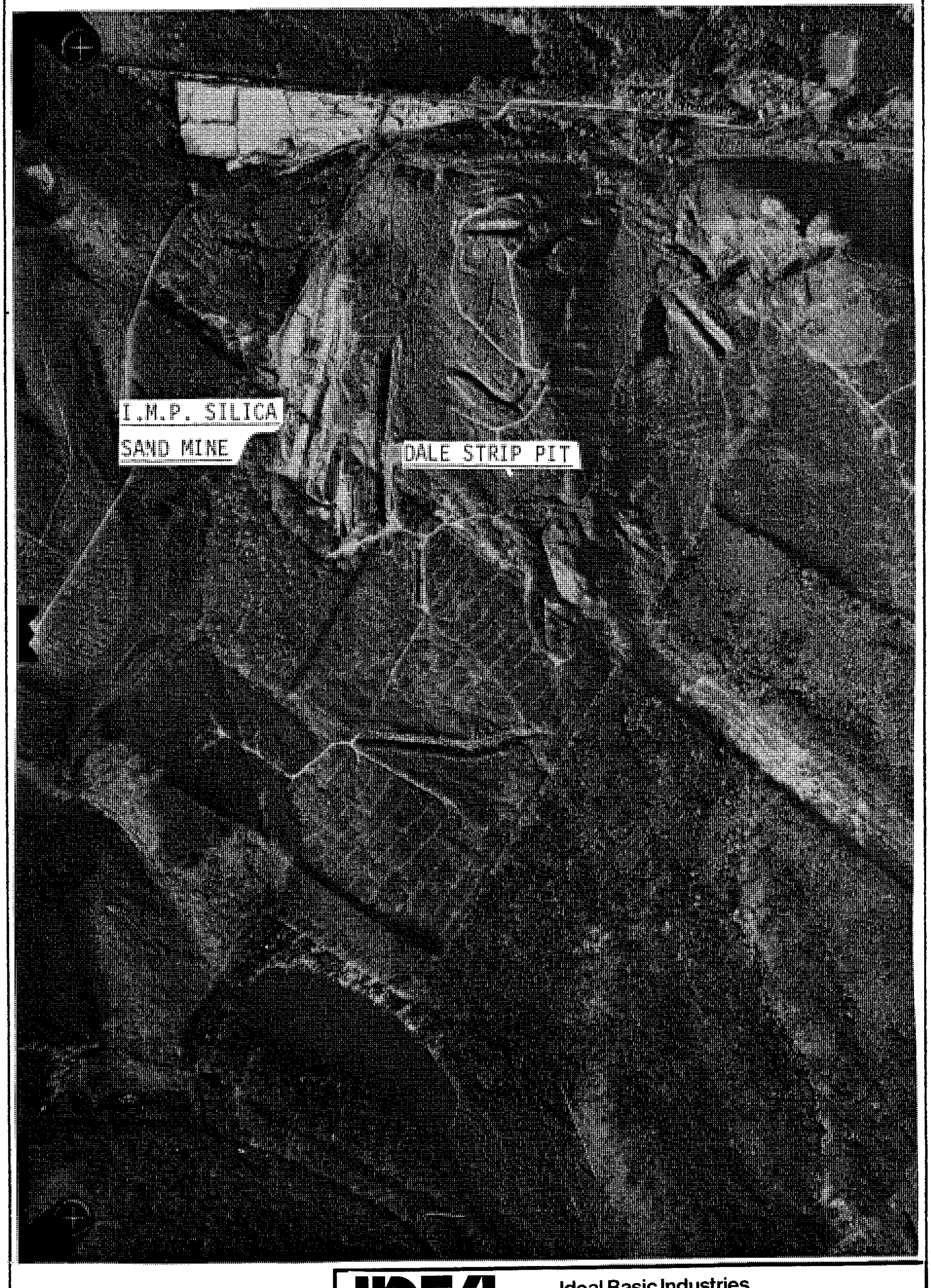
DATE: 1984

VICINITY MAP

DRAWN BY

FIGURE 13

Ravensdale Silica Sand Mine

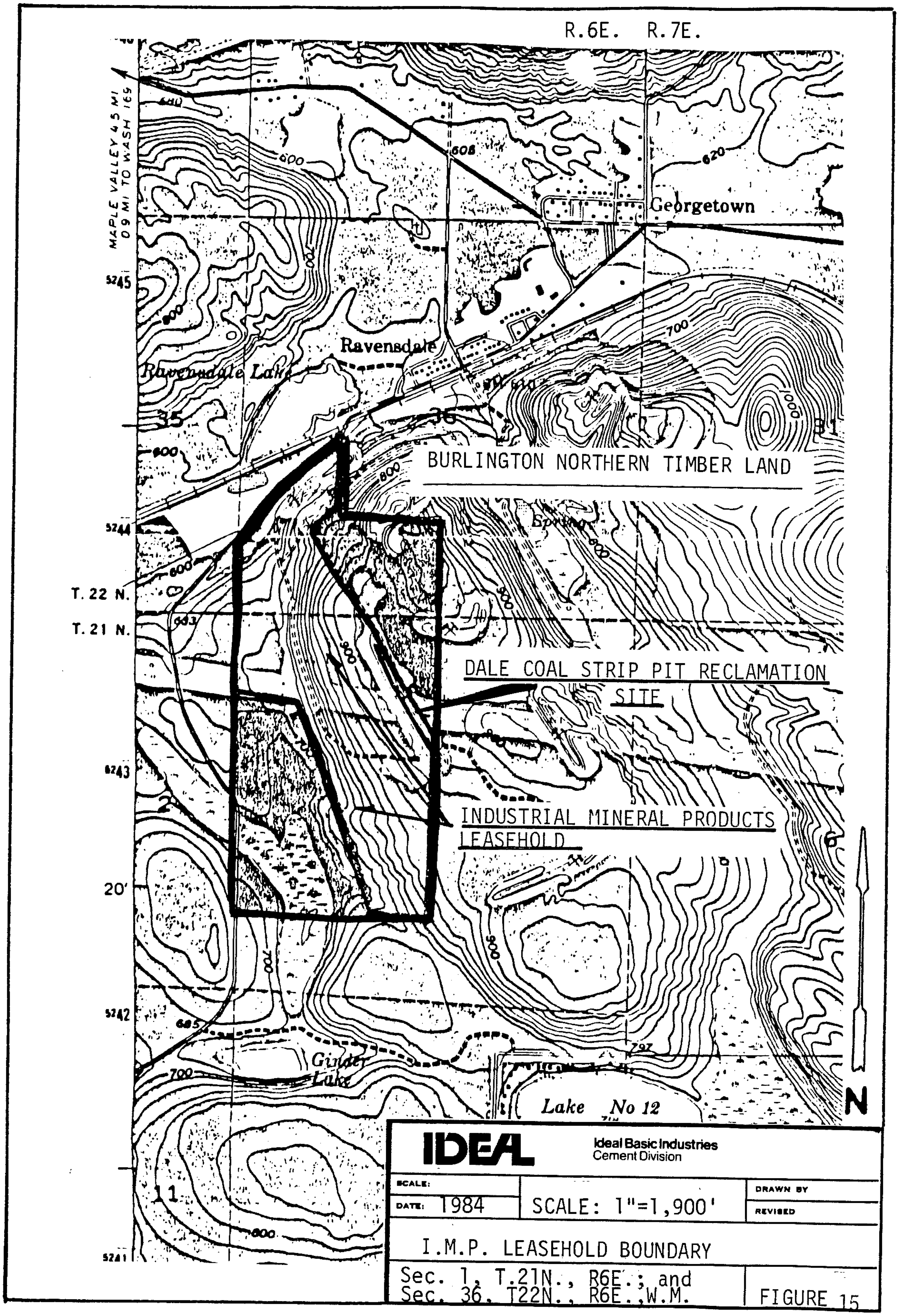


IDEAL Ideal Basic Industries
Cement Division

SCALE: 1"=1200'	APPROVED BY:	DRAWN BY
DATE: 1/83		REVISED

AERIAL VIEW OF THE DALE STRIP PIT AND I.M.P.
SILICA SAND MINE AND WASH PLANT

FIGURE 14



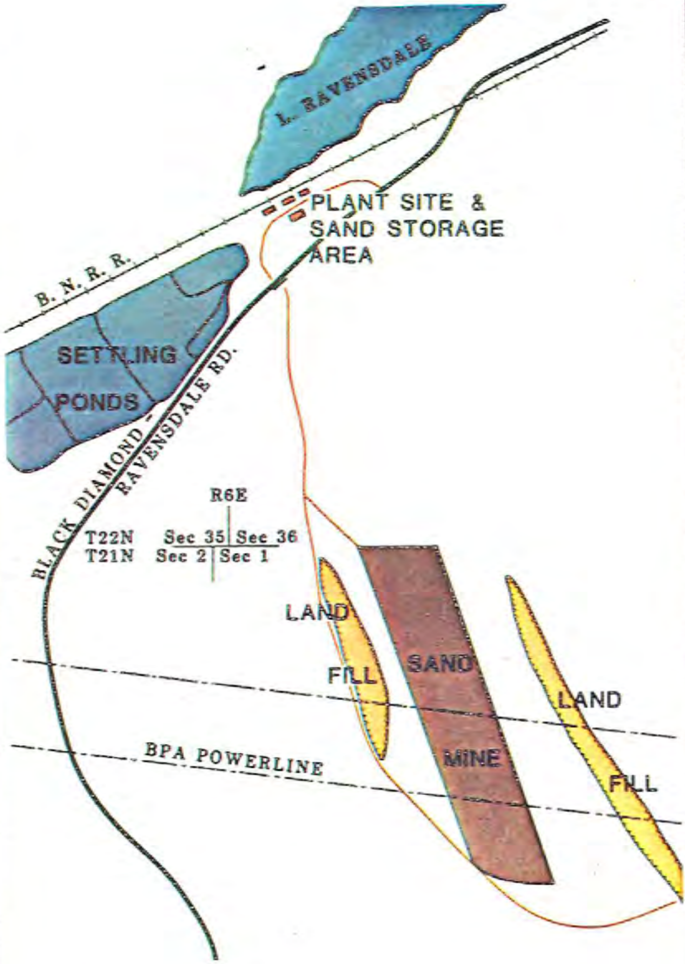
IDEAL Ideal Basic Industries
Cement Division

SCALE:		DRAWN BY
DATE: 1984	SCALE: 1"=1,900'	REVISED

I.M.P. LEASEHOLD BOUNDARY

Sec. 1, T.21N., R6E.; and
Sec. 36, T22N., R6E., W.M.

FIGURE 15



Ideal Basic Industries
Cement Division

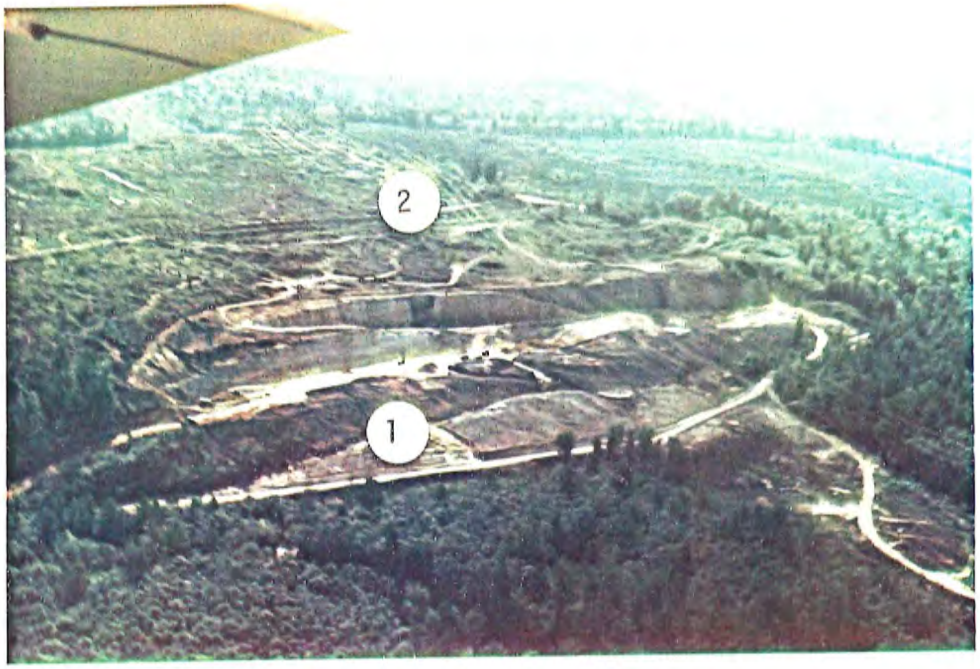
SCALE:	APPROVED BY:	DRAWN BY
DATE:	FIGURE 16	REVISED

PLOT PLAN, I.M.P. SILICA SAND MINE

Ideal Basic Industries
Cement Division

SCALE:	APPROVED BY:	DRAWN BY
DATE: 1983	FIGURE 17	REVISED

I.M.P. SILICA SAND MINE, LOOKING NORTH



1 ORIGINAL CKD FILL
2 DALE STRIP PIT

Ideal Basic Industries
Cement Division

SCALE:
DATE: 1983
APPROVED BY:
DRAWN BY
REVISED

I.M.P. SILICA SAND MINE, RAVENSDALE
CKD RECLAMATION SITES NOTED
FIGURE 18

Ideal Basic Industries
Cement Division

SCALE:
DATE: 1982
APPROVED BY:
DRAWN BY
REVISED

ORIGINAL CKD BACKFILL, LOOKING NORTH, IN
RELATION TO I.M.P. SAND MINE
FIGURE 19

highest elevations. This allows establishment of optimum drainage and benchwork, optimizes resource recovery, and assures continuous, staged reclamation.

Operating permits are required for all surface mining activities when more than 2 acres are disturbed or 10,000 tons of material is excavated in a 12-month period in accordance with Washington State's Surface Mined Land Reclamation Act, Chapter 64, Laws of 1970 Section 5 (RCW 78.44), included in Appendix C-1. A reclamation plan must accompany the application for a Surface Mining Operating Permit. The permit application and reclamation plan for the Ravensdale Silica Sand Mine are enclosed as Appendices C-2 and C-3.

RCW 78.44.090 states that:

> This reclamation plan must provide that reclamation activities, to the extent feasible, be conducted simultaneously with surface mining and, in any case, be initiated at the earliest possible time after completion or abandonment of mining on any segment of the permit area. The plan shall provide that reclamation activities shall be completed not more than two years after completion or abandonment of surface mining on each segment of the area for which a permit is requested.

The plan states, in part:

> (1) In all other excavations in soil, sand, gravel, and other unconsolidated materials, the side slopes and the slopes between successive benches shall be no steeper than one and one-half feet horizontal to one foot vertical for their entire length.

> (2) The sides of all strip pits and open pits in rock and other consolidated materials shall be no steeper than one foot horizontal to one foot vertical, or other precautions must be taken to provide adequate safety.
>
> (3) The slopes of quarry walls in rock or other consolidated materials shall have no prescribed angle of slope, but where a hazardous condition is created that is not indigenous to the immediate area, the quarry shall be either graded or backfilled to a slope of one foot horizontal to one foot vertical, or other precautions must be taken to provide adequate safety.
>
> (4) In strip mining operations, the peaks and depressions of the spoil banks shall be reduced to a gently rolling topography which will minimize erosion and which will be in substantial conformity with the immediately surrounding land area.
>
> (5) In no event shall any provision of this section be construed to allow stagnant water to collect or remain on the surface mined area. Suitable drainage systems shall be constructed or installed to avoid such conditions if natural drainage is not possible.
>
> (6) All grading and backfilling shall be made with nonnoxious, nonflammable, noncombustible solids unless approval has been granted by the director for a supervised sanitary fill.
>
> (7) Vegetative cover will be required in the reclamation plan as appropriate to the future use of the land.

Correspondence from the Department of Natural Resources (Appendix C-4), the responsible regulatory authority for surface mining in Washington, demonstrates that I.M.P. was not in compliance with state mining laws in 1977 in regard to benching or steepness of mine walls, which were near-vertical in conformance with the natural bedding planes. Due to the impermeability of the clay-cemented sandstone unit, a large, stagnant pond had collected in the bottom of the excavation which required continuous pumping for mining activities to proceed.

Excavation of this lowermost sandstone unit (Figure 20) progressed until drainage conditions and the chemical properties of the sandstone had deteriorated sufficiently to dictate development of a unit at higher elevation. In compliance with the sections of the Surface Mined Land Reclamation Act cited above, I.M.P. then initiated investigation of sources of suitable backfill material for the unsafe excavation. I.M.P.'s principal aim was to find a large-volume source of fill of uniform physical and chemical properties that would compact and provide stability, resist internal and external erosion, would not inhibit surface revegetation, and that would not pose a threat to the environment.

Because cement-kiln dust satisfied all necessary requirements, I.M.P. began backfilling the abandoned unit with CKD from Ideal Basic Industries' Seattle Cement-Manufacturing Plant, in June, 1979 (Figure 19).

IDEAL Ideal Basic Industries
Cement Division

SCALE:	APPROVED BY:	DRAWN BY
DATE: 1975		REVISED

LOWERMOST SANDSTONE UNIT EXCAVATION

I.M.P. SILICA SAND MINE — FIGURE 20

CKD Backfilling Permit Conditions

CKD backfilling operations from June 1979, to August 28, 1981, were performed in compliance with King County Building and Land Development Grading Permit No. 1122-58. Following the latter date, reclamation continued under the same grading permit, amended to include conditions pertaining to continued acceptance of the cement-kiln dust (Appendix C-5). These conditions state that:

> No filling of cement flyash shall be permitted on the site until, and unless, approved by the King County Department of Public Health through the issuance of a Solid Waste Disposal Permit. The issuance of this permit does not preclude the owners from having to obtain other required federal, state or local permits or authorizations.

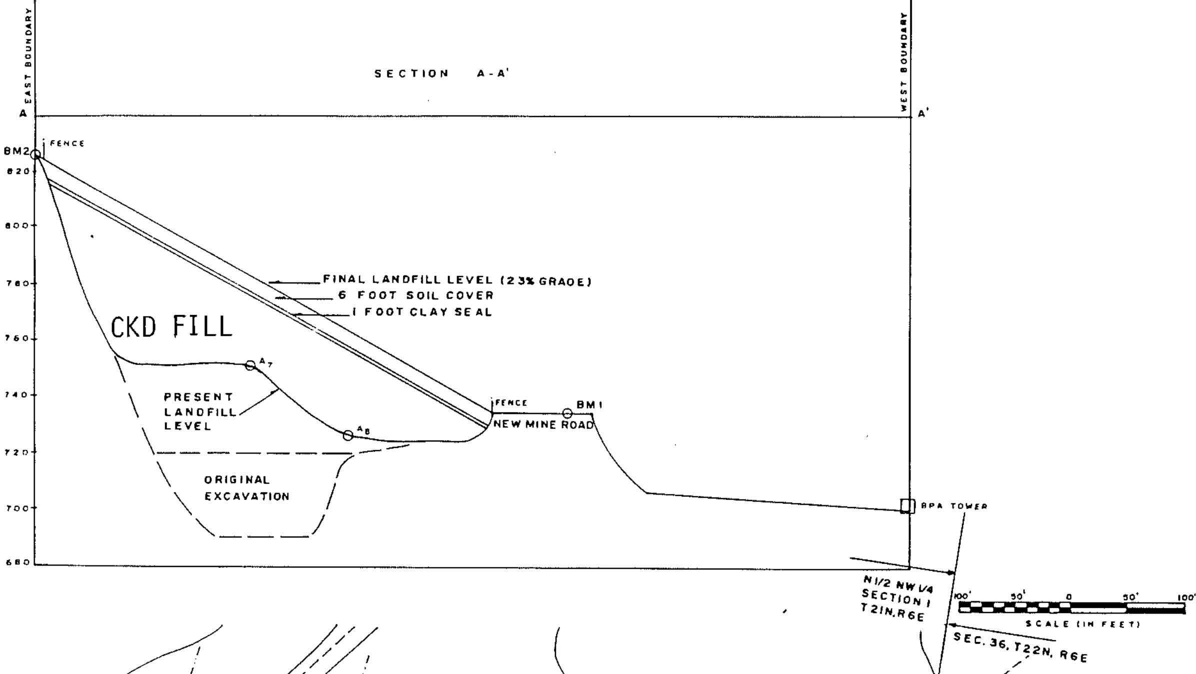
A WDOE Application for Disposal Site Permit was submitted to the King County Department of Public Health by I.M.P. on June 25, 1981 (Appendix C-6). On August 28, 1981, the site received a King County Department of Public Health Special Landfill Permit, No. 17-101 (Appendix C-7). Terms of the permit included a plan and schedule for monitoring surface and ground water, gating, fencing, posting, and recordkeeping requirements. In response to the conditional request for a plan and schedule for monitoring surface and groundwater associated with the site, I.M.P. submitted a WDOE Industrial/Commercial Waste Discharge Permit Application to the Seattle-King County Department of Public Health on

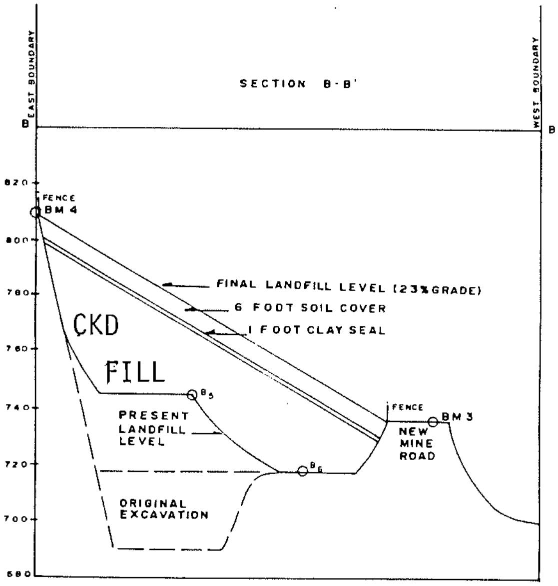
November 5, 1981, followed by a report on the Surface Water Discharge Associated with I.M.P.'s Cement-Kiln Dust Landfill on November 10, 1981 (Appendix C-8).

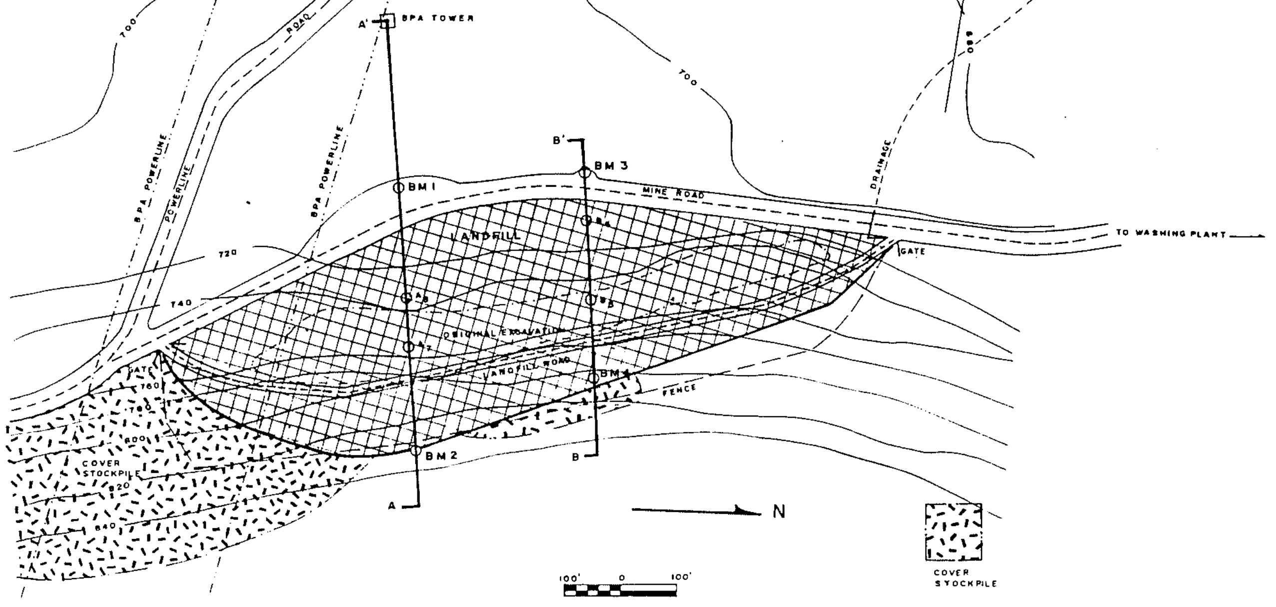
In June, 1981, the lessor, Burlington Northern Railroad (BNRR), amended I.M.P.'s silica sand mine lease as it pertained to use of cement-kiln dust as a backfill. Conditions included a five-foot hogwire fence around the entire fill perimeter, gates to restrict entry, and public warning signs. Additionally, BNRR required submission of a reclamation plan for the fill (Figure 21) with the following elements. 1) Establishment of bench marks for the finished surface profile; 2) placement of a one-foot clay cap over the finished and contoured CKD fill; 3) a minimum of six feet of soil cover over the clay seal; 4) drainage control for the reclaimed site; and 5) application of fertilizer and grass seed on the finished soil surface.

From June, 1979, to October 31, 1982, I.M.P. accepted 175,000 tons of CKD as backfill for the sandstone excavation. See Plot Plan (Figure 22) for location of original reclamation site and Figure 19 for its relationship to the adjacent, operating silica sandstone mine.

The "old" CKD site represented a 3.5-acre excavation, 40 feet deep (Figure 20). When mining ceased and drainage pumps were removed, the excavation filled with rain water. Starting in June, 1979, CKD was placed directly into this

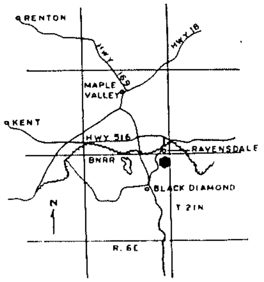






NOTES

1. Landfill site owned by Burlington Northern Railroad Company (BNRR), leased by Industrial Mineral Products, Ravensdale, Washington.
2. Landfill legal description: N½ NW¼, Sec. 1, T.21N., R.6E.
3. King County Grading Permit number 1122-58; BNRR operating permit number #90-5.81-0300.
4. Area zoning: Quarry-Mining; ultimate use: timber growth.
5. No drainage problem anticipated due to emplacement of drain tile under new mine road, final 23 percent grade of reclaimed hillside, and 6-foot soil cover.
6. All strippings from mining operations have been preserved to be utilized as top dressing. BNRR will be notified before soil cover is placed, with right of approval.
7. Clay to utilized as 1-foot landfill seal (approximately 13,000 yards) to be obtained from I&P sand washing plant settling ponds.
8. Contour lines are approximate. Minimum slope requirements and rounding for natural appearance will govern in reclamation grading.
9. All landfill area will be grass-seeded and fertilized immediately following placement of 6-foot soil cover. Seed and fertilizer types will be selected by BNRR and applied under BNRR supervision.
10. Reclamation time schedule:
    - a. Estim- completion of flue dust disposal: April, 1983
    - b. Estimated emplacement of clay seal: May, 1983
    - c. Estimated emplacement of soil cover and grading: July, 1983
    - d. Estimated time of grass seedi_ and fertilization: August, 1983



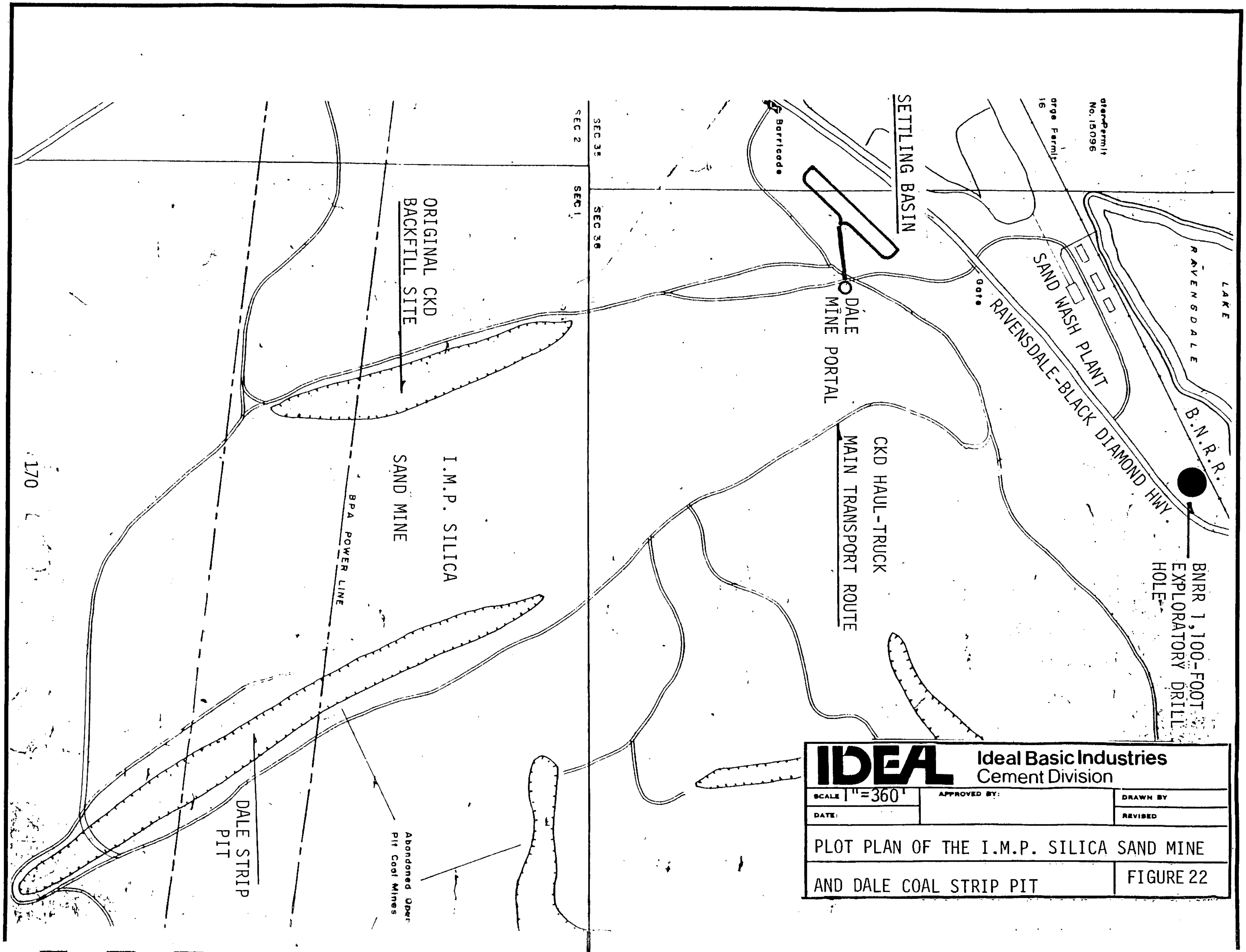
VICINITY MAP

IMP FLUE DUST LANDFILL RECLAMATION PLAN

IDEAL Ideal Basic Industries
Cement Division

SCALE:		DRAWN BY
DATE: 1981	FIGURE 21	REVISED
IMP CKD RECLAMATION PLAN FOR THE ORIGINAL LANDFILL		DRAWING NUMBER

INDUSTRIAL MINERAL PRODUCTS, INC
P O BOX 95 RAVENSDALE, WA
CEMENT FLUE DUST RECLAMATION PLAN
PREPARED BY GLENNDA MC LUCAS
OCTOBER, 1981



IDEAL Ideal Basic Industries
Cement Division

SCALE 1"=360'	APPROVED BY:	DRAWN BY
DATE:		REVISED

PLOT PLAN OF THE I.M.P. SILICA SAND MINE AND DALE COAL STRIP PIT

FIGURE 22

water with the assumption that the cementitious nature of the dust would further seal the bottom of the pit, which represented an impermeable clay-cemented sandstone unit 20 feet above the water table (see following section on ground water conditions).

Drainage from the reclamation site was diverted down the north side of Ravensdale Hill to the confluence of the Dale Coal Mine drainage. Through dilution and neutralization of the slightly acidic coal mine drainage, pH of the combined waters was maintained within the +6 to -9 range dictated by Washington State surface water regulations.

When backfilling operations had reached the point at which berm construction was necessary to contain the free-flowing dust, the finished surface was contoured in conformance with the BNRR reclamation plan (Figure 23) and terraced to control surface drainage. It was then covered with two feet of clay from an adjacent 30-foot kaolinitic clay unit to the east and from the I.M.P. settling ponds. At least seven feet of soil was then distributed over the clay surface (Figure 24) from stripping stockpiles.

In the fall of 1983, the site was fertilized and seeded with Alta Fescue grass seed. Because a great deal of the adjacent sand mine to the east of the CKD fill was contoured and reclaimed at the same time, the total acreage of the

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DATE: 1982		REVISED

CONTOURED SURFACE OF THE ORIGINAL CKD

RECLAMATION SITE FIGURE 23

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Cement Division

SCALE:	APPROVED BY:	DRAWN BY
DATE: 1983		REVISED

RECLAMATION OF ORIGINAL CKD BACKFILL AREA

CLAY AND SOIL PLACEMENT FIGURE 24

reclamation project is 10.5 acres. Figures 25 and 26 are views of the finished, partially-revegetated surface.

Appendix C-9 represents the King County Health Department Landfill Renewal Application and Approval for 1982. By summer of 1982, the sandstone excavation was nearly full and I.M.P. personnel began to investigate the availability of other geologically suitable repositories for the CKD. Several coal strip-mine excavations in the vicinity of the sand mine need reclamation attention because of their unsafe and unproductive nature (Figures 27 and 28). Geohydrologic investigation of several abandoned strip-pits demonstrated that three are ideally suited for acceptance of Ideal's CKD. Detailed geohydrologic investigation was focused on the Dale No. 4 Strip Pit because it is located within the boundaries of I.M.P.'s leasehold, and because of the availability of a comprehensive study performed on the site by METRO in 1972, as a potential repository for Seattle's sewage sludge. Major portions of the METRO study are incorporated into discussion of the ground water conditions of the Dale Strip Pit in the water section of this Checklist.

On September 20, 1982, I.M.P. submitted an Application for a Disposal Site Permit to the King County Department of Public Health for the Dale Strip Pit Special Waste Disposal Site at Ravensdale (Appendix C-10). On October 25, 1982, the Health Department issued approval for the new reclamation

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FINISHED SURFACE OF THE ORIGINAL CKD
RECLAMATION SITE, LOOKING NO. FIGURE 25

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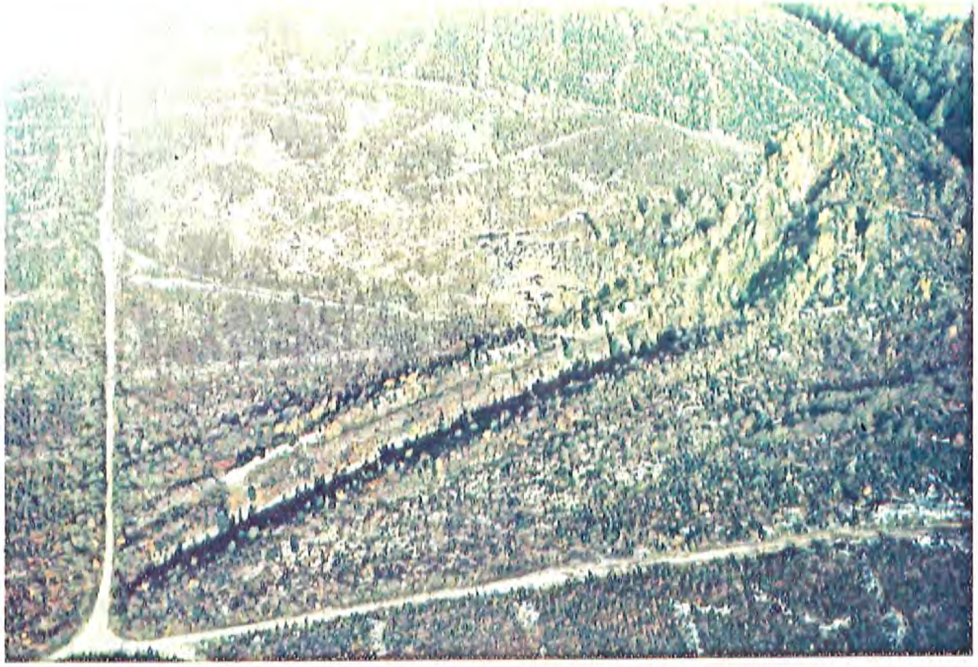
DATE 1984		REVISED

FINISHED SURFACE OF THE ORIGINAL CKD
RECLAMATION SITE, LOOKING SO. FIGURE 26



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Cement Division

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DATE: 1984		REVISED

MC KAY COAL STRIP PIT NEAR RAVENSDALE

BURLINGTON-NORTHERN LAND FIGURE 27

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DATE: 1984		REVISED

MC KAY COAL STRIP PIT

RAVENSDALE, WASHINGTON FIGURE 28

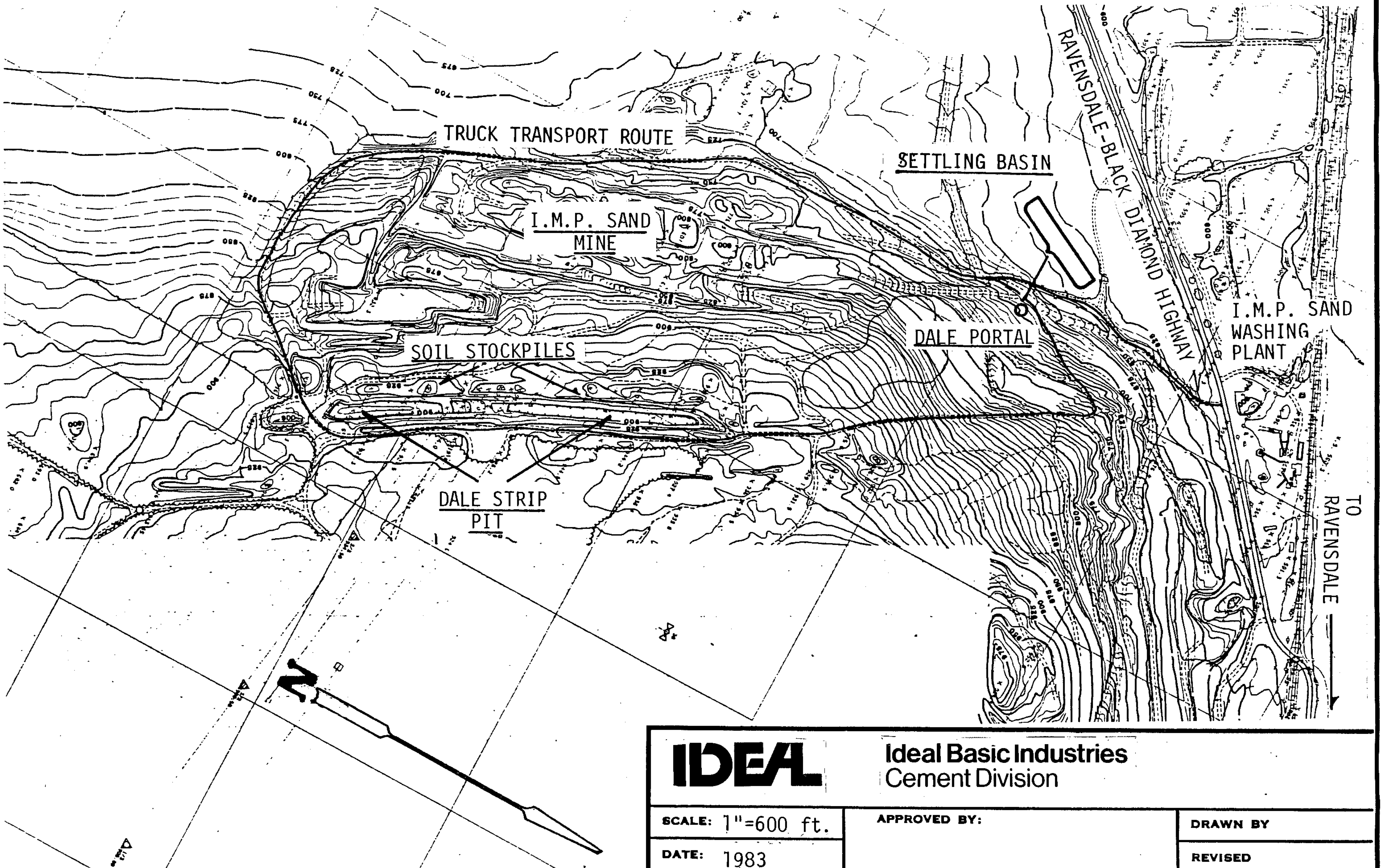
project-(Appendix C-11), with instructions to submit a final cover plan for the "old" site. Renewal applications for the Dale Strip Pit backfill operation for 1983 and 1984 are attached as Appendices C-12. Appendix 13 is notification from the King County Health Department that the 1984 Renewal Application for the Ravensdale Solid Waste Disposal Site was denied pending authorization by the WDOE to continue regulating CKD as a solid wate in King County. This is due to the loss of CKD's exclusionary status from federal and state dangerous waste regulations, effective January 1, 1984, and its capture by the Washington DOE as a dangerous waste because of failure of the Acute Static Fish Bioassay Toxicity Test. The whole purpose of this exemption document is to re-establish CKD as a solid waste so that its disposal will continue under the supervision of King County's Department of Public Health, an agency that has always viewed the Dale Strip Pit site as a safe, practical solution to Ideal's need for a disposal site and I.M.P.'s need for a reclamation resource.

I. (7). Location of the Proposal.

As indicated by the Vicinity Map (Figure 13), the Dale Strip Pit is located 40 miles south of Seattle and one mile southwest of the town of Ravensdale, in southwestern King County, Washington. It is in the eastern half of the NW 1/4, Section 1, Township 21 North, Range 6 East, near the westerly flank of Ravensdale Hill, a steep-sided bedrock hill shown on the Topographic Map in Figure 29.

The Dale Strip Pit was excavated on the surface of a plateau at 925-feet elevation, 325 feet above Ravensdale (elevation 600 feet), which occupies a former glacial meltwater channel of the Cedar River. The pit is 1,800 feet long, over 40 feet deep in some places, and averages 140 feet in width; its volume is in excess of 250,000 cubic yards.

The Dale Strip Pit is in the midst of a 50-acre watershed, all of which is part of a timber-regrowth plantation owned by Burlington Northern Railroad. There is no cultural development on all sides closer than one mile, except for the I.M.P. sand-washing plant, which is an industrial mining-related facility. The area, in general, is sparsely populated.



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Cement Division

SCALE: 1"=600 ft.
APPROVED BY:
DRAWN BY
DATE: 1983
REVISED

TOPOGRAPHIC MAP OF THE I.M.P. SILICA SAND MINE & DALE STRIP PIT

FIGURE 29

The area has historically been devoted to mining, and, in fact, is zoned Quarry- Mining in the King County Master Plan. Because of the associated coal mining activity, subsurface information is complete and readily available through examination of old coal mine maps.

The site is far removed from bodies of surface water and is underlain by impervious clay-cemented bedrock that traditionally has not produced groundwater in even moderate quantities. The opportunities for pollution of public water supplies is, therefore, negligible as discussed under the sections on surface and ground water quality.

I. (8). Estimated Date for Completion of the Proposal

Since reclamation of the Dale Strip Pit began on November 1, 1982, 53,700 tons, or 79,556 yards (one yard = 0.67 tons) of cement-kiln dust has been placed in the trench. The capacity of the Dale Strip Pit was estimated by METRO, in their 1972 engineering study of the pit as a disposal site for sewage sludge, to be in excess of 250,000 cubic yards. Therefore, 30 per cent of the strip pit has been reclaimed in a two-year period. In the original King County Solid Waste Permit Application, Industrial Mineral Products estimated a three-to four-year life for the reclamation project. At 1982 CKD production rates, that life expectancy made sense. However, examination of Table 20 in Section 910(3)(c)(vi) of the Exemption Petition Document demonstrates a dramatic drop in CKD production, as well as in the amount available to I.M.P. for reclamation purposes.

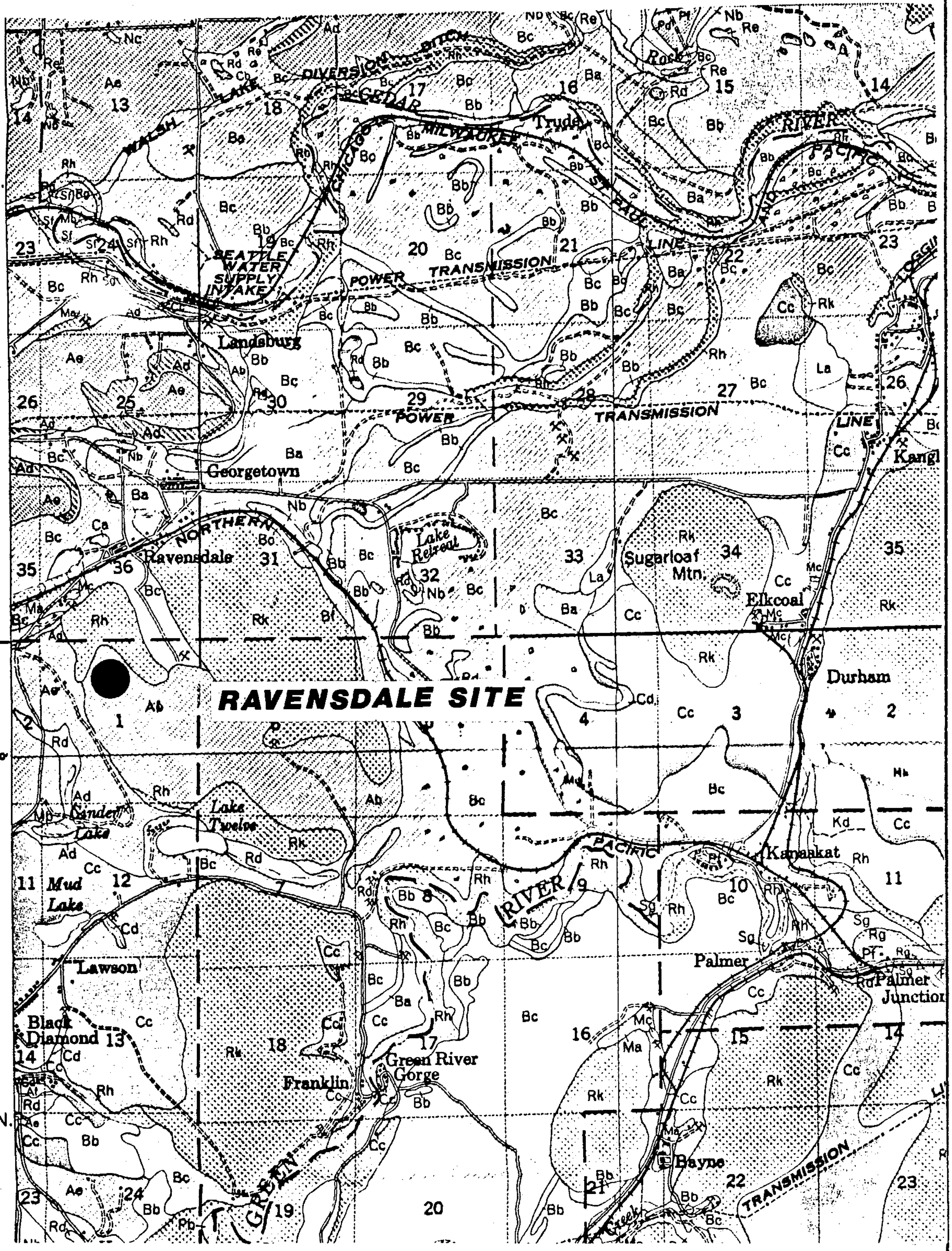
If the current rate of 13,490 tons for 1984 continues into the future, or drops to an even lower figure, the life of the Dale Strip Pit Reclamation Project will be greatly extended. At 13,490 tons/year (20,000 yards), the remaining life of the pit is 8.5 years, assuming that no other solid fill material will be used. I.M.P. does, however, accept other inert solid fill material from their two major silica sand customers, Ideal Basic Industries and Northwestern Glass (Figure 54). These solids represent rejected clay and sand batches and glass cullet, respectively, the raw materials for which are derived from the adjacent silica sand mine 1000 feet to the west. Acceptance of this material will shorten the life of the pit by two years at the current disposal rate of 4000 tons per year.

Because soil placement and grass seeding will progress down-trench, concurrent with completed filling of the pit, this portion of the reclamation project will not extend the project completion time. As such, the estimated date for completion of the proposal is June 1991.

II. (1). Earth. (b) Soils.

The soil cover and glacial substratum immediately overlying the Dale Strip Pit was stripped and stacked in windrows along the west side of the excavation in the 1940's when the Dale No. 4 coal measure was exposed. This 124,700 cubic yards of material will be used as cover material when the landfill is complete. The original soil cover is designated Alderwood Series, Ab, Alderwood and Kitsap soils on the Soils Map (Figure 30). This mapping unit is about 50 percent Alderwood gravelly sandy loam and 25 percent Kitsap silt loam. Distribution of the soils, drainage, and permeability vary within short distances.

The Alderwood series is composed of moderately well-drained gravelly loam 24-to-40 inches deep over a weakly-to strongly-consolidated, very slowly permeable substratum of glacial till (Vashon). These soils occur on uplands and terraces and formed under conifers in glacial deposits. They have convex slopes that are dominantly 0-to-30 percent but range to as much as 70 percent. Slopes greater



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Cement Division

SCALE:
DATE: 1973
SCALE: 1"=5,000'
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DALE COAL STRIP PIT RECLAMATION PROJECT

SOILS MAP

FIGURE 30

than 15 percent are generally no more than 200 feet long as exemplified by the Dale Strip Pit locale.

The surface layer is dark-brown to grayish-brown gravelly sandy loam about 27 inches thick. The substratum is grayish-brown, weakly-to strongly-consolidated glacial till that extends to a depth of 60 inches and more.

Alderwood series soils are used predominantly for timber; the effective rooting depth is 20-to-40 inches. Low available water capacity and steepness of slope prevent use of the area for farming. The area will be well-suited to use as a wildlife habitat and for recreation, once mining and landfilling operations are complete.

The cover soil has been extracted from an area designated on the attached soils map as Ab, Alderwood gravelly sandy loam, 0-to-6 percent slope. Depth to the substratum in this soil varies within short distances, but is about 40 inches in most instances. This soil is used mostly for timber growth.

WAC 173-303-910(1)(b)(iv)(bb.4)

II. (1) Earth. (c) Change in Topography or Ground Surface Relief Features.

Reclamation of the Dale Strip Pit will result in conversion of a trench about 40 feet deep, 140 feet wide, and 1,800 feet long, to a flat surface by filling the trench with approximately 250,000 cubic yards of cement-kiln dust from Ideal Basic Industries' Seattle Cement-Manufacturing Plant. Overburden stockpiled on the western edge of the strip pit during the original strip-mining operations (124,700 cubic yards) will be redistributed over the finished, contoured CKD surface. The final surface will be slightly convex to prevent precipitation from ponding on it, or will be designed in such a fashion that runoff will collect in a ditch along the eastern side of the pit. The ditch will then funnel runoff into settling basins.

Other geological aspects of the site are discussed as they pertain to ground water conditions under the following water section.

WAC 173-303-910-(1)(b)(iv)(bb.4)

II (2) Air. (a) Air Emissions or Deterioration of Ambient Air Quality

The following information is taken directly from Pacific Coast Coal Company's Proposed John Henry No. 1 Coal Mine Final EIS:

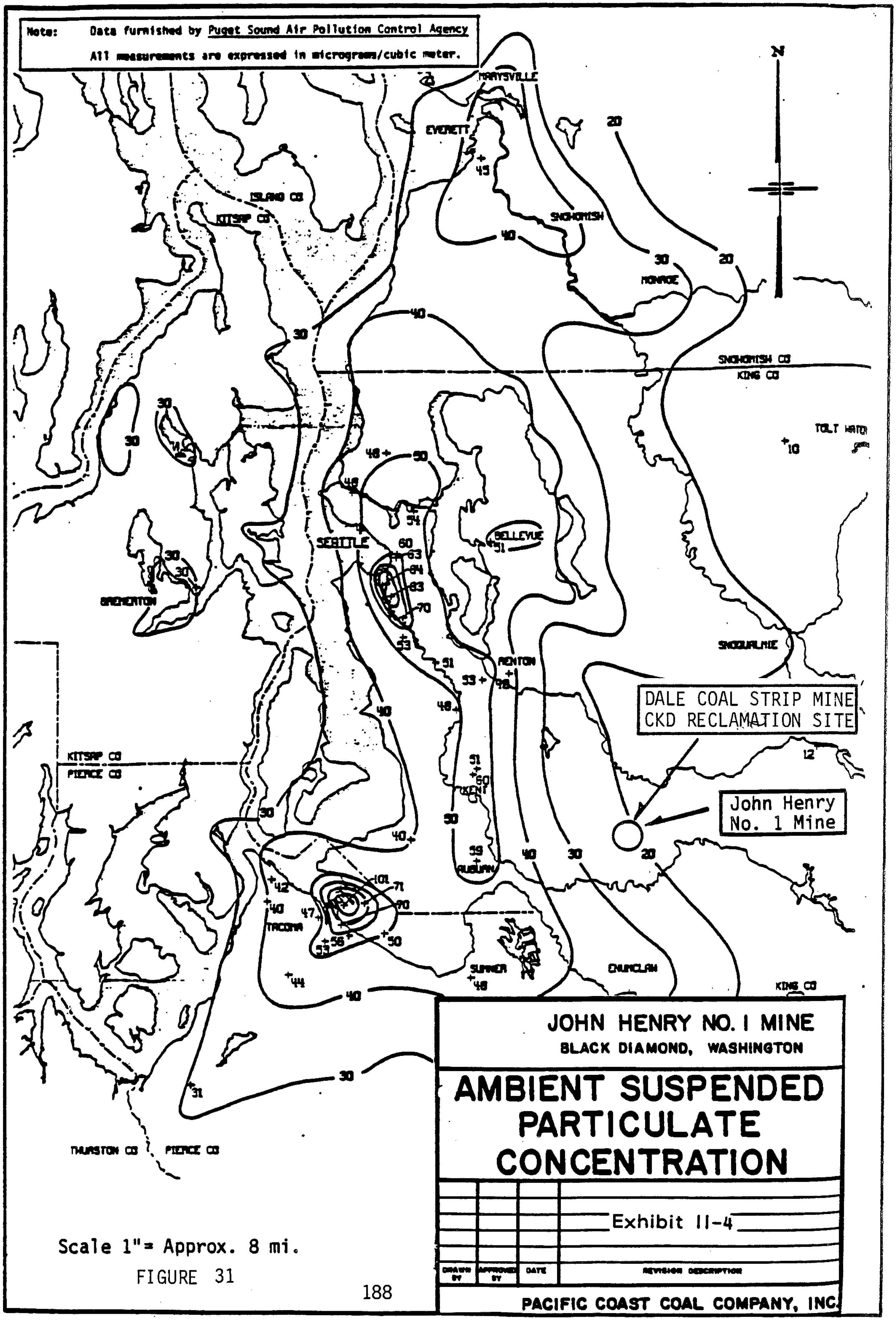
"The Puget Sound Air Pollution Control Agency (PSAPCA) has, since the 1960's, maintained an atmospheric sampling network which monitors the ambient levels of suspended paticulates in King, Snohomish, Kitsap, and Pierce Counties. The City of Black Diamond and surrounding area (including Ravensdale) is located in a rural environment and is not subject to pollutant emissions from concentrations of industrial sources. There is no air quality monitoring equipment in the Black Diamond area. The nearest stations in operation are located in the Kent, Auburn and Renton areas. These areas are much more urbanized than Black Diamond and would not be comparable to air quality conditions in the Black Diamond area. Since it is a rural area, the air quality is generally good, with annual background suspended particulate levels measuring approximately 20 to 25 ug/m^3, as compared to 45 to 500 ug/m^3 in Seattle. The annual level was provided by PSAPCA and is shown on Exhibit 11-4 of the FEIS (Figure 31). The maximum Wahington State and PSAPCA standard for particulate matter is 60 ug/m^3 on an annual basis and 150 ug/m^3 on a 24-hour basis.

Air quality in the Puget Sound region has been gradually declining in the past several years. Data from Kent, Auburn, and Renton show a general trend of increasing total suspended particulate (TSP) levels since 1977 with annual standards being exceeded on a few occasions in recent years at the Kent and Auburn stations. Much of this is caused by urbanization and vehicular traffic. However, according to PSAPCA's comments on the SDEIS, the trend in increasing particulate levels since the mid-1970's has reversed and all areas are now showing improvements. These improvements may be due to the economic recession according to PSAPCA."

Neither the EPA's Spill Table, nor the NIOSH (National Institute for Occupational Safety and Health) Registry of Toxic Effects of Chemical Substances, list inhalation data for any of the chemical compounds that compose Ideal's cement-kiln dust. Testwork by Biomed Research Laboratories demonstrates that the substance is not toxic through oral injection to rats. Section WAC 173-303-084(5)(a) states that if toxic data for a constituent cannot be found in the NIOSH

Note: Data furnished by Puget Sound Air Pollution Control Agency

All measurements are expressed in microgram/cubic meter.



JOHN HENRY NO. I MINE

BLACK DIAMOND, WASHINGTON

AMBIENT SUSPENDED PARTICULATE CONCENTRATION

Exhibit II-4

DRAWN BY	APPROVED BY	DATE	REVISION DESCRIPTION

PACIFIC COAST COAL COMPANY, INC.

Scale 1" = Approx. 8 mi.

FIGURE 31

Register or the EPA Spill Table, or other sources readily available to a person, then he need not determine the toxic category for that constituent. Since inhalation need not be considered from an air-quality standpoint, the only aspect of the cement dust that requires discussion is generation of particulate matter.

There are seven pollutants regulated by the 1970 Clean Air Act Amendments. Of these, the Dale Strip Pit air pollutant emissions are expected to consist principally of particulate matter (fugitive dust). Fugitive dust emissions are not subject to a Prevention of Significant Deterioration Permit (PSD).

Standards governing concentrations of particulates established by the EPA, Washington State and PSAPCA are as follows:

TABLE 12

Standard	Emission (ug/m^3)
24-hour	
EPA	260
Washington State	150
PSAPCA	150
Annual Geometric Mean	
EPA	75
Washington State	60
PSAPCA	60

Ambient suspended particulate levels in the Ravensdale-Black Diamond area are 20-to-25 ug/m^3 on an annual average based on PSACPA data shown on Exhibit 11-4 of the John Henry No.1 Mine FEIS (Figure 31).

CKD is a very fine-grained, predominantly minus 200-mesh substance. At the Ideal Plant in Seattle, CKD is loaded into pneumatic trucks in such a manner that dust escape is negligible. At the Dale Strip Pit, CKD is released under low pressure from these pneumatic trucks through six-inch flexible hoses, coupled to six-inch PVC pipes that extend to the pit's edge. At this point, the PVC pipes are connected to flexible six-inch rubber hoses that take the dust to the surface of water standing in the bottom of the pit (Figure 35). Ideal has designed a portable canvas bag with interior baffles that is used when unloading CKD onto dry surfaces. The bag slows and settles the dust before releasing it to the ground surface; it can readily be moved to new locations as the pit fills.

While fugitive dust release is inevitable in this situation, it is negligible with the present unloading system. In winter months, strong winds occur in this area. They sometimes redistribute fresh dust within the trench; however, the steep pit walls tend to restrict its movement up and out of the pit. Precipitation data from the John Henry No. 1 Mine FEIS indicates that the Black Diamond area receives 47.5 inches of rain per year (1979 value). Rainfall occurs often enough at the site to moisten the CKD soon after, if not during, its emplacement in the pit. Once it has hydrated by reacting with atmospheric moisture, which its "quick" nature drives it to do, the CKD crusts over. At this point, fugitive dust generation ceases to exist, even when redistributed by heavy equipment.

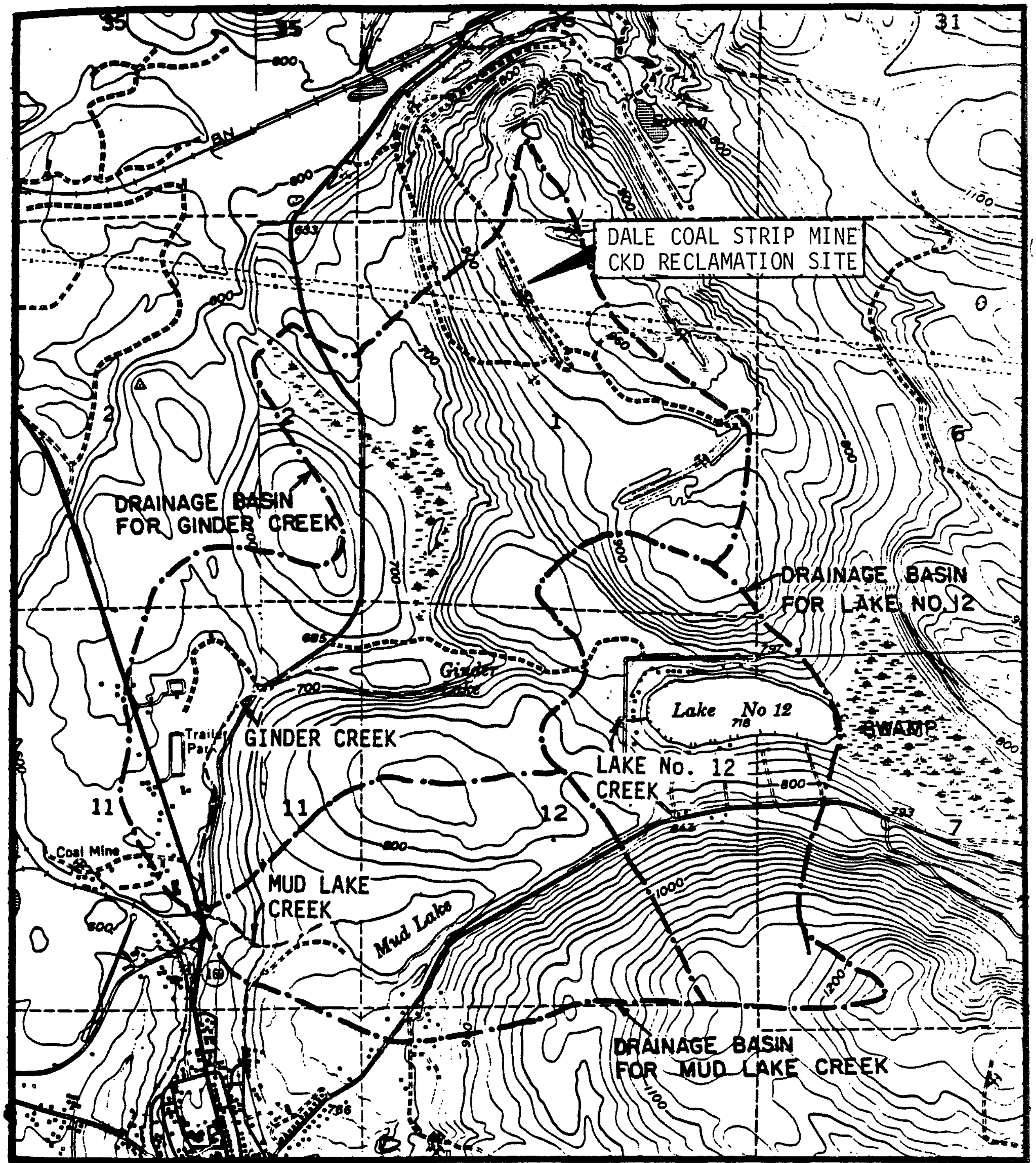
Vegetation in the immediate vicinity of the pit has thrived, especially in the areas down-wind of the site. This is not surprising, considering the proven value of CKD as a fertilizer and liming agent. The common application method for this use involves blowing it on cropland from pneumatic trucks or through fan-or spinner-fertilizer spreaders, both of which generate dust clouds in their immediate vicinity (Figure 8).

WAC 173-303-910(1)(b)(iv)(bb.4)

II. (3). Water. (a) Surface Water.

The Dale Strip Pit occupies the northernmost portion of the Ginder Creek Drainage Basin at 925-feet elevation, as shown on Figure 32. Figure 33 from the John Henry No. 1 Mine EIS provides the average monthly flows for the Ginder Creek Basin, which peak at about 55 cfs in January. Hydrographs of Lake Sawyer, one mile to the west demonstrates a seasonal variation in water level of two feet.

Figure 34, Surface and Ground Water Information Map, provides the location of surface water bodies in the area of the Dale Strip Pit, none of which are within 200 feet. Ravensdale Lake at 580-feet elevation, is a spring-fed pond 2,600 feet from the northern extent of the Dale Strip Pit. Discharge from Lake Ravensdale (formerly Beaver Lake) ultimately flows west into Lake Sawyer. Ginder Lake Swamp, at 680-feet elevation, is 2,000 feet to the southwest. It flows into Ginder Lake at 664-feet elevation, which was created for coal-washing purposes in the 1930's by damming its outflow. Ginder Lake flows westward via Ginder Creek, an intermittent stream, to Lake Sawyer. An unnamed pond at



N

FIGURE 32

Scale 1"=2000'

JOHN HENRY NO. I MINE
BLACK DIAMOND, WASHINGTON

EXISTING TOPOGRAPHY DRAINAGE BASINS

DESIGNED BY
APPROVED BY
DRAWN BY
DATE 4/18/83
DRAWING NO.
SHEET

Exhibit II-6

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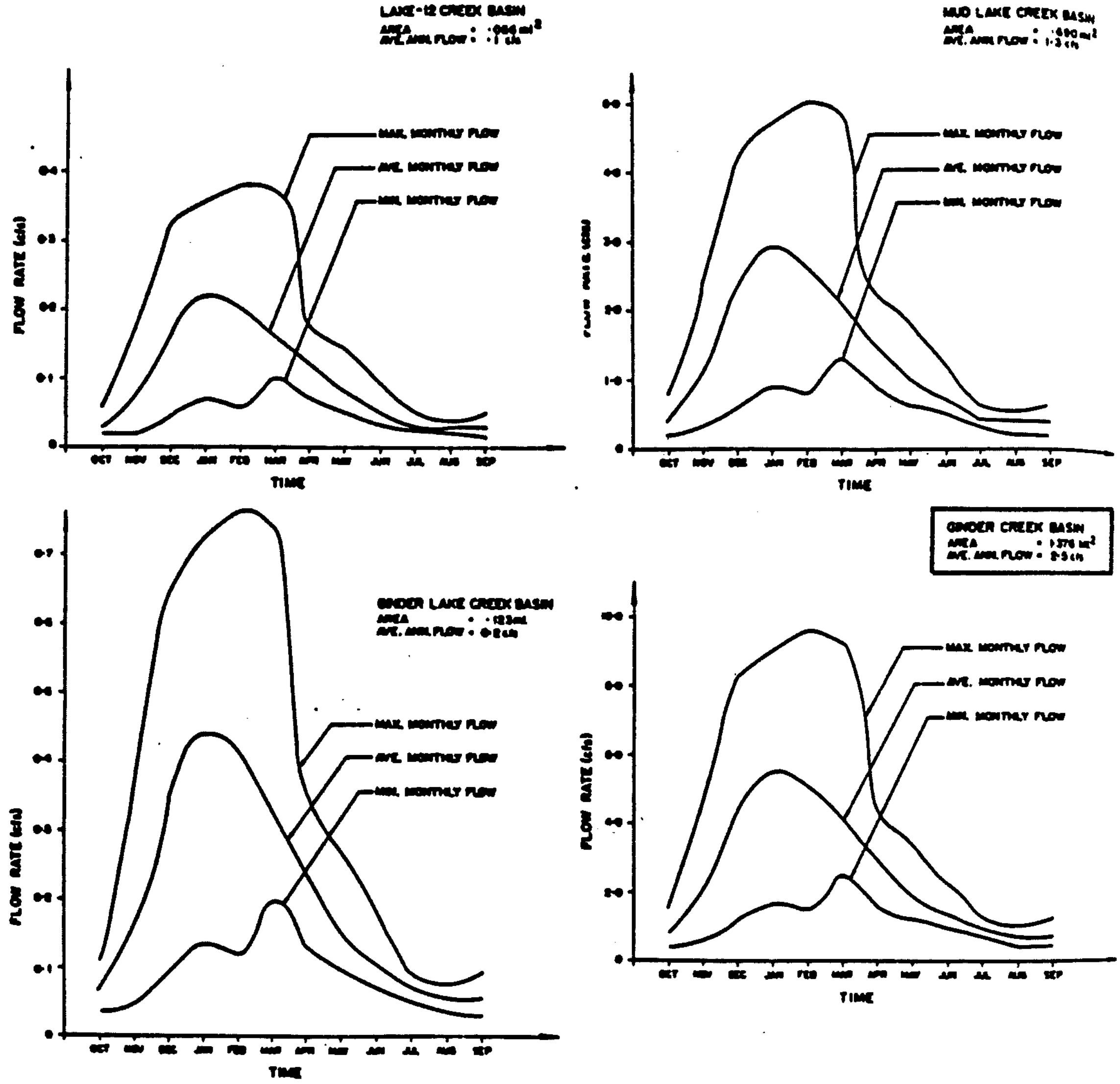
PACIFIC COAST COAL COMPANY, INC.



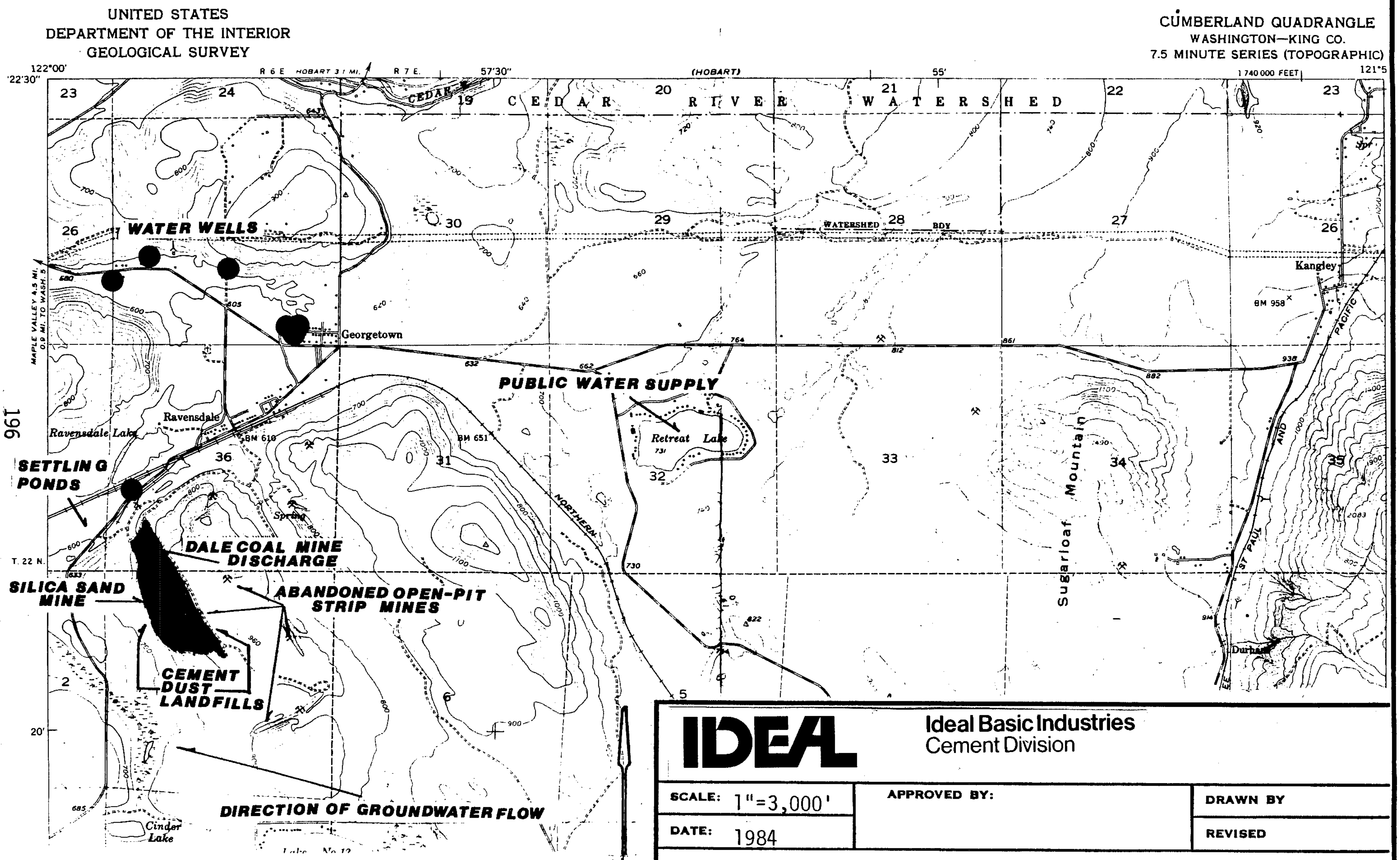
Source: Systems Architects Engineers

FIGURE 33
GINDER CREEK BASIN AVERAGE MONTHLY FLOWS

Average Monthly Flows
John Henry No. 1 Mine
King County, Washington
For
Pacific Coast Coal Company

No Scale

July 1982 John T. Boyd Company
Mining and Geological Eng
Plate II-5



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Cement Division

SCALE: 1"=3,000'	APPROVED BY:	DRAWN BY
DATE: 1984		REVISED

SURFACE AND GROUND WATER INFORMATION FOR THE AREA SURROUNDING THE DALE STRIP PIT

FIGURE 34

690-feet elevation, also created during coal mining operations in the early 1900's, is 2,600 feet to the east of the Dale Strip Pit. Lake Retreat, at 731-feet elevation, is two miles to the east and represents the water supply, transported by wooden flume, for the town of Ravensdale. Lake No. 12, at 718-feet elevation, is one mile to the southeast. It drains east through a marsh to the Green River.

There are no naturally-occurring bodies of surface water on the plateau surface of Ravensdale Hill where the Dale Strip Pit is located. Standing bodies of water have collected in the bottom of the coal strip mines in the vicinity, including the Dale Strip Pit. According to a 1972 METRO study, the Dale Strip Pit contained four million gallons of water (Figure 35) before CKD disposal began. These water bodies are fed by a combination of precipitation and ground water seeps; streams do not enter or leave them.

The Dale Strip Pit reclamation project has not required any surface-water withdrawals or diversions. The project does not involve any discharge of waste materials directly into surface waters. The Strip Pit is not located in a 100-year floodplain; however, flood flow rates for the Ginder Creek Basin are provided by the following table from the John Henry No. 1 Mine FEIS.

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DATE: 1981
REVISED

DALE STRIP PIT IN ITS PRE-RECLAMATION CONDITION, LOOKING NORTH

FIGURE 35

IDEAL Ideal Basic Industries
Cement Division

SCALE:
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DATE: 1984
REVISED

DALE STRIP PIT PERIMETER ROAD FENCING AND POSTING, LOOKING NORTH

FIGURE 36

TABLE 13

Flood Flows (Existing Conditions)

Recurrence Interval (Year)	Streamflow (cfs) Ginder Creek Basin	Ginder Lake Basin	Mud Lake Creek Basin	Lake No. 12 Creek Basin
2	24.2	3.0	13.4	1.5
5	35.3	4.4	19.5	2.2
10	41.1	5.3	22.9	2.7
25	49.8	6.4	27.7	3.3
50	57.5	7.2	31.8	3.7
100	64.6	8.1	35.7	4.1
Mean Annual	2.5	0.2	1.3	0.1

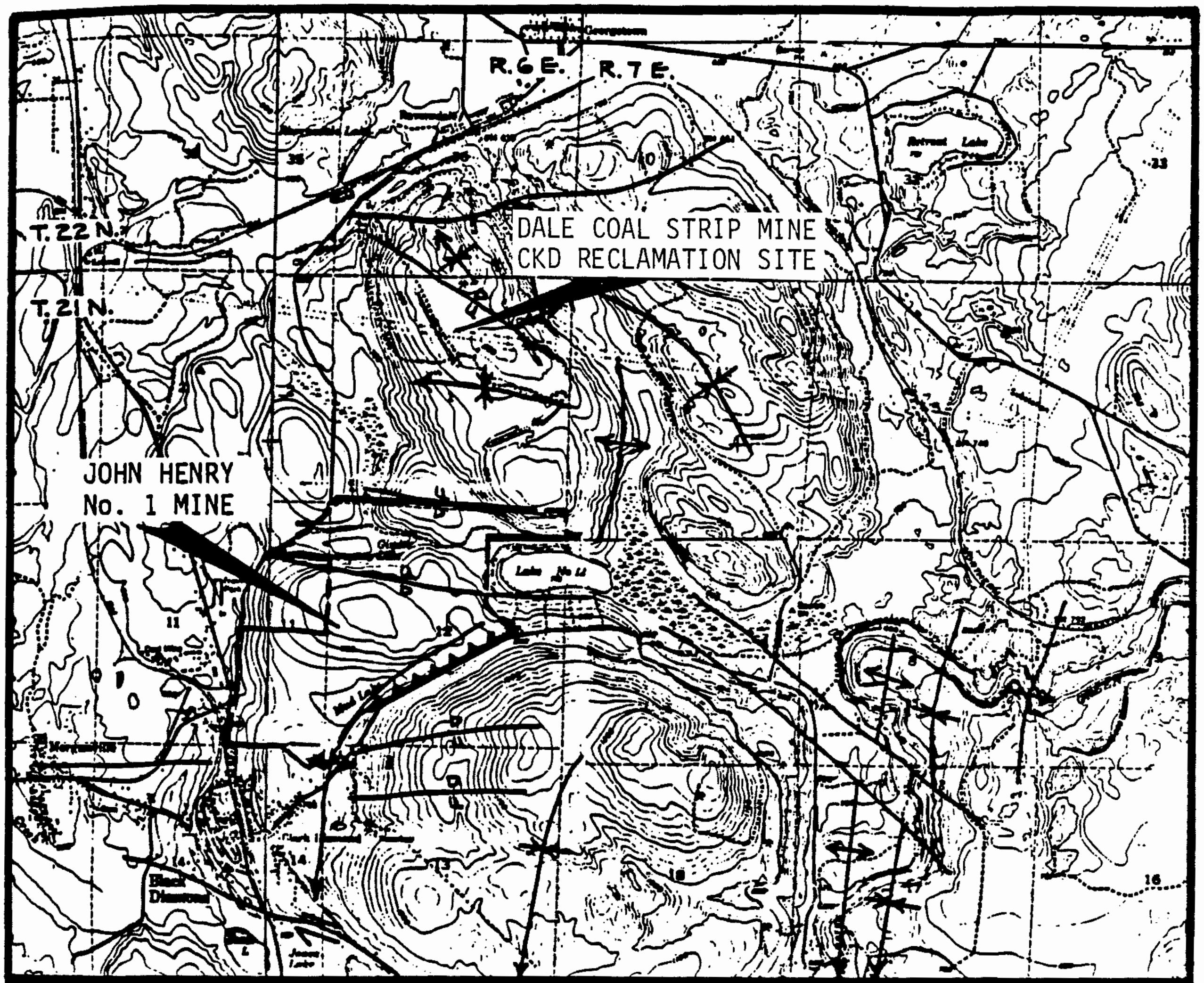
WAC 173-303-910(1)(b)(iv)(bb.4)

II. (3). Water. (b) Ground Water.

Introduction

Because ground water conditions are controlled by bedrock geology, this general discussion of the geologic makeup of the area surrounding the Dale Strip Pit will preface a detailed discussion of ground water occurrence and quality, followed by an analysis of the impact CKD disposal in the Dale Strip Pit will have on area ground water quality.

Bedrock geologic conditions in the Ravensdale area are fairly complex because of much folding and faulting that took place in late Eocene, 30-to-40 million years ago. Examination of Figure 37, Principal Structural Features, shows that the Dale No. 4 coal seam occupies the north limb of a westward-plunging, steeply-dipping synclinal fold. This flexure represents one of two major periods of folding in late Eocene time, probably due to volcanic activity and uplift in the present position of the Cascade Range. The beds in the north limb strike approximately North 30° West and dip 50° to 70° West; the south limb of the fold strikes North 40°



LEGEND

ANTICLINAL AXIS SHOWING DIRECTION OF PLUNGE

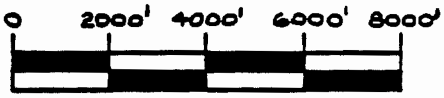
SYNCLINAL AXIS SHOWING DIRECTION OF PLUNGE

NORMAL FAULT SHOWING RELATIVE MOVEMENT

SLIP FAULT SHOWING RELATIVE MOVEMENT

REVERSE FAULT, TEETH ON UPTHROWN BLOCK

SCALE, 1:48,000



JOHN HENRY NO. I MINE
BLACK DIAMOND, WASHINGTON

PRINCIPAL STRUCTURAL FEATURES

DESIGNED BY

APPROVED BY

DRAWN BY

DATE
4/18/83

DRAWING NO.

Plate II-1

SHEET

DRAWN BY	APPROVED BY	DATE	REVISION DESCRIPTION

PACIFIC COAST COAL COMPANY, INC.

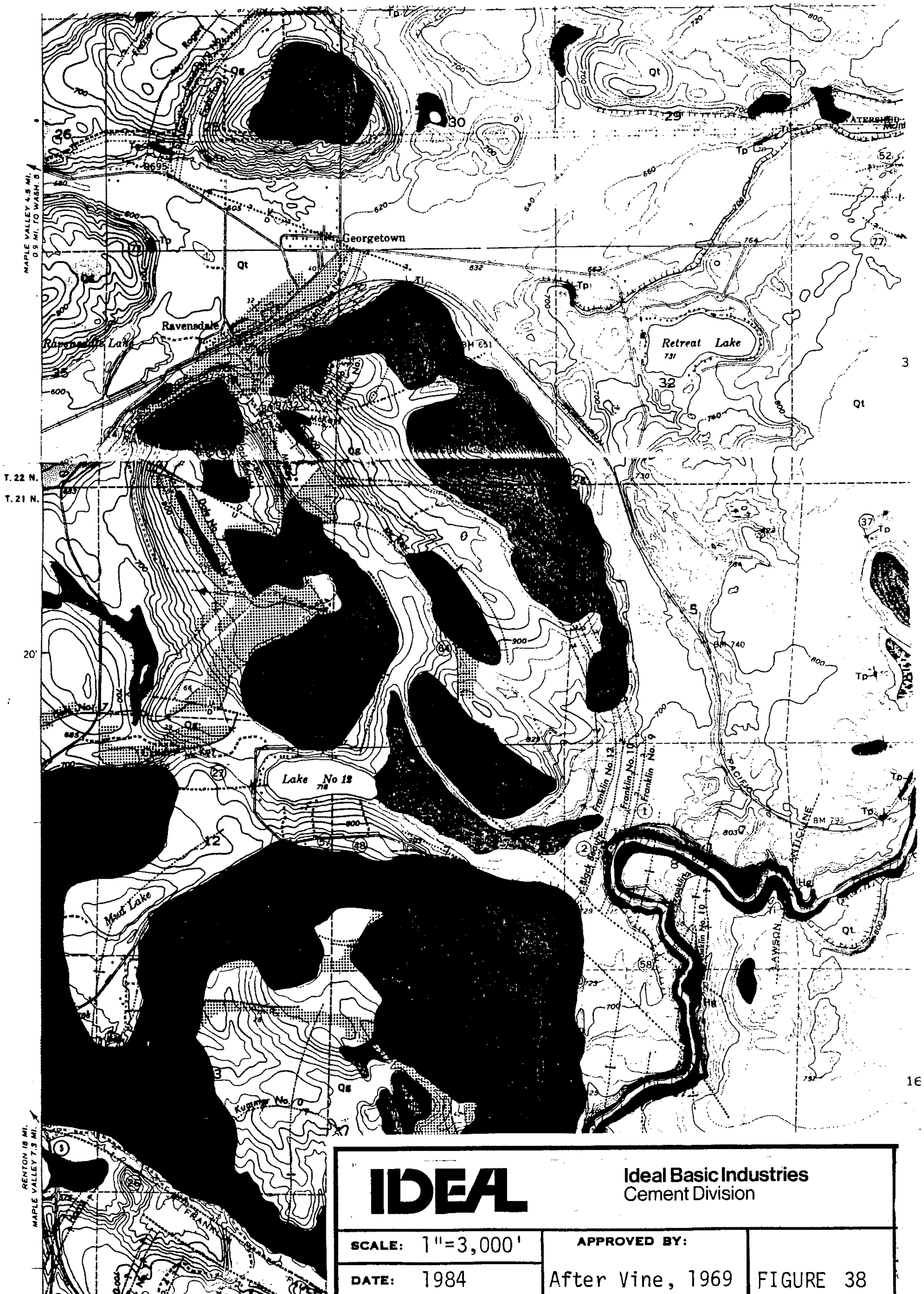
FIGURE 37

East and dips 65° to 80° Northwest. The synclinal axis is located just south of the Dale Strip Pit and trends North 80 West.

These structures occur at the northern and southern boundaries of the I.M.P. leasehold. In their immediate proximity, faults usually affect ground water flow, unless they are completely healed, by providing structural zones of weakness that collect and channel ground water along their fault plane. They can also deter passage of ground water across that fault plane by bringing less permeable bedrock units into fault contact with permeable units.

Bedrock in the Ravensdale area represents the Puget Group of sediments, deposited in a fresh-water, deltaic environment probably during late Eocene times (Buckovic). According to Mullineaux (1961), a slowly-subsiding broad coastal plain existed in the present position of the Cascade Range and the Puget Sound Lowland. About equal rates of subsidence and deposition permitted the accumulation of a great thickness of arkosic sediments carried in from a granitic source east of the coastal plain.

A geologic map and explanation of stratigraphic terminology is attached as Figures 38, and 39. The sediments include an alternating sequence of arkosic (feldspathic) sandstone, siltstone, claystone, carbonaceous shale and coal, whose alternating deposition is a reflection of shifts



IDEAL

Ideal Basic Industries
Cement Division

SCALE: 1"=3,000'	APPROVED BY:	
DATE: 1984	After Vine, 1969	FIGURE 38

GEOLOGIC MAP OF THE RAVENSDALE, WA., AREA

EXPLANATION

QUATERNARY

HOLOCENE

Qal

Alluvium

■

Peat and swamp deposits

Chiefly sedimentary, fibrous, mixed locally with sphagnum or woody peat and extraneous inorganic detritus

Ql

Landslide debris

Disoriented blocks of bedrock and glacial deposits

PLEISTOCENE

Vashon Drift

Qt

Terrace gravel and stratified drift

Pebbles, cobbles, and boulders as much as 6 feet long interstratified with sand and silt. Deposited chiefly as glacial outwash

Qs

Silt and sand

Unconsolidated silt and sand deposits locally stratified

Qg

Glacial drift

Consists chiefly of till composed of gray silty clay mixed with boulders and sand in the uplands, stratified outwash gravel adjacent to uplands, and ground moraine, chiefly till, in the lowlands. Pattern indicates drumlinized ground moraine, chiefly till. Deposited in the lowlands

■

Undifferentiated deposits

Chiefly sand in lower slopes of Cedar Valley

TERTIARY

OLIGOCENE

Ts Tsg

Sedimentary rocks

Ts, *gravel, sand, silt, and sandy clay locally derived from the Puget Group. Includes 1- to 2-foot-thick woody lignite bed*

Tsg, *gravel chiefly composed of mafic igneous rocks*

Tu

Unnamed volcanic rocks

Volcanic sandstone, conglomerate, breccia, tuff, and basaltic lava flows. Intertongue with upper part of Puget Group

EOCENE

Tr

Renton Formation

Feldspathic and arkosic micaceous sandstone, carbonaceous claystone, and coal. Thickness as much as 4,000 feet

Tt C

Tukwila Formation

Andesitic volcanic sandstone, tuffaceous siltstone, tuff breccia, volcanic conglomerate, and lava flows; interbedded locally with arkosic and chloritic sandstone beds designated C, D, E, and F. Lower part interstratified with Tiger Mountain Formation. Thickness locally as much as 6,800 feet

▨

Tiger Mountain Formation

Arkosic gray micaceous sandstone, carbonaceous siltstone, and coal. Upper part interstratified with Tukwila Formation. Thickness about 2,000 feet

■

Raging River Formation

Epiclastic volcanic sandstone and siltstone, locally conglomeratic. Contains abundant marine mollusks locally. Base not exposed. Thickness as much as 3,000 feet

Tpc ■

Puget Group, undifferentiated

Tp, *in Hobart and Maple Valley quadrangles consists of arkosic micaceous sandstone interbedded with volcanic sandstone and coal; in Cumberland quadrangle, of arkosic and feldspathic micaceous sandstone, siltstone, claystone, and coal*

Tpc, *conglomerate composed of mafic volcanic rocks*

▨

Hydrothermally altered rock

Consists chiefly of siliceous, argillaceous, and ferric minerals. Original rock undetermined

■

Intrusive rock

Igneous rock consisting chiefly of calcareous andesite in the Hobart and Maple Valley quadrangles, of porphyritic andesite in the Cumberland quadrangle

Tip

Porphyritic intrusive igneous rocks

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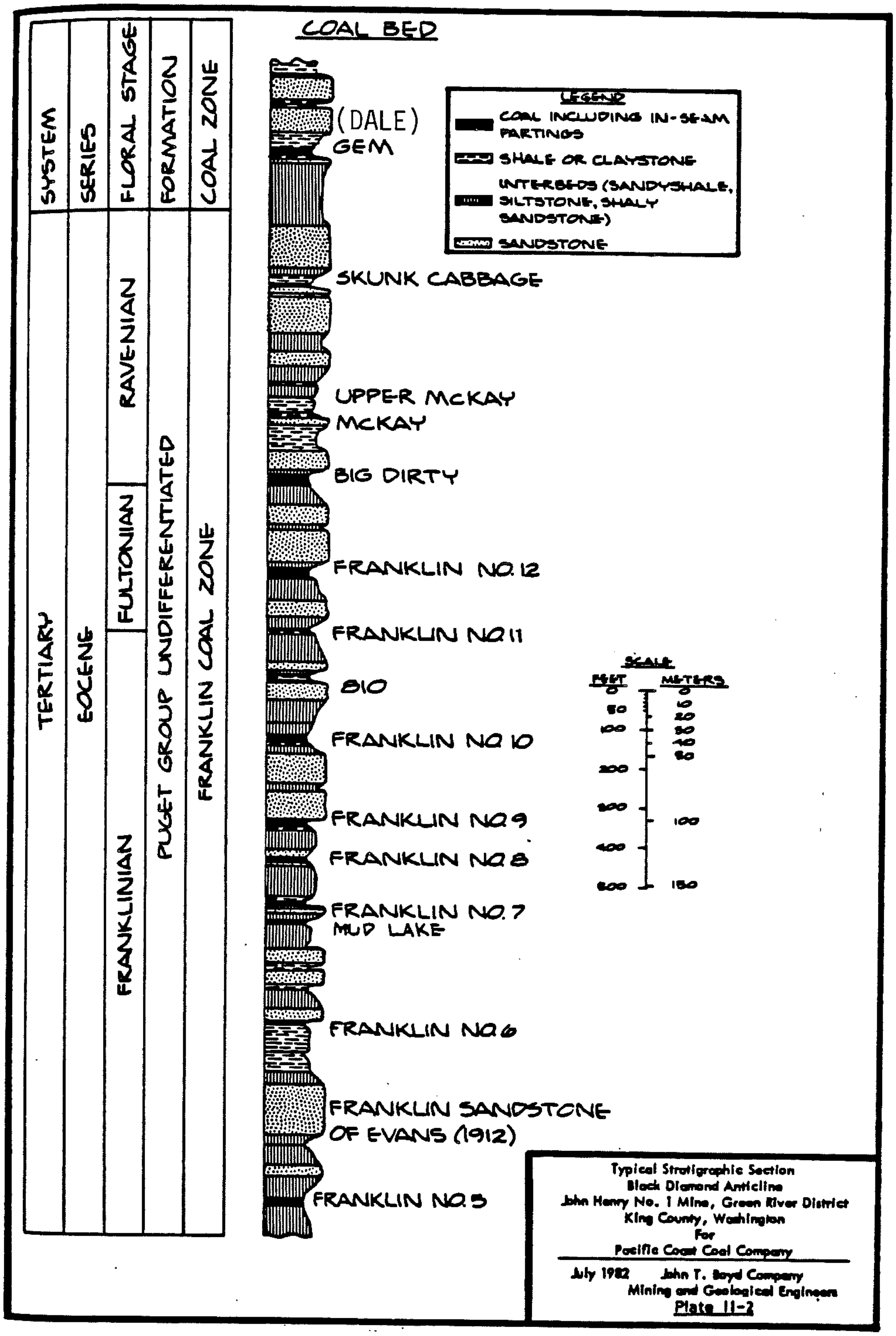
SCALE:	APPROVED BY:	DRAWN BY
DATE:	FIGURE 39	REVISED
EXPLANATION OF GEOLOGIC		
SYMBOLS		DRAWING NUMBER

in the ancient shoreline. All gradations between sandstone and siltsone are present, and most of the rocks are either silty sandstone or sandy siltstone. The sandstone beds are typically yellowish-gray to light olive-gray, fine-grained, micaceous, and arkosic or feldspathic. Most of the sandstone beds are cross-laminated and form massive outcrops. The siltstone beds are medium light gray to dark gray and contain varying amounts of finely-disseminated carbonaceous fragments.

Following deposition in late Eocene time, the area was subjected to tectonic forces that folded and faulted the sedimentary beds, essentially tipping them on their sides so that, in the vicinity of the Dale Strip Pit, they are nearly vertical in repose (Figure 41).

The sequence of non-marine sedimentary rocks underlying the Dale Strip Pit occupy approximately 750 feet in the upper part of the Franklin Coal Zone of the Puget Group. Three major quartz-rich, weathered, massive sandstone beds, 100 to 200 feet wide and separated by clay units, occur stratigraphically below the Dale No. 4 coal measure. These glass-quality sandstone units are mined by I.M.P. for their quartz content. This sequence of rocks lies between the Dale No. 7 coal bed (correlative with the Gem, shown on the accompanying Stratigraphic Column, Figure 40, taken from the John Henry No. 1 Mine EIS) and the Kummer sandstone.



Typical Stratigraphic Section
Black Diamond Anticline
John Henry No. 1 Mine, Green River District
King County, Washington
For
Pacific Coast Coal Company

July 1982 John T. Boyd Company
Mining and Geological Engineers
Plate II-2

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DATE: 1969		REVISED

STRATIGRAPHIC COLUMN OF THE PUGET GROUP OF SEDIMENTS IN THE VICINITY OF THE DALE STRIP PIT

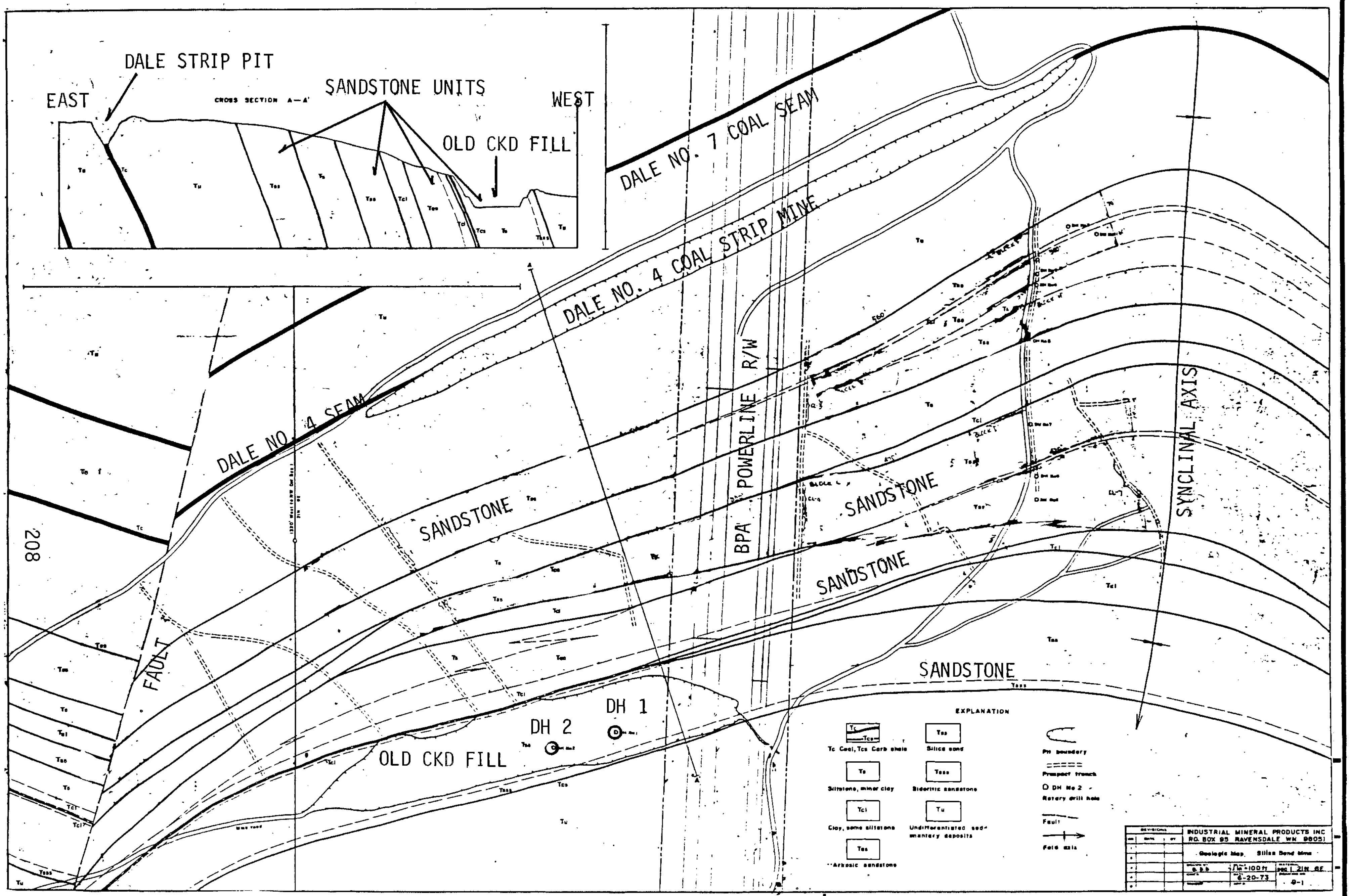
VINE, 1969

FIGURE 40

Figure 41, Detailed Geologic Map and Cross Section of the I.M.P. Silica Sand Mine, shows the relationship of the Dale No. 4 coal seam and strip pit to the quartz sandstone units and the fault. It also shows, in cross section, the orientation of sedimentary units. Ground water movement associated with these sedimenatry beds is controlled by the bedding planes oriented to the north, perpendicular to the direction of dominant surface and ground water flow. Lateral, westward ground water flow is severely restricted by these bedding planes and by the clay cementation of the fine-grained, compact sediments. The map also shows how the middle of the Dale Strip Pit is transected by the BPA powerlines, as well as the location of the original CKD backfill.

Figure 42, Cross section of the Dale Nos. 4 and 7 and the McKay Coal Measures, shows the relationship between the coal seams and the extent to which they were mined out both above-and below-ground. Figure 43 is a plan view of the underground workings for the Dale Nos. 4 and 7 coal measures, mined from 1924 to 1932.

The following summary description of the mining history of the Dale Nos. 4 and 7 coal seams is reproduced from the METRO Final Report, Geologic and Hydrologic Conditions, Sludge Disposal Site(s) Near Ravensdale, Washington, prepared by Metropolitan Engineers, Seattle, for METRO in 1972.



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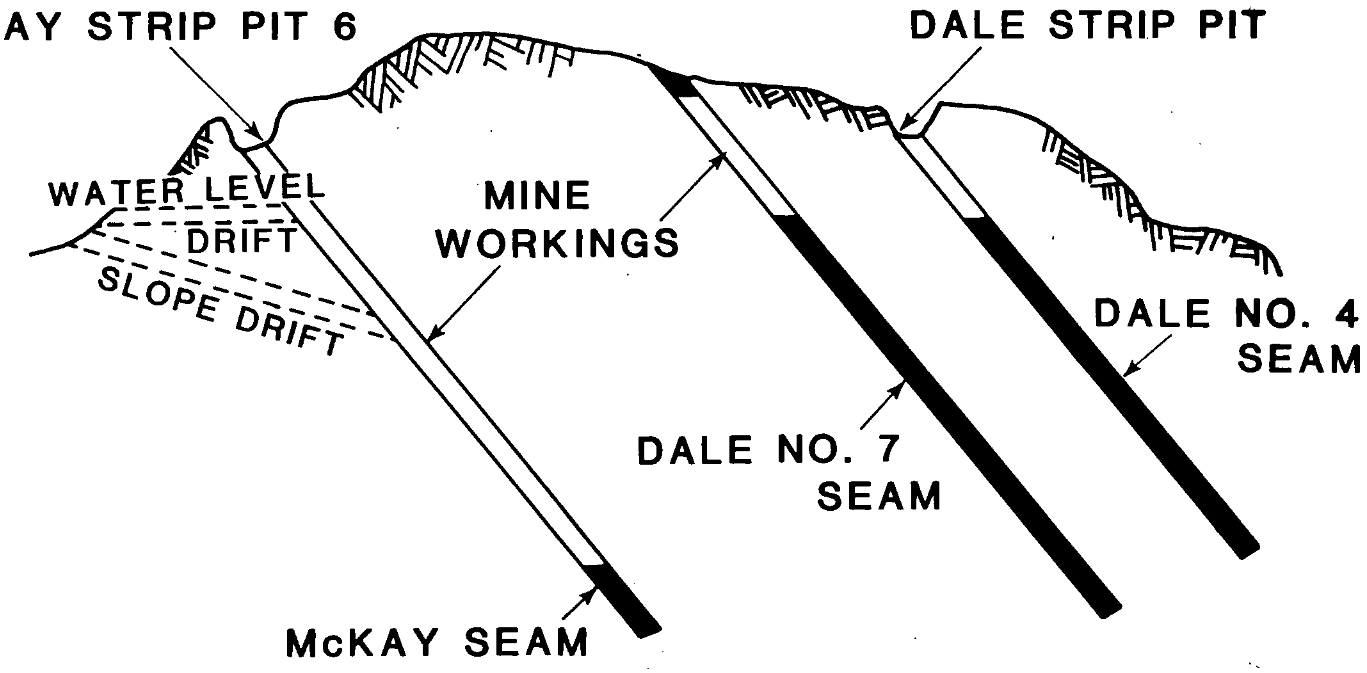
DETAILED GEOLOGIC MAP AND CROSS SECTION OF THE I.M.P. SILICA SAND MINE, RAVENSDALE, WA

FIGURE 41



TYPICAL CROSS-SECTION
(LOOKING SOUTH)

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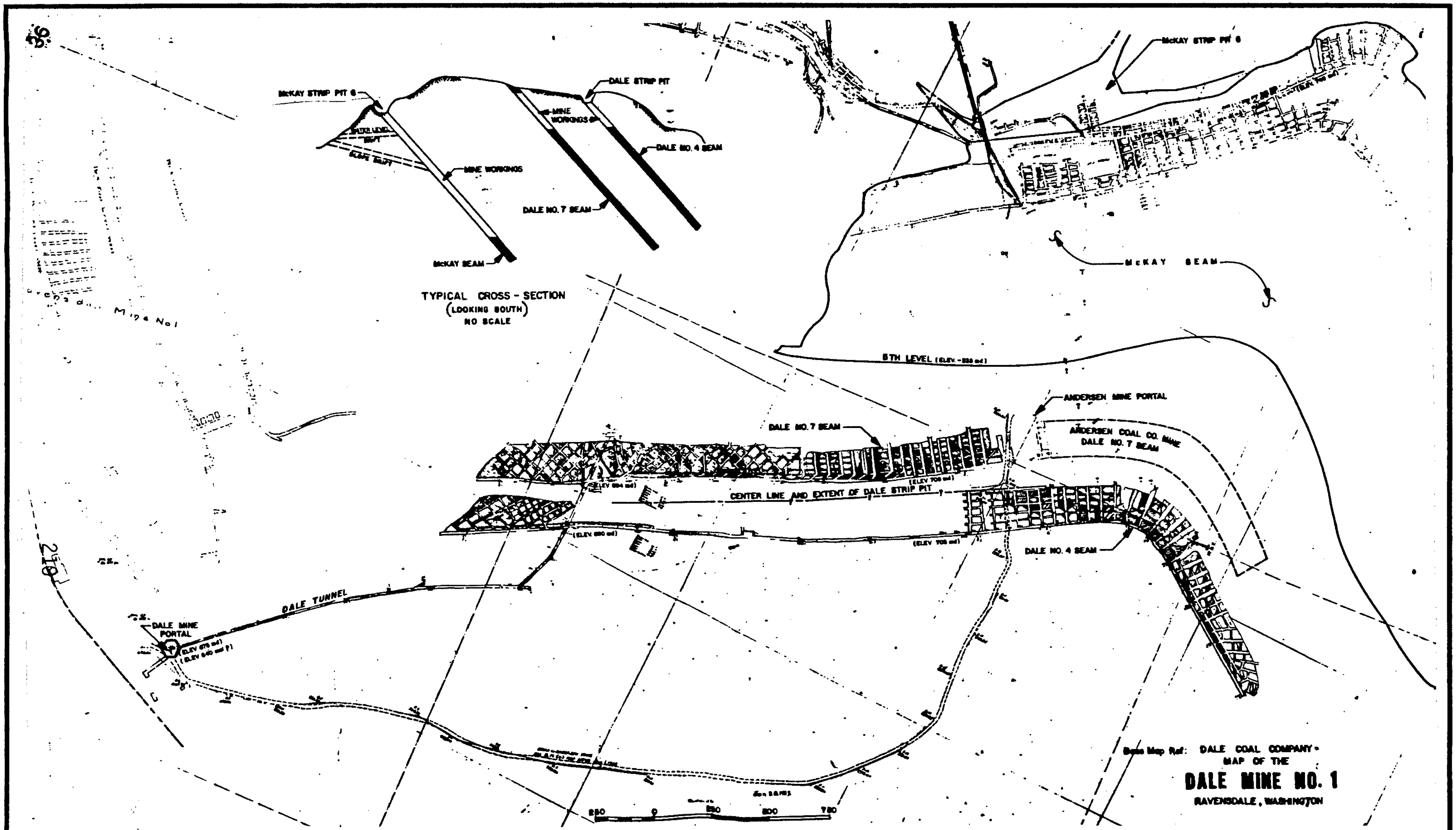
DATE: 1972		REVISED

DALE COAL STRIP PIT CEMENT KILN DUST RECLAMATION PROJECT

DALE 4 AND 7 COAL MEASURES - CROSS SECTIONS	FIGURE 42



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PLAN AND CROSS-SECTIONAL VIEWS OF THE DALE AND MC KAY COAL SEAMS

DALE TUNNEL AND DALE MINE PORTAL

FIGURE 43

Mining History of the Dale No. 4 and Dale No. 7 Seam

"The various coal seams within the Puget Group have been mined extensively throughout much of King County. Geologic maps show that considerable underground mining of certain of these seams was carried out in the Ravensdale area (Figure 52). Of specific interest are the Dales No. 4 and No. 7 seams and the McKay seam, which were also strip mined along their surface outcrops

On the basis of careful examination of a map of the Dale No. 1 Mine (Figure 43), as well as from discussions with the former superintendent of the underground mining operation and the superintendent of the stripping operation, and from the various published maps and reports of the area, the following information has been collected:

Both the Dale No. 4 seam and the Dale No. 7 seam (which lies approximately 200 feet stratigraphically below the No. 4) were worked underground in the Dale No. 1 mine from 1924 to at least 1932. The portal of the mine is located in the north flank of the hill some 2,000 feet northwest of the Dale Strip Pit at elevation 675 feet mine datum (Figure 43). From the portal, the entry tunnel was driven 1,500 feet or so along, at least partially, an unnamed coal seam overlaying the Dale No. 4 seam. From that point, a crosscut was driven easterly to intercept the No. 4 and the No. 7 seams and then a gangway was driven along each seam out to the southerly limits of the Dale workings as shown on Figure 43. The entire Dale No. 1 Mine was constructed as a self-draining mine; that is, with the portal the lowest point in the mine. Ground water that was encountered, was allowed to drain by gravity from the workings through the tunnel (water-level drift), then out the portal. The gangways were driven on a slight upwards slope to roughly elevation 710 md (Elev. 670 MSL) at their southerly limits, with the Dale No. 4 gangway being slighly lower than the Dale No. 7. The depth of the gangways below the ground surface ranged from 240 feet to 270 feet.

The method of mining in the Dale No. 1 mine was essentially the chute and pillar method. In this method, narrow chutes, at about 50-foot centers, were driven up the dip of the seam from the gangway to the chain pillar which was left to support the surface. It appears that 15 to 20 feet of chain pillar were left between the surface and the workings. At a number of locations, the chutes were driven to the surface both for ventilation and to permit dropping timbers into the mine. Cross-cuts or small drifts were driven at intervals between the chutes for ventilation, leaving blocks or pillars of coal. The pillars were then extracted on the retreat, starting at the far limits of the mine and at the top blocks, then progressing downward to the gangway and outward toward the portal. Timber posts were installed at intervals to temporarily support the roof until mining was completed in specific areas. It is reported that about a 4-foot thickness of the Dale No. 4 seam was mined and some 6 feet of the Dale No. 7 seam. The old mine map indicates that the Dale No. 7 seam was mined first, and then the Dale No. 4 seam was worked. The mining from Dale No. 1 was apparently completed by 1933. Reportedly, concrete bulkheads were constructed as seals in the Dale No. 7 gangway near the entry cross-cut from the Dale No. 4 seam. The effectiveness of these seals is, of course, unknown.

From 1945 to 1948, mining was resumed on the Dale No. 7 seam by the Andersen Coal Company. A slope drift was driven from the surface down the seam to the old gangway level and the Dale No. 7 seam mined on around the southerly limb of the syncline. Mining was apparently carried out by the chute- and pillar-method using the slope drift as the portal. Based on the reported production tonnage of 29,000 tons, the seam location, and geologic maps, the estimated extent of the Andersen Mine Company workings is shown in Figure 43.

Using the Dale No. 1 Mine map, calculations indicate that the mined underground volume during the initial mining phase was approximately 72,000 cubic yards for the Dale No. 4 seam and the water level (entry) drift and about 110,000 cubic yards for the Dale No. 7 seam. An additional 27,000 cubic years were mined on the Dale No. 7 seam by the Andersen Coal Company giving a total underground mined volume of 209,000 cubic yards. This roughly checks the reported combined production tonnage of 263,000 tons (240,000 cubic yards).

Around 1946 or 1950, the Dale No. 4 coal seam was mined from the surface as a strip mine operation over a length of approximately 1,800 feet of the seam at its surface outcrop. During the stripping operation, what is believed to have been chutes from the underground workings reportedly were encountered in the southerly part of the Dale Strip Pit. It is understood that these chutes were open when first exposed but later caved, at least to some extent. Mine wastes were believed to have been deposited into the openings that remained but, insofar as could be determined, no specific attempt was made to fill them completely for the full depth. That is, material appartently was deposited into the openings to whatever degree was needed to fill them up to the bottom of the pit.

The dimensions of the Dale Strip Pit are not accurately known at this time. However, Bonneville Power Administration drawings at the transmission line crossing near its mid-point, indicate the pit is some 140 feet wide at the surface and at least 40 feet deep, with sloping sides. Water stands in the northerly two-thirds of the pit (at least 10 feet deep at one point) with a pit width at the water surface of some 65 feet. The southerly third is dry, at least in the summer months, with the exposed bottom some 40 feet below the adjacent ground surface. Using these dimensions, the volume above the water surface is estimated at some 250,000 cubic yards. The volume below the water surface is unknown, but may be around 20,000 cubic yards.

The inferred centerline location and extent of the Dale Strip Pit relative to the underground workings are shown on Figure 43. Apparently some minor strip mining also was carried out along the Dale No. 7 seam over the Andersen Coal Company workings. A production of 4,100 tons (3,800 cubic yards) was reported for this operation. A shallow trench is visible for several hundred feet near the Andersen mine portal."

Permeability of Geologic Units

Glacial Till

During the Pleistocene, the Vashon Stade of the Puget Glacial Lobe uncomformably deposited a two-to ten-foot layer of impermeable glacial till over the bedrock Ravensdale Hill. Information gathered from the John Henry No. 1 Mine EIS demonstrates that glacial till in the area is highly impermeable and restricts the vertical movement of water. Soil formed by weathering of the glacial till allows horizontal movement of water within the soil zone such that water collects only in this zone, on top of the glacial till. This results in perched, rather than continuous, water tables.

Horizontal permeability values for the till were recorded at 18-to 31-feet per year, the higher value due to a gravelly zone encountered in the Pacific Coast Coal Company's boring. Vertical till permeability was an order-of- magnitude lower than horizontal permeability, due to minor horizontal stratifications within the till.

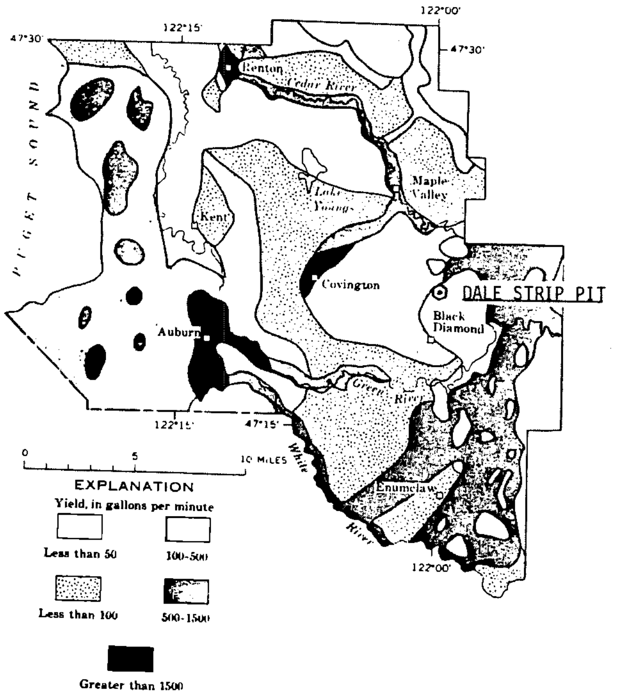
Very low permeability of the till, as evidenced by peat bogs, swamps and lakes that dot its surface, restricts recharge to underlying aquifers. Despite low permeability of the till, meager domestic supplies of ground water have been obtained from numerous uncased shallow wells drilled into the perched water-bearing zones in the upper, less compact part of the till. These wells are generally less than 30 feet deep; most fill to capacity in winter and go dry in summer. The nearest well to the Dale Strip Pit was obviously drilled in just such a geologic environment, as evidenced by examination of the driller's log, provided in the following table (Luzier, 1969).

TABLE 14

22/6-25R3. Mathew Riechart. Drilled by Johnson Drilling Co., 1961. Altitude 605 ft. Casing: 6-inch.

Topsoil	3	3
Hardpan	2	5
Sand, gravel and rocks	9	14
Hardpan	11	25
Sand and gravel, water-bearing	10	35

The adjacent valley to the north of the Dale Strip Pit, occupied by the town of Ravensdale, represents the meltwater channel of the glacial Cedar River (Figure 45), which deposited a thick sequence of very permeable bouldery recessional outwash gravel on the valley floor. In 1983, BNRR drilled a 1,100-foot exploratory hole in this valley floor on the eastern end of the I.M.P. sand-washing plant property



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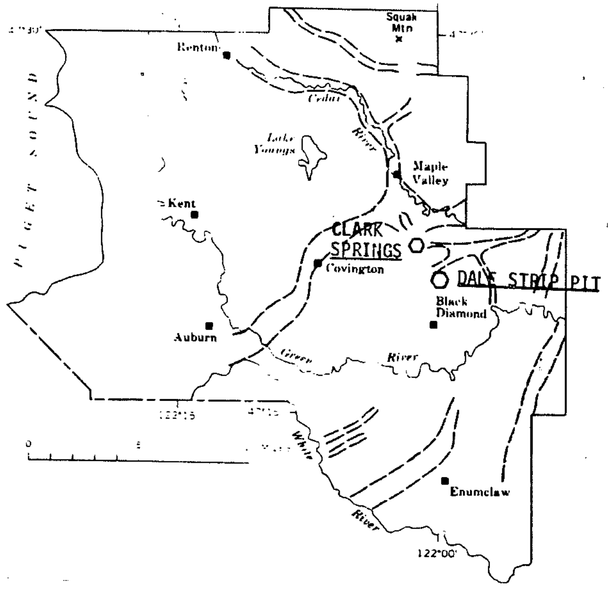
PROBABLE RANGE IN YIELD TO WELLS LESS THAN 500 FEET DEEP, LUZIER, 1969

FIGURE 44



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LUZIER, 1969
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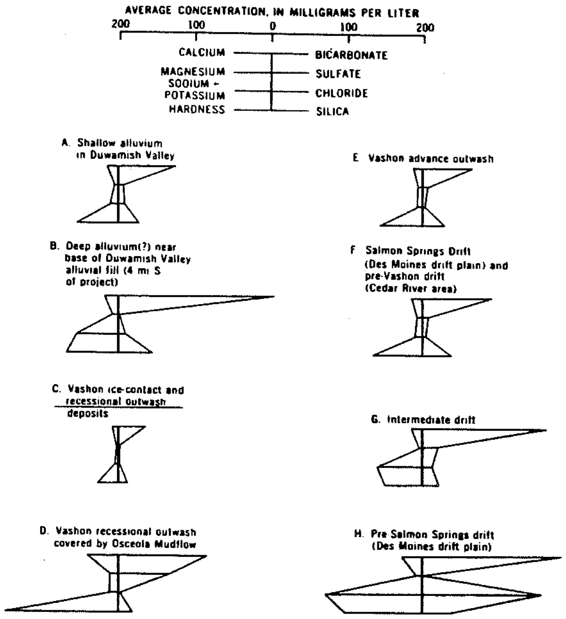
POSITIONS OF PRINCIPAL MELTWATER CHANNELS FORMED DURING GLACIAL RECESSION

FIGURE 45



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DISTRIBUTION OF MAJOR DISSOLVED CONSTITUENTS IN GROUND WATER FROM SELECTED STRATIGRAPHIC UNITS

FIGURE 46

(Figure 22, Plot Plan). This drill hole demonstrated 67 feet of recessional outwash gravel above sandstone and other sedimentary bedrock units. According to Luzier (1969), outwash in lower topographic positions such as meltwater channels usually contain perched, but highly-permeable, water-bearing zones. All drainage in the valley surrounding the sand-washing plant disappears into these gravels, including continuous drainage from the Dale Coal Mine Portal (Figure 22), and clarified overflow from the I.M.P. settling ponds. These same gravels extend throughout the lowland to the west and southwest of the Dale Strip Pit and are mined for in-house pit-run gravel needs by both I.M.P. and Palmer Coking Coal Company in Black Diamond.

Bedrock Units

According to Luzier (1969), Tertiary rocks are a secondary source of ground water in southwestern King County. Few domestic wells obtain water from the Puget Group of sediments because they are fine-grained and altered to such an extent that most are clay-cemented. Only 10 wells are known to have been drilled into Tertiary rocks of the Puget Group to obtain ground water. These wells averaged more than 200 feet in depth, and had yields generally less than 15 gpm, and specific capacities less than 1 gpm per foot of drawdown. The two deepest wells, at 325 feet and 395 feet, were dry.

There are two distinct permeability zones in the bedrock in the Black Diamond area, as indicated by borings described in the proposed John Henry No. 1 Coal Mine EIS.The upper permeability zone, from the base of glacial till to a depth of 135 feet, has permeability values ranging from 9.2 to 149 feet per year, with an average of 57 feet. The lower permeability zone extends from 135 feet to the base of the boring at 260 feet; permeabilities range from 0.4-to-6.6 feet per year, for an average of 2.6 feet per year.

Prior to development of the I.M.P. Silica Sand Mine, exploratory holes were drilled to 100 feet depth in the sedimentary units (Figure 41 provides their location).

According to the mine geologist at the time of the drilling project, all drill holes were dry to 100 feet, except drill holes 1 and 2 in the topographically lowest sandstone unit where ground water was encountered at 60 feet. This unit was excavated to 40 feet depth, 20 feet above the ground water table. The excavation held surface runoff for two years with only seasonal fluctuations in water level, because of its impermeable clay-cemented sandstone floor and walls.

Water standing in the coal strip mines on the top of Ravensdale Hill, including the Dale Strip Pit (Figure 35), are predominantly fed by precipitation, but may be fed by ground water as well. No seeps have been observed in the walls of the Dale Strip Pit and water levels 40 feet below the pit's edge (before CKD placement), fluctuated seasonally only one-to two feet.

The vertical bench faces within the sand mine are remarkably free of ground water seeps. Some small seeps do occur near the top of the sandstone working faces after heavy rainfall, however, from fractures in the bedrock. This water does not occur in sufficient quantity to require special drainage design for it within the operating mine. Evidence that the coal measures are the only water-bearing units in the vicinity, and that bedding planes control ground water movement within the sedimentary sequence, was presented by a slump in the sandstone face at the north end of the mine. A three-foot wall of sandstone is always left on the working face to insure that the underlying coal does not contaminate the quartz sand, a highly undesirable occurrence in a glass sand. In 1982, a 50-foot square segment of the east sandstone face of the middle unit slumped after a freeze of several days duration. Surface water that collected in the carbonaceous shale after its surface was stripped of soil, froze and expanded the shale and popped the sandstone face free. The shale then slumped along with the sandstone.

Review of coal mine reports from the surrounding workings indicate that the underground mines were fairly dry, except for surface water that entered through the numerous ventilation shafts driven to the surface of Ravensdale Hill. The tunnel for the Dale beds (Figure 43) was constructed on an incline to allow the mine to gravity-drain water entering from the surface. In the past, before it was filled with mining debris, the large air shaft for the Dale workings a few feet south of the Dale Strip Pit, was open to 250 feet depth. The former mine geologist dropped rocks to its bottom without encountering water.

An attempt was made to determine the ground water table gradient for the surrounding area, which is fed and driven by ground water flow from the Cascade Range, by using the elevation of the surounding lake surfaces (Figure 34). Lake surfaces were used because of the scarcity of ground water wells in the area (Figure 47). Lake Retreat occurs at 731 feet elevation to the east, and Lake Ravensdale is to the north at 580-feet elevation. A spring intermediate to the two lakes occurs at 690-feet elevation, east of the Dale Strip Pit. From this information, and given the fact that ground water tables roughly conform to topograbhy, the water table for the vicinity was determined to be a tabular body with a one-percent gradient flowing to the west-northwest.

Ground Water Conditions Associated with the Dale Strip Pit.

The follow discussion of the Dale Strip Pit subsurface hydrology is taken directly from the METRO report, cited above.

Subsurface Hydrology

"The evaluation of the hydrologic or ground water conditions underlying the vicinity of the Dale Strip Pit is complicated by the underground mine workings. It is understood that drainage from the workings continued to flow from the open Dale Mine Portal following cessation of mining. Several years ago, the portal was blocked off by filling in a short length of the Dale entry tunnel at the entrance. At that time an 18-inch culvert was installed through the blocked portal to permit mine drainage to continue. The slope of the culvert is unknown, but assuming it is the same as the entry tunnel slope, the culvert would have a capacity when flowing full of about 2,100 gallons per minute (gpm). However, staining in the culvert indicates a probable flow of 700 gpm to 1,100 gpm in the past.

In early March of this year (1972), it was reported that ground water was flowing from a subsidence pit higher on the hill over the location of the Dale entry tunnel - some 350 feet southeast of the portal. It was estimated by others that this ground water flow from the pit, which is 77 feet higher than the culvert, was on the order of 800 gpm. It was also reported that the flow of water from the portal culvert appeared less than what formerly flowed and was estimated by us at about 300 gpm. The ground water flow at the pit had decreased to about 100 gpm by May and by mid-July the subsidence pit was dry. It is probable that recent caving occurred someplace in the underground workings which, combined with a partial blocking of the portal culvert, developed sufficient head to cause a breakout at the subsidence pit.

As discussed previously, the northerly two-thirds of the Dale Strip Pit contains ponded water throughout the year which is retained by a small berm or dam formed from mine waste or slough from the pit sides. The southerly third of the pit is dry during the summer months but strand lines indicate that water has previously ponded in that part of the pit also. Following heavy rainfall, the northerly pond in early March was overflowing the dam at a reported 50 gpm into several lower ponds or depressions formed by irregular mounds of earth in the southerly part of the Dale Strip Pit.

This water in turn was retained by a wider berm which appears to have been left unexcavated during the strip mining. Located some 200 feet north of the south end of the Dale Strip Pit, this berm appears to coincide with the location of an old timber chute shown on the Dale Mine map. By March 20th, the lower pond had reportedly drained dry, although no outlet was visible in the pond bottom. Water also was ponded south of the wide berm. Visibly supplied by direct runoff from the adjacent roadway bordering the Strip Pit, the water level in this most southerly pond had dropped only slightly by March 20th. During this period METRO began obtaining water quality data, including chemical analyses, from the two southerly ponds in the Dale Strip Pit as well as the flowing subsidence pit and the culvert at the Dale Mine Portal. On March 14th, it is understood that dye was introduced into the two southerly ponds and subsequent monitoring gave no indication of dye appearing at any other location in the area. On March 21st, it was reported that dye was again introduced and approximately 200,000 gallons of water from the northerly pond was released into the south part of the Strip Pit which filled to a depth of six feet in five hours. We understand that this water had substantially drained the next morning. No visible increase in flow or dye was noted at the subsidence pit or the portal culvert on March 21st.

On March 28th, water was again released, salt introduced into the southerly part of the Dale Strip Pit and monitoring for conductivity, fluorescence and chloride content performed until May 5th at the two southerly ponds, the portal culvert, the subsidence pit and a small stream flowing from an exposed coal seam high in the silica sand pit in the west flank of the hill. Except for continuous automatic conductivity monitoring the first nine days at the subsidence pit, all parameters and locations were monitored periodically, commencing six to nine days after salt introduction, with intervals between sampling ranging from one to nine days. On April 29th (32 days), increased conductivity and chloride content were observed in the stream with a subsequent decline in both parameters at the next, and final sampling on May 5th. It was reported that no distinct increase in these parameters was observed at the other locations.

On the basis of these data and observations, it was concluded that the source of the water in the most southerly pond at the south end of the Dale Strip Pit was surface runoff from the adjacent ground. Samples from the overflow pond in the Dale Strip Pit, the flowing subsidence pit and the portal culvert were determined to be relatively similar in physical and chemical characteristics, and it was concluded that the water at the three locations had a common source or has been in contact with similar bedrock material.

We concur in these conclusions and further conclude that the water in the north 2/3 of the Dale Strip Pit probably is ponded ground water.

Considering the relation of the Dale Strip Pit to the underground workings, we also believe that the overflow from the northerly pond into the southerly end of the Dale Stip Pit drains down an old chute into the underground workings on the Dale No. 4 seam and out the Dale Mine portal culvert. While it is possible that the dye or salt tracers could have been filtered out during flow to the chute through the pond bottom and/or the base of the wide berm, it is more likely that these tracers were diluted below detectable limits by ground water in the workings. It is estimated that the Dale No. 4 workings could have contained at least 2,000,000 gallons of ground water at that time between the south end of the Dale Strip Pit and the mine portal. While test borings and/or test wells were authorized, it was felt that they would not provide sufficient positive information beyond that already available, particularly since adequate location data of necessary accuracy was unobtainable as to position of the underground gangway. Therefore, drilling explorations were deferred until project requirements were more definitive.

After the METRO water-quality monitoring studies, the operators of the silica sand quarrying operation bulldozed relatively shallow prospect trenches into bedrock at various locations on the westerly hillside. Seepage was observed in several of the prospects and four of the trenches were examined in detail by our geologist during the dry period in mid-July. The seepage was traced back to its origin and, in each trench, was observed to be issuing from a single isolated location in the bedrock. At each location, the flow was small, 1 gpm or less. It was determined by survey that the seepgae locations on the hillside ranged from 160 feet to 230 feet above the portal culvert. The water surface of the pond in the northerly end of the Dale Strip Pit was 240 feet higher than the culvert and the exposed southerly pond bottom was 228 feet higher.

On the basis of present evidence, we believe that the ground water level,or piezometric head, in the unmined areas is located at a relatively shallow depth below ground surface and generally follows the surface topography as to elevation. While exceptions can be anticipated, the quantity of ground water, where encountered, would be relatively small and possibly isolated. This is supported by the prospect pits, the lack of visible springs along the hillside and the localized seepage from the exposed face of the silica sand quarry. The ground water can reasonably be expected to more likely travel along, or parallel to, the bedding planes rather than across the steeply dipping beds where unfractured.

The underground workings may drain relatively restricted areas, primarily parallel to the strike of the beds and the workings. This is supported by the report that the sealed portal of the Andersen Mine on the Dale No. 7 seam opened, apparently in March, due to unknown causes. Reportedly, the slope drift was sounded to a depth of 100 feet (elevation 810 MSL) without encountering water.

Discussion

The utilization of the Dale Strip Pit for the disposal of digested sludge involves two primary consideration: (1) the possibility of leachates draining from the pit into the underground workings and thus out the Dale Mine portal and, (2) the possibility of leachates entering the natural ground water.

The south 300 feet to 4,500 feet of the Dale Strip Pit are underlain directly by the underground workings on the Dale No.4 seam. As discussed above, it is our opinion that at least part of this end of the pit drains directly into the workings through one or more chutes which were encountered in the strip mining operation. Because of the uncertain method and degree of backfilling the chutes, it is doubtful that an effective sealing of the pond bottom could be assured through the duration of the project. In view of this, the possibility of leachates draining into the workings and out the Dale Mine Portal could not be eliminated on the basis of present information. For this reason, it is assumed that the use of this end of the pit would be unacceptable.

Beneath the remainder, or northerly part of the Dale Strip Pit, the Dale Mine map indicates that only the gangway was mined on the Dale No. 4 seam. All presently available information indicates that no chutes or passageways to the surface underlie this portion of the Strip Pit. The northerly two-thirds of the Strip Pit contains what we conclude to be ponded ground water. Definitive information is not available as to fluctuation of the water surface during the summer months, but it has been reported to be moderate. As far as could be determined visually, no seepage flows from the northerly pond beneath its dam into the lower southerly pond during dry periods. While this does not eliminate the possibility of leachate draining into the Dale NO. 4 seam workings, it would appear to reduce it.

Little information has been reported on the surface subsidence due to underground mining in Washington. However, the information which is available indicates that mined, steeply-dipping seams similar to the Dale and McKay seams generally cave soon after mining, with the subsidence confined roughly between the surface limits of the seam outcrop and vertical projection of the seam depth of about 200 feet. Because of the proximity of the Dale No. 7 workings to the Dale Strip Pit, surface subsidence due to that seam could approach the pit. Evidence of this has not been detected; however, it could be masked by the heavy undergrtowth bordering the east side of the Dale Strip Pit. Fracturing has not been observed in the east pit wall where such evidence could be reasonably expected if subsidence had occurred.

The actual condition of the bottom of the northerly two-thirds of the Dale Strip Pit is, of course, unknown. However, in view of the reported relatively stable water surface during dry periods, it is probable that a one-to two-foot thick compacted impervious clay blanket on the bottom and the pit sides would be adequate to prevent leachates from draining out of the Strip Pit into the workings or from entering the ground water, provided subsidence has not occurred. An engineered impervious embankment should replace the existing berm retaining the south end of the ponded ground water.

Prior to finally selecting the Dale Strip Pit for a sludge disposal site, consideration should be given to draining the pit to enable the submerged bottom and sides to be examined. The configuration and depth of the Strip Pit below the pond surface is not known. As mentioned previously, the pit is at least 10 feet deep at one point. If uniform in cross-section throughout its length, the northerly two-thirds of the strip pit could contain 4,000,000 gallons of water or more. In view of this, we strongly advise that this quantity of water not be discharged into the southerly end of the Strip Pit. The condition of the underground working is unknown after the breakout at the subsidence pit near the mine portal. Therefore, the effect of discharging 4,000,000 gallons of water through the working cannot be predicted.

Draining the north part of the Strip Pit would also permit evaluation of the possibility that ground water is flowing into the Strip Pit rather than out of it. In that event, sealing against inflow would be necessary since the sludge could not be deposited into the water. In the event that sealing is required, a much thicker blanket would be needed to counteract the hydrostatic pressure. This would, of course, reduce the usuable volume of the Strip Pit.

When the Dale Strip Pit was being prepared for acceptance of Ideal's CKD in 1982, the METRO report above was used as a guide to engineering design. The haul road was constructed across the Strip Pit, 200 feet from its southern extent at the berm mentioned extensively in the METRO report. The road base was composed of clay-rich till and mining wastes. Subsequently, the entire southern third of the pit was filled with clay and fine sand from the I.M.P. settling ponds. This was done to prevent leaching of effluent from the CKD into the underground coal mine workings. Additionally, no CKD has been placed within 800 feet of the southern extent of the pit. As mentioned in section II.(10). of this checklist, the southern end of the remaining pit has been reserved for inert mineral wastes from Ideal Basic Industries and Northwestern Glass.

Other statements in the METRO report that require comment follow:

1) The estimated 4,000,000 gallons of water standing in the Dale Strip Pit have been largely absorbed by the CKD already placed in the pit.

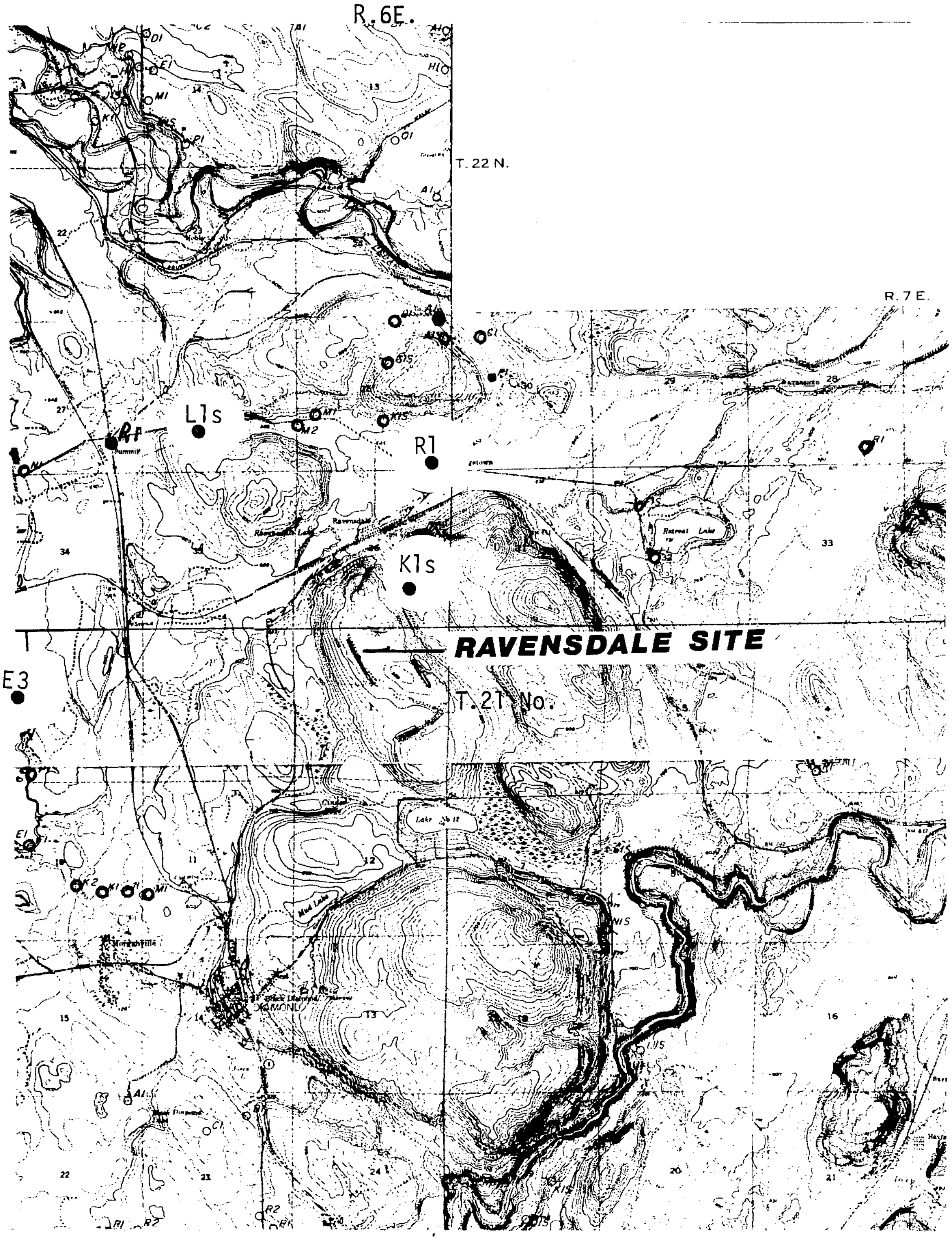
2) The combined discharge from the Dale Portal and adjacent subsidence pit has never been measured by current I.M.P. mine personnel in excess of 37 gpm.

3) Subsidence has been noted in the area directly north of, and in line with, the Dale Strip Pit by I.M.P. mine personnel since the area was logged in 1982.

Surface and Ground Water Quality in the Ravensdale Area

Figure 47, Ravensdale Area Ground Water Well Sites, shows that very few wells have been drilled in the Ravensdale area because bedrock conditions are not conducive to productive wells. Examination of Figure 44 demonstrates that the Ravensdale-Black Diamond area is one of the least-productive areas in southwest King County, with well yields that average less than 50 gpm. Ravensdale receives its water supply from Lake Retreat two miles to the east because wells of sufficient yield and quality for public consumption have not been produced. The nearest known domestic well is one mile south; to the north, the closest known well is 1.3 miles away. To the east and west, the closest known wells are 1.5 miles away. A spring that occurs one-half mile to the east is not a source of domestic water (Figure 47). The City of Kent Clark Springs site is two miles to the northwest (Figure 48). A shallow well at the I.M.P. sand-washing plant, one-half mile to the north, represents the water table expressed by Ravensdale Lake. It is used as a source of process water, not domestic water.

In 1981, 9 wells and one stream along the Maple Valley Highway, 1.5 to 2 miles to the west-northwest were sampled to establish background information on area inorganic ground



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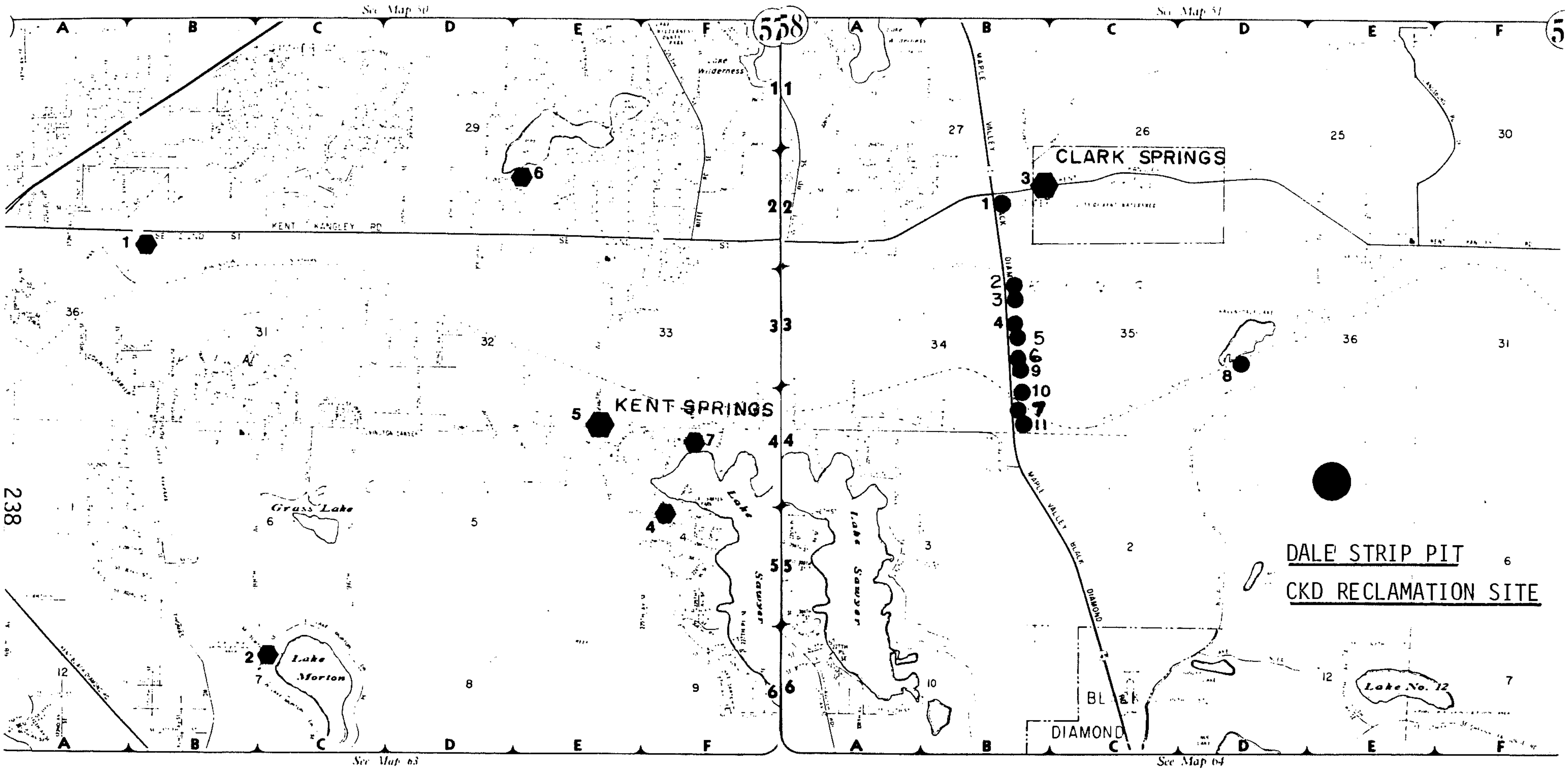
Cement Division

SCALE:
DATE: 1979
SCALE: 1"=1 mile
DRAWN BY
REVISED

RAVENSDALE AREA GROUNDWATER WELL SITES

AFTER LUZIER, 1969

FIGURE 47



LEGEND

⬢ KENT WATER DISTRICT WELLS

● I.M.P. MONITORING WELLS

●8 I.M.P. WASHING PLANT WELL

●10 MYERS MONITORING WELL

N

Ideal Basic Industries

SCALE: 1"=4,000'	APPROVED BY:
DATE: 1984	

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DALE COAL STRIP PIT CEMENT KILN DUST RECLAMATION PROJECT

OFF-SITE WATER MONITORING WELLS

FIGURE 48

water quality. Information on these wells is presented in Table 15. Calcium concentrations and pH were the parameters tested, because response to CKD leachate would be detectable first through monitoring of these parameters. Calcium occurs in CKD at an average of 50 percent, both as calcium oxide and calcium carbonate, and is directly responsible for CKD's elevated pH.

Six of the wells were shallow (12 feet or less, with no available driller's log or water-quality data. Three of the wells were deep (70 to 157 feet) and were drilled recently enough that logs were available. Values for pH ranged from 5.62 to 7.53, the normal range for western Washington ground water. Calcium values ranged from 5.9 to 37.7 ppm. Data on the I.M.P. sand-washing plant well is not included in these ranges because it is located in the middle of the plant and is, therefore, contaminated by process water. Data on Table 15 shows that both parameters occur randomly; nothing in this data indicates unusual inorganic water quality for these wells, which are in compliance with the EPA's ambient water-quality standards. Water hardness is caused by calcium content and can be a very local phenomena. Geologic literature for the Ravensdale area demonstrates that calcium-bearing formations exist.

Monitoring site No. 7 was taken from a small stream that connects the Lake Ravensdale outflow with Lake Sawyer.

TABLE

INDUSTRIAL MINERAL PRODUCTS' CEMENT KILN DUST LANDFILL REGIONAL GROUND WATER MONITORING PROGRAM, 1981 TO 1984

Date	Well No.	Ownership and Location	pH	Ca ppm
10/81	1	Amber Inn Restaurant 26844 Maple Valley Hsy. Depth: 70 feet	6.37	12.7
10/81	2	J. R. Simms, 27264 Maple Valley Hwy.	6.05	5.9
10/81	3	Ted Hanson, 27430 Maple Valley Hwy.	6.48	13.1
10/81	4	Poggel, 27448 Maple Valley Hwy.	7.30	37.7
10/81	5	Dan Cleveland, 27632 Maple Valley Hwy.	7.45	27.9
10/81	6	R. E. McLennan, 27804 Maple Valley Hwy. Two wells. Sample from main house	6.30	11.0
10/81	7	Green River Sawmill, owner Parrminder Sanghera. Well sealed. Water supply from creek connecting Lk. Ravensdale and Lk. Sawyer	6.65	11.1
8/81	8	I.M.P. Sand-washing plant well, 12 feet deep.	6.13	61.0
10/81	9	Larry Svedarsky, 28040-243d Ave. S.E.. Well 157 ft. deep; driller R.B. Deremer, N.W. Pump and Drilling	6.21	7.5
9/81	10	Loretta Meyers. Well 80 ft. deep; driller N.W. Pump and Drilling	7.53	31.7
6/82	10		7.07	32.1
7/84	10	Loretta Meyers	7.40	31.0
9/84	10	Loretta Meyers	7.20	32.0
10/81	11	F. O. Auto	5.62	19.4

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I.M.P. REGIONAL GROUND WATER MONITORING PROGRAM

TABLE 15

Comparison of the data on Table 15 for this creek with data on Table 19 for Lake Ravensdale generated in October, 1984, shows no significant change in water pH or calcium content over the intervening three years.

Well No. 10, the Loretta Meyers well, was selected as the I.M.P. monitoring well because it is in the dominant direction of ground water flow from the Dale Strip Pit, and because it is 80 feet deep, cased and is, therefore, not subject to surface contamination. It is a fairly recent well and has a complete driller's log. Table 15 shows that water pH and calcium content of this well has remained constant over three years with normal, minor fluctuations. The well driller maintains that the producing stratum is the common aquifer for the area and represents porous, permeable sand that transports water from substantial distances upgradient.

Figure 48 shows the location of the City of Kent Clark Springs public water supply facility. A great deal of water-quality data for this spring is available and is attached as Table 16 (the springs' notation is 22/6-26L1s). The spring is two miles north of the Dale Strip Pit, perpendicular to the direction of dominant ground water flow. It occurs at 545-feet elevation and yields up to 22,000 gpm. This is soft water and relatively low in mineral content because it is in the Vashon recessional outwash which is recharged largely by precipitation. Most other important

GEOLOGY AND GROUND WATER, SOUTHWESTERN KING CO., WASH.
Table 13 - Partial field laboratory analyses of water from wells

(Analyses by U. S. Geological Survey. Analytical ~~results determined~~ by field methods are approximate.

Well	Depth (feet)	Date of collection	Milligrams per liter: Bicarbonate (HCO_3)	Chloride (Cl)	Hardness at $CaCO_3$	Specific conductance (micromhos at 25°C)
21/6- 3E3	50	8-27-63	87	4	--	160
6C2	72	1- -63	25	4	25	65
6F1	90	1- -63	49	5	42	95
6P1	30	1- -63	49	23	97	340
6Q1	170	1- -63	69	4	57	130
7D1	40	1- -63	59	6	59	130
7H1	58	1- -63	140	4	160	350
7J1	36	1- -63	110	5	86	190
7N1	18	1- -63	29	9	47	120
7N2	83	1-22-63	75	4	63	130
8E1	65	1- -63	97	5	87	180
27R1	1,461	1- 9-63	2,400	--	190	17,000

GEOLOGY AND GROUND WATER, SOUTHWESTERN KING CO., WASH.
Table 13 - Partial field laboratory analyses of water from wells - Continued

Well	Depth (feet)	Date of collection	Milligrams per liter: Bicarbonate (HCO_3)	Chloride (Cl)	Hardness as $CaCO_3$	Specific conductance (micromhos at 25°C)
22/6- 1J1	202	8-22-63	110	--	--	200
1J2	62	8-22-63	100	--	--	200
3A1	110	8-22-63	73	--	--	120
11P3	150	8-22-63	56	--	--	120
12R1	20	8-22-63	32	--	--	--
12R2	134	8-22-63	56	--	--	180
14M1	75	8-22-63	45	--	--	--
17H1	161	8-22-63	130	--	--	210
17J1	250	8-22-63	87	--	--	150
25R1	40	1-22-63	23	5	25	65
29G1	128	1-25-63	46	2	34	92
29H1	180	1-25-63	110	3	80	180

GEOLOGY AND GROUND WATER, SOUTHWESTERN KING CO., WASH.
Table 11 - Records of springs - Continued

Spring	Owner or tenant	Altitude (feet)	Use	Remarks
22/6- 2H1s	John Slette	500	D,S	
2R1s	S. M. Black	460	D,S	Yields about 8 gpm. Supplies 3 families.
4H1s	Q. J. Robichaux	300	D	
12B1s	E. G. Wright	630	D	
14N1s	Reed-Ranch Road Water Co.	500	PS	Supplies 27 families.
15J1s	Orchard Grove Community Water Association	470	D	
15K1s	Mrs. Bowman	375	D	
16H1s	J. M. Sloane	375	D	
19M1s	Unknown	410	D	Supplies 2 families.
25A1s	Joe Kobe	719	D	
25G1s	Elon Scherrard	810	D,S	
25K1s	W. C. Ashley	619	D,S	
26L1s	City of Kent, Clark Springs	545	PS	Yields 1,800 to 22,000 gpm. Numerous openings. C.
33P1s	City of Kent, Kent Springs	475	PS	Yields 2,000 to 7,000 gpm.
36K1s	Unknown	690	NU	

GEOLOGY AND GROUND WATER, SOUTHWESTERN KING CO., WASH.
Table - Chemical analyses of water from wells and springs

Well or spring	Depth (feet)	Date of collection	Analyst	Milligrams per liter: Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Orthophosphate (PO_4)	Dissolved solids	Hardness (as $CaCO_3$)	Specific conductance (micromhos at 25°C)	pH
22/4-17Q1	240	4-16-46	NS	10	.03t	--	10	4.0	30c	--	76	--	8.0	--	--	--	--	42	--	--
		10- 4-63	GS	41	.40t	--	--	--	--	1.2	98	--	--	--	--	.47	129e	50	172	8.2
17Q4	1,001	5-23-52	NL	34	.56t	--	27	8.1	127c	--	184	2.0	158	--	.1	--	443	101	--	--
		10- 4-63	GS	21	.37	--	47	15	162	2.2	180	.2	280	.0	.0	.72	617c	178	1,160	7.3
28P1	342	7- -62	BC	41	.86t	.41t	--	--	--	--	82	--	3.5	--	--	--	--	64	--	7.3
22/5- 6H1s	0	6- 8-51	GS	29	.04t	--	13	8.2	5.3	4.0	78	9.6	4.2	.4	4.0	--	116	66	161	7.2
6N1	210	10- 3-62	GS	--	--	--	--	--	--	--	120	--	2.0	--	--	--	--	86	191	8.0
17R1	380	10- 4-63	GS	37	1.3t	--	15	12	6.7	2.7	103	14	4.5	.1	.2	.11	143c	88	200	7.4
24D2	150	10- 3-62	GS	--	--	--	--	--	--	--	92	--	2.5	--	--	--	--	68	153	7.3
36M1	106	3-30-63	GS	23	.12	--	11	3.5	6.3	1.7	60	6.6	1.8	.1	.1	.09	84c	42	112	7.6
22/6-11M3	97	10- 3-62	GS	--	--	--	--	--	--	--	75	--	3.2	--	--	--	--	60	142	7.3
13A2	118	1-23-63	GS	20	.29	--	12	5.0	5.1	.8	71	3.0	1.0	.1	.1	.40	83c	50	119	7.5
26L1s	0	10- 4-63	GS	13	.04	--	11	2.0	3.3	.5	44	.8	2.2	.1	.9	.02	56c	36	87	7.3

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DATE:		REVISED

CHEMICAL ANALYSES FOR SPRINGS AND WELLS
IN RAVENSDALE VICINITY
TABLE 16

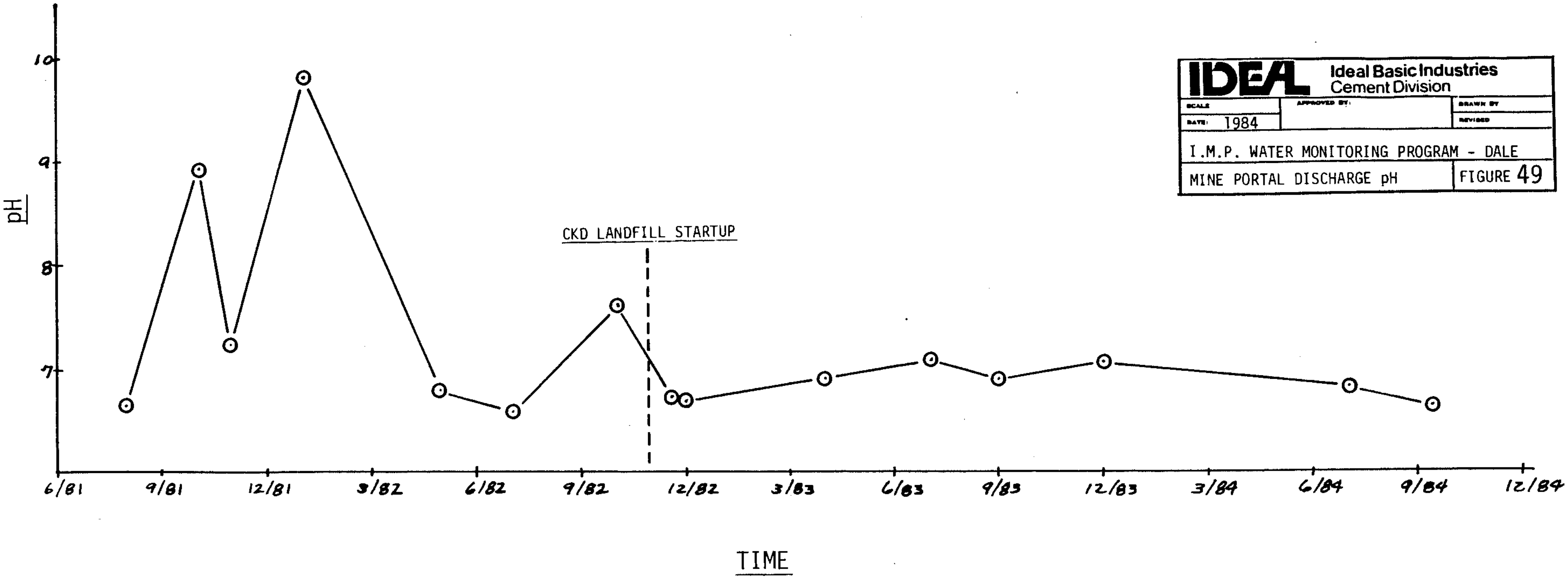
aquifers in the area, by contrast, are recharged indirectly by movement of ground water from overlying, adjacent, or underlying geologic units (Luzier, 1969). Figure 46 C demonstrates graphically how free of dissolved constituents recessional outwash aquifers are, compared to other water-bearing units in the area. Partial analyses of water from two ground water wells in the vicinity (21/6-3E3 and 22/6-25R1 are also provided.

Table 19 provides water chemistry for three surface water bodies in the area immediate to the Dale Strip Pit. One is from an unnamed spring-fed pond one-half mile to the east of the Dale Strip Pit, shown on Figure 47 and Table 16 with the notation Kls. The intermittent creek that drains from this pond was also sampled. Chemical analyses show that both pH and calcium are slightly elevated over those for Ravensdale Lake. This bears out Luzier's contention that water-bearing units overlying bedrock surfaces are influenced by bedrock mineralization because of the aquifer's topographic and stratigraphic position. Ravensdale Lake, on the other hand, rests on and is fed by, recessional outwash gravel. It demonstrates very similar chemistry to that of Clark Springs.

Water Quality of the Dale Coal Mine Drainage

Ground water conditions associated with the Dale Strip Pit were discussed thoroughly in the METRO report included above. The floor of the Dale Strip Pit was sealed naturally by clay that sloughed off the clay units bording the Dale No. 4 seam. This is apparent from the fact that for many years the Strip Pit held 4 million gallons of water with only minor, seasonal fluctuations. Tests for conductivity and chloride content performed by METRO were not successful until water from the north end of the pit was released over a berm at the south end, whereupon it exited the pit via an airway system. I.M.P. personnel isolated the south end by building an access road across the pit and by filling the entire south end with naturally-occurring clays.

CKD first entered the standing water in the middle portion of the Strip Pit; the water immediately became very alkaline. Since the extreme northern pit floor had not received the additional seal provided by the CKD, water that percolated through it could have affected the coal mine drainage pH, implied by the graph on Figure 49. There are, however, other factors in the system that undoubtedly affect pH conditions. Now that the water in the Strip Pit is greatly



Ideal Basic Industries
Cement Division

SCALE	APPROVED BY:	DRAWN BY
DATE: 1984		REVISED

I.M.P. WATER MONITORING PROGRAM - DALE

MINE PORTAL DISCHARGE pH — FIGURE 49

reduced in volume, and CKD disposal has progressed northward to further seal the floor, water pH has declined at the portal since September, 1983.

METRO reported a flow rate of between 300 gpm and 1,100 gpm from the Dale Strip Pit in 1972. I.M.P. personnel have never recorded more than 37 gpm. The drop may be due to several factors, but obviously less water is available to the system. Silica sand mining operations at Ravensdale began in 1968. Since that date, 38 acres of land overlying the Dale workings have been stripped of the vegetation and glacial till-derived soils that retained surface runoff in the past. Because the sandstone is clay-cemented, it does not absorb this runoff. The sand mine is designed to divert all runoff out of the workings and into a system of settling basins. Drainage is diverted to the south, away from the Dale Coal mine system. This drainage diversion, in conjuntion with filling of the Dale Strip Pit and its airways, has dramatically reduced the amount of ground water available to the system.

In anticipation of the Dale Strip Pit Reclamation Project, I.M.P. began monitoring the coal mine discharge at the Dale Portal (Figure 52), in August 1981, principally for pH and flow rate. Table 17 provides data from this on-going monitoring program. In January 1982, the first analysis of calcium content was made. Values were substantially higher

IMP MONITORING PROGRAM FOR CKD/ COAL MINE DRAINAGE AT THE DALE COAL MINE PORTAL, 8/81 TO 9/84

Date Sampled	Flow Rate (gpm)	pH	Calcium Content (ppm)
8/15/81	2	6.61	
10/28/81	33	8.91	
11/6/81	33	7.24	
1/11/82	33	9.81	59.0
5/12/82		6.81	
7/30/82	37	6.60	
10/4/82	37	7.62	54.0
11/1/82 CKD PROJECT STARTUP DATE			
11/15/82	37	6.76	55.7
11/18/82		6.78	55.0
12/2/82		6.69	52.0
4/12/83		6.91	66.0
7/19/83		7.11	43.0
9/21/83		6.92	4.9
12/9/83		7.08	58.0
7/20/84		6.85	58.0
9/19/84		6.67	71.0
9/25/84		6.66	70.0

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Cement Division

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DATE: 1984		REVISED

I.M.P. WATER MONITORING PROGRAM - DALE
PORTAL AND SURFACE WATERS | TABLE 17

TABLE 18
I.M.P. WATER MONITORING PROGRAM DALE COAL MINE DRAINAGE SAMPLES HEAVY METALS CONTENT

DATE SAMPLED 11/30/82

NONE OF THE FOLLOWING METALS WERE FOUND (NOT DETECTED), FOLLOWED BY DETECTION LIMIT IN PARTS PER MILLION.

ELEMENT	CONCENTRATION
Mo	< 0.04
V	< 0.08
Cd	< 0.01
Zn	< 0.01
Pb	< 0.05
Ni	< 0.02
Co	< 0.02
Fe	< 0.01
Mn	< 0.01
Cu	< 0.01
Cr	< 0.01

TABLE 19
I.M.P. WATER MONITORING PROGRAM SURFACE WATER ADJACENT TO I.M.P. SILICA SAND MINE, RAVENSDALE, WA

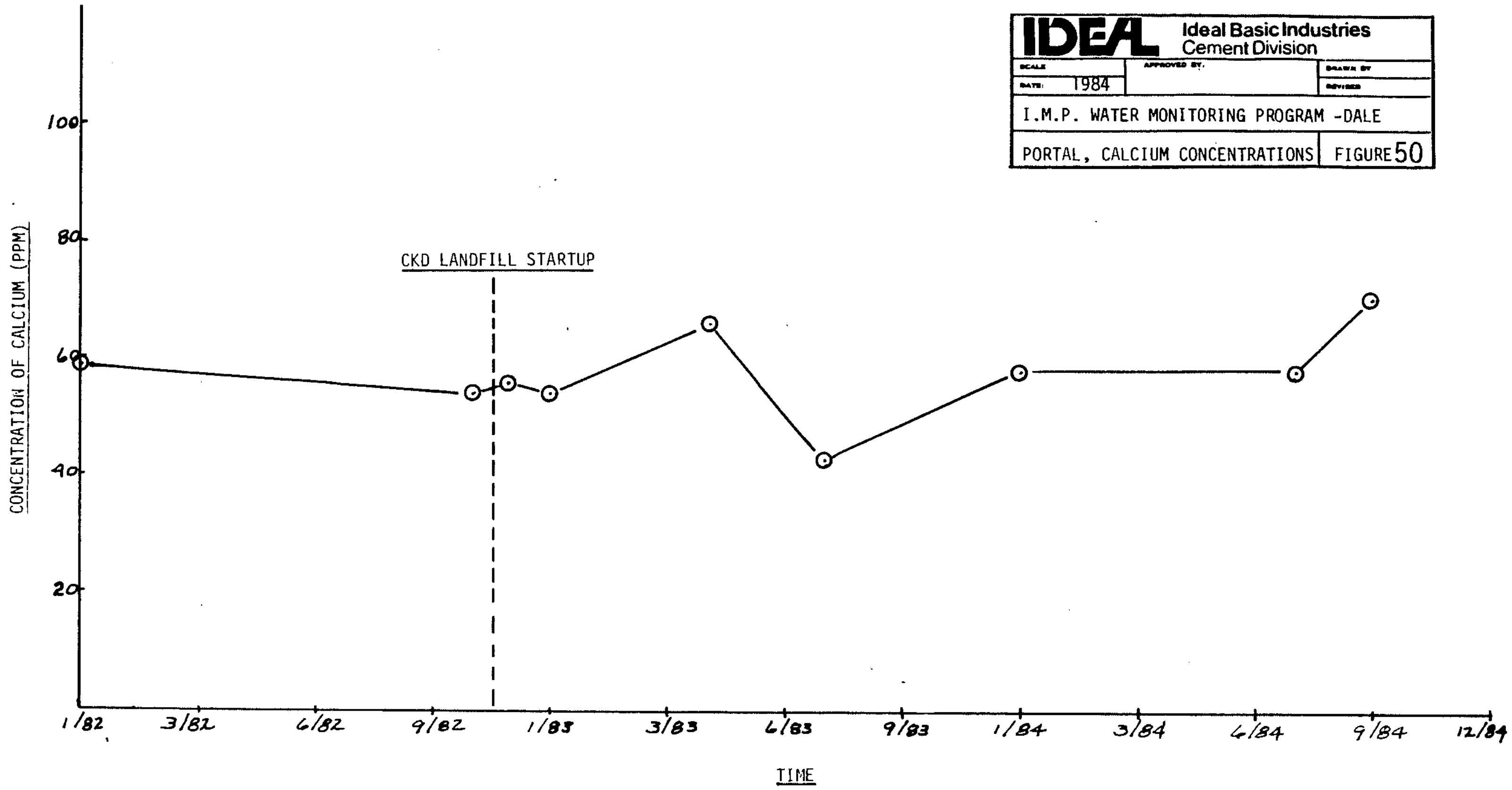
TEST CONC.	LAKE RAVENSDALE	UNNAMED POND	CINDER CREEK
pH	6.58	7.22	7.21
Ca(ppm)	11	20	40

SAMPLES TESTED OCTOBER 4, 1984

than background values for other ground and surface water in the vicinity (Tables 15 and 19). By October 1982, one month before CKD was first placed in the Dale Strip Pit, pH had dropped, but calcium remained high. One month after project startup, the drainage was analyzed for heavy-metal content. As shown on Table 18, none of the heavy metals tested for were detected. The detection limit of the atomic absorption unit used for each element tested is also provided.

On the average of once every three months, from November 1, 1982, to September 25, 1984, the Dale coal mine drainage was analyzed for calcium and pH. Results are presented on Table 17 and portrayed graphically in Figures 49 and 50. Calcium percentages have remained constant throughout the three years during which the Dale Coal Mine drainage has been monitored, with minor, season fluctuations. The sharp drop in September, 1983, is anomalous and may be due to laboratory error. Because calcium has remained at the same level in the water since before CKD disposal began, it is possible that none is being contributed by the Dale landfill. It is more probable that the tremendous dilution factor involved is preventing any noticeable change in the mine water.

Figure 49, pH Range, shows fairly dramatic variances in pH before landfill startup, followed by a decline through the remainder of 1982, a steady increase through 1983, then a steady decline through 1984. This may document further



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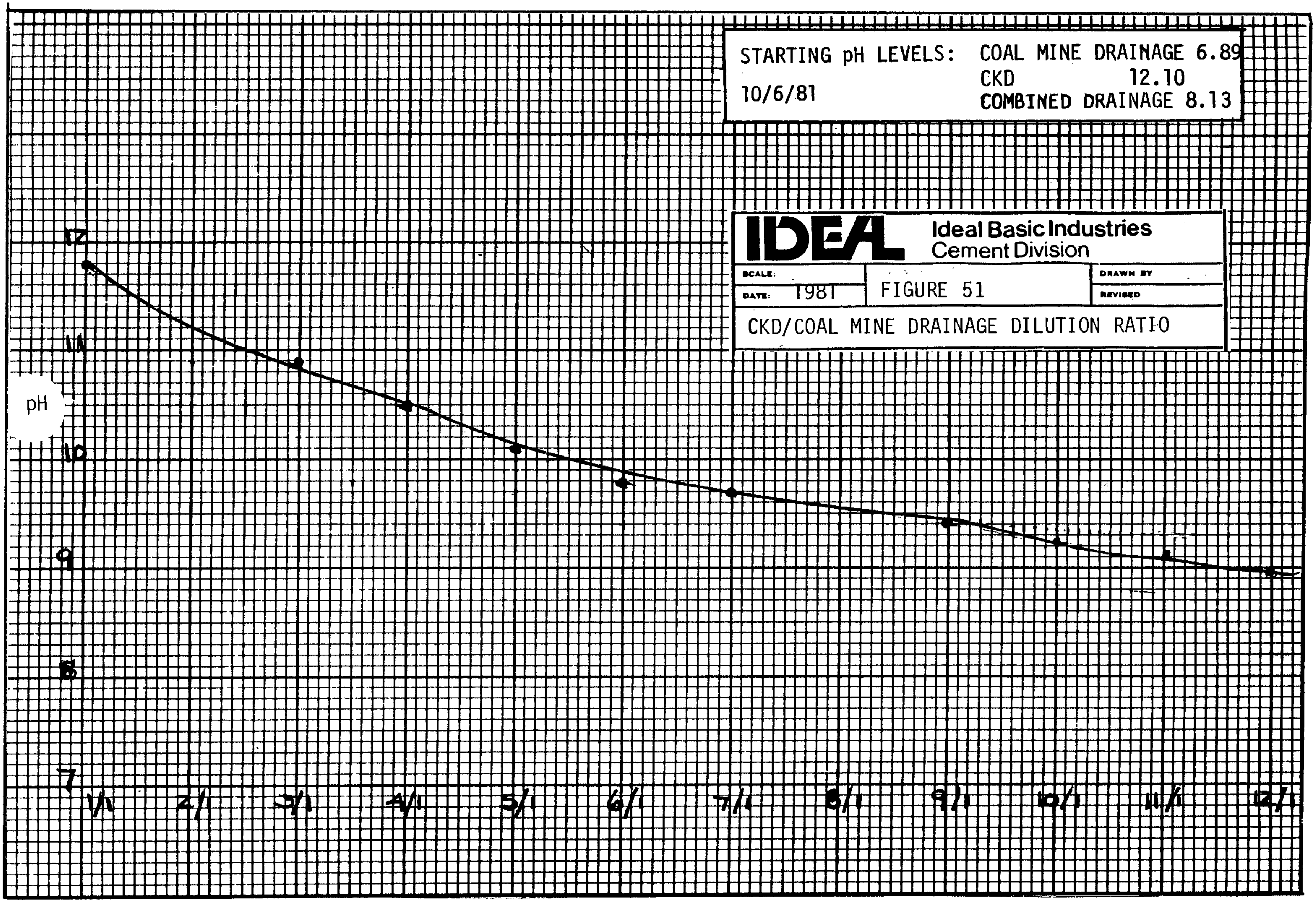
SCALE
DATE: 1984
APPROVED BY:
DRAWN BY
REVISED

I.M.P. WATER MONITORING PROGRAM -DALE
PORTAL, CALCIUM CONCENTRATIONS FIGURE 50

sealing of the Dale Strip Pit floor by CKD as it flowed into the standing water on the pit floor. METRO estimated 2 million gallons of water in the coal mine drainage system. Dilution of any landfill leachate would obviously be tremendous. In this vein, a graph (Figure 51) was prepared in October, 1981, from laboratory work performed to determine drop in pH of CKD effluent (starting pH of 12.10) in combination with coal mine drainage (starting pH 6.89). The study was not taken beyond a ratio of 12 to 1, coal mine drainage to CKD effluent, at which point the combination measured pH 9 (the upper pH limit allowed by Washington State ambient surface water quality regulations).

The EPA has two sets of standards for drinking water quality. The primary standards are health standards that are federally enforceable. The secondary standards are recommended standards only and are not federally enforceable. There are no EPA standards for calcium, potassium, sodium or magnesium, the common elements in CKD, at either the primary or secondary levels.

Washington State DOE has ambient water quality standards for drinking water and for surface waters where aquatic life may be impacted. State surface water standards dictate that discharges to surface water must fall within a pH range of 6 to 9.



STARTING pH LEVELS: COAL MINE DRAINAGE 6.89
CKD 12.10
COMBINED DRAINAGE 8.13
10/6/81

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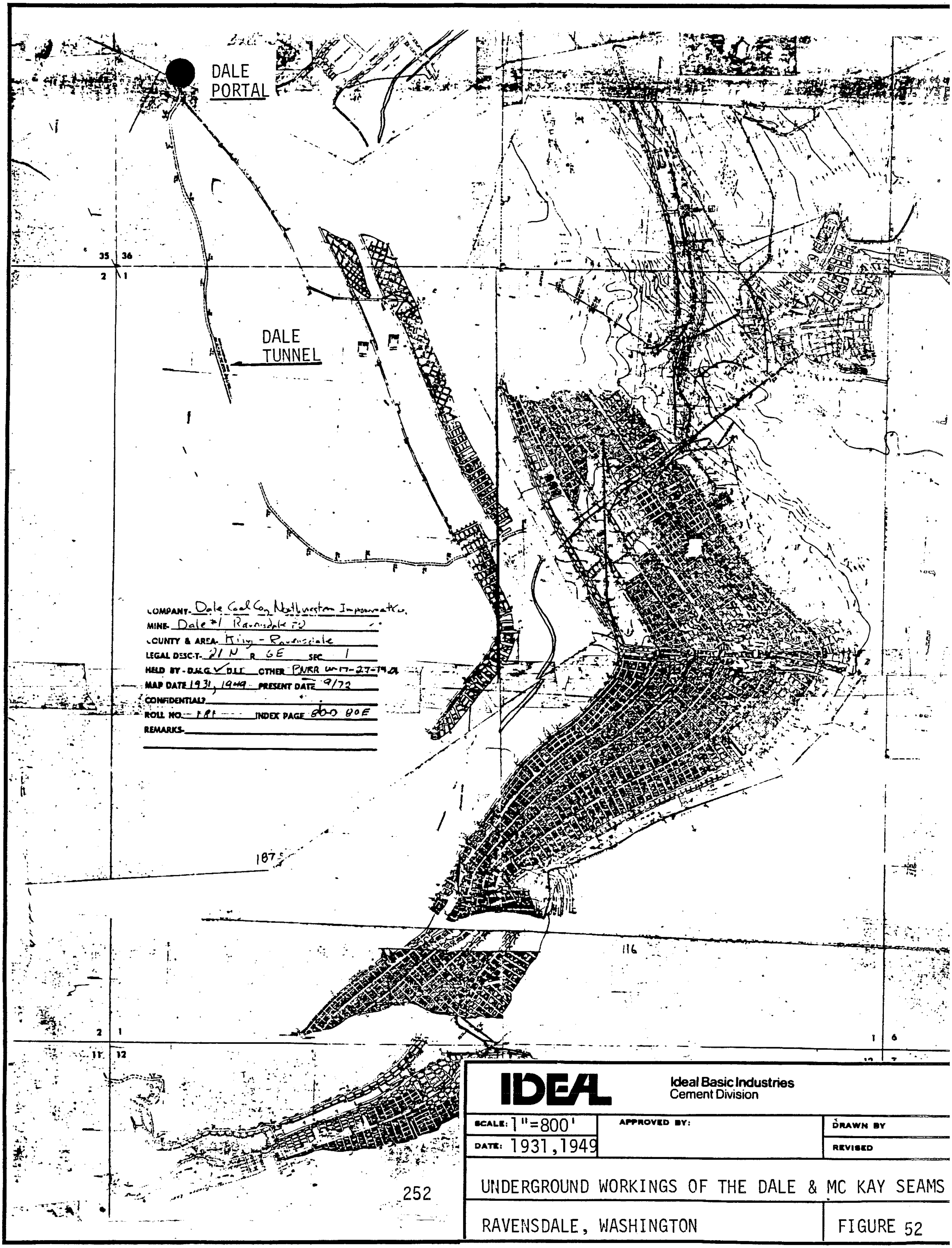
Cement Division

SCALE:
DATE: 1981
FIGURE 51
DRAWN BY
REVISED
CKD/COAL MINE DRAINAGE DILUTION RATIO

RATIO OF COAL MINE DRAINAGE WATER TO
CEMENT-KILN FLUE DUST EFFLUENT-OLD LANDFILL



COMPANY- Dale Coal Co, Northwestern Improvement Co.
MINE- Dale #1 Ravensdale #2
COUNTY & AREA- King - Ravensdale
LEGAL DESC-T- 21 N R 6E SEC 1
HELD BY - D.M.G ✓ D.L.I OTHER BNRR W-17-27-19
MAP DATE 1931, 1949 PRESENT DATE 9/72
CONFIDENTIAL?
ROLL NO.- FRF INDEX PAGE 800 80E
REMARKS-

IDEAL Ideal Basic Industries
Cement Division

SCALE: 1"=800'	APPROVED BY:	DRAWN BY
DATE: 1931,1949		REVISED

UNDERGROUND WORKINGS OF THE DALE & MC KAY SEAMS

RAVENSDALE, WASHINGTON

FIGURE 52

discharges to surface water must fall within a pH range of 6 to 9.

Dale Coal Mine drainage is not a source of drinking water. Its pH since project startup has fluctuated between 6.66 and 7.11, well within the range set by Washington State and the normal range for western Washington ground and surface water. The Dale Coal Mine drainage remains at the surface for about 100 feet before it disappears into recessional outwash gravels on the valley floor. See Figure 22, Plot Plan, for location of the settling basin that captures this drainage. Because these gravels are porous, water-bearing gravels, as discussed above, and because they are very low in mineralization, any impact on their mineral content or pH is infinitesimally insignificant.

II. (4). Flora.

The reclamation site is located under the Bonneville Power Administration transmission lines where growth of vegetation that could interfere with the lines is controlled through routine aerial defoliant spraying programs by the BPA. Grass seed (Alta Fescue variety) will be planted on the reclaimed surface; thirty percent of the site has been reclaimed and seeded to date. A Douglas Fir re-growth plantation surrounds the site on three sides. The entire area was clearcut and slash-burned in 1983. Because CKD is a proven liming agent and nutrient source of calcium and potassium, plant species in its vicinity thrive. See the portion of the Exemption Petition Document, WAC 173-303-910(1)(b)(iv)(bb.2), that discusses the agricultural benefits associated with the use of CKD.

WAC 173-303-910-(1)(b)(iv)(bb.4)

II. (5). Fauna.

Animal populations in the immediate vicinity of the Dale Strip Pit are limited by past removal of soil cover from the Dale coal measures in the 1940's, and by the continuous stripping operations of the adjacent quartz sandstone beds by I.M.P. since 1968. Continuous mining activity has discouraged animals from occupying the site. Reclamation of the site and reestablishment of grasses may provide grazing land for deer and other ruminants.

WAC 173-303-910(1)(b)(iv)(bb.4)

II (6) Noise

Background noise levels of 30-to-45 decibels in the vicinity were measured in conjunction with EIS preparation for the proposed John Henry No. 1 Coal Mine, located one mile due south of the Dale Strip Pit. A portion of that noise study is as Figure 53. Noise levels attributable to traffic on the Ravensdale-Black Diamond Highway, 3,400 feet to the north of the pit, probably range from 47-to-68, extrapolating information from the John Henry EIS (L_{10} levels in Table 11-14). Other pertinent noise sources near the Dale Strip Pit include: 1) the I.M.P. sand-washing plant and heavy equipment, 3,400 feet to the north; 2) heavy equipment operating in the adjacent silica sand mine (1 bulldozer, 1 front-end load, and 2 dump trucks), from 7:30 a.m. to 3:30 p.m., Monday through Friday; 3) daily freight-train traffic on the Burlington-Northern Railroad main line that passes within 3,600 feet north of the site, and through the town of Ravensdale; 4) chain saws from woodcutting operations in the vicinity; and, 5) helicopter traffic associated with routine

TABLE II-14

EXISTING NOISE LEVELS IN DECIBELS (dBA)

Location	L_1	L_{10}	L_{50}	L_{90}
1B	78	55	40	34
2B,3B,6B	52	47	40	30*
4B	56	50	35	30*
5B	80	67	56	45
7B	78	68	47	44

* Sound level is equal to or less than 30.

Sound levels at these locations fluctuated. A fluctuating noise is best described statistically as noise levels exceeded for given percentages of time during a prescribed time period. The commonly used levels are L_{99}, L_{90}, L_{50}, L_{10} and L_1. The subscript indicates the percentage of time that the given level was exceeded. L_{99} and L_{90} describe background sound. L_{50} is median. L_{10} is the level exceeded 10% of the time; L_1 is the level exceeded 1% of the time.

High, L_1, noise levels were due to ordinary car and truck traffic passing at the time the measurement was taken. L_{10} levels resulted from nearby traffic. L_{50} levels were the result of either chain saws from the Lake 12 residential area or the proposal site and drilling activities south of the proposal site and across the Green River Gorge Road. L_{90} levels are background. These sound levels are attributed to distant traffic. Any data below 35 dBA are suspect due to the level of accuracy of the sound level meter. This data could be as low as 25 dBA.

Ordinance 3139 is found in the King County code between Sections 12-66 and 12-100. The following table presents the maximum sound levels within each land use district.

TABLE II-15

MAXIMUM PERMISSIBLE SOUND LEVELS IN DECIBELS (dBA)

Land Use District of Sound Source	Land Use of Receiving Area			
	Rural	Residential	Commercial	Industrial
Rural	49	52	55	57
Residential	52	55	57	60
Commercial	55	57	60	65
Industrial	57	60	65	70

Between 10:00 p.m. and 7:00 a.m. on weekdays, and 10:00 p.m. and 9:00 a.m. on weekends, the maximum permissible level is 10 dBA lower than shown above.

Exceptions to these levels are stated in Section 303. For any sound source of short duration, the levels in the preceding table may be increased by:

(1) 5 dBA for 15 minutes in any 1-hour period.
(2) 10 dBA for 5 minutes in any 1-hour period.
(3) 15 dBA for 1.5 minutes in any 1-hour period.

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FIGURE 53
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REVISED

PACIFIC COAST COAL, JOHN HENRY NO. 1 MINE

EXISTING AND MAXIMUM PERMISSIBLE
NOISE LEVELS

aerial monitoring of the BPA transmission lines and, commonly, light aircraft in the area.

The silica sand mine and the Dale Strip Pit would probably be given a Class C Industrial Environmental Designation for Noise Abatement, (EDNA). No resdential properties immediately adjoin the property (see Figure 15, the I.M.P. Leasehold Boundary Map); surrounding land on all sides is owned by Burlington Northern Railroad and is devoted to forestry, a rural-receiving noise classification.

The town of Ravensdale, one mile to the north of the Dale pit, represents the closest residential receiving property. The maximum permissable sound level in decibels allowed at these residences, if they shared a common boundary with the I.M.P. leashold, which they do not, would be 60 dBA (Table 11-15, Figure 53). Another 5 dBA would be allowed for any 15 minutes in any one-hour period. This is the approximate unloading time for the CKD haul trucks. Noise levels associated with the CKD trucks which arrive on an intermittent basis, would never approach the 65 dBA limit for residences one mile away. The trucks are the only noise source associated with the reclamation project, except for a bulldozer that spends one week per year contouring the finished CKD surface and redistributing stockpiled soil over its surface.

Ravensdale is situated at 600-feet elevation at the northern toe of steep-sided Ravensdale Hill. The Dale Stip Pit is at 925-feet elevation, on a plateau. The intervening distance and topography, combined with a forested buffer zone between Ravensdale and the Dale Strip Pit, renders CKD haul truck noise negligible and indistinguishable from other noise sources in the immediate vicinity.

CKD has been delivered by 25-ton pneumatic trucks to the I.M.P. Silica Sand Mine since 1979. No public noise-related complaints have been documented during the intervening five years.

WAC 173-303-910-(1)(b)(iv)(bb.4)

II (7) Light and Glare.

Over the last five years, haul trucks have unloaded CKD at the Ravensdale site predominantly during the day. Occassionally, when cement production is up and Ideal's CKD storage silos are filled more rapidly, night-hauling becomes necessary. While vehicular light and glare are thus generated, it is not new to the area and would only be noticed by company personnel, because the Dale Strip Pit is remote from population and access to it is severely limited. Because CKD haul trucks re-enter the Ravensdale-Black Diamond Highway perpendicular to the traffic flow, light and glare from their headlights does not generate a vehicular safety hazard.

II. (8). Land Use.

The Ravensdale area has historically been a mining district and is zoned Quarry-Mining in the King County Master Plan. Cultural development has been slow. Land in the immediate vicinity of the CKD reclamation project was mined for coal from the late 1800's to the late 1940's, both underground and at the surface (Figure 43). Bedrock mining of quartz sandstone occurs 1,000 feet to the west of the Dale Strip Pit under the management of Industrial Mineral Products. The sandstone mine has been operating for 16 years; a minimum of 20 more years of strip mining is planned. One mile due south, a proposed coal mining operation (Pacific Coast Coal's John Henry No. 1 Coal Mine), has a projected life of 17 years. Several large sand-and gravel-mining operations are scattered throughout the vicinity. A large cinder-processing facility is located in Black Diamond, owned and operated by Palmer Coking Coal Company,which also operates an active surface coal mine one mile south of the Dale Strip Pit.

Timberland surrounding the subject property was clearcut in the late 1800's to facilitate early coal-mining operations and was not included in a BNRR timber management program until 1982.

The City of Kent Clark Springs Watershed includes a major public water facility on BNRR land two miles to the northwest of the Dale pit (Figure 48). The Seattle Watershed occupies major portions of the surrounding terrain to the north and east.

The middle third of the Dale Strip Pit lies under the Bonneville Power Administration power lines (Figure 16, Plot Plan). BPA severely restricts development of the right-of-way, especially for timber growth.

Steepness of the surrounding terrain and the occurrence of a compact glacial till substratum severely restricts its potential for building sites because of low percolation. Wells in the impervious clay-cemented bedrock seldom produce water in sufficient quantities for domestic water-supply requirements.

WAC 173-303-910(1)(b)(iv)(bb.4)

II. (9). Natural Resources.

While removal of CKD from the Dale Strip Pit is not anticipated because of its value as a reclamation resource in what was previously a hazardous, water-filled, and steep-walled excavation, the CKD has not been mixed with any other substance. As such, if it becomes economically conducive to do so in the future as markets for CKD develop, it would certainly be feasible to mine it.

WAC 173-303-910(1)(b)(iv)(bb.4)

II. (10). Risk of Upset.

Independent lab test-work has verified that CKD is not explosive, corrosive, ignitable, reactive, nor a heavy-metal polluter. In five years of operation, not a single spill has been recorded at the Ravensdale site. This is due to the nature of the trucks that haul CKD, as well as the nature of the Strip Pit configuration. CKD is hauled in completely-enclosed pueumatic trucks, similar in appearance to milk tankers. It is blown into the pit through thick, flexible rubber hoses, connected to six-inch PVC pipes, connected in turn to thin, six-inch flexible rubber hoses that transport it to the surface of water standing in the bottom of the pit (Figure 55). The pit walls are near-vertical, such that the haul road is within five feet of the pit's edge. This leaves very little room for spills resulting from hose rupture or other equipment malfunctions, none of which have been recorded to date. Were a spill to happen, however, heavy equipment from the sandstone mine is in close proximity to the site and available for cleanup

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SOUTH END, DALE STRIP PIT, LOOKING NORTH

INERT SOLID WASTE FILL — FIGURE 54

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Cement Division

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DATE 11/82		REVISED

FIRST DAY OF OPERATION, DALE STRIP PIT

RECLAMATION PROJECT, LOOKING E — FIGURE 55 purposes. There are no surface water bodies within close proximity of the pit, nor along the transportation route within the I.M.P. leasehold. Considering the fact that CKD is registered and routinely used as an agricultural soil liming agent and fertilizer, it is difficult to see how a spill would constitute a "risk of upset."

II. (13). Transportation/Circulation.

Cement-kiln dust has been hauled from the Ideal Basic Industries Seattle Plant on West Marginal Way to the I.M.P. Silica Sand Mine for five years. See Vicinity Map (Figure 13) for the truck-haul route. Approval of continued operations will not generate additional truck transport to the site. Because of steadily-increasing markets for CKD and process modifications at Ideal's Seattle Cement Manufacturing Plant, tonnages hauled to the Ravensdale site have been, and will be, reduced dramatically. Examination of Section 910(3)(c)(vi) of the Exemption Petition Document tabulates this steady reduction over the last five years. Because of inherent variability in the amount of CKD produced at any one time in response to sales, changes in raw material batch designs associated with different cement types produced, as well as due to the seasonal nature of agricultural lime utilization (the largest single use of CKD in Washington State), Ideal will always require a land-disposal site for its mineral by-product. Certainly, reclamation sites in the Ravensdale area will be available for many years to come, given the great extent to which the area was mined for coal, both above-and below-ground.

Historically, truck traffic has been heavy in the Ravensdale area because of extensive mining of both bedrock and surficial minerals and associated hauling into Seattle. At various times, logging-truck activity has also been heavy. Because of low population density, few pedestrians or bicyclists use the transportation routes. The limited number of trucks involved in the CKD haul do not add significantly to total vehicular activity or, therefore, to the traffic-hazard potential. A detailed discussion of the transport trucks, transportation routes, and materials-handling procedures, prepared by the hauling contractor (Fedderly-Marion, Inc.), follows.

Traffic control is not a serious consideration at the I.M.P. Silica Sand Mine, because truck-traffic is light- to-moderate. See Topographic Map (Figure 29) for intra-mine traffic routes. Most of the time, only one CKD haul truck is unloading at the facility. The Dale Strip Pit is completely removed from the silica sand-mining activity. A truck turn-around facility has been constructed at the pit to provide drivers with alternate departure routes, depending upon weather conditions. The pit access road has been upgraded to allow CKD trucks to make a continuous loop around the entire leasehold, entering , unloading and departing on the same road which passes down over the north slope of Ravensdale Hill, thence out the main gate. CKD haul trucks are equipped with two-way radios so that drivers can communicate among themselves and with I.M.P. sand-haul truck drivers.

FEDDERLY-MARION FREIGHT LINES, INC.
P.O. BOX 228 (206) 746-5444
ISSAQUAH, WASHINGTON 98027

Glenda McLucas
P.O. Box 5352
Lacey, Wa. 98503

October 29, 1984

Dear Glenda

Fedderly-Marion is regularly involved in hauling kiln dust from the Ideal Basic Industires plant on West Marginal Way, Seattle to the Industrial Mineral Product's dump site at Ravensdale, WA. This material is hauled on a sporadic basis depending on the amount produced or the amount sold to farmers for soil sweetner. Our most recent records, from July 13, 1984 through September 7, 1984, show that we hauled approximately 7,300 tons during this period. We hauled on 36 seperate days for an average of 8 loads per day. Actually, the most loads hauled in a 24 hour day was 20 (following a 3 day weekend) and as few as 2 loads.

Kiln Dust is a cementious material that is loaded into our pneumatic trailers through the bulk cement loading facilities at Ideal's plant. They have dust control facilities there and should there be a rare over spill, wash racks for the hauling unit. Our route is West Marginal Way south to I-5, I 405 to Cedar River Road through Maple Valley, at the Kent-Kangley Road left to Ravensdale where the dump site is located in Industrial Mineral's sand pit. At this pit there are several large trenches left from coal excavation mining during World War II. We pump off our loads into one of these huge trenches in order to reclaim them. Our trailers are pneumatic, which means that they can be pressurized and the product pumped out and to a place. Here at Ravensdale, we pump over the edge and down to the water retained in the bottom of the trench. Incidently this water involvement controls the amount of dust which might momentarily enter the atmosphere. As the trench fills up, we pump through 4 inch pipes out across the fill. By leaving the end of the pipe immersed in the fill, it self filters the air used to unload, again controling the dust into the atmosphere.

We have found the kiln dust so similar to Portland Cement that we treat it the same. Both materials can be mildly caustic to the skin should a persons arm or leg be immersed into it and the arm or leg be wet. However, this is not instantaneous and either material can be washed off in due time with no harmful effect to the skin.

FEDDERLY-MARION FREIGHT LINES, INC.
P.O. BOX 228 (206) 746-5444
ISSAQUAH, WASHINGTON 98027

In summing up, we have two very important responsibilities. We control the product in sealed vehicles (pneumatic trailers) from the plant to the dump site. We are also responsible to keep the Ideal plant dust silos empty so that the plant can keep in production. Should the dust collection silos from the kiln be allowed to fill, the kiln must be stopped. This can cost as much as $300,000.00 depending on whether or not the bricks in the drum fall out with rapid cooling.

We hope this explains our part in the disposing of this material. Should more information be needed, do not hesitate to call us.

Sincerely,

Whalen Burke

Whalen J. Burke, President

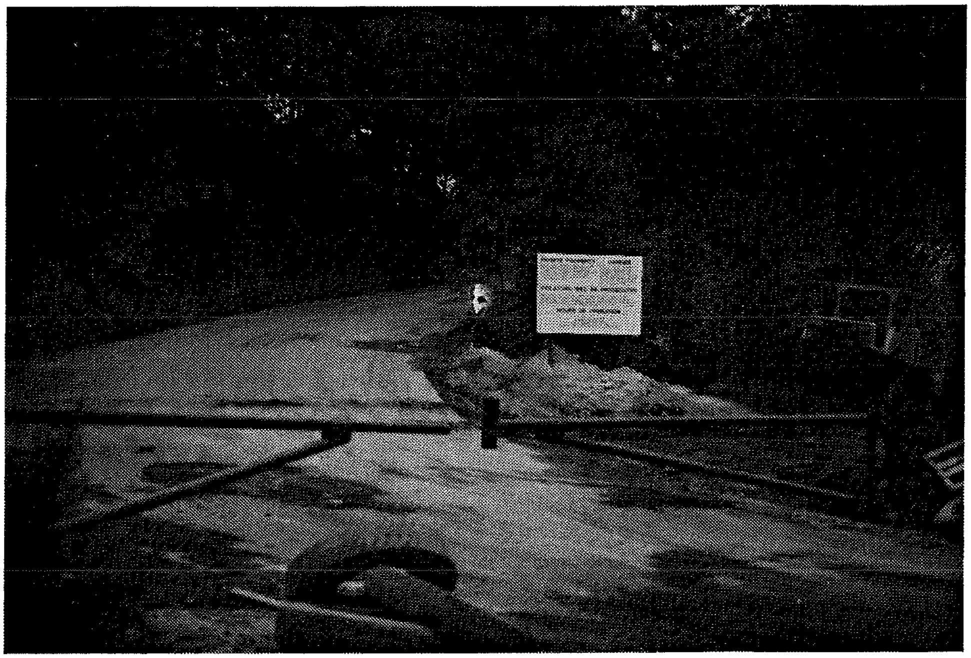
WAC 173-303-910(1)(b)(iv)(bb.4)

II. (17). Human Health.

Review of test results from Biomed Research Laboratories in Section WAC 173-303 -910(3)(c)(x) reveals that Ideal's CKD does not pose a hazard to public health. The reason it has been captured as a dangerous waste is simply due to its alkalinity. In solution, at 1000 ppm, it kills rainbow trout. When the pH of the solution is controlled, fish do not die, demonstrating that this is not a toxic substance.

Review of the water section above demonstrates that there are no public water wells within one mile of the reclamation project. Close monitoring of the only possible escape route of leachate from the Dale Strip Pit has not demonstrated a change in pH or an increase in calcium above the level common to water in southwestern King County (Luzier, 1969). Water quality monitoring of the nearest deep well one mile to the west, in the dominant direction of regional water flow, has not shown any impact on inorganic water quality whatsoever.

Examination of Figures 56 and 57 show that access to the site can be gained only by the most determined trespasser, and then under the threat of criminal prosecution. The property is gated and clearly posted and the Strip Pit is fenced and posted (Figure 36 and 58). The 30 percent of the Dale Strip Pit that is full has been covered with soil and seeded to grass (Figures 59 and 60). Physical contact with fresh CKD would be difficult for any person who determinably ignored the pit perimeter fencing because the CKD is consciously directed into the deepest part of the pit, and into standing water to speed the hydration process (Figure 55). It is during the hydration process of very fresh CKD that skin contact is most likely to cause burns, and then only if the CKD is allowed to remain on the skin for long periods of time. Heavy precipitation in the area, during most of the year, hydrates the CKD almost immediately upon placement in the Strip Pit. Company or trucking personnel who have had the most contact with CKD historically, have not reported skin burns or inhalation problems associated with handling this substance.



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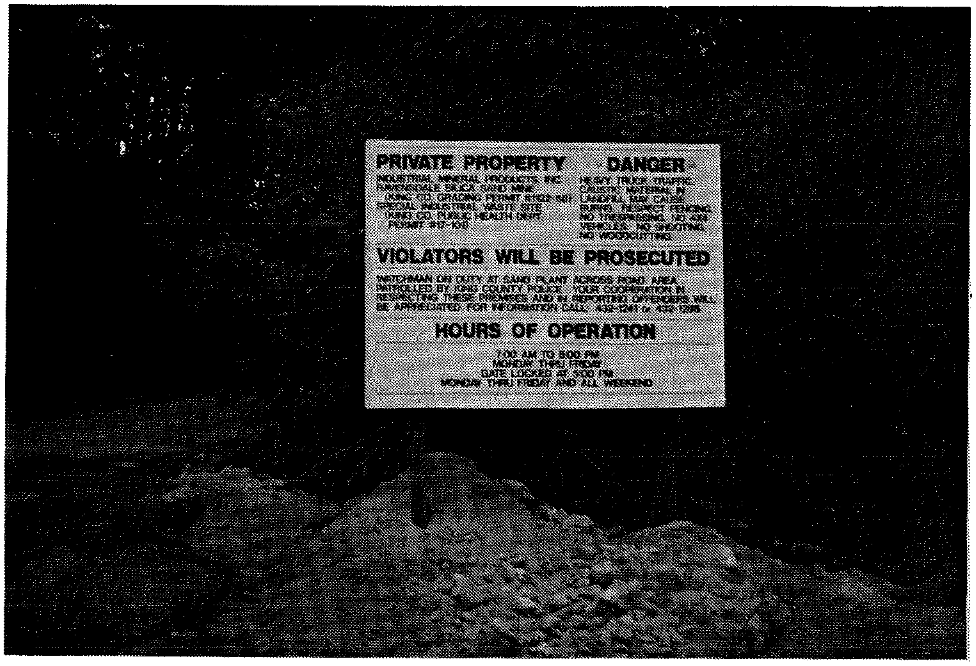
GATED ENTRANCE TO DALE STRIP PIT

I.M.P. SAND MINE, RAVENSDALE — FIGURE 56



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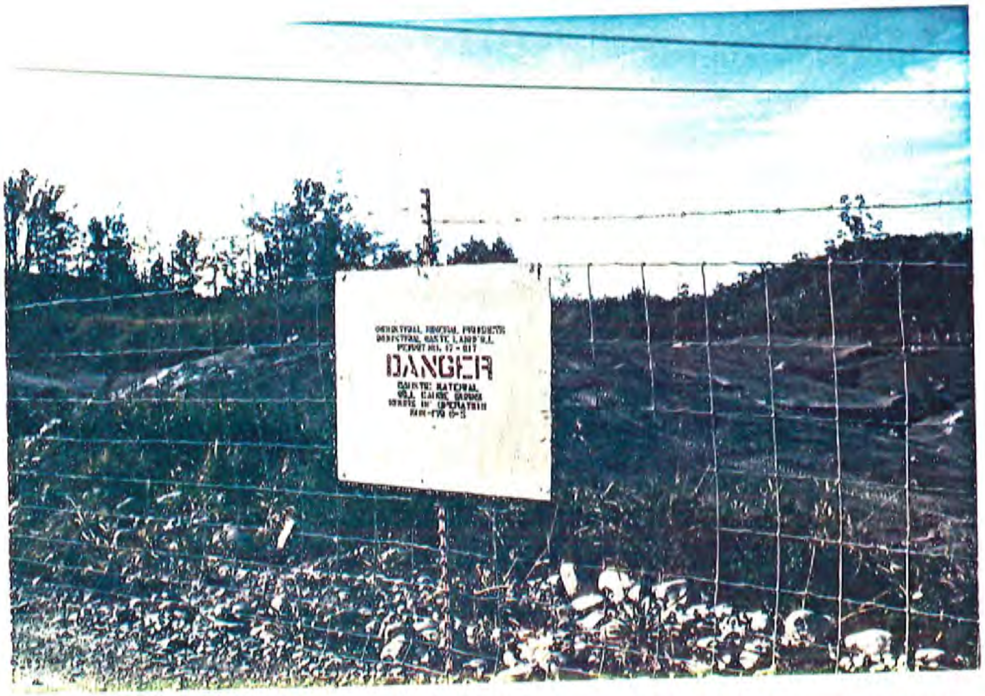
POSTING AT DALE STRIP PIT ENTRANCE ROAD

I.M.P. SILICA SAND MINE — FIGURE 57



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DALE STRIP PIT FENCING AND POSTING

FIGURE 58

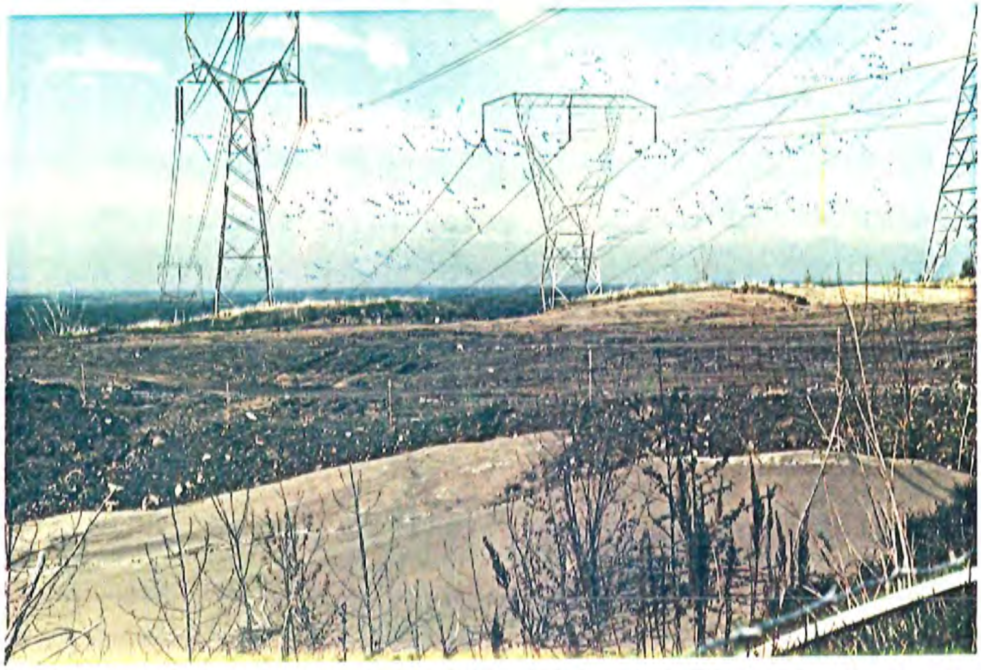
WAC 173-303-910(1)(b)(iv)(bb.4)

II. (18). Aesthetics.

Access to this privately-owned property is severely limited, except to the most persistent trespasser, as well as illegal (Figure 56 and 57). The Dale Coal Strip Pit was unsightly and unsafe in its pre-reclamation condition and represented a substantial liability to both the land owner (BNRR) and the leasee (I.M.P.). The pit was deep (40 to 50 feet), steep-walled, and contained 15 feet of stagnant water from which there was no easy escape (Figure 35). Off-hour four-wheel drive and motorcycle traffic was of concern to I.M.P., because the pit was not fenced and because bikers on this property have a history of not respecting fencing or warning signs.

Reclamation of this site will greatly improve its appearance because it will be completely filled, and because all standing water will be absorbed by fresh CKD. A soil cover is readily available from the windrows on the western pit border, created by the original strip mining. Soil will be spread over the finished CKD surface, which will then be fertilized and seeded to grass (Alta Fescue variety).

Figures 35 and 60 are photographs of the original, and a reclaimed portion of the pit, immediately under the BPA transmission lines. This portion of the pit (30 percent) was covered and seeded in the fall of 1983. The improvement over its original appearance is immediately obvious.



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DALE STRIP PIT RECLAMATION - EMPLACEMENT OF STOCKPILED SOIL OVER CKD

FIGURE 59

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DALE STRIP PIT RECLAMATION - GRASS SEEDING AND FERTILIZATION

FIGURE 60

WAC 173-303-910(1)(b)(iv)(bb.4)

II. (19). Recreation.

As explained in the previous section, the Dale Strip Pit has been closed to the public. Past practices of shooting firearms and driving recreational vehicles in the vicinity of the Strip Pit is strictly forbidden and subject to prosecution. As such, recreational activities in proximity to the reclamation project have been eliminated.

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WAC 173-303-910(1)(b)(iv)(bb.5)

ECONOMIC IMPACT TO IDEAL BASIC INDUSTRIES' SEATTLE CEMENT-MANUFACTURING PLANT IF EXEMPTION PETITION IS DENIED AND IDEAL IS FORCED TO DISPOSE OF CEMENT-KILN DUST AS A DANGEROUS WASTE

If Ideal Basic Industries is forced to dispose of its waste cement-kiln dust as a dangerous waste, the Seattle Plant will have the following options:

1. Run at normal capacity and haul the dust to Arlington, Oregon, the state-sanctioned Dangerous Waste Disposal Facility.

2. Cut back production sufficiently to lower cement-kiln dust loss to zero.

3. Cut back production to lower dust loss to a level that produces only enough cement-kiln dust to satisfy the existing agricultural liming materials market.

4. Shut the plant down and import Japanese clinker or cement.

5. Import enough clinker to make up for cement-kiln dust losses due to lower input to cement kiln.

Option 1. This option would prove very expensive at a combined hauling/dumping fee of $103. 80 per ton (hauling, $28.80 per ton; dumping, $75. per ton) quoted by Chemical Security Systems, managers of the Arlington facility. At full input the Seattle Plant produces about 170 tons per day CKD, or about 60,000 tons per year. If 25,000 tons of CKD were sold, 35,000 tons would have to be hauled to Arlington at a cost of $3,600,000 per year. This would add $7.82 to the cost of each ton of cement produced which would remove Ideal's product from a highly-competitive market. Ideal only receives $55. to $60. for its finished cement, one-half the amount quoted for its shipment and acceptance at the Arlington, Oregon, facility.

Option 2. This option is a possibility, as the Seattle Plant has done this in the past for a very short period of time. In order to run with zero dust loss, the plant would have to reduce production by about 19 percent. This would reduce sales possibilities to over 60,000 tons less than current levels, and would probably remove Ideal from several marketing areas.

Additionally, in returning all dust to the kiln, alkalies would increase to an intolerable level in the finished cement, forcing Ideal to change its raw materials sources. This, in return, would drastically affect the ability of Ideal's suppliers to remain in business, with additional impact to employment and tax bases in the Puget Sound region.

Option 3. This is another real option. During the year, Ideal can sell about 25,000 tons of dust. This would allow Ideal to increase input enough to produce this 25,000 tons of CKD over the year. This would represent a reduction in overall production of about 40,000 tons and, during good years, would prohibit Ideal from meeting customer demands. Cement-kiln dust sales are not consistent throughout the year because it cannot be applied to fields during wet weather; it must be applied to cropland before it is sown. This would force Ideal to change kiln imputs during the year in conformance with seasonal CKD market demands.

Option 4. This option is also a possibility if worst case conditions prevail. If increased costs force Ideal to shut down, 30 to 35 people would lose their jobs, resulting in close to a million dollars per year in wages lost. This would affect the supply of goods and services in Seattle and King County. If implementation of option 4 demonstrated that Ideal could not operate at a profit, there is no doubt that the plant would be shut down entirely, resulting in wholesale losses to the state.

Ideal Basic Industries is one of the largest users of electricity in Washington State, and a large consumer of natural gas as well. Power costs alone are often in excess of one million dollars per year. Hopefully, option 4 will never become a reality.

Option 5. While option 5 is a possibility, costs could be excessive due to lower kiln production. Hopefully, no personnel would be layed off. The Seattle Cement Manufacturing Plant would probably survive if most of the five options above were exercised. Profits would suffer, however, and if the most severe conditions persisted, Ideal would be forced to import foreign clinker in order to keep the plant operational. Option 3 is the most feasible at present cement sales volumes. If sales volumes were to increase, however, option 5 (or even option 4) could become more feasibile than at present.

WAC 173-303-910(3)

PETITIONS FOR EXEMPTING DANGEROUS WASTES FROM A PARTICULAR GENERATOR

WAC 173-303-910(3)(c)

Each petition must include:

(i) The Name and Address of the Laboratory Facility Performing the Sampling or Testing of the Waste.

Sampling

By Ideal personnel at the plant site under the supervision of Mr. Ed Owens, Plant Quality Control Supervisor.

Testing

Biomed Research Laboratories, Inc.
1115 East Pike Street
Seattle, Washington 98122
(206) 324-0380

WAC 173-303-910(3)(c)

(ii) The Names and Qualifications of the Persons Sampling and Testing the Waste.

Sampling

Under supervision of Mr. Ed Owens, Plant Quality Control Supervisor. See attached educational and employment record.

Testing

The following tests were performed by Biomed Research Laboratories:

1. Ignitability
2. Corrosivity
3. EP Toxicity
4. Static Acute Fish Bioassy
5. Acute Oral Rat Toxicity
6. Polycyclic Aromatic Content
7. Halogenated Hydrocarbon Content
8. Reactivity

The tests for ignitability, corrosivity, EP toxicity, reactivity, polycyclic aromatic content and halogenated hydrocarbon content were performed by Mr. Floyd R. Kirk. See attached resume.

The tests for static acute fish bioassay and acute oral rat toxicity were performed by Mr.Kevin J. Casey. See attached resume.

Edward John Owens

4345 S.W. Willow St.
Seattle, Washington 98136

206-937-2826

EDUCATION

B.A. English	1982	Washington State University
B.S. Soils	1980	Washington State University

EXPERIENCE

1980 to 1982 Research Technologist 1. Soil Chemistry Laboratory, Department of Agronomy and Soils, Washington State University. Full responsibility for laboratory and timeslip personnel. Conducted research on nitrogen transformations in soils, trace metal activity, erosion loss quantification, water quality tests, and computer modeling of environmental phenomena. Supervisor: Dr. B.L.McNeal

1979 to 1980 Laboratory Assistant, Soil Chemistry Laboratory, WSU. Performed routine soil analysis, including gas chromatography and automated analysis systems. Supervisor: Dr. B.L. McNeal

1977 to 1979 Laboratory Assistant, Malt Research Laboratory, WSU. Conducted malting quality tests on experimental barley varieties, including Kjeldahl determinations, viscosity, specific gravity and germination characteristics. Supervisor: Dr. R.L. Nilan

1973 to 1977 Service in U.S. Navy as Sonar and Anti-Submarine Weapons Technician. Worked on sonar, ASROC launch system and payload, radio transmitters, and associated peripheral equipment. Security clearances. Honorable discharge as Petty Officer Third Class.

SKILLS

Experience as an instructor of environmental biophysics laboratory. Taught theory and operation of electronic instruments used for environmental studies.

Experience with modern methods of chemical analysis for soil, water, and plant material, including: atomic absorption, automated analysis systems, IR and UV spectrophotometry, potentiometry, ion-selective electrodes, and microbiological techniques.

Basic electronics troubleshooting/maintenance training from Navy schools.

Experience with microcomputers and BASIC programming language.

Experience with repair and calibration of field test equipment and laboratory instruments.

Experience with technical writing and editing.

RESEARCH

WSU Project 13L-3019-7006, funded by the Malting Barley Improvement Association. Laboratory assistant, prepared and analyzed barley for malting characteristics as well as general lab maintenance.

WSU Project 11D-3019-4382, funded by the U.S. Forest Service. Laboratory assistant, performed routine sampling and analysis of soils and plant material, such as nitrogen, carbon, phosphorus, and trace elements, soil physical properties, and soil biomass assays.

WSU Project 11D-3019-5227, funded by the U.S.D.A. Research leader, involved with planning and preparation of test plots, and conducted extensive sampling and analysis of soils and water.

EPA Grant R-805527, funded by the Environmental Protection Agency. Research technologist, conducted field and lab work on runoff water quality, soil denitrification losses, and sediment loss.

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REFERENCES

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Washington State University
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KEVIN J. CASEY
5417 32nd AVE N.W.
Seattle, WA 98107
(206) 789-3135

JOB OBJECTIVE:

BIOLOGICAL RESEARCH TECHNICIAN with appropriate facility needing individual skilled in biological and marine management, research laboratory techniques, construction trade skills, clerical and office managerial assignments.

EXPERIENCE:

May 3, 1982 - present

BioMed Research Labs, Inc. 1115 E. Pike Street
Seattle, WA 98122 (206) 324-0380

FISHERIES BIOLOGIST
Responsible for all Department of Ecology monitored Static Acute Fish Bioassay tests and the formal reports thereof; complete research design and maintenance of a fisheries disease laboratory for the purpose of data collection and experimentation for the production of bacterin vaccines including all support chemistry, microbiology and pathological work; total care and maintenance of a 15,000 fish recirculated water laboratory system and the general biologics of the fish contained therein.

Sept, 1980 -Feb, 1981

Cumberland Farms Company. Tiverton, Rhode Island

ASSISTANT MANAGER
Originally employed as a store clerk, successfully completed managerial duties to the assistant manager's position for the operation and maintenance of this chain grocery store.

Sept, 1976 -April, 1979

University of Rhode Island, Zoology Department
B.S.C. Science Center, Kingston, Rhode Island 02881

RESEARCH ASSISTANT/STAFF PHOTOGRAPHER
Performing photographic and microscopic assignments for all professorial research projects including surgical photography and journal publication.

June, 1975 -May 1982

CONSTRUCTION CONTRACTOR/HOME REMODELING
Self-employed, experienced to the journeyman's level; employed 3-4 workers, profits utilized for same and educational self-sufficiency.

EDUCATION:

University of Rhode Island 1976-1980
Bachelor of Science Degree: ZOOLOGY

PERSONAL BACKGROUND AND INTERESTS:

Born in New England, well traveled, I enjoy all sports and outside activities including SCUBA diving, photography and the Arts. I have a deep appreciation for the animal and natural world and most enjoy hard work in that area.

References furnished upon request.

RESUME

CHEMISTRY TRAINING:

One year as chief analytical chemist.
Four years as analytical chemist.
Three years graduate study in chemistry and biochemistry.
B.S. degree in biochemistry (Phi Beta Kappa).

PROFESSIONAL EXPERIENCE:

Since 1978, I have been an analytical chemist at BioMed Research Laboratories. Major instruments used include the atomic absorption spectrophotometer, the high-pressure liquid chromatograph, and the gas chromatograph. On the gas chromatograph, routinely analyze for fatty acid methyl esters, pesticides and herbicides, and polynuclear aromatic hydrocarbons. For the past year, I have been the chief chemist in the lab: responsibilities include training workers, maintaining state certification for analysis, deciding whether to accept samples for analysis, determining the analytical method, and setting prices.

EDUCATION:

Dates: September 1974 to September 1976
College: University of Washington; Seattle, Washington
Course of Study: Ph.D. Biochemistry program (no degree)
Honors: Attended on Fellowship, GPA of 3.5

Dates: September 1973 to June 1974
College: Western Washington State College: Bellingham, Washington
Course of Study: M.S. chemistry program (no degree)
Honors: Attended on Fellowship, GPA of 4.0

Dates: September 1967 to March 1971
College: Michigan State University; East Lansing, Michigan
Degree: B.S. Biochemistry
Honors: Attended on National Merit Scholarship, GPA of 3.7,
graduated "With High Honor," elected to Phi Beta Kappa

FLOYD R. KIRK
716 N. 80th
Seattle, WA 98103

WAC 173-303-910(3)(c)

(iii) The Dates of Sampling and Testing.

Sampling

Sampling was performed during a two week period in September 1983, in accordance with attached sampling plan approved by the Washington State Department of Ecology.

Testing

A one-pound test sample was delivered by hand to Biomed Research Laboratories on September 28, 1983.

The Static Acute Fish Bioassay Testing was performed during the period from October 16, through October 25, 1983. The Oral Rat Toxicity Test was performed during the period from October 10 through October 24, 1983. The test results for both tests were reported on October 25, 1983.

May 3, 1983

Mr. James C. Knudson, P.E.
Hazardous Waste Engineer
Washington State Department of Ecology
Hazardous Waste Section
MS/PV-11
Olympia, Washington 98504

Re: Seattle Plant Waste Kiln Dust
Certification of Designation as Non-dangerous

Dear Mr. Knudson:

We are hereby requesting your approval of the sampling procedure proposed below for the testing requirement under WAC 173-303-075 for a non-dangerous certification of the waste kiln dust from our Seattle, Washington Cement Plant. Hopefully, the information which follows in regard to kiln dust generation, collection and handling at the Seattle Plant will be helpful in your evaluation of our request.

During the burning operations of the cement manufacturing process as much as 12-percent, and possibly even more, of feed materials are carried away with the kiln exhaust gases. At the Seattle Plant virtually all of these materials, known as kiln dust in the industry, are captured by a high efficiency electrostatic precipitator prior to the final exhaustion of the kiln gases through the main stack. The Seattle Plant's kiln on an average has generated about 445 tons of kiln dust per day. There are possibilities, however, for the kiln to generate in excess of 600 tons of kiln dust per day.

Because of the value of the kiln dust collected in the precipitator, every effort is made to return as much as possible of this material back to the cement manufacturing process. However, the Seattle Plant is presently capable of returning only about 43-percent of the collected dust. The remaining 57-percent by necessity becomes either a salable product or a waste material. We are presently estimating that about 45-percent of all of the collected kiln dust has been and will continue to be disposed of as a waste material. On an average this amounts to about 200 tons per day.

The precipitator at the Seattle Plant is a Buell two parallel section, three stage, 12-hopper unit designed for operation with 400,000 CFM at 700°F. The unit segregates the entrained dust by particle size by removing the heavier particles and approximately 80-percent of the dust load in the first stage. We estimate that about 16-percent and 4-percent of the total dust load is collected in the second and third stages, respectively.

From the precipitator hoppers the collected kiln dust is pneumatically conveyed to two nearby dust bins. All precipitator stage one dust is separately stored in one bin and the remaining dust from stages two and three is temporarily stored in the other bin. All process return dust is withdrawn from the stage one bin. As required, the excess dust from this bin and all of the stage two and stage three dust from the other bin is pneumatically conveyed to either of two designated truck bulk loading silos. Waste dust is withdrawn from either of these storage silos as required for final landfill disposal.

The Seattle Plant manufactures only three types of cement, Type I, Type I-II and Type III. However, Types I and I-II account for about 80 to 85 percent of the plant's production with the majority of that being of Type I-II, or about 45-50-percent of the total. For the raw material used at the Seattle Plant, typical design mixes for the three types are as follows:

	I	I-II	III
Limestone	80.2%	80.21%	80.87%
Sand		.04%	.24%
Clay	19.8%	19.68%	18.78%
Iron		.07%	.11%

As you will note, Type I differs from the other two only by the requirement of sand and iron.

The sampling procedure we are proposing is as follows: For a two week period during a production run of Type I-II cement, two one pound samples of the waste dust will be taken daily, one in the morning and one in the afternoon. The samples will be taken from the waste dust haul truck immediately after being loaded from the waste dust silo. We have selected sampling waste dust from production of Type I-II cement because the majority of the cement produced is of this type and all of the raw material ingredients are required for its production. We believe that more than adequate mixing of the waste dust will have occured prior to sampling because of all of the previously required pneumatic conveying and bin loading operations. The samples will be stored in a container provided by the plant. After all 28 samples have been taken, the stored dust will again be thoroughly mixed prior to providing final one pound samples to the Hazardous Waste Section of the Washington Department of Ecology, to our Research Department, in Fort Collins, Colorado, and to an approved commercial testing laboratory in Seattle for test purposes.

Please let us know if additional information is required.

Sincerely,

IDEAL BASIC INDUSTRIES
CEMENT DIVISION

Harlan W. Powledge
Director, Environmental Quality

HWP/nm

cc:
Mr. F. Bauer
Mr. L. Warner
Mr. W. Springman
Mr. R. Wallis
Mr. N. Greening
Mr. G. Miller

JOHN SPELLMAN
Governor

DONALD W. MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504 • (206) 459-6000

May 27, 1983

Mr. Harlan W. Powledge
Director, Environmental Quality
Ideal Basic Industries
Cement Division
Ideal Plaza
P. O. Box 8789
Denver, Colorado 80201

Dear Mr. Powledge:

This letter will confirm our conversation of May 27, 1983 concerning your sampling plan for waste kiln dust at your Seattle plant. You described the sampling in a letter dated May 2, 1983. You may consider this letter as approval for that sampling plan.

For my information, I would appreciate a list of tests you plan to perform on the samples once they have been obtained. If you have any questions please feel free to call me at any time at (206) 459-6302.

Sincerely,

James C. Knudson

James C. Knudson, P.E.
Hazardous Waste Section
Solid Waste Management Division
Office of Land Programs

JCK:drs

cc: John Conroy,NWRO, DOE

Ideal Basic Industries
Cement Division

Ideal Plaza – 950 17th Street
P.O. Box 8789
Denver, Colorado 80201

303 623 5661

September 28, 1983

IDEAL

Mr. James C. Knudson, P.E.
Hazardous Waste Section
Solid Waste Management Division
Washington Department of Ecology
Mail Stop PV-11
Olympia, Washington 98504

Re: Seattle Plant Waste Kiln Dust
Certification of Designation as
Non-dangerous.

Dear Mr. Knudson:

I am today hand delivering a one pound sample of waste cement kiln dust from our Seattle, Washington Cement Plant. The sample being provided is from a composite of 28 samples taken over a 14 day period in accordance with a sampling plan approved by the Solid Waste Management Division of the Department of Ecology by letter dated May 27, 1983.

As of this date a similar one pound sample of waste kiln dust was furnished to a Seattle commercial testing laboratory for the analyses which are required for a Certification of Designation as non-dangerous. The results from the laboratory analyses of the dust sample will be submitted with our Certificate of Designation application to the Department of Ecology.

Sincerely yours,

IDEAL BASIC INDUSTRIES
CEMENT DIVISION

Harlan W. Powledge
Director, Environmental Quality

HWP/nm

cc: Mr. F. J. Bauer
Mr. L. L. Warner
Mr. W. T. Springman
Mr. R. E. Wallis
Mr. N. Greening
Mr. G. Miller

WAC 173-303-910(3)(c)

(iv) The Location of the Generating Facility.

The waste cement-kiln dust is generated at Ideal Basic Industries' Cement Manufacturing Plant in Seattle, Washington.

The address of the plant is:

Ideal Basic Industries
Seattle Cement Plant
5400 West Marginal Way S.W.
Seattle, Washington 98106

WAC 173-303-910(3)(c)

(v) A Description of the Manufacturing Processes or Other Operations and Feed Materials Producing the Waste and an Assessment of Whether Such Processes, Operations, or Feed Materials Can or Might Produce a Waste that is Not Covered by the Demonstration.

The only process-related waste material generated at a cement manufacturing plant is cement-kiln dust.

The following description of the Seattle Ideal Cement Plant was prepared in May, 1971, by John M. Haeger, P.E., Project Engineer. It has been updated to reflect current operating practices.

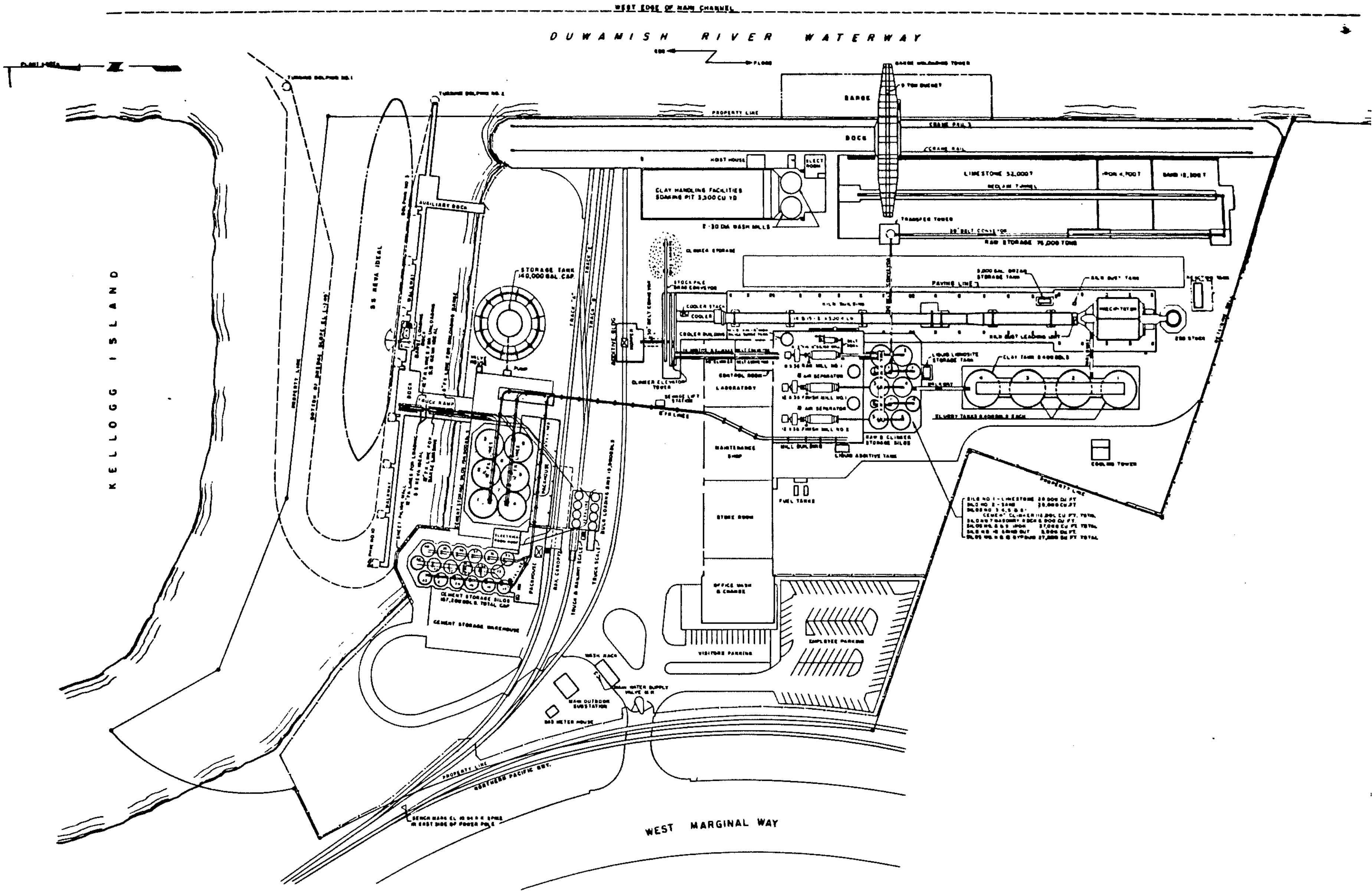
A complete description of cement and concrete, including historical perspectives, processing, composition, testing, and a description of the five common cement types is provided in Appendix D-1.

Operations Description

1. Introduction

Ideal Cement Company started operations at Seattle, Washington, in January 1962, with a cement distribution terminal. At the time when the terminal was constructed, our long range planning indicated that a production facility would be constructed on the site. Therefore, the terminal was planned and located to facilitate the addition of a plant at a later date. In November, 1964, corporate approval was given for construction of a 2,500,000 bbl. (470,000 ton) annual capacity plant at the Seattle Terminal Site. Engineering on the plant was started immediately. A contract for construction was awarded in April, 1965, and construction was started in May, 1965. The first cement was produced at Seattle in March, 1967. Figure 61 shows the general plant plan for the Seattle Cement-Manufacturing Plant.

All raw material required for production is shipped into the Seattle Plant by barge. The Seattle Plant uses a four component mix consisting of limestone, clay, sand, and iron slag. The limestone is quarried at our facility on Texada Island in British Columbia, Canada. The clay comes from our



IDEAL Ideal Basic Industries

SEATTLE CEMENT MANUFACTURING PLANT
GENERAL PLANT PLAN

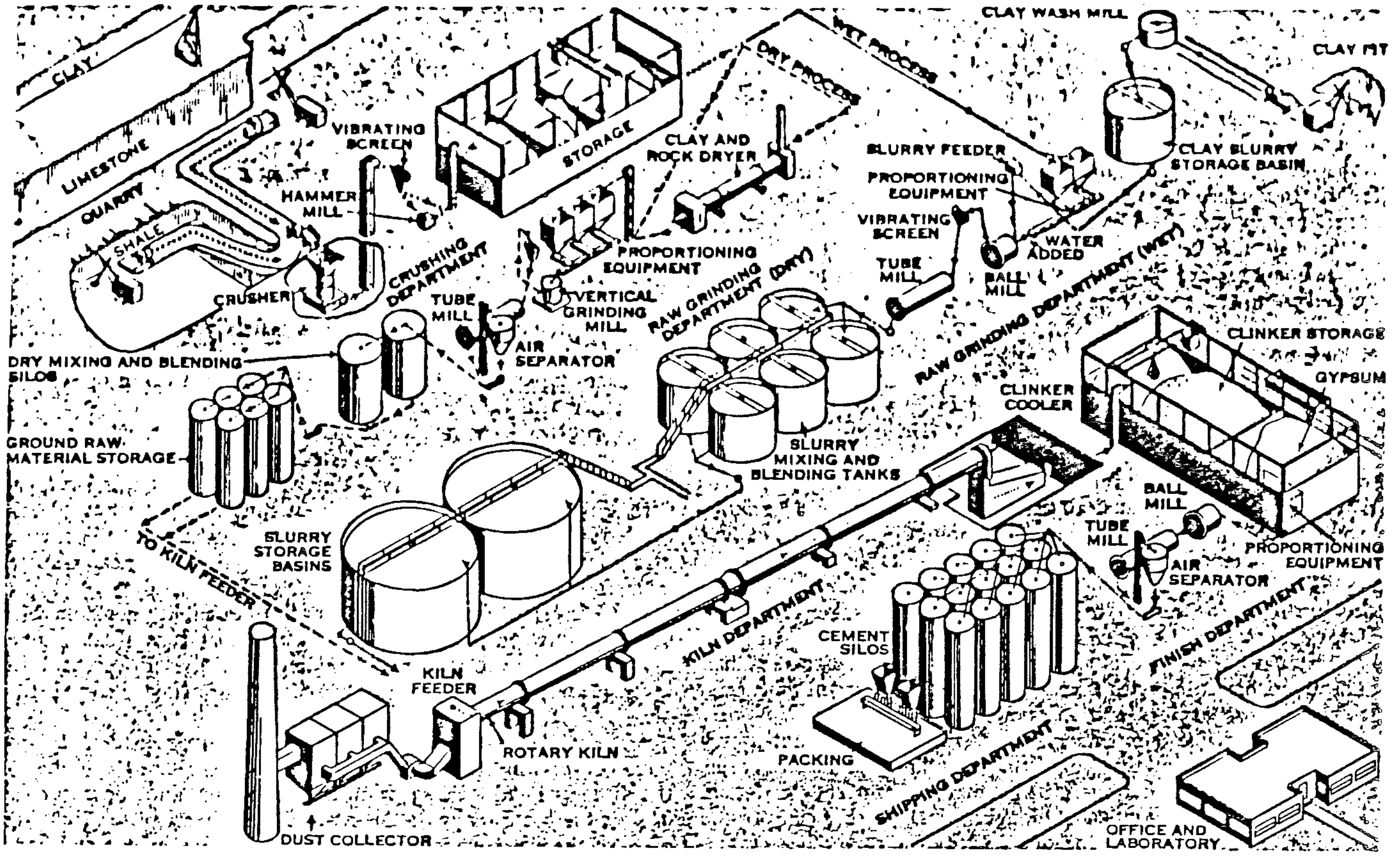
FIGURE 61

quarry at Twin Rivers, Washington, on the Strait of Juan De Fuca. Sand and iron slag are purchased from Industrial Mineral Products, Ravensdale, Washington.

With the exception of raw materials unloading, clay processing and the cement storage facilities, the entire manufacturing process is controlled from a central control room. The control room and the laboratory facilities are centrally located adjacent to the kiln and mill building. The raw proportioning, the raw mill and sand mill feed rate, the kiln and cooler operation, and the finish mill proportioning and feed rate are controlled by a direct digital computer. A laboratory type X-ray analyzer for raw material, clinker and cement analysis, is located in the control room.

2. Design Considerations

The design concept of the plant is generally that of a conventional wet process plant (Figure 62), with a central room, except that special attention was given to provisions for equipment maintenance, cleanup, safety, air and water pollution abatement. A concentrated effort was also made in the design of the plant structures to provide a facility



IDEAL

Ideal Basic Industries
Cement Division

FLOW OF MATERIALS THROUGH A CEMENT-MANUFACTURING PLANT

WET-AND DRY-PROCESS METHODS	FIGURE 62

which would have a pleasing appearance. The following is a brief discussion of these features:

a. Equipment Maintenance. In the plant design, particular attention was given to providing adequate access platforms for all equipment and to providing sufficient working room around the various pieces of equipment. Also, under this item special attention was given to the future requirement of rigging for repair work. To facilitate this, equipment hooks, monorails, jib cranes and bridge cranes were provided. It is interesting to note that many of these items could by justified in that they would nearly pay for themselves during construction of the plant. Needless to say, equipment maintenance was also a prime consideration in equipment selection.

The majority of the air compressors required for the plant were located in a central compressor room. The compressors provided a source of clean air which is filtered through a dust collector. The use of a dust collector eliminated the maintenance on many individual filters and resulted in a cleaner source of air.

All electrical rooms are pressurized with clean air filtered through dust collectors. This has been the most satisfactory method of pressurizing these electrical rooms used to date.

b. Cleanup. Careful consideration was given to plant cleanup. In some cases, use of cleanup conveyors under the belt conveyors was justified. In other cases, because of the length of the conveyors, it was necessary to rely on belt scrapers and brushes to minimize the cleanup problem. In reviewing the equipment supports, it was found that in many cases the cost of supporting the equipment from the ceiling or overhead beams was only slightly higher than the cost of supporting it from the floor. By eliminating the support to the floor, cleanup was appreciably facilitated. Vacuum cleaning systems were also provided as an important aid to cleanup.

c. Safety. This item goes hand-in-hand with the items discussed under a. and b. The access platforms, working room, monorails, etc., are not only factors in reducing maintenance costs but are also important safety features. Adequate cleanup is another safety consideration. Along with these items, proper guarding of equipment, together with providing the necessary handrails and toe plate, are important factors in providing a safe place for personnel to work.

d. Air and Water Pollution Abatement. All domestic sewage discharges into the METRO sanitary sewer. All plant waste water is recycled; therefore, the only discharge into the Duwamish Waterway is surface drainage. The latest equipment and technology is used for dust collection at the plant. There are 60 dust collectors throughout the plant, with an electrostatic precipitator on the kiln. This plant was one of the first to use a bag-type dust collector on the clinker cooler.

3. Barge Unloading.

The raw material barges are unloaded by a traveling unloading tower which is equipped with a 9-ton grab bucket and has a free digging rate of 1000 TPH. The average unloading rate is approximately 750 TPH. At this rate the raw material required for one week's operation can be unloaded in approximately 30 hours. The traveling unloading tower is equipped with a dump hopper, apron feeder and a stacker belt conveyor for placing the material into storage. It is also possible to place the material directly into storage with the bucket. This feature is used when unloading clay.

When unloading into the dump hopper, the dumping cycle is automatic. The hold, close and trolley motions are equipped with controls to provide automatic slowing down, and stopping of the trolley over the hopper, opening the bucket and restarting the trolley out to the barge. As the bucket returns to the barge, the control is transferred back to the operator who manually controls the digging cycle.

4. Raw Storage and Reclaim.

Limestone, sand and iron slag are stored in outside storage piles. The clay is stored in a clay soaking pit which will be discussed under item 5. The following are the capacities of the outside storage piles:

	Total	Live
1. Limestone	52,000 tons	25,000 tons
2. Iron	11,700 tons	2,300 tons
3. Sand	12,300 tons	3,000 tons

The limestone is reclaimed by a rotary plow feeder which has a capacity range of 530 TPH to 200 TPH. The normal rate of reclaim is 400 TPH. The rotary plow feeder has a big advantage over more conventional feeders in that the live storage is approximately 50 percent of the total, compared with 25 percent for the conventional feeders. The rotary plow transverses approximately 340 feet in the reclaim tunnel. The plow is controlled from the central control room. The tunnel is divided into seventeen 20 foot long sections. Each section has an indicating light on the control panel which lights when the plow is in that particular section.

The iron slag is reclaimed by a vibrating feeder which has a maximum capacity of 200 TPH. The sand is reclaimed by one of two vibrating feeders. Each has a maximum capacity of 400 TPH.

The limestone, sand, and iron slag feeders discharge onto a 30" belt conveyor which is one of four belt conveyors used to convert the raw materials to the storage silos. A belt scale is located on the third belt conveyor which gives the operator an indication of the feed rate of a starvation condition.

The belt conveyors have a capacity or 400 TPH. At each of the transfer points a dust collector has been provided. The last conveyor discharges directly into either a limestone silo, a sand silo, or a screw conveying system. The screw conveying system consists of three 24" screw conveyors which have a capacity of 200 TPH. These screw conveyors distribute the materials to two iron slag silos or a masonry rock silo.

The raw material silos have the following storage capacities:

1. Limestone Silo	1,600 tons
2. Sand Silo	1,300 tons
3. Two-Iron Slag Silos	875 tons each
4. Masonary Rock Silo	300 tons

All of these silos are vented by dust collectors.

5. Clay Processing

The clay is unloaded into a clay soaking pit where it is stored prior to washing in the washmills. The storage capacity of the soaking pit is 13,000 tons and is divided down the center so that two grades of clay can be stored.

A drag scraper is used to move the clay from the soaking pit to the washmills. The drag scraper is equipped with a 4 cubic yard crecent scraper and has a working capacity of approximately 200 cubic yards per hour. The washmills are 30'-0" in diameter and are capable of handling a liquid depth of approximately 10'0". Each wash mill can wash approximately 55 tons of dry clay per hour. The resulting clay slip has a moisture content of approximately 54 percent.

Two sump type slurry pumps, one in each wash mill, are used to pump the clay slip from the washmill to a screen where any trash or clay particles larger than 3/16" are separated from the clay slip. The sump pumps and the screen have a capacity of 1875 gpm of clay slip.

The clay slip which passes the screen falls into a sump. From this sump the clay slip is pumped to a clay storage tank by a slurry pump having a capacity or 1875 gpm. The clay slip storage tank has a storage capacity of 631,500 gals. (1700 tons dry) and is equipped with an air lift type agitator.

6. Raw Material Proportioning and Grinding

The sand silo has an 8'-0" long by 1'-4" wide slotted discharge. The iron slag silos have a 4'-0" long x 1'-4" wide slotted discharge. This type of discharge opening has been very effective in preventing the bridging of material in the hoppers. The sand, in some cases the sand and iron slag, is pre-ground before being added to the raw mill. The sand and iron slag are proportioned to a reversible belt conveyor by belt type weight feeders which have a capacity range of 10 to 1. The reversible belt conveyor normally will feed the sand to the sand mill feed belt conveyor; however, if a breakdown should occur in the sand mill circuit, it will feed the sand directly to the raw mill feed belt conveyor. The sand mill has a capacity of approximately 30 TPH and is 6'-7" inside diameter, by 14'-0" long. The sand mill is powered by a 250 horsepower motor. The product of the sand mill discharges to a sump and then to a rubber lined slurry pump which pumps the sand slip to a silica surge tank. This tank has a maximum capacity of approximately 25,000 gallons and is equipped with a propeller type agitator. The sand is pumped to the raw mill from the surge tank by a rubber throttling valve in combination with a magnetic flow meter.

The limestone silo has a conventional discharge hopper and the limestone is proportioned to the raw mill feed belt conveyor by a belt type weigh feeder which also has a capacity range of 10 to 1.

The clay required for the raw mix is pumped directly to the raw mill from the clay slip storage tank. It is also proportioned by a hydraulically actuated throttling valve in conjunction with a magnetic flow meter.

The proportioning of all the raw materials and the process water are controlled by the computer in conjunction with a laboratory type X-ray analyzer.

Approximaterly 90 percent of the required water is added to the inlet of the raw mill. The final 10 percent is added to the raw mill discharge sump and is controlled by a density gage in the slurry transport line.

The raw mill is an 11'-0" inside diameter by 36'-0" long ball mill with a trunion drive. The mill is driven at 17.4 RPM by a 2000 HP synchronous motor. The mill circuit is designed for a maximum capacity of 200 TPH (dry basis). From the raw mill the discharge pump pumps the slurry to two DSM Screens. The oversize are returned by gravity to the raw mill and the fines discharge into a sump. From this sump the slurry is pumped to one of three kiln feed tanks. These kiln feed tanks each have a capacity of 631,500 gals. (2,480 tons dry basis).

7. Kiln Feed

The three kiln feed tanks are equipped with combination air lift and rake type slurry agitators. Each tank has a storage capacity slightly in excess of one day's kiln feed.

Four slurry pumps were providid to pump the slurry from the kiln feed tanks to the kiln or to recirculate of transfer the slurry from one tank to another. The volume of the kiln feed is controlled by the computer in combination with a hydraulically-actuated throttling valve and magnetic flow meter. A standby magnetic flow meter was also provided, Through the use of air-operated valves the operator in the control room can interchange pumps. Flow valves are provided throughout the system so that maintenance can be performed on the pumps, air operated valves, hydraulically operated throttling valves and flow meters without interruption of operation.

8. Kiln and Cooler

The kiln has a diameter of 15'-6" at the feed end and a diameter of 14'-0" at the discharge end. It is 500' long and is supported on six piers. It was installed on a slope of 3/8" per foot. The kiln is equipped with a hydraulic thrust mechanism which consists of three axially-free thrust rollers held uphill by three interconnected hydraulic cylinders as to absorb the full downhill thrust of the kiln, with three equal loads being transmitted to the three riding rings. If the kiln moves downhill, a limit switch turns on the hydraulic pump which pumps additional fluid into the hydraulic cylinders to move the kiln back uphill until it contacts another limit switch, which shuts off the hydraulic pump. If the kiln is operating uphill from its normal operating position, a limit switch opens a solenoid valve, which drains a portion of the hydraulic fluid out of the cylinders, and allows the kiln to move down hill. When the kiln is back to the normal operating position, a limit switch closes the solenoid valve. The thrust mechanism is also equipped with limit switches which give the operator an alarm if the kiln is running up or down hill, past what is considered the normal operating range.

The kiln is driven by a pair of 300 HP D.C. motors with a magnetic amplifier controller. A 60 HP emergency drive was provided which is driven from a 125 KW diesel electric generating set.

The kiln hood is of stationary design, but does have a retractable front section to permit entry of a fork truck. The side of the hood has an additional access door. The front of the hood has openings for a combination gas and oil burner pipe, T.V. camera, insufflation pipe and a rayotube. A 50,000 CFM shell cooling fan and a ventilating duct were provided to cool approximately 90 feet of the kiln shell at the burning end as an aid in the formation of the protective coating on the kiln refractory.

The clinker cooler is a two stage unit with a clinker breaker between the two stages. The cooler has a capacity of 1360 TPH and cools the clinker to a final temperature of less than 150 degrees F. The first stage has three compartments and each of these compartments has a separate cooling fan. The last stage also has three compartments, but has only a single fan, with air distibution being achieved by a series of dampers.

The excess air from the cooler is exhausted through a Nomex-bag type dust collector. The dust collector bags are cleaned by a high pressure air pulse and their air-to-cloth ratio is 7.8 to 1. To protect the bags from high temperature during an upset condition, two safety features were provided. The first is an automatic damper which will bleed in outside air when the temperature of the exhaust gases reaches a pre-determined temperature. If the temperature continues to climb and a second set point is reached, a high pressure water spray system in the cooler is activated.

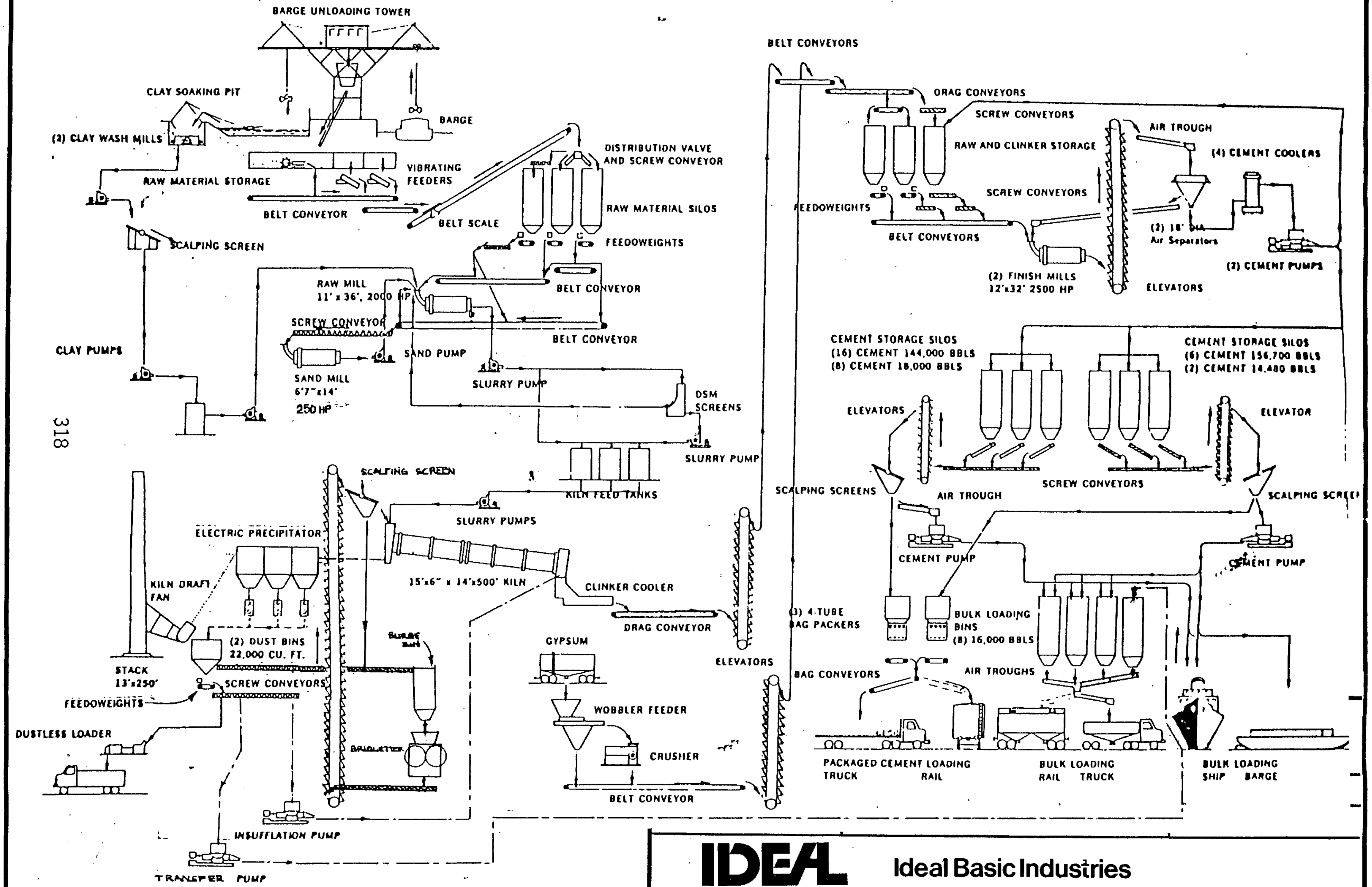
Two drag conveyors were provided which run the full length of the cooler and extend beyond the end of the cooler to two cross-drag conveyors. These drag conveyors pick up any cooler load to the cross-drag conveyors.

9. The Wet Process Cement Kiln

The wet process cement kiln, shown in Figure 63 is the heart of the cement-making process. Gases heated at one end flow through the kiln to heat solid materials introduced at the other end. The flow of hot gases through the kiln is controlled by an induced draught fan located at the feed end.

The feed, consisting of an aqueous slurry of limestone rock, finely ground clay, sand, iron waste, and water (30 to 35%), passes first through the chain section, which serves as a heat transfer medium, and then into progressively hotter sections of the kiln, until it passes through the flame and falls. Hot clinker is cooled by streams of air forced through the cooler grates, and then conveyed to storage or the cement-grinding process.

The kiln itself may be divided into six zones in which a certain sequence of physical and chemical reactions occur.



IDEAL Ideal Basic Industries

SEATTLE CEMENT MANUFACTURING PLANT
FLOW SHEET

DRAWING NUMBER
FIGURE 63

8½X11 PRINTED ON NO. 1000H CLEARPRINT

Zone 6 (feed zone) is where the raw slurry enters the kiln and approaches the chain section. Zone 5 (preheating zone) contains the chain section and dries the slurry to a nodulized or powdered solid. In zone 4 (dehydration zone), the solid is further heated and chemically-bound water from clays and other minerals is lost. Into zone 3 (calcining zone) the main calcium carbonate phase decomposes into quick lime and carbon dioxide gas.

As the calcined feed moves into zone 2 (clinkering zone), high-temperature chemical reactions occur. First, a liquid phase forms, consisting of calcium aluminates and aluminoferrites, then the feed balls into clinker nodules, about 1/2 inch to 2 inches in diameter. Upon further heating, to about 2700 degrees F., calcium silicate minerals form by crystallization out of the melt phase. Finally, the clinker cools somewhat as it moves through zone 1 (cooling zone) behind the flame, the melt phase solidifies, and the clinker is discharged into the cooler at a temperature of about 2150 degrees F.

10. Kiln Dust Collection and Dust Return

The exhaust gases from the kiln pass through an electrostatic precipitator which has three fields and is designed to handle 400,000 CFM at 700°F., at an inlet loading of 12 grains per cubic foot. The efficiency of the precipitator is rated at 99.83 percent at the above conditions.

The induced draft fan is sized for the same gas quantity as the precipitator and is located between the precipitator and a 13'-0" I.D. x 250' high stack. The air volume through the fan is varied by remote controlled dampers on the inlet of the fan.

The dust from the precipitator is collected in 12 pyramidal hoppers. From these hoppers the dust is conveyed to two dust bins by two pneumatic conveying systems. One of these systems has a capacity of 35 TPH and the other a capacity of 21.5 TPH. Six pneumatic feeders were provided, one for each two hoppers. The feeders have a single inlet with a double outlet. This arrangement makes it possible to segregate the dust which is collected by the various fields. This type of conveying system has an advantage over the conventional screw conveyor system in that it achieves a positive seal and prevents air infiltration into the precipitator.

The dust can be transferred to two loading bins at the packhouse from the two storage bins by an FK pump (6" size) connected to a C250 air compressor.

The following methods of returning the dust are provided.

1. Insufflation.
2. Briquetting the dust and feeding it in with the kiln feed.

Depending on the chemical properties of the dust, the operator can choose which of these methods to use; both are desirable.

11. Clinker and Gypsum Storage

From the clinker drags under the cooler, the clinker discharges to one of two double 12" drag conveyors which convey the clinker to two 24" continuous type elevators. One of the drag conveyors is strictly a standby conveyor;

however, one of the elevators is normally used to convey the gypsum from the gypsum unloading hopper to the storage silos. In case there is a breakdown in the main clinker elevator, the clinker can be switched into the gypsum elevator.

The gypsum received by truck or rail is unloaded into a dump hopper over a Wobbler Feeder. A car shaker is provided over the hopper as an aid to unloading the rail cars. The Wobbler Feeder has a maximum capacity of 150 TPH and has 3/4" openings between the bars. Any oversize material is fed to a granulator also having a maximum capacity of 150 TPH. A belt conveyor conveys the gypsum from the feeder and the crusher to the gypsum elevator previously mentioned. From the elevators the clinker and gypsum discharge to two identical conveying systems that convey the materials to their respective storage silos. Each conveying system consists of a belt conveyor and a drag conveyor which have a capacity of 150 TPH. Because belt conveyors were used within these conveying systems, a hot clinker drag conveyor was installed to take the clinker to an outside storage pile when the clinker temperature exceeds a predetermined temperature. The system is completely automatic and is activated by a thermocouple at the discharge of the cooler.

Four clinker silos were provided, each having a capacity of 7000 bbls of clinker (1260 tons). Two gypsum silos were provided each with a capacity of 575 tons.

The elevators, all belt conveyor transfer points, and the silos are vented by dust collectors.

12. Finish Proportioning and Grinding

Two identical systems for finish grinding have been provided except that only one mill can grind masonry. Each system includes a 2500 HP trunion drive finish mill. The clinker and gypsum, and raw limestone on one mill only, are proportioned on to a 30" belt conveyor by weigh belt-feeders. Where possible, the feeders are mounted above the belt conveyor so that any dribble from the feeders will be picked up by the belt conveyor. Where it was necessary to install the belt feeder perpendicular to the belt conveyor, a cleanup screw conveyor was mounted beneath the feeder to pickup the dribble.

The finish mill belt was also provided with a cleanup conveyor for its complete length. In this instance an 8" drag conveyor was used to pick up the dribble. All of the transfer points on the conveying systems were vented to dust collectors on top of the silos.

The finish mills are 12'-0" inside diameter, by 32'0" long ball mills. The mills are driven at 17.2 RPM by a 2500 HP synchronous motors. The finsih mill circuit is designed for a 450 percent circulating load. The mill discharges into a 20" pneumatic conveyor which conveys the load to a 36" elevator. The elevator discharges into another 20" pneumatic conveyer which conveys the material to an 18'-0" diameter air separator powered by a 250 HP motor. The oversize from the separator is conveyed by a 20" pneumatic conveyor back to the feed end of the finish mill. The finished product discharges by gravity to two cement coolers. Diverting valves were also provided to allow the operator to go directly to a pneumatic pump.

The cement coolers are 6'-6" diameter by 17'-7" high and will cool the cement to a final temperature of 130^0 F. The cement coolers discharge to a pneumatic pump. The pneumatic pump on either mill circuit can pump the cement to any of the silos or to a marginal bin, except that only one pump only can pump to the masonry cement storage silo.

Three dust collectors were provided on each mill circuit. Two dust collectors in parallel are used to air sweep the separator and vent the pneumatic pump hopper. The third collector vents the finish mill and the finish mill elevator.

13. Cement Storage and Shipping.

The original cement distribution facility consisted of six storage silos and two interstices which have a total storage capacity of approximately 195,000 bbls (36,700 tons), a packhouse with one four tube bag filling machine, facilities for loading sack, truck and rail, and bulk loading facilities for loading rail, truck and barge. The rail and truck-bulk loading failities included eight bulk-loading bins having a total storage capacity of approximately 16,000 bbls. (3,000 tons) of cement. Four of these bulk-loading bins are mounted over a combination rail and truck scale. The other four bins are mounted over a truck scale. The original terminal also has facilities for unloading cement from ship, barge, rail cars and bulk truck, and all are still in existence.

When the plant was built, twenty-four additional silos and bins were added which have a total capacity of approximately 167,000 bbls. (31,400 tons) of cement. Included with the new silos was a packhouse which has two four tube bag-filling machines and bag conveyors which were tied into the conveyors constructed as part of the original facility. One of the bag-filling machines is for packing masonry only and is used in conjunction with a captive masonry storage and conveying system. The bag conveyors are laid out so that sack cement can be loaded into trucks or rail cars, or can be palletized and stored in the warehouse which was constructed adjacent to the new silos.

A pneumatic conveying system was also provided in the new silos for transferring cement to the bulk-loading tanks or for direct loading into ships or barges.

The bulk-loading facilities are capable of loading bulk truck and rail at approximately 1500 bbls. per hour (282 TPH), barge at 1000 bbls. per hour (188 TPH), and ship at 2000 bbls. per hour (376 TPH).

(vi) A Description of the Waste and an Estimate of the Average and Maximum Monthly and Annual Quantities of Waste Covered by the Demonstration.

Description of the Waste

Cement-kiln dust produced at Ideal Basic Industries' Seattle Cement Manufacturing Plant is a solid, dry, non-combustible, inorganic mineral byproduct. It occurs in shades of gray. Its bulk density ranges from three to seven lbs/gal, or 22 to 58 lbs/cu. ft. (average 50 lbs/cu. ft.). While all raw materials at the cement plant are ground to minus 200-mesh, a significant amount of fine particulates are swept up the stack by hot combustion gases where they are captured by the electrostatic precipitator. Particle sizes of the CKD range from -6 to +68 microns. An important factor associated with CKD dust particle size is the distribution of alkalies in the dust. Sodium and potassium sulfates, chlorides and carbonates exhibit a strong tendency to concentrate in the fine fraction of collected dust because the specific surface area of the particles increases dramatically as effective diameter decreases (Davis and Hooks, 1975).

The average chemical composition of Ideal's CKD is shown on Figure 4. Chemical composition of the CKD is determined by the raw material composition and the conditions the dust particles have encountered in the kiln. Careful analysis of most CKD samples reveal a variety of trace elements, shown in the EP Toxicity Test results under Section -910(3)(c)(x).

The collected CKD has experienced some degree of calcination and thus has a lower content of CO_2 than the raw materials. The loss-on-ignition value of the dust averages 24.8 percent compared to a higher value for raw materials. The degree of CO_2 depletion is an indication of how hot the dust became and, therefore, the distance it traveled down the kiln before becoming airborne and escaping with the gases. Because the CKD is partially calcined, it has the ability to harden somewhat upon exposure to moisture (Davis and Hooks, 1975). The pH of Ideal's fresh CKD attains a high of 12.4. Through time and exposure to atmospheric moisture, pH drops to at least 9.9, as demonstrated by analysis of a sample collected from the South Park land fill where CKD was deposited in the late 1960's.

Average Maximum and Minimum and Annual Quantities of Waste CKD

The following information was provided by Larry Darby, Production Manager for the Ideal Basic Industries' Seattle Plant, in the following letter, dated October 2, 1984:

Current dust loss is at 90 tons/day. The maximum in the last year was 125 tons/day, or about 3,800 tons per month leaving the system, some of which was sold for soil conditioner and fertilizer. The minimum was 77 tons/day, for 2,300 tons/month. The average daily cement-kiln dust loss per month is charted in Figure 64.

The estimated annual tonnage for 1984 will be the lowest in the last six years, as can be seen by Table 20, Cement-Kiln Dust Production from 1979 to 1984 for the Seattle Plant. The estimated annual tonnage for 1984 will be 44,000 tons lost and only 13,490 tons hauled to waste. This drop in CKD production is due to lower input and the fact that in June, 1983, Ideal started burning a coke-coal mixture instead of straight coal.

The tonnages reported here differ from those reported on the December, 1983, Petition for Exemption (Appendix A-4). The current results are more accurate because they represent actual conditions throughout the year, rather than projections developed by corporate headquarters. The reasons for the pronounced difference in tonnages put to waste are stated in the preceding paragraph.

Ideal Basic Industries
Cement Division

Seattle Plant
5400 West Marginal Way S.W.
Seattle, Washington 98106
206 937 8025

IDEAL

Seattle Plant Dust Production

October 2, 1984

Glennda McLucas
Consulting Geologist
P.O. Box 5352
Lacey, WA 98503

Glennda:

Waste dust generation is down this year, compared to previous years. By the attached chart you can see the drop clearly. This is due to lower input and the fact that in June of 1983 we started burning a coke-coal mix instead of straight coal.

Our current rate of dust loss is at 90 tons/day. The maximum in the last year was 125 tons/day, or about 3800 tons leaving the system, some of which was sold for soil conditioner and fertilizer. The minimum was 77 tons for a daily average or 2300 tons for a monthly total. Our estimated annual tonnage for 1984 will be our lowest in the last 6 years at 44000 tons lost and only 13490 hauled to waste.

Samples of very old dust from the original dump sites as well as dust from older IMP dump sites were sent to our Research Lab for testing.

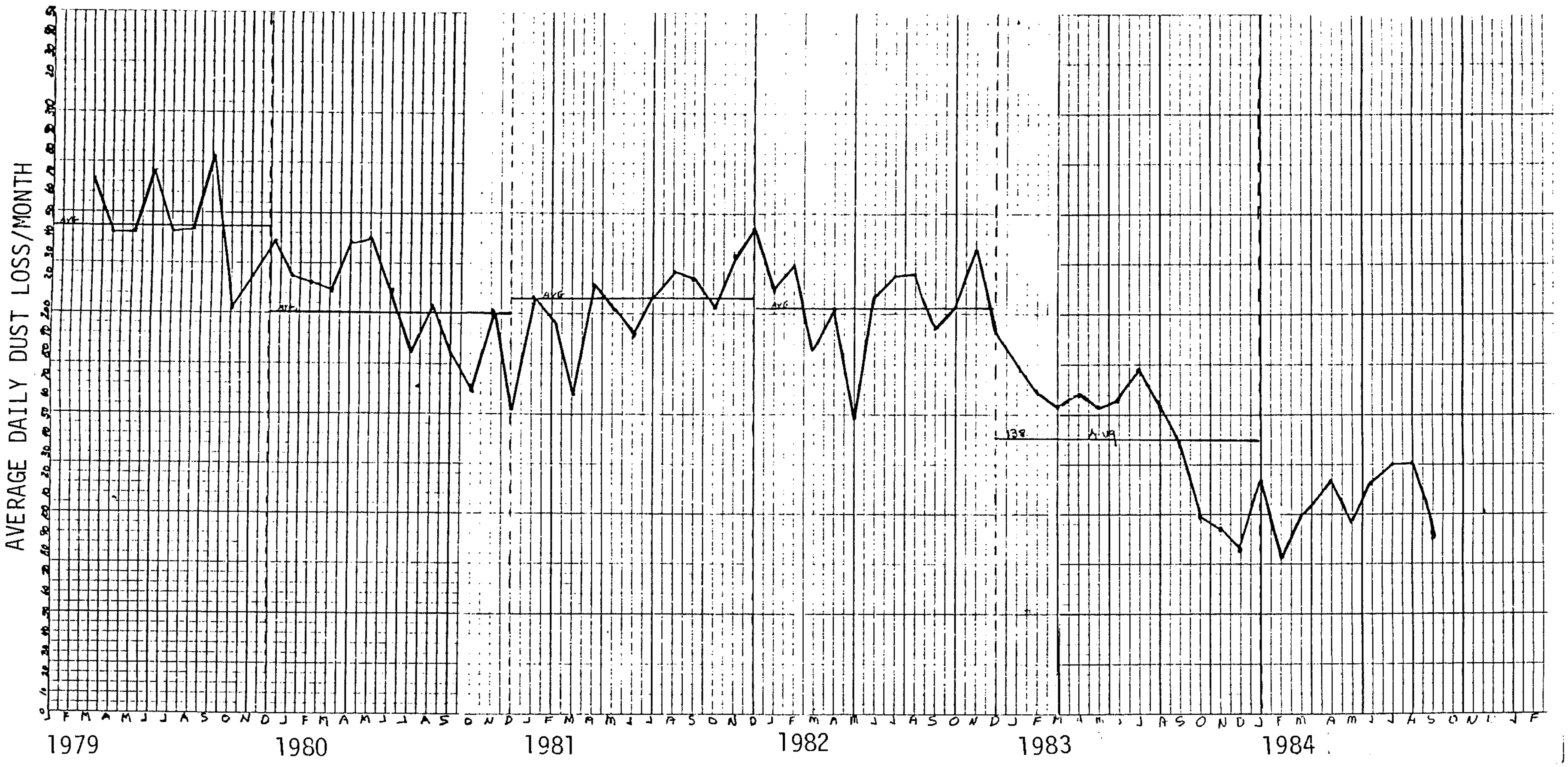
Attached please find an updated sheet of dust produced over the years.

Sincerely,

L Darby

L. Darby

LD:dp



Ideal Basic Industries

SCALE:	**APPROVED BY:**	**DRAWN BY**
DATE:		**REVISED**

AVERAGE DAILY CEMENT KILN DUST LOSS PER MONTH

FIGURE 64

IDEAL

TABLE 20

Cement-Kiln Dust Production from 1979 to 1984, for the Seattle Plant. October 2, 1984.

Year	Waste Status		Tonnages
1979	WASTED *	=	67198
	SOLD	=	35544
	HAULED	=	31654
	RETURNED **	=	93563
	GENERATED	=	160761 TONS
1980	WASTED	=	70747
	SOLD	=	22138
	HAULED	=	48610
	RETURNED	=	112374
	GENERATED	=	181321 TONS
1981	WASTED	=	71061
	SOLD	=	15385
	HAULED	=	55676
	RETURNED	=	87317
	GENERATED	=	158378 TONS
1982	WASTED	=	87394
	SOLD	=	21747
	HAULED	=	65647
	RETURNED	=	71285
	GENERATED	=	158679 TONS
1983	WASTED	=	56282
	SOLD	=	23696
	HAULED	=	32586
	RETURNED	=	64744
	GENERATED	=	121026 TONS
1984 YR. TO DATE	WASTED	=	29167
	SOLD	=	20174
	HAULED	=	8993
	RETURNED	=	46855
	GENERATED	=	76022 TONS
1984	WASTED	=	43751
	SOLD	=	30261
	HAULED	=	13490
	RETURNED	=	70283
	GENERATED	=	114034 TONS

* WASTED = SOLD + HAULED (TO LANDFILL)

** RETURNED TO KILN

(vii) Pertinent Data on and Discussion of the Factors Delineated in WAC 173-303-072(3) and Where Applicable, (4) and (5).

WAC 173-303-072(3) states: Basis for exempting wastes: To successfully petition the department to exempt a waste, the petitioner must demonstrate to the department that:

(a) He has been able to accurately describe the variability or uniformity of his waste over time, and has been able to obtain demonstration samples which are representative of his waste's variability or uniformity; and, either

(b) The representative demonstration samples of his waste are not designated DW or EHW by the dangerous waste criteria, WAC 173-303-100 through 103; or

(c) It can be shown, from information developed by the petitioner through consultation with the department, that his waste does not otherwise pose a threat to public health or the environment, except that this basis for exemption is not applicable to wastes which exhibit any of the characterisitics specified in WAC 173-303-090.

3(a) The uniformity of CKD composition over time was demonstrated through execution of the sampling plan submitted to and approved by DOE on May 3 and May 27, 1983, respectively [see sampling plan, Section -910(3)(c)(iii) above]. For a two-week period, two one-pound samples of the subject CKD were collected daily, one in the morning and one in the afternoon. Splits of these samples were submitted to the DOE and to Biomed Research Laboratories, Inc., Seattle.

3(b) Ideal's CKD was captured as a dangerous waste by WAC 173-303-101 Toxic Dangerous Wastes, Subsection (3)(c) the bioassay testing methods adopted under WAC 173-303-110(3) Biological Testing Methods, revised July, 1981, describing procedures for (i) Static Acute Fish Toxicity Test.

The subject CKD was not captured by any other testing methods under WAC 173-303-101, nor by Sections WAC 173-393-100 Dangerous Waste Criteria; WAC 173-303-102 Persistent Dangerous Wastes; nor WAC 173-303-103, Carcinogenic Dangerous Wastes. Neither is CKD captured by WAC 173-303-082, Dangerous Waste Sources List, nor by WAC 173-303-083, Infectious Dangerous Wastes.

3(c) Ideal's CKD does not exhibit any of the Dangerous Waste Characteristics specified in WAC 173-303-090, including ignitiability, corrosivity, reactivity, or EP toxicity. Proof of this is provided by the independent testing laboratory results provided in Section WAC 173-303-910(3)(c)(x). The petitioner has demonstrated that CKD from the Seattle Plant of Ideal Basic Industries does not otherwise pose a threat to public health or the environment through development of evidence presented in Section WAC 173-303-910(1)(b)(iv) above. The reader is, therefore, referred to that section of this exemption document.

Sections WAC 173-303-910 (4) and (5) are not applicable because Ideal's CKD is not captured under WAC 173-303-081 or WAC 173-303-082 and because its designation is not based solely on the basis of chromium content.

(viii) A Description of the Methodologies and Equipment Used to Obtain the Representative Samples.

The following sampling plan was approved by the Department of Ecology:

Because of the value of the cement-kiln dust collected in the precipitator, every effort is made to return as much as possible of this material back to the cement-manufacturing process. However, the Seattle plant is presently capable of returning only about 61-percent of the collected dust. The remaining 39-percent, by necessity, becomes either a salable product or a waste material. Ideal is presently estimating that about 45-percent of all of the collected kiln dust has been, and will continue to be, disposed of as a waste material. On an average, this amounts to about 90 tons-per-day.

The precipitator at the Seattle plant is a Buell two-parallel-section, three-stage, 12-hopper unit designed for operation with 400,000 CFM at 700°F. The unit segregates the entrained dust by particle size by removing the heavier particles and approximately 80-percent of the dust load in the first stage. Ideal estimates that about 16-percent and 4-percent of the total dust load is collected in the second and third stages, respectively.

From the precipitator hoppers, the collected kiln dust is pneumatically conveyed to two nearby dust bins. All precipitator stage-one dust is separately stored in one bin and remaining dust from stages two and three is temporarily stored in the other bin. All process return dust is withdrawn from the stage-one bin. As required, the excess dust from this bin and all of the stage-two and stage-three dust from the other bin is pneumatically conveyed to either of two designated truck bulk-loading silos. Waste dust is withdrawn from either of these storage silos as required for final landfill disposal.

The Seattle Plant manufactures only three types of cement, Type I, Type I-II and Type III. However, Types I and I-II account for about 80 to 85 percent of the plant's production, the majority of which is Type I-II,for about 45 to 50-percent of the total. For the raw material used at the Seattle Plant, typical raw material design mixes for the three cement types are as follows:

	CEMENT TYPE		
	I	I-II	III
Limestone	80.2%	80.21%	80.87%
Sand		.04%	.24%
Clay	19.8%	19.68%	18.78%
Iron		.07%	.11%

Type I cement differs from the other two types only by the requirement of sand and iron.

The sampling procedure proposed by Ideal is as follows: For a two-week period during a production run of Type I-II cement, two one-pound samples of the waste dust were taken daily, one in the morning and one in the afternoon. The samples were taken from the waste dust-haul truck immediately after it is loaded from the waste dust silo. Waste kiln-dust samples are taken from production of Type I-II cement because it represents the majority of the cement produced at Seattle, and because all raw-materials are required for its production. Because of the pneumatic-conveying and bin-loading operations that take place up to the time of sample-gathering, adequate mixing of the waste kiln-dust had occurred. Samples were stored in a container provided by the plant. After all 28 samples had been taken, the stored dust was thoroughly remixed prior to submitting final one-pound samples for testing to the Hazardous Waste Section of the Washington State Department of Ecology, to Ideal's Research Department in Fort Collins, Colorado, and to Biomed Research Laboratories in Seattle.

(ix) A Description of the Sample Handling and Preparation Techniques, Including Techniques Used for Extraction, and Preservation of Samples.

All necessary information is included in Ideal'sampling plan included in subsection (viii).

(x) Description of Tests Performed (Including Attached Results).

The following tests were performed by Biomed Research Laboratories:

1. EP Toxicity
2. Halogenated Hydrocarbon Content
3. Polycyclic Aromatic Hydrocarbon Content
4. Static Acute Fish Bioassay
5. Acute Oral Rat Toxicity
6. Corrosivity
7. Ignitability
8. Reactivity

In accordance with Chemical Testing Methods for Complying with the Dangerous Waste Regulations, revised July, 1983, referenced in WAC 173-303-110(3), the following test procedures were used:

(1) Determination of extraction procedure (EP) toxicity: Extraction Procedure Test Methods, Appendix D.

(2) Determination of halogenated hydrocarbon concentrations: Parr Bomb Test for Total Chlorine; Section III, Narrative of WDOE Tests for Criteria Covering Persistent Classes of Chemical Compounds, Subsection B, p.5.

(3) Determination of polycylic aromatic hydrocarbon concentrations: Analysis for Polynuclear Aromatic Hydrocarbons; Section III, Narrative of WDOE Tests for Criteria Covering Persistent Classes of Chemical Compounds, Subsection c, p.5.

(4) Determination of aquatic fish toxicity (TLM or Aquatic LC): Static Acute Fish Toxicity Test, described in Biological Testing Methods, referenced in WAC 173-303-110(3)(b)(i).

(5) Determination of oral rat toxicity (LD_{50}): Acute Oral Rat Toxicity Test described in Biological Testing Methods, revised July, 1981, referenced in WAC 173-303-110(3)(b)(i).

(6) Determination of corrosivity: as per Test Method For Determining pH of Solutions in Contact with Solids, March, 1984: Chemical Testing Methods (Addendum), WDOE 83-13.

(7) Determination of ignitability: Test Methods for Evaluating Solid Wastes - Physical Chemical Methods, EPA-SW-846, Federal Register, May 19, 1980, referenced in Section II, Narrative of EPA Tests for Hazardous Waste Characteristics, p.1, WDOE Chemical Testing Methods, March, 1982.

(8) In a letter to Ideal Basic Industries, dated October 8, 1984 (attached to test results), Biomed Research Laboratories suggested that the Reactivity Test need not be performed on Ideal's CKD because, by the nature of the industrial processes that generate CKD and its chemical composition, it was not expected to exert any of the characteristics that define reactive waste materials.

Ideal personnel chose to have the reactivity test performed, nonetheless, using the Narrative of EPA Tests for Hazardous Waste Characteristics, p. 2, WDOE Chemical Testing Methods, March 1982

WAC 173 303 910 (3)(c)

(xi) The Names and Model Numbers of the Instruments Used in Performing the Tests and the Date of the Last Calibration for Instruments Which Must Be Calibrated According to Manufacturer's Instructions.

The following information was received from Biomed Laboratories on September 13, 1984.

TEST	INSTRUMENT OR EQUIPMENT	MODEL NO.	DATE SERVICED
EP TOXICITY			
Metals	Instrumentation Laboratory AA/AE Spectrophotometer	151	April, 1983
Pesticides and Herbicides	Varian Aerograph gas Chromotograph	374000-00	April, 1983
Halogenated & Polycyclic Aromatic Hydrocarbons	Classical		
CORROSIVITY	Corning pH Meter	12	April, 1983
IGNITABILITY	Classical (open cup)		
ACUTE ORAL RAT TOXICITY	As required by WAC Standard		
STATIC ACUTE FISH BIOASSAY	As required by ASTM E 729-80		
REACTIVITY	Lab glassware		

BIOMED
RESEARCH LABORATORIES, INC.

October 25, 1983

Ideal Basic Industries
Cement Division
Ideal Plaza
950 17th Street
P.O. Box 8789
Denver, Colorado 80201

ATTENTION: Harlan W. Powledge

SUBJECT: Static acute fish bioassay testing on juvenile rainbow trout, Salmo gairdneri.

Acute oral rat toxicity on male albino white rats.

SAMPLE ID: Lab #10041 Waste cement kiln dust

PROCEDURE: The above sample was tested on fish at the 1000 ppm level, then retested at the 100 ppm level. The sample was tested on fish a third time at the 1000 ppm level under pH controled conditions. The procedure followed is outlined in the State of Washington's General Procedure for Static Acute Fish Bioassay Testing.

RESULTS: Thirty (30/30) of the fish tested with BioMed sample #10041 at the 1000 ppm level died within 2 hours of adding the toxicant to the water.

None (0/30) of the fish tested at the 100 ppm level died throughout the four day test period.

None (0/30) of the fish tested at the 1000 ppm, pH adjusted to approximately 7.0 level died throughout the four day test period.

None (0/90) of the control fish tested died throughout the test period.

None (0/10) of the rats gavaged with BioMed sample #10041 died throughout the 14 day test period.

None (0/10) of the control rats died throughout the same test period.

CONCLUSIONS: Ideal sample of waste cement kilm dust, BioMed #10041 was found to be toxic to juvenile rainbow trout at the 1000 ppm level, and is therefore to be considered a dangerous waste material under Washington State Guidelines. (Note: "A waste material would be designated a dangerous waste if greater than 11 cumulative deaths out of 30 test organisms occurred within 96 hours at a concentration of 1000 ppm." I hope that the rest of the information contained in this report and the findings of the Chemistry Department will be of value to you in determining the exact toxic nature of this substance.

Respectfully submitted,

Kevin Casey

Kevin Casey,
Fisheries Biologist

BIOMED
RESEARCH LABORATORIES, INC.

November 16, 1983

Harlan Powledge
C/0 Ideal Basic Industries
Ideal Plaza
950 17th St.
P.O.Box 8789
Denver, Colorado 80201

Waste Analysis of Cement Kiln Dust

Lab# 10041

Substance	EP Tox Limit (ppm)	Concentration found (ppm)
Ag	5	<0.1
As	5	<1.
Ba	100	<50
Cd	1	<0.1
Cr	5	<0.5
Hg	0.2	<0.1
Pb	5	<1.
Se	1	<0.1
Endrin	0.02	<0.005
Lindane	0.4	<0.01
Methoxychlor	10	<5
Toxaphene	0.5	<0.2
2, 4-D	10	<3
2,4,5-TP	1	<0.3

Respectfully submitted,

Floyd R. Kirk

Floyd R. Kirk
Chemist

BIOMED
RESEARCH LABORATORIES, INC.

LABORATORY REPORT

CUSTOMER:

Harlan Powledge
C/O Ideal Basic Industries
P.O. Box 8789
Denver, CO 80201

LABORATORY USE ONLY
LAB #: 10041
REPORT DATE 9/25/84
CUSTOMER P.O.#
APPROVED

SAMPLE I.D.

SAMPLE DESCRIPTION Cement Kiln Dust Analysis

These results are being re-sent to you in response to your phone call.

PAH:	< 1%
Chlorinated hydrocarbons:	< 0.01%
Ignitibility:	No
Corrosivity:	No

Respectfully Submitted,

Floyd R. Kirk

Floyd R. Kirk,
Chemist

BIOMED
RESEARCH LABORATORIES, INC.

October 8, 1984

Ms. Glenda McLucas
Consulting Geologist
P.O. Box 5352
Lacey, WA 98503

Dear Ms. McLucas;

Thank you for your call regarding testing for Reactivity as defined by Chapter 173-303 of the W.A.C. The cement kiln dust from Ideal Basic Industries, by the nature of industrial processes which formed it and the expected chemical composition of the dust itself, is expected to exert none of the characteristics that define reactive waste materials. For that reason I believe that attempting to run the typical tests as defined by Chemical Testing Methods for Complying with the Dangerous Waste Regulation (DOE, 7/83) would prove futile.

Thank you for your inquiry and please let me know if I can be of further service.

Sincerely,

Craig E. Delphey

Craig E. Delphey, Ph.D.
Director of Chemistry

CED/gd

Washington Department of Ecology

DATA SHEET FOR STATIC BASIC ACUTE FISH TOXICITY TEST*

Industry/Toxicant: Ideal Basic Industries - Cement Division
Address: Ideal Plaza 950 17th Street P.O. Box 8789 Denver Co. 80201
Collector: HARLAN W. Partridge
Date Sample Collected: 4/4/93

Laboratory: Biomed Research Labs
Analyst: KEVIN CASEY
Beginning Date: 10/4/93 Time: 12.00 Am
Ending Date: 10/8/93 Time: 12.00 Am
Test Organism: Salmo gairdnerii (Rainbow trout)
Required Test Temperature Range: 11.5°C - 12.5°C

Laboratory Reference Number	Test Container No.	Conc. (mg/l)	Number of Cumulative Deaths 0	24	48	72	96	Dissolved Oxygen (mg/l) 0	24	48	72	96	pH 25 C 0	24	48	72	96	Temperature (C) 0	24	48	72	96	Total Hardness (mg/l as CaCO$_3$) 0	96	Total Alkalinity (mg/l as CaCO$_3$) 0	96	Conductivity uMHOS 0
Control	1	–	0	0	0	0	0	11	10	8	7	6	6.8	—	—	→	6.4	12	12	12	12	12	26.3	26.3	24.0	25.0	75
Control	2	–	0	0	0	0	0	11	10	9	7	6	6.4	—	—	→	6.2	12	12	12	12	12	26.0	25.7	23.0	29.7	70
Control	3	–	0	0	0	0	0	11	10	8	7	6	6.9	—	—	→	6.4	12	12	12	12	12	25.4	25.4	22.0	27.0	80
smolt TF																											
10041	4	1000ppm	10					11	10	8	7	6	11+	—	—	—	→	12	12	12	12	12	103.2	—	93.5	—	47
10041	5	1000PPM	10	w/in 2 hours				11	10	8	7	6	11+	—	—	—	→	12	12	12	12	12	91.1	—	75.0	—	352
10041	6	1000PPM	10					11	10	8	7	6	11+	—	—	—	→	12	12	12	12	12	103.0	—	106.5	—	352
10041	7	100 PPM	0	0	0	0	0	11	10	8	7	6	9.2	—	—	→	6.4	12	12	12	12	12	54.2	67.4	33.5	57.0	110
10041	8	100 PPM	0	0	0	0	0	11	10	8	7	6	9.0	—	—	→	6.4	12	12	12	12	12	71.7	67.2	32.5	57.0	110
10041	9	100 PPM	0	0	0	0	0	11	10	8	7	6	9.2	—	—	→	6.4	12	12	12	12	12	61.7	67.2	34.5	60.0	110
10041	10	1000 PPM	0	0	0	0	0	11	10	8	7	6	5.0	—	—	→	6.6	12	12	12	12	12	562	256	129	40.1	600
10041	11	1000 PPM	0	0	0	0	0	11	10	8	7	6	7.4	—	—	→	6.4	12	12	12	12	12	56[illegible]	253	72	47.5	650
10041	12	1000 PPM	0	0	0	0	0	11	10	8	7	6	7.9	—	—	→	6.4	12	12	12	12	12	56[illegible]	257	91.5	56.5	600
PH adjust to	≥7.0																										

B

Sample Description: Waste Cement Kiln Dust - semidissolvable in water.
Average Weight: 6.15 gms/ Mean Length: 6.9 cm Longest: 5.0 cm Shortest: 6.3 cm Ratio (long/short): 1.26
Number of organisms per chamber: 10 fish Ratio of flesh to water: 1.83 gms/L Comments: Waste Cement Kiln dust dissolved well in water. Killed fish within 2 hours at the 1000 ppm level. All fish survived at the 100 ppm level but were somewhat affected behaviorally. PH adjusted at the 1000 ppm level [illegible]

* Method on file with the Department of Ecology
GENERAL PROCEDURE FOR STATIC BASIC ACUTE FISH TOXICITY TEST

DATA VERIFIED BY Kevin Casey DATE 10/21/93

EHW > 10/30
DW > 11/30

ECY 090-1-48

DATA SHEET FOR ACUTE ORAL RAT TOXICITY TEST

INDUSTRY/TOXICANT Ideal Basic Industries
BIOMED RESEARCH LABORATORIES, INC. # 10241
ADDRESS Ideal Plaza 950 17th Street P.O. Box 8789
ANALYST Kevin Casey
COLLECTOR Denver, Co. 80201 C/o Harlan Powedge
BEGINNING TIME & DATE 10/10/83 12:00 Am Noon
DATE SAMPLE COLLECTED 4/4/83
ENDING TIME & DATE 10/24/83 12:00 Am Noon
TEST ORGANISM Male Albino white RATS
DOSAGE LEVEL Control Animals.

RAT # Controls	WEIGHT	DOSAGE	OBSERVATIONS
#1	345 gms	—	a) After dosage: All 10 control animals
2	365	—	b) One hour: were handled and weighed in
3	370	—	c) Four hour: the same manner as the
4	365	—	d) One day: test animals. All control
5	380	—	e) 14 days: animals were observed to respond
6	375	—	to this in a similar manner as did
7	350	—	the test animals. There were no
8	360	—	deaths throughout the 14 day
9	365	—	test period.
10	355	—	Kevin Casey

BIOMED
RESEARCH LABORATORIES, INC.

LABORATORY REPORT

CUSTOMER:

Mrs. Glenda McLucas
Consulting Geologist
PO Box 5352
Lacey, WA 98503

LABORATORY USE ONLY
LAB #: 3164
REPORT DATE 10/29/84 CUSTOMER P.O.# APPROVED

SAMPLE I.D.

SAMPLE DESCRIPTION Reactivity of Cement Kiln Dust

This sample of cement kiln dust, tested according to "Chemical Testing Methods for Complying with the Dangerous Waste Regulation :Chapter 173-303 WAC" of March 1982 (revised July 1983), was found to be not reactive.

Respectfully submitted,

Floyd R. Kirk

Floyd R. Kirk
Chemist

WAC 173-303-910(3)(c)

(xii) The Following Statement Signed by the Generator of the Waste or His Authorized Representative:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this demonstration and all attached documents, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Fred Bauer
Senior Vice President and
General Manager, Pacific
Region

REFERENCES

Harper, J. M., and Curran, R. J., 1971, Interesting Features of Ideal's Seattle, Washington Plant: Presented at I.E.E.E. Cement Industry Technical Conference, Seattle, Washington, May 1971, 10 p.

Portland Cement Association, 1963, Cement and Concrete: Reprinted with Permission, Volume 5, pages 153-158 and Volume 6, pages 263-269 of the Encyclopedia Britannica, (Copyright, 1963).

Washington State Department of Ecology, March, 1982, Chemical Testing Methods for Complying with the Dangerous Waste Regulations, Chapter 173-303 WAC, 6 p. with appendices.

APPENDIX A

CKD CHARACTERIZATION AND BACKGROUND REGULATORY INFORMATION

IDEAL BASIC INDUSTRIES, 1984

APPENDIX A-1

IC 8885

Bureau of Mines Information Circular/1982

Characterization of U.S. Cement Kiln Dust

By Benjamin W. Haynes and Gary W. Kramer

UNITED STATES DEPARTMENT OF THE INTERIOR

APPENDIX A-1

Information Circular 8885

Characterization of U.S. Cement Kiln Dust

By Benjamin W. Haynes and Gary W. Kramer

March 3, 1849

UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

BUREAU OF MINES
Robert C. Horton, Director

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1. Cement—Analysis. I. Kramer, Gary W. II. Title. III. Series: Information circular (United States. Bureau of Mines) ; 8885.

TP882.3.H39 666'.94 82-600149 AACR2

CONTENTS

TABLES

CHARACTERIZATION OF U.S. CEMENT KILN DUST

By Benjamin W. Haynes[1] and Gary W. Kramer[2]

ABSTRACT

Cement kiln dust (CKD) produced in the contiguous United States and Hawaii was characterized as part of the Bureau of Mines' program in minerals environmental technology. The mineralogical and chemical composition was determined for 113 CKD samples from 102 plants that normally send CKD waste to landfill. Characterization included the determination of 28 elements, 7 anion species, carbon dioxide, noncarbonate carbon, and chemically bound water. Mercury was determined in 16 samples. Interelement correlation coefficients were determined for 23 elements, 5 anions, CO_2, noncarbonate carbon, and chemically bound water.

To assess the hazardous waste potential of CKD, the U.S. Environmental Protection Agency Extraction Procedure (EP) toxicity test was performed on all 113 CKD samples. All but one sample were in compliance with the test; the noncomplying sample slightly exceeded the EP toxicity test criterion for lead.

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[1] Supervisory research chemist, Avondale Research Center, Bureau of Mines, Avondale, Md.

[2] Research chemist, Avondale Research Center, Bureau of Mines, Avondale, Md.

INTRODUCTION

Cement kiln dust (CKD) is a waste product that accumulates at the rate of 4 to 12 million tons per year in the United States (2, 4)[3]. This dust has considerable resource potential: It is already being used as a neutralizer for coal mine waste effluents, and the agricultural and construction industries are beginning to use it more extensively as a substitute for lime. In the proposed hazardous waste guidelines of 1978 (4) promulgated under the Resource Conservation and Recovery Act (RCRA) of 1976 (11), the Environmental Protection Agency (EPA) placed CKD in a "Special Wastes" category pending more information on the composition, characteristics, and degree of hazard posed by this waste. In 1980 the "Special Wastes" category was removed (5), but a 3-year EPA study of the hazard potential of CKD was approved by Congress (10). Part of the concern over the environmental effects of waste CKD resulted from a single study of the heavy metals content of a CKD sample from Blaubeuren, West Germany, showing lead and zinc contents of 5,620 and 16,200 µg/g, respectively (3). The only other analysis of CKD for heavy metals used in the EPA study was sample from Polk County, Ga., showing 124 µg/g for lead and 145 µg/g for zinc (12). A contracted EPA study of the received in 1-gallon cans and prepared cement industry concluded that:

> Waste kiln dust is probably the most serious pollution control problem facing the cement industry at this time. Relatively little is known about the dust, so environmentally adequate management techniques are difficult to specify (2).

An exploratory evaluation of the environmental effects and of the resource recovery potential of the elements present in CKD was initiated at the Bureau of Mines Avondale (Md.) Research Center shortly after publication of the 1978 EPA guidelines. Results of the first phase of this research (8), discussed major, minor, and trace element concentrations, mineralogy, anion composition, chemically bound water, CO_2, and EP toxicity leach test results. The present report gives characterization data for the U.S. cement industry nationwide. Information on noncarbonate carbon has been added for all samples, as have mercury determinations on selected samples, and significant interelement correlation coefficients for the major, minor, and trace elements.

SAMPLES

Samples of CKD were requested from operating plants located in the contiguous United States and Hawaii; 113 samples from 102 plants, representing about 70 percent of the total U.S. cement industry, were received and analyzed. The remaining plants either did not respond to the inquiry or had no disposal problems because all their waste dust was recycled. Table 1 lists the States and the number of samples received from each State. Samples were received in 1-gallon cans and prepared for analysis by the following procedure:

1. The sample as received was blended in a twin-shell blender for 30 minutes, then riffle-split into two portions.
2. One half of the sample was labeled and stored, and the other half was passed through a 100-mesh sieve. Any portion of the sample coarser than minus 100 mesh was ground in a Wiley mill[4] to pass 100 mesh.

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[3] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

[4] Reference to specific brand names is made for identification only and does not imply endorsement by the Bureau of Mines.

TABLE 1. - Cement kiln dust samples received, by State[1]

State	Number of samples	State	Number of samples	State	Number of samples
Alabama......	4	Kentucky.......	1	Ohio...........	5
Arizona......	3	Louisiana......	1	Oklahoma.......	3
Arkansas.....	2	Maine..........	0	Oregon.........	1
California...	11	Maryland.......	3	Pennsylvania...	9
Colorado.....	4	Michigan.......	3	South Carolina.	1
Florida......	2	Mississippi....	1	South Dakota...	3
Georgia......	1	Missouri.......	6	Tennessee......	5
Hawaii.......	1	Montana........	1	Texas..........	14
Idaho........	1	Nebraska.......	3	Utah...........	1
Illinois.....	2	Nevada.........	0	Virginia.......	1
Indiana......	2	New Mexico.....	1	Washington.....	4
Iowa.........	4	New York.......	2	Wisconsin......	0
Kansas.......	5	North Carolina.	1	Wyoming........	1

[1] Only those States are listed that have cement plants in operation.

3. The minus 100-mesh material (~ 1/2 gallon) was reblended for 30 minutes.

4. The sample was then riffle-split again into two fractions for characterization.

All mineralogical and chemical analysis data were obtained using the minus 100-mesh material. The extraction procedure (EP) toxicity leach test was performed on the blended as-received material. Samples were coded based on receipt date, and the tables of data have no correlation with the State listings in table 1.

MINERALOGY

Standard X-ray diffraction procedures using CuKα radiation were performed on the minus 100-mesh material to determine the minerals present. The results are given in table 2. All but seven samples contained calcite ($CaCO_3$) as a major constituent, and those seven samples had calcite as a minor constituent. All but two samples contained quartz (SiO_2). Lime (CaO) and anhydrite ($CaSO_4$) were present in most samples; amounts ranged from <5 to >30 wt-pct. Other minerals identified in the samples included aphthitalite [$(K,Na)_2SO_4$, nine samples], arcanite (K_2SO_4, nine samples), sylvite (KCl, nine samples), slaked lime [$Ca(OH)_2$, six samples], halite (NaCl, one sample), and gypsum ($CaSO_4 \cdot 2H_2O$, one sample). Two samples contained low levels of chlorite [$Mg_3(Si_4O_{10})(OH)_2 \cdot Mg_3(OH)_6$].

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TABLE 2. - Mineralogical composition of U.S. cement kiln dust samples[1]

Sample	Calcite	Lime	Anhydrite	Quartz	Dolomite	Mica	Feldspar
1	Major	Minor	Minor	Minor	Minor		Minor
2	Major	Minor	Very low	Minor			
3	Major	Minor	Low	Low	Minor		Low
4	Major	Minor	Minor	Low	Low	Very low	
5	Major	Minor	Minor	Low	Very low	Very low	
6	Major	Major	Major	Very low			
7	Major	Major	Minor	Low			Low
8	Major	Minor	Low	Low	Low		Minor
9	Major		Low	Low	Low	Very low	Minor
10	Major	Minor	Minor	Very low	Low	Very low	
11	Major	Minor	Low	Minor			
12	Major		Low	Low	Minor	Very low	Minor
13	Major		Very low	Low	Minor	Low	Minor
14	Major		Minor	Low	Minor		
15	Major	Minor	Minor	Minor	Minor		
16	Major	Minor	Low	Low	Low		
17	Major		Low	Minor	Low		Low
18	Major	Minor	Minor	Minor			
19	Major	Minor	Minor	Minor	Minor		Very low
20	Major	Minor	Low	Very low			
21	Major	Minor	Minor	Low	Minor		
22	Major	Low	Minor	Low			
23	Major		Low	Very low	Low		
24	Major	Low	Low	Low	Low		
25	Minor	Major		Low			
26	Major	Minor	Minor	Very low			
27	Major	Minor	Low	Low			
28	Major	Low		Low			
29	Major	Minor		Low			
30	Major	Minor	Minor	Low	Low		
31	Major		Very low	Low			
32	Major	Minor	Low	Low			
33	Major	Low	Low	Very low			
34	Major	Minor	Low	Low			
35	Major	Minor	Minor	Low			
36	Major	Minor	Minor	Very low			
37	Major	Low	Minor	Very low	Low		
38	Major	Very low		Low	Low		
39	Major	Minor	Low	Low	Low		
40	Major	Minor		Very low	Low		
41	Major	Minor	Low	Very low			
42	Major	Major	Minor	Very low			
43	Major	Minor	Minor	Very low			
44	Major	Very low	Minor	Very low	Very low		
45	Major	Very low	Very low	Very low			
46	Minor			Very low		Very low	
47	Major	Low	Low	Very low	Low		
48	Major			Very low		Very low	

[1] See footnotes at end of table.

TABLE 2. - Mineralogical composition of U.S. cement kiln dust samples[1] —Continued

Sample	Calcite	Lime	Anhydrite	Quartz	Dolomite	Mica	Feldspar
49	Major		Low	Very low	Low		
50	Major			Very low			
51	Major	Very low	Low	Very low	Very low		
52	Major	Minor	Low	Very low			
53	Major	Low	Low	Low		Very low	
54	Major	Minor		Very low	Low	Very low	
55	Major	Major	Very low	Very low	Very low		
56	Major	Minor	Very low	Low	Low		Low
57	Major			Very low		Very low	
58	Major			Very low	Low		
59	Major	Low	Low	Very low			
60	Major	Low	Low	Very low	Low		
61	Major	Low	Low	Very low			
62	Major	Minor	Low	Very low	Low		
63	Major			Very low	Low		
64	Major	Major		Very low	Very low		
65	Major		Low	Very low	Minor		
66	Major	Low	Low	Very low	Low		
67	Major			Very low	Low		
68	Major			Very low			
69	Major	Low		Very low	Low		
70	Major	Low		Very low			
71	Major	Minor	Very low	Very low			
72	Major	Minor		Low			
73	Major	Low	Very low	Very low			
74	Major	Low	Low		Low		
75	Major	Minor	Low	Very low			
76	Major			Low	Low		
77	Major	Minor	Low	Low			
78	Major	Low	Very low	Low		Very low	
79	Major	Very low	Low	Low	Very low		
80	Major	Minor		Low		Very low	
81	Major	Very low		Very low			
82	Major	Minor		Very low			Low
83	Major	Minor	Low	Very low			
84	Major	Minor	Very low	Very low			
85	Major	Very low		Very low			Very low
86	Major	Minor	Low	Very low			
87	Major	Low	Low	Very low	Very low		
88	Major	Low		Very low			
89	Major	Low		Low			
90	Minor	Major	Minor	Very low			
91	Minor	Major	Low	Very low			
92	Major	Minor	Very low	Very low			Minor
93	Major	Low	Low	Very low			
94	Major	Low		Very low			

---

[1] See footnotes at end of table.

TABLE 2. - Mineralogical composition of U.S. cement kiln dust samples[1] --Continued

Sample	Calcite	Lime	Anhydrite	Quartz	Dolomite	Mica	Feldspar
95	Major	Minor	Minor				
96	Major	Low	Low	Low		Very low	
97	Major	Low	Low	Very low			
98	Major		Very low	Low		Very low	
99	Major	Low	Low	Very low			
100	Major	Very low		Very low			
101	Major	Minor	Very low	Very low		Very low	
102	Minor	Major	Low	Very low			
103	Major	Low	Low	Low			
104	Major	Minor		Low			
105	Major	Low		Very low			
106	Major	Minor	Very low	Very low			
107	Major		Very low	Very low			
108	Low	Major	Very low	Very low			
109	Major		Minor	Very low			
110	Major	Low	Low	Very low			
111	Major	Low	Low	Low	Low		
112	Major	Minor		Low			
113	Very low	Major		Very low			

Major >30 wt-pct.
Minor 10-30 wt-pct.
Low 5-10 wt-pct.
Very low <5 wt-pct.
Blank Not detected.

---

[1] Analysis by C. W. Huggins, research chemist, Avondale Research Center, Bureau of Mines, Avondale, Md.

CHEMICAL ANALYSES

The chemical analyses of the CKD samples are discussed in three sections as follows: (1) Chemically bound water, carbon dioxide and noncarbonate carbon concentrations; (2) anion concentrations; and (3) major, minor, and trace element concentrations. The samples used for the analyses were the blended minus 100-mesh materials.

Chemically Bound Water, Carbon Dioxide, and Noncarbonate Carbon

The amount of chemically bound water and carbon dioxide (CO_2) present in CKD was determined using thermogravimetric analysis (TGA). Chemically bound water and CO_2 are defined as the water and CO_2 requiring temperatures greater than 110° C to expel them from the material being analyzed. The results of the TGA analyses are shown in table 3. Chemically bound water was low in all samples, ranging from 0.4 to 3.8 wt-pct. The CO_2 content ranged from 4.4 to 34.4 wt-pct. No data are reported for chemically bound water and CO_2 for samples 17, 46, 57-59, 72, 82, and 84 because under the high-temperature, low-vacuum conditions of the analysis, vapors from the samples repeatedly corroded the 20-mil platinum-rhodium hangdown wire to the breaking point before the determination could be made. These samples contained high levels of sylvite (KCl), which attacks platinum-rhodium alloys.

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TABLE 3. - Chemically bound water, CO_2, and noncarbonate carbon in U.S. cement kiln dust, wt-pct

Sample	Chemically bound water[1]	CO_2[1]	Noncarbonate carbon	Sample	Chemically bound water[1]	CO_2[1]	Noncarbonate carbon
1	0.7	22.3	0.41	46	ND	ND	1.83
2	.4	23.8	.51	47	1.2	22.9	.19
3	.8	19.4	1.01	48	1.0	22.9	.44
4	1.9	26.5	.62	49	.8	30.2	.21
5	1.3	24.2	.78	50	1.1	34.4	.32
6	.4	8.0	.50	51	2.9	16.5	.82
7	.4	8.8	.56	52	1.0	20.5	.10
8	.4	17.5	.50	53	1.0	21.0	.26
9	.8	21.9	.58	54	1.3	27.3	.61
10	1.3	22.6	1.00	55	1.5	19.2	.20
11	.9	19.1	.42	56	1.4	26.0	.48
12	1.1	19.6	.41	57	ND	ND	.54
13	1.3	23.7	.18	58	ND	ND	.53
14	1.1	21.7	.65	59	ND	ND	<.01
15	.8	12.4	.85	60	2.1	18.1	.78
16	1.0	23.9	.05	61	.9	22.0	.23
17	ND	ND	.75	62	1.5	26.4	1.40
18	1.3	19.6	.74	63	.8	34.2	1.22
19	.7	29.4	1.23	64	1.0	13.5	.56
20	1.2	26.2	.68	65	1.1	22.2	.41
21	.9	27.1	.70	66	2.0	19.0	1.00
22	2.0	20.6	.32	67	2.0	25.1	.41
23	.7	10.4	.54	68	3.8	23.0	.72
24	1.8	23.5	.23	69	1.4	22.2	1.02
25	1.4	14.3	.49	70	.6	25.1	1.63
26	1.8	16.8	.38	71	1.5	20.8	.54
27	.8	15.2	.77	72	ND	ND	.44
28	1.1	27.7	<.01	73	1.0	30.9	.51
29	.9	23.8	.44	74	1.1	25.9	1.10
30	1.0	31.3	.61	75	1.1	20.7	.42
31	2.9	24.3	.23	76	1.0	33.2	<.01
32	1.4	24.3	.52	77	1.3	13.0	.40
33	1.3	19.8	.46	78	1.2	30.1	.29
34	1.1	23.8	.66	79	2.5	21.8	.12
35	3.0	17.1	.39	80	1.5	23.3	.55
36	2.0	20.7	.30	81	1.5	12.6	.07
37	1.1	24.0	.49	82	ND	ND	<.01
38	1.1	32.6	.71	83	.7	26.0	.88
39	1.0	26.5	.77	84	ND	ND	.45
40	1.1	22.1	.78	85	1.6	28.3	.24
41	.9	25.9	1.60	86	1.0	17.9	.62
42	1.0	19.2	.97	87	1.6	22.4	.19
43	1.1	20.4	.98	88	.7	18.3	.03
44	1.2	25.2	.84	89	1.0	24.0	.14
45	2.1	20.0	.99	90	1.0	15.3	.20

[1] See footnotes at end of table.

TABLE 3. - Chemically bound water, CO_2, and noncarbonate carbon in U.S. cement kiln dust, wt-pct—Continued

Sample	Chemically bound water	CO_2	Noncarbonate carbon	Sample	Chemically bound water	CO_2	Noncarbonate carbon
91	1.8	12.0	0.15	103	2.8	22.4	0.18
92	1.2	27.0	.17	104	1.3	25.1	.86
93	1.8	19.1	.25	105	1.2	26.6	.23
94	.9	15.4	.15	106	1.4	23.0	.21
95	1.3	20.6	.06	107	1.0	31.7	.56
96	1.3	24.0	.23	108	2.4	4.4	.34
97	1.7	23.8	.11	109	3.0	21.9	.70
98	1.9	23.8	.13	110	1.4	20.5	1.23
99	1.1	33.3	.44	111	.5	31.5	.44
100	1.3	23.3	.11	112	.9	23.7	.33
101	1.0	21.8	.24	113	.8	8.2	.45
102	7.7	8.7	.64				

ND Not determined.

[1] Analysis by J. V. Scalera, chemist, Avondale Research Center, Bureau of Mines, Avondale, Md.

Noncarbonate carbon was determined by treating a weighed sample with dilute HCl and heating to dissolve the carbonate minerals present (calcite, dolomite.) After evolution of CO_2 ceased, the samples were rinsed to remove excess acid and analyzed by a LECO carbon analyzer. Noncarbonate carbon is generally unburned coal or fuel oil in the CKD samples. The concentrations as shown in table 3 ranged from <0.01 to 1.83 wt-pct.

Anions

The anion species present in the CKD samples were determined using a Dionex 10 ion chromatograph. The CKD samples were weighed and then fused with Na_2CO_3. After fusion, the samples were leached with high purity deionized distilled water and diluted to a standard concentration; and aliquots of a 1-to-10 dilution were injected into the ion chromatograph.

Details of this procedure are given elsewhere (7). Determinations of chloride (Cl^-), fluoride (F^-), nitrate (NO_3^-), phosphate (PO_4^{3-}), and sulfate (SO_4^{2-}) were obtained from a single sample injection. The results of these determinations on the U. S. CKD samples are presented in table 4. Chloride ranged from <0.01 to 12.3 wt-pct, fluoride from 0.01 to 0.60 wt-pct, nitrate from <0.02 to 1.67 wt-pct, phosphate from <0.02 to 0.16 wt-pct, and sulfate from 0.41 to 31.6 wt-pct. Bromide (Br^-) and nitrite (NO_2^-) can also be determined by this method from the same injection of solution, but no samples were found to contain either Br^- or NO_2^- at levels greater than the detection limit (<0.02 wt-pct) for these anions.

Major, Minor, and Trace Elements

The elements Al, Si, K, Ca, Ti, and Fe were determined for the majority of samples by a fused-disk fluorescent X-ray spectrography procedure. Fifteen CKD samples were analyzed for the above elements by wet chemical techniques, and these samples were used as secondary standards for the X-ray method. Other major, minor, and trace elements were determined by flame atomic absorption spectroscopy (AAS). Samples were

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TABLE 4. - Anions in U.S. cement kiln dust, wt-pct

Sample	Cl^-	F^-	NO_3^-	PO_4^{3-}	SO_4^{2-}
1	0.01	0.13	0.76	<0.02	9.77
2	.04	.08	.05	.05	2.63
3	.90	.09	.32	<.02	9.06
4	.18	.13	.11	.05	7.43
5	.10	.14	.23	.05	7.93
6	.04	.36	.32	.08	12.2
7	.66	.31	.23	.02	12.4
8	1.93	.10	.09	<.02	19.2
9	5.18	.07	1.00	<.02	12.0
10	.42	.26	.37	.05	7.95
11	<.01	.05	<.02	<.02	4.15
12	.17	.22	.21	<.02	10.7
13	.52	.04	.23	.10	14.7
14	.18	.10	.05	<.02	18.6
15	<.01	.23	<.02	<.02	14.2
16	.21	.12	.56	.10	4.96
17	.89	.09	.09	<.02	6.05
18	1.17	.20	.23	.16	4.91
19	.57	.03	.19	<.02	12.4
20	.19	.08	1.67	.03	10.4
21	.56	.11	.10	<.02	7.27
22	.38	.12	.12	<.02	10.5
23	.40	.35	<.02	<.02	31.6
24	.12	.16	<.02	<.02	3.77
25	.04	.13	<.02	<.02	1.66
26	.15	.09	<.02	<.02	10.9
27	1.01	.05	<.02	<.02	6.63
28	.28	.11	<.02	<.02	9.52
29	.35	.11	.74	<.02	6.16
30	.15	.15	<.02	<.02	6.27
31	1.13	.14	<.02	<.02	5.85
32	.45	.04	<.02	<.02	.86
33	1.97	.01	<.02	<.02	1.83
34	.47	.10	.15	<.02	5.31
35	.41	.05	.41	<.02	5.72
36	.49	.10	<.02	<.02	8.01
37	.51	.07	.15	<.02	7.20
38	.82	.09	<.02	<.02	.61
39	.31	.06	.23	<.02	2.35
40	.78	.18	.18	<.02	5.46
41	.52	.12	<.02	<.02	4.85
42	.13	.14	<.02	<.02	8.37
43	.58	.13	<.02	.02	15.7
44	.44	.07	<.02	<.02	10.8
45	.11	.09	<.02	<.02	5.68
46	12.3	.05	<.02	<.02	31.5
47	.84	.12	<.02	<.02	9.05
48	.82	.04	.07	<.02	1.01
49	.73	.05	.07	.02	2.86
50	.48	.07	<.02	.04	.49
51	.39	.20	<.02	<.02	15.3
52	.52	.05	<.02	<.02	6.43
53	.36	.07	<.02	<.02	7.15
54	.31	.09	<.02	<.02	4.04
55	.34	.12	<.02	<.02	6.86
56	.39	.10	<.02	<.02	1.70
57	.72	.33	<.02	<.02	22.0
58	1.03	0.06	<0.02	<0.02	2.02
59	1.09	.09	<.02	<.02	10.8
60	.35	.16	<.02	<.02	10.6
61	.89	.12	<.02	.02	8.21
62	.19	.04	.12	<.02	6.63
63	.16	.06	<.02	<.02	1.15
64	.24	.26	.07	<.02	2.64
65	.29	.08	<.02	<.02	19.8
66	.40	.12	<.02	<.02	10.8
67	.13	.14	<.02	.02	3.56
68	.26	.20	<.02	<.02	5.38
69	.06	.04	<.02	<.02	4.26
70	.13	.68	<.02	.02	6.29
71	.52	.05	.07	<.02	2.60
72	3.32	.15	<.02	<.02	3.73
73	.58	.08	<.02	<.02	2.22
74	.59	.05	<.02	.02	6.59
75	.63	.11	<.02	<.02	7.42
76	.48	.10	<.02	.03	6.02
77	.49	.25	<.02	<.02	10.7
78	.38	.05	<.02	<.02	.82
79	.62	.07	<.02	<.02	7.52
80	.35	.07	<.02	.03	2.29
81	1.20	.20	.11	.02	21.5
82	.70	.19	<.02	<.02	12.5
83	.51	.10	<.02	<.02	7.59
84	1.36	.19	<.02	<.02	3.48
85	.49	.15	<.02	<.02	.41
86	.55	.16	<.02	<.02	11.6
87	.51	.14	<.02	<.02	5.12
88	.52	.22	.09	.02	6.51
89	.38	.12	<.02	<.02	3.83
90	.57	.16	<.02	<.02	12.3
91	.86	.20	<.02	<.02	6.61
92	.38	.04	<.02	<.02	3.80
93	.42	.16	<.02	.02	7.68
94	.39	.19	<.02	<.02	6.16
95	.42	.07	<.02	<.02	10.2
96	.49	.10	<.02	<.02	5.42
97	.25	.13	<.02	<.02	6.12
98	.80	.06	<.02	<.02	7.15
99	.42	.05	<.02	<.02	3.70
100	.46	.29	.07	<.02	9.16
101	.47	.20	<.02	<.02	3.38
102	.16	.09	<.02	<.02	5.31
103	.87	.09	<.02	<.02	5.92
104	.43	.11	<.02	<.02	2.13
105	1.00	.09	<.02	<.02	3.42
106	1.32	.13	<.02	<.02	4.84
107	.35	.07	<.02	<.02	2.21
108	1.84	.16	<.02	<.02	14.0
109	.71	.05	.16	<.02	13.9
110	.47	.16	<.02	.02	11.8
111	.21	.14	<.02	<.02	2.92
112	.22	.31	<.02	<.02	2.30
113	2.56	.40	<.02	<.02	5.22

prepared for AAS analysis by dissolving 2 grams of CKD sample in a mixture of 10 ml concentrated HNO_3, 5 ml HF, and 40 ml distilled H_2O. The sample was evaporated to dryness. The dried sample was redissolved in 5 vol-pct HNO_3 to which 5 ml of 30-pct H_2O_2 was added. The solution was gently heated and, after the H_2O_2 reaction had subsided, 5 to 10 ml of concentrated HCl was added to dissolve the remaining solids. The samples were cooled and transferred to volumetric flasks for AAS analysis.

Arsenic and antimony were determined by a reliable graphite furnace AAS method developed by the Bureau of Mines (6, 9). Mercury was determined using the method of Agemian and Chau (1) as modified by Haynes (9).

Duplicate analyses were performed on all CKD samples. To verify the results obtained by chemical dissolutions, the flame AAS procedure, and other procedures used in this report, a National Bureau of Standards (NBS) Standard Reference Material (SRM) cement standard, SRM-637, was analyzed, and these values were compared with certificate results. The results are listed in table 5 and show good agreement between certified values and values obtained by the methods used in this study.

The results for the major and minor element concentration [arbitrarily chosen as greater than 0.05 wt-pct (500 µg/g)] are given in table 6. Table 7 gives the trace element concentration [arbitrarily selected as less than 0.05 wt-pct (500 µg/g)].

Also listed in table 7 are seven elements, and their detection limits, that were not detected by flame atomic absorption in any of the samples. Twenty-eight elements were examined in all of the samples. Thallium was detected in only one sample, at 185 µg/g. The presence of thallium in sample 9, as determined by flame AAS, was verified by fluorescent X-ray spectrography and optical emission spectroscopic techniques.

TABLE 5. - Comparison of NBS SRM-637 certificate values with Bureau of Mines analytical method values, wt-pct

Constituent	Concentration	Certified value[1]
CaO......	65.8	66.0(4)
SiO_2.....	23.2	23.0(7)
Al_2O_3....	3.15	3.2(8)
Fe_2O_3....	1.72	1.80
SO_3......	2.28	2.3(8)
MgO......	.62	.6(7)
K_2O......	.22	.25
TiO_2.....	.21	.21
Na_2O.....	.13	.15
SrO......	.08	.09
P_2O_5.....	.22	.24
Mn_2O_3....	.06	.06
F........	.04	.04
ZnO......	.01	.01
Cr_2O_3....	.01	.01

[1] Parentheses indicate estimated level by NBS of next digit.

Table 8 lists the range, arithmetic mean, and median found for each element in the 113 CKD samples. Ranges over three orders of magnitude are seen for some elements. The median may indicate the most probable value for the CKD samples where an anomalously high or low value for an element was found in one of the samples. Except for Ca, Ni, and Si, the median is lower than the mean for each element, indicating that the high concentrations are less frequent than the lower concentrations.

Because traces of mercury were leached from only a few samples by the EP toxicity test, these samples and a few additional samples were chosen to insure an adequate geographic representation of the plants in the United States. Table 9 gives the results of analysis of 16 samples chosen by the above procedure. Mercury was determined by standard cold vapor AAS procedures (1, 9).

APPENDIX A-1

TABLE 6. - Major and minor elements in U.S. cement kiln dust, wt-pct

Sample	Al	Ca	Fe	K	Mg	Na	Si	Sr	Ti
1	1.74	31.6	1.41	1.96	1.76	0.73	6.68	0.02	0.12
2	2.05	36.1	1.58	.68	.87	.50	5.29	.02	.16
3	2.66	31.8	1.51	5.04	.37	.47	6.33	.04	.14
4	2.89	29.4	1.38	2.50	1.39	.45	6.63	.08	.13
5	2.71	32.8	1.17	1.50	1.16	.42	5.72	.08	.12
6	3.82	32.0	3.61	3.73	.96	.45	7.62	.17	.20
7	3.40	27.3	2.58	3.65	1.21	.54	7.16	.18	.16
8	1.69	22.2	1.10	11.9	.68	.59	4.14	.02	.09
9	2.37	19.8	1.03	8.78	1.01	.96	4.93	.04	.10
10	3.99	24.0	2.24	4.16	1.12	.57	6.24	.08	.20
11	2.61	34.1	2.53	1.10	.70	.19	8.64	.04	.13
12	2.58	29.2	1.48	3.53	1.91	1.18	6.93	.08	.12
13	2.44	23.6	1.39	5.99	1.59	.91	4.13	.08	.13
14	1.71	23.9	.89	6.89	1.26	1.15	4.35	.17	.09
15	2.53	30.3	1.81	5.95	1.10	.58	7.09	.07	.12
16	2.21	33.7	1.35	2.43	1.01	.62	6.93	.04	.14
17	2.50	30.5	1.31	3.53	.63	.48	5.90	.03	.11
18	5.02	21.3	2.39	2.01	.31	1.44	11.1	.50	.29
19	2.07	31.5	1.62	2.68	.35	.98	6.00	.07	.14
20	2.34	33.5	1.41	2.21	.48	.50	5.31	.04	.13
21	1.97	30.5	1.83	1.66	1.46	.30	7.79	.05	.11
22	2.50	28.5	1.50	2.42	.81	.44	8.16	.03	.13
23	1.44	11.3	2.29	15.1	.34	2.36	3.30	.02	.07
24	3.22	26.7	1.94	2.79	1.56	.20	8.94	.04	.16
25	2.10	34.5	1.64	2.11	1.10	.25	7.33	.06	.11
26	2.58	31.6	2.37	1.43	.66	.21	6.83	.04	.10
27	2.05	31.6	1.18	2.43	1.02	.16	7.65	.01	.10
28	1.92	28.7	1.11	4.34	.56	.48	4.90	.02	.09
29	1.80	33.0	1.35	1.77	.64	.23	7.40	.02	.08
30	1.86	33.2	1.03	1.86	1.35	.09	5.53	.01	.11
31	1.95	30.7	1.22	2.19	.34	.89	8.02	.22	.11
32	2.54	33.2	1.72	.72	.29	.15	8.71	.01	.13
33	2.99	32.7	1.50	2.56	.31	.20	5.63	.12	.16
34	2.62	31.8	1.81	2.47	.30	.18	7.56	.05	.10
35	2.45	33.8	1.77	.61	.35	.18	7.53	.11	.10
36	2.01	32.0	1.68	2.35	.46	.30	6.51	.07	.09
37	2.64	28.4	1.60	3.05	1.17	.30	8.20	.04	.13
38	1.84	31.6	.98	1.84	1.66	.05	6.55	.03	.08
39	2.04	33.4	.91	1.69	1.38	.22	6.72	.02	.10
40	2.63	30.9	1.43	2.55	.79	.07	7.13	.05	.13
41	2.11	34.6	1.42	.86	.69	.32	6.16	.10	.10
42	2.11	34.6	1.42	.86	1.48	.18	6.16	.05	.10
43	2.52	27.3	1.33	5.51	.31	.48	5.63	.08	.12
44	2.03	28.3	1.30	3.72	.84	.38	6.17	.02	.12
45	2.32	27.2	1.56	5.04	.64	.77	6.72	.12	.12
46	.99	10.6	.66	23.2	.24	.71	3.60	.01	.06

TABLE 6. - Major and minor elements in U.S. cement kiln dust, wt-pct —Continued

Sample	Al	Ca	Fe	K	Mg	Na	Si	Sr	Ti
47	2.50	28.4	1.65	3.53	1.20	0.40	7.07	0.02	0.16
48	2.23	33.2	1.27	1.02	.66	.14	5.72	.03	.13
49	1.90	33.1	1.36	1.11	1.24	.12	6.51	.02	.16
50	2.26	36.0	1.00	.67	.34	.10	5.20	.05	.11
51	2.12	27.3	1.10	5.16	.30	.43	4.97	.08	.10
52	1.97	31.7	1.60	3.05	.41	.25	6.51	.02	.07
53	2.40	30.3	1.49	2.82	.82	.33	6.89	.06	.14
54	2.62	31.2	1.16	3.58	.76	.22	4.95	.05	.12
55	2.26	34.4	1.01	3.36	.77	.15	3.65	.05	.09
56	2.10	30.5	1.27	1.12	.98	.30	5.31	.04	.10
57	2.07	13.3	1.03	19.8	.57	.51	3.17	.03	.09
58	2.36	28.4	1.32	3.42	.78	.20	5.78	.05	.12
59	1.87	27.8	1.07	3.69	.70	.34	5.98	.08	.09
60	2.14	26.4	1.26	5.22	1.07	.76	6.19	.04	.12
61	2.16	27.2	2.03	5.19	.49	.35	6.20	.02	.11
62	2.14	34.5	1.16	1.87	.80	.49	5.08	.01	.11
63	2.35	33.8	1.01	1.28	.65	.09	5.66	.02	.12
64	2.72	34.1	1.41	3.80	.54	.45	5.83	.07	.12
65	1.72	21.5	.75	11.0	.65	.76	2.72	.03	.09
66	2.60	28.7	2.50	3.98	.53	.42	5.90	.03	.11
67	2.78	28.0	1.41	3.77	1.42	.68	7.28	.04	.14
68	1.92	27.0	.90	6.47	1.33	.88	5.69	.04	.11
69	1.98	31.6	1.52	2.25	1.06	.58	7.31	.02	.09
70	1.37	25.7	.79	11.6	.52	2.32	2.69	.02	.06
71	1.67	35.8	2.32	.34	.26	.15	7.00	.03	.07
72	2.30	27.3	1.93	4.46	.43	2.77	7.25	.88	.11
73	2.19	33.4	1.26	1.64	.91	.27	5.39	.07	.09
74	2.31	31.4	1.28	1.80	.52	.30	7.25	.01	.12
75	2.33	25.8	1.51	2.58	.81	.20	5.54	.07	.13
76	1.92	33.0	.98	.97	.80	.22	6.49	.07	.09
77	1.82	29.1	2.00	3.09	.84	.47	7.68	.04	.08
78	2.43	33.4	1.18	.65	.56	.22	7.09	.02	.12
79	2.72	29.4	1.77	2.19	.81	.42	7.43	.22	.14
80	1.72	34.9	1.59	1.07	.63	.28	7.12	.01	.10
81	2.63	19.4	1.59	10.1	.34	1.11	5.70	.07	.13
82	2.12	27.1	.10	5.52	.65	1.09	6.27	.02	.05
83	1.83	31.5	1.65	2.53	.60	.37	5.80	.06	.08
84	1.85	33.1	1.04	2.16	.49	.38	6.37	.08	.10
85	2.51	29.2	1.51	5.29	.20	.58	6.36	.06	.12
86	2.40	29.2	.94	5.56	.22	.27	6.97	.03	.11
87	2.46	32.0	1.52	2.48	.62	.21	6.88	.02	.12
88	2.28	26.5	1.16	6.38	1.05	.99	7.40	.02	.11
89	2.49	31.5	1.77	2.17	.59	.20	7.35	.08	.13
90	2.98	28.7	2.27	3.92	.67	.29	7.79	.03	.15
91	2.58	31.8	1.38	3.27	1.52	.26	6.26	.02	.12
92	1.93	35.1	1.26	.96	.27	.36	5.71	.06	.09
93	2.54	30.5	2.02	2.65	.43	.23	6.86	.17	.11

TABLE 6. - Major and minor elements in U.S. cement kiln dust, wt-pct --Continued

Sample	Al	Ca	Fe	K	Mg	Na	Si	Sr	Ti
94	2.64	30.4	1.27	3.27	0.45	0.26	7.15	0.17	0.11
95	1.90	31.6	1.12	1.14	.80	.29	6.56	.03	.09
96	1.72	27.7	1.15	4.44	.20	.73	6.72	.04	.09
97	2.66	27.7	1.74	2.80	.32	.34	7.34	.05	.13
98	1.86	28.1	1.46	2.70	.23	1.22	6.52	.12	.11
99	2.51	34.1	1.17	1.39	.34	.18	4.57	.04	.12
100	2.39	27.1	.93	5.97	.33	.83	5.77	.11	.10
101	2.96	29.8	1.43	2.74	.95	.18	8.54	.06	.17
102	2.45	34.3	1.48	1.98	.69	.19	6.55	.03	.12
103	2.05	32.2	1.81	1.73	.56	.72	5.67	.12	.23
104	1.87	29.3	1.68	2.08	.50	.14	7.26	.03	.10
105	2.05	31.1	.96	2.73	1.81	.20	5.46	.03	.09
106	2.18	30.1	1.06	3.37	1.70	.29	5.88	.03	.11
107	2.67	31.7	1.13	1.55	.36	.19	6.59	.08	.11
108	2.83	29.8	1.41	4.74	1.61	.24	6.53	.02	.14
109	2.92	26.1	4.44	1.93	1.38	.19	5.40	.04	.18
110	2.28	28.2	.95	5.09	.43	.32	6.36	.05	.11
111	2.43	33.4	1.35	2.03	.68	.21	7.33	.03	.12
112	2.61	35.2	1.74	1.96	.47	.10	7.70	.09	.13
113	2.53	36.7	.88	4.23	.54	.13	5.91	.08	.11

TABLE 7. - Trace elements in U.S. cement kiln dust, μg/g[1]

Sample	Ag	As	Cd	Cr	Cu	Li	Mn	Ni	Pb	Sb	Zn
1	<3	14	<1.5	30	18	17	205	<12	<26	<1.6	111
2	<3	7.2	<1.5	42	44	18	305	45	<26	<1.6	48
3	<3	23	6.8	27	23	19	588	18	159	<1.6	200
4	<3	5.9	<1.5	34	63	26	268	20	<26	<1.6	214
5	<3	4.3	<1.5	29	19	25	414	23	43	<1.6	50
6	<3	74	<1.5	69	28	14	278	45	44	3.0	118
7	<3	60	<1.5	59	24	14	341	<12	30	1.9	136
8	<3	15	29	29	18	26	166	<12	569	<1.6	455
9	<3	1.6	12	32	28	76	180	72	1,010	<1.6	127
10	<3	28	<1.5	51	26	58	334	32	366	<1.6	171
11	<3	13	<1.5	59	27	24	864	25	35	<1.6	112
12	17	5.7	<1.5	62	23	56	166	20	91	1.9	110
13	<3	1.5	5.8	34	29	37	1,330	<12	282	<1.6	180
14	12	8.0	<1.5	51	28	71	111	<12	187	<1.6	88
15	<3	20	1.6	99	22	19	250	37	106	<1.6	140
16	<3	7.3	5.8	41	18	33	202	24	<26	<1.6	216
17	<3	15	58	64	30	34	101	20	578	<1.6	229
18	<3	9.8	4.3	101	199	28	113	54	560	<1.6	1,330
19	<3	26	9	34	14	37	114	<12	900	<1.6	260
20	<3	14	11	116	17	16	63	31	84	1.6	76

[1] See footnote at end of table.

TABLE 7. - Trace elements in U.S. cement kiln dust, µg/g[1]--Continued

Sample	Ag	As	Cd	Cr	Cu	Li	Mn	Ni	Pb	Sb	Zn
21	11	5.1	8.6	29	27	<4	440	26	154	<1.6	299
22	11	6.3	22	48	30	23	489	33	204	1.6	500
23	11	34	22	172	34	62	139	18	454	1.9	774
24	14	11	6.4	47	57	18	204	34	278	3.4	475
25	11	9.3	6.2	35	18	<4	668	24	101	<1.6	67
26	6.7	8.4	6.4	64	18	<4	835	44	132	<1.6	156
27	6.7	11	7.7	43	18	<4	620	36	92	<1.6	162
28	7.0	14	5	18	56	<4	284	22	760	<1.6	1,860
29	6.5	12	4.5	24	94	<4	390	17	322	<1.6	1,330
30	6.5	8.7	5.8	22	18	<4	164	25	246	<1.6	38
31	7.2	19	3.2	34	24	<4	372	22	90	2.7	54
32	5.0	15	3.5	28	17	<4	150	26	76	2.3	53
33	6.0	7.6	5	58	24	24	222	29	73	<1.6	83
34	8.8	31	30	57	40	13	238	59	308	3.9	1,100
35	6.4	32	19	36	40	<4	632	47	56	3.3	180
36	5.9	20	8.2	36	24	14	535	32	128	5.8	228
37	5.0	6.9	5	30	26	18	224	26	128	3.9	295
38	6.6	6.6	5.4	49	23	18	488	16	112	<1.6	126
39	6.6	4.3	8.9	24	16	<4	174	14	86	<1.6	32
40	6.7	7.6	6	120	20	7.5	390	14	595	3.1	372
41	12	18	8.9	32	42	14	439	34	161	<1.6	167
42	11	6	6.9	42	28	12	128	37	66	1.7	145
43	10	18	8.2	31	27	23	1,370	52	231	2.5	516
44	7.5	7.1	7.3	21	24	11	2,410	41	223	<1.6	155
45	8.4	16	7.6	42	21	12	485	28	166	2.2	952
46	6.9	3.4	11	28	44	42	125	20	446	<1.6	628
47	6.4	8.6	7.8	53	34	11	376	30	494	<1.6	290
48	8.8	3.7	3.8	27	22	8.2	244	22	35	<1.6	105
49	8.6	4.6	8.8	90	54	<4	266	91	368	6.7	391
50	6.6	3	4.9	21	12	12	398	20	111	<1.6	55
51	9.8	17	8.6	64	30	14	462	33	216	3.9	354
52	3	28	70	34	56	<4	559	20	336	2.4	243
53	7.3	29	6	30	26	<4	343	26	101	2.7	220
54	9.7	8.8	6.4	40	52	<4	236	28	148	3.8	8,660
55	9.7	4.3	9.4	32	39	6.5	240	23	232	3.7	2,740
56	4.2	7.1	8.2	38	22	5	250	28	86	2.6	99
57	14	6.5	20	77	22	21	176	18	1,590	3	468
58	7.4	11	7	34	23	16	156	32	148	4.4	144
59	14	4	62	31	28	22	408	28	964	<1.6	158
60	11	2.3	18	33	26	18	173	28	202	<1.6	401
61	4.8	12	19	62	30	16	154	<12	132	<1.6	243
62	6.9	9.5	<1.5	36	27	16	252	12	76	<1.6	58
63	6.4	4.9	4	29	16	12	279	<12	36	<1.6	88
64	<3	7.1	4	56	20	20	457	<12	420	<1.6	167
65	<3	3.4	45	28	16	22	90	<12	288	<1.6	254
66	<3	33	2.8	39	32	18	677	16	160	<1.6	167
67	<3	5.2	14	64	28	16	304	12	126	<1.6	113
68	5.3	3.4	13	67	18	20	280	<12	94	<1.6	75

[1] See footnote at end of table.

TABLE 7. - Trace elements in U.S. cement kiln dust, µg/g[1]--Continued

Sample	Ag	As	Cd	Cr	Cu	Li	Mn	Ni	Pb	Sb	Zn
69	4.7	13	<1.5	35	21	6	240	<12	54	<1.6	71
70	7	44	6.8	56	18	18	67	<12	221	<1.6	199
71	5.4	18	2.6	27	24	8	188	<12	169	<1.6	146
72	5.5	5.8	<1.5	43	22	16	141	<12	68	<1.6	67
73	15	24	10	38	28	19	290	<12	150	11	154
74	7.4	10	2.6	37	54	32	239	17	98	<1.6	206
75	12	509	42	48	56	14	534	24	260	29	702
76	12	518	42	47	64	14	542	24	258	27	714
77	6.3	27	10	71	46	12	168	86	73	<1.6	158
78	8.8	29	8	43	23	10	357	<12	134	<1.6	125
79	5.5	12	9.5	33	18	17	424	<12	138	<1.6	778
80	7.9	25	5	47	34	8	236	14	31	<1.6	129
81	<3	23	7.8	43	46	47	1,090	<12	272	<1.6	703
82	<3	16	35	11	12	4.2	136	<12	1,240	<1.6	115
83	13	77	16	28	206	9.2	638	<12	1,750	42	7,860
84	<3	11	10	21	16	19	650	<12	204	<1.6	134
85	<3	19	12	47	18	20	580	<12	162	<1.6	200
86	<3	15	2	33	14	26	456	<12	81	<1.6	243
87	<3	20	3.1	23	9.4	11	592	<12	130	<1.6	258
88	<3	81	2.7	22	63	28	235	<12	568	18	1,650
89	<3	8	3.4	26	15	22	234	<12	<26	2	53
90	<3	54	3.4	23	36	21	350	<12	126	<1.6	580
91	<3	15	<1.5	37	10	14	300	<12	39	<1.6	32
92	<3	29	<1.5	24	34	15.6	274	<12	221	19	207
93	<3	10	12	30	25	17	1,060	<12	740	<1.6	1,220
94	<3	12	4.6	45	21	17	1,250	<12	376	<1.6	1,060
95	<3	80	8.8	16	29	7.6	265	<12	426	70	792
96	<3	13	26	49	12	6.6	370	<12	998	<1.6	120
97	<3	7.6	<1.5	80	21	21	286	<12	88	<1.6	83
98	<3	1.7	1.7	27	7	18	644	<12	142	<1.6	114
99	<3	2.2	<1.5	15	10	8.8	335	<12	34	<1.6	37
100	<3	2.1	5	33	11	45	259	<12	56	1.9	445
101	<3	3.9	64	34	28	46	300	<12	144	<1.6	516
102	<3	4.7	16	18	7.6	11	592	<12	80	2.7	88
103	<3	1.3	34	39	32	9.4	226	<12	62	2	104
104	<3	4.2	16	35	8.3	7.4	302	<12	66	2.7	83
105	<3	2.9	352	26	14	8.4	280	<12	182	<1.6	88
106	<3	2.8	305	23	18	9.4	266	<12	206	<1.6	108
107	<3	2.3	100	18	14	10	820	<12	362	<1.6	398
108	<3	11	24	35	24	16	410	<12	150	<1.6	150
109	<3	4.6	18	30	34	19	336	<12	542	1.8	207
110	<3	3.1	81	18	12	55	177	<12	182	1.9	322
111	<3	1.9	9.9	14	12	6.9	198	<12	38	<1.6	58
112	<3	1.7	66	15	13	8.2	203	<12	28	2.9	38
113	<3	3	141	18	16	10	248	<12	72	1.8	79

[1] Elements not detected in any of the samples:
Ba <55; Be <2; Bi <50; Co <10; Mo <50; Sn <100; V <100.

TABLE 8. - Elemental and anion variation in U.S. cement kiln dust, µg/g

Element or anion	Range	Mean[1]	Median
Ag................	<3 - 17	5.4	4.8
Al................	9,900 - 50,200	23,200	23,100
As................	1.3 - 518	24	9.3
Ba................	<55	<55	<55
Be................	<2	<2	<2
Bi................	<50	<50	<50
Ca................	106,000 -367,000	295,000	305,000
Cd................	<1.5 - 352	21	7.3
Co................	<10	<10	<10
Cr................	11 - 172	41	34
Cu................	7 - 206	30	24
Fe................	1,000 - 44,400	14,700	14,100
Hg[2]...............	<0.13- 1.0	<.13	<.13
K.................	3,400 -232,000	36,600	26,800
Li................	<4 - 76	18	16
Mg................	1,980 - 19,100	7,820	6,820
Mn................	63 - 2,410	383	280
Mo................	<50	<50	<50
Na................	495 - 27,700	4,700	3,190
Ni................	<12 - 91	22	29
Pb................	17 - 1,750	253	148
Sb................	<1.6 - 70	3.2	<1.6
Si................	26,900 -111,000	63,500	65,100
Sn................	<100	<100	<100
Sr................	62 - 8,750	670	430
Ti................	500 - 2,900	3,530	1,100
Tl................	<60 - 185	<60	<60
V	<100	<100	<100
Zn................	32 - 8,660	462	167
Br^-...............	<200	<200	<200
Cl^-...............	<100 -123,000	6,900	4,900
F^-................	100 - 3,600	1,300	1,000
NO_2^-..............	<200	<200	<200
NO_3^-..............	200 - 16,700	<200	<200
PO_4^{3-}.............	200 - 1,600	<200	<200
SO_4^{2-}.............	4,100 -316,000	77,800	68,600

[1] A value of 1/2 the detection limit was arbitrarily used to calculate the mean for those elements having concentrations both above and below the detection limit.

[2] Mercury value based on only 16 samples.

TABLE 9. - Mercury in selected U.S. cement kiln dust samples, µg/g

Sample	Mercury	Sample	Mercury
8......	<0.13	52....	0.25
9......	1.0	58....	.13
13......	.13	64....	<.13
14......	<.13	65....	.38
17......	<.13	68....	<.13
19......	<.13	104....	1.0
35......	.63	108....	<.13
49......	<.13	110....	.63

Interelement Correlations

Interelement correlation coefficients were generated using linear regression analysis on a total of 23 elements, anions, carbonate carbon as CO_2, noncarbonate carbon, and chemically bound water. Coefficients with values $r \geq 0.4$ or $r \leq -0.4$ were taken as significant positive or negative correlations. Of the 23 parameters tested, only 14 parameters showed significant correlation. Table 10 shows the interelement correlation coefficients for the 23 pairs. Some very significant correlations

TABLE 10. - Interelement correlation coefficients for U.S. cement kiln dust[1]

Element or anion	Al	Ca	Cl⁻	CO	F⁻	Fe	K
Al..................	1					0.46	
Ca..................		1	-0.45				-0.85
Cl⁻..................		-.45	1				.56
CO				1	-0.42		
F⁻..................				-.42	1		
Fe..................	.46					1	
K..................		-.85	.56				1
Li..................		-.54					.44
Na..................		-.55			.42		.47
Pb..................		-.42					
Si..................	.48						-.55
Sr..................							
SO_4^{2-}..................		-.77		-.51			.77
Ti..................	.77					.49	

Element or anion	Li	Na	Pb	Si	Sr	SO_4^{2-}	Ti
Al..................				0.48			0.77
Ca..................	-0.54	-0.55	-0.42		-0.77	-0.77	
Cl⁻..................							
CO						-.51	
F⁻..................		.42					
Fe..................							.49
K..................	.44	.47		-.55		.77	
Li..................	1	.41				.49	
Na..................	.41	1			0.52		
Pb..................			1				
Si..................				1		-.44	.42
Sr..................		.52			1		
SO_4^{2-}..................	.49		-.44	-.44		1	
Ti..................				.42			1

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[1] Blank indicates that correlation coefficient is insignificant ($-0.4 < r < 0.4$).

(r>0.7, r<-0.7) were found for Al and Ti (r = 0.77), Ca and K (r = -0.85), Ca and SO_4^{2-} (r = -0.77), and K and SO_4^{2-} (r = -0.77). Chlorine and potassium (the mineral sylvite, KCl) showed a positive correlation coefficient of r = 0.56. The remaining parameters of As, noncarbonate carbon, Cd, Cr, Cu, chemically bound water, Mg, Mn, and Zn had no significant correlations with any of the other parameters.

EPA HAZARDOUS WASTE TEST

According to EPA regulations, a solid waste must be listed as hazardous if it exhibits ignitability, corrosivity, reactivity, or toxicity, using the extraction procedure outlined in the Federal Register (4-5). CKD does not meet the criteria for a hazardous waste under ignitability, corrosivity, or reactivity. Briefly, the EP toxicity test as applied to CKD in this study consisted of adding 100 grams of CKD to 1,600 ml of distilled water, gradually adding 400 ml of 0.5-normal acetic acid, and agitating for 24 hours. Although 400 ml of acetic acid was the maximum amount specified by the test procedure, the pH never approached the specified pH of 5 ±0.2. The resulting extract in the EP toxicity test must not exceed 100 times the National Drinking Water Standard with respect to the concentration of eight metals: As, Ba, Cd, Cr, Pb, Hg, Se, and Ag. Table 11 lists the allowed maximum concentrations. Only one sample exceeded any of the limits; this sample (83) exceeded the 5-µg/ml lead limit with an average of 15 µg/ml in duplicate runs. Sample 83 contained the highest lead value of the 113 samples, but this concentration is still a factor of 3 less than the concentration reported in the West German sample (3). Additional supplies of sample 83 could not be obtained from the plant to see if this high lead value was anomalous. The highest zinc level was found in sample 54 with a concentration of 8,660 µg/g, which is a factor of 2 less than the value reported for the West German sample. Although zinc is not a factor in the EP toxicity tests, it is of environmental interest.

TABLE 11. - Maximum concentration of contaminants allowed for EP toxicity test (4 5)

EPA hazardous waste number	Contaminant	Maximum concentration µg/ml
D004.........	Arsenic....	5.0
D005.........	Barium.....	100.0
D006.........	Cadmium....	1.0
D007.........	Chromium...	5.0
D008.........	Lead.......	5.0
D009.........	Mercury....	.2
D010.........	Selenium...	1.0
D011.........	Silver.....	5.0

SUMMARY AND CONCLUSIONS

As part of the Bureau of Mines' minerals environmental technology program, the Avondale Research Center has completed an extensive characterization of dusts generated from U.S. cement kilns. Because of the interest of the EPA and Congress (4-5, 10) in CKD as a large-volume waste of unknown environmental impact, the mineralogical and chemical compositions and the hazardous waste potential of CKD were investigated. Data from mineralogical analysis show that the major constituents of CKD are calcite, lime, and anhydrite with varying amounts of quartz and dolomite.

A total of 28 elements was determined in 113 CKD samples. In addition, seven anion species, carbon dioxide, noncarbonate carbon, and chemically bound water were determined in all samples. Mercury was determined in 16 selected samples.

Chemical analyses show 13 elements or anion species occurring in CKD at concentrations consistently greater than 0.05 wt-pct. These constituents are Al, Ca, Cl^-, CO_2, F^-, Fe, K, Mg, Na, Si, SO_4^{2-}, Sr, and Ti. The upper range limits for heavy metal concentrations such as lead and zinc are a factor of 2 or 3 less than the value reported for a CKD sample from Blaubeuren, West Germany (3).

The U.S. Environmental Protection Agency EP toxicity test was performed on all samples. Only 1 of the 113 samples had a leachate concentration that exceeded any of the limits; it slightly exceeded the criterion for lead.

Cement kiln dust is a large-volume material and a potential resource as a substitute for lime. Any environmental considerations are minor, as the results of this extensive survey show that U.S. CKD is not a hazardous waste as defined by current regulations established under RCRA.

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9. Haynes, B. W., J. C. McConnell, and S. L. Law. Antimony, Arsenic and Mercury in the Combustible Fraction of Municipal Solid Waste. BuMines RI 8293, 1978, 11 pp.

10. U.S. Congress. Conference Report on S. 1156, Solid Waste Disposal Act Amendments. Congressional Record - House, Oct. 1, 1980, pp. H10174-H10187.

11. _____. Resource Conservation and Recovery Act of 1976, Public Law 94-580, Oct. 21, 1976.

12. Wheeler, W. E., and R. R. Oltjen. Cement Kiln Dust in Diets for Finishing Steers. U.S. Dept. Agriculture, Agricultural Research Service, ARS-NE-88, 9 pp.

(b) Any person subject to the provisions of this Act shall, at all reasonable times, upon notice by a duly authorized representative of the Secretary, afford such representative access to his premises or facility and opportunity to examine the premises or facility, the garbage thereat, and books and records thereof, to copy all such books and records and to take reasonable samples of such garbage.

(c) For the efficient execution of the provisions of this Act, and in order to provide information for the use of Congress, the provisions (including penalties) of sections 6 and 8 through 10 of the Federal Trade Commission Act, are made applicable to the jurisdiction, powers, and duties of the Secretary in enforcing the provisions of this Act and to any person subject to the provisions of this Act, whether or not a corporation. The Secretary, in person or by such agents as he may designate, may prosecute any inquiry necessary to his duties under this Act in any part of the United States.

COOPERATION WITH STATES

SEC. 9. In order to avoid duplication of functions, facilities, and personnel, and to attain closer coordination and greater effectiveness and economy in administration of this Act and State laws and regulations relating to the feeding of garbage to swine, the Secretary is authorized to enter into cooperative agreements with State departments of agriculture and other State agencies charged with the administration and enforcement of such State laws and regulations and to provide that any such State agency which has adequate facilities, personnel, and procedures, as determined by the Secretary, may assist the Secretary in the administration and enforcement of this Act and regulations hereunder. The Secretary is further authorized to coordinate the administration of this Act and regulations with such State laws and regulations whenever feasible: *Provided*, That nothing herein shall affect the jurisdiction of the Secretary under any other Federal law, or any authority to cooperate with State agencies or other agencies or persons under existing provisions of law, or affect any restrictions upon such cooperation.

STATE PRIMARY ENFORCEMENT RESPONSIBILITY

SEC. 10. (a) For purposes of this Act, a State shall have the primary enforcement responsibility for violations of laws and regulations relating to the treatment of garbage to be fed to swine and the feeding thereof during any period for which the Secretary determines that such State—

(1) has adopted adequate laws and regulations regulating the treatment of garbage to be fed to swine and the feeding thereof which laws and regulations meet the minimum standards of this Act and the regulations hereunder: *Provided*, That the Secretary may not require a State to have laws that are more stringent than this Act;

(2) has adopted and is implementing adequate procedures for the effective enforcement of such State laws and regulations; and

(3) will keep such records and make such reports showing compliance with paragraphs (1) and (2) of this subsection as the Secretary may require by regulation.

Except as provided in subsection (c), the Secretary shall not enforce this Act or the regulations hereunder in any State which has primary enforcement responsibility pursuant to this section.

(b) Whenever the Secretary determines that a State having primary enforcement responsibility pursuant to this section does not have adequate laws or regulations or is not effectively enforcing such laws or regulations, the Secretary shall notify the State. Such notice shall specify those aspects of the administration or enforcement of the State program that are determined to be inadequate. The State shall have ninety days after receipt of the notice to correct any deficiencies. If after that time the Secretary determines that the State program remains inadequate, the Secretary may terminate, in whole or in part, the State's primary enforcement responsibility under this Act.

(c) Nothing in this section shall limit the authority of the Secretary to enforce this Act whenever the Secretary determines that emergency conditions exist that require immediate action on the part of the Secretary and the State authority is unwilling or unable adequately to respond to the emergency.

ADVISORY COMMITTEE

SEC. 11. The Secretary shall appoint an advisory committee or committees consisting of representatives of appropriate State agricultural or State animal health agencies, animal health organizations, the food waste feeder industry, and swine producer organizations to consult with the Secretary concerning matters within the scope of this Act, including evaluating State programs for purposes of section 10 of this Act and assuring effective coordination among State programs and Federal and State programs.

REGULATIONS

SEC. 12. The Secretary is authorized to issue such regulations and to require the maintenance of such records as he deems necessary to carry out the provisions of this Act.

AUTHORITY IN ADDITION TO OTHER LAWS; EFFECT ON STATE LAWS

SEC. 13. The authority conferred by this Act shall be in addition to authority conferred by other statutes. Nothing in this Act shall be construed to repeal or supersede any State law prohibiting the feeding of garbage to swine or to prohibit any State from enforcing requirements relating to the treatment of garbage to be fed to swine or the feeding thereof which are more stringent than those under this Act or the regulations hereunder.

AUTHORIZATION OF APPROPRIATIONS

SEC. 14. There are hereby authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act.

Mr. DE LA GARZA (during the reading). Mr. Speaker, I ask unanimous consent that the committee amendment be considered as read and printed in the RECORD.

The SPEAKER pro tempore. Is there objection to the request of the gentleman from Texas?

There was no objection.

The committee amendment was agreed to.

The bill was ordered to be engrossed and read a third time, was read the third time, and passed, and a motion to reconsider was laid on the table.

GENERAL LEAVE

Mr. DE LA GARZA. Mr. Speaker, I ask unanimous consent that all Members may have 5 legislative days in which to revise and extend their remarks on the three bills just passed.

The SPEAKER pro tempore. Is there objection to the request of the gentleman from Texas?

There was no objection.

CONFERENCE REPORT ON S. 1156, SOLID WASTE DISPOSAL ACT AMENDMENTS

Mr. STAGGERS submitted the following conference report and statement on the Senate bill (S. 1156) to amend and reauthorize the Solid Waste Disposal Act.

CONFERENCE REPORT (H. REPT. NO. 96-1444)

The committee of conference on the disagreeing votes of the two Houses on the amendments of the House to the bill (S. 1156) to amend and reauthorize the Solid Waste Disposal Act having met, after full and free conference, have agreed to recommend and do recommend to their respective Houses as follows:

That the Senate recede from its disagreement to the amendment of the House to the text of the bill and agree to the same with an amendment as follows: In lieu of the matter proposed to be inserted by the House amendment insert the following:

SECTION 1. This Act may be cited as the "Solid Waste Disposal Act Amendments of 1980".

SEC. 2. (a) Section 1004(14) of the Solid Waste Disposal Act is amended to read as follows:

"(14) The term 'open dump' means any facility or site where solid waste is disposed of which is not a sanitary landfill which meets the criteria promulgated under section 4004 and which is not a facility for disposal of hazardous waste."

(b) Section 1004(19) of such Act is amended to read as follows:

"(19) The term 'recovered material' means waste material and byproducts which have been recovered or diverted from solid waste, but such term does not include those materials and byproducts generated from, and commonly reused within, an original manufacturing process.".

SEC. 3. Section 1006 of the Solid Waste Dispose Act is amended by adding the following new subsection at the end thereof:

"(c) INTEGRATION WITH THE SURFACE MINING CONTROL AND RECLAMATION ACT OF 1977.—(1) No later than 90 days after the date of enactment of the Solid Waste Disposal Act Amendments of 1980, the Administrator shall review any regulations applicable to the treatment, storage, or disposal of any coal mining wastes or overburden promulgated by the Secretary of the Interior under the Surface Mining and Reclamation Act of 1977. If the Administrator determines that any requirement of final regulations promulgated under any section of subtitle C relating to mining wastes or overburden is not adequately addressed in such regulations promulgated by the Secretary, the Administrator shall promptly transmit such determination, together with suggested revisions and supporting documentation, to the Secretary.

"(2) The Secretary of the Interior shall have exclusive responsibility for carrying out any requirement of subtitle C of this Act with respect to coal mining wastes or overburden for which a surface coal mining and reclamation permit is issued or approved under the Surface Mining Control and Reclamation Act of 1977. The Secretary shall, with the concurrence of the Administrator, promulgate such regulations as may be necessary to carry out the purposes of this subsection and shall integrate such regulations with regulations promulgated under the Surface Mining Control and Reclamation Act of 1977.".

SEC. 4. (a) The heading for section 2001 of the Solid Waste Disposal Act is amended by adding the following at the end thereof: "AND INTERAGENCY COORDINATING COMMITTEE".

(b) The item in the table of contents relating to section 2001 of such Act is amended by adding the following at the end thereof: "and interagency coordinating committee".

(c) Section 2001 of such Act is amended by inserting "(a) OFFICE OF SOLID WASTE.—" after "2001," and by inserting a new subsection (b) as follows at the end thereof:

APPENDIX A-2

"(b) INTERAGENCY COORDINATING COMMITTEE.—(1) There is hereby established an Interagency Coordinating Committee on Federal Resource Conservation and Recovery Activities which shall have the responsibility for coordinating all activities dealing with resource conservation and recovery from solid waste carried out by the Environmental Protection Agency, the Department of Energy, the Department of Commerce, and all other Federal agencies which conduct such activities pursuant to this or any other Act. For purposes of this subsection, the term 'resource conservation and recovery activities' shall include, but not be limited to, all research, development and demonstration projects on resource conservation or energy, or material, recovery from solid waste, and all technical or financial assistance for State or local planning for, or implementation of, projects related to resource conservation or energy or material, recovery from solid waste. The Committee shall be chaired by the Administrator of the Environmental Protection Agency or such person as the Administrator may designate. Members of the Committee shall include representatives of the Department of Energy, the Department of Commerce, the Department of the Treasury, and each other Federal agency which the Administrator determines to have programs or responsibilities affecting resource conservation or recovery.

"(2) The Interagency Coordinating Committee shall include oversight of the implementation of

"(A) the May 1979 Memorandum of Understanding on Energy Recovery from Municipal Solid Waste between the Environmental Protection Agency and the Department of Energy;

"(B) the May 30, 1978, Interagency Agreement between the Department of Commerce and the Environmental Protection Agency on the Implementation of the Resource Conservation and Recovery Act; and

"(C) any subsequent agreements between these agencies or other Federal agencies which address Federal resource recovery or conservation activities.

"(3) The Interagency Coordinating Committee shall submit to the Congress by March 1, 1981, and on March 1 each year thereafter, a five-year action plan for Federal resource conservation or recovery activities which shall identify means and propose programs to encourage resource conservation or material and energy recovery and increase private and municipal investment in resource conservation or recovery systems, especially those which provide for material conservation or recovery as well as energy conservation or recovery. Such plan shall describe, at a minimum, a coordinated and nonduplicatory plan for resource recovery and conservation activities for the Environmental Protection Agency, the Department of Energy, the Department of Commerce, and all other Federal agencies which conduct such activities.".

SEC. 5. Section 2002(a) of the Solid Waste Disposal Act is amended as follows:

(1) in paragraph (4), by striking out "and" at the end thereof;

(2) in paragraph (5), by striking the period and inserting in lieu thereof "; and"; and

(3) by adding the following new paragraph at the end thereof:

"(6) to delegate to the Secretary of Transportation the performance of any inspection or enforcement function under this Act relating to the transportation of hazardous waste where such delegation would avoid unnecessary duplication of activity and would carry out the objectives of this Act and of the Hazardous Materials Transportation Act.".

SEC. 6. (a) Section 2006(b) of the Solid Waste Disposal Act is amended by inserting after "subsection (a)" a comma and the phrase "or $5,000,000 per fiscal year, whichever is less,".

(b) Section 2006 of such Act is amended by adding the following new subsection at the end thereof:

"(d) STATE AND LOCAL SUPPORT.—Not less than 25 per centum of the total amount appropriated under this title, up to the amount authorized in section 4008(a)(1), shall be used only for purposes of support to State, regional, local, and interstate agencies in accordance with subtitle D of this Act other than section 4008(a)(2) or 4009.".

SEC. 7. Subsection (b) of section 3001 of the Solid Waste Disposal Act is amended by inserting "(1)" after "(b)" and by adding the following new paragraphs at the end of such subsection:

"(2)(A) Notwithstanding the provisions of paragraph (1) of this subsection, drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil or natural gas or geothermal energy shall be subject only to existing State or Federal regulatory programs in lieu of subtitle C until at least 24 months after the date of enactment of the Solid Waste Disposal Act Amendments of 1980 and after promulgation of the regulations in accordance with subparagraphs (B) and (C) of this paragraph. It is the sense of the Congress that such State or Federal programs should include, for waste disposal sites which are to be closed, provisions requiring at least the following:

"(i) The identification through surveying, platting, or other measures, together with recordation of such information on the public record, so as to assure that the location where such wastes are disposed of can be located in the future; except however, that no such surveying, platting, or other measure identifying the location of a disposal site for drilling fluids and associated wastes shall be required if the distance from the disposal site to the surveyed or platted location to the associated well is less than two hundred lineal feet; and

"(ii) A chemical and physical analysis of a produced water and a composition of a drilling fluid suspected to contain a hazardous material, with such information to be acquired prior to closure and to be placed on the public record.

"(B) Not later than six months after completion and submission of the study required by section 8002(m) of this Act, the Administrator shall, after public hearings and opportunity for comment, determine either to promulgate regulations under this subtitle for drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil or natural gas or geothermal energy or that such regulations are unwarranted. The Administrator shall publish his decision in the Federal Register accompanied by an explanation and justification of the reasons for it. In making the decision under this paragraph, the Administrator shall utilize the information developed or accumulated pursuant to the study required under section 8002(m).

"(C) The Administrator shall transmit his decision, along with any regulations, if necessary, to both Houses of Congress. Such regulations shall take effect only when authorized by Act of Congress.

"(3)(A) Notwithstanding the provisions of paragraph (1) of this subsection, each waste listed below shall, except as provided in subparagraph (B) of this paragraph, be subject only to regulation under other applicable provisions of Federal or State law in lieu of this subtitle until at least six months after the date of submission of the applicable study required to be conducted under subsection (f), (n), (o), or (p) of section 8002 of this Act and after promulgation of regulations in accordance with subparagraph (C) of this paragraph:

"(i) Fly ash waste, bottom ash waste, slag waste, and flue gas emission control waste generated primarily from the combustion of coal or other fossil fuels.

"(ii) Solid waste from the extraction, beneficiation, and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore.

"(iii) Cement kiln dust waste.

"(B)(i) Owners and operators of disposal sites for wastes listed in subparagraph (A) may be required by the Administrator, through regulations prescribed under authority of section 2002 of this Act—

"(I) as to disposal sites for such wastes which are to be closed, to identify the locations of such sites through surveying, platting, or other measures, together with recordation of such information on the public record, to assure that the locations where such wastes are disposed of are known and can be located in the future, and

"(II) to provide chemical and physical analysis and composition of such wastes, based on available information, to be placed on the public record.

"(ii)(I) In conducting any study under subsection (f), (n), (o), or (p), of section 8002 of this Act, any officer, employee, or authorized representative of the Environmental Protection Agency, duly designated by the Administrator, is authorized, at reasonable times and as reasonably necessary for the purposes of such study, to enter any establishment where any waste subject to such study is generated, stored, treated, disposed of, or transported from; to inspect, take samples, and conduct monitoring and testing; and to have access to and copy records relating to such waste. Each such inspection shall be commenced and completed with reasonable promptness. If the officer, employee, or authorized representative obtains any samples prior to leaving the premises, he shall give to the owner, operator, or agent in charge a receipt describing the sample obtained and if requested a portion of each such sample equal in volume or weight to the portion retained. If any analysis is made of such samples, or monitoring and testing performed, a copy of the results shall be furnished promptly to the owner, operator, or agent in charge.

"(II) Any records, reports, or information obtained from any person under subclause (I) shall be available to the public, except that upon a showing satisfactory to the Administrator by any person that records, reports, or information, or particular part thereof, to which the Administrator has access under this subparagraph if made public, would divulge information entitled to protection under section 1905 of title 18 of the United States Code, the Administrator shall consider such information or particular portion thereof confidential in accordance with the purposes of that section, except that such record, report, document, or information may be disclosed to other officers, employees, or authorized representatives of the United States concerned with carrying out this Act. Any person not subject to the provisions of section 1905 of title 18 of the United States Code who knowingly and willfully divulges or discloses any information entitled to protection under this subparagraph shall, upon conviction, be subject to a fine of not more than $5,000 or to imprisonment not to exceed one year, or both.

"(iii) The Administrator may prescribe regulations, under the authority of this Act, to prevent radiation exposure which presents an unreasonable risk to human health from the use in construction or land reclamation (with or without revegetation) of (I) solid waste from the extraction, beneficiation, and processing of phosphate rock or (II) overburden from the mining of uranium ore.

"(iv) Whenever on the basis of any information the Administrator determines that

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ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 261

[SWH-FRL 1675-1]

Identification and Listing of Hazardous Waste

AGENCY: Environmental Protection Agency.

ACTION: Interim final amendment to rule with request for comments.

SUMMARY: This regulation amends the hazardous waste regulations (40 CFR § 261.4(b)) to exclude from regulation under Subtitle C of the Resource Conservation and Recovery Act (1) solid waste from the extraction, beneficiation and processing of ores and minerals (including coal), including phosphate rock and overburden from the mining of uranium ore and (2) cement kiln dust wastes. This action is being taken to bring the regulation into conformance with Section 7 of the recently enacted Solid Waste Disposal Act Amendments of 1980. The Agency, for the time being, is interpreting the scope of these exclusions broadly but is unsure that this interpretation is consistent with the intent of the Congress. Therefore, over the next 90 days, it intends to carefully examine the legislative history of the statutory amendment and consider the public comments being solicited by this action. Based on this review, the Agency, in subsequent rulemaking action, may further narrow the exclusion being promulgated today.

DATE: Effective Date: November 19, 1980.

Comment Date: This amendment is promulgated as an interim final rule. The Agency will accept comments on it until January 19, 1981.

ADDRESSES: Comments on the amendment should be sent to Docket Clerk (Docket No. 3001), Office of Solid Waste (WH-565), U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460.

FOR FURTHER INFORMATION CONTACT: For general information, contact Alfred W. Lindsey, Office of Solid Waste, U.S. Environmental Protection Agency, 401 M Street SW., Washington, D.C. 20460, (202) 755-9185. For information on implementation, contact:

Region I, Dennis Huebner, Chief, Radiation, Waste Management Branch, John F. Kennedy Building, Boston, Massachusetts 02203, (617) 223–5777
Region II, Dr. Ernest Regna, Chief, Solid Waste Branch, 26 Federal Plaza, New York, New York 10007, (212) 264–0504/5
Region III, Robert L. Allen, Chief, Hazardous Materials Branch, 6th and Walnut Streets, Philadelphia, Pennsylvania 19106, (215) 597–0980
Region IV, James Scarbrough, Chief, Residuals Management Branch, 345 Courtland Street NE., Atlanta, Georgia 30365, (404) 881–3016
Region V, Karl J. Klepitsch, Jr., Chief, Waste Management Branch, 230 South Dearborn Street, Chicago, Illinois 60604, (312) 886–6148
Region VI, R. Stan Jorgensen, Acting Chief, Solid Waste Branch, 1201 Elm Street, First International Building, Dallas, Texas 75270, (214) 767–2645
Region VII, Robert L. Morby, Chief, Hazardous Materials Branch, 324 E. 11th Street, Kansas City, Missouri 64106, (816) 374–3307
Region VIII, Lawrence P. Gazda, Chief, Waste Management Branch, 1860 Lincoln Street, Denver, Colorado 80203, (303) 837–2221
Region IX, Arnold R. Den, Chief, Hazardous Materials Branch, 215 Fremont Street, San Francisco, California 94105, (415) 556–4606
Region X, Kenneth D. Feigner, Chief, Waste Management Branch, 1200 Sixth Avenue, Seattle, Washington 98101, (206) 442–1260

SUPPLEMENTARY INFORMATION:

I. Reason and Basis for Today's Amendments

On May 19, 1980, EPA promulgated regulations implementing Subtitle C of the Resource Conservation and Recovery Act (RCRA). See 45 FR 33066–33588. These regulations define solid wastes and hazardous wastes and establish requirements applicable to generators, transporters, treaters, storers and disposers of hazardous wastes. These regulations also require owners and operators of hazardous waste treatment, storage and disposal facilities to obtain RCRA permits.

The definition of solid waste is provided in § 261.2 of these regulations. The definition of hazardous waste is provided in § 261.3 of these regulations. Both definitions are sufficiently broad to include many solid wastes generated in the extraction, beneficiation and processing of ores and minerals, exclusive of mining overburden returned to the mine site (see § 261.4(b)(3).) Specifically, eight mining and mineral processing wastes (EPA hazardous waste Nos. FO13–FO15 and KO64–KO68) were listed as hazardous wastes in §§ 261.31 and 261.32 of the May 19 regulations (see 45 FR 33123–33124). In addition, other mining and mineral processing wastes may be hazardous wastes because they exhibit one or more of the characteristics of hazardous wastes in Subpart C of Part 261. By virtue of these definitions, a number of mining and mineral processing wastes will be subject to the regulations on November 19, 1980, the effective date of the regulations.

Additionally, some cement kiln dust waste could be hazardous waste under the regulations, if it exhibits any of the characteristics of hazardous waste in Subpart C of Part 261. Thus, some cement kiln dust waste may be subject to the regulations on and after November 19, 1980.

In Section 7 of the recently enacted Solid Waste Disposal Act Amendments of 1980 (P.L. 94–482, October 21, 1980), the Congress amended Section 3001 of RCRA to prohibit EPA from regulating certain wastes under Subtitle C of RCRA until after completion of certain studies and certain rulemaking. Among these wastes are (1) "solid waste from the extraction, beneficiation and processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore" and (2) "cement kiln dust waste." Accordingly EPA is today amending its regulations, at § 261.4, to incorporate this statutory change.

Several trade associations, representing the mining and cement industries, have asked EPA to amend its regulations by November 19, 1980, the effective date of these regulations, to incorporate the 1980 amendments concerning these wastes. In addition these associations have sought a clarification of the scope of the exclusion, particularly regarding the types of mining operations that are excluded. The statutory exclusion of mining wastes in Section 3001(b)(3) is limited to "solid waste from the extraction, beneficiation and processing of ores and minerals." One mining trade association has argued that this exclusion covers wastes from the exploration, mining, milling, smelting and refining of ores and minerals (including coal.)

In the interest of providing the mining and cement industries clear guidance on whether they are subject to the regulations, EPA is amending the regulations before the November 19 date. At the same time EPA questions whether the Section 3001(b)(3) was to be interpreted as broadly as the trade associations suggest. To resolve these questions, the Agency will have to examine carefully the legislative history and consult with the mining and cement industries and the public. The Agency could not accompish this by November 19, 1980, given the extremely large workload with which it is burdened in developing the Phase II regulations, in responding to other requests for regulatory amendments and interpretations, and in responding to petitions for judicial review of the regulations.

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Consequently, the Agency has decided to provide an immediate but temporary accommodation of the requests on this matter by promulgating today interim final amendments to § 261.4(b) which provide the requested exclusion using the language of the statutory amendments. Until the Agency takes further rulemaking action on this matter, it will interpret the language of today's amendments, with respect to the mining and mineral processing waste exclusion, to include solid waste from the exploration, mining, milling, smelting and refining of ores and minerals.

This exclusion does not, however, apply to solid wastes, such as spent solvents, pesticide wastes, and discarded commercial chemical products, that are not uniquely associated with these mining and allied processing operations, or cement kiln operations. Therefore, should either industry generate any of these non-indigenous wastes and the waste is identified or listed as hazardous under Part 261 of the regulations, the waste is hazardous and must be managed in conformance with the Subtitle C regulations.

II. Intended Reconsideration of Today's Amendments

The Agency fully intends to consider the appropriate scope of the statutory exclusion and may well take rulemaking action to lessen the scope of the exclusion being promulgated today. To aid in this consideration, the Agency is soliciting public comments on this matter. In particular EPA questions whether Congress intended to exclude (1) wastes generated in the smelting, refining and other processing of ores and minerals that are further removed from the mining and beneficiation of such ores and minerals, (2) wastes generated during exploration for mineral deposits and (3) wastewater treatment and air emission control sludges generated by the mining and mineral processing industry. EPA specifically seeks comment on whether such wastes should be part of the exclusion. EPA also seeks comment on how it might distinguish between excluded and non-excluded solid wastes.

If EPA narrows the scope of the exclusion being promulgated today in future rulemaking, those who generate, transport, store, treat or dispose of wastes affected by such a change will have six months to prepare for compliance with the regulations. This six month delay in the effective date is provided under authority of Section 3010(b) of RCRA.

In addition to the consideration of the scope of the exclusion discussed above, the Agency will be considering regulatory amendments to implement other provisions of Section 3001(b)(3). Section 3001(b)(3)(B) recognizes EPA authority to issue regulations under Section 2002 of RCRA to place requirements on owners and operators of disposal sites for excluded wastes. These requirements concern identification and recording of information on the location of disposal sites as well as on the composition of the wastes that are disposed. EPA also invites public comment on how it should formulate such requirements.

III. Effect of Today's Amendments

Today's amendments relieve persons who generate or manage hazardous wastes produced in, and unique to, the exploration, mining, milling, smelting or refining of ores or minerals and persons who generate or manage a cement kiln dust waste from having to comply with EPA's regulations under Subtitle C of RCRA with respect to these wastes. Owners and operators of existing treatment, storage and disposal facilities do not have to submit a Part A, RCRA permit application by November 19, 1980, or comply with the interim status standards of Part 265 after November 19, 1980, with respect to such wastes. Also, owners and operators of new facilities for the treatment, storage or disposal of the subject wastes will not have to apply for and obtain a RCRA permit before constructing or operating such facilities.

Today's action does not relieve persons who generate or manage those wastes herein discussed from compliance with other Federal and State regulations including State regulations designed to implement Subtitle D of RCRA and State regulations being implemented in lieu of the Federal Subtitle C regulations where the State has interim or full authorization under Section 3006 of RCRA.

IV. Relationship to Final Listing of Certain Hazardous Waste in §§ 261.31 and 261.32

On November 12, 1980, in a separate rulemaking action (see 45 FR 74884), the Agency has finalized the list of most of the hazardous wastes listed in §§ 261.31 and 261.32. Included in this action was finalization of seven of the mining and mineral processing wastes mentioned above (EPA hazardous waste nos. F014–15 and K064–68). One of the wastes previously mentioned (F013) was deleted from the list of hazardous waste (§ 261.31) in that separate action. Because of the Agency's uncertainty with respect to the scope of the statutory amendments, as discussed above, it has gone ahead with the finalization of the aforementioned listed wastes. Notwithstanding, the effect of today's action is to suspend those final listings of hazardous wastes, unless and until the Agency reduces the scope of today's exclusion in subsequent rulemaking action.

V. Coal Mining Waste

The Solid Waste Disposal Act Amendments of 1980 also included special provisions (Sections 1006(c) and 3005(f)) designed to coordinate regulation of coal mining waste with the requirements of the Surface Mining Control and Reclamation Act, 30 U.S.C. § 1201 *et seq.* EPA believes that these provisions present problems of legal interpretation which cannot be resolved by November 19, 1980. The Agency may seek public comment on its interpretation of those provisions in later rulemaking actions. This interim final rule does not attempt to interpret the scope of Sections 1006(c) and 3005(f). However, since coal is arguably a "mineral or ore" under Section 3001(b)(3), wastes from the extraction, beneficiation and processing of coal are excluded from RCRA Subtitle C regulation in today's amendment to § 261.4(b). Until EPA has had an opportunity to analyze the intended scope of the exclusion, the terms "extraction, beneficiation and processing" will be interpreted broadly to include coal exploration, mining, cleaning, classification, and other processing activities. As with other elements of this exclusion, EPA will be examining this exclusion, particularly the exclusions for classification, and other processing activities, in more detail later and may decide to narrow its scope.

VI. Effective Date

Section 3010(b) of RCRA provides that EPA's hazardous waste regulations and revisions thereto take effect six months after their promulgation. The purpose of this requirement is to allow persons handling hazardous wastes sufficient lead time to prepare to comply with major new regulatory requirements. The amendments promulgated today, however, serve to put in regulatory form what is already stated in statute. To establish a deferred effective date would only serve to confuse the regulated community. Consequently, the Agency is establishing an immediate effective date for this amendment.

VII. Request for Comments

The Agency invites comments on these amendments and on the issues discussed in this preamble and,

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therefore, is providing a 60-day comment period.

Dated: November 14, 1980.

Douglas M. Costle,

Administrator.

Title 40 of the Code of Federal Regulations is amended by adding the following paragraphs to § 261.4(b):

§ 261.4 [Amended]

* * * * *

(b) * * *

(6) Solid waste from the extraction, beneficiation and processing of ores and minerals (including coal), including phosphate rock and overburden from the mining of uranium ore.

(7) Cement kiln dust waste.

These amendments are issued under the authority of Sections 1006, 2002(a) and 3001 of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), as amended, 42 U.S.C. 6905, 6912(a) and 6921.

[FR Doc. 80-36129 Filed 11-18-80; 8:45 am]

BILLING CODE 6560-30-M

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40 CFR Parts 261 and 262

[SWH-FRL 1675-3]

Hazardous Waste Management System: Identification and Listing of Hazardous Waste Standards for Generators of Hazardous Waste

AGENCY: Environmental Protection Agency.

ACTION: Interim final rules and request for comments.

SUMMARY: In regulations promulgated in May, 1980, establishing a federal program for the management of hazardous wastes, EPA excluded from full regulation persons handling hazardous wastes generated in small quantities (40 CFR 261.5, 45 FR 33066, 33120 (May 19, 1980)). This amendment clarifies the operation of the special requirements for hazardous waste generated by small quantity generators. Part 262 of the regulations has also been amended to ensure that these generators determine whether their wastes are hazardous.

DATE: Effective Date: November 19, 1980.

Comment Date: EPA will accept public comments on this regulation until January 19, 1981.

ADDRESSES: Comments on this regulation should be sent to the Docket Clerk [Docket Number 3001], Office of Solid Waste (WH-562), U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460.

The public docket for this regulation is located in Room 2711, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. and is available for viewing from 9 a.m. to 4 p.m. Monday through Friday, excluding holidays. Among other items, the docket contains the background document for this regulation which has been revised to accommodate these amendments.

FOR FURTHER INFORMATION CONTACT: Robert Holloway, Office of Solid Waste, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, (202) 755-9200.

SUPPLEMENTARY INFORMATION:

I. Introduction

Pursuant to Subtitle C of the Resource Conservation and Recovery Act of 1976, as amended ("RCRA"), 42 U.S.C. § 6901 *et seq.*, EPA recently promulgated regulations establishing a comprehensive regulatory program for the management and control of hazardous wastes (45 FR 33066 (May 19, 1980)). The regulations, among other things, identify the characteristics of hazardous wastes, list particular wastes as hazardous, and establish standards for generators and transporters of hazardous waste and owners and operators of hazardous waste management facilities.

The regulations also define special requirements for hazardous waste generated by generators who produce less than 1,000 kilograms of hazardous waste during a calendar month. (See 40 CFR 261.5, 45 FR 33120). Hazardous waste generated by a small quantity generator is generally excluded from full regulation provided the generator stores, treats, or disposes of his hazardous waste in facilities specified as acceptable or ensures that his hazardous waste is delivered to such facilities. However, if a small quantity generator generates or accumulates acutely hazardous waste in quantities greater than specified, or if he accumulates more than a total of 1,000 kilograms of hazardous waste at any time, all quantities of hazardous wastes for which an exclusion level is exceeded are fully regulated.

Since the publication of the regulation, members of the regulated community have raised a number of questions concerning the operation of the small quantity exclusion. EPA has been persuaded that, in certain respects, the regulation is ambiguous and does not clearly address certain situations. In addition, the regulation contains certain technical errors which would cause the exclusion to operate in a manner not intended by the Agency or contrary to the manner explained in the preamble to the regulation and the supporting materials. This amendment to the regulation is intended to clarify the original regulation and to correct the errors contained in it.

The revisions to the small quantity generator exclusion principally concern five aspects of the regulation: the determination of who is a small quantity generator; the requirements applicable to hazardous waste accumulated on-site; the requirements applicable to acutely hazardous wastes; the conditions applicable to wastes excluded from full regulation; and the requirements applicable to mixtures. The changes to the regulation are described in this preamble. The underlying rationale and basis for § 261.5 remain unchanged and are set forth in the preamble to the May regulation. (See 45 FR at 33102-33105.)

The background document supporting the requirements for small quantity generators has been revised to explain in greater detail the operation of § 261.5. In addition to describing the changes made by today's amendments, the background document provides guidance on the operation of regulations applicable to the small quantity generator.

It should be noted that the Agency has received a petition from the National Solid Waste Management Association ("NSWMA") which requests the Agency to make substantive revisions to § 261.5. EPA has noticed and requested comments on the petition. (45 68409 (October 15, 1980).) The amendment to § 261.5 published today does not constitute the Agency's response to the NSWMA petition. EPA's action with regard to that petition will be the subject to further notice and/or rulemaking.

II. Amendments to the Regulation

A. *Determination of Small Quantity Generator Status.*

Section 261.5(a) of the May regulation set forth the general test for determining who may qualify as a small quantity generator:

> * * * if a person generates, in a calendar month, a total of less than 1,000 kilograms of hazardous wastes, those wastes are not subject to regulation * * *.

Since publication of the regulation, persons have raised two questions basic to the operation of this section: (a) should the section be keyed to generators rather than persons; and (b) what wastes should be counted in determining the amount of waste generated in a calendar month? The regulation has been revised to resolve both of these questions.

JOHN SPELLMAN
Governor

DONALD W. MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504 • (206) 459-6000

April 4, 1983

Mr. Harlan Powledge
Director of Environmental Quality
Ideal Basic Industries, Cement Division
P.O. Box 8789
Denver, Colorado 80201

Dear Mr. Powledge:

This letter will confirm our meeting of March 29, 1983 concerning cement kiln flue dust generated at your Seattle plant. As a preface to my comments, the best way to avoid regulation of your waste as a dangerous waste is to show that the material is not designated by our rules in the first place. The exclusion then becomes academic unless the rules of designation are changed in the future or you begin generating a waste that is designated. As a point of information, in order to be permanently excluded, a class of generators must petition the department under WAC 173-303-910(4). You may still wish to do this in cooperation with the state's three other generators of cement kiln dust.

If you wish, you, as a single cement kiln dust generator, could also proceed under WAC 173-303-910(3), Petitions For Exempting Dangerous Waste From A Particular Generator, or, more desirable, under WAC 173-303-075, Certification of Designation. Under the latter approach, the department could issue a certificate of designation as non-dangerous if the data presented is adequate.

If you ask for a certificate, you should follow the certification guidelines and fill out the Appendix 4, the Certificate of Designation Application. Items F, G, H and I on the application are most pertinent.

For a successful certificate, I would suggest you address the following according to WAC 173-303-100 to WAC 173-303-103:

1. Establish that the type of cement you make (Types I, II, etc.) does not affect appreciably the chemical composition of flue dust composition.
2. Develop a waste sampling plan to sample your flue dust over a period of two weeks, daily. The plan should reflect how you would sample, such as where, how the sample would be composited, subdivided, etc. We would be glad to review such a plan before it is executed and would be interested in splitting a sample with you.

3. You should plan on analyzing such samples for:
   a. EP Toxicity
   b. Fish and rat bioassay
   c. Polycyclic Aromatic and Halogenated Hydrocarbon content according to methods given to you at the meeting.
   d. A statement that no carcinogenic wastes above 1% are present in the wastes as specified in WAC 173-303-103.

Please note that you may be able to "book designate" for fish and rat toxicity if you have sufficient chemical information to do so. (See WAC 173-303-101(2) through (4).)

Please let me know if I can be of further assistance.

Sincerely,

James C. Knudson

James C. Knudson, P.E.
Hazardous Waste Section
Solid Waste Management Division
Office of Land Programs

JCK:js

cc: John Conroy, WDOE, NW Region
Cleve Schneeberger, Portland Cement Association

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Ideal Basic Industries
Cement Division

Ideal Plaza – 950 17th Street
P O Box 8789
Denver, Colorado 80201

303 623 5661

December 12, 1983

Mr. James C. Knudson, P.E.
Hazardous Waste Section
Solid Waste Management Division
Washington Department of Ecology
Mail Stop PV 11
Olympia, Washington 98504

Subject: Petition for Exempting Waste Cement Kiln Dust
Seattle, Washington Cement Plan

Dear Mr. Knudson:

The Cement Division of Ideal Basic Industries is hereby filing a petition for exempting from the Washington State Dangerous Waste Regulation the waste cement kiln dust generated at its Seattle, Washington Cement Plant.

We believe that, with the exception of providing the names and qualifications of persons involved in the sampling and testing of the waste dust and certain analytical instrument data, all of the information necessary for a successful petition exemption has been furnished to the Washington State Department of Ecology in our application for a certificate of designation of the material as a non-dangerous waste. (Additional copy attached). If necessary, all omitted information can be furnished at a later date.

The analytical results presented in our certificate of designation application should more than adequately demonstrate that the waste kiln dust for the Seattle Cement Plant does not pose a threat to public health or the environment. Supportive of our position, on a much broader scale, is the Bureau of Mines extensive study conducted on 113 samples of waste kiln dust from 102 plants in the United States, representing about 70 percent of the U. S. industry, which concluded that, "Cement kiln dust is a large-volume material and a potential resource as a substitute for lime", and that "Any environmental considerations are minor, as the results of this extensive survey shows that U.S. cement kiln dust is not a hazardous waste as defined by current regulations established under RCRA."

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If additional information is necessary, we will appreciate your informing us at the earliest possible time as to what extent and the time frame requirements for submittal.

Sincerely yours

Harlan W. Powledge

Harlan W. Powledge
Director Environmental Quality

HWP:rel

Enclosure

cc: Fred Bauer
Larry Warner
Jim Hutchison
Ron Wallis (w/enc.)

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CERTIFICATE OF DESIGNATION APPLICATION

Attn: Hazardous Waste Section
Mail Stop PV-11
Department of Ecology
Olympia, Washington 98504
Telephone: (206) 459-6301

For WDOE Use Only

Application # ______________
Date Received ______________

NOTE: Completion and submission of this application is entirely voluntary. WAC 173-303-075, Certification of Designation, and the Certification Guidelines published thereunder set forth the process by which a generator may request that the Department of Ecology determine whether his solid waste is designated as either dangerous (DW), extremely hazardous (EHW), or undesignated by chapter 173-303 WAC, Dangerous Waste Regulations. This application form is to be used by any generator who wishes to apply to the department for a certificate designating his waste. The information provided by the generator on this form will be used as the basis for deciding his waste's designation status. The department may request additional information needed for proper designation. If information is not adequate, the department will not issue a certificate of designation.

INSTRUCTIONS: Type or print application responses in ink and submit the completed form to the address listed above. You should be as accurate and thorough as possible in the information you provide. After you have completed this form to the best of your ability, sign and date it in the space provided on the last page. Submission of false or incomplete information may form the basis for certificate denial. Please provide a separate application form for each waste for which you are requesting certification.

APPENDIX A-4

A. GENERATOR INFORMATION

Name Ideal Basic Industries, Cement Division
Seattle, WA Cement Plant Telephone (206) 937-8025
Address 5400 W. Marginal Way S.W.
Seattle, Washington

Name of Technical Contact Person Harlan Powledge, Denver Office (303) 623-5661
EPA/State Identification Number (if one has been issued) -

B. BUSINESS DESCRIPTION

Give a general description of the type of business, type of products, and the four digit Standard Industrial Classification (SIC) number or numbers which best describe your business.
Portland cement manufacturing by the wet process.
S.I.C. 3241

C. CURRENT WASTE MANAGEMENT

How is the waste typically packaged, and what Department of Transportation (DOT) labels, if any, are affixed to waste shipments?
The waste material is not packaged and there are no DOT labels affixed to shipments. The waste has been temporarily excluded from the RCRA hazardous waste regulations and the WA State Dangerous Waste Rec

How is the waste transported? Pneumatic transport tracks.

Where is the waste currently being sent and what type of management (e.g., landfill, neutralization, treatment plant) is it undergoing?
Permitted industrial land fill located near Ravensdale, Washington.

D. WASTE QUANTITY

What is the maximum quantity of waste you generate? (Approx. 45% of total generate)
~~Pounds~~ per month: 9,000 Tons ~~Pounds~~ per year: 108,000 Tons
What is the average quantity of waste you generate?
~~Pounds~~ per month: 6,000 Tons ~~Pounds~~ per year: 72,000 Tons
How frequently do you generate this waste (e.g., continuously, weekly, monthly, etc.)? Continuously

E. GENERAL WASTE DESCRIPTION

1. Common waste name Cement kiln dust.
2. Describe completely the process which generates the waste, including the names of the primary raw chemicals used, any waste mixing which occurs, and any in-line treatment or pretreatment the waste undergoes before discharge.
   See attached letter dated May 3, 1983 from Ideal to Mr. James C. Knudson, Hazardous Waste Engineer, Washington State Department of Ecology.

3. In what physical form does the waste normally occur? (Check one) Solid X Liquid ____ Sludge ____ Compressed Gas ____
4. What color or colors is the waste normally? Shades of gray.
5. Describe any noxious odors or gases which the waste emits.
There are no noxious odors or gases emitted from the waste kiln dust.
6. What is the waste density in:
Pounds per gallon 3-7 AND Pounds per cubic foot 22-58 Avg. Approx. 50
7. What is the general waste composition in percent by weight?
% Water 0 % Organics 0 % Inorganics 100
8. Is the waste currently designated as dangerous waste (DW)? No
As extremely hazardous waste (EHW)? No If yes, what is its Dangerous Waste Number or numbers? --

F. WASTE CHARACTERISTICS

1. Does the waste have a flashpoint less than 140°F (60°C)? No
2. If the waste is liquid or aqueous, what is its pH? The waste is nonagueous
3. Is the waste explosive or unstable? No Does it react violently or form explosive mixtures with water? No Does it generate toxic fumes or gases when mixed with water, mild acids or mild caustics? No
4. If the waste has been tested against the Extraction Procedure (EP) toxicity test, give concentrations in parts per million (PPM) for the following:

As < 1.0	Pb < 1.0	Endrin < 0.005
Ba < 50	Hg < 0.1	Lindane < 0.01
Cd < 0.1	Se < 0.1	Toxaphene < .02
Cr (VI) < 0.5	Ag < 0.1	2,4-D < 3.0
Methoxychlor < 5.0		2,4,5-TP Silvex < 0.3

G. SPECIFIC WASTE COMPOUNDS

For any chemical constituents known to be in the waste, list their names and approximate concentration ranges. NOTE: You are not required to test your waste for this information. Use any data which you currently have available (e.g., previous tests, calculations, etc.).

SiO	12.5	SO_3	4.8
Al_2O_3	2.9	Na_2O	0.5
Fe_2O_3	1.9	K_2O	1.4
CaO	49.7	Loss	24.8
MgO	0.7		

H. WASTE TESTS

Describe below (or on a separate sheet) any tests which have been performed on the waste, who performed the tests, how samples for testing were obtained, and who performed the waste sampling. Include the final results of tests that were performed, the dates on which the tests were made, and the dates on which samples were obtained. Also, wherever appropriate, include statistical summaries, mean values, and standard deviations. (Attach copies of any test data sheets which are available for the waste and which would provide information useful for designation.) NOTE: This does not require you to perform any new tests, this is only a request for any existing test data which you presently have. The department may, as part of its request for additional information (if necessary), ask you to perform certain tests on your waste to assure proper designation and certification.

See Attachment H - Waste Tests.

I. WASTE CONSTANCY

Describe below (or on a separate sheet) how long the waste has been generated, how frequently the process which generates the waste changes, and what the process changes are, and indicate any future process changes which you expect will occur. NOTE: You may wish to consult with the department to determine how best to provide this information.

At the present time there are no operational modifications, production deviations or raw material supply changes planned for the Seattle Cement Plant.

Cement kiln dust has been generated at the Seattle Plant since the beginning of operations in 1967. As discussed in the attached letter dated May 3, 1983, kiln dust is continuously generated during the kiln burning process. On a yearly basis, the kiln at the Seattle Plant operates in excess of 90% of all possible time.

Since it has been found that complete reprocessing and/or beneficial reuse of all generated kiln dust is not possible, a considerable portion, by necessity, becomes a waste material. At the present time approximately 45% of all generated kiln dust is wasted.

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attached documents, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe it to be true, accurate, and complete.

Generator's Signature Harlan W. Powledge Date 11/28/83

Harlan W. Powledge

ATTACHMENT H - WASTE TESTS

On September 28, 1983 a one pound sample of waste cement kiln dust was provided for Biomed Research Laboratories, Inc. of Seattle, Washington, to perform the analyses required for properly designating the material under the Washington State Dangerous Waste Regulation. The sample was obtained from a composite of approximately 28-pounds collected by plant personnel during a 14-day period in August of this year in accordance with a sampling plan approved by the Washington State Department of Ecology. Please see the following attached letters:

1. May 3, 1983 - Proposed Sampling Plan from Ideal Basic to Mr. James C. Knudson, Washington Department of Ecology.
2. May 27, 1983 - Approval of Sampling Plan from James C. Knudson, Washington Department of Ecology to Ideal Basic.
3. September 28, 1983 - Sample Delivery from Ideal Basic to Mr. James C. Knudson, Washington Department of Ecology.

The following tests were performed by Biomed Research Laboratories:

1. Ignitability
2. Corrosivity
3. EP Toxicity
4. Static Acute Fish Bioassay
5. Acute Oral Rat Toxicity
6. Polycyclic Aromatic Content
7. Halogenated Hydrocarbon Content

With the exception of the fish bioassay, all of the tests performed by Biomed Research Laboratories show the waste cement kiln dust from the Seattle Plant to be a non-dangerous material under the Washington State dangerous waste criteria.

It was concluded from the Static Acute Fish Bioassay that the waste dust is toxic to juvenile rainbow trout at a concentration of 1000 ppm, but non-toxic at a concentration of 100 ppm. However, on a bioassay retest at 1000 ppm under controled pH conditions, the material was found to be non-toxic. On the basis of the bioassay retest, we have concluded that the only toxic characteristic of the waste cement kiln dust is its high pH (11+) and that the material should either be designated as non-dangerous or excluded from the Washington State Dangerous Waste Regulation.

APPENDIX A-4

BIOMED
RESEARCH LABORATORIES, INC.

October 25, 1983

Ideal Basic Industries
Cement Division
Ideal Plaza
950 17th Street
P.O. Box 8789
Denver, Colorado 80201

ATTENTION: Harlan W. Powledge

SUBJECT: Static acute fish bioassay testing on juvenile rainbow trout, Salmo gairdneri.

Acute oral rat toxicity on male albino white rats.

SAMPLE ID: Lab #10041 Waste cement kiln dust

PROCEDURE: The above sample was tested on fish at the 1000 ppm level, then retested at the 100 ppm level. The sample was tested on fish a third time at the 1000 ppm level under pH controled conditions. The procedure followed is outlined in the State of Washington's General Procedure for Static Acute Fish Bioassay Testing.

RESULTS: Thirty (30/30) of the fish tested with BioMed sample #10041 at the 1000 ppm level died within 2 hours of adding the toxicant to the water.

None (0/30) of the fish tested at the 100 ppm level died throughout the four day test period.

None (0/30) of the fish tested at the 1000 ppm, pH adjusted to approximately 7.0 level died throughout the four day test period.

None (0/90) of the control fish tested died throughout the test period.

None (0/10) of the rats gavaged with BioMed sample #10041 died throughout the 14 day test period.

APPENDIX A-4

None (0/10) of the control rats died throughout the same test period.

CONCLUSIONS: Ideal sample of waste cement kilm dust, BioMed #10041 was found to be toxic to juvenile rainbow trout at the 1000 ppm level, and is therefore to be considered a dangerous waste material under Washington State Guidelines. (Note: "A waste material would be designated a dangerous waste if greater than 11 cumulative deaths out of 30 test organisms occurred within 96 hours at a concentration of 1000 ppm." I hope that the rest of the information contained in this report and the findings of the Chemistry Department will be of value to you in determining the exact toxic nature of this substance.

Respectfully submitted,

Kevin Casey

Kevin Casey,
Fisheries Biologist

APPENDIX A-4

BIOMED
RESEARCH LABORATORIES, INC.

November 16, 1983

Harlan Powledge
C/0 Ideal Basic Industries
Ideal Plaza
950 17th St.
P.O.Box 8789
Denver, Colorado 80201

Waste Analysis of Cement Kiln Dust

Lab# 10041

Substance	EP Tox Limit (ppm)	Concentration found (ppm)
Ag	5	<0.1
As	5	<1.
Ba	100	<50
Cd	1	<0.1
Cr	5	<0.5
Hg	0.2	<0.1
Pb	5	<1.
Se	1	<0.1
Endrin	0.02	<0.005
Lindane	0.4	<0.01
Methoxychlor	10	<5
Toxaphene	0.5	<0.2
2, 4-D	10	<3
2,4,5-TP	1	<0.3

Respectfully submitted,

Floyd R. Kirk

Floyd R. Kirk
Chemist

BIOMED
RESEARCH LABORATORIES, INC.

LABORATORY REPORT

CUSTOMER:

Harlan Powledge
C/O Ideal Basic Industries
P.O. Box 8789
Denver, CO 80201

LABORATORY USE ONLY
LAB #: 10041
REPORT DATE 9/25/84
CUSTOMER P.O.#
APPROVED

SAMPLE I.D.

SAMPLE DESCRIPTION Cement Kiln Dust Analysis

These results are being re-sent to you in response to your phone call.

PAH: < 1%
Chlorinated hydrocarbons: < 0.01%
Ignitibility: No
Corrosivity: No

Respectfully Submitted,

Floyd R. Kirk

Floyd R. Kirk,
Chemist

APPENDIX A-4

Ideal Basic Industries
Cement Division

Seattle Plant
5400 West Marginal Way S W.
Seattle, Washington 98106
206 937 8025

IDEAL

TYPICAL WASTE DUST ANALYSIS

SiO	12.5	
Al_2O_3	2.9	
Fe_2O_3	1.9	
CaO	49.7	
MgO	0.7	
SO_3	4.8	
Na_2O	0.5	
K_2O	1.4	
Loss	24.8	
Fineness	-325	86%
	-200	95%

JOHN SPELLMAN
Governor

1889

DONALD W. MOOS
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504 • (206) 459-6000

RECEIVED SEP 21 1984

September 19, 1984

Mr. Robert J. Castelli
Regional Production Administrator
Ideal Basic Industries
Cement Division - Pacific Region
3030 One Union Square
600 University Street
Seattle, Washington 98101

Dear Mr. Castelli:

This letter will serve as the Department of Ecology's completeness review of your December 12, 1983 petition for exempting waste cement kiln dust from your Seattle plant. Mr. Harlan Powledge of your Denver office attached the Certificate of Designation application since it contains much of the information required for a petition application under WAC 173-303-910(3) of the Dangerous Waste Regulations.

Your application needs to be supplemented as follows:

1. WAC 173-303-910(3)(c)(ii) - The names and qualifications of the persons sampling and testing the waste. This can be the names and resumés of the individuals involved.

2. WAC 173-303-910(3)(c)(vii) - References WAC 173-303-072)3). Information to satisfy WAC 173-303-072(3)(c). This must be a showing that the waste does not otherwise pose a threat to public health or the environment. I would suggest a discussion of how threats to direct contact with the waste and fugitive dust may be avoided or mitigated at the Ravensdale site of Industrial Mineral Products. You should also discuss any potential enivronmental threats from leachates to surface and groundwater. The hydraulogy and geology of the Ravensdale site should be presented as part of that discussion.

3. WAC 173-303-910(3)(c)(x) - Description of tests including the results. your application describes the tests and summarizes the results. Backup data sheets are available only for the EP toxicity and corrosivity tests. Please include the backup data sheets for the remaining tests.

APPENDIX A-5

4. WAC 173-303-910(3)(c)(xi) - The names and model numbers of the instruments used in performing the tests and the date of the last calibration for instruments which must be calibrated according to manufacturer's instructions.

5. WAC 173-303-910(3)(c)(xii) - Certification. This certification as worded in the regulations must accompany the supplemental submissions.

6. Submission of an Environmental Checklist for compliance with SEPA rules.

   You may make reference to the petition application where information required by the checklist is duplicative.

You should submit this information by October 21, 1984, if at all possible, to assure timely processing of your petition.

Sincerely,

James C Knudson

James C. Knudson, P.E.
Hazardous Waste Section

JCK:m
Enclosure
cc: John Conroy
Harlan Powledge
Glenda McLucas ✓

APPENDIX A-6

99. EPA/STATE HAZARDOUS WASTE I.D.# W A

(a) ☐ RCRA/STATE
(b) ☐ STATE ONLY
(c) ☐ SMALL QUANTITY
(d) ☐ NON REGULATED
(e) ☐ ONE TIME ONLY
(f) ☐ EMERGENCY
(g) ☐ OTHER ______

INIT: ______
DATE: ______
EPA: ______
ACK: ______
COPY: ______
REGION: ______

DEPARTMENT USE ONLY

FORM 2

NOTIFICATION OF DANGEROUS WASTE ACTIVITIES

(send to) Attn: DW Notifications
Washington State Department of Ecology
M/S PV-11 Olympia, WA. 98504
(206) 459-6300/6305/6306

DATE IN TO DEPARTMENT

DEPARTMENT USE ONLY

1. ☒ A. FIRST NOTIFICATION
☐ B. REVISED NOTIFICATION (enter current I.D.# in upper left)
revisions effective: MO. ____/ DAY ____/ YR. ____
☐ C. WE REQUEST TO HAVE OUR I.D.# WITHDRAWN (enter current I.D.# assigned to you in section 99 in upper left)
☐ D. REACTIVATE OUR NOTIFICATION (complete all sections)

2.A. WASHINGTON STATE DEPARTMENT OF REVENUE REGISTRATION (TAX) NUMBER: 409-007-438

2.B. SIC CODE(S)
PRIMARY: 5098
SECONDARY:
OTHER:

3. NAME OF COMPANY: Ideal Basic Industries Inc.

4. MAILING ADDRESS
STREET, P.O. BOX, OR RURAL ROUTE & BOX NO.: 5400 West Marginal Way SW
CITY OR TOWN: Seattle
STATE: WA
ZIP CODE: 98106 -

5. LOCATION OF WASTE ACTIVITIES (Installation)
DESCRIPTION OF PHYSICAL LOCATION (Follow Instructions Carefully): Same
CITY OR TOWN:
STATE:
ZIP CODE: -

6. COUNTY WHERE THIS INSTALLATION IS LOCATED: King

7. DANGEROUS WASTE ACTIVITIES YOUR BUSINESS IS CONDUCTING
(Read & Follow Instructions Carefully—Enter an "X" in appropriate box(es))

A. ☒ GENERATOR
B. ☐ UNDERGROUND INJECTION

C. ☐ WASTE MANAGEMENT FACILITY (TSD) (refer to definitions in instructions)
(1) ☐ TREATMENT
(2) ☐ STORAGE
(3) ☐ DISPOSAL
(4) ☐ WE ACCEPT OFF-SITE WASTES

D. ☐ TRANSPORTER (complete this section only if YOU are transporting waste for hire or your own waste to an off-site facility)
(1) Mode(s) of Transport YOU Operate
(a) ☐ HIGHWAY (b) ☐ AIR (c) ☐ RAIL
(d) ☐ WATER (e) ☐ OTHER ______

8. CONTACT PERSON
NAME (last): Darby (first): Larry
TITLE: Production Supervisor
PHONE NO. (area code & number): 206-937-8025

9. OWNERSHIP
(Legal Owner(s) of this Installation): Ideal Basic Industries

10. TYPE OF OWNERSHIP
(enter letter code in box): P

ECL-812
ECY 030-5 (3/84)

APPENDIX A-6

11. WASTE IDENTIFICATION

A. LINE NUMBER	B. Description of Waste(s)	C. Dangerous Waste Number (refer to WAC 173-303)	D. Estimated or Actual Annual Waste Quantity	E. WEIGHT CODE
1	Cement Kiln Dust	WT02	150000	
2				
3				
4				
5				
6				
7				
8				
9				
10				

12. ESTIMATED MAXIMUM QUANTITY of all wastes listed above to be produced in any given month (consecutive 30 days) or per processing batch.

		QUANTITY	WEIGHT CODE
A. ☒ Batch Frequency	PerDay	120	
B. ☒ PER MONTH		3600	

13. COMMENTS (Enter Information by Section & Line Number—See Instructions)

14. FORMS AND INFORMATION REQUEST

(Check the box(es) of those items desired and indicate how many)

A.______ ☐ NOTIFICATION FORM
B.______ ☐ PART A PERMIT FORM FOR TSD FACILITIES
C.______ ☐ BIOLOGICAL TEST PROCED.
D.______ ☒ GENERATOR ~~ANNUAL~~ REPORT FORM
E.______ ☐ CHEMICAL TEST PROCED.
F.______ ☐ TSD FACILITY ANNUAL REPORT/UNMANIFESTED WASTE REPOR
G.______ ☐ DANGEROUS WASTE LEGISLATION (RCW 70.105) AND REGULATIONS (WAC 173-303)
H.______ ☐ DANGEROUS WASTE FEES LEGISLATION (RCW 70.105A) & REGULATION (WAC 173-305)
I.______ ☐ OTHER (specify)______

15. CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

SIGNATURE: Larry Darby
PRINTED NAME:
OFFICIAL TITLE (Print)
DATE SIGNED:

APPENDIX B

WIDESPREAD USES FOR CEMENT-KILN DUST

IDEAL BASIC INDUSTRIES, 1984

APPENDIX B-1

N-VIRO
N-Viro Energy Systems Ltd.

September 28, 1984

Dr. Glenda McLucas
P.O.Box 5352
Lacey, Washington 98502

Dear Dr. McLucas,

I appreciate your kind comments on our efforts concerning cement kiln dust utilization.

Within 250 miles of Toledo, Ohio, we are involved in negotiations for the use of over 500,000 tons of kiln dust in 1985. Cement kiln dust is a valuable national resource.

Enclosures one thorugh seven are publications that we have prepared on kiln dust utilization. We particularly call your attention to enclosure #3 on N-Viro Soil technology.

Enclosures eight through ten are speeches or articles in national publications.

We are prepared to immediately institute a marketing program for Ideal Cement in the Washington area. If we can be of further assistance, please advise.

Best wishes.

Sincerely,

Pat Nicholson

J. Patrick Nicholson,
Chief Executive Officer.

JPN/ss

Enclosures.

3450 West Central Avenue Suite 250 Toledo, Ohio 43606 Telephone: 419/535-6374

RECEIVED SEP 20 1984

EPA-670/2-75-043
May 1975

Environmental Protection Technology Series

DISPOSAL AND UTILIZATION OF WASTE KILN DUST FROM CEMENT INDUSTRY

National Environmental Research Center
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

APPENDIX B-2

EPA-670/2-75-043
May 1975

DISPOSAL AND UTILIZATION OF WASTE KILN DUST FROM CEMENT INDUSTRY

By

Thomas A. Davis
Don B. Hooks
Southern Research Institute
Birmingham, Alabama 35205

Project No. R-801872
Program Element No. 1BB036

Project Officer

Edmond Lomasney
U.S. Environmental Protection Agency
Region IV
Atlanta, Georgia 30309

NATIONAL ENVIRONMENTAL RESEARCH CENTER
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

REVIEW NOTICE

The National Environmental Research Center--Cincinnati has reviewed this report and approved its publication. Approval does not signify that the contents necessarily reflect the views and policies of the U. S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable sources.

The studies for this report were undertaken to determine the nature, quantity and fate of dust collected from the effluent gases of cement kilns, to identify and describe potential uses for the dust, and to identify specific areas where the Agency's participation in the development of new technology could have maximum effect on the cement industry's efforts to protect our Nation's environment.

A. W. Breidenbach, Ph.D.
Director
National Environmental
Research Center, Cincinnati

ABSTRACT

A survey that included 60% of the cement manufacturing plants in the United States was made to determine the fate of dust collected from the gases emanating from cement kilns. Because of high alkali content, large quantities of the dust cannot be returned to the cement-making process. A survey was made of the literature in the United States and Europe pertaining to handling, reclaiming, and utilizing the collected dust. Abstracts of 71 references are included in the Appendix. Acid neutralization capacity and potash content make the dust valuable for application to farmland, and the potential market for agricultural use alone could consume all of the waste dust that is now being discarded.

This report was submitted by Southern Research Institute in fulfillment of Project No. R-801872 under the sponsorship of the Environmental Protection Agency.

CONTENTS

Sections

FIGURES

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ACKNOWLEDGMENTS

The authors gratefully acknowledge the assistance of the Portland Cement Association in our literature survey and in establishing contact with appropriate individuals in the cement industry. We express appreciation to the managers of the individual plants who generously provided data and insights concerning problems of dust handling. We especially appreciate the assistance of Mr. Bruce E. Kester, Vice President, Environmental Systems, Missouri Portland Cement Company, who contributed greatly to our understanding of the industry and who verified the technical descriptions presented in this report.

We acknowledge the aid of Mr. George A. Wieczorek of the Division of Chemical Development, Tennessee Valley Authority, in providing considerable information concerning the use of cement dust for fertilizer, and of Dr. Robert C. Rund, Secretary of the Association of American Plant Food Control Officers, for providing information on specifications for fertilizer materials.

Dr. Charles E. Feazel, Senior Research Advisor, Southern Research Institute, assisted in our literature survey by translating a number of patents and journal articles that were available only in German or Russian. He also assisted in editing this report.

SECTION I

CONCLUSIONS

The exhaust gases from portland cement kilns carry away an average of 12.2% of the kiln feed. To reduce particulate emissions, an average of 96% of this material is removed from the exhaust gases by dust collectors. Since the dust has an estimated value of $2 per ton, it is returned to the kiln whenever possible. Of the 16.4 million tons of dust collected annually from cement kiln exhausts, 11.9 million tons are returned to the cement-making process, and 4.5 million tons are discarded.

The major factor preventing return of more dust to the kilns is that the high concentration of alkalies in the dust would cause the alkali content of the clinker to exceed the limit of 0.6%. Seven plants employ a leaching process to remove the alkalies so that the dust can be returned, but the alkalies in the leachate pose a serious water pollution problem. Several other techniques for removing alkalies are described in the literature, but none is presently used in the United States.

Most waste kiln dust is stored in open piles on the ground or in abandoned quarries. The highly alkaline runoff of rainwater from disposal sites can cause pollution of streams or ground water unless it is contained and treated. The combined costs of hauling the dust and controlling runoff appear to make dust disposal economically and ecologically unattractive. In most cases cement manufacturers would give away their waste dust if someone would take it.

The markets for agricultural lime and potash fertilizer materials are large enough to consume all of the waste kiln dust that is currently being discarded. Moreover, on the basis of numerous studies cited in this report, the chemical composition of kiln dust appears suitable for the dust to be applied to acidic soils and to soils that require additional potassium. However, only small amounts of the dust are being used for this purpose in the United States.

Other uses for waste dust from cement kilns include landfill, soil stabilization, neutralization of acidic wastes (e.g. mine drainage and pickle liquor), absorption of SO_2 from stack gases, water treatment, glass making, and production of light-weight aggregate.

APPENDIX B-2

SECTION II

RECOMMENDATIONS

This state-of-the-art study was limited to a survey of the industry to determine present practice of dust disposal and utilization and a survey of the literature to identify potential alternatives to wasting high-alkali kiln dust. It was not within the scope of the program to perform demonstration experiments or to establish the economic feasibility of various alternatives for dust utilization.

Since agricultural uses appear to be the most promising applications of dust that cannot be returned to the cement-making process, we recommend that action be initiated with the Association of American Plant Food Control Officials (AAPFCO) to have cement dust specified as an agricultural liming material and as a potassium fertilizer material. The data obtained in our survey concerning the quality and quantity of dust available from cement plants could be used by the AAPFCO to establish specifications that might allow the dust to be applied to farmlands without any modifications of its properties. Specifications that require little or no monitoring and control of the composition of the material would facilitate distribution and marketing of the dust by the cement manufacturers. On the other hand, AAPFCO may determine that modifications of the chemical composition and physical form of the dust would make it more suitable as a fertilizer material. This may require a research program to develop methods of treating the dust from various cement plants to meet the specifications.

The dust leaching systems presently in operation at seven plants appear to be economically attractive; however, substantial modifications to the leaching process will be required to meet water pollution control regulations. We recommend that studies be undertaken to determine the economic feasibility of recovering alkalies from the leachate so that they are not discharged to the environment. If alkali recovery appears justified, we recommend that pilot plant facilities be set up and operated with an existing leaching operation to demonstrate technical feasibility.

SECTION III

INTRODUCTION

The manufacture of portland cement is accompanied by the generation of large quantities of dust. Grinding and conveying raw materials, heating them in a rotary kiln, and grinding the resulting clinker are all dust-producing operations, and the dust escaping from these operations must be collected to prevent air pollution.[1] Dust collected in raw material processing operations can be returned to the process, and dust from clinker grinding can be sold as cement. Since the manufacturer has economic incentive to collect and reuse these dusts,[2] their disposal is seldom a problem, and they will not be discussed further in this report.

The dust generated in the rotary kiln is difficult to collect because it is entrained in large volumes of hot exhaust gases. Moreover, it often contains unacceptably high concentrations of alkalies (sodium and potassium) which make it unsuitable for return to the cement-making process. Disposal of the dust is complicated by the presence of soluble alkalies in the dust; when these are leached out by rainwater, they can cause pollution of surface or ground waters. This study was undertaken to assess the problems associated with kiln-dust disposal and to find and evaluate possible solutions to these problems with an emphasis on utilization of waste dust rather than development and maintenance of expensive and wasteful disposal systems.

A successful assessment of the state of the art of collection, disposal and utilization of waste kiln dust required a review of pertinent technical literature. Chemical Abstracts, the reference files of the Portland Cement Association and a bibliography from the Tennessee Valley Authority were used to gain initial access to the literature. The literature search yielded numerous references, both foreign and domestic, which were screened for their applicability to the purpose of the study. Polish, Russian, and German articles made up the bulk of the pertinent foreign literature. Whenever the title or published abstract of an article appeared relevant, the original article was copied and read. In several cases we corresponded with the author to update or elaborate on the information published in his article or patent. Many articles in foreign languages were translated by members of the staff of Southern Research Institute. Abstracts for references cited in this report are given in the Appendix.

Concurrent with this study, we were also engaged in a survey to obtain the background data necessary to establish the Effluent Limitation Guidelines for the Cement Industry. The data forms used to record information from phone calls and plant visits for that study also had space for data on collection, disposal, and utilization of kiln dust. Later another data form shown in Figure 1 was used for further contacts with cement manufacturers. Data from about 60% of the active cement plants in the United States were processed by computer to provide a basis for estimating the amounts of kiln dust collected, discarded, and utilized by the entire industry.

In addition to contacts with plant personnel for acquisition of operating data, we contacted corporate environmental and managerial personnel of several cement companies, consultants, equipment manufacturers, EPA personnel, potential consumers of waste dust, and suppliers of materials for which kiln dust may be a substitute. These contacts were made to solicit opinions and facts on problems attendant to utilization of dust in particular applications and to seek additional potential applications.

APPENDIX B-2

CEMENT KILN-DUST WORKSHEET

SRI ID ____________

Company name ____

Plant name and location ________________________________

Contact ______________________________ Ph: ____________

1. Kiln-dust collection

   a. Collection equipment (check one or more)

      Cyclones or multiclones......... ☐
      Baghouse....................... ☐
      Electrostatic precipitator...... ☐
      Wet scrubber................... ☐
      Other (specify)................ ☐
      None........................... ☐

   b. Estimated collection efficiency (%) __________

2. Kiln-dust disposition

   a. Total collected (tons/day) __________
      Alkali content - K_2O (%) __________
      - Na_2O (%) __________
      - Na_2O equivalent (%) __________

   b. Total returned to kiln (tons/day) __________
      Alkali content - K_2O (%) __________
      - Na_2O (%) __________
      - Na_2O equivalent (%) __________

      Method of return
      insufflation.................. ☐
      mixed with feed............... ☐
      leached....................... ☐

   c. Total discarded (tons/day) __________
      Alkali content - K_2O (%) __________
      - Na_2O (%) __________
      - Na_2O equivalent (%) __________

      Method of disposal
      Surface piling................ ☐
      Quarry piling................. ☐
      Slurry to quarry.............. ☐
      Slurry to pond................ ☐
      Other (describe).............. ☐
      Utilization (describe)......... ☐

____

____

   c. Does this company have plans for future utilization of cement dust? If yes, how? ______________________

____

____

3. Additional remarks (novel practices, special problems, etc)

____

____

____

Figure 1. Sample form used to record survey data.

SECTION IV

THE INDUSTRY

Portland cement is composed of the oxides of calcium, silicon, aluminum, and iron, bound in a complex mineralogical matrix, with the ability to hydrate and harden into a stone-like material. The raw materials generally include a calcium carbonate source such as limestone, cement rock, marl, chalk or oyster shell, a silica source such as sand, quartzite or Fuller's earth, an alumina source such as clay, shale, slag, aluminum ore tailings or fly ash, and an iron source such as iron ore, iron oxide, blast furnace flue dust or iron pyrites.[3] Some raw materials contain several of the necessary constituents and thereby reduce the number of materials that must be handled by a manufacturer. The most common combinations of materials are: cement rock; limestone and clay; limestone and shale; and limestone, clay, and iron ore. Naturally occurring raw materials contain unnecessary or undesirable elements such as magnesium, potassium, sodium, sulfur, chloride, fluoride, phosphate, and heavy metals; however, when these are present in only trace amounts, they are not deleterious to the manufacturing process or to the product.

The principal steps in the manufacture of portland cement are quarrying (or dredging of shells), crushing, grinding, blending, firing, and finish grinding. The quarrying and crushing operations are not unique to the cement industry, in fact, almost all mineral quarrying and crushing operations use the same techniques and equipment. Raw grinding of the sized materials reduces them to a fineness of about 200 mesh. Most plants employ ball mills for raw grinding and some add water to the material being ground. Those plants grinding raw material as a water slurry usually keep the material wet until it is dried in the kiln, thus the term "wet process". In those plants grinding raw material dry the term "dry process" has been adopted. Wet process plants pump the ground material to large stirred tanks, called slurry tanks, where the composition is adjusted as necessary and the batch is stirred to assure uniformity. The analogous dry process equipment is a homogenizing or blending silo stirred by introduction of compressed air at the base. Factors that determine whether wet or dry grinding will be used include: moisture content of the raw materials, availability of water, and the price of fuel. (Wet-process plants require additional fuel to evaporate the moisture in the kiln feed.)

Quarrying, crushing, grinding, and blending prepare raw material for the most important step in processing, burning in the kiln. The kiln feed (also called raw meal or raw mix) is continuously metered into the upper end of the kiln to begin its transit of one to four hours through the kiln. A burner maintains the temperature at the lower end of the kiln at about 1500°C and the feed temperature approaches this value as it traverses the kiln. During the movement of feed through the kiln, three thermally induced events occur: moisture is driven off, the calcium carbonate calcines to calcium oxide, and then the entire mass fuses into semi-liquid, marble-size balls called clinker. The fusion step involves several complex chemical reactions resulting in a new mineralogical material, portland cement clinker.

Clinker discharged from the kiln, usually onto a moving grate clinker cooler, is cooled by a stream of air passing up through the grate. Usually a portion of the hot air from the clinker cooler is used as combustion air for the burner. Water spray cooling is the only other significant clinker cooling method in the industry. After cooling, gypsum (usually about 5% by weight) is added to the clinker to retard hydration. Then the mixture is finely ground (325 mesh) prior to bagging or bulk shipment.

The various standard grades of cement available are all produced with the same equipment and essentially the same raw materials. The differences between cement grades are achieved by variations in kiln operating conditions and ratios of raw materials.

The cement industry is now in a period of growth in production capacity. During the period 1965-70 the cement industry suffered from excess capacity. There were 177 active plants in 1964,[1] and several of these were shut down due to reduced profits and air pollution regulations that required expensive additions of emission control devices. During the 1970's the number of plants has remained in the range of 165 to 170 as new plants come on stream and older plants are closed. However, the larger capacity of newer plants and the expansion of some existing plants resulted in a steady increase of cement shipments in the United States from 75.3 million tons* in 1970 to 87 million tons in 1973.[4] The value of the 1972 cement shipments was about $1654 million, producing a profit of about 9% return on net worth.[5]

Locations of portland cement plants are dictated normally by distance to market, availability of transportation and availability of raw materials. Typically, the market area is considered to be within 100-200 miles from the plant along transportation routes. Low cost transportation such as rail or water is usually required to profitably ship cement further than the 10-50 mile radius of the local market. Similarly, proximity of raw materials is imperative if a plant is to compete economically. Most plants utilize

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*The cement industry has adopted the short ton, 907 kg, as its standard unit of weight. Therefore, all production figures in this report will be expressed in short tons.

stone quarries adjacent to the plant so that raw material transportation costs are kept low. Some plants, however, are located so as to minimize distribution problems and must transport raw materials several miles from quarry to plant site. Still other plants purchase shell or stone from other suppliers.

The costs of cement production do not depend as much on materials as on labor, which accounts for roughly one-third of the total inplant cost for producing cement. Examples of major costs for 14 plants are given in Table 1.

The future of portland cement is good despite the more stringent pollution control laws. Demand is increasing due to increased construction and increased use of prestressed concrete products. The average annual increase in shipments of portland cement is predicted to be about 3.4%.[4] Factors which could adversely affect the cement industry are as yet speculative. The greatest threat to the industry is the fuel shortage, which is likely to result in significant process modifications to improve thermal efficiency.

APPENDIX B-2

Table 1. PLANT PRODUCTION COSTS
(1973 dollars per short ton)

Plant	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Avg.
Purchased Raw Material	0.69	1.82	1.13	0.76	4.22	5.25	0.76	0.59	0.76	0.85	0.91	4.17	0.65	0.59	1.65
Freight on Limestone			1.06					1.01						1.38	0.25
Waste Dust Disposal		0.16													0.01
Labor	5.85	5.00	6.40	7.23	5.75	4.52	8.40	6.80	7.08	5.48	4.00	3.84	5.59	5.96	5.85
Fuel	2.18	2.39	2.83	2.39	2.39	1.76	3.46	3.40	2.29	1.80	3.09	2.13	2.08	2.66	2.49
Power	1.17	1.92	1.17	1.55	1.86	1.70	1.17	0.75	1.27	1.54	1.59	1.27	1.13	0.75	1.34
Operating and Repair Supplies	1.92	2.07	2.12	2.44	1.92	1.23	1.27	1.75	1.38	1.97	2.44	1.81	2.24	2.92	1.96
Taxes and Insurance	0.37	0.32	0.53	0.21	1.59	0.59	0.11	0.80	0.48	0.64	0.37	0.53	0.32	0.69	0.54
Miscell-aneous	0.05	0.05	0.05	0.05	0.50	0.50	0.05	0.05	0.05	0.16	0.05	0.05	0.05	0.05	0.06
Depreciation & Depletion	1.49	2.55	1.59	1.81	1.59	2.39	0.59	1.27	1.59	1.70	1.92	1.59	3.03	1.86	1.78
Total Plant Cost	13.72	16.28	16.86	16.33	19.25	17.45	15.80	16.44	14.89	14.15	14.36	15.37	15.05	16.86	15.91

Source: J.D. Wilson, Bendy Engineering Company, St. Louis, Missouri.

SECTION V

DUST COLLECTION

The Environmental Protection Agency and most state air pollution control agencies have set standards for particulate emissions from cement manufacturing processes. United States Environmental Protection Agency guidelines call for a maximum dust emission from the stack of 0.3 lb of particulates per ton of dry raw feed, and a maximum dust emission from the clinker cooler of 0.1 lb per ton of dry raw feed to the kiln.[2,6] Because it is almost always relatively coarse and low in alkalies, clinker cooler dust can be collected and returned to the process without any problems. Since clinker cooler dust is seldom discarded it was not covered in this study.

An example of the level of control represented by the EPA guidelines can be demonstrated by the following calculations:

- The average production of a portland cement plant in the United States is about 1670 tons per day.
- Approximately 1.6 tons of raw material are required to produce one ton of clinker resulting in an average feed of about 2672 tons per day.
- The average amount of dust collected (not emitted) is 312 tons per day.
- The average collection efficiency of 101 plants studied is about 96%, so total dust generated is about 325 tons/day.
- The average amount of dust generated per ton of feed is 325/2672 or 0.122 tons (244 lb) of dust per ton of feed.
- To reduce emission to 0.3 lb of dust per ton of feed, 243.7 lb of dust must be collected which is (243.7/244) x 100% or 99.88% removal.

This example is consistent with actual requirements faced by the industry. Most modern dust collection equipment is certified above 98% for normal operating conditions and some collectors have tested as high as 99.98%. The amount of dust that must be removed from exhaust gases depends, naturally, on the total amount of dust in the gases and this can vary tremendously. Dust generation depends on almost every factor that affects cement making. Some of the more noticeable causes of high dust generation are non-uniformity of feed particle size and operation of kilns above the design production rate.

The most important step in preventing air pollution is preventing escape of kiln dust to the atmosphere. To prevent kiln dust escape, many types of collectors have been utilized by cement manufacturers. The types of dust collectors used in the 101 plants surveyed are shown in Table 2.

Table 2. DISTRIBUTION OF KILN DUST COLLECTION SYSTEMS IN WET AND DRY PROCESS CEMENT PLANTS

Kiln-dust collection system	Type of Process and Number of Plants	
Single dust collector	Wet	Dry
Cyclones	2	2
Precipitators	31	3
Baghouses	3	3
Wet scrubbers	1	0
Settling chamber	1	0
Combinations of dust collectors		
Precipitators and wet scrubbers	1	0
Cyclones and wet scrubbers	1	0
Cyclones and precipitators	14	12
Cyclones and baghouses	4	16
Cyclones, baghouses, and precipitators	2	2
Baghouses and precipitators	1	1
Baghouses and wet scrubbers	0	1

The earliest and least expensive dust collector is the settling chamber. A settling chamber is typically a large box in the duct between a kiln and the exhaust stack or chimney. Exhaust gases passing through the chamber experience a reduction in velocity due to the larger cross sectional area of the chamber compared to that of the kiln. Reduced velocity allows large dust particles to settle to the bottom of the chamber. Such "dense" particles are usually 20 to 30% of the dust emanating from a cement kiln. The settled dust is removed from the chamber and usually added to the kiln feed. Only one plant contacted in our survey used a settling chamber as its only dust collector, and this plant is in the process of upgrading its collection system. Although not reported, it is likely that many plants still use settling chambers ahead of more efficient dust collectors.

Cyclones produce better separation results than settling chambers and are utilized extensively in the cement industry. Over half of the plants surveyed use cyclones for kiln dust collection, but only four plants still use them as the only dust collectors. The operating principle of the cyclone is the application of centripetal force to a moving gas stream by introducing the gas tangentially to the inner surface of a cylinder thus forcing the gas in a circular path. The radial acceleration experienced by the dust particles concentrates them against the wall of the cylinder while gases depleted of dust are removed from along the axis of the cylinder. Both cyclones and settling chambers use a force directed at right angles to the stream flow to remove dust particles but in a cyclone the percentage of dust removed is greater because the radial acceleration is much greater than the acceleration of gravity employed in a settling chamber.

Electrostatic precipitators have been in use in the cement industry for many years. Early installations were generally only slightly better than cyclones but continuing research in construction and materials have made precipitators extremely efficient and have improved economy. The principle of electrostatic precipitation involves the attraction of electrically charged particles to an electrode of opposite charge. As dust laden gas passes through a precipitator, the dust particles are exposed to a corona discharge in an electric field and acquire static electrical charges. Under the influence of the electric field, the charged particles are attracted to electrodes bearing a charge opposite to that imparted to the particles, and are deposited on these electrodes, from which they fall to hoppers below. Usually, electrostatic precipitators comprise two, three, or four stages pneumatically in series.

Electrostatic precipitators are used in 67 of the 101 plants surveyed. As shown in Table 2, they are the preferred dust collector for wet process plants (49 of the 61 plants). The moisture content of the exhaust gases helps in the conditioning of the dust particles that results in electrical conductivity properties of collected dust that are desirable for electrostatic precipitation.

The fabric filters most commonly used to collect cement kiln dust are baghouses. They consist of hundreds of siliconized-glass fabric tubes through which the dust laden gases flow, leaving the dust particles on the inside walls of the vertically hanging bags. The bags are shaken to dislodge the dust which falls into a hopper. The maximum temperature tolerated by the glass bags is somewhat less than 300°C.[7]

Wet scrubbers are employed by only two of the plants in our survey. Only one scrubber is actually used as the primary dust collector, and it has a history of mechanical problems. The dust laden exhaust gases are brought into contact with a high-velocity water spray that entraps the dust particles. The droplets are collected in cyclones and sent to a settling pond. The sludge from the settling pond is usable as kiln feed, but the overflow is a potential water pollution problem.[8]

Combination systems utilizing the best features of two or more collectors are quite common in the cement industry. The most common multiple systems are cyclones with precipitators and cyclones with baghouses. Cyclones are used ahead of the other collectors to remove coarser particles inexpensively and the second system then collects the finer particles. Usually, when alkali problems are encountered with the dust collected in a combination system, only the fine fraction from the final dust collector needs to be discarded.

SECTION VI

CHARACTERISTICS OF KILN DUST

In the process of grinding the raw materials to a fineness of minus 200 mesh, a significant amount of extremely fine particulate matter is produced. When the raw materials are subjected to the tumbling action of the kiln, these fine particles become airborne and are swept away by the hot combustion gases.

Dust collected in an efficient (i.e 98-99.9%) collector shows a wide range of particle sizes depending upon the type and extent of grinding, the type of kiln, and the type of dust collection system employed. The dust sample in Table 3 was extremely fine; most of the particles were less than 6 microns in diameter.[9] Other studies of particle size analysis reported substantial fractions of the dust with particle sizes as large as 100 microns.[10]

Table 3. PARTICLE SIZE ANALYSIS AND DISTRIBUTION OF ALKALIES IN A SPECIMEN KILN DUST FROM AN ELECTROSTATIC PRECIPITATOR[9]

Particle Size Range (Microns)	Weight Percent	Total Alkalies %		Water Soluble Alkalies, %		Water Insoluble
		Na_2O	K_2O	Na_2O	K_2O	K_2O, %
+68	0	-	-	-	-	-
-68+48	0.3	0.30	3.62	*	*	-
-48+34	0.4	0.31	3.46	*	*	-
-34+24	0.7	0.35	4.51	0.094	1.927	2.58
-24+17	1.8	0.38	5.08	0.117	2.560	2.52
-17+12	5.1	0.40	5.15	0.134	3.072	2.08
-12+6	27.3	0.33	5.35	0.134	3.252	2.10
-6	64.4	0.42	10.72	0.242	8.191	2.53

---

*Insufficient sample for analysis.

An important factor associated with dust particle size is the distribution of alkalies in the dust. Sodium and potassium sulfates, chlorides, and carbonates exhibit a strong tendency to concentrate in the finer fractions of collected dust because the specific surface area of the particles increases dramatically as effective diameter decreases. This relationship is best shown by the data in Table 3. The relationship of alkali content to surface area is explained by the following sequence of events. First, as the raw materials proceed down the kiln and increase in temperature, sodium and potassium compounds reach their boiling or subliming temperature and vaporize; then, as the gases containing airborne raw material and vaporized alkalies leave the hot part of the kiln, the alkalies cool and begin to condense both as a fume and onto particles in the gas stream. The fume produced is composed of extremely fine particles and apparently accounts for only a small part of the volatilized alkali. Most of the alkali present in the gases condenses on entrained dust particles, and since the finer particles have more surface per unit of weight to be coated, they contain more alkali per unit of weight, i.e., higher concentration of alkalies than the larger particles.

The chemical composition of kiln dust is determined by the composition of the raw materials and the conditions the dust particles have encountered in the kiln. Published data on the proportions of major constituents, Ca, Mg, Si, K, Na, S, C, etc. vary so widely that no really typical dust composition can be assumed.[10] Careful analysis of a dust sample would reveal a variety of elements, some present in only trace concentrations as shown in Table 4. This particular sample had a high concentration of the usual alkali metals Na and K and smaller concentrations of the others in that group, Li, Rb, and Cs.[11] Most of the cations are associated with CO_3^{--} and SO_4^{--}, but halide anions are also present. Volatile heavy metals such as Zn and Pb are likely to be present in concentrations significantly higher than those found in the raw materials.

The collected kiln dust has experienced some degree of calcination and thus has a lower content of CO_3^{--} than the raw materials. The "loss on ignition" value of the dust may range from 10 to 35% compared to a typical value of about 36% for raw materials. The degree of CO_3^{--} depletion is an indication of how hot the dust became and, therefore, how far down the kiln it traveled before becoming airborne and escaping with the gases. Since the dust is partially calcined it has the ability to harden somewhat upon exposure to moisture.

APPENDIX B-2

Table 4. COMPOSITION OF DRIED KILN DUST[11]

		Weight, %	
Clay (HCl insoluble, fired at 800°)		4.61	
Organic substance		2.06	
Cations			Meq/100 g
Lithium	Li^+	0.0064	0.92
Sodium	Na^+	12.25	523
Potassium	K^+	24.50	627
Rubidum	Rb^+	0.475	5.56
Cesium	Cs^+	0.0074	0.06
Magnesium	Mg^{++}	Trace	
Calcium	Ca^{++}	9.26	462
Strontium	Sr^{++}	0.015	0.34
Sum of Cations			1,618.88
Anions			
Fluoride	F^-	0.46	24.2
Chloride	Cl^-	1.43	40.3
Bromide	Br^-	0.040	0.5
Iodide	I^-	0.0552	0.44
Carbonate	CO_3^{--}	29.59	987
Sulfate	SO_4^{--}	9.06	189
Sulfide	S^{--}	Trace	
Borate	BO_3^{--}	0.152	2.58
Phosphate	PO_4^{--}	Not detectable	
Sum of Anions			1,244.02

Heavy Metals			Heavy Metal Oxides	
Chromium	Cr	0.011	Cr_2O_3	0.016
Manganese	Mn	0.013	MnO_2	0.021
Iron	Fe	0.84	Fe_2O_3	1.19
Zinc	Zn	1.62	ZnO	2.02
Lead	Pb	0.562	PbO	0.607

Sum of all determinations	97.825
Oxygen (from CaO not bound in carbonate)	2.98
Sum of all constituents	100.805

SECTION VII

THE ALKALI PROBLEM

The major sources of alkalies in the raw materials for cement manufacture are the argillaceous and siliceous components rather than the limestone or the fuel. Fixed alkali cations in the raw materials are not susceptible to removal by direct water leaching or ion-exchange methods. The only practical way of removing them is through decomposition of the clay structure by heating a lime-clay mix at ratios approaching the formulation of portland cement.[12] Under these conditions changes in mineralogical structure of the clay allow the alkalies to escape as vapors that subsequently condense on the surfaces of cool dust particles in the kiln. When necessary, $CaCl_2$ can be added to the kiln feed to further volatilize the alkalies.

The alkali content of collected kiln dust is the most important characteristic determining whether the dust can be reused in the manufacture of cement. If the total alkali content of the dust (expressed as Na_2O equivalent) is below about 1%, usually most or all of the dust can be returned to the kiln. Alkalies in the dust upset kiln operation by lowering the fusion temperature of the other materials and thereby increasing the fluidity of the kiln load. This causes a reduction in the thickness of the layer of material coating and protecting the refractory lining of the kiln. Also, the presence of substantial quantities of free alkalies in the kiln material during the burning process results in the formation of free lime, as an equilibrium product.[13] Moreover, since most of the alkali returned to the kiln eventually finds its way into the clinker, return of high-alkali dust can result in the production of clinker with an alkali content above the limit of 0.6% specified for low-alkali cement. This specification is an effort to avoid problems with the well known "alkali-aggregate reaction".

When the aggregate in concrete contains amorphous silica, alkalies in the cement can react with the silica to cause swelling of the concrete.[14,15] This slow, insidious deterioration of concrete can be a serious problem in construction of a dam or the foundation of a building, but it would be of no consequence in a sidewalk or driveway. High alkali content of the cement also has an adverse effect on the rate at which concrete gains strength.[16]

Many construction contracts and codes routinely specify low-alkali cement, even when non-reactive aggregate is to be used. This trend has forced many cement manufacturers to supply low-alkali cement when normal cement would be quite adequate. If the manufacturer is fortunate enough to have raw materials with low alkali content he can make low-alkali clinker with no problem. However, if the raw materials contain more alkali than can be tolerated in the clinker, some of the alkali must be removed and discarded. Since alkalies tend to accumulate in the fine dust entrained in the exhaust gases of the kiln, discarding dust is the easiest way to reduce the alkali content of clinker. As dust collection efficiencies for cement kiln effluent gases are improved from the average of 96% presently achieved to the 99.88% required by the New Source Performance Standards, the amount of high-alkali dust collected will increase substantially.

SECTION VIII

DUST DISPOSAL

Kiln dust with a high alkali content or other property making it unsuitable for return to the process is usually discarded. Of the 101 plants surveyed, 16 discard all of the dust they collect, and 57 discard a portion of their dust. The most common method of disposal is piling on plant property. Most often these piles are begun on an unused, fairly level location, convenient to the collection equipment and downwind of the plant proper. Another common practice is to dump the waste dust into an abandoned quarry near the plant. In either case, water pollution problems are encountered due to the solubility of the alkalies in kiln dust. Typically, 30 to 60% of the alkalies present in kiln dust are water soluble and can be leached out as water percolates through the dust piles. The runoff from a dust pile usually has a pH of 12 to 13 and will kill most vegetation. One dust pile containing discarded cyclone dust at least 5 years old produced a leachate solution with a pH of 12.5 while a nearby pile of freshly deposited dust collected in an electrostatic precipitator produced a leachate solution with a pH of 12.9. Thus, the alkalies leached from a dust pile in this instance decreased very little over a period of 5 years. A considerable retention time must be assured before runoff from a dust pile can be released untreated to the environment.

Effluent guidelines for the cement industry require containment of a rainwater runoff from materials storage piles including waste kiln dust piles.[17] In many cases this will require construction of a dike around the dust piles as illustrated in Figure 2. Facilities will be needed for adding acid to obtain a pH in the range of 6 to 9 for the runoff water that percolates through the pile into the containment pond before it is released to the receiving stream. Water slurries of dust occur when wet scrubbers are used for dust collection as in two plants of the 101 surveyed. Another situation resulting in water slurries of dust arises when plants mix dust with water and pump the slurry to a disposal pond or lagoon.[18] Some plants use abandoned quarries as the disposal site for dust-water slurries. Others construct ponds or lagoons where the water slurry can settle, concentrating the suspending solids as a sludge in the lagoon. Most plants that dispose of dust as a slurry use waste water from the plant and discharge the supernatant liquid from the settling pond to surface waters. Naturally, the waste water must be retained or treated before discharge just as rainfall runoff from a dry disposal pile. One alternative to treating water before discharge is to maintain a closed water system by recycling the supernatant liquid back to slurry more dust. In areas where the mean annual evaporation exceeds the rainfall, large evaporation ponds could be used to dispose of alkaline wastewater.

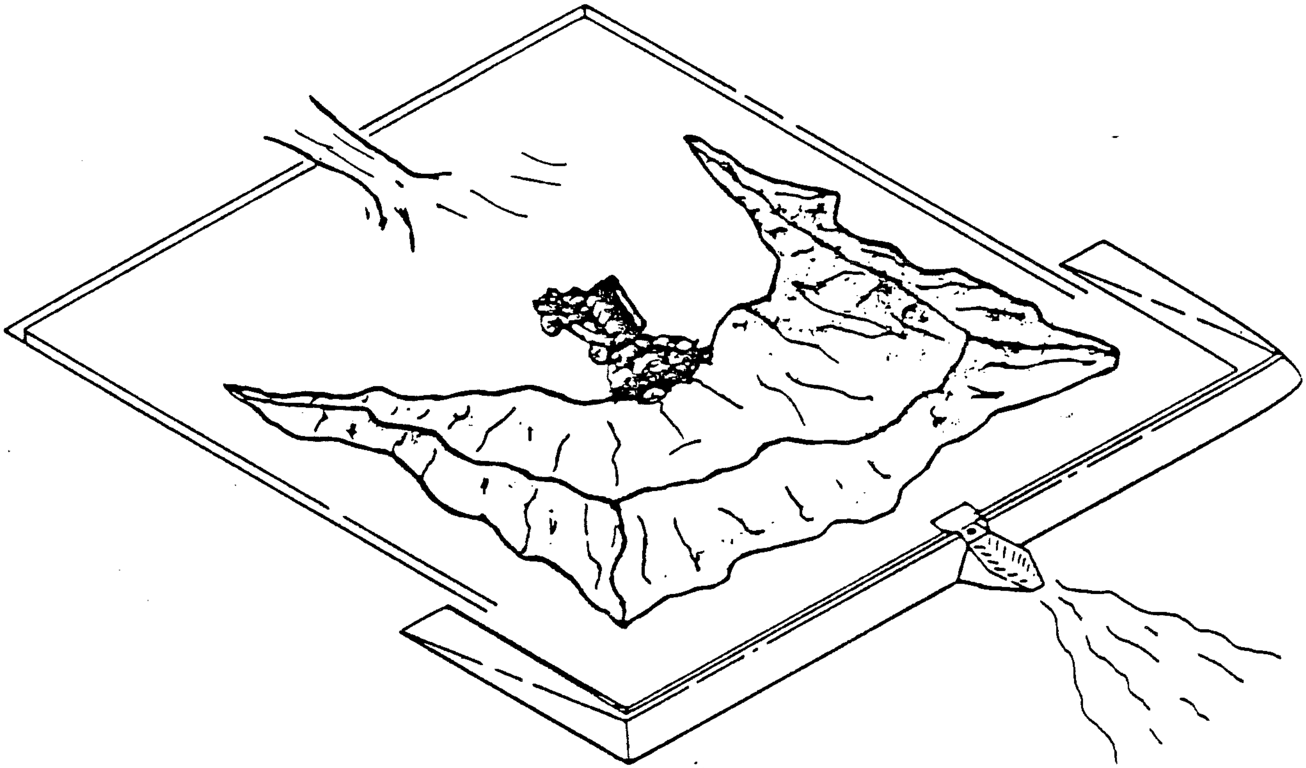

Figure 2. System for containment and treatment of runoff from kiln dust disposal pile.

APPENDIX B-2

SECTION IX

DUST RECLAMATION

Presently, 28 out of the 101 plants surveyed return all of the dust they collect to the process, while 16 discard all of the dust they collect. The remainder of the plants, well over half of those surveyed, recycle as much dust as they can without exceeding the limits for alkali content in their clinker, and they waste the remaining dust. On an industry-wide basis, our survey of the amounts of dust collected and discarded indicated that about 73% of the collected dust is reprocessed to make cement. A variety of methods are employed for recycling dust to the kiln. Dust can be introduced to the kiln by insufflation through the burner pipe or a pipe parallel to the burner pipe so that the dust reaches reaction temperature very rapidly.[19,20] One disadvantage of insufflation is the tendency of the dust to remain airborne due to its fineness, thus establishing a recirculating dust load and wasting energy for collection and reheating. Also, in insufflation the dust cloud in and around the burner causes difficulty in measuring flame temperatures by optical methods.

A second method of dust return employs scoops located about mid-length of the kiln which feed dust from a collar around the kiln to the interior. Scoops appear to be decreasing in popularity as a means of dust return.

Probably the most popular method of dust return to dry process kilns is by blending with the raw feed to obtain a uniform mix so that a more consistent product is obtained. In wet process plants blending of dust with kiln feed is difficult because the partially calcined dust tends to harden when exposed to moisture. Some wet process plants have solved their dust return problems by carefully adding dry dust to the feed slurry just before it enters the kiln. A Russian plant made a slurry of the dust and mixed it with the feed slurry.[21] Other plants use additives such as molasses or lignosulfonates from pulpwood mills to retard the setting of the dust when it is hydrated.[22]

As mentioned previously, most manufacturers discard dust that has too much alkali to allow it to be returned directly to the kiln. The dust has an estimated value of $2 per ton as a cement raw material because it has already been mined, crushed, and ground. The 4.5 million tons of dust discarded in the United States in 1972 would have been worth $9 million if it had been used to make cement. Although a variety of methods for reclaiming high alkali dust have been investigated, only one process, leaching, is in use in the United States, and this process is now practiced in only seven plants, six of which are wet-process plants. All of the leaching plants use electrostatic precipitators to collect the dust.

In the leaching process, collected dust is thoroughly mixed with water in a pugmill or mixing tank. This slurry which contains about 10% solids is pumped to a clarifier or thickener where the solids settle to the bottom and excess water overflows.[23] The underflow from the clarifier, a slurry containing about 50% solids is returned to the kiln and burned to clinker. In the single dry-process leaching plant this slurry is injected through a pipe extending down from the feed end of the kiln into a region where the temperature is high enough to flash off the water. In wet process leaching plants the underflow is either mixed with the feed slurry or pumped into the kiln through a pipe parallel to the kiln feed.[24]

Disposal of the alkaline wastewater from the leaching process is a serious problem faced by cement manufacturers. Two leaching plants discharge their wastes to municipal sewage treatment systems where they claim it is beneficial in neutralizing the acidic wastes in the sewage. Presumably they will be allowed to continue this practice in the foreseeable future. One plant adds acid to the leachate to lower the pH to acceptable levels and one plant carbonates the leachate with stack gas. The other plants discharge the alkaline wastewater directly to rivers, a practice that will be prohibited by the Effluent Limitation Guidelines recently promulgated by the Environmental Protection Agency.[17] By 1977 the levels of pH and suspended solids of the discharge must be controlled, and by 1983 discharge of dissolved solids must be curtailed. This gives manufacturers almost ten years to find a way to recycle leachate or face shutdown of their leaching operations.

The diagram in Figure 3 shows a scheme for eliminating discharge of pollutants from a dust leaching operation. The overflow from the primary clarifier, the water that is now being discharged by most leaching plants, is saturated in lime, has a pH of 13, and contains 10,000 ppm of dissolved solids. In the first carbonator CO_2 from the stack gas reacts with OH^- ions in the leachate to form CO_3^{--} ions. If the alkalinity of the leachate exceeds the hardness, almost all of the calcium is precipitated as $CaCO_3$ which has its minimum solubility, 16 ppm, at pH 9.5.[25] This precipitate settles to the bottom of the secondary clarifier and is ultimately returned to the kiln. Residual suspended $CaCO_3$ in the overflow from the secondary clarifier redissolves as the pH decreases in the secondary carbonator.[26] This overflow would be within the limits of pH and suspended solids required by 1977.

Electrodialysis appears to be the process of choice to remove alkali salts from the leachate and concentrate them in a solution for recovery of valuable by-products by evaporation and fractional crystallization. The operation of an electrodialysis stack is

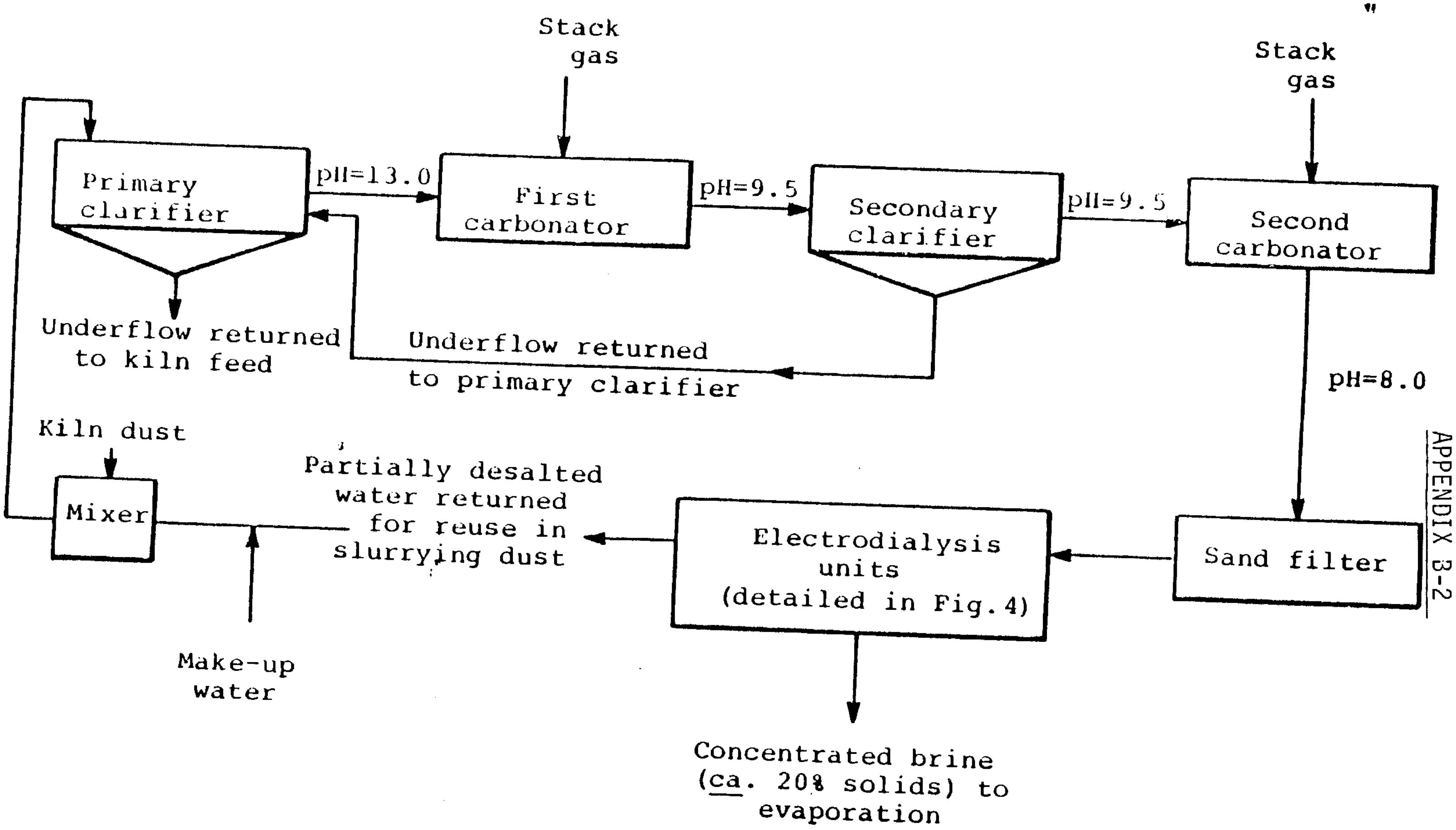

Figure 3. Flow diagram showing steps in electrodialytic concentration of leachate.

shown in Figure 4. An electric potential forces ions through semipermeable membranes into a concentrated brine. Water enters the brine by osmosis and carries away the concentrated salts. The partially desalted water is reused to leach alkalies from collected dust, and no water is discharged.

In electrodialysis of water containing appreciable concentrations of calcium, problems are encountered with precipitations of $CaSO_4$ and $CaCO_3$ from the concentrated brine. These precipitates damage membranes and block the flow of solutions in the electrodialysis stack. Therefore, it is important that the calcium content of the water be reduced to a very low level by the carbonation procedure described above. Univalent cation-selective membranes that prevent the passage of calcium ions can be used if the alkalinity (OH^- ion content) of a particular leachate is insufficient to allow nearly complete removal of calcium upon carbonation.[27] However, this problem would be expected to occur only in plants that use fuel with very high sulfur content.

The concentrated brine from the electrodialysis stack would contain about 20% dissolved solids, mainly K^+, Na^+, CO_3^{--}, and SO_4^{--}. Since the ratio of K to Na in the solution is likely to be greater than 10:1, the concentrated leachate may be suitable as a liquid fertilizer. Further purification and concentration of the K, which is the more valuable of the two alkalies, could be achieved by fractional crystallization and evaporation.

Other processes for leaching alkalies from dust have been reported but none is presently being used commercially. During World War I potassium was produced by the Riverside Cement Company.[28] CaF_2 was added to the kiln feed to volatilize the K which was subsequently converted to K_2SO_4 in the combustion gases. Collected dust was leached, the leachate was filtered and evaporated, and a precipitate of K_2SO_4 was collected.

A process described in a British patent by Singleton and Bruce utilizes a strong solution of potassium chloride to selectively remove Na from the dust.[29] Then K_2SO_4 is removed from the dust by a second extraction. The leached dust is suitable for return to the kiln and the separated K_2SO_4 is a valuable by-product.

Leaching with hot water is reported to be more effective than leaching at ambient conditions. Patzias found that a larger portion of the total alkali in the dust was soluble when the dust-water slurry was heated.[30,31] Palonen and Kaiser found that high concentrations of alkalies in the leachate could be achieved by countercurrent extraction with hot water.[13]

APPENDIX B-2

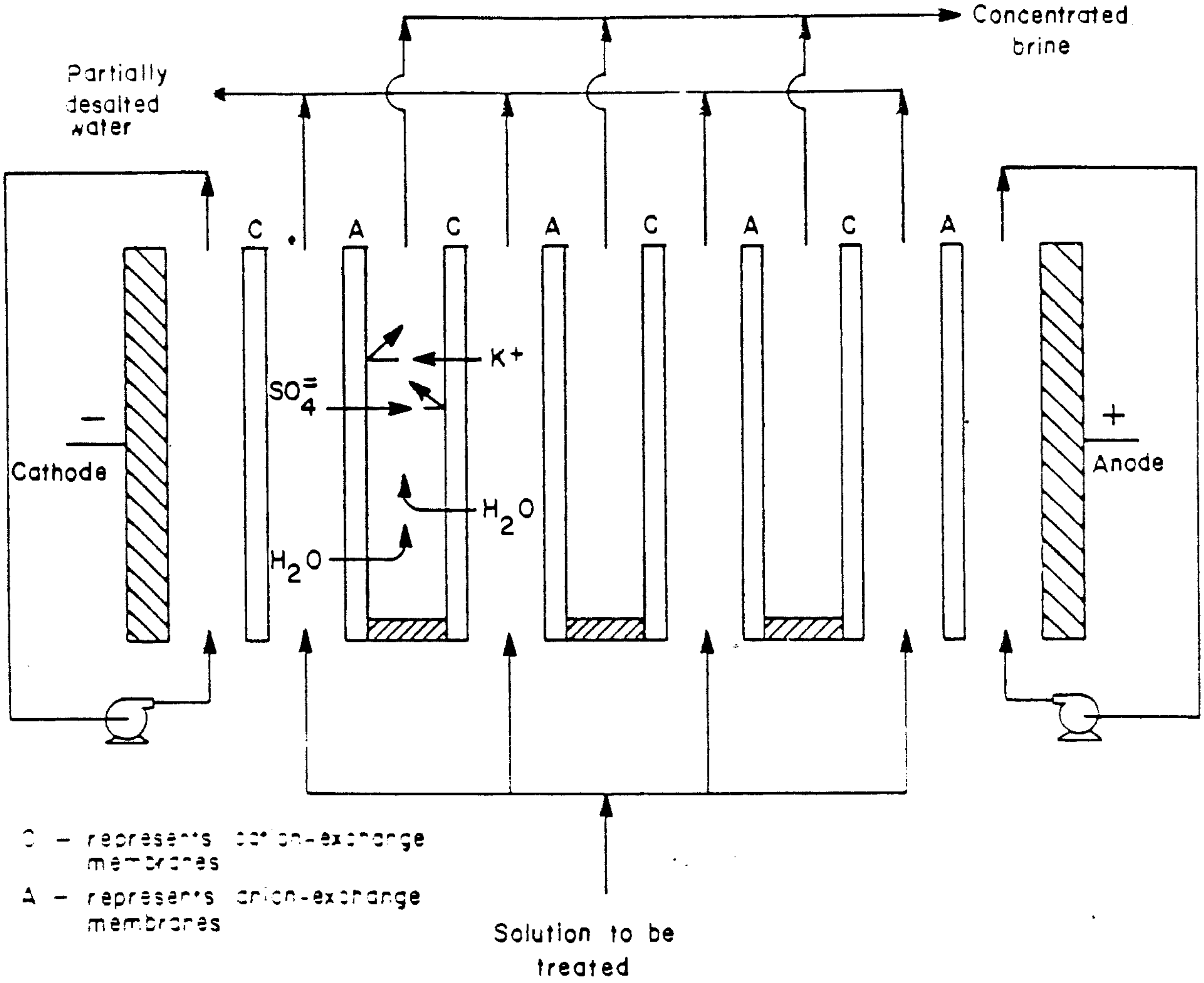

Figure 4. Diagram of electrodialytic concentration stack.

One reason that electrostatic precipitators have found wide acceptance as kiln dust collectors is their ability to separate coarse and fine dust particles. Coarse particles are more easily collected and they tend to predominate in the fraction of dust collected in the first section of the precipitator. The finest particles, which because of their large surface-to-mass ratio have high alkali content, predominate in the fraction of dust collected in the last section of the precipitator. Discarding this fine, high-alkali fraction allows the manufacturer to discard the minimum amount of dust while maintaining acceptably low alkali content in the clinker. Heilmann patented a process in which dust collected in intermediate sections of the precipitator is subjected to further size classification to achieve greater fractionation of alkalies.[32]

In a process developed by Bade, hot gases from the kiln with alkalies still in vapor form are cleared of coarse dust particles by a cyclone.[33] Then cool fine dust particles are mixed with the hot gases to condense the alkalies which are subsequently removed with the dust in a second cyclone. Then the hot gases are used to preheat raw materials in a turbulence stack. Cool exhaust gases from the turbulence stack are cleaned by an electrostatic precipitator and the collected dust is recycled to condense alkalies.

A process developed and tested in Russia used cyclone heat exchange to recover heat and large particles of dust from hot exhaust gases. Then the gases were cooled with finely dispersed water spray to condense the alkalies so they could be subsequently removed in a second dust collector as a powder with 70 to 80% alkali carbonates and sulfates.[34]

When cement is made in a fluidized bed, the hot exit gases carry away the volatile alkalies. When these gases are cooled either by heat exchangers or by water sprays, the alkalies condense in a form that can be used as a high-grade by-product.[35,36,37] Fluidized-bed reactors emit very low levels of particulates and they can use low-grade fuels such as kerogen-rich shale. However, since they, unlike rotary kilns, do not employ countercurrent flow of gases and raw materials, expensive heat exchangers are required to achieve reasonable utilization of heat in the system. Figure 5 shows schematically how such a system operates. A fluidized bed pilot plant was operated by the Fuller Company several years ago, but no commercial operation is in existence.

Flame volatilization for alkali recovery utilizes the high temperature of a flame to volatilize the alkalies from the surface of dust particles. The alkali vapors are removed from the hot gases by condensation on a cool surface.[9] Although flame volatilization actually occurs during insufflation, the alkalies recondense on the dust particles in the kiln, and useful separation of alkalies is not achieved.

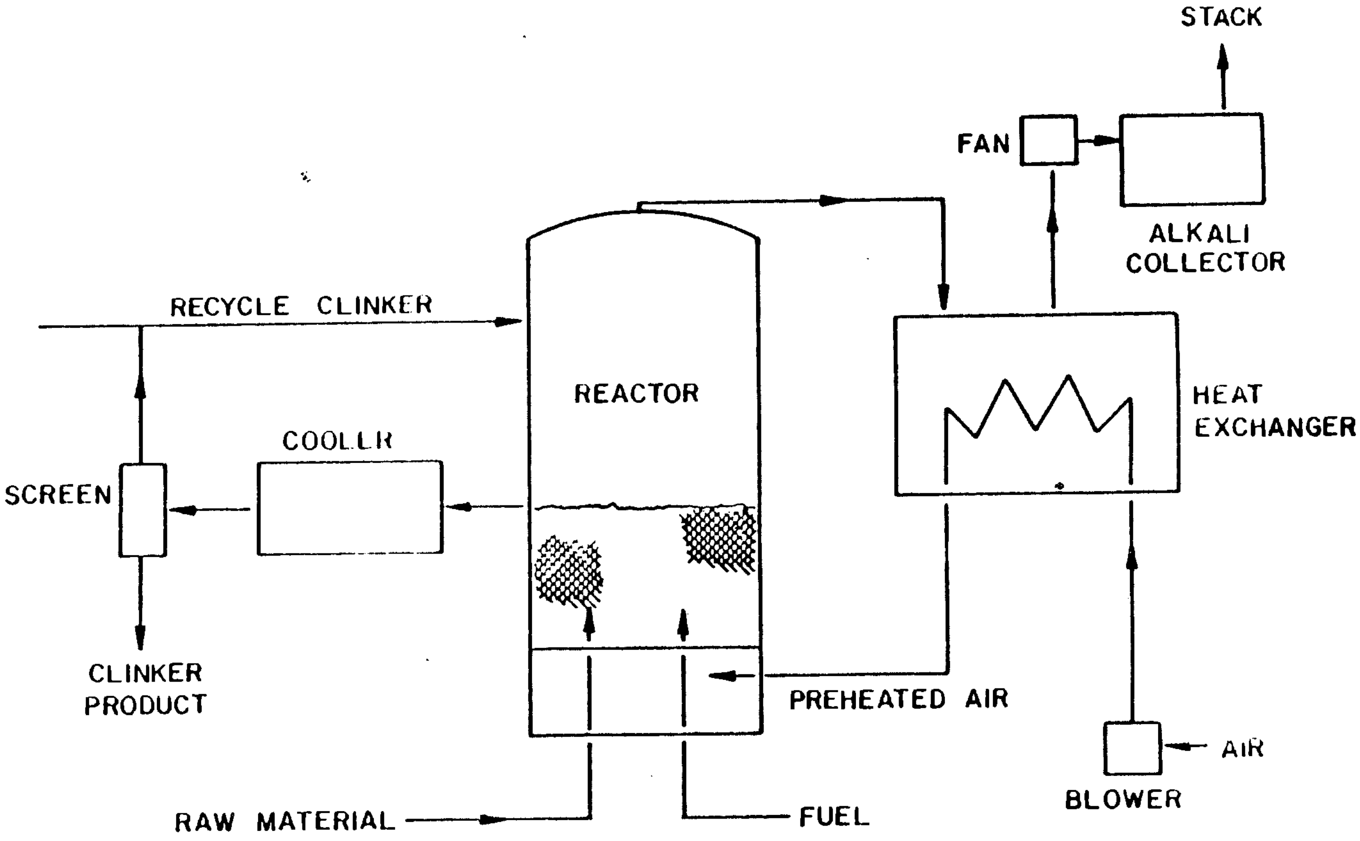

Figure 5. Fuller-Pyzel fluidized bed process for production of clinker and by-product alkalies.

Preheater kilns are commonly used in Europe for fuel economy, and their use is likely to increase in the United States as the fuel shortage worsens. Hot gases from the kiln are brought into direct contact with raw materials in cyclonic-, grate-, or hearth-type preheater. Since alkali vapors in these hot gases will condense on the cool feed materials, preheaters cannot be used with high-alkali raw materials unless the alkalies can be removed from the kiln gases.

Several processes for removing alkalies from preheater kilns are described in the European literature. Polysius developed a process for removing alkali-laden gases from the Lepol preheater collecting the dust, leaching the alkalies, and evaporating the leachate to dryness in a thin film evaporator.[38] In a process developed in France, alkalies are condensed from hot kiln gases onto a curtain of moving endless chains.[39] The chains are then drawn through a water bath where the alkalies on their surfaces are dissolved and the chains are cooled. In a similar process for removing alkalies from a preheater kiln, the hot, alkali-laden gases pass over cool tubes.[40] The alkalies that condense on the tube surfaces are scraped off and recovered.

Alkalies can also be removed from preheater kilns <u>via</u> bypass of a portion of the kiln gas that would ordinarily enter the preheater. Nordquist and Heian reported substantial alkali reduction in the clinker produced in a traveling grate preheater (Lepol) kiln when 30% of the 870°C gas was bypassed, cooled to 315°C by mixing with ambient air, cleaned by a cyclone and returned to dry the raw materials.[41] Weber found that considerable alkali reduction could be achieved in a Lepol preheater, but very little alkali was lost from a suspension preheater.[42] However, his study showed that the alkali content of the clinker could be reduced by adding $CaCl_2$ to the kiln feed to increase the alkali volatility. Brachthauser patented a process for converting alkalies to the more volatile hydroxide form by vaporizing water in the clinker cooler and blowing this hot moist air into the burner section of the kiln.[43]

A process for making low alkali clinker from feed materials which may have high alkali content has been patented by Union Carbide.[44] In this process, the kiln is replaced by a much smaller, stationary, vortex reactor in which clinkering occurs. Alkalies are removed in the gas stream from the clinker reactor. A separate burner and off-gas system are used for suspension preheating the feed prior to clinkering. The process seems particularly useful for converting high alkali dust into clinker and fertilizer.

SECTION X

DUST UTILIZATION

In our survey we found that of the 73 plants that discard some or all of their collected kiln dust, only 13 reported any utilization of the discarded dust. From the figures they reported we estimated that about 1.5% of the 4.5 million tons of waste kiln dust discarded annually is actually being used constructively, and over half of that usage is for landfills. In our review of the literature we found many documented uses of cement dust and in our discussions with industry personnel we received many suggestions for potential uses.

The largest single use of waste dust in the United States is for landfill. In many cases it is difficult to ascertain whether the purpose of the landfill is to dispose of dust or to increase the value of the land. In the former case the cement manufacturer may pay to have his dust hauled to the landfill; whereas, in the latter case he may be able to sell the dust. Both cases were found in our survey. The high temperature when collected and the extreme fineness of the waste dust make it difficult to handle.[45] Windblown fugitive dust from waste piles or landfills is a significant source of air pollution. Spraying the dust with water is helpful in alleviating this problem.

Some manufacturers employ a rotary unloader like the one shown in Figure 6 to agglomerate the dust before loading it into trucks. The device consists of a rotating inclined drum with water sprays inside. As the hot, dry dust tumbles through the drum it becomes moist and forms nodules that are easy to handle and can be hauled in open trucks to disposal sites. The moisture in the nodules hydrates the cement to some extent so that the nodules do not disintegrate as they dry. Thus, compared to loose dust, the nodulized dust is not as subject to wind erosion or flowing down the pile when it is dumped.

The ability of waste kiln dust to harden after exposure to moisture makes it useful for soil stabilization. One plant in our survey reported that their waste dust was mixed with shells and used as a sub-base for roads. Another reported that they dump their dust in strip mines where it neutralizes acid mine drainage and precipitates iron from the runoff water. Such an application could potentially use large quantities of waste dust.

Kiln dust has also been used as a mineral filler for bituminous paving materials and asphaltic roofing materials. It has also been suggested as a filler for plastics and for asphaltic products

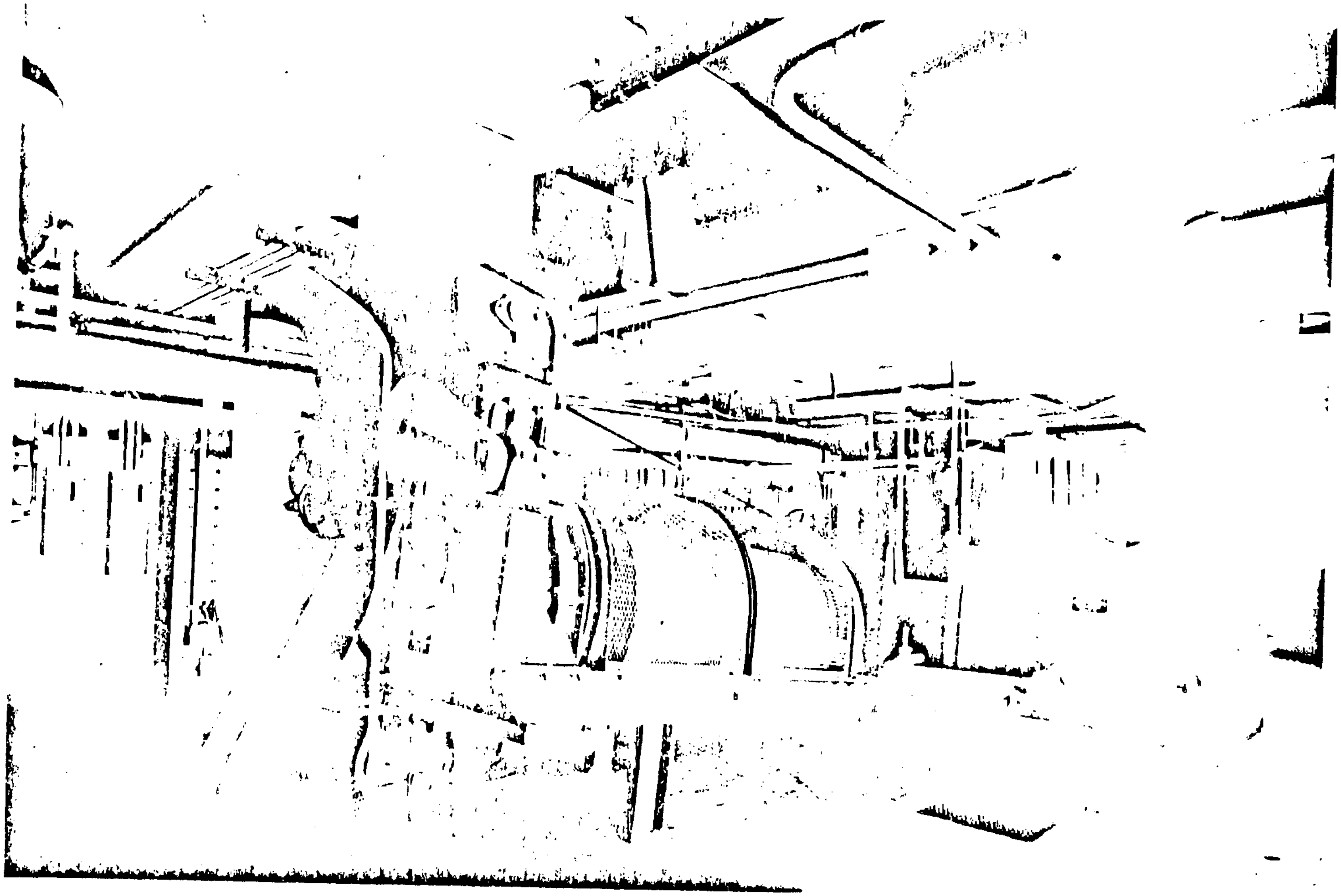

Figure 6. Rotary unloader for nodulizing waste kiln dust (photograph courtesy of United Conveyor Corp.)

such as insulating board, concrete expansion strips and sound deadening material. There is at least one process under development to use waste kiln dust in the manufacture of lightweight aggregate.

The lime content of the dust makes it useful as a neutralizing agent for acidic bogs, lakes and streams. In a study carried out in 1957, waste kiln dust was used to kill vegetation in an acidic bog.[46] Considerable interest has been expressed in the possible use of waste kiln dust to treat acid mine drainage. Since fresh dry dust flows so easily, it might be pumped into abandoned mines to neutralize acid, precipitate dissolved iron, and possibly reduce seepage of water from the mine. Industrial acidic wastes that might be neutralized by kiln dust include spent pickle liquor and wastes from leather tanning and cotton seed delinting processes.

Kiln dust has been successfully substituted for lime in coagulation processes. In Oregon, kiln dust was used as a partial and total replacement for lime in the preparation of alum flock for removal of turbidity from water.[47] The dust successfully neutralized the water and in addition improved flocculation, apparently becauce the small residual insoluble dust particles provided dense nucleation sites for the alum floc.

In the adsorption of SO_2 from stack gases by wet scrubber slurry, cement kiln dust was found to be better than limestone and almost as good as lime.[48] Surprisingly, problems of scaling in the scrubber system were less severe with kiln dust than with lime in the slurry.

In the manufacture of glass large amounts of soda are used. Emer found that kiln dust could be used beneficially as a partial replacement for soda in making green glass, because it increased the rate of decomposition of sulfates which is the main cause of foaming in glass baths.[49] Gregor and Hives reported similar success in the use of kiln dust to make glass where color and high chemical stability are not essential considerations.[10]

Agricultural use of kiln dust promises to be a way of converting a waste material into a valuable by-product. Two properties of the dust that make it useful for agricultural purposes are its acid neutralizing capacity and its potassium content. Researchers at the United States Department of Agriculture station at Beltsville, Md., found that cement dust had about 80% of the soil neutralizing capacity of lime and about the same liming qualities as pulverized limestone.[50,51] Studies carried out in Latvia showed that cement dust could fully replace lime for treatment of acidic soils to grow sugar beets or corn, and the dust could partially replace lime for growing potatoes and rye.[52] A study in Hungary indicated that in addition to its stimulation of plant growth, it also had insecticidal properties.[53]

In Russia and Poland several studies have demonstrated the utility of cement dust application on potato crops. One group found that, whereas most inexpensive potassium fertilizers contain appreciable amounts of chloride which is bad for potatoes, the high alkali fraction of kiln dust had essentially no chloride and was an acceptable, inexpensive substitute fertilizer for potatoes.[54] Rogalov found that application of cement dust increased the starch content of potato tubers but had no greater affect on the yield of potatoes than other fertilizers.[55] Litynski explained that the sulfate in kiln dust was responsible for the increased starch content of potatoes fertilized with the dust.[56] He also suggested that the presence of calcium in fertilizer favorably influenced the uptake of potassium in acidic soils.[57]

A Dutch study indicated that comparable yields of oats were achieved when cement dust or limestone and K_2SO_4 were used for fertilizer.[58] Litynski found that mixed peas-and-oats crops fertilized with kiln dust contained about 2% more protein than crops grown with KCl fertilizer.[59] He also found that the dust produced more starch in fodder and more sugar in sugar beets.[60]

The size of the market for agricultural lime and limestone makes it potentially a very good route for disposal of waste kiln dust. More than 20 million tons of lime and limestone are sold each year for agricultural purposes.[61] This single market if properly developed could use most of the 4.5 million tons of kiln dust being discarded in the United States each year. Figure 7 shows the usage of agricultural lime in the United States on a statewide average basis. Also shown are the locations of plants that our survey revealed to be discarding major amounts of dust. Most of these plants appear to be located in or near states where substantial amounts of agricultural lime are used.

Approximately 94% of the potash consumed in the United States is used in fertilizer.[62] Of the 14 chemical elements essential to plant growth, nitrogen, phosphorus, and potassium are the most rapidly exhausted from the soil and must be replaced by the addition of fertilizers to assure optimum plant growth.[63,64] Examples of amounts of potassium withdrawn by various crops are presented in Table 5.

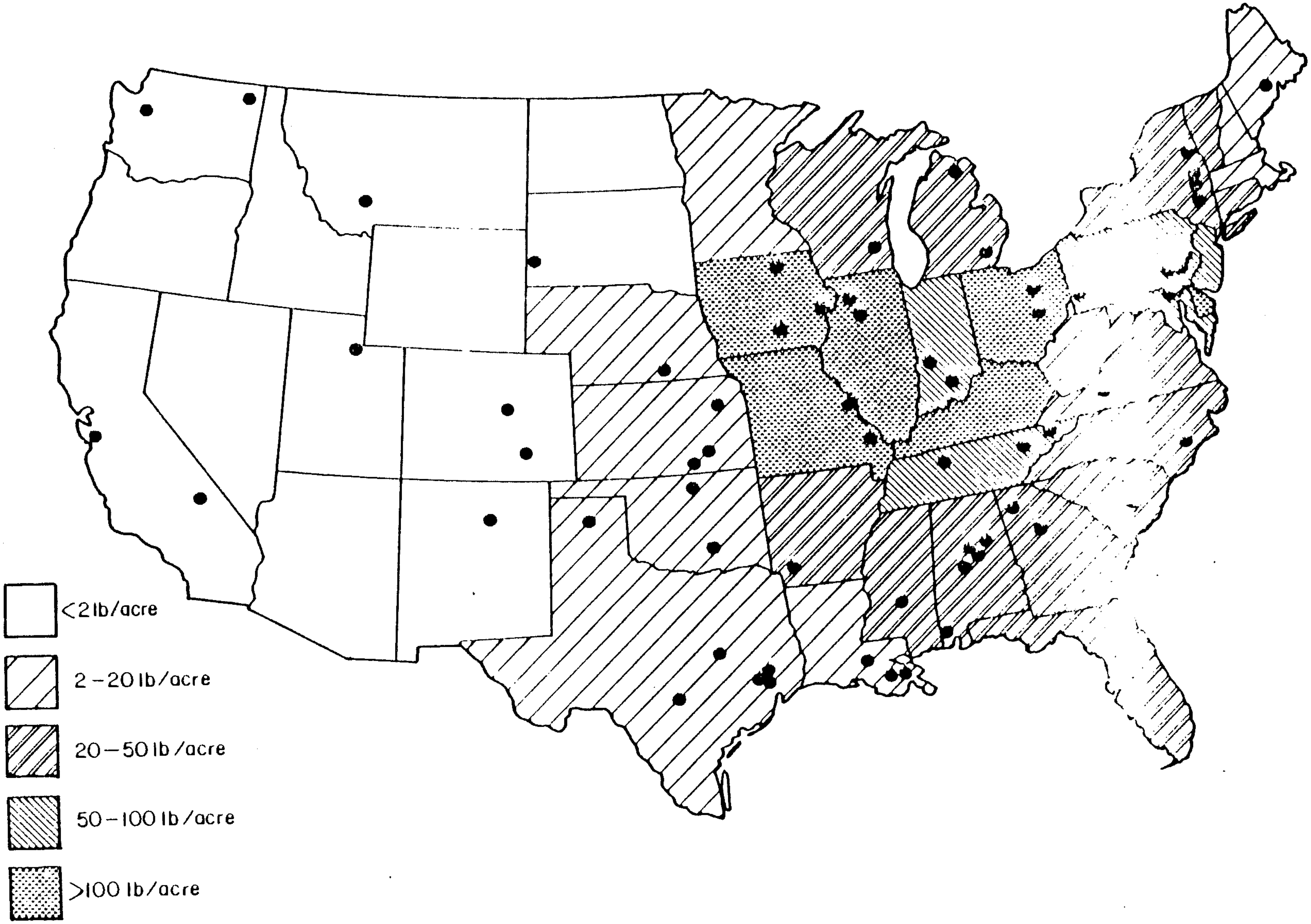

Figure 7. Agricultural lime and limestone usage in the contiguous United States,[60] and locations of plants known to be discarding kiln dust.

TABLE 5. WITHDRAWAL OF POTASSIUM BY AGRICULTURAL CROPS[65]

Crop	Good Acre Yield	K_2O Removed, lb/acre
Soybean	50 bu	120
Clover grass	9000 lb	175
Peanuts	3000 lb	120
Alfalfa	6 tons	270
Coastal Bermuda grass	10 tons	400
Cabbage	25 tons	210
Irish potatoes	20 tons	310
Tomatoes	30 tons	480
Sugar beets	30 tons	550
Sugar cane	100 tons	590
Rice	4500 lb	110
Corn, ears	150 bu	195
Corn, silage	30 tons	245
Wheat	60 bu	110
Cotton	1250 lb	90
Tobacco	2800 lb	190
Apples	600 bu	135
Peaches	600 bu	120
Grapes	10 tons	80
Oranges	800 boxes	175

Many of the cement manufacturers contacted in our survey reported that local farmers occasionally visit their plants and haul away truck loads of waste kiln dust to spread on their fields. Although the farmers and cement manufacturers alike recognize the value of the dust as a fertilizer material, apparently no great effort has been made to exploit this resource. One hindrance to its exploitation appears to be fertilizer specifications.

Fertilizer is sold on the basis of its nutrient content. The three nutrients mentioned earlier (nitrogen, phosphorus, and potassium) are measured in "units", each unit representing one percent of an available nutrient. A 6-8-4 fertilizer, for example, is guaranteed to contain at least 6 percent of available nitrogen, 8 percent of available phosphoric acid, and 4 percent of available potash (K_2O). There are at least 33 cement plants discarding dust with an average potash content greater than 7 percent. With additions of phosphorus and nitrogen compounds a commercially acceptable fertilizer could be produced using kiln dust without further concentration of the potassium present. Under regulations set by the Alabama Department of Agriculture and Industry, fertilizers offered for sale must meet certain minimum standards for available nutrient content. There is a regulation which, while not written to cover the sale of cement dust, allows the sale of cement dust without major modifications. Under section 3(b)(1), Act 434, a material which ". . . contains important quantities of no more than one of the primary plant nutrients (nitrogen, phosphorus, and potassium)" is defined as a "fertilizer material."[65] Cement dust satisfies [illegible] is considered. Other [illegible] dust are in the areas of [illegible] liming material.

Most of the states adhere to the Uniform State Fertilizer Bill suggested by the Association of American Plant Food Control Officers. This bill cites definitions in the AAPFCO annual publication. Cement dust easily meets fertilizer material definition C-13.[67] Thus cement dust can meet commercial content requirements.

Once the question of the legality of sale and use of kiln dust for fertilizer is settled, the next question is how can it be applied. One serious problem is the handling of the fine dust. When dry, it flows readily and is easily carried away by the wind. A Russian patent suggests the preparation of granules by rolling the dust in water.[68] A device like the rotary unloader shown in Figure 6 can be used for this purpose. Then the granules are treated with CO_2 to make them non-hygroscopic and mechanically strong.

If fertilizer markets for kiln dust are developed, it is likely that the manufacturer will want to modify the composition of the fertilizer to meet specific soil and crop needs. Chlorination roasting was used by a Russian group to raise the K_2O content of kiln dust to over 20%.[69] A Russian patent describes a process in which kiln dust is mixed with a nitric acid-phosphate extract to yield a ternary N-P-K fertilizer.[70]

Fortunately there are abundant supplies of potash in North America so that there is no danger of long-term shortage. However, the potash fertilizer consumption in the United States is over 5 million tons per year,[62] and there is a general shortage of other fertilizer materials.[71] Cement manufacturers with waste dust problems would be well advised to contact their State Fertilizer Control Officers for a first-hand opinion of the possibilities of using the dust as a fertilizer material.

SECTION XI

LIST OF PUBLICATIONS

1. Davis, T. A., and D. B. Hooks. Utilization of waste kiln Dust from the Cement Industry. In: Proceedings of the Fourth Mineral Waste Utilization Symposium, Aleshin, E. (ed.). Chicago, IIT Research Institute, 1974. p. 354-363.

2. Davis, T. A. Disposal of Waste Dust From Cement Kilns. Record of the 1974 IEEE Cement Industry Technical Conference. Library of Congress Catalog Number 75-28930. IEEE Catalog Number 74CH0785-6 IA.

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SECTION XII

APPENDIX

1. Kreichelt T. E., D. A. Kemnitz, and S. T. Cuffe. Atmospheric Emissions From the Manufacture of Portland Cement. Bureau of Disease Prevention and Environmental Control, Cincinnati, Ohio. PHS No. 999-AP-17. 1967.
Abstract: Air pollution control in cement manufacturing was studied in detail. This report gives descriptions of raw materials, processes, equipment, volumes of dust, and methods of dust control employed.

2. Anonymous. Background Information for Proposed New-Source Performance Standards: Portland Cement Plants. NTIS Publication PB-202 459, Technical Report 3, August 1971.
Abstract: Proposed standards for particulate emission of 0.3 lb from the kiln and 0.1 lb from the clinker cooler per ton of kiln feed (dry basis) are justified. The economic impact of the proposed standards is also presented.

3. Anonymous. Concrete Information. Portland Cements (IS 004.04T), Portland Cement Association, Skokie, Illinois, 1971.
Abstract: Raw materials, processes, types, chemical compositions, physical properties and handling requirements of Portland Cement are discussed.

4. Levine, S. and E. W. Stearn. The Year Ahead--1974. Rock Products, 39-43, December 1973.
Abstract: Construction minerals shipments and values for past years and estimates for 1974 are tabulated. Included is a list of cement plants, capacities, and process types.

5. Grancher, R. A. Cement's Second Look at Capacity. Rock Products. 50-53, 74, December 1973.
Abstract: Cement plant capacity increases, especially in the Southeastern U.S., are forecast through 1978.

6. Anonymous. Standards of Performance for New Stationary Sources. Federal Register 36(159): 15707, August 17, 1971.
Abstract: Standards of performance for portland cement plants are specified for new sources, including plant expansions. Particulate emissions are set at 0.3 lb per ton of feed and 10% opacity (1/2 on Ringleman scale) for the kiln gas effluent. For the clinker cooler these values are 0.1 lb per ton of feed and 1/4 on the Ringleman scale.

7. McCubbin, T. L. Dust Control Techniques for a Portland Cement Plant. Minerals Processing. 24-25, 35, May 1969. Abstract: Generation, composition, and return of kiln dust are discussed. Design and operation of glass-fabric bag collectors are described.

8. Goldberger, R. H. Rx for Cement Dust. Rock Products. 55, 76, 78, August 1973. Abstract: The wet scrubber used for kiln dust collection at National Portland Cement Company's plant in Bethlehem, Pennsylvania, is described in detail. Water that accumulates in the quarry is pumped through venturi scrubbers where it washes out particles of dust from the exit gases of the kilns with 97.7% efficiency. The CO_2 and SO_2 in the gases neutralize the alkalies leached from the dust. The water is then treated in an 80-ft-diameter clarifier where the suspended dust particles are removed for return to the kiln feed. After treatment to oxidize dissolved H_2S, the scrubber water is diluted with quarry water and discharged to a nearby creek.

9. Greening, N. R., R. J. Hinchey, and H. Nagao. Elimination of Water Pollution by Recycling Cement Plant Dust. Progress Report No. 2, Contract No. 802196, Project CR-7050, Basic Research Department, Portland Cement Association, Skokie, Ill., for Office of Research and Monitoring, U. S. Environmental Protection Agency. October 1973. Abstract: A system for flame volatilization of alkalies is described. Particle size analysis, chemical analysis, alkali distribution, and results of experiments are presented.

10. Gregor, M., and L. Hives. Potash Balance of Cement Shaft Kilns with Special Regard to Possibilities of Potash Recovery. Proc. 6th Conf. Silicate Ind., Budapest 1961. 177-89, Pub. (in English) 1963. Abstract: Flue dust samples from shaft kilns at a cement plant were analyzed over a period of 12 weeks. The raw material was lime marl which had a K_2O content of 1.2%. The K_2O content of the flue dust averaged 34%. The quantity of dust collected was 1.7% of the weight of clinker produced. The clinker contained 0.86% K_2O. In addition to its value as an agriculture material, tests showed the flue dust to be a satisfactory substitute for potash in making glass where color and high chemical stability are not essential considerations.

11. Kasz, W. Chemical Investigation of the Dust Collected in an Electrostatic Precipitator at a Portland Cement Plant in Blaubeuren. Jahresber. Mitt. Oberrhein. Geol. Ver. (Stuttgart). 46:1-8, January 12, 1964.
Abstract: The dust was analyzed by chemical methods and x-ray fluorescence spectroscopy, and the composition of the dust was compared with that of the Upper Weissjura marl and chalk, which is the raw material. The dust was enriched in the elements from the raw material that were volatilized in the kiln, specifically, rubidium (0.475% of dust by weight), cesium (0.0074%), iodine (0.0552%), zinc (1.62%), and lead (0.562%).

12. Kester, B. E. Development of Low Alkali Processes in Portland Cement. Preprint No. 63H43, a paper presented at the Annual Meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc., Dallas, Texas, February 24-28, 1963.
Abstract: The source and nature of alkalies in cement and their effects on certain aggregates are discussed. Leaching systems for wet and dry process plants are described. Steam treatment was studied as a method for destroying hydraulic set properties of dust. The use of $CaCl_2$ to volatilize alkalies was found to be effective but was more expensive than leaching.

13. Palonen, C. V. and E. W. Kaiser. Inorganic Dust Treatment Process. U. S. Patent No. 2,871,133, January 27, 1959.
Abstract: Kiln dust is pelletized and heated to about 950°C and then leached. The normal 10 to 60% water-soluble content is raised to 94 to 96%.

14. Kryzhanovskaya, I. A., et al. The Effect of Alkalies on the Behavior of Cement. Tsement (Moscow), April 1969. Translation by R. Keen. Cement and Lime Manufacture (London). 97-100, September 1969.
Abstract: Data are presented on cure rates and strengths of cements containing varying amounts of added alkali. The investigations established that, in the presence of 0.6% alkali, the activity of portland cement is reduced irrespective of the kind of alkali compounds present. An increase in the alkali content reduces the activity both at early and late ages due to suppression of the hydration of the clinker materials by the alkalies in the liquid phase.

15. DePuy, G. W. Experiments with Alkali-silica Reactive Constituents of Sand-gravel Aggregate. National Academy of Science - National Research Council, Publ. No. 1367. 41-9, 1966.
Abstract: A pilot study investigated the effect of alkali-silica reactive constituents in a sand-gravel aggregate in the sealed moist-storage and the Conrow cycle mortar bar expansion tests. A highly alkali-silica reactive sand-gravel from the Republican River was tested against South Platte River aggregate as control. It produced deleterious expansion in both the sealed moist-storage test and the Conrow cycle mortar tests. The removal of the alkali-silica reactive particles reduced expansion in the sealed moist-storage test to within safe limits, but in the Conrow cycle test, expansion was reduced but a significant amount of expansion remained. The remaining expansion appeared to be due to the characteristic cement-aggregate reaction of sand-gravel aggregates. The tests indicate that the alkali-silica reaction is a major factor in the cement-aggregate reaction with alkali-silica reactive sand-gravel aggregates. The tests also indicate that the Conrow cycle mortar bar expansion test is sensitive to alkali-silica reaction.

16. McCoy, W. J. and O. L. Eshenour. Significance of Total and Water Soluble Alkali Contents of Portland Cement. Journal of Materials, JMLSA. 3(3):684-45, September 1968.
Abstract: The amount of alkali in cement clinker depends on the raw materials, the burning temperature, and the presence of SO_3. The ratio of water-soluble to non-soluble alkali can vary from 1:9 to 6:4 (10% to 60%). Relation of Na_2O volatilization to K_2O volatilization: Na_2O volatilizes until about 30% of the K_2O present has volatilized and after that point K_2O volatilizes about 50% faster than Na_2O. Tests reveal that early strengths of cements are higher with some alkali than with none. The amount of soluble alkali has little effect on the pH of aqueous extracts of cement.

17. Anonymous. Effluent Guidelines and Standards - Cement Manufacturing Point Source Category. Federal Register 39(35): 6590, February 20, 1974.
Abstract: Plants in which kiln dust is not contacted with water as an integral part of the process are in the nonleaching subcategory. Effluent limitations (maximum for any one day) for these plants are 0.005 kg of suspended solids per kkg of product, temperature not to exceed 3°C rise above inlet temperature, and pH within the range 6.0 to 9.0. These standards apply to both existing sources and new sources. Plants in which kiln dust is contacted with water (leaching for dust reuse, slurrying for dust disposal, and wet scrubbing for dust collection or gas conditioning) are in the leaching subcategory. By 1977 new or existing leaching plants must meet effluent limitations of 0.4 kg suspended solids per kkg of dust leached, temperature not to exceed 3°C rise above inlet temperature, and pH within the range of 6.0 to 9.0. By 1983 leaching plants must meet the same standards as nonleaching plants. For all existing cement manufacturing plants, the runoff of rainfall which derives from the storage of materials, including raw materials, intermediate products, finished products, and waste materials, must meet effluent limitations of 50 mg/l and pH within the range at 6.0 to 9.0 except when the flow exceeds the 10 year, 24 hour rainfall event.

18. Cohrs, F.W. How the Newer Plants Handle Kiln Dust Disposal. Rock Products. 58-59, 80-82, November 1971.
Abstract: An overview is given of dust collection, return and wasting, with results of a questionnaire sent to 30 plants built after 1960 detailing the trend of thinking about dust and the dust handling methods employed. A description is given of the wet dust disposal system at Charlevoix, Michigan, giving the particulars of the system: alkali reduction in the dust, neutralization of the disposal (leachate) water, and suspended solids content of the water (15 ppm). Reuse of the leached and dried dust as a raw material for dry plants is suggested.

19. Rygaard, O. F. Utilization of Cement-kiln Dust. U.S. Patent No. 3,206,526, September 14, 1965.
Abstract: Insufflation of dust as a cloud above the burner pipe avoids obscuring optical pyrometry measurements of flame and clinker. The cloud also helps insulate the upper side of the kiln from radiated heat. Further, a uniform clinker is produced because the dust is mixed with the clinkering mass before its temperature reaches the reaction point.

20. Siegert, L. D. Kilns Reuse Dust the Insufflation Way. Rock Products. 52-54, 81, 84, February 1974. Abstract: This is a discussion of methods of insufflation of dust and parameters affecting or affected by insufflation, including fuel, flame emissivity, flame propagation, exhaust gas velocity, dust loading, particle size, position of insufflation pipe, and coating of refractories.

21. Dyatlov, I. P. Utilization of Dust Collected in Electrostatic Precipitators. Tsement (Moscow). 28(3):18-19, 1962. Abstract: The Kuvasaisk cement combine in Russia experimented with techniques for returning collected dust to their wet-process kiln. With 97% collection efficiency in an electrostatic precipitator, the dust represented 10 to 20% of the dry mass of kiln feed. Adding dry dust to the feed slurry containing 31-35% moisture resulted in the formation of hard rings that interfered with the movement of the charge through the kiln. The problem was solved by making a slurry of the dust with 45 to 48% water. The dust slurry and the normal slurry were mixed in a scoop slurry feeder and introduced to the kiln *via* a batch feeder.

22. Dersnah, W. R. and C. F. Clausen. Can That Dust be Used Again? Pit and Quarry. 84-85, 88-91, September 1958. Abstract: Problems associated with return of dust to wet-process kilns are discussed. Methods of return include hydration and regrinding, leaching, insufflation, and addition via scoops, feed pipes, vortex feeders, and pug mills. Addition of molasses to inhibit hardening is also discussed.

23. Goller, C. H., Jr. Is Dust Leaching Worthwhile? Pit and Quarry, 122-123, August 1966. Abstract: The four most popular ways to produce low-alkali cement are: use low-alkali raw materials, waste the dust, increase the amount of alkali in the dust and gas, and leach alkalies from the dust to be returned to the kiln. In comparison with the first three ways, the disadvantages of leaching are: higher capital investment, lower reliability, large water consumption, and water pollution.

24. Lindsay, G. C. Don't Throw Away Dust. Rock Products. 65:87-89, 125, July 1962.
Abstract: Missouri Portland's reprocessing of kiln-dust is described. Plant operating advantages are cited: less mud-ring buildup, more uniform product allowing uniform gypsum addition, reduction of alkali sulfate buildup on electrostatic precipitator electrodes, and better control of dust addition to kiln.

25. Quinn, E. L. and C. L. Jones. Carbon Dioxide. American Chemical Society Monograph Series No. 72, 1936. p. 121-1[illegible].
Abstract: The action of carbonic acid on calcium compounds, solubility of $CaCO_3$ in water solutions of CO_2, and relationship of CO_2 and pH in natural waters are explained.

26. Wilson, J. B. Controls Spark Waste Water Dilemma. Rock Products. 75-76, 92, March 1973.
Abstract: The major water discharges from cement plants are cooling water and water that has been in contact with kiln dust containing soluble alkalies. Leaching of alkalies may occur from runoff of rainwater from waste dust piles, from dust-slurry disposal ponds, or from dust leaching facilities. Leachate may be used to adjust the pH of sewage plants or acid mine drainage. Carbonation of leachate reduces its pH to levels acceptable for discharge.

27. Nishiwaki, T. Concentration of Electrolytes Prior to Evaporation with an Electromembrane Process. In: Industrial Processing with Membranes, Lacey, R. E., and S. Loeb (ed.). New York, Wiley-Interscience, 1972. p. 83-106.
Abstract: This book was written for engineers who wish to determine whether membrane processes should be considered for a given situation and, if so, which process should be used. It also offers theoretical and practical information for the design and operation of membrane processing plants. The use of electrodialysis to recover NaCl from sea water is described in detail. From an initial concentration of 3%, the concentration of salt in the brine is raised to about 20% with an expenditure of about 250 KW-hr per ton of salt concentrated.

28. Anonymous. Potash from Cement at the Riverside Portland Cement Company. Metallurgical and Chemical Engineering. 16(12):701-703, June 15, 1917.
Abstract: A process to recover 6 lb of K_2SO_4 per bbl of clinker manufactured for each 1% K_2O in the raw mixture (theoretical yield) gave, in fact, 2/3 of this amount. KF is formed when CaF_2 is added to the raw material and the temperature reaches 1100°C; this is above the KF boiling point and about 90% volatilizes. The combustion gases convert this to K_2SO_4 and the fluoride recombines with calcium in the dust. The dust is leached and the leachate is filtered and evaporated to saturation to precipitate K_2SO_4. The CaF_2 in the filter cake is returned to the kiln feed.

29. Singleton, F. H. and J. W. Bruce. Improvements relating to the Treatment of Inorganic Dust. British Patent No. 1,131,354, October 23, 1968.
Abstract: A solvent extraction method for removing alkali metals from cement-kiln dust as sulfates and chlorides is described. The process relies on the solubilities of the alkali sulfates and chlorides in various chloride and sulfate solutions. Batch and continuous schemes use compounds recovered in one step to prepare the solvent in the next.

30. Patzias, T. Extraction of Potassium Oxide From Cement Kiln Flue Dust. M.S.C.E. Thesis, Wayne State University, Detroit, Michigan. 1959.
Abstract: Kiln dust is leached with hot water to increase solubility of alkalies. Leached dust is suitable for return to the kiln. K_2SO_4 is recovered from the leachate by crystallization, and the supernatant is recycled to the leaching system.

31. Patzias, T. Recovery of Potassium Sulfate from Cement-kiln Flue Dust. U.S. Patent 2,991,154, July 4, 1961.
Abstract: Cement rotary-kiln flue dusts are leached for extraction and recovery of K_2SO_4. For example, cement dust is drawn from bins under an electrostatic precipitator and mixed with H_2O in closed tanks. The steam pressure is kept at 150 lb/sq in. absolute, and the extraction is completed in 30 min. The mixture is then filtered, and the solution containing 4.5% K_2SO_4 is evaporated to 19.4%. This solution is neutralized with H_2SO_4 and crystallized. The K salt is centrifuged, and the mother liquor is recycled to the evaporator. When [illegible] tons of flue dust is extracted with a water-dust ratio of 3:1, 85% of the K_2SO_4 is recovered. The K salts can be worked up for use in fertilizers.

32. Heilmann, T. Treatment of Dust from Cement Kilns. British Patent No. 1,145,827, March 19, 1969.
Abstract: Fractionation of dust in multistage electrostatic precipitators is a method of removing the high-alkali dust for use as a potash fertilizer and returning the coarse, low-alkali dust to the kiln. Data on percentages of potassium, sodium, sulfate and chloride vs particle size are given.

33. Bade, E. Method of and Apparatus for Recovering Substances with a High Alkali Percentage from the Flue Gases of Cement Kilns. U. S. Patent No. 3,288,450, assigned to Polysius G. M. B. H., November 29, 1966.
Abstract: Large particles of dust are recovered from flue gases by cyclones and small particles by an electrostatic precipitator. The large, low-alkali particles collected in the first cyclone are returned directly to the kiln with the feed. The fine precipitator dust is then added to the still hot flue gases where the volatile alkalies condense on the cooler dust particles, increasing their size and weight. The alkali-coated particles are collected in a second cyclone, and the cooler gas with its uncoated dust passes through the precipitator where the dust is collected for recycle to the hot flue gases.

34. Kravchenko, I. V. and I. A. Fridman. Process of Removing Volatile Compounds. Russian Patent 258,906, June 29, 1970.
Abstract: Volatile compounds, e.g., alkalies, are removed from the gaseous effluent of cement kilns by preliminary dedusting followed by cooling with finely dispersed water. The gas stream is cooled to the temperature of condensation of the volatile compounds -- alkali sulfates 900-950°C, carbonates 800-850°C, etc. The consumption of water for removing the volatile alkalies is 0.08-0.09 kg water per kg calcined charge. Full-scale experiments carried out in a dry-process kiln produced a powder containing 70-80% alkali carbonates and sulfates suitable for use in fertilizer.

35. Van Dornick, E. New Cement Process Offers many "Pluses". Rock Products. 57, 89, August 1972.
Abstract: A heat exchanger is proposed to preheat incoming gases above (1100°C), thus preventing condensation of volatilized alkali within the kiln but allowing condensation and recovery from the self-scouring heat exchanger outside the kiln.

36. Van Dornick, E. Will Kilns Give Way to Fluo-Solid Reactors? Rock Products. 116, 138, September 1969.
Abstract: The Fluo-solid reactor is compared with rotary kiln. No specific data are given because of the status of a patent application.

37. Pyzel, R. Hydraulic Cement Process. U.S. Patent No. 3,013,786, December 19, 1961.
Abstract: A process is claimed for production of portland cement by maintaining reaction temperature in a fluidized bed of raw materials in contact with the burning fuel. The fuel can be pulverized coal suspended in the bed, carbonaceous raw materials, or gas mixed with the fluidizing air stream. Advantages claimed include lower capital cost due to smaller equipment necessary, elution of volatilized alkalies away from reacting mass, and small clinker size.

38. Polysius, G. M. B. H. Method of Recovering the Content of Alkali Metal Compounds from Alkali-Rich Dust Obtained when Producing Cement Clinker and Apparatus for Performing the Same. British Patent No. 1,000,984, August 11, 1965.
Abstract: Dust collected from preheater gases at 100 to 300°C is leached with water. The leachate is evaporated in a heat exchanger and dried in a thin film evaporator. Heat for evaporation comes from steam generated by exhaust gases from the clinker cooler. Evaporation is carried out under partial vacuum.

39. Deynat, G. Device for Continuous Extraction of Alkalies from the Escape Gases of a Cement Kiln. U.S. Patent 3,503,187, March 31, 1970.
Abstract: An array of endless chains is exposed to the exhaust gases of a cement kiln, and alkali metal compounds condense on the cool chains. The chains coated with alkalies are revolved out of the gas stream, and the alkalies collected thereon are removed by immersion in a tank of water which dissolves the compounds and cools the chain.

40. Schlauch, R. G. Method for the Production of Hydraulic Cement. U.S. Patent No. 3,043,703, July 10, 1962.
Abstract: A means of condensing alkali vapors on cooled tubes and recovering the alkalies is described. Alkalies in the gases emanating from the reaction zone of a cement kiln condense as a solid on tubes cooled with air or water. The condensed alkalies are scraped from [illegible] tubes and collected in a bin.

41. Nordquist, E. A. and G. A. Heian. Alkali Removal via the Grate-kiln System. Rock Products 7th International Cement Industry Seminar. 17-27, 1971.
Abstract: Portions of kiln exhaust gases are cooled to 230°C to solidify gaseous alkalies. Then the warm gases are used to dry the pelletized feed. Alkalies in the clinker and recirculating in the kiln are reduced. Various configurations of the traveling-grate preheater kiln with and without bypass and cooling of portions of gas stream are described.

42. Weber, P. Alkali Problems and Alkali Elimination in Heat-Economizing Dry-Process Kilns. Zement-Kalk-Gips (Wiesbaden, Germany). 17:335-44, August 1964.
Abstract: Investigation of alkali conditions in 11 Lepol kilns and 7 suspension-preheater kilns showed that suspension preheaters allow very little alkali (3 to 19%) to escape from the kiln system into the dust collectors or the atmosphere. Lepol kilns allow more alkali (34 to 100%) to escape so that alkali content of the clinker is lower. Material balance is used to develop an alkali cycle factor that is a function of the volatility and content of raw material alkalies and the amount of residual alkali in the clinker.

43. Brachthauser, K. Process for Producing Substantially Alkali-free Kiln Output when Burning Minerals Containing Difficult-to-volatilize Alkali. U.S. Patent 3,365,521, January 23, 1968.
Abstract: A process is described for converting alkalies to the more volatile hydroxide form by reaction with vaporized water in the kiln.

44. Kiyonaga, K. and P. Wrampe. Method and Apparatus for Producing Cement Clinker. U. S. Patent No. 3,584,848, June 15, 1971.
Abstract: Cement-forming raw materials are introduced into a swirling stream of hot gas in a cylindrical reaction zone where the raw materials react to form clinkers and where the gas stream holds the clinker particles in suspension until the particles grow heavy enough to drop to the lower portion of the reaction zone. Apparatus suitable for carrying out the process is also described.

45. [illegible], J. H. Kiln Dust - Properties and Handling. Pit and Quarry. [illegible] 144-6, [illegible], March 1964.
Abstract: Kiln dust is difficult to handle because of its fineness, excessive heat, aeration, stickiness, lumpiness, and alkali content. Flow sheets are presented for a variety of methods for discarding dust or returning it to the kiln.

46. Trembly, F. J., J. A. Mihursky, and E. W. Hertz. Use of Cement Plant Stack Dust as a Neutralizing Agent in Acid Water Lakes. Trans. Northeast Wildlife Conf. 1:55-60, 1958.
Abstract: Cement dust, applied at 40 tons per acre, successfully killed off the acidophilic vegetation in a bog that was to become the bottom of a new lake. A study was begun in 1958 on long term cement kiln dust neutralization of some acidic lakes and ponds in Pennsylvania.

47. Farnham, W. Process of Clarifying Turbid Water Using Cottrell Flour and Acidifying Coagulant. U.S. Patent 2,964,466, December 13, 1960.
Abstract: Kiln-dust from the Oswego plant of Oregon Portland Cement, used as a partial of total replacement for lime as a co-coagulant with alum, improved floc formation so that three test waters were substantially clearer than when treated with alum and lime. The dust successfully neutralized the water to the required range of pH 6.1 to 6.9 and apparantly provided floc nucleation sites by virtue of the very small insoluble particles in the dust.

48. Gorman, P. G. Cement Dust as an Absorbent for SO_2 Removal from Stack Gases. Master of Science in Engineering Thesis-Graduate School of University of Missouri. 1972.
Abstract: Cement dust was compared with lime and crushed limestone as a sorbent for SO_2 from stack gases in a wet scrubber slurry. The dust was found to be better than limestone and almost as good as lime for sorption of SO_2 and even better than lime when scaling problems are considered.

49. Emer, P. Formation of Foam on the Surface of Molten Glass Baths. Glastech. Ber. (Frankfurt, Germany). 42:30, June 1969.
Abstract: Kiln dust can serve as a partial replacement for the soda used in glass making. Decomposition of sulfate in the melt is responsible for foaming problems, and the potassium in cement kiln dust accelerates the decomposition, allowing more rapid degassing.

50. C. W. Whittaker, C. J. Erickson, K. S. Love, and D. M. Carroll. Liming Qualities of Three Cement Kiln Flue Dusts and a Limestone in a Greenhouse Comparison. Agronomy Journal. 51:280-2, 1959.
Abstract: Three cement kiln flue dusts had about the same soil liming qualities as pulverized limestone. [illegible] to be exceeding those produced by the limestone and had similar effects on soil pH, potassium and calcium contents of the crop, and on crop reduction through overliming.

APPENDIX B-2

51. Carroll, D. M., C. J. Erickson, and C. W. Whittaker. Agronony Journal. 56:373-76, 1964.
Abstract: Researchers in Beltsville, Md. evaluated kiln dust from 21 cement plants as a substitute for agricultural lime and found that it had about 80% of the soil neutralization power of lime. Kiln dust was found to be superior to crushed limestone for some applications.

52. Bambergs, K. and R. Apenite. Cement Dust as a Lime Fertilizer. Tr. Latv. Sel'skokhoz. Akad. (Latvia). 18:151-63, 1967.
Abstract: Cement dust containing 42-47% CaO (of which 44-59% was $CaCO_3$, the rest Ca silicates), 2.57-2.64% MgO and 1.3% available K_2O was rotary-hoed into acidic soils in the month of May. It was applied at 2-10 tons/ha. and supplemented with lime. If soil with pH above 4.5 was used for neutral-soil plants, e.g., sugarbeets or corn, cement dust could fully replace lime, but for plants growing in slightly more acidic soils, e.g., potatoes or rye, cement dust addition could be 50-60% of total lime.

53. Simakin, A. I. Agrcchemical Properties of Slime Dust of Cement Plants. Vestn. Sel'skokhoz. Nauk. Ves. Akad. Sel'skokhoz. Nauk (Budapest). 8(5):62-4, 1963.
Abstract: Slime dust of cement plants proved useful as a fertilizer on acidic soils. A typical composition on air-dry basis is N 0.2, P_2O_5 0.1, and K_2O 15.4%. Trace elements include Mg 1, Mn 0.03, Pb 0.03-0.1, Ag 0.001, Ba 0.01-0.03, Be 0.001, Cr 0.003, Ti 0.1-0.3, V 0.003, Zr 0.001 and Sr 0.1%. It also had insecticidal properties.

54. Kobeleva, E. N., N. N. Popova, and L. G. Shvetsova, Cement Dust - A Valuable Potassium Fertilizer for Potatoes. Trudy Sverdlovsk. Sel'skokhoz. Inst. (Sverdlovsk, USSR). 15:59-68, 1969.
Abstract: Cheap potassium fertilizer usually contains an appreciable amount of chloride which can markedly interfere with the development and yield of potatoes, and better grades are too expensive for use on potatoes. The high-alkali fraction of cement dust, which has essentially no chloride, was found to be an inexpensive and acceptable substitute fertilizer.

55. Rogalev, I. E. Improved Forms of Potassium-Cement Dust and its Effect on Potato, Peas, Flax, and some other Crop Yields. Agrokhimiya (Moscow). 56-9, January, 1966. Abstract: Three forms of K-cement dust were used to fertilize a heavy loam podzol soil growing potatoes, peas, and flax and a light sandy soil growing corn. The content of K_2O in the three K-cement dusts were 34.9% (in the sulfate form), 40.3% (in the carbonate and sulfate forms), and 41.0% (in a reduced-carbonate and sulfate forms), respectively. It was established that these forms of dusts had no greater effect on yield than ordinary mineral fertilizers. In their effect on the quality of the crops, these K-cement dusts have proven to be superior to KCl. As a result of dust applications, the content of starch in the potato tubers increased 1.3-1.6% compared to results obtained from an application of KCl. The same differences were found for peas (an increase in weight of grains) and flax (an increase in fiber and straw). The intensity of absorption of K in the growth phase from the K-cement dust does not substantially differ from that obtained by the application of ordinary mineral K fertilizers.

56. Litynski, T., K. Mazur, and A. Siekanski. Fertilization of Potato Fields with Cement-kiln Dust. Zesz. Nauk. Wyzszej Szkoly Rolniczej, Krakow, Rolnictwo (Warsaw, Poland) 5:85-95, 1958. Abstract: Crops of potatoes exactly similar in quantitative respects were obtained by using cement-kiln dust or 40% K salts as a K fertilizer. Starch content in potato tubers was higher in the case of cement-kiln dust. The favorable effect on starch content is probably due to K being present in the sulfate form. Sulfate ions, unlike chloride ions, have a contracting effect on the colloids of the plasma; this causes a rise in starch content of potatoes.

57. Litynski, T., and K. Gorlach. Fertilizing Value of Cement Plant Flue Dust Dependent on Soil Reaction. Roczniki Nauk Rolniczych, Ser. A. (Warsaw, Poland). 90 (1):113-30, 1965. Abstract: Two problems were investigated: (1) whether and to what extent the presence of Ca in cement plant flue dust influences its K fertilizing properties, and (2) to what extent the [illegible] [illegible] to the flue

dust changes in relation to the pH value of the soil. The experiments were carried out under strictly contolled conditions by a pot culture of sunflower, oats, white mustard, and buckwheat. It has been ascertained that Ca present in cement plant flue dust favorably influences the uptake of K from it, and at the same time it creates more favorable conditions for plant development by reducing the soil acidity. On acidic soils the fertilizing value of flue dust vastly exceeds that of the 40% K salt fertilizer. If however, the pH of the soil is raised by liming, the uptake of K from the flue dust remains practically unchanged while the uptake of K from the K salt fertilizer increases. The reason for this phenomenon may be attributed to different solubility of K in both types of fertilizer and (or) to the antagonism between Ca and K. In general, the raising of the soil pH by liming increases the availability of K in it.

58. Hudig, J., and J. P. Planje. The Cement Dust of the Cement Industry as Fertilizer. Landbouwkund. Tijdschr. (Wageningen, Netherlands). 48:593-624, 1936.
Abstract: Comparative yields of oats fertilized with cement dust, $CaCO_3$, K_2SO_4 and K_2CO_3 separately and in various combinations are given. The cement dust contained about 4% K in one case and 10% in another. The content of Ca in the form of silicate and carbonate was about 40%. Both Products had about the same effect as combinations of limestone and K_2SO_4. The cement dust does not add superfluos material to the soil, as most artificial fertilizers do. The authors consider the application of this material as an advantage in cases where K- and Ca- poor soils are to be brought back to profitable production.

59. Litynski, T. Cement-kiln Dusts and their Value for Agriculture. Zesz. Nuak. Wyzszej Szkoly Rolniczej. Krakow, Rolnictwo (Wroclaw, Poland). 4:3-27, 1958.
Abstract: Cement-kiln dusts from rotary kilns in the production of portland cement may be an important source of K for plants. The dusts contain approximately 9% K_2O (70% soluble in H_2O, the rest soluble in 2% citric acid) and can be enriched by adding aluminosilicates to the crude mixture. K in these dusts occurs as K_2SO_4, which by some plants is preferred to KCl. The important other components of the dust are sulfates, [illegible] and colloidal silica. [illegible] fertilizer good [illegible] field experiments showed it equal to, or better than, KCl and 40% K salts as a source of K. Mixed peas-and-oats crops con-

tained more proteins (about 2% more than crops grown on the latter mixture). The cement dust increased especially the content of starch in potato tubers. It was a good K fertilizer for meadows, where in two experiments protein synthesis was enhanced.

60. Litynski, T. Flue Dusts from Cement Rotary Kilns as Chemical Fertilizers. Przemysl Chem. (Warsaw, Poland). 40:260-2, 1961.
Abstract: The potential use of flue dust from cement rotary kilns containing SiO_2, Al_2O_3, CaO, and K_2O was investigated in Poland. Potassium compounds in dusts are partly soluble in H_2O and about 80% soluble in 2% citric acid. Field and pot tests showed good fertilizing properties for clinker dusts which contained SiO_2 24.16, CaO 19.94, and K_2O 13.36%. Fertilizing action of this dust compared favorably with that of equivalent quantities of 40% H_2O-soluble standard K fertilizer. It produced more proteins in fodder, starch in potatoes, and sugar in sugar beet roots. Cement dust can be used as chemical fertilizer, preferably in a granulated form as a low grade K fertilizer.

61. Hargett, N. L. 1972 Fertilizer Summary Data. National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Alabama. 1972.
Abstract: Agricultural materials (limestone, potash, etc) are listed by region and State with consumption from 1950 through 1971.

62. Anonymous. Commodity Data Summaries. Bureau of Mines, Department of Interior. January 1974.
Abstract: Data on production, consumption, and value and forecasts for 95 minerals, metals, and fuels, including cement, lime, potash, phosphate rock and nitrogen compounds.

63. Lodge, F. S. Potash in the Fertilizer Industry. Ind Eng Chem, 30:878-882, August 1938.
Abstract: Sources of potash that have been used in the manufacture of fertilizer are described.

64. Rouse, R. D. Potassium Requirements of Crops on Alabama Soils. Bulletin 324, Agricultural Research Station, Auburn University, March 1960.
Abstract: An analysis of 50,000 Alabama soil samples shows that [illegible] fertilized with equal amounts of N and P and [illegible] requirements of and response to K are discussed.

65. Anonymous. Potassium for Agriculture. American Potash Institute. Revised January 1965.
Abstract: History of potassium in agriculture, function in plants and animals, and relationship to other nutrients are given as introduction. Description of various potassium fertilizer materials, production methods, application methods, and crop responses to potassium are given.

66. Alabama Legislature (Young and Smith), Alabama Fertilizer Law of 1969. Act 434, Regular Session, 1969.
Abstract: This act of the Alabama Legislature sets forth the regulations applicable to the manufacture and sale of fertilizer, fertilizer materials, and other plant food and soil conditioning materials. The regulations follow the recommendations of the Association of American Plant Food Control Officials.

67. Association of American Plant Food Control Officials. Official Publication No.27 Lafayette, Indiana, 1974. p. 37.
Abstract: Officially adopted documents of the Association included in the Uniform State Fertilizer Bill are; Rules and Regulations, Statement of Uniform Interpretation and Policy, Official Fertilizer Terms, and Definitions of Fertilizer Materials. Definition C-13 reads in part, "Waste lime, by-product lime is any industrial waste or by-product containing calcium or calcium and magnesium in forms that will neutralize acids."

68. Dymshits, P. A., N. N. Tikhomirova, E. Ya. Gryazina, E. N. Ostapenko, and L. V. Melidova. Granular Fertilizers from Cement Dust. Russian Patent 220, 277, June 28, 1968.
Abstract: Granular fertilizers are prepared from cement dust with a high K_2CO_3 content by rolling the dust with an additive of water or a solution of this dust. To prepare non-hygroscopic, mechanically strong granules, the granules are treated with CO_2 or gases containing CO_2.

69. Nudel'man, B. I., S. Tokhtakhodzhaev, and M. N. Nabiev. Preparation of Quality Standardized Potassium Fertilizers During the Production of a Portland Cement Clinker by Means of Chlorination Roasting. Dokl. Akad. Nauk. Uzb. SSR (Tashkent, 24(10):30-1, 1967.
Abstract: [illegible]
[illegible]
[illegible]
NaCl or $CaCl_2$ is added to the charge. K, present in various compounds and minerals, is converted

into KCl by their interaction with the added Cl and sublimed off. The K_2O content of the flue dust of the Kuvasai and Dushanbe plants is thus increased from 6.0 and 7.1 to 13.81 and 20.72%, respectively. The dust can be used efficiently as K_2O- and CaO-bearing raw material by the local fertilizer industry.

70. Tokhtakhodzhaev, S. T., M. N. Nabiev, and B. I. Nudel'man, Process For Munufacturing Fertilizer. Russian Patent No. 176,595, November 17, 1965.
Abstract: The familiar process for manufacturing fertilizer from cement dust consists of recovering the dust obtained from calcining the cement slurry, mixing it with water and neutralizing the alkaline content with phosphoric acid in a mixture of mineral acids. With the goal of manufacturing a fertilizer with a high content of soluble potassium salts, NaCl is added to the cement slurry before it is calcined. The cement dust is recovered in an electrostatic precipitator and mixed with water. The solution obtained is freed from insoluble particles and is mixed with a nitric acid-phosphate extract. The solution may be applied as a liquid ternary N-P-K fertilizer or converted to a solid fertilizer.

71. Anonymous, Potassium Phosphate Fertilizer Use Expands. Chem. Eng. News. 17-18, September 10, 1973.
Abstract: Pennzoil's plant in Hanford, Calif. is doubling its production of P_2O_5 to 60 tons/day with plans to produce a 0-50-40 fertilizer by next year. Rising production costs have stimulated the replacement or augmentation of organic and nitrogen fertilizers with potassium-phosphorus fertilizers. Some production costs and material values are given.

APPENDIX B-2

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

REPORT NO. EPA-670/2-75-043	2.	3. RECIPIENT'S ACCESSION NO.
TITLE AND SUBTITLE DISPOSAL AND UTILIZATION OF WASTE KILN DUST FROM CEMENT INDUSTRY		5. REPORT DATE May 1975; Issuing Date 6. PERFORMING ORGANIZATION CODE
AUTHOR(S) [illegible] A. Davis and Don B. Hooks [illegible] [illegible] Research Institute [illegible] 9th Avenue, South Birmingham, Alabama 35205		8. PERFORMING ORGANIZATION REPORT NO. [illegible] [illegible] R-801872
SPONSORING AGENCY NAME AND ADDRESS National Environmental Research Center Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE
SUPPLEMENTARY NOTES		

ABSTRACT

A survey that included 60% of the cement-manufacturing plants in the United States was made to determine the fate of dust collected from the gases emanating from cement kilns. Because of high alkali content, large quantities of the dust cannot be returned to the cement-making process. A survey was made of the literature in the United States and Europe pertaining to handling, reclaiming, and utilizing the collected dust. Abstracts of 71 references are included in the Appendix. Acid neutralization capacity and potash content make the dust valuable for application to farmland, and the potential market for agricultural use alone could consume all of the waste dust that is now being discarded.

KEY WORDS AND DOCUMENT ANALYSIS

DESCRIPTORS	b. IDENTIFIERS OPEN ENDED TERMS	c. COSATI Field Group
*Portland cements *Dust control Alkali aggregate reactions Fertilizers Potassium inorganic compounds		13B

DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS (This Report) UNCLASSIFIED 20 SECURITY CLASS (This page) UNCLASSIFIED	21 NO. OF PAGES 63 22 PRICE

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State of Washington
Department of Agriculture
406 General Administration Building
Olympia, Washington 98504

APPLICATION FOR THE REGISTRATION OF COMMERCIAL FERTILIZER IN WASHINGTON

PLEASE NOTE
RENEWAL APPLICATION FILED AFTER JANUARY 1ST OF ANY ONE YEAR IS SUBJECT TO A $10.00 PER BRAND LATE ASSESSMENT.

OFFICE USE ONLY
DATE 11-7-83
RECEIPT NO. 01106
AMOUNT 25.00
CASHIER EK

Application is hereby made for the registration of 1 *brands of commercial fertilizer at $ 25. per brand for the period ending December 31, 19* 84. *(Payable to the Washington Department of Agriculture).*

REGISTRANT: IDEAL BASIC INDUSTRIES, INC.

REET ADDRESS AND POST OFFICE BOX	CITY	STATE	ZIP
5400 W. MARGINAL WAY SW.	SEATTLE	WASHINGTON	98106

AUTHORIZED AGENT (PLEASE PRINT)	TITLE	SIGNATURE OF AUTHORIZED AGENT	TELEPHONE NO.	DATE
R. E. WALLIS	Plant Manager	REWallis	206-937-8025	11-3-83

CERTIFICATE OF REGISTRATION

THIS CERTIFIES THAT THE FOLLOWING BRANDS OF COMMERCIAL FERTILIZER HAVE BEEN APPROVED FOR SALE IN WASHINGTON BEGINNING WITH THE DATE OF REGISTRATION AND ENDING DECEMBER 31, 19 84. OK

DEPARTMENT USE ONLY

APPROVED
WASHINGTON STATE
DEPARTMENT OF AGRICULTURE
MAY 02 1984

APPENDIX B-3

BRAND NAME	N	P_2O_5	K_2O	GUARANTEED ANALYSIS % SECONDARY AND MINOR PLANT NUTRIENTS Ca	Mg	S	B	Cl	Co	Cu	Fe	Mn	Mo	Na	Zn
Kiln Lime															

Rev.10/83)

(CONTINUE ON REVERSE SIDE)

BRAND NAME	N	P_2O_5	K_2O	GUARANTEED ANALYSIS %											
				SECONDARY AND MINOR PLANT NUTRIENTS											
				Ca	Mg	S	B	Cl	Co	Cu	Fe	Mn	Mo	Na	Zn

LIME REGISTRATION

BRAND NAME	GUARANTEED ANALYSIS %					
	$CaCO_3$	$MgCO_3$	TOTAL N.P.*	% PASSING		
				100 Mesh	60 Mesh	10 Mesh
KILN LIME	80.0		81.5	90	98	100

* TOTAL N.P. IS THE TOTAL NEUTRALIZING POWER EXPRESSED IN TERMS OF CALCIUM CARBONATE.

GYPSUM REGISTRATION

BRAND NAME	GUARANTEED ANALYSIS %		
	$CaSO_4 2H_2O$	SULFUR	OTHER (SPECIFY)

SYMBOLS USED ON THIS FORM ARE AS FOLLOWS:

N	TOTAL NITROGEN
P_2O_5	AVAILABLE PHOSPHORIC ACID **
K_2O	SOLUBLE POTASH
$CaCO_3$	CALCIUM CARBONATE (LIMES ONLY)
$MgCO_3$	MAGNESIUM CARBONATE (LIMES ONLY)

** *Where bonemeal, tankage, manipulated animal and vegetable manures and organic phosphatic materials are sold as such, (singly), the guaranteed analysis of phosphatic materials shall be expressed as total phosphoric acid.*

APPENDIX B-3

MINIMUM ACCEPTABLE GUARANTEED PERCENTAGES OF SECONDARY AND MINOR PLANT NUTRIENTS ARE LISTED BELOW. GUARANTEES MUST BE IN ELEMENTAL FORM, AND SOURCES MUST BE SHOWN ON THE LABEL.

Ca	CALCIUM	1.00	Cu	COPPER	0.05
Mg	MAGNESIUM	0.50	Fe	IRON	0.10
S	SULFUR	1.00	Mn	MANGANESE	0.05
B	BORON	0.02	Mo	MOLYBDENUM	0.0005
Cl	CHLORINE	0.10	Na	SODIUM	0.10
Co	COBALT	0.0005	Zn	ZINC	0.05

APPENDIX B-3

PRODUCT DATA SHEET

For the Registration of Agricultural Lime

Cottrell Lime (Kiln Dust)
(Name of product)

Date 11/8, 19 83

Manufactured by: Ideal Basic Industries
(Firm name)

5400 W. Marginal Way S. W., Seattle WA 98106
(Street and No.) (City) (State) (Zip Code)

Registered by:
(Firm name)

(Street and No.) (City) (State) (Zip Code)

(NOTE: For Limestone, Hydrated Lime, Dolomite, or mixtures of these materials guarantee the following:)

Calcium Carbonate not less than 80 %

Calcium Hydrate not less than -- %

Magnesium Carbonate 1.5 %

Total neutralizing power expressed in terms of calcium carbonate 81.5 %

Amount passing 10 mesh sieve 100 %

Amount passing 20 mesh sieve 100 %

Amount passing 40 mesh sieve 98 %

Amount passing 100 mesh sieve 90 %

Moisture (when over 2%) **Not more than** 2 %

LIME SCORE (OREGON) 78

/-22 815.01

D[illegible]TMENT OF
AGRICULTURE

AGRICULTU[illegible].DG.
SALEM, OREG[illegible]7310

ICY AG PROGRAM AREA 1A LICENSE TYPE 62 FIRM NUMBER LICENSE NUMBER

SSUMED BUSINESS NAME Ideal Basic Industries
LICENSEE NAME Cement Division
STREET ADDRESS P.O. Box 24452
CITY, STATE, ZIP Seattle, WA 98124

LICENSE EXPIRES

PHONE NUMBER

BUSINESS LOCATION
STREET ADDRESS 5400 W. Marginal Way S. W.
CITY, STATE Seattle, WA 98106

CHECK ONE OF THE FOLLOWING: RENEWAL NEW LICENSE [✓ X] ADDITIONAL INFORMATION DELETION

CHECK TYPE OF OWNERSHIP: INDIVIDUAL A,B PARTNERSHIP C,D CORPORATION E,F COOPERATIVE G,H GOVERNMENTAL AGENCY I,J ASSUMED BUSINESS NAME

*************************************** AGRICULTURAL LIME ***************************************

BRAND OR PRODUCT REGISTERED

Cottrell Lime (Kiln Dust)

$10.00 PER BRAND PER CALENDAR YEAR.
FEE COVERS ALL GRADES LISTED UNDER THIS BRAND NAME.

A LABEL FOR EACH GRADE SOLD UNDER THE REGISTERED BRAND NAME MUST ACCOMPANY THIS REGISTRATION.

PROVIDE LIST OF ALL NEW GRADES TO BE SOLD UNDER THE BRAND NAME REGISTERED.

TOTAL FEE SUBMITTED $10.00

SIGNATURE V.S. Sykora TITLE Quality Control Supv. DATE 11/8/83

PRINT OWNER OR SIGNATORY NAME Violet Sykora

MAKE REMITTANCE PAYABLE TO OREGON STATE DEPARTMENT OF AGRICULTURE.

APPENDIX B-3

APPENDIX B-4

6-3

NATION LIMESTONE INSTITUTE, I .

Report of Tonnage of Agricultural Limestone Used in the United States in 1978 Compared with the Tonnage Report in 1977 and the Annual Application Needed as Determined by the Respective States

STATE	NEEDS	1977	1978
Alabama	4,000,000	1,125,248	1,288,912
Arkansas	2,500,000	601,912	457,376
California	153,183	110,789	177,420
Connecticut	184,000	41,000	42,500
Delaware	141,750	113,503	137,240
Florida	1,316,743	938,150	982,047
Georgia	2,350,000	1,304,862	783,638
Hawaii	(Unestimated)	21,449	27,956
Idaho	(Unestimated)	750	1,000
Illinois	8,006,667	3,514,524	3,433,996
Indiana	4,437,400	1,476,537	1,765,000
Iowa	7,700,000	4,991,670	2,305,906
Kansas	2,327,573	264,317	460,142
Kentucky	4,640,911	1,962,377	1,916,614
Louisiana	1,250,000	411,760	465,000
Maine	556,000	130,000	156,000
Maryland	875,000	358,321	387,798
Massachusetts	280,000	67,281	77,206
Michigan	3,725,050	580,000	583,303
Minnesota	3,377,250	300,000	375,000
Mississippi	2,035,340	803,000	931,000
Missouri	10,000,000	2,770,000	3,600,000
Nebraska	1,400,000	200,000	210,000
New Hampshire	234,666	19,758	23,152
New Jersey	360,827	168,843	227,309
New York	2,425,500	497,918	639,070
North Carolina	2,348,667	1,367,301	1,026,282
Ohio	4,900,000	1,265,409	1,429,377
Oklahoma	1,797,231	226,946	193,620
Oregon	497,167	175,605	172,121
Pennsylvania	3,425,000	1,021,469	1,112,289
Rhode Island	27,136	11,318	12,767
South Carolina	1,885,000	586,241	663,180
South Dakota	(Unestimated)	1,500	1,500
Tennessee	2,625,000	1,193,366	1,197,801
Texas	2,500,000	240,000	250,000
Vermont	362,750	81,029	80,008
Virginia	5,871,904	833,309	723,299
Washington	262,500	85,356	78,763
West Virginia	549,750	149,320	137,643
Wisconsin	4,540,000	1,365,909	1,245,596
Wyoming	9,000	3,000	3,000
TOTAL	95,878,965	31,381,047	29,781,831

Waste Kiln Dust As a Fertilizer and Soil Conditioner

A Literature Review

by

J. J. Shideler*

There has been a long but sporadic interest in the use of waste kiln dust as a fertilizer. In 1912 and again in 1915, F. Schott (1,2) was issued a German patent for "Recovering Salts Suitable for Use as Fertilizer from the Waste Gases from Portland Cement Furnaces." Since that time many patents have been issued, and considerable discussion has been published on methods of collecting, concentrating, and extracting alkaline salts from kiln dust for use as fertilizer. However, most of the work and publications are of foreign origin, primarily German, Russian, and Polish.

A fertilizer may be applied to the foliage or to the soil. The reports on application of dust to foliage are controversial. In controlled tests (3), the yield of some vegetables, such as cucumbers and cabbages, were depressed while for a dozen others the dust increased the yield an average of 12 percent. However, this gain is attributed in part to the protection against insect pests, rather than nutrient values. F. Scheffer (4), et al, in a 2-year field experiment in Germany showed that the deposition of kiln dust was not damaging to four agricultural crops. A. T. Czaja (5) conducted investigations on plants exposed under natural conditions to dust emission in the vicinity of cement plants and reported the formation of hard crystalline crusts adhering to leaves and needles, and also that the solution of calcium hydroxide penetrated through the epidermis and destroyed living tissue.

The general conclusion to be derived from these several reports is that the kiln dust is more beneficial than injurious when applied to both the foliage and the soil.

There is total agreement that kiln dust is useful a a liming agent and fertilizer when applied to the soil. In 1936, J. Hudig and J. P. Planje (6) reported comparative yields of oats fertilized with "cement dust," $CaCO_3$, K_2SO and K_2CO_3 separately and in various combinations. The "cement dust" contained about 4 percent potassium in one case and 10 percent in another. The content of calcium in the form of silicate and carbonate was 40 percent. Both products had about the same effect as combinations of lime stone and K_2SO_4. Since the "cement dust" does not add superfluous materials to the soil, the authors considered the application of this material as an advantage in cases where potassium- and calcium-poor soils are to be brough back to profitable production.

Several Polish authors (7,8,9) have published articles recently on recovery of potassium from kiln dust for use in the chemical industry and as fertilizer.

Many cement dusts, however, are low in potassiu and would have very little value as a potash fertilizer. Whether or not kiln dusts contain potassium and other soil nutrients, they can be compared to agricultural limestone a liming agent.

At this point we might digress to get a little background on the purpose and extent of "liming" (10). Liming refers to the addition to the soil of any product consisting calcium or calcium and magnesium carbonates, oxides, or hydroxides in sufficient quantity to neutralize soil acidity, such as burned lime, hydrated lime, ground or pulverized limestone, limestone screenings, and aglime. The most commonly used product is pulverized limestone.

Why use a liming agent?

- It supplies calcium or calcium and magnesium to growing plants.

---

*Director, Construction Methods Department, Research and Development Division, Portland Cement Association.

- It neutralizes soil acids and creates the best conditions for the availability of minor elements.
- It increases the activity of beneficial bacteria releasing nitrogen and phosphorus for plant growth.
- It counteracts acid-forming sources of nitrogen, such as ammonia in fertilizers.
- It reduces the uptake of strontium 90.
- Calcium is of vital importance for the health of humans and other animals, and much of it comes through products of the soil.
- Almost all crops and plants have greatest yields when the pH falls in the range of 5.5 to 7.0.

About 39 million tons of agricultural limestone were used in 1968, but it is estimated that more than three times this amount could have been used beneficially.

The following table (11) gives approximate limestone requirements to raise the pH one unit for various types of soil in warm and tropical regions. About 20 percent more would be required in cooler climates.

Limestone Requirements to Raise pH One Unit
(tons per acre)

Initial pH	3.5	4.5	5.5
Sand	0.3	0.3	0.4
Sandy loam	--	0.5	0.7
Loam	--	0.8	1.1
Silt loam	--	1.2	1.4
Clay loam	--	1.5	2.0
Muck	2.5	3.3	3.8

The government subsidizes, under the Agricultural Conservation Program (ACP), about 75 percent of the limestone used for agricultural purposes to the extent of about 50 percent of the total cost (10). The amount varies greatly among the states and even within a state, with a range of $1.59 to $6.75 per ton with an average of $2.46 (1963 statistics).

Forty-one states have specifications (12) for liming materials. Most require that the calcium carbonate ($CaCO_3$) equivalent exceeds 80 percent, and a few require 90 percent. The $CaCO_3$ equivalent is the sum of the calcium and magnesium oxide contents of a liming material when both are expressed as their equivalents in calcium carbonate. It is usually expressed as a percentage. For pure limestone the value is 100 percent; for pure dolomite it is 108.6 percent. Specifications also have a fineness requirement, generally requiring more than 80 percent passing the No. 10 sieve and more than 25 to 40 percent passing the No. 100 sieve. Some states allow indices of combined purity and fineness. There are a great many differences in specifications among the states.

Most states require that the seller of liming material register with the state and give complete informatio on the material. Presumably material not meeting the specfications cannot be sold, and violators are prosecuted.

Very comprehensive research on the use of dust a a liming agent has been carried out by Dr. Whittaker, et a of the Soil and Water Conservation Research Division, Agricultural Research Service, U. S. Department of Agriculture. Two series of tests have been reported, one in 1959 involving three kiln dusts (13), and one in 1964 usi 21 kiln dusts (14) in cooperation with the Portland Cement Association and members in the industry, and relate to the liming qualities of kiln dust.

The effectiveness of the dusts was compared to th of a pulverized and a coarse ground limestone in a greenhouse experiment with alfalfa in two types of soil.

The grading of the limestone was:

Sieve Size	% Passing	
	Pulverized	Coarse
10	100	97
20	99	40
60	88	15
100	61	11

The 21 dusts were compared with the coarse and pulverized limestones, and with each other for effects on yield, soil pH, and chemical composition of alfalfa. The average chemical composition of the 21 kiln dusts are given in the following table:

Chemical Composition of 21 Kiln Dusts (%)

Component	Mean	Range
CaO	45	37-53
SiO_2	15	11-21
SO_3	7	1-15
K_2O (total)	5	1- 8
(soluble)	3	1- 8
Na_2O	0.7	0.2- 1.7
$CaCO_3$ Equiv.	82	67-99

Details for each dust are given in Reference 14. Dust No. 14 deviated greatly from all others and is omitted from the range values.

The "$CaCO_3$ equivalent" is the important index with respect to liming. The average $CaCO_3$ equivalent for agricultural limestone is about 96. On the average, therefore, if the $CaCO_3$ equivalent correctly measures the soil neutralizing power of the dusts, 1.16 tons of dust are equivalent to 1 ton of limestone. Soil 1 was a loamy sand with a pH of 4.8 which required 0.75 tons of $CaCO_3$ per acre to provide a pH of 6.5. Soil 2 was a silt loam with a pH of 5.2 and required .75 tons of $CaCO_3$ per acre.

Two amounts of liming materials were used, 1 a 2 times the lime requirement ($CaCO_3$ required to provide pH 6.5 in greenhouse cultures). Amounts of dusts were a justed as indicated by the determined calcium carbonate equivalent, to give the same neutralizing power at a given rate. All cultures received the same total amount of solu ble potassium by addition of KH_2PO_4 and K_2SO_4. The alfalfa was harvested five times, and all pots were sampl six times for pH determination during the 10-month experiment.

Cuttings were analyzed for yield and calcium and potassium contents. Yields from the dusts seldom differ significantly from those obtained with pulverized limeston However, the pulverized limestone usually ranked among higher yielding dusts on both soils. Yields from the coar limestone were significantly lower than for the dusts.

The following table gives the potassium and calci contents of the alfalfa at the first, second, and fifth cuttin

K and Ca Contents of Alfalfa

Cuttings	Potassium %		Calcium %	
	Limestone	21 Dusts	Limestone	21 Dust
Soil 1				
1	3.5	3.5 ± 0.2	1.5	1.4 ± 0.
2	3.9	3.9 ± 0.2	1.2	1.1 ± 0.
5	1.8	2.1 ± 0.4	3.8	3.0 ± 0.
Soil 2				
1	3.3	3.2 ± 0.2	1.7	1.7 ± 0.
2	3.6	3.4 ± 0.2	1.3	1.3 ± 0.
5	2.0	1.9 ± 0.5	3.0	3.0 ± 0.

The potassium content of the cuttings increased a the second cutting but by the fifth had fallen off about 40 percent. An inverse relationship occurred with calcium, first and second cuttings had the lowest calcium content, b it almost doubled by the fifth cutting. This might be expec since the pH at the soil decreased during the experiment.

The important point is that all the cement dusts were similar to each other and to pulverized limestone as suppliers of plant nutrient calcium and in their effect on the absorption of potassium.

A further conclusion of the paper was that if applied at the rate of 4 tons per acre the dusts would supply, on the average, 3 times the magnesium, 6 times the sulfur, 0.9 times the potassium, and 16 times the calcium removed in a typical 5-year rotation. The dusts supply, on the average, nearly as much calcium as agricultural limestones do, less magnesium, but much more potassium and sulfur, two elements found in limestone in insignificant amounts. Dusts of high soluble potash content would often meet crop needs of that nutrient when applied at liming rates.

This research of the USDA at Beltsville, Maryland firmly establishes that an average kiln dust is a very effective liming agent and supplier of soil nutrients. However, it appears that probably half would not meet state specifications for $CaCO_3$ equivalent, and thus would not be allowed an Agricultural Conservation Program subsidy. This is a serious deterrent to their use and seems to be an area where further study is needed.

Selected References

1. Schott, F., "Recovering Salts Suitable for Use as Fertilizer from the Waste Gases from Portland Cem Furnaces," German Patent 291,070, Nov. 13, 1912.
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10. "A Handbook for the Aglime Salesman," (1962) Nation Limestone Institute, Inc., 210 H Street, N.W., Washington, D. C. 20036.
11. "Farm Chemical Handbook," (1968) Meister Publishin Company, 37841 Euclid Avenue, Willoughby, Ohio 44

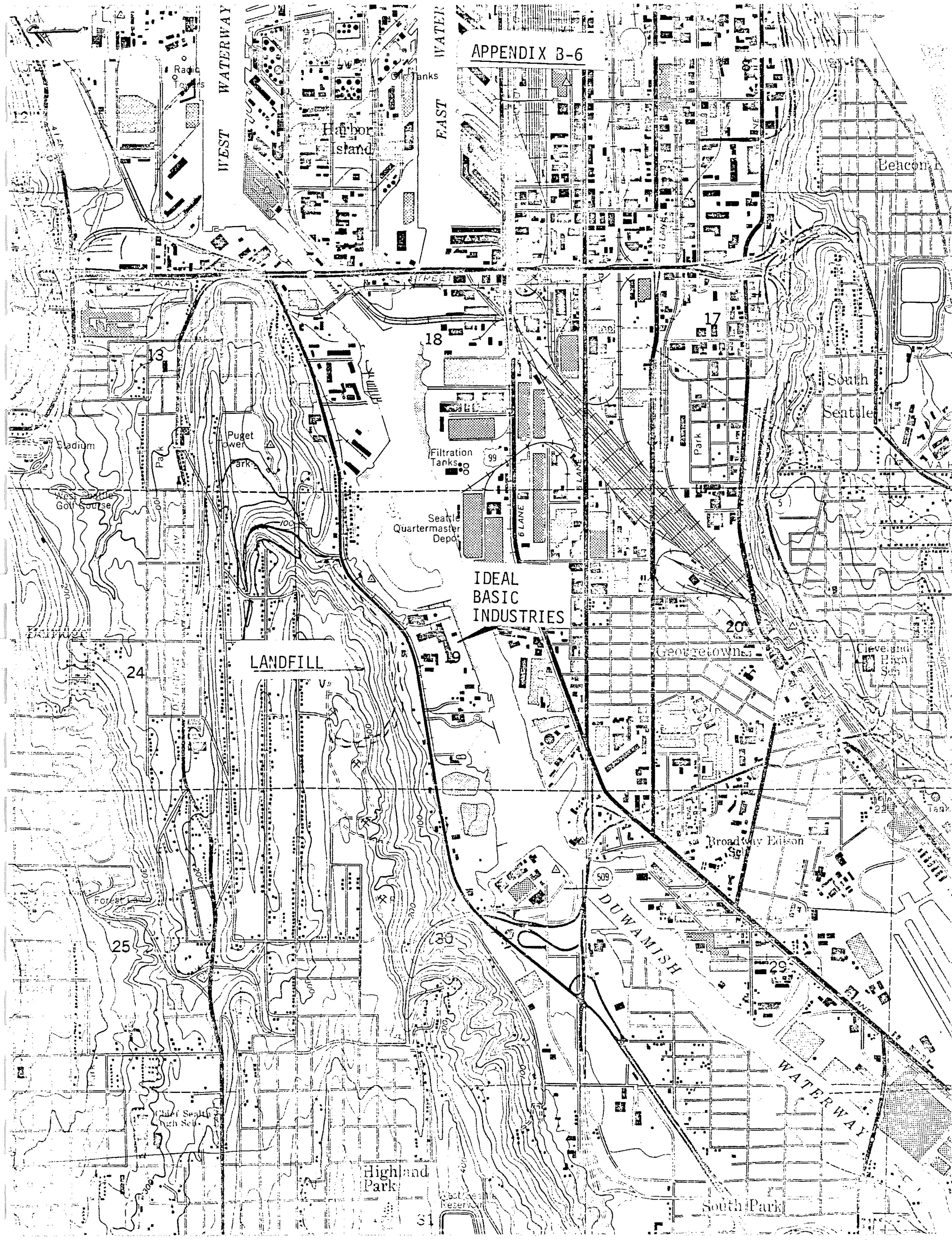
APPENDIX B-5

12. "Abstract of State Laws and ACP Specifications for Agricultural Liming Materials," National Limestone Institute, Inc., 210 H Street, N.W., Washington, D. C. 20036.

13. Whittaker, C. W., et al, "Liming Qualities of Three Cement Kiln Flue Dusts and a Limestone Greenhouse Comparison," Agronomy Journal 51, 280-282, 1959.

14. Carroll, D. M., Erickson, C. J., and Whittaker, C. W., "Cement Kiln Flue Dusts for Soil Lining," Agronomy Journal 56, 373-376, 1964.

APPENDIX B-6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Park
Filtration Tanks
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Seattle Quartermaster Depot
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West Seattle Golf Course
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IDEAL BASIC INDUSTRIES
LANDFILL
24
19
20
Georgetown
Cleveland High Sch
Broadway Edison Sch
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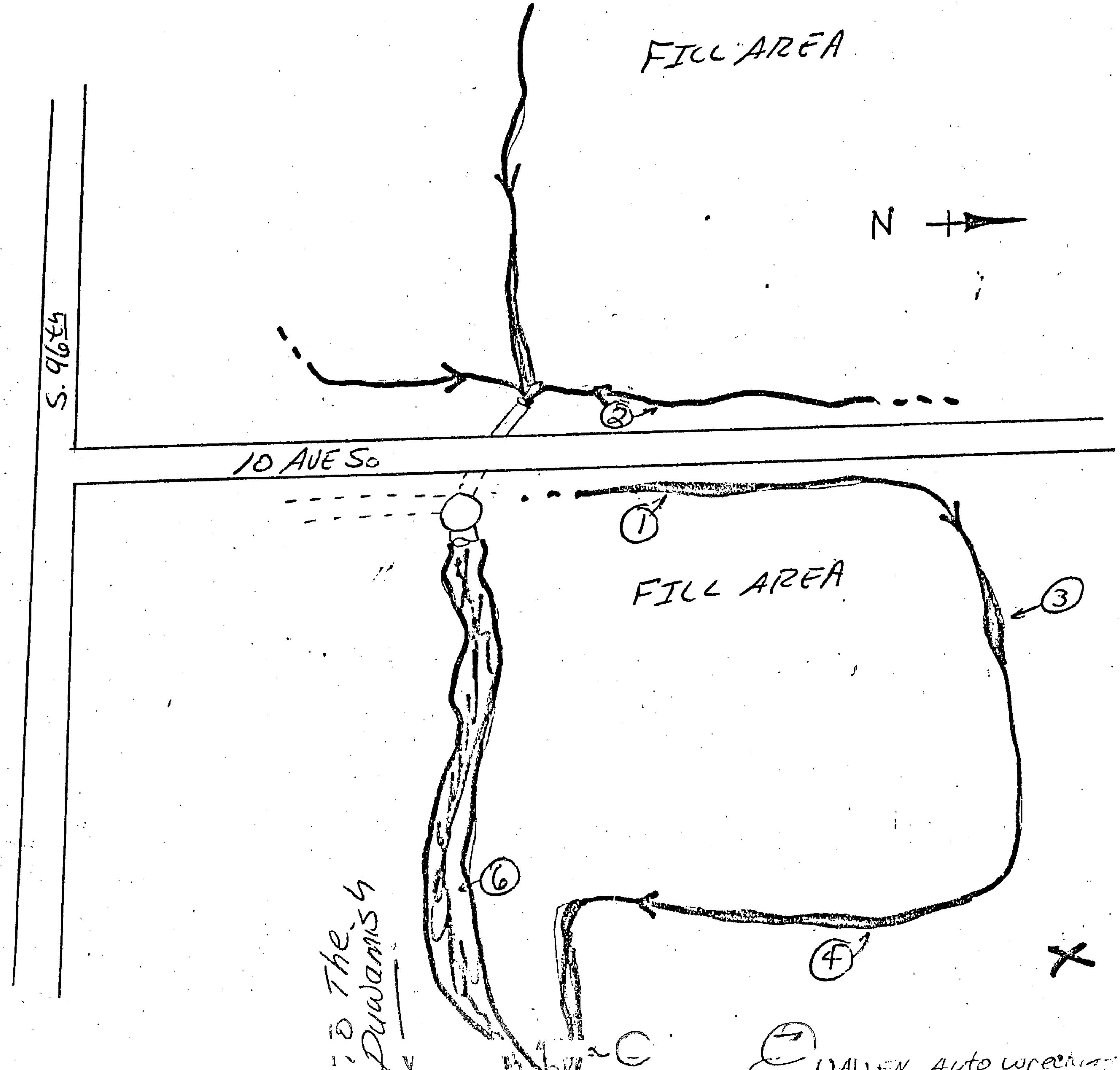
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APPENDIX B-6

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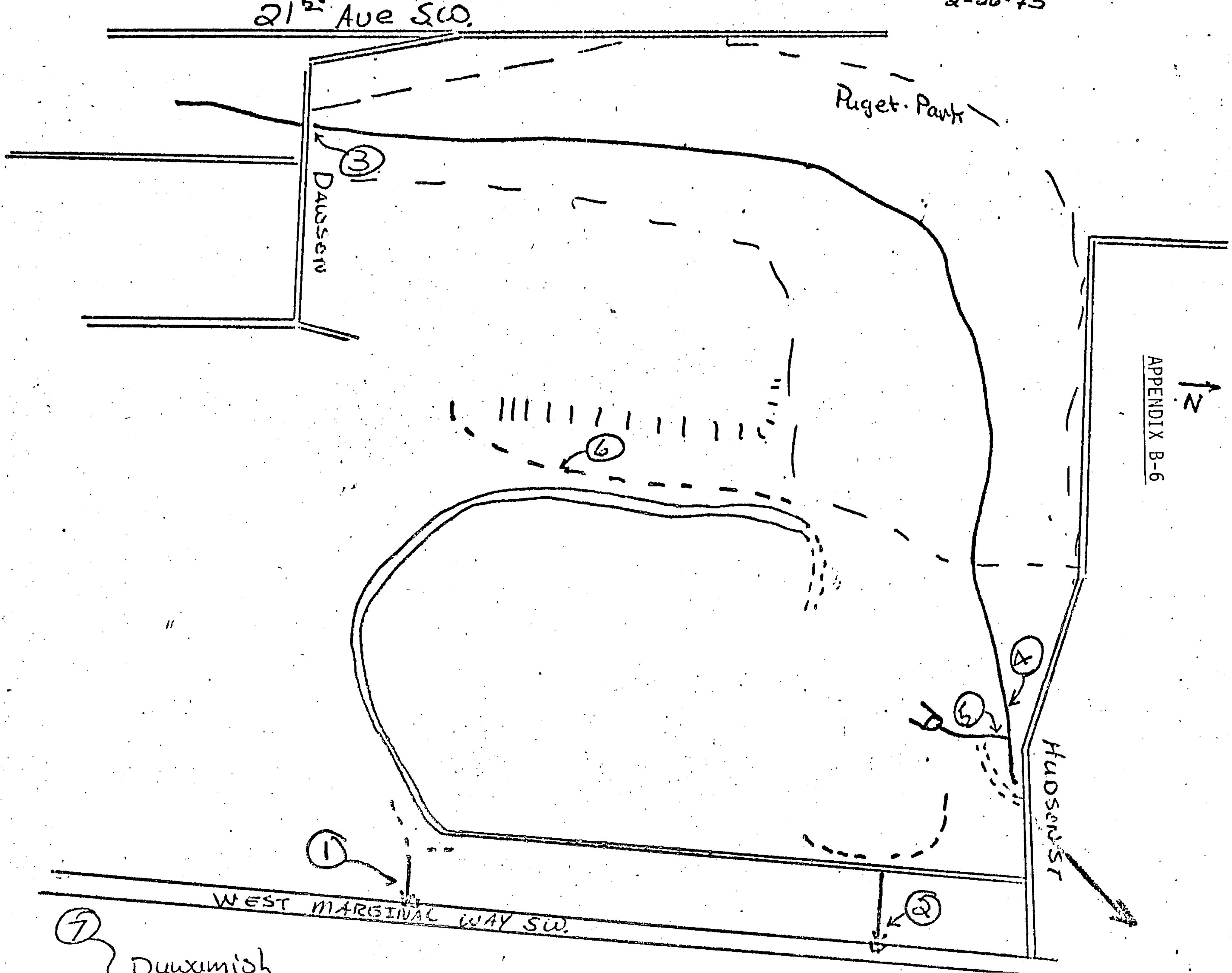

APPENDIX B-6

GLENNDA MC LUCAS

CONSULTING GEOLOGIST

2 October, 1984

Ginger Kaldenbach
Office of Surface Mining
1020 15th Street
Denver, CO 80202

Dear Ms. Kaldenbach:

Thank you for taking the time to discuss with me the potential use of cement kiln dust produced in Washington State as a backfill in abandoned surface and underground coal mines. As per my offer to send literature on the techniques and results of past use of this by-product in coal mines, and in neutralization of acid mine drainage, I have enclosed copies of everything at my disposal at the moment. Upon your visit to the area toward the end of October, I will try to have more information available for you.

Ideal Basic Industries, Seattle, has produced CKD since their plant start-up in 1967. They have a public record of safe and responsible land disposal of CKD in this area. At the present, they are trucking the material to a mining company in Ravensdale, Washington, for use as a backfill in an abandoned coal strip mine. From an environmental standpoint, this fill is exceptionally clean and has not affected surface or ground water to date. It appears to have lived up to its reputation as a good landfill liner and grout, because our direct water monitoring site has shown little pH or dissolved solids increase in two years of landfill operation.

I was particularly interested in your description of the Coal Creek, abandoned mine problems, especially the subsidence problem, which you have assigned the highest priority in terms of reclamation and hazard abatement. Should OSM decide to fill these pits, or any deep mine shafts, we want to be in the position to suggest CKD as a fill source. It is one of the few large-volume, environmentally sound fill sources available for such a project in western Washington. Should you decide to use excavated material from the Mount Baker Ridge Tunnel project, CKD could be mixed with it to provide a very stable fill.

I am looking forward to your visit. I would like to show you the Dale Strip Pit Reclamation Site at Ravensdale and introduce you to Ideal personnel who are actively pursuing beneficial uses for this valuable mineral by-product.

Sincerely,

Glennda McLucas

Glennda McLucas, Geologist

cc: Don Moos, WDOE
Ron Wallis, Ideal

USE OF WASTE KILN DUST FOR SOIL CONSOLIDATION

by

W. J. McCoy* and R. W. Kriner+

The fact that large tonnages of lime and lime-fly ash mixtures are being used successfully for soil stabilization and consolidation suggests that perhaps waste kiln dust could also be used for this purpose, because the fineness and chemical composition of many kiln dusts are not entirely unlike that of lime-fly ash mixtures. To obtain some specific information on this possibility, samples of kiln dust were obtained from four different cement plants and tested for soil consolidation properties, using ASTM Method D558, Moisture-Density Relations of Soil-Cement Mixtures. Some of the specimens obtained in this program were moist-cured for 7 days and then tested for compressive strength. The results of these tests, in which a clay type soil was used, are summarized in Table I and they indicate that kiln dusts possess the property to consolidate soil.

Table I

Moisture-Density and 7-day Strength Values for 10% Additions to Clay Soil (A-6 or A-7) ASTM D558

Addition	Moisture Content, %	Density, lbs./ft.^{3}	Compr. Strength, p.s.i.
Type I Cement	24.1	122.8	466
Dust A	21.9	125.5	410
Dust B	20.0	127.9	425
Dust C	20.6	127.5	295
Dust D	20.1	124.4	320
Hydrated Lime	24.6	123.8	139

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The chemical analysis of the four kiln dusts as shown in Table II illustrate that the composition of the dust varies from plant to plant.

Table II

Chemical Analysis of Kiln Dust from Four Cement Plants

	A	B	C	D
SiO_2	18.3%	18.4%	12.3%	19.3%
Al_2O_3	8.3	3.6	4.0	6.8
Fe_2O_3	1.8	6.0	1.6	6.0
CaO	49.7	50.9	57.3	48.6
MgO	1.5	1.3	3.1	2.6
SO_3	8.4	8.9	2.0	6.6
$S^=$	.00	.03	.00	.13
K_2O	3.0	3.4	7.2	3.0
Na_2O	.40	.43	.49	.47
CO_2	7.7	6.2	10.3	5.7
Loss - CO_2	.69	.45	1.3	.32
Total	99.79%	99.61%	99.59%	99.52%
Ign. loss at 1000°C	8.4	6.6	11.6	6.0
Water Soluble K_2O	1.2	1.4	5.3	1.2
Water Soluble Na_2O	.12	.14	.34	.12
Free Lime	15.7	14.6	14.3	7.8
Insoluble Residue	9.1	8.7	3.7	9.0

After obtaining these rather favorable results in this first series of tests, it appeared advisable to proceed with additional tests on other soil and stack dust samples. Two samples of kiln dust were obtained from the same plant, where one of the samples was taken from the base of the stack and the other from the waste heat collectors. The soil sample which was obtained for this second series of tests would be classified as medium textured. Similar tests as before, using ASTM Method D558, were conducted on this second soil sample with both of the dust samples (E and F) at 8 and 10% addition rates.

The analysis data in Table III show that the chemical composition of kiln dusts E and F are considerably different, even though they were obtained from the same plant.

Table III

Chemical Analysis of Kiln Dust

	Stack Dust E From Base of Stack	Flue Dust F From Waste Heat Dust Collectors
SiO_2	32.3%	19.7%
Al_2O_3	10.5	6.5
Fe_2O_3	3.1	3.1
CaO	25.8	47.7
MgO	1.8	1.1
SO_3	0.43	10.3
$S^=$	0.14	0.67
K_2O	1.6	4.8
Na_2O	0.54	0.66
CO_2	20.9	3.4
Loss - CO_2	2.7	0.84
Total	99.81%	98.77%
Free CaO	trace	10.0
Loss 1100/20	23.6	4.2

The relative ability of these two kiln dusts to consolidate soil is indicated by the data in the following table:

Table IV

Moisture-Density and 7-day Strength Values for Additions to Medium Textured Soil; ASTM D558

Addition	Moisture Content, %	Density, lbs./ft.^{3}	Compr. Strength, p.s.i.
8% Type I Cement	20.5	119.5	775
8% Dust E	21.1	120.5	300
10% Dust E	22.6	120.7	331
8% Dust F	19.6	123.9	443
10% Dust F	21.1	123.3	581

If we examine the analysis data for Dusts E and F in Table III, it would be logical to predict that Dust F woul probably be more effective as a soil consolidation agent than E, since it has significantly higher free lime and alkali sulfate contents and only a small amount of uncalcined material. Examination of the data in Table IV confirms this prediction.

After obtaining the rather encouraging results in these two exploratory test series, we discussed our findings with representatives of the R and D staff of the Portland Cement Association and arrangements were made for them to conduct soil consolidation tests on two kiln dust samples. Thi work was done under the direction of Dr. Eivind Hognestad, Director of Engineering Research. A considerable portion of the following text of this paper has been excerpted from an unpublished PCA internal report received from Dr. Hognestad.

The three soil samples used in the PCA study were obtained from Texas. Maximum dry densities, optimum moisture contents, and particle sizes are given in Table V. Moisture-density relationships were determined according to ASTM Method D558-57 and particle sizes according to ASTM Method D422-54T.

Table V

Moisture-Density Relationship and Particle Size of Soils used in Kiln Dust Study

	Soil No.1	Soil No.2	Soil No.3
Maximum Density (lbs./ft.^{3})	92	102	100
Optimum Moisture, %	25	21	21
% Particle Size			
Gravel (76.2-2.0 mm)	0	1	0
Coarse Sand (2.0-0.42 mm)	2	2	0
Fine Sand (0.42-0.074 mm)	4	1	20
Silt (0.074-0.005 mm)	40	23	52
Clay (smaller than 0.005 mm)	54	73	28

Modification of the soils was accomplished using either Type I portland cement, hydrated lime, or kiln dust. The cement consisted of a blend of three brands and the lime consisted of a blend of two brands purchased in the Texas market. Two types of kiln dust were used, one with high and the other with low alkali content. These dusts were obtained from different kilns at the same plant.

To compare the behavior of the modified soils, tests were made to determine changes in (1) liquid, plastic, and shrinkage limits, (2) triaxial compressive strengths, and (3) unconfined compressive strengths. Soil samples were prepared by passing them through a No. 4 mesh sieve after sufficient air drying. No appreciable material was retained on the No. 4 sieve for any of the soils tested. Samples for liquid, plastic, and shrinkage limit tests were further prepared by first selecting a representative 500 gr. amount of the soil using a sample splitter. Either 3 or 5 percent by weight of cement, lime, or kiln dust was then mixed with the soil using a spatula and the mixture was placed in a 5-in. by 9-in. by 5-in. deep pan. Sufficient water was added over the top surface and the soil sample was mixed in the pan with a spatula to obtain a uniform moisture content approximately equal to the liquid limit. After a delay period of 24 hrs., the mixture was washed over a No. 40 mesh sieve. The material passing the No. 40 sieve was allowed to settle in a pan and the clear water was siphoned off. The wet mixture was then placed into a large plaster of Paris absorption dish until enough excess water was absorbed to determine the liquid, plastic, and shrinkage limits. Samples for limit tests on soils without additions of cement, lime, or kiln dust were prepared by washing a representative amount over a No. 40 mesh sieve and drying by an absorption dish. Liquid, plastic, and shrinkage limits were determined according to ASTM Methods D423-54T, D424-54T, and D427-39, respectively.

Triaxial and unconfined compressive strength specimens were 2.8 in. in diameter and 5.6 in. high. They were molded according to ASTM Method D1632-63 entitled "Standard Method of Making and Curing Soil-Cement Compression and Flexural Test Specimens in the Laboratory". Densities and moisture contents of the strength specimens corresponded to maximum densities and optimum moisture contents determined by standard Proctor (ASTM D558-57) moisture-density tests on th mixtures used in the program. All specimens were cured in polyethylene bags at 73F. until tested either 7 or 28 days after molding.

Unconfined compressive specimens were tested accor ing to ASTM D1633-63 entitled "Standard Method of Test for Compressive Strength of Molded Soil-Cement Cylinders". A hydraulic machine was used and the loading rate was 10.8 psi/sec. The average compressive strength of three specime is reported for each mixture considered in this test progra

Triaxial compression specimens were tested with th equipment described in PCA Development Department Bulletin D entitled "Shear Strength and Elastic Properties of Soil-Ceme Mixtures under Triaxial Loading". A loading rate of 0.028 per min. producing axial strain of 1/2 percent per min. was used.

Results of the liquid, plastic, and shrinkage limi tests are given in Table VI. The liquid limit and the plas limit define the upper and lower limits, respectively, of th plastic range of a soil. The difference between these two limits expresses the plasticity of a soil and is termed the plasticity index. Previous tests indicated that additions 3 and 5 percent by weight of cement or lime reduced the plasticity index of the soils used in this study. For comparis liquid and plastic limits were determined with additions of 3 and 5 percent kiln dust. As shown in Table VI, the reduction in plasticity index of the three soils when treated wit high alkali (H) kiln dust was not as great as that produced an equal weight of cement or lime. The low alkali (L) kiln dust caused an increase in the plasticity index of the three soils and was therefore not subjected to further testing.

The shrinkage limit of a soil is the moisture content at which further loss in moisture will not cause a decrease in its volume. An important benefit obtained by treating a clay soil with either cement, lime, or the high alkali kiln dust is to increase the shrinkage limit to a val greater than the optimum moisture content. As such a mixtu will be compacted at a moisture content less than the shrinkage limit, shrinkage will not occur if moisture is los after compaction. As shown in Table VI, additions of 3 and percent cement, lime, and high alkali (H) kiln dust increase the shrinkage limits of the three soils to values greater than the optimum moisture contents with the exception of 3 percent cement with soil 1, and 3 percent kiln dust (H) with soil 2.

Table VI

Results of Liquid, Plastic, and Shrinkage Limit Tests

Soil No.	Additive	Liquid Limit	Plastic Limit	Shrinkage Limit	Plasticity Index
1	None	63	30	13	33
	3% cement	65	41	23	24
	5% cement	61	43	32	18
	3% lime	59	43	27	16
	5% lime	55	42	29	13
	3% kiln dust (H)	63	36	26	27
	5% kiln dust (H)	61	42	29	19
	5% kiln dust (L)	66	25		41
2	None	62	21	12	41
	3% cement	64	31	22	33
	5% cement	65	38	29	27
	3% lime	64	31	22	33
	5% lime	64	35	29	29
	3% kiln dust (H)	65	29	19	36
	5% kiln dust (H)	64	34	22	30
	5% kiln dust (L)	68	20		48
3	None	43	23	16	20
	3% cement	48	39	31	9
	5% cement	45	43	38	2
	3% lime	45	39	34	6
	5% lime	45	38	37	7
	3% kiln dust (H)	45	33	27	12
	5% kiln dust (H)	47	38	35	9
	5% kiln dust (L)	48	19		29

Unconfined compressive strengths determined from 28-day triaxial tests are given in Table VII.

Table VII

Triaxial Compressive Test Results (28-day Cure)

Soil No.	Additive	Unconfined Compressive Strength (p.s.i.)
1	3% cement	110
	5% cement	160
	3% lime	104
	5% lime	137
	3% kiln dust (H)	100
	5% kiln dust (H)	135
2	3% cement	132
	5% cement	190
	3% lime	145
	5% lime	188
	3% kiln dust (H)	98
	5% kiln dust (H)	170
3	3% cement	223
	5% cement	295
	3% lime	254
	5% lime	300
	3% kiln dust (H)	141
	5% kiln dust (H)	267

These soils have an AASHO classification of A-7-6 and would require at least 10 percent cement to make soil-cement. As shown in Table VII, the addition of 3 percent high alkali kiln dust resulted in unconfined compressive strengths averaging 73 and 57 percent of those for an equal weight of cement and lime, respectively. The addition of 5 percent high alkali kiln dust resulted in strengths averaging 89 and 92 percent of those for an equal weight of cement and lime, respectively.

The unconfined compressive strengths determined from 7-day unconfined compressive tests are given in Table VIII. The addition of 3 and 5 percent high alkali kiln dust resulted in strengths averaging 77 percent of those for an equal weight of cement. The addition of 7 percent high alkali kiln dust provided a strength about equal to that for 5 percent cement. The low alkali kiln dust mixtures had very low strengths.

Table VIII

Unconfined Compressive Test Results (7-day Cure)

Soil No.	Additive	Unconfined Compressive Strength (p.s.i.)
1	3% cement	98
	5% cement	160
	3% kiln dust (H)	86
	5% kiln dust (H)	100
	3% kiln dust (L)	54
2	3% cement	114
	5% cement	174
	3% kiln dust (H)	106
	5% kiln dust (H)	163
	3% kiln dust (L)	42
3	3% cement	147
	5% cement	237
	3% lime	131
	5% lime	175
	3% kiln dust (H)	105
	5% kiln dust (H)	140
	7% kiln dust (H)	243
	3% kiln dust (L)	43
	7% kiln dust (L)	44

The results of a subsequent series of tests conducted by the PCA staff on a sample of kiln dust from another plant indicated that perhaps the large difference in the performance of the two dusts, identified as high and low alkali dusts, was not due primarily to their alkali contents. To obtain additional information on this point, we conducted complete chemical analysis tests and fineness determinations on the two dusts identified as (H) and (L), which had been obtained from different length kilns at the same plant. Examination of the data in Table IX shows tha the high alkali dust (H) is well calcined and of nominal fineness, while the low alkali dust sample (L) is essentially a very fine uncalcined raw mix which would not be expected to have any significant value for use in soil stabilization.

Table IX

Chemical Analysis and Fineness of Waste Dust from Old and New Kilns at the same Cement Plant

	(H) High Alkali-Low Fineness Waste Dust 140-ft. Kilns	(L) Low Alkali High Finenes Waste Dust 400-ft. Kiln
Chemical Analysis		
SiO_2	17.3%	11.0%
Al_2O_3	6.3	5.1
Fe_2O_3	1.8	0.86
CaO	51.3	42.7
MgO	3.5	1.6
SO_3, total	7.9	2.2
K_2O, total	6.0	2.8
Na_2O, total	0.65	0.35
Loss, 110° to 550° C	0.95	2.8
Loss, 550° to 1000° C	4.8	30.8
Total	100.50%	100.21%
Fineness		
Specific Gravity	2.90	2.76
Blaine A.P. Fineness	2290.	9365.

The results of these preliminary tests indicate that some waste kiln dusts do have value as soil stabilization agents since their use resulted in a reduction in the plasticity index, an increase in the shrinkage limit and an increase in the compressive strength of the soil. It is obvious that considerably more investigative work needs to be done before a comprehensive evaluation can be made.

9/14/71

Kiln Dust from Cement Factories for Vacuum Filter Processing of Sewage Sludge

The economic advantages and conservation of energy resulting from the use of kiln dust instead of hydrated lime are obvious.

DALE E. BAKER STEPHEN WELCH WILLIAM STOUT WILLIE DOTY

The Pennsylvania State University University Park, Pennsylvania

Professor of Soil Chemistry, Plant Superintendent, University Joint Authority, and Research Assistants in Soil Chemistry

FROM A GREENHOUSE experiment conducted by Carroll, Erickson and Whittaker (2), it was concluded that cement kiln flue dusts have about the same ability to promote yields of alfalfa and to raise the pH of acid soils as a pulverized limestone. The kiln dust was more effective than coarse limestone. From the chemical composition results obtained from the Hercules Cement Company, Table 1, it was postulated that kiln dust from the cement factory could be used as a substitute for calcium oxide or hydrated lime used for vacuum filter processing of sewage sludge. In addition, the presence of aluminum and iron oxides of very fine particle size (99% less than 325 mesh) was expected to aid in the removal of phosphate from effluent.

The objective of the study was to compare the kiln dust to hydrated lime in the vacuum filter processing of sewage sludge within an operational sewage treatment plant. Since the sludge filter cake from the treatment plant is applied to cropland as a source of plant nutrients, the effect of the process on properties and composition of the filter cake was of major concern. Aspects of chemical monitoring of soils and wastes in relation to environmental quality and animal and human health have been reviewed recently by Baker and Chesnin (1).

Methods and Procedures:

The vacuum filter process of sludge as performed with the equipment available included the use of hydrated lime and ferric chloride as flocculants. For comparing the kiln dust with hydrated lime, the coil filter* was operated one day using the hydrated lime and the following day using the kiln dust. The hydrated lime was of the following analysis:

Minimum CaO	72.0%
Minimum MgO	0.5%
Minimum CaO as $CaCO_3$	2.0%
Less than 20 mesh	100%
Less than 60 mesh	98%
Less than 100 mesh	95%

Analyses of the kiln dust over time are presented in Table 1. Two mixing units are operated to prepare suspensions of lime and ferric chloride. In one mixing unit lime or kiln dust were used at a rate of 50 pounds in 30 gallons of water to produce a suspension which was metered into approximately 550 gallons of raw aerobically digested sludge per hour. From the other mixing unit, ferric chloride was metered in at a rate of three pounds per 550 gallons of raw sludge. This suspension was then slowly mixed, transferred to the filter vat and picked up by the rotating vacuum drum. The filter cake was produced by a vacuum equivalent to 10 to 12 inches of mercury. The filtrate was pumped back into the inlet side of the treatment plant.

Samples were taken from the raw digested sludge, lime suspensions, filter cake, and filtrate associated with each material. The samples were analyzed for nitrogen by the Kjeldahl method and other elements were determined on nitric-perchloric acid digests of the samples (3). Phosphorus was determined by the Vanadomolybdophosphoric yellow color method (3). Other elements were determined by atomic absorption spectrometry. The required analytical techniques and factors affecting precision and accuracy have been discussed by Baker and Chesnin (1). Dry matter percentages were determined by gravimetric procedures, and all elements were reported as concentrations within the dry matter. All determinations were in duplicate, which permitted the results to be subjected to an analysis of variance.

Results and Discussion:

The results are summarized in Table 2. For vacuum filter processing, the capacity of the material to maintain a pH of 11 to 12 is important. The pH of the filter cake produced with kiln dust was 9.25 compared with 11.9 for the lime. The comparison of the results for the two materials show that the kiln dust suspension was substantially higher in K and Mg but lower in Ca than the lime suspen-

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* *Operating Instructions for Coil Filter, Job S-775 for University Area Joint Authority, Lemont, Pa., pp. 17-22. Komline-Sanderson Engineering Corp., Pea Pack, N. J.*

Contribution of the Department of Agronomy, The Pennsylvania State University, University Park, Pennsylvania and University Area Joint Authority, State College, Pennsylvania, as journal series number 4867 of the Pennsylvania Agricultural Experiment Station. The Hercules Cement Company, Bethlehem, Pennsylvania, is acknowledged for supplying kiln dust and partial financial support of the study.

sion. By converting these results into K_2O, MgO and CaO, it was calculated that the rate of kiln dust should be 1.32 times the rate of lime required for the vacuum filter processing of sludge. The calculated value was verified by titration of lime suspension samples with acetic acid.

The percentage of dry matter in the filter cake from the use of kiln dust was substantially higher (6.7%) than from the use of lime. For the samples collected these results were checked, and the mean difference found for four determinations was 6.5 percent.

Table 1. Chemical composition and properties of kiln dust used for vacuum filter processing of sewage sludge. Results were provided by Hercules Cement Company, Bethlehem, Pennsylvania.

	3/15/74	4/16/74	5/1/74	6/3/74
SiO_2	15.26	16.82	17.06	18.28
Al_2O_3	1.95	2.67	2.23	2.14
Fe_2O_3	0.95	0.99	1.03	1.32
CaO	45.77	44.53	44.36	43.03
MgO	2.14	2.16	2.24	2.15
SO_3	5.89	8.33	5.66	4.21
Loss	16.14	19.95	16.25	20.37
Na_2O	0.11	0.44	0.35	0.33
K_2O	1.86	1.62	2.06	1.85
Na_2O Eq.	1.33	1.51	1.71	1.55
Free CaO	7.20	6.75	7.59	6.30
200 m	100.0	99.9	99.9	100.0
325 m	99.2	98.7	98.6	98.9
Sp. Gr.	2.81			

The higher percentage dry matter for the filter cake from kiln dust was associated with lower percentages of N and P than was obtained with lime. These differences were attributed to a greater amount of water associated with the raw sewage used with the kiln dust than that used with lime and the lower amounts of effluent included with the sample of filter cake analyzed. Under the conditions of this experiment, the kiln dust was more effective than lime for removing water from the sludge. While the P and N concentrations of the filter cake were lower for kiln dust than for lime, so were the P and N concentrations within the filtrate lower for kiln dust than for lime. If the kiln dust had been used at 1.3 times the rate of lime, a decrease in filtrate P could be postulated because of the effect of Fe and the high specific surface of the kiln dust on the adsorption of orthophosphate.

The composition of the filter cake and filtrate with respect to K and Mg reflect the higher concentration of these elements within the kiln dust. The additional K and Mg within the filter cake and filtrate from the use of kiln dust would be beneficial where the effluent and/or filter cake are applied to cropland. The sewage sludge and effluent are normally deficient in K and Mg compared with P and N for crop production (1).

The concentrations of Fe, Al and Mn were higher in filter cake and filtrate produced from kiln dust. Both Fe and Al are added routinely for removal of P. While additional Fe and

Table 2. Summary of results for pH, dry matter (D.M.), and chemical composition of raw sewage sludge, lime suspension produced from hydrated lime and kiln dust (K.D.), filter cake produced by the vacuum filter process, and filtrate removed from the sludge in the process.

	pH		D. M. (%)		K (%)		Ca (%)		Mg (%)	
	Lime	K.D.	Lime	K.D.	Lime	K.D.	Lime	K.D.	Lime	K.D.
Raw Sludge	6.40	6.50	1.76	1.56*	0.84	0.86	3.03	2.44	0.66	0.68
Suspension	12.40	12.30	17.24	19.03	0.04	1.19**	41.0	29.2*	0.31	1.04**
Filter Cake	11.90	9.25**	14.94	21.61*	0.20	0.79*	16.3	15.3	0.56	0.96**
Filtrate	12.30	10.20**	0.82	1.12*	0.82	1.26*	21.0	16.4*	0.55	0.90**

	N (%)		P (%)		Fe (%)		Al (%)		Mn (ppm)	
Raw Sludge	6.41	6.15	3.16	3.19	0.70	0.72	0.38	0.36	87	88
Suspension	0.05	0.05	0.06	0.06	0.10	0.95*	0.14	1.15*	19	225*
Filter Cake	3.28	1.92	1.50	0.88	2.04	2.18	0.30	1.23*	80	209*
Filtrate	2.91	2.36	1.18	1.08	1.58	1.76*	0.22	0.91*	80	210*

	Na (%)		Zn (ppm)		Cu (ppm)		Cr (ppm)		Pb (ppm)	
Raw Sludge	0.52	0.59*	998	838	2487	2414	40	37	122	141
Suspension	0.10	0.18**	24	46*	6	10	5	8*	85	98*
Filter Cake	0.07	0.08	613	431*	1414	894	38	28*	118	104
Filtrate	1.12	0.84*	469	410*	1200	1092	30	26*	148	124

	Ni (ppm)		Co (ppm)	
Raw Sludge	43	44	9.8	5.3
Suspension	79	79	65.4	50.6**
Filter Cake	63	72	35.8	39.4
Filtrate	83	75*	51.4	36.7**

*, ** *The lime materials were different at the 5 and 1% levels, respectively.*

plication on soils which fix P, their association with Si in the kiln dust should be beneficial compared with other sources.

The results for Na, Zn, Cu, Cr, Pb, Ni, and Co were not affected substantially by the different lime materials. The Cd concentration of the raw sludge ranged from 7.4 to 8.4 ppm, which is considered safe for use on cropland (1). Other elements potentially toxic to man including Ni, Cr and Pb were below the concentrations considered harmful. The concentrations of Cu in the filter cake were relatively high, and prolonged applications of high rates (more than 10 tons dry matter per acre per year) could lead to a toxicity of Cu to crops on soils of Pennsylvania after 3 to 7 years.

Summary:

An experiment was conducted within a sewage treatment plant to compare kiln dust from cement factories with hydrated lime for vacuum filter processing of sewage sludge. The results indicate that kiln dust was equal to hydrated lime for processing sewage sludge and could be superior especially if it were used at a rate of 1.3 times that normally used for lime. The additional K and Mg in the kiln filter cake and/or filtrate effluent were used as sources of nutrients for crop production.

The postulated increase in P retention by the filter cake from use of kiln dust was not obtained in this experiment. However, with the use of higher rates of kiln dust the P retention by filter cake should increase or remain the same with the use of equal and perhaps lower amounts of $FeCl_3$.

The economic advantages and conservation of energy resulting from the use of kiln dust instead of hydrated lime are obvious. Kiln dust delivered to the treatment plant would be worth 75% as much as hydrated lime with no value applied to the beneficial effects of K and Mg contained in the kiln dust if the filtered sewage sludge and the filtrate were used on cropland.

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Rockefeller Foundation Award To Resource Recovery Center

A GRANT OF $40,000 has been made by the Rockefeller Foundation to the National Center for Resource Recovery to fund a training program in solid waste management and resource recovery.

The grant will aid in the training of 12 fellows during the 18-month period which began June 1, 1975.

The grant will be used to help support NCRR's Resource Recovery Fellows Program, which aids state and local governments and other organizations in resource recovery evaluation, planning and implementation. Under this program, the organizations send representatives to work closely with the NCRR research staff for four to six months, during which time the Center provides training and experience in various phases of solid waste management and resource recovery. The representatives are then able to carry the information gained back to their organizations to apply it in effectively planning and implementing resource recovery and solid waste management programs.

The National Center is a non-profit research organization supported largely by American industry and labor and headquartered in Washington, D.C.

METHANE FROM MANURE INCREASING IN USE

THERE IS enough manure in the United States to supply 15 percent of the nation's energy requirements, according to a spokesman for Era, Incorporated, which has just signed an agreement to supply methane gas generated from 80,000 tons of cow manure annually. The contract was the second signed by the Lubbock, Texas, supplier and the Natural Gas Pipeline of America.

Last fall, Natural Gas Pipeline announced it would purchase methane from a cow dung processing plant to be built in the Oklahoma Panhandle by Calorific Recovery Anerobic Process, Inc., Oklahoma City, Okla.

Turn Garbage into Compost

FISHMEAL PLANTS are the highly mechanized garbage collectors of the fish packing industry, Barbara A. Riegel has reported in the *Maine Times*. They utilize fish and waste products from sardine canneries, fish fileting operations and freezing plants to make a high protein concentrate called fishmeal which is an additive found in poultry feed, salmon and trout farm feed, and even pet food. Concentrated, it is also the base for newly popular fish emulsion fertilizer.

Fish waste or "garbage" from fish packing plants is not in short supply. The entire fishmeal industry depends upon the availability of anchovies off the coast of Peru. When the catch is up, the world market is flooded with cheap fish. The abundance of cheap fish drives the prices paid by fishmeal plants to domestic packers and freezers down to economic lows.

Two processes are used in fishmeal production—dry rendering, in which oil is extracted from dehydrated fish, and wet rendering, the most common method. In wet rendering fish oil is extracted from wet masses of fish. The fish are cooked and mechanically pressed to expel all free liquid. The resulting cake, about 50 percent moisture, is dried in a vacuum dehydrator. The extracted liquid is screened to remove solids; the liquid is then reheated and centrifuged to extract fish oil. What remains is called stockwater, which is reduced by vacuum evaporation to leave a material called fish solubles, which is about 50 percent solids. This soluble protein is added to the initial cake obtained by pressing the fish, and the total mass is dehydrated, screened and ground into fishmeal. What results is a highly concentrated fish protein which contains all the nutrients initially found in fish except those extracted in the oil.

Fishmeal is used for mink feed on mink farms, for which it must pass exacting standards. Since it rehydrates thoroughly and quickly—due to vacuum dehydration—it also qualifies for use in pet foods. Its primary use is as a high protein concentrate additive for swine and poultry feed. Fish solubles, removed before final dehydration into fishmeal, are used as the base of fish emulsion fertilizer.

BACKFILLING TECHNIQUES AND ALKALINE ADDITION TO CONTROL ACID MINE DRAINAGE IN A COAL STRIP MINE

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Antrim Mining, Inc. in Tioga County, Pennsylvania was faced with developing techniques to control acid mine drainage (AMD) in a proposed strip mine adjacent to a deep mine complex. As much as 40 feet (12.2m) of the total overburden contained shale high in pyrite; this shale is a known AMD-producer.

Four separate problem areas were identified. To prevent oxidation of the pyrite, and allow the discharge from the strip mine to meet state regulations, a waste product from lime manufacturing was used in an attempt to maintain alkaline conditions. A sandstone underdrain was constructed to minimize saturated ground water conditions and to direct ground water either to monitoring sumps before release into the abandoned deep mines or toward a common discharge point for treatment. The underdrain capacity was designed to exceed the recharge rate by more than an order of magnitude. Runoff will be promoted and recharge thus reduced by grading the backfill into rolling swales with drainageways floored on compacted glacial till.

The fourth task was to develop a materials-handling plan which allowed for the segregation of acidic spoil and selective placement of the alkaline material. The plan developed was economically feasible, under the coal company's contract price commitment, and practical in terms of the available mining equipment and stratigraphic sequence of the mine site.

Initial water quality monitoring data from the active unreclaimed mining operation and the performance of the rock underdrain are encouraging. The final evaluation of this experimental mining plan cannot be made until backfilling, final grading and revegetation are completed in the next two years.

BACKGROUND

Antrim Mining, Inc. of Blossburg, Pennsylvania has developed an 85-acre (34.4ha) bituminous coal strip mine site near the town of Antrim in

Tioga County. Because of the serious acid mine drainage (AMD) problems associated with strip mining in this geologic setting, and because the site lies adjacent to a large deep mine complex, innovative techniques were required to control AMD in order to obtain a mining permit from PA Department of Environmental Resources (DER).

Geology

The Allegheny Group is the major coal-bearing stratigraphic unit of the north-central coal fields of Pennsylvania. In ascending order, the local coals being mined at this site are equivalent to the Lower Kittanning or B-coal and the Middle Kittanning or C-coal. More than 28 drill holes were logged at the mine site, so the stratigraphy is well-defined; Figure 1 is a generalized geologic section of the site. Drilling with a reverse-circulation, air rotary drill rig allowed accurate collection of discrete stratigraphic intervals and drilling below the deep mine in the upper split of the B or Bloss coal.

We sampled and analyzed three overburden holes according to the procedures outlined by Sobek, et al. (1978). The rock chips were analyzed for total and pyritic sulfur percentage. Since past experience suggested there was no significant amount of alkaline material, and because no dependence was placed on any naturally occurring alkalinity to control the pH of water in the mine backfill, neutralization potential of the overburden was not analyzed.

The stratigraphic interval from the upper Bloss rider coal down to the Bear Creek coal consistently contains numerous zones of high pyritic sulfur, ranging up to 9.25% and averaging about 2.5%. Above this zone the pyritic sulfur is consistently low, ranging from 0.03% to 0.23%.

Glacial drift covers the surface of the entire mine site and varies from 2 to 30 feet (0.6-9m) in depth. Sieve analyses performed on four samples show that the glacial drift is a gravelly loam to a gravelly sandy loam. Overburden analyses indicate that total sulfur content is less than 0.08%.

Structurally, the site is located about 2600 feet (793m) south of the Blossburg synclinal axis which has a strike of N60°-80°E. Figure 2 shows the location of the site in relation to the structure contours on the Bloss coal as shown by Kantz (1976). Within the strip mine site dip ranges from north to northwest averaging 5-6%, with bedrock strike paralleling the synclinal axis. As much as 8 feet (2.4m) of structural relief was observed along strike in local "rolls" on the Bear Creek coal. As the coal approaches its structural outcrop to the south, dips steepen up to 11%.

Mining History

Deep mining in the site area began more than 100 years ago and continued into the early part of this century. Approximately 1360 acres (550ha) of Bloss coal was mined in the Antrim No. 1 deep mine, which lies immediately adjacent to the northern, downdip boundary of the strip mine site (Figure 2).

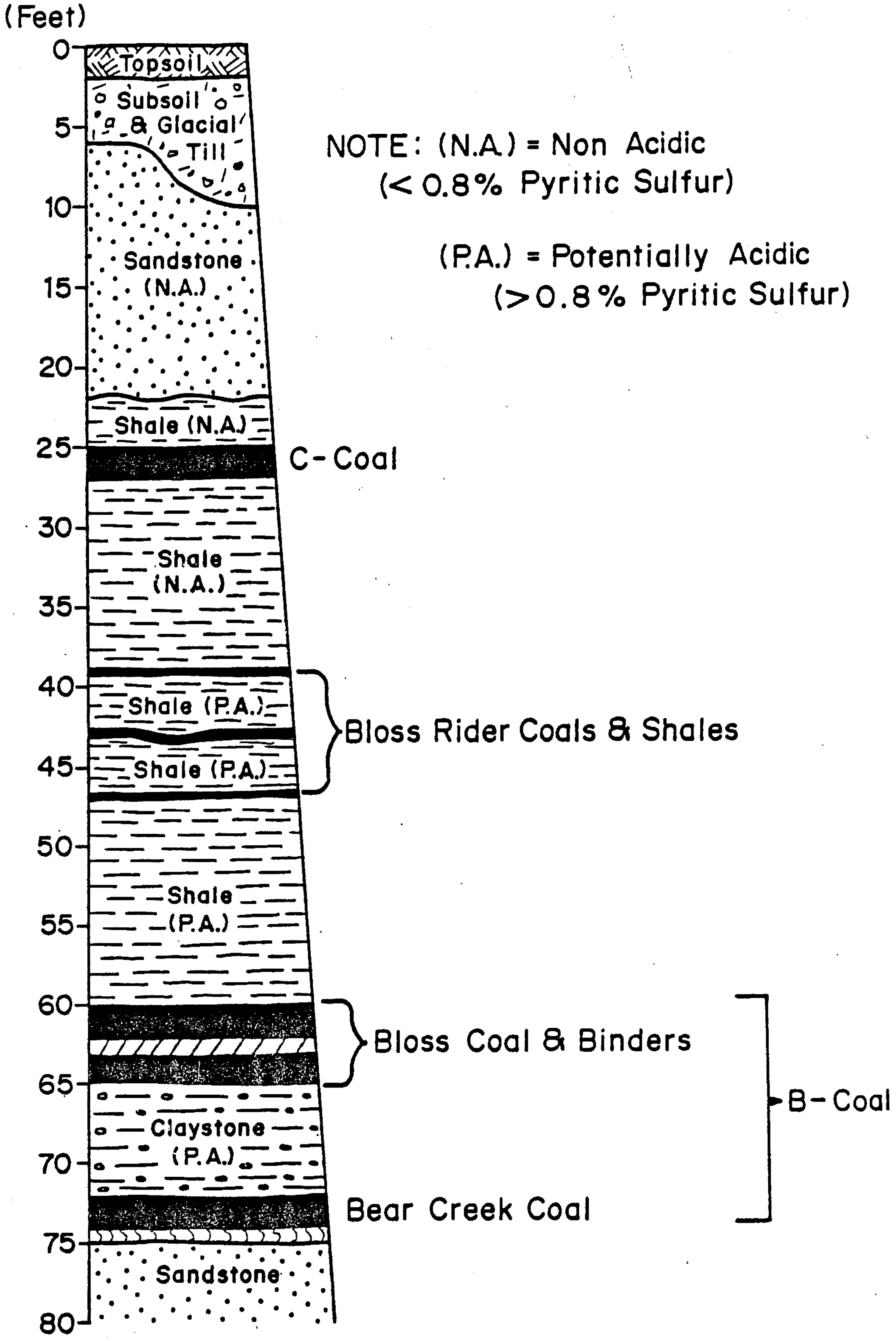

Figure 1. Generalized Geologic Section

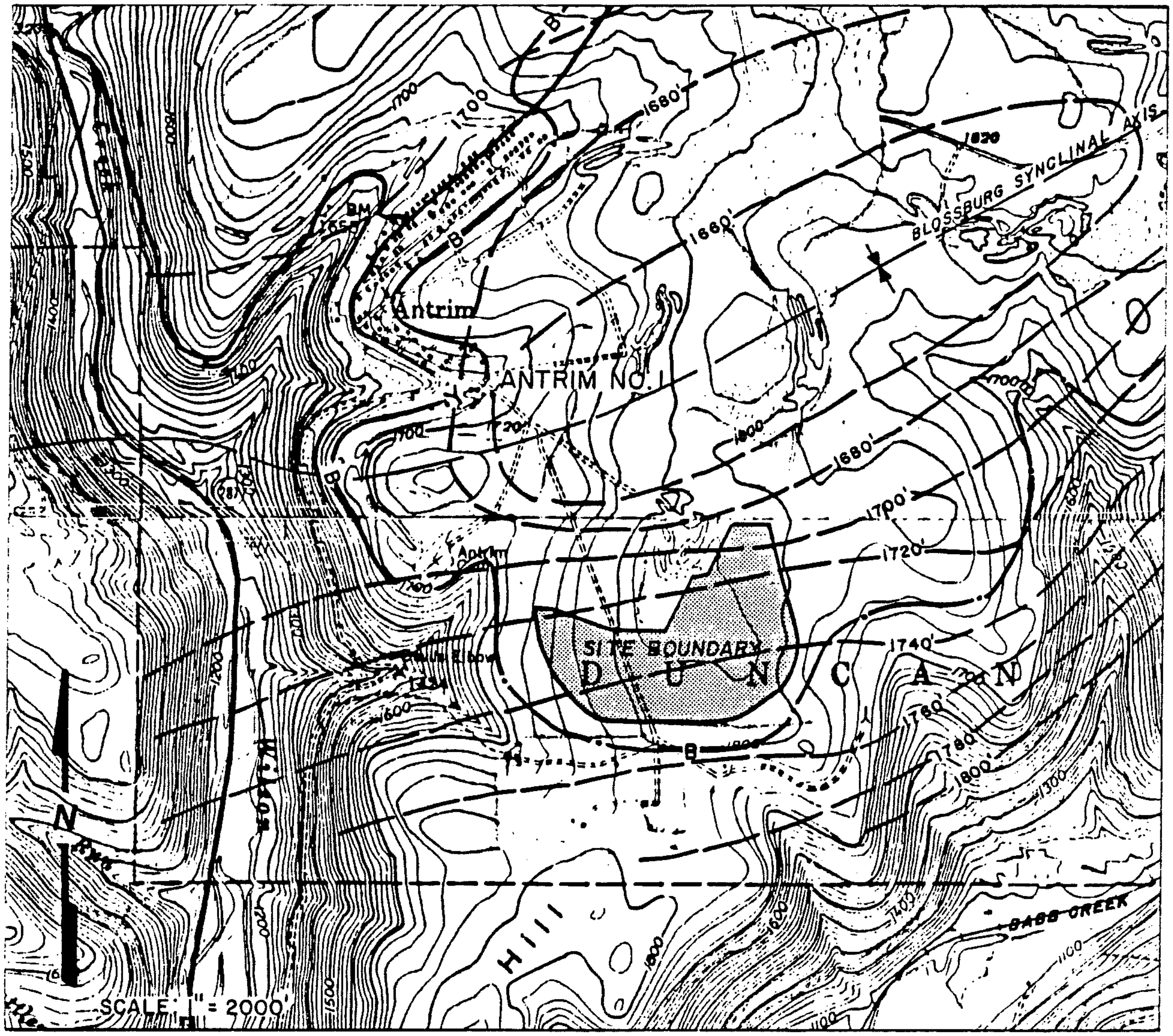

Figure 2. Topographic map from Morris and Antrim, PA USGS $7\frac{1}{2}'$ quadrangles showing location of Antrim Mining's strip mine site and structural contours on the Bloss coal from Kantz (1976). Scale 1" = 2000'.

Ground water from the entire deep mine complex discharges from the Antrim No. 1 drift which is 3000 feet (915m) north and downdip of the site. Surface mining began in the 1940s and by 1970 roughly 500 acres (202ha) had been disturbed on the four mineable coal seams in the deep mine area.

Hydrology

The site occupies a broad upland plateau having nearly flat to gentle slopes. Within 1000 feet (305m) to the east and 600 feet (183m) to the west of the site are precipitous slopes approaching a 50% grade and dropping some 500 feet (152m) in elevation to Wilson Creek and Babb Creek (Figure 2).

There are no defined perennial surface streams draining this upland. Ephemeral springs flow on the southern and western sides of the mine area, fed by the shallow glacial till aquifer.

Detailed stream flow and mine discharge records kept by the U.S.G.S. from 1978 through 1982 on a nearby upland glaciated watershed, underlain by extensive deep mining on the Bloss coal, provided an analogy for the Antrim strip mine site. One deep mine discharge in this analogous setting, the Hunter Drift, drains some 400 acres (162ha) of Bloss coal deep mine, overlain by large areas of unreclaimed open strip mining. Discharges during water years 1978, 1979 and 1980 from Hunter Drift ranged from 20.4 to 29.5 inches (51.8cm to 74.93cm) or 47% to 74% of total annual precipitation was recharged to the deep mine system. Based on Penn State University research in the Bloss Coal Basin currently underway by D.R. Buss (1982 personal comm.), recharge in a 1940's poorly-reclaimed strip mine in his research area was about 25% of precipitation or about 10 inches (25.4cm) per year.

In order to define the ground water flow systems of this site, we installed nested piezometers in four test holes. Our interpretation of the water levels in the piezometers suggests that there are three major ground water flow systems in the site area. The upper system is found in the various perched stratified zones within the glacial till. The degree of interconnection with lower systems and extent of true perching of the shallow till ground water is seasonally variable.

The intermediate bedrock system above the Bloss coal shows the underdrain effects of the nearby Bloss deep mine. There is a steep hydraulic gradient to the north, down structural dip towards the deep mine.

The lower ground water system is found in the thick sandstones below the Bear Creek coal where flow follows the regional structure. Recharge to this zone is primarily from leakage through the overlying Bloss and Bear Creek underclays.

Ground water discharge from this site occurs in three primary areas. The ground water system in the till contributes to ephemeral springs. Ground water in the intermediate system above the Bear Creek coal eventually drains downdip to the open Bloss deep mine workings and discharges from the main heading of the Antrim No. 1 deep mine. Subsidence fracturing in the strata overlying the deep mine enhances vertical drainage to this vast underdrain system. The lower sandstone system below the B-coal drains primarily downdip and contributes to the base flow of the stream in the incised valley near the axis of the syncline. This stream also receives the discharge from the Antrim No. 1 deep mine.

The water quality of discharges immediately around the site area that have not been affected by previous mining are generally good, with specific conductances of less than 60 umhos/cm, sulfates less than 20 mg/1, acidity less than 50 mg/1, and iron generally below 0.3 mg/1. The Antrim No. 1 discharge is the single largest ground water discharge in the area. This and other deep mine discharges west of Antrim render Wilson Creek unsuitable for any fish life (Figure 2). Table 1 shows the range of flows and water quality analyses of the Antrim No. 1 deep mine discharge. Flows are measured with a calibrated V-notch weir each time a water quality sample is collected. Monthly samples were collected from February 1981 to October 1982; since November 1982 weekly samples have been collected.

Table 1. Flow and Water Quality from Antrim No. 1 Deep Mine Discharge.

	Low	High	Mean
Flow gpm (1/sec)	326 (20)	5030 (317)	1130 (71)
pH units	2.9	3.5	3.1
Acidity mg/1	140	380	230
Iron mg/1	1.6	34	12
Manganese mg/1	2.9	36	5.2
Aluminum mg/1	1.8	180	12
Sulfate mg/1	130	520	270
Specific Conductance umhos/cm	380	880	680

TECHNIQUES TO CONTROL AMD

The design team for the strip mine permit application took a unique point of view toward a coal mine in that the first priority was to design a backfill plan. We decided that a redundant system of AMD prevention measures would be used since no single measure could be counted on to completely eliminate AMD as mandated by Federal and State law. The basic measures to be employed were:

1. chemical control of pH and neutralization of AMD in the backfill by alkaline addition (lime blending)
2. hydrologic control of ground water in the backfill to minimize saturated conditions and route ground water flow beneath the acid-forming overburden
3. runoff control to minimize infiltration to the backfill
4. a materials handling plan to allow segregation of acidic spoil and selective placement of alkaline material that is economically feasible and practical.

Chemical Theory of Lime Addition

Acid mine drainage has been and continues to be a major problem generated by the mining of coal. Although some of the basic chemistry is understood as a result of research over the past twenty years, Rose, et al. (1983) concluded that the process is complex enough that we are not yet able to make accurate predictions of future acid generation at mine sites or to prevent or ameliorate acid drainage at an economically acceptable cost.

This project attempts to economically control the generation of AMD by maintaining a pH above 7 in the backfill by the addition of a waste lime material. Microorganisms control the overall rate of the AMD reaction by "mediating the oxidation of ferrous iron since it, alone, is the rate determining step" (Stumm & Morgan, 1970, p. 542). Controlling the growth of the microbes *Thiobacillus* and *Ferrobacillus ferrooxidans* can greatly reduce AMD production, possibly by one million times; at a pH of greater than 5.5, the catalytic effect of the bacteria becomes insignificant (Singer and Stumm, 1969). As long as the water infiltrating through the mine spoil backfill is maintained at a pH above 7.0, the AMD reaction is suppressed since the pyrite, no matter what its concentration, is nearly unavailable for reaction.

According to the work done by Rose, et al. (1983), acidity produced from the AMD reaction is strongly related to the pyritic sulfur content of the spoil material. Overburden containing less than about 1% pyritic sulfur generates "negligible" amounts of acidity (p. 39). A more conservative approach was used in this project in that any overburden material containing more than 0.8% pyritic sulfur was considered potentially acid-producing. Figure 1 shows the acid and non-acid-producing zones in the overburden. Leaching tests done by Rose, et al. (1983) show that calcite as a layer above the acid-producing rock produces a greater reduction in both acidity and sulfate than leaching tests where the calcite was mixed with the overburden sample. This suggests that the relatively alkaline water produced by passing through the calcite inhibits the acid-producing reaction, rather than just neutralizing the acid after it is produced.

At this site, lime addition is incorporated both above the acid-producing spoil and within this zone in the backfill. The waste lime material used in the alkaline addition to the Antrim backfill is from the baghouse of a large lime manufacturing plant. The waste is 20% CaO, 57% $CaCO_3$ and 23% inert. Since the waste lime is stockpiled outside, most of the CaO has slaked to $Ca(OH)_2$ (hydrated lime); 20 tons (18t) of CaO is equivalent to 26 tons (24t) of $Ca(OH)_2$. The approved mine design required that 400 tons (362t) of waste lime be added to the backfill material for every acre (0.4ha) mined. An additional 50 tons/acre (112t/ha) was spread on the Bear Creek coal pavement.

The dissolution of the waste lime, which will maintain a pH greater than 7.0, will determine the longevity of the alkaline material in the backfill. Work in a similar geologic setting near the study area, described earlier, indicates that 25% of precipitation or about 10 inches (25.4cm) of ground water recharge per year in a poorly-reclaimed strip mine is realistic. As will be discussed later, this is a conservatively high estimate for the Antrim site since techniques are included to maximize runoff at this site.

If all of the 10 inches (25.4cm) per year that becomes recharge reaches an initial alkalinity of 1000 mg/l as $CaCO_3$ as it dissolves the lime, then 1680 pounds (762kg) of $Ca(OH)_2$ will dissolve per year per acre (0.4ha). The equivalent of 104 tons (94t) of $Ca(OH)_2$ is added to the backfill with every 400 tons (362t) of waste lime added. Thus, it should take at least 124 years for the water that infiltrates through the backfill to dissolve all of the hydrated lime. As the lime is depleted, the recharge water will reach a concentration of about 100 mg/l as $CaCO_3$ in contact with the limestone portion of the baghouse lime. Under these conditions, 227 pounds (103kg) of limestone will dissolve per year per acre (0.4ha). Ideally, it would take approximately 2000 years for all of the limestone to dissolve at this rate.

Sandstone Underdrain

A primary objective of the backfill plan is to minimize contact of the acid-producing mine spoils with ground water, based on the assumption that it takes water to make mine drainage. Starting from the bottom up, a 3-foot (1m) thick blanket of coarse sandstone blocks is dumped on the mine floor. This provides a rock blanket underdrain beneath the overlying spoil. The mining plan calls for block cuts oriented parallel to structural dip and for mining updip to produce a "furrowed" effect in the backfill. This, in combination with the rock blanket drain, facilitates drainage on the Bear Creek coal pavement such that no ground water builds up in the spoil.

The post-mining outlet for the downdip drainage is provided by the open, free-draining deep mine system, seen in the northern downdip highwall. During mining and initial backfilling, the pit drainage is collected in sumps along the open highwall cut to hydrologically isolate the active strip mine from the deep mines. In the event that monitoring of this sumped drainage shows water quality unfit for release into the deep mines, it can be routed via rock drains to the northwestern corner of the permit for discharge or treatment.

The hydraulic conductivity of the sandstone rock drain appears to be far more than adequate to handle backfill drainage. Consider downdip drainage along an average mine pavement slope of 5% at a depth of 1 foot (0.3m) saturation in the rock blanket. Textbook hydraulic conductivities for natural sand and gravel deposits range up to 10,000 gallons per day per square foot (gpd/ft^2) (0.47cm/s), while clean gravels exceed 100,000 gpd/ft^2 (4.7cm/s) (Todd, 1959, p. 53). Saturated flow through this material can be described by Darcy's Law:

$$Q = KiA$$

where:
K = hydraulic conductivity (gpd/ft^2) (cm/s)
i = hydraulic gradient (fraction)
A = cross sectional area of flow (ft^2) (m^2)
Q = flow (gpd) (1/s).

As an example of flow for a gradient of unity (100%) through a saturated column 1 square foot in cross-section of sand and gravel with K = 10,000 gpd/ft^2:

$$Q = 10{,}000 \text{ gpd/ft}^2 \times 1 \times 1 \text{ ft}^2$$
$$Q = 10{,}000 \text{ gpd or } 7 \text{ gpm } (0.441/s).$$

At a field gradient of 5%, such as found down the dip of the Antrim strip mine pavement, flow in each 1-foot width of rock drain, saturated to a depth of only 1 foot, and assuming a K = 10,000 gpd/ft^2 (typical for clean sand or sand and gravel) will be:

$$Q = 10{,}000\text{gpd/ft}^2 \times 0.05 \times 1 \text{ ft}^2$$
$$Q = 500 \text{ gpd or } 0.35 \text{ gpm } (0.0221/s).$$

As the width (parallel to strike) of the mining operation is some 2700 feet

(823m), the rock drain capacity at 1-foot saturation depth flowing down an average dip of 5%, still assuming K = 10,000 gpd/ft^2, is:

Q = 0.35 gpm/ft of width x 2700 ft wide = 950 gpm (601/s).

Assuming a hydraulic conductivity of 100,000 gpd/ft^2, typical for clean gravels as cited earlier, increases the drain capacity by 10 times to over 9500 gpm (6001/s).

Intuition suggests that tabular blocks of sandstone 1/2 to 1-foot (0.1-0.3m) thick will drain at even higher flow rates than will a sand and gravel deposit. B.K. Hough (1969, p. 76) describes a material called "one-man stone" composed of 4 to 12-inch (10-30cm) diameter stone aggregate having an "effective size" of 6 inches (15cm). From our observations, this is on the average similar to the C-sandstone rubble seen at Antrim's operation. The permeability of "one-man stone" is shown to be 30cm/sec (640,000 gpd/ft^2). Using this value for hydraulic conductivity in our previous calculations yields a rock drain capacity of:

Q = KiA
Q = 640,000 gpd/ft^2 x 0.05 x 2700 ft^2
Q = 60,000 gpm rock drain capacity (38001/s)

where:
A = 2700 ft wide x 1 ft deep
i = 5%

Assuming 10 inches (25.4cm) per year of effective recharge to the backfill as described in earlier sections, this is equal to an average input of about 0.5 gpm/acre (0.0131/s/ha). Distributed over 85 acres (34ha) of strip mine this totals only 43 gpm (2.71/s), far less than the capacity of the drain, which is one to three orders of magnitude greater than the anticipated flow.

Control of Infiltration to the Backfill

By considering the acid-producing mine spoil as a type of waste product, we developed a landfill-type of backfilling program. This includes minimizing infiltration by utilizing a low-permeability cap. This approach seemed appropriate to reduce "leachate" generation, in this case mine drainage. The samples of till tested in the laboratory showed reworked permeabilities at 90% Standard Proctor densities (attainable in the field with conventional equipment) that were about 1 x 10^{-7}cm/sec. Curiously enough, this is the same value U.S. EPA requires for landfill liners.

A compacted till layer 1 to 2 feet (0.3-0.6m) thick below the final 4 feet (1.2m) of subsoil and topsoil should minimize infiltration recharge to the mine spoil. By grading the backfill into rolling swales with drainageways floored on the compacted till layer, lateral soil drainage will be facilitated above the backfilled mine spoil.

As in the case of landfill management, the cover capping system need not be a perfect liner; "leaks" are acceptable as they represent only a small portion of the total volume of water which is precluded from entering the backfilled mine.

Decreasing recharge significantly has the added benefit of reducing the required drainage capacity of the rock underdrain system, and of increasing the longevity of the availability of alkaline materials (lime and limestone) to infiltrating ground waters. The predicted rates of consumption (dissolving) of lime and limestone previously calculated were based on infiltration recharge of 25% of precipitation or 10 inches (25.4cm) per year. If the proposed compacted till cap can eliminate only half of this conservatively high estimate, the "life" of the alkaline materials will double.

Materials Handling Plan

Materials handling is ordinarily the primary concern of the mine designer, but in our case it was secondary to environmental concerns. As previously discussed, we found that the overburden above the C-coal seam was low in pyritic sulfur, hence, low in AMD potential. This meant that it could go anywhere in the backfill. Standard area mining practice would have been to place this low-sulfur overburden in the open strip cut first, thus it would have been on the bottom of the backfill. Our plan, though, called for non-acid-forming overburden to be on the top of the backfill. Figure 3 shows the sequencing of the backfill. We came up with several different methods of accomplishing this sequence using draglines, trucks and loaders for the rock overburden. Scrapers are used to haul glacial till and topsoil around the end of the active cut to the backfill area where they simultaneously spread and compact this material.

The backfilling sequence begins by placement of a lime blanket, at the rate of 50 tons per acre, (20.2ha) on the Bear Creek underclay (Figure 3, Zone G). After blasting the sandstone overlying the C-coal in the adjacent active cut, a dragline casts the sandstone into the empty pit where a dozer spreads it to construct the rock underdrain (Figure 3, Zone F-G). For areas of the mine where the dragline cannot reach, trucks haul the shot sandstone to make the underdrain. The small amount of excess sandstone not used in the underdrain has lime spread on it and is then hauled to the backfill area where it is placed on top of the acid-forming spoil (Figure 3, Zone C-D). Approximately 150 tons (136t) of lime is spread on the glacial till before it is hauled into Zone C-D.

Overburden tests showed that the 35 feet (10.7m) of shale between the C-coal and Bloss coal had several zones containing high pyritic sulfur. These zones were not consistent nor were they readily identifiable in the field. We decided to classify the entire 35 feet (10.7m) between the C-coal and Bloss coal as an acid-producing zone to simplify materials handling.

A dragline positioned on the C-coal pavement in the active cut casts all the zone below it into the adjacent open pit. The dragline also accomplishes lime blending. Lime is spread on the C-coal pavement at the rate of 200-300 tons/acre (448-673t/ha). As the dragline removes the overburden beneath it, the lime is proportionally blended into the overburden, then placed in the zone above the rock drain (Figure 3, Zone E-F).

APPENDIX B-1-

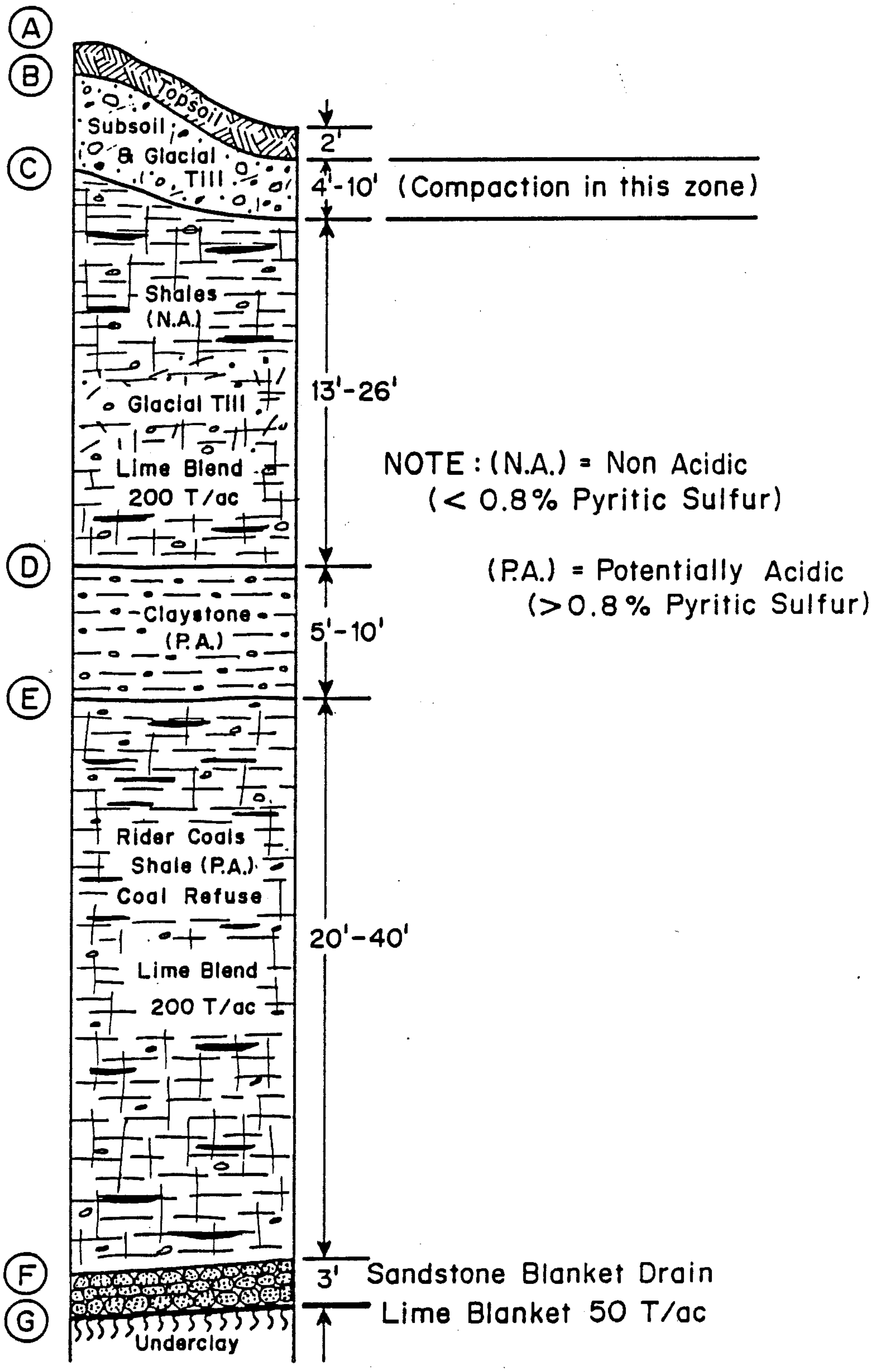

Figure 3. Backfill Sequence

APPENDIX B-10

The binder between the Bloss and Bear Creek coals is 5 to 7 feet (1.5 to 2.1m) thick. This binder is ripped by a dozer and then hauled out of the pit and dumped on the acid-forming spoil (Figure 3, Zone D-E) to be covered later by non-acid-forming spoil (Zone C-D). Since this binder is high in pyritic sulfur, lime is spread on this interval at the rate of approximately 150 tons/acre (336t/ha) prior to ripping.

The special handling requirements at this mine add $10,000 to $12,000 of cost per acre (0.4ha) mined, or about $1.00 per ton (0.9t) of coal produced. If the coal seams were thinner and yielded fewer tons per acre, the special handling could make the whole process uneconomical. The lime blend was designed for 450 tons per acre (1000t/ha); actual usage has averaged 650 tons per acre (1460t/ha). The additional lime consumption is caused by difficulty in metering the lime, and the tendency of the equipment operators to always err on the high side of the application rate as directed by mine management. The lime itself costs about $5,200 per acre (0.4ha) or about $.50 per ton (0.91t) of coal produced.

RESULTS AND IMPLICATIONS

Antrim Mining agreed with PA DER to monitor the effectiveness of the mine plan for one year after starting the mine. This monitoring took place in a sump located along the downdip highwall at the lowest point on the job which received drainage from the rock underdrain. The sump was developed immediately after the start of mining. The first year saw the mining of 18 acres (7.3ha). At any time during the lift of the active mine there will be four stages of reclamation:

1. open active pit with coal and coal pavement exposed
2. acid-forming spoil placed on top of the rock underdrain but not covered with non-acid-forming spoil
3. rough-graded, non-acid-forming spoil on top of acid-forming spoil
4. completed, revegetated backfill with diversion ditches and topsoil.

Water in the sump is a blend from all four sources. During the early stages of the mine, the completed revegetated area, stage #4, is negligible but grows as the mine matures and eventually becomes 100% of the area when mining is completed. At the end of the first year there was less than 8 acres (3.2ha) in stage #4 of a total 18 acres (7.3ha) mined. Water quality was measured in the sump and in the open pit, and the water quality of the rainfall was also checked. These water quality analyses are summarized in the following tables.

Table 2. Water contribution from the open active pit before contact with alkaline material.

pH	2.8	units	iron	127	mg/1
conductivity	1700	umhos/cm	manganese	18.9	mg/1
alkalinity	0	mg/1	aluminum	43.7	mg/1
acidity	714	mg/1	sulfate	1440	mg/1

APPENDIX B-10

Table 3. Range and median values of water quality analyses from 15 samples of the downdip highwall sump, collected during first year of mining.

		Low	High	Median
ph	units	5.1	11	7.4
conductivity	umhos/cm	230	850	710
alkalinity	mg/l ($CaCO_3$)	15	66	68
acidity	mg/l ($CaCO_3$)	0	78	11
iron	mg/l	<0.1	1.8	0.15
manganese	mg/l	<0.1	12.3	8.4
aluminum	mg/l	<1	5.3	<1
sulfate	mg/l	56	530	350

Table 4. Average quality of five rainfall samples.

pH	4.9 units
acidity	45 mg/l
alkalinity	13 mg/l

As can be seen from these data the water quality was altered from the time it entered the mine site as rainfall to its appearance in the sump. The alkaline quality of the sump which includes the severe AMD in the open pit floor (Table 2), implies that most of the drainage from the backfilled area must be strongly alkaline. Water quality standards as set by U.S. EPA for discharges from mining sites are generally met in the sump water for pH (6-9 units), acidity (no net acidity) and iron (3.0 mg/l, 30-day average), but not for manganese (2.0 mg/l, 30-day average). The high levels of manganese in the sump water are coming from the open pit AMD. When the sump pH exceeds 8, then the manganese should precipitate out. As the mine area becomes larger, the open pit acreage will remain basically the same, but the backfill acreage will grow, so that backfill water contribution to the sump will increase in relation to the runoff from the open cut. Hence, the resulting sump water pH and alkalinity should go up. DER allowed the sump area to be backfilled during January 1984, as the unbackfilled pit was detracting from reclamation performance.

Initial water quality monitoring data from the active unreclaimed mining operation and the performance of the rock underdrain are generally encouraging. The final evaluation of this experimental mining plan cannot be made until backfilling, final grading and revegetation are completed in the next two years.

Factors which allowed implementation of this experimental plan to control AMD at the Antrim mining site are:

1. source of low-cost lime
2. favorable stripping ratio of 11.5 to 1 (special handling and lime costs boosted the total mining costs to an apparent ratio of 16 to 1)
3. long-term coal sales contract allowed uninterrupted mining at a fixed price (without this the recent coal market depression would have made mining uneconomical)
4. Abundant glacial till and topsoil to cap the backfill

5. Antrim Mining management commitment to carry out the complex mining plan successfully.

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TREATMENT OF ACID WASTE WATERS WITH CEMENT-KILN FLUE DUST

by

A. A. Spinola*

Introduction

Stream pollution in coal-mining regions has been a long-standing problem. Streams can become polluted by the flow of acid drainage from mines where sulfur-bearing material is exposed to air and water.

When sulfur-bearing material is exposed to air in the presence of water vapor, an oxidation reaction takes place that results in the formation of ferrous sulfate and sulfuric acid. Water that percolates into a coal mine from the surface leaches and dissolves the products of oxidation and transports them out of the mine and eventually to a stream. Complex materials are formed with analyses similar to that shown in Table I. The exact composition depends, of course, on the nature of the formation the water passes through and to some degree on the method of handling the water in the mine.

The most common method for elimination of these pollutants has been to mix the acid mine water with a slurry of lime to neutralize the water and form an insoluble iron compound, which is then allowed to settle in ponds. If the degree of oxidation is low, then the products of neutralization are usually aerated to oxidize the ferrous iron to the less soluble ferric iron. The accumulated sludge from the neutralization system consists mainly of calcium sulfate and an iron-oxide-hydroxide. Most stream-pollution control regulations now require that all discharges from mines have a pH between 6 and 9 and an iron content of less than 10 milligrams per liter.

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*Applied Research Laboratory, United States Steel Corporation

Although conventional lime neutralization of acid mine drainage is the only generally practical means used to date, it has a number of disadvantages. The process is relatively costly and slow. It requires the disposal of large quantities of sludge that is very wet and difficult to handle. In many cases, the location of disposal sites presents a serious problem when settling ponds become full.

Because of the disadvantages of conventional lime neutralization, a research study was conducted by the Applied Research Laboratory of U. S. Steel to develop an improved method of neutralizing acid mine drainage. It was discovered that a readily available industrial waste product has exceptionally good qualities for this application. The product is cement-kiln flue dust. It is highly effective, rapid in action, and results in a small volume of sludge that can easily be handled and might be suitable in certain areas as a soil conditioner. The process involves adding an appropriate amount of cement-kiln flue dust to the waters to be neutralized and agitating the mixture or permitting it to stand until neutralization is complete.

Laboratory Batch Tests

Tests were conducted in the laboratory on neutralization of mine drainage with both lime and cement-kiln flue dust to compare quantities required, reaction times, quantities of sludge produced, and sludge filterability. The chemical properties of acid mine drainage and cement-kiln flue dust were determined before testing was initiated.

Table I shows some of the average analysis of the mine drainage used in part of these studies.

Table II shows the range of the constituents of cement-kiln flue dust from various plants.

The amount of cement-kiln flue dust required to attain various degrees of neutralization was studied by adding different weights of the dust to samples of acid mine drainage. These samples were continuously stirred on a multiple stirrer for two hours prior to pH measurement. These tests were then repeated using lime as the neutralizing agent.

To determine the volume of settleable sludge generated, samples of acid mine drainage were neutralized by the addition of lime or cement-kiln flue dust until a pH of 7.0 was attained. The volume of sludge produced was then measured after two hours of quiescent settling. The iron content of the sample was measured prior to neutralization and immediately after the settling tests.

Also, the reaction times of lime and various cement-kiln flue dusts were compared. These tests were carried out in a manner similar to those previously described.

Batch Test Results

The results of the laboratory batch tests showed that more flue dust is needed to attain neutralization, but neutralization is more nearly complete and faster when flue dust is used, and less sludge is formed. Also, iron content of the treated mine drainage is below 10 milligrams per liter.

Figure 1 presents the data obtained on the amount of material required to neutralize the acid mine drainage to various levels of pH. The data show that about 2 grams of cement-kiln flue dust were required per liter of acid mine water to achieve a pH of 7.0 as compared with about 0.5 gram of lime per liter of acid mine water. A comparison of reactic times, as shown in Table III, indicates a faster and slightly better neutralization with flue dust than with lime. It should b pointed out that the neutralizing strength of the dust from a given plant might vary with changes in operating practice and/ or raw materials, either of which could affect the degree of alkalinity of the flue dust.

When lime and cement-kiln flue dust were used to neutralize acid mine drainage to a given pH, comparison of the sludge volumes produced indicated an 80 percent reduction in sludge volume when flue dust was the neutralizing agent. The decrease was due to the formation of a gritty sludge with a flue dust. Lime neutralization produced a very gelatinous, noncompacting precipitate. Thus, as indicated earlier, even though more flue dust, when compared to lime neutralization, would be required to neutralize an equal amount of mine drainage water, the volume of sludge to be disposed of would be significantly less. This would reduce transportation costs and ease the problem of sludge disposal. Finally, the total iron content of the treated acid mine drainage was under 10 milligrams per liter in all the neutralization tests, thereby satisfying current stream-pollution control regulations.

Laboratory Pilot Plant Tests

To confirm the results of the laboratory batch tests on continuous operation, a 30-liter-per-hour pilot plant was set up in the laboratory to neutralize acid mine drainage with cement-kiln flue dust, Figure 2. Acid mine water was pumped into a reaction tank along with a slurry of cement-kiln flue dust. The flowing mixture was continuously agitated and oxidized by air diffused into the bottom of the reaction tank. In the initial testing, mixing was done by mechanical stirring and the sludge formed was a ferrous hydroxide precipitate, leaving some soluble ferrous iron to be oxidized. Since this was not a desirable result, air was introduced to effect oxidation and agitation in one operation, so that the amount of soluble iron in the effluent stream would be reduced. The neutralized mixture was then pumped into a settling tank with about 30 minutes detention time to separate the sludge from the flowing stream.

These tests confirmed the information gained in the batch tests. The pH of the effluent stream from the settling tank was monitored and maintained at 8.0 with 2.2 grams of cement-kiln flue dust per liter of acid mine drainage, or about 18 pounds per 1000 gallons. In appearance, the effluent from the pilot test unit was like that of tap water and its analysis is shown in Table IV. The iron content was nondetectable.

On-Site Testing

Because the laboratory results proved promising, the next phase of testing was conducted at a 250-gallon-per-minute on-site pilot neutralization plant. In this plant, shown in Figures 3 and 4, the neutralizing material was dry-fed directly to the mixing-aeration chamber from a 3-ton hopper. The overflow from the chamber passed through an 8-inch flow diverter that permitted the flow to go to either of two settling basins. Each basin was equipped with four baffles to keep most of the settled sludge near the feed end of the basin.

During the test program, lime was used as the neutralizing agent for the first few days of operation, after which cement-kiln flue dust was used. Sludge samples from both lin and flue-dust neutralization were examined to determine filtering characteristics. These results shown in Tables V and VI, show that either lime or flue dust has the capability of reducin the iron content of the effluent to below 10 milligrams per lite The effluent turbidity was reduced to about the same range wit either material.

The results of the filtration tests are given in Table VII. The sludge generated from flue-dust treatment resulted i a considerably drier filter cake (about 37 percent solids) than did the lime-produced sludge (about 20 percent solids). The flue-dust filter cake was thus lower in volume and easier to handle. Also, the flue-dust sludge could be more readily removed from the filter than the lime sludge. As also shown, f given filter and drying times (for example, 1 minute and 2 minutes, respectively), the filtration rate was much greater for t flue-dust sludge than for the lime sludge. These results indicate that the sludge from a flue-dust neutralization system can be dewatered by vacuum filtration to facilitate disposal.

Summary

The tests to compare neutralization of acid mine drainage with cement-kiln flue dust against conventional lime neutralization indicate that flue dust has several advantages over lime for this application. It was pointed out earlier that conventional lime neutralization requires a mixture of acid mine water and a slurry of lime. The flue dust can be more readily dry-fed directly to the acid mine drainage, thereby eliminating the need for a slurry mixer. Moreover, the sludg produced by flue-dust neutralization occupies considerably les volume and can be filtered much more easily than the products of lime neutralization.

In addition to offering a promising alternative to lime for neutralizing acid mine drainage, the use of cement-kiln flue dust provides a filtered sludge product which might b useful in certain areas as a soil conditioner. Last but not leas the work demonstrates that in certain situations, research wor can be successful in utilizing waste products from pollution-abatement facilities to effectively solve pollution problems in completely unrelated areas.

Table I

Analysis of Mine Acid Drainage

pH	2.8
Concentration of Constituents, parts per million	
Ferrous iron	99
Ferric iron	288
Total iron	387
Aluminum	40
Calcium	278
Magnesium	123
Sodium	850
Chloride	119
Manganese	7
Sulfate	4000
Acidity, as $CaCO_3$	1100
Suspended solids	300
Dissolved solids	6270
Total solids	6570

Table II

Analysis of Cement-Kiln Flue Dusts

Component*	Range, percent
SiO_2	10.94 - 16.32
Total iron	0.91 - 3.12
Fe_2O_3	0.61 - 2.96
FeO	0.04 - 1.35
S	0.68 - 6.75
Al_2O_3	3.40 - 6.87
CaO	28.73 - 58.20
MgO	0.70 - 1.82
Na_2O	0.27 - 1.00
K_2O	1.78 - 12.61

* The components reported in the analysis are not necessarily present in that form.

Table III

Comparison of Lime and Cement-Kiln-Dust Neutralization

pH of Acid Mine Drainage After Treatment With	
1 Gram/Liter of Lime	2 Grams/Liter of Cement-Kiln Dust
2.7	2.7
4.5	5.8
6.4	6.9
6.8	7.1
7.0	7.1
7.1	7.5

Table IV

Analysis of Laboratory Pilot-Plant Effluent

pH	8.0
Component*	**Parts per Million**
SiO_2	35
Al_2O_3	1.5
CaO	931
MgO	61
MnO	8
Ferrous Iron	None detected
Ferric Iron	None detected

* The components reported in the analysis are not necessarily present in that form.

Table V

Results of Tests Using Lime At Neutralization Plant

Dust Feeder Setting, percent	Influent			Effluent		
	pH	Total Iron, mg/l	Turbidity, JTU*	pH	Total Iron, mg/l	Turbid JTU
20	6.4	37	235	7.9	5.2	55
20	6.3	37	265	7.7	5.2	58
20	6.3	28	290	7.1	8.8	50
20	5.6	42	270	6.6	21.5	45
35	6.5	24	435	6.6	27.0	62
50	6.4	33	240	8.1	8.5	48
50	6.4	35	225	9.2	5.3	25
25	6.7	19	290	8.5	5.3	50

*Jackson Turbidity Units

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Table VI

Results of Tests Using Cement-Kiln Flue Dust at Neutralization Plant

Dust Feeder Setting, percent	Influent pH	Influent Total Iron, mg/l	Influent Turbidity, JTU*	Effluent pH	Effluent Total Iron, mg/l	Effluent Turbidity, JTU
30	6.2	27	320	7.1	8.0	62
30	-**	-	-	7.2	7.5	58
30	6.3	33	300	7.4	6.4	60
30	6.1	46	255	7.4	7.6	75
30	-	-	-	7.3	7.5	65
30	-	-	-	7.2	7.5	70
48	6.7	104	2680	6.9	10.6	112
48	6.3	30	285	7.6	6.5	85
48	6.3	33	280	7.6	5.5	85
48	6.5	30	300	8.4	4.8	85
48	6.6	37	275	9.4	2.1	30
48	6.5	25	500	9.3	2.3	25
48	6.3	38	325	9.1	6.5	38
48	6.1	26	450	8.0	3.3	22
48	6.0	90	75,000	8.1	13.0	165

* Jackson Turbidity Units
** Not determined

Table VII

Sludge-Filtration Test Results

Type of Neutralization	Vacuum, in. Hg	Filter Time, min	Drying Time, min	Cake Solids, percent	Cake Thickness, in.	Filtration Rate, lb/hr/ft2
Lime	8	1	2	19.2	1/16	0.2
Lime	16	1	2	21.3	3/32	0.2
Lime	20	1	2	21.3	5/64	0.2
Cement-kiln flue dust	8	1/2	2	35.6	-*	9.4
Cement-kiln flue dust	8	1	2	35.8	-	6.5
Cement-kiln flue dust	8	2	2	36.8	-	6.2
Cement-kiln flue dust	16	1/3	2/3	37.3	3/16	20.1
Cement-kiln flue dust	16	1/2	1	37.7	1/4	16.8
Cement-kiln flue dust	16	1	2	37.7	5/16	10.8
Cement-kiln flue dust	20	1/3	2/3	38.6	1/8	19.6
Cement-kiln flue dust	20	1/2	1	37.3	3/16	16.3
Cement-kiln flue dust	20	1	2	37.6	1/4	10.6

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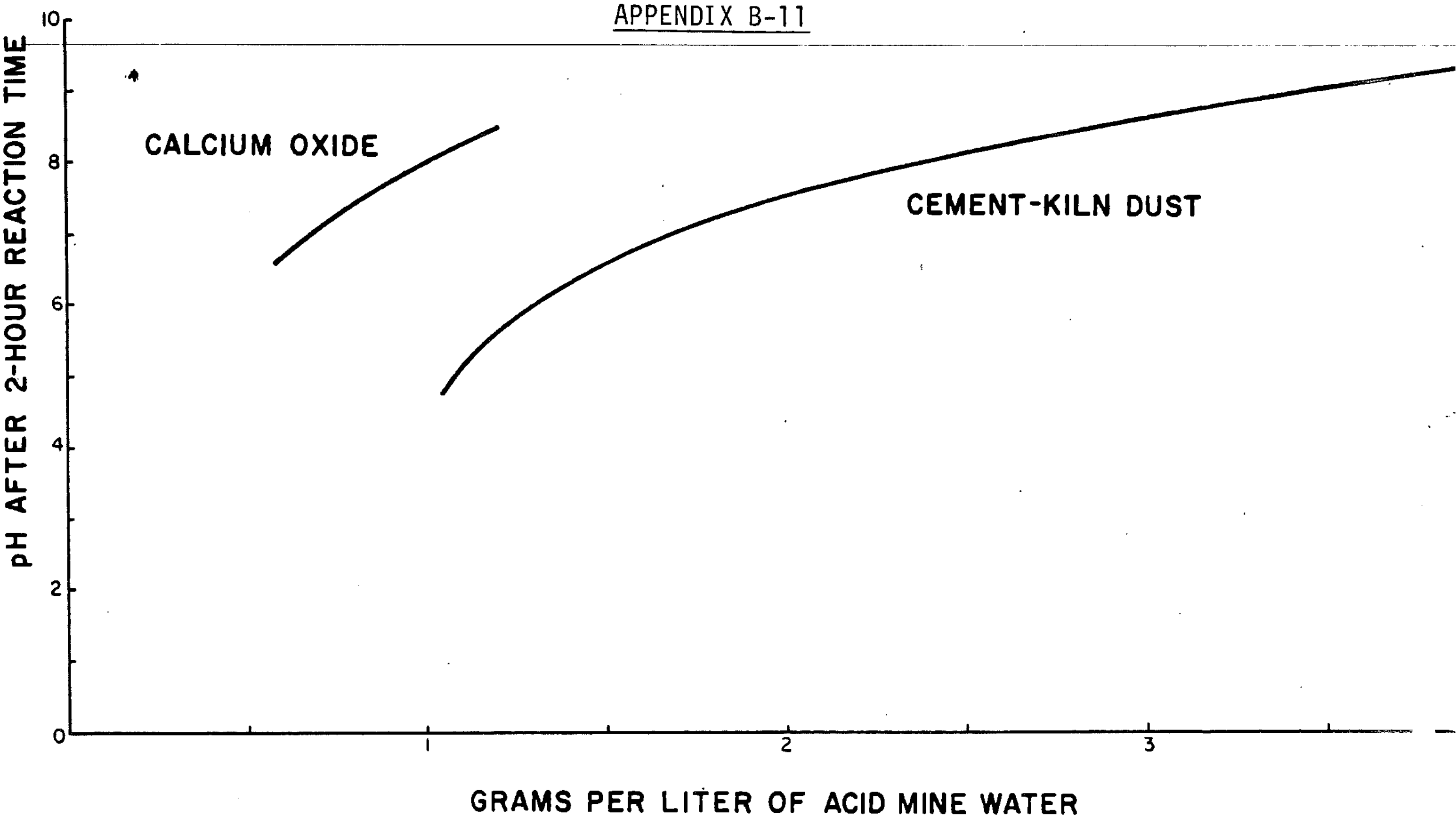
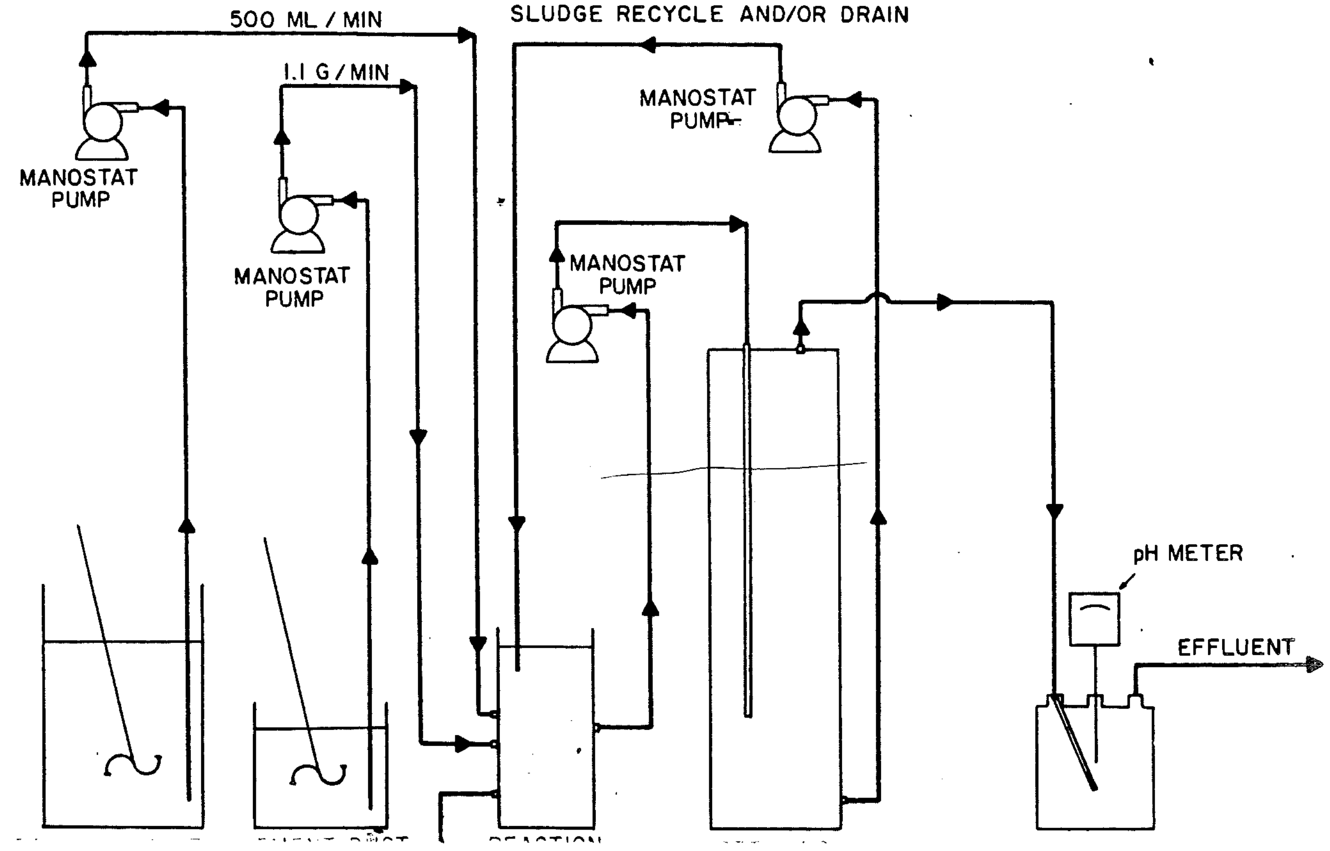


NEUTRALIZING EFFECTIVENESS: CALCIUM OXIDE VS CEMENT-KILN FLUE DUST

FIGURE I



NEUTRALIZATION-PLANT FEED SYSTEM

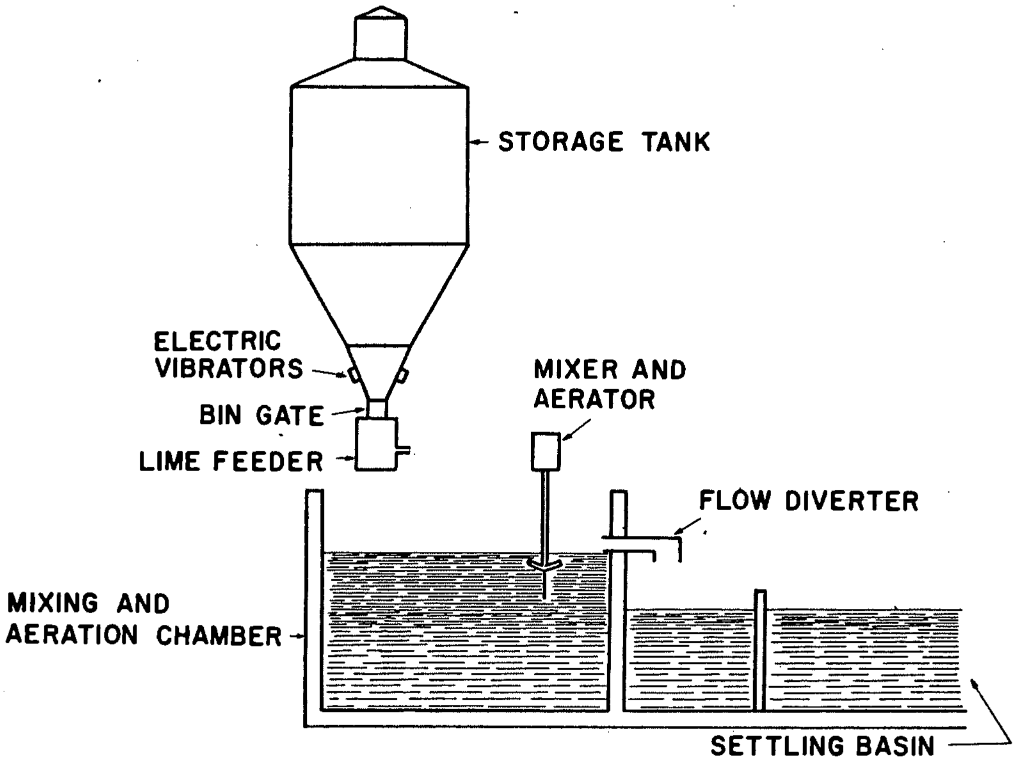


FIGURE 3

NEUTRALIZATION-PLANT SETTLING BASIN

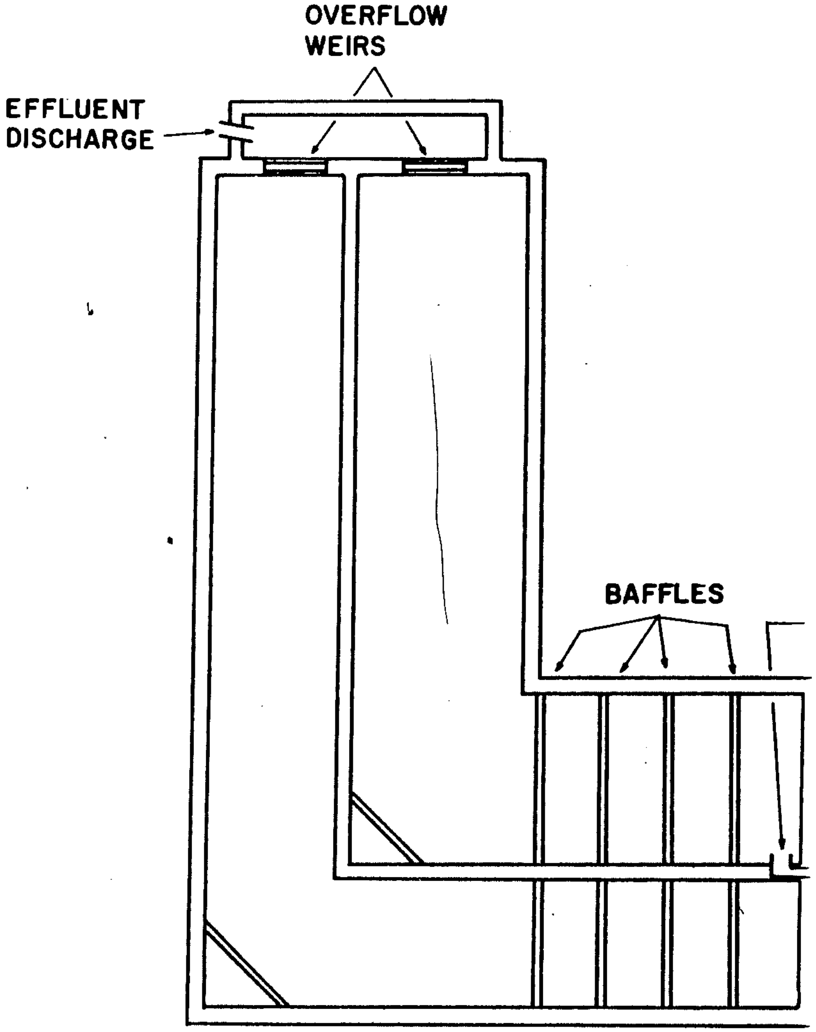


FIGURE 4

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G[illegible]nda your file

Monsanto

MONSANTO INDUSTRIAL CHEMICALS CO.
9229 East Marginal Way South
P. O. Box 80963
Seattle, Washington 98108
Phone: (206) 764-4450

July 27, 1982

Ms. Glennda McLucas
Industrial Mineral Products
P.O. Box 95
Ravensdale, WA 98051

Dear Ms. McLucas,

Per our telephone conversation today concerning the possibility of landfilling some solids from our storage vessels. The material has been reviewed with Mr. Swofford of the King County Department of Public Health and Mr. Conroy of the Department of Ecology. Toxicity information for the material has revealed it to be non-toxic by state RCRA definition and the DOE and DPH are presently proceeding to certify it as such.

The physical characteristics of the material are a slurry of 60% to 70% solids with a pH of 4.9. The material is from sulfite pulping manufacture. It is composed of calcium sulfite and calcium sulfate salts mixed with lignin liquor. The material has the physical properties of being a binding agent which will combine with dry materials to make a soft solid substance. It also acts as an acid buffer which will permit its use to neutralize strong basic material.

We currently estimate about 4,000 to 5,000 cubic feet of this material will be available to landfilling. The material will be available starting the week of August 2, 1982.

If you need additional information please contact me.

Sincerely,

M.N. Miller
TSD Superintendent

MNM:tm

a unit of Monsanto Company

APPENDIX C

DALE STRIP PIT RECLAMATION PROJECT

BACKGROUND REGULATORY INFORMATION

IDEAL BASIC INDUSTRIES, 1984

APPENDIX C-1

Chapter 78.44
SURFACE MINING

Sections

Reviser's note: Chapter 64, Laws of 1970 ex.s. has been codified as a new chapter in Title 78 RCW "Mines, Minerals, and Petroleum" although section 1 of the act states "Sections 2 through 25 of this act shall constitute a new chapter in Title 76 RCW." As the act pertains solely to surface mining, the change in placement has been made to preserve the subject matter arrangement of the code.

78.44.010 Legislative finding. The legislature recognizes that the extraction of minerals by surface mining is a basic and essential activity making an important contribution to the economic well-being of the state and nation. At the same time, proper reclamation of surface mined land is necessary to prevent undesirable land and water conditions that would be detrimental to the general welfare, health, safety, and property rights of the citizens of the state. Surface mining takes place in diverse areas where the geologic, topographic, climatic, biologic, and social conditions are significantly different, and reclamation specifications must vary accordingly. It is not practical to extract minerals required by our society without disturbing the surface of the earth and producing waste materials, and the very character of many types of surface mining operations precludes complete restoration of the land to its original condition. However, the legislature finds that reclamation of surface mined lands as provided in this chapter will allow the mining of valuable minerals and will provide for the protection and subsequent beneficial use of the mined and reclaimed land. [1970 ex.s. c 64 § 2.]

78.44.020 Purpose. The purpose of this chapter is to provide that the usefulness, productivity, and scenic values of all lands and waters involved in surface mining within the state will receive the greatest practical degree of protection and restoration. It is a further purpose of this chapter to provide a means of cooperation between private and governmental entities in carrying this chapter into effect. [1970 ex.s. c 64 § 3.]

78.44.030 Definitions. As used in this chapter, unless the context indicates otherwise:

(1) "Surface mining" shall mean all or any part of the process involved in mining of minerals by removing the overburden and mining directly from the mineral deposits thereby exposed, including open-pit mining of minerals naturally exposed at the surface of the earth, mining by the auger method, and including the production of surface mining refuse. For the purpose of this chapter surface mining shall mean those operations described in this paragraph from which more than ten thousand tons of minerals are produced or more than two acres of land is newly disturbed within a period of twelve consecutive calendar months. Surface mining shall not include excavation or removal of sand, gravel, clay, rock or other materials in remote areas by an owner or holder of a possessory interest in land for the primary purpose of

construction or maintenance of access roads to or on such landowner's property. Surface mining shall not include excavation or grading conducted for farming, onsite road construction or other on-site construction, but shall include adjacent or off-site borrow pits except those on landowner's property for use on access roads on such property. Prospecting and exploration activities shall be included within the definition of surface mining when they are of such nature and extent as to exceed the qualifying sizes listed above or when collectively they disturb more than one acre per eight acres of land area.

(2) "Unit of surface mined area" shall mean the area of land and water covered by each operating permit that is actually newly disturbed by surface mining during each twelve-month period of time, beginning at the date of issuance of the permit, and shall comprise the area from which overburden and/or minerals have been removed, the area covered by spoil banks, and all additional areas used in surface mining operations which by virtue of such use are thereafter susceptible to excessive erosion.

(3) "Abandonment of surface mining" shall mean a cessation of surface mining, not set forth in an operator's plan of operation or by any other sufficient written notice, extending for more than six consecutive months or when, by reason of examination of the premises or by any other means, it becomes the opinion of the department of natural resources that the operation has in fact been abandoned by the operator: *Provided*, That the operator does not, within thirty days of receipt of written notification from the department of his intent to declare the operation abandoned, submit evidence to the department's satisfaction that the operation is in fact not abandoned.

(4) "Minerals" shall mean coal, clay, stone, sand, gravel, metallic ore, and any other similar solid material or substance to be excavated from natural deposits on or in the earth for commercial, industrial, or construction uses.

(5) "Overburden" shall mean the earth, rock, and other materials that lie above a natural deposit of mineral.

(6) "Surface mining refuse" shall mean all waste soil, rock, mineral, liquid, vegetation, and other material directly resulting from or displaced by the mining, cleaning, or preparation of minerals during the surface mining operations on the operating permit area, and shall include all waste materials deposited on or in the permit area from other sources.

(7) "Spoil bank" shall mean a deposit of excavated overburden or mining refuse.

(8) "Operator" shall mean any person or persons, any partnership, limited partnership, or corporation, or any association of persons, either natural or artificial, including every public or governmental agency engaged in surface mining operations, whether individually, jointly, or through subsidiaries, agents, employees, or contractors.

(9) "Department" shall mean the board of natural resources.

(10) "Reclamation" shall mean the reasonable protection of all surface resources subject to disruption from surface mining and rehabilitation of the surface resources affected by surface mining. Although both the need for and the practicability of reclamation will control the type and degree of reclamation in any specific instance, the basic objective will be to reestablish on a continuing basis the vegetative cover, soil stability, water conditions, and safety conditions appropriate to the intended subsequent use of the area.

(11) "Reclamation plan" shall mean the operator's written proposal, as required and approved by the department, for reclamation of the affected resources which shall include, but not be limited to:

(a) A statement of the proposed subsequent use of the land after reclamation and satisfactory evidence that all owners of a possessory interest in the land concur with this proposed use;

(b) Evidence that this subsequent use would not be illegal under local zoning regulations;

(c) Proposed practices to protect adjacent surface resources;

(d) Specifications for surface gradient restoration to a surface suitable for the proposed subsequent use of the land after reclamation is completed, and proposed method of accomplishment;

(e) Manner and type of revegetation or other surface treatment of disturbed areas;

(f) Method of prevention or elimination of conditions that will create a public nuisance, endanger public safety, damage property, or be hazardous to vegetative, animal, fish, or human life in or adjacent to the area;

(g) Method of control of contaminants and disposal of surface mining refuse;

(h) Method of diverting surface waters around the disturbed areas;

(i) Method of restoration of stream channels and stream banks to a condition minimizing erosion and siltation and other pollution;

(j) Such maps and other supporting documents as reasonably required by the department; and

(k) A time schedule for reclamation that meets the requirements of RCW 78.44.090. [1970 ex.s. c 64 § 4.]

78.44.040 Administration of chapter. The board of natural resources is charged with the administration of this chapter by utilizing the services of the department of natural resources. In order to implement the chapter's terms and provisions, the department, under the provisions of the administrative procedure act (chapter 34.04 RCW), as now or hereafter amended, may from time to time promulgate those rules and regulations necessary to carry out the purposes of this chapter. [1970 ex.s. c 64 § 5.]

78.44.050 Chapter cumulative and nonexclusive—Other laws not affected. This chapter shall not affect any of the provisions of the state fisheries laws (Title 75 RCW), the state water pollution control laws (Title 90 RCW), the state game laws (Title 77 RCW), or any other state laws, and shall be cumulative and nonexclusive. [1970 ex.s. c 64 § 6.]

78.44.060 Investigations, research, etc.——Dissemination of information. The department shall have the authority to conduct or authorize investigations, research, experiments and demonstrations, and to collect and disseminate information relating to surface mining and reclamation of surface mined lands. [1970 ex.s. c 64 § 7.]

78.44.070 Cooperation with other agencies——Receipt and expenditure of funds. The department may cooperate with other governmental and private agencies in this state and other states and agencies of the federal government, and may reasonably reimburse them for any services the department requests that they provide. The department may also receive any federal funds, state funds and any other funds and expend them for reclamation of land affected by surface mining and for purposes enumerated in RCW 78.44.060. [1970 ex.s. c 64 § 8.]

78.44.080 Operating permits——Required——Applications. After January 1, 1971, no operator shall engage in surface mining without having first obtained an operating permit from the department. Except as otherwise permitted in this section a separate permit shall be required for each separate surface mining operation. Prior to receiving an operating permit from the department an operator must submit an application on a form provided by the department, which shall contain the following information and any other pertinent data required by the department:

(1) Name and address of the legal landowner, any purchaser of the land under a real estate contract, and the operator and, if any of these are corporations or other business entities, the names and addresses of their principal officers and resident agent for service of process;

(2) Materials to be surface mined;

(3) Type of surface mining to be performed;

(4) Expected starting date of surface mining;

(5) Anticipated termination date of the surface mining project;

(6) Expected amount of mineral to be surface mined;

(7) Maximum depth of surface mining;

(8) Size and legal description of the area that will be disturbed by surface mining. If more than ten acres will be disturbed by surface mining or, regardless of the amount of land to be disturbed, if the department finds that conditions warrant it and so requests, a map of the area to be surface mined shall be submitted. The map shall show the boundaries of the area of land which will be affected; topographic detail; the location and names of all streams, roads, railroads, and utility lines on or immediately adjacent to the area; location of proposed access roads to be built in conjunction with the surface mining operation; and the names of the surface and mineral owners of all lands within the surface mining area;

(9) A plan of surface mining that will provide, within limits of normal operational procedure of the industry, for completion of surface mining and associated disturbances on each segment of the area for which a permit is requested so that reclamation can be initiated at the earliest possible time on those portions of the surface mined area that will not be subject to further disturbance by the mining operation. Whenever feasible, visual screening, vegetative or otherwise, will be maintained or established on the property containing the surface mining to screen the view of the operation from public highways, public parks, and residential areas.

(10) A reclamation plan that must be acceptable to and approved by the department, except as provided in RCW 78.44.100. An operator may not depart from an approved plan without having previously obtained from the department written approval of his proposed change.

The department may adopt rules and regulations permitting an operator of more than one surface mining operation to submit a single application for a combined operating permit covering all of his surface mining operations. Such application may require detailing of information required by this section for each separate location. An operator operating under such a combined permit may submit a consolidated reclamation program covering all his operations under rules and regulations prescribed by the department, but may be required to furnish specific information relative to reclamation of any single operating area if the department determines that such is necessary to carry out the purposes of this chapter. [1970 ex.s. c 64 § 9.]

78.44.090 Reclamation plans. The reclamation plan shall provide that reclamation activities, particularly those relating to control of erosion, shall, to the extent feasible, be conducted simultaneously with surface mining and in any case shall be initiated at the earliest possible time after completion or abandonment of mining on any segment of the permit area. The plan shall provide that reclamation activities shall be completed not more than two years after completion or abandonment of surface mining on each segment of the area for which a permit is requested.

A reclamation plan will be approved by the department if it adequately provides for the accomplishment of the activities specified in the definition of "reclamation plan", RCW 78.44.030(11), and meets those of the following minimum standards that are applicable:

(1) Excavations made to a depth not less than two feet below the low groundwater mark, which will result in the establishment of a lake of sufficient area and depth of water to be useful for residential, recreational, game, or wildlife purposes, shall be reclaimed in the following manner:

(a) All banks in soil, sand, gravel, and other unconsolidated materials shall be sloped to two feet below the low groundwater line at a slope no steeper than one and one–half feet horizontal to one foot vertical;

(b) Portions of solid rock banks shall be stepped or other measures be taken to permit a person to escape from the water.

(2) In all other excavations in soil, sand, gravel, and other unconsolidated materials, the side slopes and the slopes between successive benches shall be no steeper than one and one-half feet horizontal to one foot vertical for their entire length.

(3) The sides of all strip pits and open pits in rock and other consolidated materials shall be no steeper than one foot horizontal to one foot vertical, or other precautions must be taken to provide adequate safety.

(4) The slopes of quarry walls in rock or other consolidated materials shall have no prescribed angle of slope, but where a hazardous condition is created that is not indigenous to the immediate area, the quarry shall be either graded or backfilled to a slope of one foot horizontal to one foot vertical or other precautions must be taken to provide adequate safety.

(5) In strip mining operations the peaks and depressions of the spoil banks shall be reduced to a gently rolling topography which will minimize erosion and which will be in substantial conformity with the immediately surrounding land area.

(6) In no event shall any provision of this section be construed to allow stagnant water to collect or remain on the surface mined area. Suitable drainage systems shall be constructed or installed to avoid such conditions if natural drainage is not possible.

(7) All grading and backfilling shall be made with nonnoxious, nonflammable, noncombustible solids unless approval has been granted by the director for a supervised sanitary fill.

(8) In all types of surface mining, in order to prevent water pollution, all acid-forming surface mining refuse shall be disposed of by covering all acid-forming materials with at least two feet of clean fill. The final surface covering shall be graded so that surface water will drain away from the disposal area.

(9) Vegetative cover will be required in the reclamation plan as appropriate to the future use of the land.

(10) All surface mining that will disturb streams must comply with the requirements of the state fisheries laws (Title 75 RCW), and every application for an operating permit for such operations must have a reclamation plan that shall have been approved by the department of fisheries with regard to operations in streams as required by Title 75 RCW. [1970 ex.s. c 64 § 10.]

78.44.100 Inspections——Provisional permits——Duration of operating permits——Modification of reclamation plan——Successor operators. Upon receipt of an application for a permit, the surface mining site must be inspected by a representative of the department. Within twenty-five days of receipt of the application and reclamation plan by the department and receipt of the permit fee, the department shall either issue an operating permit to the applicant or return any incomplete or inadequate application to the applicant along with a description of the deficiencies.

Failure to act within the twenty-five day period on the reclamation plan shall not be cause for a denial of a permit. The department shall set the amount of the bond or other security required for a provisional permit governing the surface mining operation set forth in the application. A provisional permit shall be granted pursuant to conditions prescribed by the department until a plan is approved as long as the operator complies with the bond or security requirements established by the department: *Provided, however,* That a provisional permit shall not be granted if the department considers the site unsuitable for surface mining.

If the department refuses to approve a reclamation plan in the form submitted by the operator, it shall notify the operator, in writing, stating the reasons for its refusal and listing such additional requirements to the operator's reclamation plan as are necessary for the approval of the plan by the department. Within thirty days, the operator shall either accept such additional requirements as part of the reclamation plan or file notice of appeal. If notice of appeal is filed by the operator, a provisional permit shall be granted as herein specified.

The operating permit shall be granted for the period required to mine the land covered by the plan and shall be valid until the surface mining authorized by the permit is completed or abandoned, unless the permit is suspended by the department as provided in this chapter. The operating permit shall provide that the reclamation plan may be modified, after timely notice and opportunity for hearing, at any time during the term of the permit for any of the following reasons:

(1) To modify the requirements so that they will not conflict with existing laws;

(2) The department determines that the previously adopted reclamation plan is clearly impossible or impracticable to implement and maintain;

(3) The department determines that the previously adopted reclamation plan is obviously not accomplishing the intent of this chapter; or

(4) The operator and the department mutually agree to change the reclamation plan.

When one operator succeeds to the interest of another in any uncompleted surface mining operation by sale, assignment, lease, or otherwise, the department may release the first operator from the duties imposed upon him by this chapter as to such operation: *Provided,* That both operators have complied with the requirements of this chapter and the successor operator assumes the duty of the former operator to complete the reclamation of the land, in which case the department shall transfer the permit to the successor operator upon approval of the successor operator's bond as required under this chapter. [1970 ex.s. c 64 § 11.]

78.44.110 Fees. The permit fees required under this chapter shall be as follows:

(1) The basic fee for the permit shall be twenty-five dollars per permit year for each separate location, payable with submission of the application and annually thereafter with submission of the report required in RCW 78.44.130.

(2) In addition, there shall be a five dollar per acre fee for all acreage exceeding ten acres which was newly disturbed by surface mining during the previous permit

year, which acreage fee shall be paid at the time of submission of the report required in RCW 78.44.130. [1970 ex.s. c 64 § 12.]

78.44.120 Performance bonds and other security. Upon receipt of an operating permit an operator other than a public or governmental agency shall not commence surface mining until the operator has deposited with the department an acceptable performance bond on forms prescribed and furnished by the department. This performance bond shall be a corporate surety bond executed in favor of the department by a corporation authorized to do business in the state of Washington under the provisions of chapter 48.28 RCW and approved by the department. The bond shall be filed and maintained in an amount equal to the estimated cost of completing the reclamation plan for the area to be surface mined during the next twelve-month period and any previously surface mined area for which a permit has been issued and on which the reclamation has not been satisfactorily completed and approved. If an operator increases the area to be surface mined during the twelve month period, the department may increase the amount of the bond to compensate for the increase. The department shall have the authority to determine the amount of the bond that shall be required, and for any reason may refuse any bond not deemed adequate. In no case shall the amount of the bond be less than one hundred dollars or more than two thousand five hundred dollars per acre or fraction thereof.

The bond shall be conditioned upon the faithful performance of the requirements set forth in this chapter and of the rules and regulations adopted pursuant thereto.

In lieu of the surety bond required by this section the operator may file with the department a cash deposit, negotiable securities acceptable to the department, or an assignment of a savings account or of a savings certificate in a Washington bank on an assignment form prescribed by the department.

Liability under the bond shall be maintained as long as reclamation is not completed in compliance with the approved reclamation plan unless released prior thereto as hereinafter provided. Liability under the bond may be released only upon written notification from the department. Notification shall be given upon completion of compliance or acceptance by the department of a substitute bond. In no event shall the liability of the surety exceed the amount of the surety bond required by this section.

A public or governmental agency shall not be required to post a bond under the terms of this chapter.

A blanket performance bond covering two or more surface mining operations may be submitted by an operator in lieu of separate bonds for each separate operation. [1977 c 66 § 1; 1970 ex.s. c 64 § 13.]

78.44.130 Reports. Within thirty days after completion or abandonment of mining on an area under permit or within thirty days after each annual anniversary date of the operating permit, whichever is earlier, or at such later date as may be provided by department rules and regulations, and each year thereafter until reclamation is completed and approved, the operator shall file a report of activities completed during the preceding year on a form prescribed by the department, which report shall:

(1) Identify the operator and permit number;

(2) Locate the operation by subdivision, section, township, and range, and with relation to the nearest town or other well known geographic feature;

(3) Estimate acreage to be newly disturbed by surface mining in the next twelve-month period; and

(4) Update any maps previously submitted or provide such maps as may be specifically requested by the department. Such maps shall show:

(a) The operating permit area;

(b) The unit of surface mined area;

(c) The area to be surface mined during the next twelve-month period;

(d) If completed, the date of completion of surface mining;

(e) If not completed, the area that will not be further disturbed by the mining operations; and

(f) The date of beginning, amount, and current status of reclamation performed during the previous twelve months. An operator operating under a combined operating permit may submit a single annual report, but such report shall include the data required in this section for each separate operating area. [1970 ex.s. c 64 § 14.]

78.44.140 Inspection of permit area——Deficiencies——Extension of performance periods——Performance actions by department——Recovery of expenses——Enforcement. Upon receipt of the operator's report, and at any other reasonable time the department may elect, the department shall cause the permit area to be inspected to determine if the operator has complied with the reclamation plan and the department's rules and regulations.

The operator shall proceed with reclamation as scheduled in his reclamation plan. Following any written notice by the department noting deficiencies, the operator shall commence action within thirty days to rectify these deficiencies and shall diligently proceed until the deficiencies are corrected: *Provided*, That deficiencies that also violate other laws that require earlier rectification shall be corrected in accordance with the applicable time provisions of such laws. The department may extend performance periods referred to in this section and in RCW 78.44.090, for delays clearly beyond the operator's control, but only when the operator is, in the opinion of the department, making every reasonable effort to comply.

Within thirty days after notification by the operator and when in the judgment of the department reclamation of a unit of surface mined area is properly completed, the mining operator shall be notified in writing and his bond on said area shall be released or decreased proportionately.

If reclamation of surface mined land is not proceeding in accordance with the reclamation plan and the operator has not commenced action to rectify deficiencies within thirty days after notification by the department, or if reclamation is not properly completed in conformance with the reclamation plan within two years after completion or abandonment of surface mining on any segment of the permit area, the department is authorized, with the staff, equipment and material under his control, or by contract with others, to take such actions as are necessary for the reclamation of the surface mined areas. The department shall keep a record of all necessary expenses incurred in carrying out any project or activity authorized under this section, including a reasonable charge for the services performed by the state's personnel and the state's equipment and materials utilized.

The department shall notify the operator and his surety by order. The order shall state the amount of necessary expenses incurred by the department in reclaiming the surface mined land and a notice that the amount is due and payable to the department by the operator and the surety.

If the amount specified in the order is not paid within thirty days after receipt of the notice, the attorney general, upon request of the department, shall bring an action on behalf of the state in the superior court for Thurston county or any county in which the persons to whom the order is directed do business to recover the amount specified in the final order of the department. The surety shall be liable to the state to the extent of the bond.

The amount owed the department by the operator for the reclamation performed by the state may be recovered by a lien against the reclaimed property, which may be enforced in the same manner and with the same effect as a mechanic's lien.

In addition to the other liabilities imposed by this chapter, failure to commence action to rectify deficiencies in reclamation within thirty days after notification by the department or failure satisfactorily to complete reclamation work on any segment of the permit area within two years after completion or abandonment of surface mining on any segment of the permit area shall constitute sufficient grounds for cancellation of a permit and refusal to issue another permit to the delinquent operator until such deficiencies are corrected by the operator. [1970 ex.s. c 64 § 15.]

78.44.150 Operating without permit——Penalty. Any operator conducting surface mining within the state of Washington without a valid operating permit shall be guilty of a gross misdemeanor. Each day of operation shall constitute a separate offense. [1970 ex.s. c 64 § 16.]

78.44.160 Enjoining or stopping illegal operations. When the department finds that an operator is conducting surface mining on an area for which a valid operating permit is not in effect, or is conducting surface mining in any manner not authorized by his operating permit or by the rules and regulations adopted by the department, the department may forthwith order such operator to suspend all such operations until compliance is effected or assured to the satisfaction of the department. In the event the operator fails or declines to obey such order, the facts may be reported by the department to the attorney general. The attorney general shall forthwith take the necessary legal action to enjoin, or otherwise cause to be stopped, such conduct of surface mining. [1970 ex.s. c 64 § 17.]

78.44.170 Appeals. Appeals from determinations made under this chapter shall be made under the provisions of the administrative procedure act (chapter 34.04 RCW), as now or hereafter amended and shall be considered a contested case within the meaning of the administrative procedure act (chapter 34.04 RCW). [1970 ex.s. c 64 § 18.]

78.44.180 Confidentiality. All reclamation plans, operators' reports and other required information under this chapter shall be for the confidential use of the department which shall by rule or regulation provide for the release thereof to proper interested persons. [1970 ex.s. c 64 § 20.]

78.44.900 Existing operations——Temporary permits. Operators of surface mines in operation on January 1, 1971 shall have ninety days thereafter to submit an application for an operating permit. Any such operator who has timely filed an application for an operating permit but for reasons beyond his control has neither received an operating permit nor had his application denied within twenty-five days after his application has been submitted as provided in RCW 78.44.080, shall have issued to him by the department a temporary operating permit, which, if the applicant is diligently pursuing his application, shall be effective until a regular operating permit is either issued or denied. [1970 ex.s. c 64 § 19.]

78.44.910 Previously mined land. This act shall not direct itself to the reclamation of land mined prior to January 1, 1971. [1970 ex.s. c 64 § 22.]

78.44.920 Effective date——1970 ex.s. c 64. This act shall become effective January 1, 1971. [1970 ex.s. c 64 § 23.]

78.44.930 Severability——1970 ex.s. c 64. If any provision of this act or its application to any person or circumstance is held invalid, the remainder of the act or the application of the provision to other persons or circumstances shall not be affected. [1970 ex.s. c 64 § 24.]

APPENDIX C-2

INDUSTRIAL MINERALS INC.
P.O. BOX 95
RAVENSDALE, WN 98051
GE 2-0655

March 30, 1971

State of Washington
Department of Natural Resources
Enumclaw, Washington 98022

re: Surface Mining Operating
Permit 10346

Gentlemen:

Smith Bros., Silica Sand Co. Inc., hereby makes application for a Surface Mining Operating Permit as required by the Surface Mining Reclamation Act. This application is being submitted by Industrial Minerals Inc., the operating company for Smith Bros. Silica Sand Co., Inc. Attached to this letter is a report on the property being mined. The enclosed map is a copy of one which was submitted with our application for a King County Grading permit. Because of poor weather conditions we have not been able to remap the area in time for this application. A copy of the new map will be submitted when this work is completed.

Please address all correspondence to the above letterhead address.

Very truly yours

A. B. Berg

A. B. Berg
President

ABB:ab
Enc.

APPENDIX C-2

RECEIVED
APR 8 1971
COMMISSIONER OF PUBLIC LANDS
No.________________

Route 3, Box 596A
Enumclaw, Washington 98022

April 7, 1971

Mr. A. B. Berg
Smith Bros. Silica Sand Co., Inc.
P. O. Box 95
Ravensdale, Wa. 98051

Dear Sir:

Find enclosed your application for operating permit, SM-2; attached letters and plats and SM-6 County recommendations Surface mining.

After conversation Monday, April 5, with Mr. Dick Rector of the Burlington Northern Railway Co., he decided that the proposed use of the land after mining would be to restore it to a natural condition and conforming to the requirement of a 1½ to 1 backslope on all excavations. If you have any questions about this, please call Mr. Rector at Burlington Northern's Seattle office at MA3-5560, which is 650 Central Bldg., Seattle.

Very truly yours,

BERT L. COLE
Commissioner of Public Lands

By ________________
Tom M. Anderson, Jr.
District Administrator

TMA:mw
cc: Don Ford
Stratton
Files
Encl.

10346
10346

APPENDIX C-3

Smith Bros. Silica Sand Co., Inc.

Report for Surface Mining Operating Permit

INTRODUCTION

Smith Bros. Silica Sand Co., Inc., has been mining and processing sand used in the manufacturing of glass since the early 1930's. In 1968, the plant was moved to its present site near Ravensdale and a new mine located approximately one-half mile south of the plant was opened.

The raw material occurs as a quartz-rich clay cemented sandstone which is unique in the several thousand feet of sediments in the Puget Sound trough. Mining, therefore, is limited to the areas which are underlain by this sandstone and which are physically and economically feasible to operate under the conditions of an expanding urban development. The location of the mine is situated in such an area.

location and geography:

The area to be included in the permit lies approximately one-half mile south of Ravensdale in the NW$\frac{1}{4}$ and the N$\frac{1}{2}$SW$\frac{1}{4}$ of sec 1 21N 6E, and the S$\frac{1}{2}$SW$\frac{1}{4}$ of sec 36 22N 6E W.M. King County, Washington. The plant site is situated in the NW$\frac{1}{4}$SW$\frac{1}{4}$ of sec 36 and is bounded on the northwest by the mainline of the Burlington Northern and on the southeast by the Black Diamond- Ravensdale Road. The official address of the plant is 26000 Black Diamond-Ravensdale Road.

The mine area is on the west flank of a topographic high known locally as Ravensdale Hill and is in the same area as the Dale coal mine, one of several in the area which was worked until about 1947. The area has been logged although thick stands of alder and vine maple shield the mine from view. The corridor of the BPA power line R/W offers the only indication that activity is present on the hill.

The southern part of the mine has a thin soil developed from the bedrock; the northern part and scattered areas are covered by glacial till and stratified drift. No natural drainages are evident as the runoff from the hill permeates the glacial gravels.

zoning and existing permits:

The land occupied by the mine and the plant is held in fee title (surface and mineral) by the Burlington Northern. The right to mine, remove, process and sell silica sand and related nonmetalic minerals was granted Smith Bros. Silica Sand Co. Inc., under T&M Contract No. 4489 dated July 1, 1967, for the period of twenty years. Under the terms of this contract, the operator is required to comply with the QM reclamation clauses of the King County zoning code.

#10346

A Special Permit No. ZA 67-18 within RA zoning was granted the Northern Pacific Ry Co. (now the Burlington Northern) for Smith Bros. This permit is also for a period of twenty years. A reclamation clause and performance bond are included in the permit. A copy of the bond is enclosed. The bond is in the name of the land owner but is covered by a bond from Smith Bros.

A surface water permit No. 15096, certificate No. 11039, was obtained from the Department of Water Resources. A waste discharge permit No. 2945 was obtained from the Water Pollution Control Commission.

We are registered and have received a permit to construct dust control devices from the Puget Sound Air Pollution Control Agency. This equipment is installed.

We have applied for a King County Grading permit which is now being processed.

GEOLOGY

The sequence of non-marine sedimentary rocks underlying the mine area is of Eocene age and occupies approximately 750 feet in the upper part of the Franklin coal zone of the Puget Group. Three major quartz-rich sandstone beds, 100 to 200 feet thick, are separated by two clay units with intercalated thin-bedded sandstones which are 100 to 150 feet thick. This sequence of rocks which lie between the Dale no. 7 coal bed (correlative to the Gem) and the Kummer sandstone is involved in a somewhat shallow westward plunging syncline. This flexure represents one of two major periods of folding in Eocene time. The beds in the north limb strike approximately N30W and dip 50 to 70° west; the south limb strikes N40E and dips 65 to 80° westward.

The continuity of the beds is abruptly cut off by northwest-southeast trending faults near the north and south lines of section 1. North of here the structure of the beds is exceedingly complex being broken up by folding and faulting although within the mine area no displacement has been seen. The mine is further divided into two sections by the BPA power line R/W which trends east-west through the N½ of section 1.

MINING METHODS

The uppermost stratigraphic sandstone is the lowermost topographic unit exposed near the base of the west sloping flank of the hill. That section of sandstone between the power line and the north fault is the segment which is now being mined. Approximately 60,000 to 70,000 cubic yards of material are mined yearly. The mine is developed along strike and across the full width of the sandstone. The entire strike-length from the power line to the fault, which represents an area of about 5 acres, is mined in one continuous operation. This is to maintain adequate drainage on the floor of the mine. As mining progresses the floor is lowered by benches, maintaining the drainage slope.

The depth to which the sandstone can be mined is dictated by physical and economic conditions as well as the chemical composition. These sandstone units have a certain amount of syngenetic (?) siderite-anchorite minerals present. We cannot beneficiate the siderite in our washing process and therefore are limited to the units in which the siderite has altered to goethite-hematite minerals. This is usually in the oxidation zone but it is questionable whether this is controlled mainly by the present or recent zone or an ancient one. Samples from drill hole cuttings indicate the oxidation zone is at least 60 feet deep.

We have not enough information to determine whether the next phase of the mining will proceed to the middle sandstone unit of the northern section or continue along the lower sandstone south of the power line. Further exploration work to be conducted in the near future and the economics of the adjacent clay beds will govern this.

RECLAMATION

The attitude of the sandstone which best resists erosion and which is more stable to resist mass movement during the mining period is one which maintains the slope parallel to the bedding plane or in a nearly vertical position. This is simply because the sandstone is susceptible to gullying. This was evident prior to our mining operation on the access roads along the contours of the hill where they would be blocked by debris washed down by the runoff. By constructing ditches running normal to the runoff much of the water is intercepted and rapid erosion is controlled.

In our reclamation program by which we will fill the mined out areas with material from the intervening beds and overburden we do not intend to leave vertical slopes but grade to conform with adjacent physiographic features. In order to control erosion from runoff it will necessitate the construction of ditches across the slope. Where these ditches will be placed will depend on the amount of material removed. The backfilling will be done as we proceed from one sandstone to another. There is one complication which may affect the timing of the backfilling. The interstratified clay beds could be of economic value. At least two companies are sampling and testing to explore this possibility. In any event this will not affect the final outcome of the reclamation work. It will only mean that the reclaimed slope will have a lower angle.

The use for which this land will be put after the mining has been completed has been discussed with the landowner and because the term of the mine is for several years it is difficult to speculate what program of development would be suitable at that time. The land has no use now other than mining being broken up by power lines and coal mines. The only answer is that future use will be compatible with existing uses and will not conflict with zoning regulations.

STATE OF WASHINGTON
Department of
Natural Resources

COMMISSIO
BERT COL

DON LEE FRAS
SUPERVISOR

28329 SE 448th Street
Enumclaw, Washington 98022

RECEIVED
MAR 29 1977
COMMISSIONER OF PUBLIC LANDS

March 25, 1977

Industrial Mineral Products, Inc.
P.O. Box 95
Ravensdale, Wa. 98051

Attn: A.D. Berg

Dear Mr. Berg:

On March 4, 1977, an annual inspection was made of your surface mining site near Ravensdale. Several deficiencies in your operation were discovered during this inspection.

A slump in the lower mine has damaged approximately 100 feet of fence. Apparently the slump occurred during the winter of 1975 and the fence has not been repaired yet.

The slump also displaced water in the mine floor causing a tremendous surge of water to flow out, damaging the drainage ditch and eroding some of the stockpiled material; at the present time this drainage system is non-functional.

The drainage system for the mine, under the powerlines in the southwest portion of the operation, is inadequate. If you intend to continue pumping water from the bottom of this pit area, adequate settling basins must be constructed to allow the suspended material to settle out of the discharge.

Your land status maps indicate that you will have 7.5 acres under mining and 8.3 acres under clearing. During our inspection, we found that 1.5 acres designated as clearing were actually mining acres. Therefore, a more accurate acreage would be 9 acres under mining and 6.8 acres clearing.

From our inspection we have determined that $12,250.00 bond will be required for the 21.5 acres which has been disturbed by your mining operation.

10346

APPENDIX C-4

You are currently bonded for $12,000 which, at this time, is inadequate. Rather than increase your bond to cover the additional $250, you may reclaim the 1.5 acres under the powerline which is being used as a spoils area. As per our conversation on March 7, 1977, I am sure this can be accomplished in a day or less. It will be necessary for you to level the piles out and ditch along both sides of the road for drainage. This should be accomplished before the next inspection which is scheduled for August.

Future operations on the permit site depends upon your cooperation in correcting the deficiencies. If there are any questions, please contact our Area office in Enumclaw at 825-1631.

Very truly yours,

BERT L. COLE
Commissioner of Public Lands

Fred C. Hart, Area Manager

Ben R. Cleveland

Ben R. Cleveland
Tech II - Blk. Diamond Unit

BRC/mc
cc: Geology
f~~ile #10326~~
#10346

APPENDIX C-4

COPY

28329 SE 448th Street
Enumclaw, Washington 98022
December 20, 1973

10346

Industrial Minerals Products, Inc.
P.O. Box 236
Auburn, Wa. 98002

Attention: Mr. George Prater

RE: Surface Mining Permit #10326

Gentlemen:

On November 29, 1973, an annual inspection was made of your surface mining site near Ravensdale. Several gross deficiencies in your operation were discovered during this inspection.

The existence of a nearly vertical wall in your pit area may reduce erosion of the exposed mineral surface but clearly does not follow the intent of the surface mining laws in preventing undesirable land conditions detrimental to the health and safety of the citizens of the state. If the nearly vertical slopes are to be maintained during your operations, a servicable fence consisting of three (3) strands of barbed wire strung on metal fence posts must be maintained on the undisturbed land above the exposed mineral face and no closer than fifty (50) feet to the upper edge of the cut slope. The fence must be of sufficient length to limit access to the top of the cut slope and must be moved back as the slope is worked to maintain its effectiveness.

Maintenance of a 1½:1 slope on all of the working faces of the pit would preclude the need for fencing but would necessitate the construction of an adequate drainage facility to prevent water from collecting in the bottom of the pit and forming a deep lake.

Drainage conditions as they presently exist are totally inadequate. Natural runoff is currently channeled across the northwest corner of the pit access area then allowed to run freely across the spoils area and off into a natural water course. This runoff is carrying suspended material eroded from the disturbed mining area and must be remedied by construction of adequate settling basins. Spillways of the basins must be adequately constructed to prevent erosion of the spillway.

APPENDIX C-4

If water is to continue to be pumped from the bottom of the pit area, adequate settling basins must be constructed to allow the suspended material to settle out of the discharge.

The inspection also revealed that your operation has expanded into the southeast part of your permit area. Runoff in this newly exposed area must also be contained in an adequate series of settling basins.

It is also apparent that continued expansion of the pit beneath the powerline will not allow this particular area to be reclaimed in accordance with your reclamation plan without undermining a powerline tower.

With the present expansion of your operations and the need for the construction of adequate settling basins, your present bond is inadequate to sustain operations any longer. Due to the extent of operations under this permit we will hereinafter require that a twelve (12) month operating plan be submitted each year.

In reviewing the deficiencies noted and the needed increase in bonding, we would appreciate meeting with you to discuss the situation in detail. We will expect to hear from you within ten (10) days to establish a meeting date.

Future operations on the permit site depends upon the correction of the deficiencies and an increased bond to cover the operation.

COPY

Very truly yours,

BERT L. COLE
Commissioner of Public Lands

by Charles H Neth
Charles H. Neth
Area Manager

Don Clift/mc
Enumclaw Local Manager

cc: Don Ford - Mines & Geology
cc: Milt Lechalt - King County Bldg. Dept.
cc: Carl F. Robinson - Dist. Mining Geologist
Tickler - 1-2-74

GRADING PERMIT RENEWAL APF 'CATION

BUILDING & LAND DEVELOPMENT DIVISION
KING COUNTY, WASHINGTON

this block for staff use only

GRADING FILE NO. 1122-58
ISSUE DATE:
RENEWAL EXPIRATION: [illegible]
Sec.,T.,R.: 1-21-6
Zoning: QM
PROJECT NAME: Ravensdale Sand Pit
PROJECT LOCATION: 26000 Block Diamond-Ravensdale Hwy.
Received by:
Date:

BONDS

	yes	no	amount
Operating	(✓)	( )	$ 500.00
Landscape	( )	( )	$
Performance	( )	( )	$
Rehabilitation	( )	( )	$ 5000.00
S.M. Bond	(✓)		20,000.00

FEES

	yes	no	amount
Plan Review	( )	(✓)	$ [illegible]
Operating Acreage	( )	(✓)	$ [illegible]
Yardage	(x)	( )	$ [illegible]
TOTAL:			$ [illegible]

THIS APPLICATION BECOMES THE PE
WHEN APPROVED, SIGNED AND STAMP

APPROVED subject to conditi
of approval attached hereto
and supplemental sheet when
necessary.

BUILDING & LAND DEVELOPMENT
King County, Washington
by:
date:

I certify that the information fu for this permit is true and corre I guarantee that applicable King Ordinances and operating conditic be my responsibility and violatic of will be cause for code enforce action, and I fully understand th work can continue beyond the expi of this permit without first secu new permit.

date: [illegible]

APPLICANT: complete the following items only

Total size in acres of site: AREA UNDER LEASE APPROXIMATELY
Total amount of material in cubic yards to be moved: 100,000
Number of acres open and not rehabilitated during next 24 months: 37.6
Cubic yards to be filled or excavated during next 24 months: 100,000
Number of acres to be rehabilitated during next 24 months: [illegible]

If this permit is for work to be done in conjunction with any of the follow please check and note file number.

Unclassified Use Permit	(X)	File # [illegible]
Subdivision	( )	File #
Planned Unit Development	( )	File #
Shoreline Management Permit	( )	File #
Building Permit	( )	File #

APPLICANT: INDUSTRIAL MINERAL PRODUCTS
ADDRESS: P.O. BOX 95
CITY/STATE/ZIP: RAVENSDALE, WA 98051
TELEPHONE: 432-1286

OWNER: BURLINGTON NORTHERN RAILROAD
ADDRESS: 650 CENTRAL BLDG.
CITY/STATE/ZIP: SEATTLE, WA 98104
TELEPHONE: 625-6159

Relationship of applicant to property:

- ( ) owner
- ( ) contractor
- (X) lessee
- ( ) other

A COPY OF PERMIT CONDITIONS AND A SET OF THE APPROVED PLANS MUST BE ON THE SITE AT ALL TIMES DURING CONSTRUCTION.

F-200 - (d)
rev. 3/81

APPENDIX C-5

GRADING PERMIT CONDITIONS OF APPROVAL

Grading File No.: 1122-58

Applicant's Name: Industrial Mineral Products, Inc.
(Ravensdale Pit)

In acceptance of this Grading permit the applicant does hereby acknowledge that failure to comply with all the conditions set forth herein shall necessitate an immediate work stoppage until such time as compliance with the stipulated conditions is attained. Additionally, the granting of this permit should not be construed as satisfying the requirements of any other Federal, State an local permits or authorizations. The operation to be undertaken through this Grading Permit shal be conducted in accordance with the following conditions:

A. STANDARD CONDITIONS OF APPROVAL.

1. No external signs shall be permitted except those authorized by the King County Zoning Code or as required by this permit.

2. Hours of operation shall be limited to 7^{00} a.m. to 7^{00} p.m., Monday throug Friday.

3. As a measure to minimize problems of dust, mud and traffic circulation, on-site access roads shall be located and maintained to the satisfaction of the King County Department of Public Works.

4. The permittee shall maintain a liability policy in the amount of $100,000.00 per individu $300,000.00 per occurrence and $50,000.00 property damage naming King County as an additional insured. The additional insured clause must read: *"It is hereby understood and agreed that King County, its appointed and elected officials and employees, while acting within the scope of their duties as suc is named as an additional insured."* No other wording will be accepted.

5. The permittee shall abide by the regulations of the Puget Sound Air Pollution Control Age

6. The permittee shall abide by the provisions of King County Ordinance #3139 relating to nc control.

7. Temporary settling ponds must be constructed in accordance with King County Ordinance #2 Chapter 20.50 K.C.C.

8. If at any time truck traffic generated by this grading operation interferes with normal traffic flows within the immediate area, flag men shall be required.

9. The permittee shall notify the Building & Land Development Division 48 hours prior to the commencement of grading activities (206) 344-7900 Grading Section.

10. Any structures on filled areas shall comply with the conditions of the Uniform Building Code relating to the placement of building foundations.

B. CONDITIONS PURSUANT TO K.C.C. 16.82.100 and 16.82.110:

16.82.100 Operating conditions and standards of performance. Cuts and fills shall conform tc the provisions of this section unless otherwise approved by the director.

(1) SLOPE. No slope of cut and fill surfaces shall be steeper than is safe for the intended use and shall not exceed two horizontal to one vertical, unless otherwise approved by the director.

(2) EROSION CONTROL.. All disturbed areas including faces of cuts and fill slopes shall be prepared and maintained to control erosion. This control may consist of effective planting. The protection for these areas shall be installed as soon as practical and prior to bond release. Where areas are not subject to erosion, as determined by the director, such protection may be omitted.

(3) PREPARATION OF GROUND. The ground surface shall be prepared to receive fill by removing unsuitable material such as concrete slabs, tree stumps, brush and car bodies.

(4) FILL MATERIAL. Except in an approved sanitary landfill, only earth materials which have no rock or similar irreducible material with a maximum dimension greater than eighteen inche shall be used.

(5) DRAINAGE. Provisions shall be made to:
(a) Prevent any surface water or seepage from damaging the cut face of any excavations o the sloping face of a fill;
(b) Carry any surface waters that are or might be concentrated as a result of a fill or excavation to a natural watercourse, or by other means approved by the Department of Public Works;
(c) Prevent any sediment from leaving the site.

(6) BENCH/TERRACE. Benches, if required, at least ten feet in width shall be back-sloped ar shall be established at not more than twenty-five feet vertical intervals to control surface drainage and debris. Swales or ditches on benches shall have a maximum gradient of five percent.

(7) ACCESS ROADS - MAINTENANCE. Access roads to grading sites shall be maintained and locat to the satisfaction of the King County Department of Public Works to minimize problems of du mud and traffic circulation.

(8) ACCESS ROADS - GATE. Access roads to grading sites shall be controlled by a gate when required by the director.

APPENDIX C-5

(9) WARNING SIGNS. Signs warning of hazardous conditions, if such exist, shall be affixed · ~~locations as required by the director~~.

(10) FENCING. Fencing, where required by the director, to protect life, limb and property shall be installed with lockable gates which must be closed and locked when not working the site. The fence must be no less than five feet in height and the fence material shall have horizontal opening larger than two inches.

(11) SETBACKS. The tops and the toes of cut and fill slopes shall be set back from property boundaries as far as necessary for safety of the adjacent properties and to prevent damage resulting from water runoff or erosion of the slopes.

The tops and toes of cut and fill slopes shall be set back from structures as far as is necessary for adequacy of foundation support and to prevent damage as a result of water runo or erosion of the slopes.

Slopes and setbacks shall be determined by the director.

~~(12) EXCAVATIONS TO WATER PRODUCING DEPTH. All excavations must either be made to a water-producing depth or grade to permit natural drainage. The excavations made to a water-produc depth shall be reclaimed in the following manner:~~

~~(a) The depth of the excavations must not be less than two feet measured below the low-water mark.~~
~~(b) All banks shall be sloped to the water line no steeper than three feet horizontal to one foot vertical.~~
~~(c) All banks shall be sloped from the low water line into the pond or lake with a minim slope of three feet horizontal to one foot vertical to a distance of at least twenty-five fe~~
~~(d) In no event shall the term water-producing depth as herein used be construed to allow stagnant or standing water to collect or remain in the excavation.~~
~~(e) The intent of this provision is to allow reclamation of the land which will result ir the establishment of a lake of sufficient area and depth of water to be useful for residenti or recreational purposes.~~

(13) HOURS OF OPERATION. Hours of operation, unless otherwise authorized by the director, sha be between seven a.m. and seven p.m.

16.82.110 LAND RESTORATION.

(1) Upon the exhaustion of minerals or materials or upon the permanent abandonment of the quarrying or mining operation, all nonconforming buildings, structures, apparatus or appurtenances accessory to the quarrying and mining operation shall be removed or otherwise dismantled to the satisfaction of the director. This requirement shall not require land restoration on projects completed prior to January 1, 1971, except those covered under previously existing zoning requirements.

(2) Final grades shall be such so as to encourage the uses permitted within the underlying zc classification.

(3) Grading or backfilling shall be made with nonnoxious, nonflammable, noncombustible and nc putrescible solids.

(4) Such graded or backfilled areas, except for roads, shall be sodded or surfaced with soil a quality at least equal to the topsoil of the land areas immediately surrounding, and to a depth of at least four inches or a depth of that of the topsoil of land areas immediately sur rounding if less than four inches.

(5) Such topsoil as required by subdivision (4) shall be planted with trees, shrubs, legumes grasses, and said flora shall be so selected as to be indigenous to the surrounding area.

(6) Graded or backfilled areas shall be reclaimed in a manner which will not allow water to collect and permit stagnant water to remain. Suitable drainage systems approved by the Department of Public Works shall be constructed or installed if natural drainage is not possi

(7) Waste or soil piles shall be leveled and the area treated as to sodding or surfacing and planting as required in subdivisions (4) and (5) of this section.

C. ADDITIONAL CONDITIONS listed hereafter and/or on supplemental sheet attached.

(1) No filling of cement fly ash shall be permitted on the site until, and unless, approv by the King County Dept. of Health thru the issuance of a Solid Waste Disposal P

(2) The issuance of this permit does not preclude the owners from having to obtai other required Federal, State, & local permits or authorizations.

(3) ______

(4) ______

(5) ______

Grading Permit and conditions of approval accep and received by:

name date

GRADING TECHNICAL COMMITTEE:

GRADING, Building & Land Development Division

SEPA, Building & Land Development Division

P-Suffix; Zoning-Building & Land Development

TRAFFIC DIVISION, Department of Public Works

HYDRAULICS DIVISION, Department of Public Works

Planning Division, Dept. Plan. & Com. Dev.

APPENDIX C-6

State of
Washington
Department
of Ecology

APPLICATION FOR DISPOSAL SITE PERMIT

PART I (All Sites)

1. Name of Site Ravensdale Silica Sand Mine
2. Address 26000 Black Diamond-Ravensdale Highway (½ mile west of Ravensdale, ½ mile south of Ravensdale-Black Diamond Highway)
3. Owner of Record Burlington Northern, Inc.
4. Operator Industrial Mineral Products
5. Site Number | | | County | | | | Serial
6. Address Victor Hoffman, Pres.
P.O. Box 95
Ravensdale, WA 98051
7. Application Date | 8 | 1 | 0 | 6 | 2 | 5 | Year Month Day
8. Location | S | 0 | 1 | T | 2 | 1 | N | R | 0 | 6 | E |

9. Check Type of Site:

___	Sanitary Landfill	___	Land Spreading	___	Shredding
X	Industrial Landfill	___	Drop Box	___	Baling
___	Transfer Station	___	Composting	___	Other
___	Incinerator	___	Resource Recovery		

10. Is this an existing site? X Yes ___ No

PART II Governmental Approval

A. Have any other permits or approvals been applied for from:

	Yes	No	N/A
1. Municipality Approval	___	___	___
2. King County Planning Commission Approval (Grading File #1122-58)	x	___	___
3. Shorelines Management, County Approval	___	___	___
4. Consistent with County Solid Waste Management Plan per this application	___	___	___
5. Department of Game/ Fisheries Hydraulic Permit	___	___	___

	Yes	No	N/A
6. a. Department of Ecology Discharge Permit	#2945 x	___	___
b. Department of Ecology Flood Control Permit	___	___	___
7. Department of Natural Resources; Surface Mining Permit #10346	X	___	___
8. Fire Department Approval	___	___	___
9. Other ________ (Specify)	___	___	___

(Local Health Department Use Only)

Final Approval Date | | | | | | | Year Month Day

Approved by: ______________

APPENDIX C-6

PART II - Governmental Approval (Continued)

B. Zoning

1. Classification of Site Area Quarry-Mining (QM)
2. Enforcement Agency King County Department of Planning and Community Dvlpt. Building and Land Dvlpt. Div, Grading and Excavation Sect
3. Restrictions (If any)) None
4. Use of Adjacent Properties within a Quarter Mile (Check Appropriate Box)

	North	East	South	West
a. Residential				
b. Commercial				
c. Light Industrial				
d. Heavy Industrial				
e. Agricultural (timber)	1 mile	5 miles	2 miles	2 miles
f. Mixed				
g. Other ____________ (Specify)				

PART III - Solid Waste Characteristics

A. Type of Clientele Served: Ideal BASIC INDUSTRIES Cement Company, Seattle Estimated Number: 1

B. Source or Type:

	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
1. Garbage			
x 2. Rubbish	mineral waste	120,000	600,000
3. Ashes			
4. Bulky wastes			
5. Abandoned vehicles			
6. Construction and demolition wastes			

APPENDIX C-6

PART III - Solid Waste Characteristics (Continued)

B. (Continued)

	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
X 7. Industrial wastes	cement kiln dust, non-combustible inorganic mineral waste	120,000	600,000
8. Hazardous waste			
9. Sewage treatment residues			
10. Street refuse			
11. Litter			
12. Agricultural waste			
13. Mining wastes			
14. Other (Specify)			

C. Daily Waste Quantities:

200 to 300 tons

	Volume	Weight
1. Estimated per customer daily waste quantities		200-300 tons
→ 2. Total maximum daily volume or weight		300 tons
→ 3. Total average daily volume or weight		200 tons

4. Additional comments

D. Daily Customer Traffic

	Number
1. Estimated number of transfer vehicles	2
2. Estimated number of municipal collection vehicles	
3. Estimated number of private collection vehicles	
→ 4. Estimated commercial/industrial/special trucks	
5. Estimated residential pickup trucks/station wagons daily	
6. Estimated residential cars	

7. Additional comments ~~Each truck makes 5 to 8 trips per day, 6 days per week on the average~~

APPENDIX C-6

PART IV - Soil and Geological Characteristics (All Sites)

A. Location:

Attach copy of USGS Topographical map to each copy of Application using 7.5 minute quadrangle map, if published.

1. Plot on topographical map the following on site or within one mile of outer perimeter of site:

		Checkoff
a.	Wells, water	x
b.	Springs	x
c.	Swamps	x
d.	Streams	x
e.	Public water supplies	none
f.	Other bodies of water	none
g.	Underground or surface mines	x
h.	Mining spoil piles	x
i.	Irrigation canals	none
j.	Irrigation pools	none
k.	Mine pools and discharge points	x
l.	Gas and oil wells	none
m.	Other (specify)	

2. Describe the Topographical Setting The disposal site is on the west flank of a gently rising slope that is part of Ravensdale Hill. The floor of the fill is at 700 feet and the crest is at 900 feet.

B. Flood Plains:

1. Is the facility in the 100-year flood plain? ___ Yes _x_ No

2. Size of watershed above the landfill is less than 1 acres. (see attached sheet)

C. Soils: (see attached sheet)

1. List all soil series and phases within site and approximate thickness.

2. List all soil series and phases to be used as cover material.

3. A copy of soil map or references to site location and source of cover material on published soil survey must be included.

APPENDIX C-6

PART IV - Soil and Geological Characteristics (All Sites) (Continued)

D. Geology:
see attached sheet

1. Glacial geology or

a. Type(s) of deposit(s) Vashon glacial till

b. Texture of deposit(s) Compact mixture of gravel and boulders in a silty sand matrix

c. Thickness of deposit(s) Variable but extends to depths of 60 inches

2. Bedrock

a. Type(s) Quartz-rich clay-cemented sandstone

b. Depth to 50 feet below present surface of landfill

c. Extent of weathering Unit oxidized to a minimum depth of 60 feet

d. Name and age of formation(s) Eocene. The upper part of the Franklin coal zone of the Puget Group See attached stratigraphic column.

E. Surface Water:	Yes	No
1. Will there be a discharge of leachate to surface waters?		x
2. Will leachate collection and treatment facilities be constructed?		x
a. If yes, have you applied for Waste Discharge Permit?		

3. Rainfall (in inches)

a. Annual value 57.73 inches (Mud Mountain Dam Weather Station, 1979 value)

b. Peak 24-hour value 1.45 inches (Dec. 3, 1980)

c. Peak 1-hour value information not available

F. Ground Water

1. Depth to ground water 40 feet

a. How determined 2 core drill holes (see geologic map) and standing water level in sand excation before it was backfilled with kiln dus

b. Seasonal variation 3 feet

PART IV - Soil and Geological Characteristics (All Sites) (Continued)

F. Ground Water (Continued)

c. If depth to ground water cannot be determined, it is recommended that a boring or well be drilled outside of, but adjacent to, the solid waste disposal area. Additional information on construction type and materials may be obtained from the regional office of the Department of Ecology.

	Checkoff
(1) Locate well on site map	
(2) Provide complete log (description of well)	
(3) Indicate method of drilling	
2. Direction(s) of ground water movement	X
3. Discharge of ground water (indicate on topographical map)	X
a. Distance and direction of discharge point(s)	X
b. Name(s) of discharge point(s), i.e., springs, streams, etc.	X
c. Area tributary to discharge point(s)	X

4. Subsurface information: (Detailed information is needed on subsurface conditions for proper analysis of the site. This information on soils, geology, and ground water may be determined from deep cuts, borings and wells, backhoe pits, strip mines, quarries, natural outcrops, or road or railroad cuts). Describe location, detailed description and findings, and locate on topographic map, logs.

see attached description

5. How was information determined?

core drill holes

PART V - Disposal Sites - Design and Operation

A. Detailed Plans and Maps of Disposal Site:

Submit one copy of each set of plans with each set of application forms.

1. Property Line Map

a. One map should indicate property lines of site, use of adjacent properties, all right of ways (fuel, power line, roads, etc.).

(1) If right of way exists, name of owner Bonneville Power Administration

(2) Does owner/~~operator~~ own mineral rights? x Yes ___ No

(3) If not, name and address of owner of mineral rights.

Owner, Burlington Northern, Inc.
650 Central Building, Seattle, Wa. 98104

2. Detailed topographic maps of the site should include the following. More than one map may be used to show the required information on site and within 1/4 mile perimeter of site.

	Item	Checkoff
a.	Scale 1":400' or larger	x
b.	~~Five~~ foot contour interval or less twenty foot contour	x
c.	Location of access roads and roads on landfill	x
d.	Location of permanent fencing	x
e.	Location of weighing facilities/gate attendant	x
f.	Location of existing and proposed utilities (water, sewers, electricity, gas, telephone, etc.)	x
g.	Location of right of ways for power lines over 1 kv	x
h.	Location of discharge point of ground water	x
i.	Location and identity of monitoring wells	n/a
j.	Location and identity of other wells	x
k.	Direction of ground water flow (indicate all directions found)	x
l.	Fire protection facilities if beyond 1/4 mile, show on general topographic map (non-combustible waste)	n/a
m.	Leachate collection and treatment facilities	n/a
n.	Employee facilities	x
o.	Equipment storage and repair buildings	x
p.	Salvaging facilities	n/a
q.	Buffer zone, plantings, etc.	x
r.	Location and identity of springs	x
s.	Location and identity of swamps	x
t.	Location and identity of streams	x
u.	Location and identity of fire hydrants	n/a
v.	Location and identity of fire ponds	n/a
w.	Diversion ditches and water control structures	x
x.	Lifts described, not shown on map	n/a
y.	Cover stock piles	x
z.	Other (specify)	

PART V - Disposal Sites - Design and Operation (Continued)

3. Lift Design (landfill only) (see attached sheet)

	Checkoff
a. Total thickness of each lift	
b. Working grade of each lift	x
c. Slope and width of working face	x
d. Approximate time interval between lifts	n/a
e. Sequence of lifts and cover usage in fill area	x
f. Final slope sequence	x
g. Cover supply sources	x
h. Drainage and water control devices	x
i. Other (specify)	x

4. Plans for Finished Site (Check each item included)

a. Slope and contour	
b. Buildings	x
c. Surface water management	x
d. Road construction	x
e. Revegetation procedure	x
f. Final site maintenance	x
g. Maps and a statement of fact recorded as part of deed with county auditor (WAC 173-301-310)	x
h. Other (specify)	

5. Leachate Collection and Treatment - Required? ___ Yes ___ No

x Not at this time

a. Location of collection and treatment facilities	
b. Cross sections and elevations of collection system	
c. Cross sections and elevations of treatment facilities	
d. Location of discharge points of treated leachate	
e. Comments	

6. Location of proposed ground water monitoring points

Not required at this time. See attached ground water information.

a. Number	
b. Depth	
c. Log of boring or well	
d. Sampling method	
e. Sampling frequency	
f. Comments	

The absence of a domestic well within 2 miles in any direction precludes domestic ground water contamination

PART V - Disposal Sites - Design and Operation (Continued)

B. General Plan of Operation. (Describe in addendum, check as completed.)

→ 1.	Proposed landfill method	x
→ 2.	Schedule of filling	x
→ 3.	Site preparation	x
→ 4.	Designation of unloading area	x
→ 5.	Size of working face	n/a
→ 6.	Cell construction	n/a
→ 7.	Compaction and cover practice	x
8.	Blowing litter control	n/a
→ 9.	Surface water management	x
→ 10.	Dust control	x
11.	Gas venting provisions	n/a
→ 12.	Road construction	x
→ 13.	Erosion control	x
→ 14.	Traffic control	x
15.	Final cover	x
16.	Final slope	x
17.	Revegetation procedure	x
18.	Final site maintenance	x
→ 19.	Record system	x
20.	Salvaging system	n/a
→ 21.	Noise control	x
22.	Employee facilities	x
23.	Vector control	n/a
24.	Other (specify)	

PART VI - Operational Support

	Yes	No
A. Employee Facilities:		
Are employee facilities provided in accordance with (WAC 248-62)? (Facilities available at washing plant site, ½ mile away)	x	
B. Disease - Vectors: not applicable		
1. Facility will apply daily cover.		
2. Facility will practice other techniques.		
Explain ______________________		
3. Control program for: Rodent, Fly, Bird? (circle)		
C. Disease - Sewage Sludge and Septic Tank Pumpings: not applicable		
1. Are sewage sludge or septic tank pumpings to be applied to the land surface or incorporated into the soil?		
2. Are crops for human consumption to be planted within 18 months after application of waste?		
3. Will the waste be treated by a process to significantly reduce pathogens and is access controlled 12 months for the public, 1 month for grazing animals?		
D. Air Quality: not applicable		
Will open burning of solid waste be practiced at the facility?		
Control program for odors?		

PART VI - Operational Support (Continued)

E. Safety - Gas:

Will methane or other explosive gases be generated? ____ Yes _X_ No

If generated, how will they be controlled? ____________________

____

____

F. Safety - Fire Protection: n/a non-combustible mineral waste

1. Fire Department (Name and Address - Telephone) ____________________

____

Distance from site ____________________

2 Pond

a. Location ____________________

b. Volume of water ____________________

c. Elevation ____________________

3. Soil Stockpile

a. Location ____________________

b. Volume ____________________

4. Water Under Pressure

a. Location ____________________

b. Owner ____________________

c. Volume of water ____________________

d. Pressure ____________________

e. Distance to fire hydrant ____________________

5. Comments ____________________

____

____

____

____

____

PART VI - Operational Support (Continued)

G. Safety - Bird Hazards to Aircraft:

1. Will the disposal facility be within 5,000 feet from any airport runway used by piston-type aircraft or 10,000 feet from any airport runway used by turbojet aircraft? no

2. Does the facility receive putrescible wastes like food waste, sewage sludge, septic tank pumpings, animal manures, animal carcasses, etc.? no

H. Safety - Access:

1. Will access of unauthorized persons into the facility be controlled? yes.

   How? Disposal site (3 acres) is posted and will be fenced with a five foot hog wire fence; mine operates up to 6 days a week which provides company supervision of site; live-in watchman resides at sand wash plant.

2. Will authorized persons be controlled within the facility so as not to expose them to potential health and safety hazards? yes

   How? Truck and dozer operators wear dust masks and are advised as to the causticity of the material before it is slaked (wetted). Fence will eliminate casual walks across landfill.

I. Control Programs:

1. Dust control During dry season, dust is wetted by water tank truck; during remainder of year, rainfall is adequate for dust control.
2. Odor control n/a
3. Noise control n/a except for periodic truck arrival
4. Other

J. Endangered Species:

Is the facility within a critical habitat or the range of an endangered or threatened species as listed pursuant to the Endangered Species Act of 1973 (16 U.S.C. 1530 ET. Seq. as amended) in 50 C.F.R. Part 17? ___ Yes x No

K. Public Utilities

	On site Yes or No	Off site Yes or No	Distance from Site	Date Available
1. Electricity	no	yes	½ mile	1968
2. Water	no	yes	½ mile	1968
3. Sewage	no	yes	½ mile	1968
4. Telephone	no	yes	½ mile	1968
5. Other (explain)				

All facilities available at main company sand washing plant, ½ mile away

APPENDIX C-6

PART VI - Operational Support (Continued)

L. Weighing and Measuring Facilities:

1. Scales

a. Description Truck scales are certified platform type

b. Location Ideal BASIC INDUSTRIES Cement plant - Seattle

c. Charges None - weight ticket issued

2. Other (specify) none

a. Type

b. Description

c. Location

M. Records System (See Guide in Instructions): x Yes ___ No

Records of tonnage and trips maintained by Ideal Cement, Industrial Mineral Products, Inc., and hauling contractor, Moulden and Sons, Enumclaw.

Prepared by: Glennda B. McLucas
Industrial Mineral Products, Inc.
Box 95, Ravensdale, WA. 98501

Title: Mine Geologist

Date: June 24, 1981

GLENNDA B. McLUCAS
Glennda McLucas
No. G 834
GEOLOGIST

APPENDIX C-6

INTRODUCTION

Exhaust from rotary kilns used to manufacture portland cement carries to waste an average of 12 percent of the kiln feed. In compliance with federal air pollution standards, cement companies recover 96 percent of this kiln dust with electrostatic precipitators or other dust collection systems. Since the dust has value as a cementitious substance, it is re-fed to the kiln whenever possible. In some processes, such as the one employed by Ideal Cement, Seattle, the dust cannot be recycled because of build-up of alkalies (sodium and potassium) that would cause the cement clinker alkali content to exceed the 0.6 percent industry limit.

Most waste kiln dust is stored in surface piles or in abandoned rock quarries. The combined hauling and disposal costs to cement companies are immense; therefore, they either attempt to sell the dust or dispose of it within short distances from their plants. Markets for the dust include agricultural lime and potash fertilizer, landfill, soil stabilization, neutralization of acidic waste (e.g. coal mine drainage), absorption of SO_2 from stack gases, water treatment, glass making, and production of lightweight aggregate. Because the largest volume use for kiln dust has been for agricultural soil additives, it is difficult to understand how use of the material as a landfill can pose an environmental hazard.

Ideal Cement produces 200 to 300 tons of cement kiln dust a day. They have been successful in marketing a very small percentage of their total production. Continued operation of their plant absolutely depends upon disposal of the dust because they do not own sufficient land at their plant site to store it.

For two years Industrial Mineral Products has provided a service to Ideal Cement and King County by the safe disposal, in a geologically conducive environment, of approximately 120,000 tons of kiln dust. In the process, I.M.P. has complied with federal surface mining regulations that dictate backfilling of open pits such that the original topography of the mine site is restored. There are several reasons why the material is attractive to I.M.P. as a backfill, among them: 1) the kiln dust is available in tonnages approximating those removed in our silica sand mining operation; 2) because the material sets up, upon contact with water, to a solid mass that is resistant to internal and external erosion, liquification, and slope instability, and therefore provides a near-perfect landfill; 3) it provides our mining/hauling contractor a full load upon his return from silica sand delivery trips to Ideal Cement.

Physical and Chemical Properties

The cement flue dust is collected by an electrostatic precipitator and is composed of two types labled stage B and stage C. The ratio in weight of B to C is approximately 4:1. Bulk density of B is 58 lbs./ft^3; bulk density of C is 22 lbs./ft^3. The difference between the two is in the grain size resulting in the separation of the two products. In stage B, 95% passes the 200 mesh sieve and in stage C, 98% passes the 325 mesh sieve. On a volume basis, stage B comprises 60% of the dust; stage C comprises 40% of the dust.

The mineral and chemical composition varies between the two stages depending on the amount of burning and point of collection. A composite chemical analysis of the dust is listed below.

CHEMICAL ANALYSIS

SiO_2	12.40
TiO_2	0.07
Al_2O_3	2.92
Fe_2O_3	1.25
MgO	0.58
CaO	51.59
Na_2O	0.72
K_2O	1.29
SO_3	4.08
LOI	25.10

The mineral composition as determined by X-ray diffraction is comprised mainly of calcite. Lesser amounts of quartz and lime with minor gypsum are present. Acid and water baths with accompanied weight losses indicate the dust contains approximately 65 percent calcite. Gravimetric determinations of available lime (CaO) give an amount of 13 percent. The relatively low percentage of lime shows that most of the material is unburned. There is no noticeable reaction with the addition of water and no exothemic reaction.

Regulations Pertaining to Cement Flue Dust

According to Environmental Protection Agency regulations, a solid waste must be classified as a hazardous waste if it demonstrates any of the following properties: ignitability, corrosivity, reactivity, toxicity, or pH values below 2.0 or above 12.5. The Bevel amendment to the Federal Resource Conservation and Recovery Act gave cement flue dust a three-year grace period for determination of whether or not it constitutes a hazardous waste.

The dust can not correctly be classified as a dangerous waste either, because that classification includes only liquid wastes or slurries. The dust is delivered from Ideal dry and doesn't encounter moisture until it is dumped in the landfill. As soon as water is added, the lime is slaked and sets up into a solid, cementitious mass.

The E.P.A. toxicity test is a determination of concentrations of eight metals in flue dust leachates. The attached toxicity test results from Ideal Cement demonstrates that the dust is far below E.P.A. standards. The reason that trace metals do not leach out of the flue dust has to do with its high alkalinity (approximately 12.05 pH). Most metals are soluble only in acid; it would take copious quantities of concentrated acid to elevate the dust pH to the point that constituent metals would drop out.

Land Use Considerations

The Ravensdale area is historically a mining district. Cultural development has been slow. Land in the immediate vicinity of the dust disposal site was mined for coal through the 1940's. Timberland was clearcut to facilitate early mining and has not been included in a timber management program until very recently. One half of the disposal site lies under the Bonneville Power Administration's powerline right-of-way which severly restricts future development of the site, especially for timber growth. Steepness of the terrain and the occurrence of a compact glacial till substratum severely restricts its potential for building sites.

PART IV B2 SOIL AND GEOLOGICAL CHARACTERISTICS: WATERSHED

The area above the landfill was originally mantled by glacial drift and a thin soil cover. No natural drainage was evident because runoff from the hill permeated the glacial gravels or was diverted into abandoned open pit coal mines and air shafts. At present, the area above the landfill is composed of two nearly vertically-dipping (70°) stratigraphic units (100 to 200 feet wide) of kaolinitic clay and silica sand. To the east of these units for 100 to 200 feet, clay and silica sand units have been removed to 50 feet depth.

PART IV C. SOILS

The soil cover and glacial substratum in the immediate vicinity of the kiln dust disposal site have long since been removed during excavation of the original silica sand deposit. However, the original soil cover on the site was specifically designated Alderwood Series, AkF, Alderwood and Kitsap soils, very steep (see attached soils map). This mapping unit is about 50% Alderwood gravelly sandy loam and 25% Kitsap silt loam. Distribution of the soils, drainage, and permeability vary within short distances.

The Alderwood series is composed of moderately well-drained gravelly loam 24 to 40 inches deep over a weakly-to-strongly-consolidated, very slowly-permeable substratum of glacial till (Vashon). These soils occur on uplands and terraces and formed under conifers in glacial deposits. They have convex slopes that are dominantly 0 to 30 percent but range to as much as 70 percent. Slopes greater than 15 percent are generally no more than 200 feet long, as exemplified by the flue dust disposal site where the relief is 100 feet over a distance of 200 feet (50% slope).

The surface layer is dark-brown to grayish-brown gravelly sandy loam about 27 inches thick. The substratum is grayish-brown, weakly to strongly consolidated glacial till that extends to a depth of 60 inches and more.

Alderwood series soils are used predominantly for timber; the effective rooting depth is 20 to 40 inches. Low available water capacity and steepness of slope prevent use of the area for farming. The area will be well suited to use as a wildlife habitat and recreational areas, once mining operations are complete.

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Cover material will be provided by soil stripped from the surface of silica sand units presently being mined to the east of the landfill site (see Reclamation Plan, Figure 21, for soil stockpile locations). Before the six feet of soil cover required by our lease holder (Burlington Northern), is emplaced, a clay seal from the I.M.P. settling ponds will be distributed over the entire landfill surface. This seal will prevent potential upward migration of soluble salts into the root zone of vegetation planted during reclamation.

The cover soil has been extracted from an area designated on the attached soils map as AgB, Alderwood gravelly loam, rolling 15 to 30 percent slopes. Depth to the substratum in this soil varies within short distances, but is commonly about 40 inches. This soil is used mostly for timber.

APPENDIX C-6

PART IV F GROUND WATER

Groundwater conditions in the area of the landfill are fairly difficult to describe with precision because: 1) few wells have been drilled in the area and those that have been are shallow and, with one exception (attached), do not have drilling logs. As a result, published information on local groundwater conditions is meager; 2) the area is mantled with glacial till which creates a barrier to groundwater percolation as well as drainage derangement because of its clay content and degree of compaction. Isolated clay lenses create perched water tables that can give a false impression of true regional water table levels and gradients; 3) the bedrock in the area is highly folded and faulted such that ground water barriers are probably common and continuity of aquifers difficult to predict. For example, a sizable fault occurs at the northern extent of the silica sand mine, between the landfill and Ravensdale Lake, and undoubtedly influences the manner in which ground water flows downslope; 4) the area is riddled with open pit and underground coal workings that collect and channel ground water through them. Water discharges from at least two adits or air shafts in the immediate vicinity (north) of the landfill from water that is captured by the Dale #7 open pit coal mine at the crest of Ravensdale Hill several hundred feet east of the landfill. This is a beneficial circumstance because most of the ground water from the watershed is diverted past the landfill by this process. Water discharged from the coal workings is acidic, as evidenced by classic iron oxide slime coatings on stream beds. Surface drainage from the kiln dust landfill is diverted into this coal mine drainage such that the alkalinity of the landfill effluent should effectively and beneficially neutralize the acid discharge.

Two exploration holes were drilled into the sand units that originally occupied the landfill site (see geologic map, drill holes 1 and 2). The core was not preserved but they demonstrated a silica sand unit to the limit of the hole (100 feet). This unit is a clay-cemented sandstone with very low permeability. It is bounded to the east and west by nearly vertical clay units that create a dam and prevent most of the lateral percolation of ground water. The floor of the silica sand pit was partially sealed by clay that sloughed into it.

Groundwater in the area has a northwesterly gradient (see topographic map). This was determined by analyzing the water level of local water bodies and area topography, since no well records are available. The lakes to the south and east of the landfill are as much as 140 feet higher (approximately 720 feet elevation) than those to the north and west (approximately 580 feet elevation at Lake Ravensdale. A spring intermediate to the highest and lowest lakes occurs at 690 feet. Stream drainage is dominantly to the west also. Taking into account that ground water tables conform to the topography and migrate downhill, the dominant direction of ground water movement must be northwesterly. Seasonal variation of the water table at the landfill site has been between 2 and 3 feet as determined by observations of the standing water level in the sand excavation (40 feet below present landfill surface) before it was backfilled with the dust. Hydrographs of Lake Sawyer one mile to the west ~~demonstrates~~ a seasonal variation of three feet.

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Very few wells have been drilled in the area of the landfill. Only one has a drilling record but even it is over one mile away. Water was encountered at 24 feet in this well. The well at the sand washing plant is not domestic; it is very shallow and represents the intersection of the water table at Ravensdale Lake. The town of Ravensdale receives its water supply by flume from Lake Retreat. Therefore, it is difficult to see how the landfill could pose a drinking water hazard to the population of the region.

PART V A 4. PLANS FOR FINISHED SITE

Flue dust will be placed in the landfill in such a manner that, upon completion, it will blend with the surrounding topography and conform to the original site slopes of approximately 50 percent. It will be capped with clay to prevent any migration of soluble salts. Although the original soil cover averaged 24 inches or less, the property owner, Burlington Northern, may require as much as six feet of soil cover and will have the right to approval before its placement. Industrial Mineral Products will fertilize and seed the site to grass immediately following soil placement under Burlington Northern's direction as to proper seed mixtures and fertilizer type and quantity.

Burlington Northern is involved in a logging and reforestation program that will influence the final revegetation of the site. However, proximity to the B.P.A. power line may severly restrict reforestation. See figure 21 for reclamation plan.

Surface water has been diverted from landfill site (see attached maps). The cementitious nature of the material reduces erosion potential and a final clay cap should prevent any foreseeable surface water contamination.

The construction of buildings on the site is not anticipated because of the steepness of the natural terrain and poor foundation and percolation conditions. No additional road construction across the site is anticipated.

Land use following completion of mining has been discussed with the land owner. Because the term of the mining lease is for several years, it is difficult to speculate about what development program would be suitable at that time.

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The land has no use now other than for mining because it is broken up by the power line and abandoned coal strip mines. Future use should be compatible with existing use to prevent zoning regulation conflicts.

Upon completion of landfill, maps and a statement of fact will be recorded as part of deed with county auditor (WAC 173-301-310).

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PART V. DISPOSAL SITE DESIGN AND OPERATION

B. General Plan of Operation

Cement kiln dust from Ideal BASIC INDUSTRIES Cement Company has been transported from Seattle and dumped on the landfill site for two years. The original silica sand excavation involved three acres to 50 feet depth. The pit was abandoned because of depletion of marketable sand and because a unit of clay on the east side of the pit partially slid into the excavation, sealing part of the pit floor. This seal helps prevent the downward percolation of any soluble substances in the flue dust. Additionally, a vertical clay unit bounds the landfill to the east, thereby limiting the effect of lateral, northwesterly ground water movement through the fill (see geologic map). At present, the original excavation is full. The original access road is being re-routed (see plan map) and elevated 25 feet to form a berm and basin that will allow additional flue dust disposal. This will bring the fill to an elevation that will allow a smooth slope upward and eastward to the crest of the sand/clay unit standing between the disposal site and units presently being mined.

The method employed has simply involved dumping the flue dust in lifts from belly-dump trucks into the pit floor, followed by redistribution and compaction by a dozer to maintain an even fill and road access to the site. During rainy weather, the dust is slaked almost immediately so that wind-blown dust and corrosivity are no longer a problem. During dry weather, a water tank truck wets the dust down. As soon as the dust is slaked it sets up, or hardens, such that internal erosion and surface erosion by sheet wash is minimal and a very stable fill is generated.

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Stream drainage into the mine area has been diverted into channels north and south of landfill site (see maps).

At present dumping rates of 200 to 300 tons per day, the landfill site will be full in two years or less. At that time, the floor of the area presently being excavated will be backfilled with the dust as the silica sand resource is depleted. The company also plans to fill several abandoned coal strip mines to the east of the mine, pending Burlington Northern approval.

As soon as the landfill site is full so that it conforms to the topography of the surrounding landscape, the dust will be covered with a cap of clay from the washing plant settling ponds, or clay from the mine, to prevent any upward migration of soluble salts. The site will then be covered with topsoil stockpiled at the locations designated on the plan map. Proximity to the Bonneville Power Administration powerline right-of-way will prevent reforestation of the site.

Traffic to the landfill involves only two trucks making five to eight trips a day, 6 days a week on the average. This does not constitute a traffic problem either in the landfill area or at the access to the Black Diamond-Ravensdale Road. The only noise associated with the operation is that generated by truck arrival and the dozer. Trip and tonnage records are kept by Ideal BASIC INDUSTRIES Cement, Industrial Mineral Products, and Moulden and Sons, Enumclaw, the hauling contractor.

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PART IV D SOIL AND GEOLOGICAL CHARACTERISTICS - GEOLOGY

The bedrock underlying the area of the silica sand mine and the present kiln dust landfill site are a sequence of non-marine sedimentary units of Eocene age that occupy approximately 750 feet in the upper part of the Franklin coal zone of the Puget Group. See attached stratigraphic column, figure 40. Three major quartz-rich sandstone beds, 100 to 200 feet thick, are separated by two clay units with intercalated thin-bedded sandstones which are 100 to 150 feet thick. This sequence of rocks lie between the Dale No. 7 coal bed and the Kummer sandstone and are involved in a shallow westward-plunging syncline. This flexture represents one of two major periods of folding in Eocene time. See figure 37, principal structural features. The beds in the north limb strike approximately N30W and dip 50 to 70° west; the south limb strikes N40E and dips 65 to 80° west. The uppermost stratigraphic sandstone unit is the lowermost topographic unit exposed near the base of the west sloping flank of the hill. This unit, excavated to 50 feet depth, formerly occupied the area beneath the kiln dust landfill.

The area is ideally suited geologically for a kiln dust landfill. The bedrock is composed of clay-cemented sandstones, siltstones, and clays with minor interbeds of carbonaceous shales. The units strike almost north-south and dip steeply to the west. The rocks are tight and have very low permeability and consequently act as an underground dam against the westward-trending hydraulic gradient. Ground water has very little mobility in the area of the mine.

The surficial units overlying bedrock in the area of the landfill before stripping took place, involved 24 to 40 inches of soil underlain by up to a 60 inch glacial till substratum.

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The till was deposited by the Vashon Ice Lobe 13,500 to 10,000 years before present and represents a compact mixture of gravel and boulders in a gray silty sand matrix. It also includes sand and gravel within and on top of the till. The low permeability of the till partly restricts recharge to the ground-water reservoir in the area. Along valley walls it is important as a confining layer to ground water movement.

PART V A3 DISPOSAL SITES - DESIGN AND OPERATION - LIFT DESIGN

The landfill site dimensions are approximately 1200 feet by 150 feet (3+ acres). The site has been uniformily filled from north to south in daily 10 inch lifts that are compacted to 6 to 8 inches. The 200 to 300 tons of material that are dumped each day have been uniformly spread out over a working area of about 3/4 of an acre with a 5% working grade. The lifts were developed from toe to crest (west to east) of the landfill with a final proposed grade of 30 to 50 percent. Because the dust sets up into a solid, compact mass upon wetting, we need not be concerned with an angle of repose. There is no sequence of lifts and cover at this site. A final clay cover will be applied from washing plant settling pond excavations and topsoil from sand mine overburden stripping. No water control devices are required because surface drainage has been diverted to the north and south of landfill. See attached maps for location of landfill road. After fence is installed (July 15th, 1981) and gates are established at both ends of the fill, transfer trucks will use only the landfill road, dump the dust over its west bank, and a dozer will redistribute the material towards the toe of the fill.

REFERENCES

Davis, T.A.; Hooks, D.B., 1975, Disposal and utilization of waste kiln dust from cement industry: Environmental Protection Technology Series, E.P.A. 670-2-75-043, 55 p.

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Luzier, J.E., 1969, Geology and ground-water resources of southwestern King County, Washington: Washington Department of Water Resources Water Supply Bulletin 28, 260p.

U.S. Department of Agriculture, 1973, Soil survey King County area, Washington: Soil Conservation Service, 93 p.

Seattle-King County/**DEPARTMENT OF PUBLIC HEALTH**
400 Yesler Way Seattle, Washington 98104 (206) 625-2161

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

August 28, 1981

Victor Hoffman, President
Industrial Mineral Products
P.O. Box 95
Ravensdale, WA 98051

Attention: Glennda McLucas

Dear Mr. Hoffman:

Re: Status of Solid Waste Disposal Site Permit Application
at Ravensdale Silica Sand Mine

We have completed our review of the above indicated Solid Waste Disposal Site Permit Application. Based on the information presented in the application, site inspections and hearings, it has been determined the landfill operation currently meets all the applicable Minimum Standards for Solid Waste Handling identified in the King County Board of Health Rules and Regulations No. VIII. We are therefore enclosing a Conforming Solid Waste Disposal Site Special Permit for Industrial Mineral Products, and ask that it be posted in a conspicuous location in the scale house.

The following conditions should be closely followed to insure continuation and renewal of your Special Landfill Permit:

1. A plan and schedule for monitoring surface and ground water must be established by October 31, 1981. Please be advised that Seattle-King County Health Department and Washington State Department of Ecology staff will be available to assist you in identifying key water sample locations and formulating a monitoring schedule;
2. Gates and fences must be maintained around the site to insure continued restricted access. The landfill gates must be closed during non-business hours;
3. a. A sign must be posted in a conspicuous location that identifies the disposal site including the permit number, hours of operation, and restriction to accept flue dust only.
   b. In addition, there should be notification that the waste dust is potentially dangerous; eg -

DANGER
Caustic Material
Will Cause Burns

at both entrance gates; and

4. A daily record must be maintained showing a minimum of - the date, number of loads hauled, and tonnage.

As you are aware, the Washington State Department of Ecology is currently in the process of finalizing their proposed Dangerous Waste Regulations (Draft WAC 173-303). These rules are scheduled to be adopted in October or November of this year. A fish toxicity analyses is presently being performed on a sample of your flue dust waste material. Should the test results show your waste classified as either Dangerous or Extremely Hazardous, you will fall under the direct jurisdiction and regulation of the State Department of Ecology - following passage of the Dangerous Waste legislation. You should receive notification within 30-60 days if this shift in regulatory authority is to take place.

If you have any questions or would like additional information please call Greg Bishop, Solid Waste Program Supervisor at 625-2125.

Yours truly,

John P. Nordin

John P. Nordin
Chief of Environmental Health Services

JPN:gbb
Enc.

cc: Bob McCormick, Director
    Northwest Region Office
    Department of Ecology
  Mark Mitchell
    Grading & Environmental
    Building and Land Development
  L. Kirchner
    Southeast District Office

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INDUSTRIAL MINERAL PRODUCTS, INC.

P.O. BOX 95 RAVENSDALE, WASHINGTON 98051 (206) 432-1286

4 November, 1981

Wally Swofford
Seattle-King County Dept. Public Health
400 Yesler Way
Seattle, WA 98104

Dear Wally:

In response to the attached letter from John Nordin, Chief of King County's Environmental Health Services Division, August 28, 1981, Industrial Mineral Products has completed a plan for monitoring surface and ground water associated with the Ideal Cement kiln dust landfill at Ravensdale.

In compliance with state regulations requiring the pH of surface water to fall between 6 and 9, we have rechanneled the discharge from the landfill along a new route that allows it to commingle with an acid coal mine drainage, resulting in a net pH less than 9.

We have also completed an exhaustive survey of the domestic groundwater wells to the northwest of the landfill in the direction of groundwater flow, including the Kent watershed wells, and have found no elevated pH's or element percentages that indicate contamination by the flue dust effluent.

The attached report outlines the measures we have taken to conform with state regulations including a location map of the discharge route and monitoring wells, along with a compilation of water chemistry data.

We have had a fair amount of contradictory information from the county and state DOE concerning whose jurisdiction this matter falls under. I would appreciate a clarification of who represents the lead regulatory agency and if we are to be operating under some kind of waste water permit. If so, I consider the attached report to be our application for such a permit.

If there's anything more I can do for you on this matter, please let me know. However, it seems we have spent an inordinate amount of time and money on this site analysis and we would like to see it draw to a reasonable conclusion.

Sincerely,

Glennda McLucas

Glennda McLucas
Mine Geologist

State of Washington
Department of Ecology

For Office Use Only

Date Received Nov. 5, 1981
Application/Permit No.
Type of Industry
Waterway Segment No.

INDUSTRIAL/COMMERCIAL WASTE DISCHARGE PERMIT APPLICATION FORM

Application is hereby made for a permit to discharge wastewater to state waters or to a municipal sewerage system in accordance with Chapter 90.48 RCW and Chapter 372.24 WAC.

1. NAME OF FIRM Industrial Mineral Products, Inc., Ravensdale, WA 98051

   Type of Industry (description of industrial or commercial activity) Silica sand mine and processing plant

2. MAILING ADDRESS P.O. Box 95, Ravensdale, WA 98051

3. PLANT LOCATION 26000 Black Diamond-Ravensdale Highway

   PHONE 432-3910 CONTACT PERSON Glennda McLucas, Geologist

   EMERGENCY PHONE (nights, weekends) 456-8248

4. TYPE OF WASTEWATER TREATMENT (if any) Dilution

5. WASTE FLOW: (Submit on separate sheet) 2 gallons perminute average

   Describe in detail the sources, treatment and disposal of all liquid wastes at the plant. Include a schematic flow diagram showing the sources and flow pattern of all wastes. See attached report and maps

6. SOLID WASTE DISPOSAL: (Submit on separate sheet) not applicable, submitted in June, 1981 on separate forms

   Describe the types of solid wastes accumulated at the plant and list the source, volume, storage provision, frequency of removal, and final disposal of each solid waste. Include all sludges, dusts, scraps, trimmings and left-over, spoiled or returned products.

7. WASTEWATER DISPOSAL:

	Maximum Gallons/Day
☐ Evaporation Lagoon or Pond	
☒ Subsurface Ground Disposal	from less than 1 to 10 (2 avg.)
☐ To Surface Waterway ____ (name of waterway)	
☐ To Sanitary Sewerage System ____ (name of municipal system)	

Location of Discharge Point(s) and/or connection to municipal sewer system: (Include latitude and longitude)

8. WATER SUPPLY: not applicable; water generated by surface runoff on landfil surface that comingles with coal mine drainage

☐ Private Well Recorded Water Right No. ________

☐ Surface Water ____________________ Recorded Water Right No. ________
(name of waterway)

☐ Public System ____________________
(name of system)

Location of private well or plant surface water intake:

Section ________, Township ________, Range ________

9. WATER SUPPLY VOLUMES:

	Average Gallons/Day	Maximum Gallons/Day
Private Well		
Surface water		
Public System		
TOTAL		

10. WASTEWATER DESCRIPTION:

	Average Gallons/Day	Maximum Gallons/Day
Sanitary Wastes		
Process Wastewater		
Cooling Water Discharge		
Other (Specify) landfill drainage	2	10
TOTAL		

11. EFFLUENT ANALYSIS: (Submit on separate sheet)

List the significant physical and chemical properties of the effluent(s) to be discharged, and include a description of the sampling and analytical methods used to derive this information. Include BOD, COD, suspended solids, pH, fecal coliform bacteria, heavy metals, etc.

12. DOES YOUR DISCHARGE CONTAIN ONE OR MORE OF THE FOLLOWING SUBSTANCES: cyanide, aluminum, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, phenols.

☒ Yes ☐ No

13. PLANNED WASTE TREATMENT IMPROVEMENTS: (Submit on separate sheet)

Describe any additional treatment or changes in waste disposal methods in planning or under construction.

See attached report

14. STORMWATER TREATMENT AND CONTROL: **Name of Waterway or Storm Sewer**

not applicable

☐ No Treatment ____________________

☐ Treated Stormwater to Waterway ____________________

Type of Treatment: ____________________

☐ Contaminated Stormwater to Sanitary Sewer **Type of Treatment (if any)**

Size of Intercepted Area ____________________

__________ Square Feet

15. PLANT OPERATION:

	Days per Year	Number of Employees per Shift Day	 Night	 Swing
Average	250	2	2	
Maximum	300			

16. RAW MATERIALS AND CHEMICALS USED IN PROCESSES: cement flue dust

Brand Name	Chemical, Scientific or Actual Name	Quantity Used per Day Average	 Maximum

17. Are there any oil products or hazardous materials stored or used at the plant site?

☐ Yes ☐ No

cement flue dust is not classified as a hazardous waste at this time.

If yes, give quantities and type and indicate whether a spill could reach a sewer, storm drain, or public waters.

____

The information given on this application is complete and accurate to the best of my knowledge.

Glennda McLucas
Signature

Glennda B. McLucas
Printed

Mine Geologist
Title

5 November 1981

REPORT ON THE SURFACE WATER DISCHARGE ASSOCIATED WITH THE INDUSTRIAL MINERAL PRODUCTS CEMENT FLUE DUST LANDFILL, RAVENSDALE, WASHINGTON

PREPARED BY

GLENNDA McLUCAS
MINE GEOLOGIST
10 NOVEMBER 1981

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The Industrial Mineral Products' cement flue dust landfill at Ravensdale has a surface water discharge at its northern extremity resulting from surface runoff and groundwater springs that issue from the northeastern landfill containment wall. To the best of our knowledge, downward and lateral percolation of leachate through the underlying impermeable clay-cemented sandstone and adjacent vertical kaolinitic clay units is virtually negligible. For a detailed description of the geology and hydrology of the landfill site, refer to the landfill permit application submitted by I.M.P. to King County/ DOE in June, 1981. The surface runoff averages two gallons per minute, with a range of less than one-to-ten gallons per minute, depending upon the weather. The pH of this effluent as it leaves the landfill is 12.36 as measured by a Chemtrix Model 60-A pH meter in our analytical lab. The elevated pH is due to leaching of the 13 percent CaO contained in the cement dust. An average of five percent of the effluent volume represents suspended matter that drops out over a short distance. This suspended matter is representative of the flue dust, with no concentration of any particular chemical constituent. Chemical analyses of the flue dust and the effluent are attached. The effluent was analyzed for calcium, magnesium, sodium, and potassium levels as these are the elements that contribute to alkalinity and water hardness. Heavy metal concentrations are not of particular concern because of their immobility in a non-acid environment. However, Ideal Cement has analyzed the flue dust for heavy metal concentrations and that report is also attached.

In the previous one-year period when we've had a landfill discharge, we have allowed it to run unconfined down the northwest flank of Ravensdale Hill about 1,000 feet into a barrow pit by the Ravensdale-Black Diamond Highway. The pit is in some porous, very permeable, glacial outwash gravels.

No water leaves the pit except by evaporation or percolation through its bed. Since the water table is near-surface at the site (less than 5 feet), the effluent is undoubtedly diluted very rapidly. The area is riddled with underground coal mine workings so it is even conceivable that the effluent disappears into this system. Just a few hundred feet to the northeast, an acid coal mine drainage of 33 gpm and a pH of 6.61 also disappears into the same gravel unit, providing additional dilution.

Washington State DOE water-quality personnel became aware of the effluent situation as a result of our general permit application for the landfill to King County/DOE in June, 1981, and were unhappy with the elevated pH of the discharge. State surface water regulations require a pH range of 6 to 9 for any affected surface drainage. They dictated (see attached letter) neutralization with acid at a holding tank to be installed at the top of the hill where the effluent originates. They did not provide any advice as to how this neutralization was to be engineered, however, or the impact of 55-gallon drums of acid being discharged, enmasse, to ground water when the insidious, ever-present local vandals shot them full of holes. The main deterrent to neutralization by acid, besides cost, is an absence of power on the hill to operate the necessary metering pump.

We chose to plug the old drainage culvert and divert the effluent along a ditch adjacent to the mine road to a confluence with the acid coal mine drainage (see location map) which, as previously mentioned, disappears into glacial gravels. We dug a sump/collection pond inside the flue dust fence (for public safety), then buried a 40-foot culvert under the landfill entrance road to channel the effluent to the mine-road ditch. We deepened the ditch, then laid in a six-inch, flexible, corrugated, PVC drain pipe along the 1,100 feet from the culvert to the coal mine drainage. Corrugated pipe was chosen to aid in the confinement of suspended matter to the vicinity

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The initial pH readings of the combined effluent/acid coal mine drainage by both I.M.P. and Washington State DOE personnel demonstrated a pH of 8 (DOE) to 8.08 (I.M.P.). Therefore, we have complied with state regulations concerning surface water quality.

We have also investigated the pH and chemistry of 10 wells along Highway 169 approximately one mile northwest of the landfill, two wells in the Kent watershed, and the well at our sand processing plant. To our knowledge, no wells exist between the ones we sampled and the fill. Those of the Kent watershed are probably too far north to be in line with the dominent ground water flow direction. Sample site #7 is from a creek that runs between Lakes Ravensdale and Sawyer. The pH and chemical data for all these collection points is attached. Nothing in our analyses indicate contamination by the landfill effluent. pH's range from 5.62 to 7.53, the normal range for western Washington ground water. It must be kept in mind that water hardness, caused by calcium and magnesium content, can be a very local phenomenon and that geologic literature for this area demonstrates that calcium-magnesium bearing formations exist. For further information regarding the geology and groundwater conditions of the Ravensdale area, the reader is referred to the references attached to this report.

Very little additional well information was available because most have been drilled so long ago that drilling logs are unavailable/nonexistent and current property owners are unable to provide useful information.

Because of its close proximity to the landfill, alignment with the dominant groundwater direction, and cooperativeness of the well owner, well number 10 has been selected as a monitoring well. We plan to monitor this well on a monthly basis. Additionally, we plan to monitor the pH of the effluent/acid mine drainage on a weekly basis until we have established the pH range through the whole range of precipitation conditions.

REFERENCES

Luzier, J. E., 1969, Geology and ground-water resources of southwestern King County, Washington: Washington Department of Water Resources Water-Supply Bulletin no. 23.

Vine, J. D., 1969, Geology and coal resources of the Cumberland, Hobart, and Maple Valley Quadrangles, King County, Washington: U.S. Geological Survey Professional Paper 624, 67 p.

APPENDIX C-9

Seattle-King County / DEPARTMENT OF PUBLIC HEALTH
400 Yesler Way Seattle, Washington 98104 (206) 625-2161

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

January 25, 1982

Victor Hoffman, President
Industrial Mineral Products
P.O. Box 95
Ravensdale, WA 98051

Dear Mr. Hoffman:

Please complete and return the enclosed renewal applications with the appropriate fees for the following disposal site:

Special waste site--Industrial Mineral Products (Ravensdale Site)
Permit Fee--$100.00

If you have questions concerning the revewal application, please contact Greg Bishop at 625-2125.

Sincerely,

John P. Nordin
Chief of Environmental Health Services

JPN:gbc
Enc.

District Service Centers:

CENTRAL
1500 Public Safety Bldg.
Seattle 98104
625-5536

Environmental Health Services
172 20th Ave.
Seattle 98122
625-2763

NORTH
10501 Meridian Ave. N.
Seattle 98133
363-4765

COLUMBIA HEALTH CENTER
3722 Hudson
Seattle 98118
625-5151

SOUTHWEST
10820 8th Ave. S.W.
Seattle 98146
244-6400

EAST
2424 156th Ave. N.E.
Bellevue 98007
885-1278

SOUTHEAST
Renton
3001 N.E. 4th St.
Renton 98056
228-2620

Auburn
20 Auburn Ave.
Auburn 98002
852-8400

SEATTLE-KING COUNTY DEPARTMENT OF PUBLIC HEALTH
SOLID WASTE PROGRAM

RENEWAL APPLICATION FOR ANNUAL DISPOSAL SITE PERMIT

(ORIG) 6/25/81

Part I

Date of Application 2/4/82

Name of Site: Ravensdale Silica Sand Min Site Attendant/Manager G. McLucas
Address: 26000 Black Diamond-Ravensdale Highway, Ravensdale, Wa.
Phone (if any): 432-3910 1981 Permit No. 1122-58
(King Co. GRADING Permit #)
Owner: Burlington Northern Railroad
Address: 650 Central Bldg. Seattle, Wa. 98104
Phone: 625-6132

Type of Facility: (check) Industrial Landfill

Sanitary Landfill ___
Non-putrescible Landfill X
Transfer Station ___
Drop Box Facility ___

Incinerator (Standard) ___
Incinerator (Steam Recovery) ___
Composting Facility ___
Reclamation Site X

Part II

GOVERNMENT APPROVAL

Health Department

1981 Solid Waste Permit Classification: Conforming X Non-Comforming ___

NOTE: If Non-Comforming, please describe status of compliance with each of the conditions that accompanied the permit and attach it to the application.

Other

The applicant has appropriate operating permits and follows guidelines established by other Department/Agencies (e.g. Puget Sound Air Pollution Control Agency, Zoning, Planning, Department of Ecology, etc.) Yes X No ___

NOTE: If no, indicate deficiency and measures taken to conform

---

APPENDIX C-9

Part III

APPENDIX C-9
SOLID WASTE CHARACTERISTICS

Please indicate any changes or updated information you may have in the following categories that would be different from that indicated in your original permit application: No change

A. Source or Type:	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
1. Garbage			
2. Rubbish			
3. Ashes			
4. Bulky Wastes			
5. Abandoned vehicles			
6. Construction and demolition wastes			
7. Industrial wastes			
8. Hazardous waste			
9. Sewage treatment residues			
10. Street refuse			
11. Litter			
12. Agricultural waste			
13. Mining wastes			
14. Other			

B. Daily Waste Quantities No Changes	Volume	Weight
1. Estimated per capita daily waste quantities		
2. Maximum daily volume or weight		
3. Average daily volume or weight		

4. Additional comments ______________________________

____

C. Daily Customer Traf no Changes

Number

1. Estimate number of transfer vehicles ____
2. Estimated number of municipal collection vehicles ____
3. Estimated number of private collection vehicles ____
4. EStimated commercial/industrial/special trucks ____
5. Estimated residential pickup trucks/station wagons daily ____
6. Estimated residential cars ____
7. Additional comments ____

Part IV.

GENERAL OPERATION

Please indicate any significant change, modification, addition or deletion in your general method of operation from that described in your original permit application (e.g. new equipment, road surfacing, installation of dust control sprinklers, noise control measures, traffic revision, blowing litter control, leachete collection, etc.):

Leachate (2 to 10 gpm) has been rerouted to ditch along mine Road, through pvc pipe to confluence with acid coal mine drainage where it's neutralized to the -9.0 pH level required by Wash. State DOE surface water regs, whereupon all water disappears into porous glacial gravels. Please refer to report on this subject submitted to King County Public Health and Wash. State DOE on 10 Nov. 1981.

(Use additional sheets if necessary)

REGISTERED PROFESSIONAL GEOLOGIST
OREGON
No. G 834

Prepared by Glenda McLucas

Phone 432-3910

Date 4 February, 1982

APPENDIX C-10

INDUSTRIAL MINERAL PRODUCTS, INC.

P.O. BOX 95 RAVENSDALE, WASHINGTON 98051 (206) 432-1286

20 September, 1982

Greg Bishop
Seattle-King County Department of Public Health
400 Yesler Way
Seattle, WA 98104

Dear Greg:

Enclosed is I.M.P.'s application for disposal site permit for the Dale Strip Pit Industrial Waste Disposal Site in Ravensdale. I have also enclosed a copy of Metro's report on the proposed use of this pit as a disposal site for sewage sludge. I have not described the hydrologic conditions of the pit in great depth because they are covered so extensively in Metro's report. We believe this pit to be essentially impermeable because it holds standing water year round with little fluctuation in water level. The pit walls and floor will be further sealed by the layer of hardened cement that will form upon addition of cement dust to the standing water.

I look forward to a reply from the county as soon as possible on this permit application. We already have approval from Burlington Northern to use their land for this purpose, pending approval from King County and DOE.

Sincerely,

Glennda McLucas

Glennda McLucas
Mine Geologist

State of Washington
Department of Ecology

APPENDIX C-10

APPLICATION FOR DISPOSAL SITE PERMIT

PART I (All Sites)

1. Name of Site: Industrial Mineral Products Industrial Waste Landfill

2. Address: 26000 Black Diamond-Ravensdale Highway (½ mile west of Ravensdale, ½ mile south of Black Diamond-Ravensdale Highway)

3. Owner of Record: Burlington Northern Railroad Company

4. Operator: Industrial Mineral Products

5. Site Number: County ☐☐ Serial ☐☐☐

6. Address: P.O. Box 95
Ravensdale, WA

7. Application Date: 8 2 0 8 2 5 (Year Month Day)

8. Location: S 0 1 T 2 1 N R 0 6 E

9. Check Type of Site:

- ___ Sanitary Landfill
- X Industrial Landfill
- ___ Transfer Station
- ___ Incinerator
- ___ Land Spreading
- ___ Drop Box
- ___ Composting
- ___ Resource Recovery
- ___ Shredding
- ___ Baling
- ___ Other

10. Is this an existing site? ___ Yes X No

PART II Governmental Approval

A. Have any other permits or approvals been applied for from:

	Yes	No	N/A
1. Municipality Approval		X	
2. Planning Commission Approval Grading File # 1122-58	X		
3. Shorelines Management, County Approval			X
4. Consistent with County Solid Waste Management Plan Operating Permit # 17-101	X		
5. Department of Game/ Fisheries Hydraulic Permit			X

	Yes	No	N/A
6. a. Department of Ecology Discharge Permit			X
b. Department of Ecology Flood Control Permit			X
7. Department of Natural Resources; Surface Mining Permit #10346	X		
8. Fire Department Approval			X
9. Other ________ (Specify)			

(Local Health Department Use Only)

Final Approval Date: ☐☐☐☐☐☐ (Year Month Day)

Approved by: ____________________

ECY 030-38 10/80

AV/L6(B2-16)

APPENDIX C-10

PART II - Governmental Approval (Continued)

B. Zoning

1. Classification of Site Area Quarry-Mining (QM)

2. Enforcement Agency Seattle-King County Department of Public Health

3. Restrictions (If any)) None

4. Use of Adjacent Properties within a Quarter Mile (Check Appropriate Box)

	North	East	South	West
a. Residential				
b. Commercial				
c. Light Industrial				
d. Heavy Industrial				
e. Agricultural (Timber)	1 Mile	5 Miles	2 Miles	2 Miles
f. Mixed				
g. Other ________ (Specify)				

PART III - Solid Waste Characteristics

A. Type of Clientele Served: Cement Manufacturer (Ideal Basic Industries) Estimated Number: 1

B. Source or Type:

	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
1. Garbage			
2. Rubbish			
3. Ashes			
4. Bulky wastes			
5. Abandoned vehicles			
6. Construction and demolition wastes			

APPENDIX C-10

PART III - Solid Waste Characteristics (Continued)

B. (Continued)

	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
7. Industrial wastes	Cement Kiln Dust: Non-combustible, inorganic, mineral waste	74,000 tons/year	290,000 tons
8. Hazardous waste			
9. Sewage treatment residues			
10. Street refuse			
11. Litter			
12. Agricultural waste			
13. Mining wastes			
14. Other (Specify)			

C. Daily Waste Quantities:

	Volume	Weight
1. Estimated per customer daily waste quantities	422 yards	285 tons
2. Total maximum daily volume or weight	1481 yards	1,000 tons
3. Total average daily volume or weight	422 yards	285 tons

4. Additional comments 1 yard = .675 tons

D. Daily Customer Traffic

	Number
1. Estimated number of transfer vehicles	none
2. Estimated number of municipal collection vehicles	none
3. Estimated number of private collection vehicles	none
4. Estimated commercial/industrial/special trucks	5
5. Estimated residential pickup trucks/station wagons daily	none
6. Estimated residential cars	none

7. Additional comments Vehicles used are 25-ton capacity tractor-pneumatic semi-trailer combinations that deliver to the landfill around the clock, 5 days a week, averaging 11.4 trips per day.

APPENDIX C-10

PART IV - Soil and Geological Characteristics (All Sites)

A. Location:

Attach copy of USGS Topographical map to each copy of Application using 7.5 minute quadrangle map, if published.

1. Plot on topographical map the following on site or within one mile of outer perimeter of site:

	Checkoff
a. Wells, water	X
b. Springs	X
c. Swamps	X
d. Streams	X
e. Public water supplies	X
f. Other bodies of water	X
g. Underground or surface mines	X
h. Mining spoil piles	X
i. Irrigation canals	none
j. Irrigation pools	none
k. Mine pools and discharge points	X
l. Gas and oil wells	none
m. Other (specify)	

2. Describe the Topographical Setting See attached sheet

B. Flood Plains:

1. Is the facility in the 100-year flood plain? ____ Yes __X__ No

2. Size of watershed above the landfill is 50 acres.

C. Soils: See attached sheet.

1. List all soil series and phases within site and approximate thickness.

2. List all soil series and phases to be used as cover material.

3. A copy of soil map or references to site location and source of cover material on published soil survey must be included.

APPENDIX C-10

PART IV - Soil and Geological Characteristics (All Sites) (Continued)

D. Geology:

1. Glacial geology or

a. Type(s) of deposit(s) Vashon glacial till

b. Texture of deposit(s) Compact mixture of gravel and boulders in a silty soil matrix.

c. Thickness of deposit(s) Variable, but generally extends to 60 inches.

2. Bedrock

a. Type(s) Sandstone and siltstone with numerous carbonaceous shale and coal seams, and minor amounts of claystone and conglomerate.

b. Depth to 5 feet

c. Extent of weathering In the vicinity of the Dale Strip Pit the arkosic sandstone units are weathered to at least 100 foot depth.

d. Name and age of formation(s) Puget Group of Eocene age

E. Surface Water:

	Yes	No
1. Will there be a discharge of leachate to surface waters?		X
2. Will leachate collection and treatment facilities be constructed?		X
a. If yes, have you applied for Waste Discharge Permit?		

3. Rainfall (in inches)

a. Annual value 57.73 inches (Mud Mountain Dam Weather Station, 1979 value)

b. Peak 24-hour value 1.45 inches (December 3, 1980)

c. Peak 1-hour value information not available

F. Ground Water

1. Depth to ground water 20 to 40 feet below bottom of strip pit.

a. How determined Examination of underground coal mine records for workings underlying strip pit, and comparison of standing water level in pit with that of abandoned silica sand mine 300 feet to the west.

b. Seasonal variation 3 to 4 feet.

PART IV - Soil and Geological Characteristics (All Sites) (Continued)

F. Ground Water (Continued)

Depth of groundwater has been determined

c. If depth to ground water cannot be determined, it is recommended that a boring or well be drilled outside of, but adjacent to, the solid waste disposal area. Additional information on construction type and materials may be obtained from the regional office of the Department of Ecology.

	Checkoff
(1) Locate well on site map	
(2) Provide complete log (description of well)	
(3) Indicate method of drilling	

2. Direction(s) of ground water movement slightly north of west

3. Discharge of ground water (indicate on topographical map) X

a. Distance and direction of discharge point(s) 2000 to 4000 feet northwest

b. Name(s) of discharge point(s), i.e., springs, streams, etc. Dale Mine Portal

c. Area tributary to discharge point(s) Underground coal mine workings in the Dale numbers 4 and 7 coal seams

4. Subsurface information: (Detailed information is needed on subsurface conditions for proper analysis of the site. This information on soils, geology, and ground water may be determined from deep cuts, borings and wells, backhoe pits, strip mines, quarries, natural outcrops, or road or railroad cuts). Describe location, detailed description and findings, and locate on topographic map, logs.

See attached 1972 report prepared for Metro concerning the disposal of municipal sewage sludge in the Dale Strip Pit #4. Specifically address page 10, subsurface hydrology

5. How was information determined? Detailed information drawn from September, 1972, report to METRO on the geologic and hydrologic conditions of the Dale Strip Pit as a potential sewage sludge disposal site near Ravensdale.

PART V - Disposal Sites - Design and Operation

A. Detailed Plans and Maps of Disposal Site:

Submit one copy of each set of plans with each set of application forms.

1. Property Line Map

a. One map should indicate property lines of site, use of adjacent properties, all right of ways (fuel, power line, roads, etc.).

(1) If right of way exists, name of owner Bonneville Power Administration

(2) Does owner/operator own mineral rights? ___ Yes X No

(3) If not, name and address of owner of mineral rights.

Burlington Northern Railroad Company
650 Central Building, Seattle, WA

2. Detailed topographic maps of the site should include the following. More than one map may be used to show the required information on site and within 1/4 mile perimeter of site.

		Checkoff
a.	Scale 1":400' or larger	X
b.	Five-foot contour interval or less	X
c.	Location of access roads and roads on landfill	X
d.	Location of permanent fencing	X
e.	Location of weighing facilities/gate attendant	none
f.	Location of existing and proposed utilities (water, sewers, electricity, gas, telephone, etc.)	none
g.	Location of right of ways for power lines over 1 kv	X
h.	Location of discharge point of ground water	X
i.	Location and identity of monitoring wells	none
j.	Location and identity of other wells	X
k.	Direction of ground water flow (indicate all directions found)	X X
l.	Fire protection facilities if beyond 1/4 mile, show on general topographic map	X
m.	Leachate collection and treatment facilities	none
n.	Employee facilities	none
o.	Equipment storage and repair buildings	X
p.	Salvaging facilities	none
q.	Buffer zone, plantings, etc.	X
r.	Location and identity of springs	X
s.	Location and identity of swamps	X
t.	Location and identity of streams	X
u.	Location and identity of fire hydrants	none
v.	Location and identity of fire ponds	X
w.	Diversion ditches and water control structures	none
x.	Lifts	none
y.	Cover stock piles	X
z.	Other (specify)	none

APPENDIX C-10

PART V - Disposal Sites - Design and Operation (Continued)

3. Lift Design (landfill only) See attached sheet

		Checkoff
a.	Total thickness of each lift	na
b.	Working grade of each lift	na
c.	Slope and width of working face	X
d.	Approximate time interval between lifts	na
e.	Sequence of lifts and cover usage in fill area	X
f.	Final slope sequence	X
g.	Cover supply sources	X
h.	Drainage and water control devices	X
i.	Other (specify)	

4. Plans for Finished Site (Check each item included)

a.	Slope and contour	X
b.	Buildings	na
c.	Surface water management	X
d.	Road construction	X
e.	Revegetation procedure	X
f.	Final site maintenance	X
g.	Maps and a statement of fact recorded as part of deed with county auditor (WAC 173-301-310)	X
h.	Other (specify)	

5. Leachate Collection and Treatment - Required? ___ Yes ___ No
x Not at this time

a.	Location of collection and treatment facilities	Dale Mine Portal
b.	Cross sections and elevations of collection system	n/a
c.	Cross sections and elevations of treatment facilities	n/a
d.	Location of discharge points of treated leachate	n/a
e.	Comments	

6. Location of proposed ground water monitoring points

a.	Number	1
b.	Depth	surface
c.	Log of boring or well	none
d.	Sampling method	see below
e.	Sampling frequency	1/week
f.	Comments	

Samples will be collected by immersing bottle in stream, then will be analyzed by atomic absorption for Ca, Na, K, Mg, and water hardness.

PART V - Disposal Sites - Design and Operation (Continued)

B. General Plan of Operation. (Describe in addendum, check as completed.)

1.	Proposed landfill method	X
2.	Schedule of filling	X
3.	Site preparation	X
4.	Designation of unloading area	X
5.	Size of working face	X
6.	Cell construction	na
7.	Compaction and cover practice	X
8.	Blowing litter control	na
9.	Surface water management	X
10.	Dust control	X
11.	Gas venting provisions	na
12.	Road construction	X
13.	Erosion control	X
14.	Traffic control	X
15.	Final cover	X
16.	Final slope	X
17.	Revegetation procedure	X
18.	Final site maintenance	X
19.	Record system	X
20.	Salvaging system	na
21.	Noise control	X
22.	Employee facilities	X
23.	Vector control	na
24.	Other (specify)	

PART VI - Operational Support

	Yes	No
A. Employee Facilities:		
Are employee facilities provided in accordance with (WAC 248-62)? Facilities available at sand washing plant, ½ mile away	X	
B. Disease - Vectors: n/a		
1. Facility will apply daily cover.		X
2. Facility will practice other techniques.		X
Explain When landfill is complete, area will be covered with seven feet of clay and soil		
3. Control program for: Rodent, Fly, Bird? (circle)		X
C. Disease - Sewage Sludge and Septic Tank Pumpings: n/a		
1. Are sewage sludge or septic tank pumpings to be applied to the land surface or incorporated into the soil?		
2. Are crops for human consumption to be planted within 18 months after application of waste?		
3. Will the waste be treated by a process to significantly reduce pathogens and is access controlled 12 months for the public, 1 month for grazing animals?		
D. Air Quality:		
Will open burning of solid waste be practiced at the facility?		X
Control program for odors?		X

PART VI - Operational Support (Continued)

E. Safety - Gas:

Will methane or other explosive gases be generated? ___ Yes X No

If generated, how will they be controlled? ___

F. Safety - Fire Protection:

1. Fire Department (Name and Address - Telephone) 432-0200
Ravensdale Fire Department

Distance from site 1 mile

2 Pond

a. Location 300 feet to the west of strip pit

b. Volume of water 200,000 cubic feet

c. Elevation 900 feet

3. Soil Stockpile

a. Location Windrows on both sides of Dale Strip Pit

b. Volume 124,700 cubic yards

4. Water Under Pressure none

a. Location ___

b. Owner ___

c. Volume of water ___

d. Pressure ___

e. Distance to fire hydrant ___

5. Comments ___

PART VI - Operational Support (Continued)

G. Safety - Bird Hazards to Aircraft:

1. Will the disposal facility be within 5,000 feet from any airport runway used by piston-type aircraft or 10,000 feet from any airport runway used by turbojet aircraft? no

2. Does the facility receive putrescible wastes like food waste, sewage sludge, septic tank pumpings, animal manures, animal carcasses, etc.? no

H. Safety - Access:

1. Will access of unauthorized persons into the facility be controlled? yes.

   How? By erection of hog-wire fence around the perimeter of the landfill

2. Will authorized persons be controlled within the facility so as not to expose them to potential health and safety hazards? yes

   How? Truck drivers and other equipment operators will be advised not to work close to edge of pit and will be issued dust masks.

I. Control Programs:

1. Dust control Water standing in strip pit will eliminate any dust for several months. Dust will be blown through pipes that extend into existing piles of dust in landfill which greatly reduces dust generation. I.M.P. owns a water tank truck which will be used in dry summer months to aid in dust compaction.
2. Odor control none
3. Noise control No additional noise will be generated at this site over that generated by operation of existing landfill and silica sand mine.
4. Other

J. Endangered Species:

Is the facility within a critical habitat or the range of an endangered or threatened species as listed pursuant to the Endangered Species Act of 1973 (16 U.S.C. 1530 ET. Seq. as amended) in 50 C.F.R. Part 17? ___ Yes X No

K. Public Utilities

	On site Yes or No	Off site Yes or No	Distance from Site	Date Available
1. Electricity	no	yes	1.8 miles	1968
2. Water	no	yes	1.8 miles	1968
3. Sewage	no	yes	1.8 miles	1968
4. Telephone	no	yes	1.8 miles	1968
5. Other (explain)				

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PART VI - Operational Support (Continued)

L. Weighing and Measuring Facilities:

1. Scales

   a. Description Truck scales are certified platform type

   b. Location Ideal Basic Industries

   c. Charges none - weight ticket issued

2. Other (specify) none

   a. Type

   b. Description

   c. Location

M. Records System (See Guide in Instructions): X Yes ___ No

Records of tonnage maintained by Ideal Basic Industries and Industrial Mineral Products.

REGISTERED PROFESSIONAL GEOLOGIST
OREGON
GLENNDA B. McLUCAS
No. [illegible]

Prepared by: Glennda B. McLucas

Glennda B. McLucas

Title: Mine Geologist

Date: 25 August, 1982

APPENDIX C-10

INTRODUCTION

Exhaust from rotary kilns used to manufacture portland cement carries to waste an average of 12 percent of the kiln feed. In compliance with federal air pollution standards, cement companies recover 96 percent of this kiln dust with electrostatic precipitators or other dust collection systems. Since the dust has value as a cementitious substance, it is re-fed into the kiln whenever possible. In some processes, such as the one employed by Ideal Basic Industries, the dust cannot be recycled because of build-up of alkalies (sodium and potassium) that would cause the cement clinker alkali content to exceed the 0.6 percent industry limit.

Most waste kiln dust is stored in surface piles or in abandoned rock quarries. The combined hauling and disposal costs to cement companies are immense; therefore, they either attempt to sell the dust or dispose of it within short distances from their plants. Markets for the dust include agricultural lime and potash fertilizer, landfills, soil stabilization, neutralization of acidic waste (e.g. coal mine drainage), absorption of SO_2 from stack gases, water treatment, glass making, and production of light-weight aggregate. Because the largest volume use for kiln dust has been for agricultural soil additives, it is difficult to understand how use of the material as a landfill can pose an environmental hazard.

Ideal Basic Industries produces 200 to 300 tons of cement kiln dust a day. They have been successful in marketing a very small percentage of their total production. Continued operation of their plant absolutely depends upon disposal of the dust because they do not own sufficient land at their plant site to store it.

For three years, Industrial Mineral Products has provided a service to Ideal Basic Industries and King County by the safe disposal of approximately 175,000 tons of kiln dust in a safe geologic environment. In the process, I.M.P. has complied with state and federal surface mining regulations that dictate back-filling of open pits so that original topography of a mine site is closely approximated. The cement dust is attractive to I.M.P. as a backfill for several reasons, among them: 1) it is available in tonnages approaching those removed by our silica sand mining operation; and 2) because the material sets up, upon contact with moisture, to a solid mass that is resistant to internal and external erosion, liquification, and slope instability, and therefore provides a near-perfect landfill.

Physical and Chemical Properties

The cement flue dust, collected by electrostatic precipitators, is composed of two types labled stage B and stage C. The ratio in weight of B to C is approximately 4:1. Bulk density of B is 58 lbs./ft^3; bulk density of C is 22 lbs./ ft^3. The difference between the two is in the grain size which results in separation of the two products. In stage B, 95 percent passes the 200-mesh sieve and in stage C, 98 percent passes the 325-mesh sieve. On a volume basis, stage B comprises 60 percent of the dust; stage C comprises 40 percent.

The mineral and chemical composition varies between the two stages depending upon the amount of burning and point of collection. A composite chemical analysis of the dust is listed below.

CHEMICAL ANALYSIS

SiO_2	12.40
TiO_2	0.07
Al_2O_3	2.92
Fe_2O_3	1.25
MgO	0.58
CaO	51.59
Na_2O	0.72
K_2O	1.29
SO_3	4.08
LOI	25.10

The mineral composition, determined by x-ray diffraction, is predominantly calcite. Lesser amounts of quartz and lime with minor gypsum are present. Acid and water baths with accompanied weight losses indicate the dust contains approximately 65 percent calcite. Gravimetric determinations of available lime demonstrate 13 percent CaO. The relatively low percent of lime shows that most of the material is unburned. There is no noticeable reaction with the addition of water and no exothermic reaction.

Regulation Pertaining to Cement Flue Dust

The Bevel Amendment to the Federal Resource Conservation and Recovery Act gave cement flue dust a three-year grace period for determining whether or not it constitutes a hazardous waste. New dangerous waste regulations (Chapter 173-303 WAC) promulgated by Washington State in March, 1982, have also excluded cement flue dust from regulation until January, 1984. The Washington State Department of Ecology will study data provided by the cement industry to assess the need for permanent exclusion. Should permanent exclusion not be granted by 1 January, 1984, the substance will be subject to regulation under Chapter 173-303 WAC.

APPENDIX C-10

The E.P.A. toxicity test is a determination of concentration of eight metals in flue dust leachates. The attached toxicity test results from Ideal Basic Industries demonstrates that the dust is far below limits established by E.P.A. standards. The reason that trace metals do not leach out of flue dust has to do with its high alkalinity (approximately 12.05 pH) Most metals are soluble only in acid; the buffering properties of the cement dust would necessitate addition of copious quantities of acid to elevate pH to the point that constituent metals would drop out.

Land Use Considerations

The Ravensdale area is historically a mining district. Cultural development has been slow. Land in the immediate vicinity of the cement dust disposal site was mined for coal through the late 1940's. Timberland was clearcut to facilitate early mining and has not been included in a timber management program until very recently. The middle third of the disposal site lies under the Bonneville Power Administration's powerline right-of-way which severely restricts future development of the site, especially for timber growth.

PART IV - SOIL AND GEOLOGICAL CHARACTERISTICS: A2 TOPOGRAPHICAL SETTING

The Dale Strip Pit, at 920 feet elevation, occupies a flat area at the top and near the westerly flank of a bedrock hill (Ravensdale Hill) three quarters of a mile southwest of the town of Ravensdale. Ravensdale Hill has a relief of 300 feet. Ravensdale Lake, at 580 feet elevation, occupies an area at the northwest base of the hill in a valley scoured out by glacial meltwater.

C1/2 SOILS

The soil cover and glacial substratum immediately overlying the Dale Strip Pit were removed and stacked in windrows or berms along both sides of the excavation. This material will be used as cover material when the landfill is complete. The original soil cover was specifically designated Alderwood Series, Ab, Alderwood and Kitsap soils (see attached map). This mapping unit is about 50 percent Alderwood gravelly sandy loam and 25 percent Kitsap silt loam. Distribution of the soils, drainage, and permeability vary within short distances.

The Alderwood series is composed of moderately well-drained gravelly loam 24 to 40 inches deep over a weakly- to strongly-consolidated, very slowly permeable substratum of glacial till (Vashon). These soils occur on uplands and terraces and formed under conifers in glacial deposits. They have convex slopes that are dominantly 0 to 30 percent but range to as much as 70 percent. Slopes greater than 15 percent are generally no more than 200 feet long as exemplified by the Dale Strip Pit locale.

The surface layer is dark-brown to grayish-brown gravelly sandy loam about 27 inches thick. The substratum is grayish-brown, weakly-to strongly-consolidated glacial till that extends to a depth of 60 inches and more.

Alderwood series soils are used predominantly for timber; the effective rooting depth is 20 to 40 inches. Low available water capacity and steepness of slope prevent use of the area for farming. The area will be well-suited to use as a wildlife habitat and for recreation, once mining and landfilling operations are complete.

Before the six feet of soil cover required by our lease-holder (Burlington Northern) is emplaced, a clay seal from our settling ponds or from clay interbeds in the sand mine will be distributed over the entire landfill surface to a depth of one foot. This seal will prevent upward migration of soluble salts into the root zone of vegetation planted during reclamation.

The cover soil has been extracted from an area designated on the attached soils map as Ab, Alderwood gravelly sandy loam, 0 to 6 percent slope. Depth to the substratum in this soil varies within short distances, but is about 40 inches in most instances. This soil is used mostly for timber growth.

D1/2 GEOLOGY

A thin (2 to 10 feet) layer of glacial till, consisting of clay, sand, cobbles, and boulders unconformably blankets much of the bedrock comprising Ravensdale Hill. The underlying bedrock is mapped as the nonmarine sedimentary rocks of the Puget Group, Eocene in age. The Puget Group is composed of sandstone and siltstone with a number of carbonaceous shale and coal beds and minor amounts of claystone and conglomerate. All gradations between sandstone and siltstone are present, most of the rocks being either silty sandstone or sandy siltstone. The sandstone beds are typically yellowish gray to light olive gray, fine-grained, micaceous, and arkosic, but in the vicinity of the Dale Strip Pit, some are quartz-rich and weathered. Most of the sandstone beds are cross-laminated and form massive outcrops. The siltstone beds are commonly medium light gray to dark gray and contain varying amounts of finely disseminated carbonaceous fragments (R. F. Wilcox and others, 1972).

The structure of the Puget Group in this area is complex, with much folding and faulting. In Section 1, T.22N., R.6E., the beds of the Puget Group have been folded into a westward-plunging syncline with the synclinal axis located justsouth of the Dale Strip Pit and trending about N80°W. The bedding on the north limb of the syncline strikes N30°W and dips approximately 50° to the west. On the south limb, the bedding strikes S45°W and dips slightly steeper at about 60° to the northwest. The syncline is terminated at about the north and south section lines of Section 1 by major faults (R. F. Wilcox and others, 1972).

PART V - DISPOSAL SITE - DESIGN AND OPERATION: B. GENERAL PLAN OF OPERATION

1. The proposed landfill method involves reclamation of the Dale Strip Pit which is approximately 40^{+} feet deep, 150 feet wide, and 1,800 feet long, with a capacity of 250,000 cubic yards. Flue dust will be blown by pneumatic transport trucks over the bank of the excavation where it will encounter at least 10 feet of standing water. Upon contact with this water, the cement dust

will set up and form a seal on the bottom and sides of the excavation that will further reduce the probability of leachate percolation through the substrate.

2. The schedule of filling will begin upon completion of the proposed haul road (approximately 1 November) and upon approval by regulatory agencies of this disposal site permit application. At present dumping rates, the landfill should have a life of three to four years. Vehicles will deliver dust five days a week, around the clock, at an average volume of 422 yards per day.

3. The Dale Strip Pit will be prepared for filling with cement flue dust in the following manner: a) a new haul road will be constructed as delineated on the accompanying map across land currently under lease by I.M.P.; b) a road that parallels the rim of the Dale Strip Pit to the east will be upgraded to accomodate the pneumatic cement dust delivery trucks and will include at least two turn-around circles. Flue dust will be blown out of trucks parked on this road; c) the Dale Strip Pit will be brushed out near its upper rim to facilitate placement of hoses and use of heavy equipment; d) additional fill material will be added at the dam mentioned in the attached METRO report, to insure that flue dust does not migrate to the extreme southern portion of the strip pit. This fill material will become part of the new haul road system.

4. The unloading area will be represented by the entire length of the road that borders the eastern side of the Dale Strip Pit (see accompanying map). From this road, truck operators can place their flexible rubber hoses over the pit bank and blow flue dust down into standing water.

5. Dumping will begin at the southern end of the strip pit, then progress northward along the entire length of the pit. The cross-sectional area of the pit is 6,000 square feet. This is probably representative of the area that we will be actively operating in at any given time.

7. Initially, the flue dust will be solidified and compacted by the 10+ feet of water standing in the bottom of the pit. Following addition of the volume of flue dust necessary to absorb this 4,000,000 gallons of water, the dust will be compacted by addition of water from a company tank truck.

When the first segment of the southern end of the excavation is full, a clay cap will be applied and the soil stockpile bordering the pit will be pushed over the top to at least six feet depth. This will allow entry of heavy equipment onto the fill for compaction of the dust, as we progress northward along the length of the excavation. Application of cover material will then be a progressive process that takes place during the entire life of the landfill.

9,13,16. Surface water management and erosion control are not a serious consideration at this site. The excavation occupies a plateau at the top of Ravensdale Hill. No surface streams exist in association with the fill. Sheet wash in the immediate vicinity will drain into the pit. The final reclaimed site will be flat to slightly convex such that surface runoff will not be ponded over the finished fill. We will dome the cover enough to accomodate some inevitable compaction of the fill to insure that surface water ponding does not occur.

10. Dust control will initially be achieved by blowing the dust directly into water in the pit. Following depletion of this water supply, water will be added to the dust by a company tank truck, mostly in dry summer months when rainfall is at a minimum.

14. Traffic control is not a serious consideration at this site. Most of the time only one truck is unloading dust at the landfill. This proposed new landfill site is completely removed from the vehicle activity associated with the sand mine, such that traffic congestion will be reduced beyond its present level. Two truck turn-arounds are being constructed along the pit dump road to facilitate entrance and exit from the pit. Additionally, delivery trucks are equipped with radios for driver communication.

17, 18. Revegetation will follow emplacement of soil cover over the final segment of the fill. Fertilization and grass seeding will be supervised by Burlington Northern. Location of the landfill under the BPA powerlines will largely dictate the type of vegetation that is selected.

Final site maintenance will be minimal since there will be no release of gas from this site. Maintenance of vegetation falls under the jurisdiction of the BPA and Burlington Northern. I.M.P. will continuously monitor the Dale Mine Portal discharge to detect any pH change in this water. Should the pH rise above ± 9, the limit for state surface waters, a treatment/neutralization facility will be designed and operated until water pH is no longer a problem.

APPENDIX C-10

Inter-Office Correspondence

Date: June 16, 1981

Office: Research

EPA Toxicity Test Results

IDEAL

To: Mr. R. E. Wallis

From: J. W. Yule

Subject: Seattle Waste Dust

Two (2) samples of Seattle waste dust collected when different iron sources were in use were analyzed according to the EPA Toxicant Extraction Procedure (Federal Register, Vol. 45, No. 98, Monday, May 19, 1980) as follows:

EPA Hazardous Waste Number	Contaminant	EPA Maximum Concentration (mg/L)	Determined Values (mg/L) 80-752 Iron-BMS	Determined Values (mg/L) -1070 Iron-TS
D004	As	5.0	<0.01	<0.01
D005	Ba	100.0	1.3	1.4
D006	Cd	1.0	0.04	0.04
D007	Cr	5.0	0.10	0.10
D008	Pb	5.0	0.25	1.1
D009	Hg	0.2	<0.01	<0.01
D010	Se	1.0	<0.01	<0.01
D011	Ag	5.0	0.05	0.05
	pH	12.5 Max.	12.40	12.45

JWY/lca

cc: F. J. Bauer
R. J. Castelli
N. R. Greening

JWYule

APPENDIX C-11

Seattle-King County/**DEPARTMENT OF PUBLIC HEALTH**
400 Yesler Way Seattle, Washington 98104 (206) 625-2161

October 25, 1982

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

Industrial Mineral Products, Inc.
P.O. Box 95
Ravensdale, WA 98051

Attention: Glennda McLucas

Dear Glennda:

This office has reviewed Industrial Mineral Product's application for establishing a new flue dust disposal site. The information presented in the application appears to be consistent with the applicable standards in King County's Minimum Functional Standards for Solid Waste, Rules and Regulations VIII. We therefore approve your application on the basis that you utilize the existing permit to warrant the operation of the new fill site through the remainder 1982.

The current permit does not authorize the site to accept pickle liquor or any other potentially dangerous/extremely hazardous waste without specific approval of both this office and the State Department of Ecology. For this reason, the matter of determining what substance(s) can or cannot be introduced to the new site for burial will be handled on a case-by-case basis.

The "old" site should receive final cover as per Section 4.05 C.5 of Rules and Regulations VIII. A plan reflecting the final cover phase of the operation should be forwarded to this office for review.

If you have any questions or wish further information, please contact me at 625-2125.

Sincerely,

Greg Bishop

Greg Bishop
Solid Waste Program Supervisor

GB:mg

cc: Larry Kirchner
Southeast Health District
Bob McCormick
Redmond Office, DOE
Mark Mitchell
Grading Permits, BALD

District Service Centers:

CENTRAL
1500 Public Safety Bldg.
Seattle 98104
625-5536
Environmental Health Services

NORTH
10501 Meridian Ave. N.
Seattle 98133
363-4765

COLUMBIA HEALTH CENTER
3722 S. Hudson
Seattle 98118
625-5151

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10820 8th Ave. S.W.
Seattle 98146
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2424 156th Ave. N.E.
Bellevue 98007
885-1278

SOUTHEAST
Renton
3001 N.E. 4th St.
Renton 98056
228-2620
Auburn

APPENDIX C-12

Seattle-King County / **DEPARTMENT OF PUBLIC HEALTH**
400 Yesler Way Seattle, Washington 98104 (206) 625-2161

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

December 15, 1982

Victor Hoffman, President
Industrial Mineral Products
P.O. Box 95
Ravensdale, WA 98051

Dear Mr. Hoffman:

Please complete and return the enclosed renewal application with the appropriate fee for the following disposal site:

Special waste site - Industrial Mineral Products (Ravensdale Site)

Annual Permit Fee: $100.00

If you have questions concerning the renewal application please contact Greg Bishop at 587-2722.

Sincerely,

John P. Nordin
Chief of Environmental Health Services

JPN:gbg
Enc.

District Service Centers:

CENTRAL
1500 Public Safety Bldg.
Seattle 98104
625-5536

Environmental Health Services
172 20th Ave.
Seattle 98122
625-2763

NORTH
10501 Meridian Ave. N.
Seattle 98133
363-4765

COLUMBIA HEALTH CENTER
3722 S. Hudson
Seattle 98118
625-5151

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Seattle 98146
244-6400

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Bellevue 98007
885-1278

SOUTHEAST
Renton
3001 N.E. 4th St.
Renton 98056
228-2620

Auburn
20 Auburn Ave.
Auburn 98002
852-8400

APPENDIX C-12

SEATTLE-KING COUNTY
DEPARTMENT OF PUBLIC HEALTH

RENEWAL APPLICATION FOR
ANNUAL DISPOSAL SITE PERMIT

Part I

Date of Application 19 December, 1982

Name of Site: Industrial Mineral Products' Industrial Waste Disposal Site
Site Attendant/Manager Glennda McLucas
Address: 26000 Black Diamond-Ravensdale Highway, Ravensdale, WA 98051
Phone (if any): 432-3910
1982 Permit No. 17-101
Owner: Victor J. Hoffmann, Industrial Mineral Products, Inc.
Address: P.O. Box 95, Ravensdale, WA 98051
Phone: 432-1286

Type of Facility: (check) Industrial Waste Landfill

Sanitary Landfill ___
Non-putrescible Landfill X
Transfer Station ___
Drop Box Facility ___

Incinerator (Standard) ___
Incinerator (Steam Recovery) ___
Composting Facility ___
Reclamation Site X

Part II

GOVERNMENT APPROVAL

Health Department

1982 Solid Waste Permit Classification: Conforming X Non-Comforming ___

NOTE: If Non-Comforming, please describe status of compliance with each of the conditions that accompanied the permit and attach it to the application.

Other

The applicant has appropriate operating permits and follows guidelines established by other Department/Agencies (e.g. Puget Sound Air Pollution Control Agency, Zoning, Planning, Department of Ecology, etc.) Yes X No ___

NOTE: If no, indicate deficiency and measures taken to conform

APPENDIX C-12

Part III

SOLID WASTE CHARACTERISTICS

Please indicate any changes or updated information you may have in the following categories that would be different from that indicated in your original permit application: No changes

A. Source or Type:	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
1. Garbage			
2. Rubbish			
3. Ashes			
4. Bulky Wastes			
5. Abandoned vehicles			
6. Construction and demolition wastes			
7. Industrial wastes			
8. Hazardous waste			
9. Sewage treatment residues			
10. Street refuse			
11. Litter			
12. Agricultural waste			
13. Mining wastes			
14. Other			

B. Daily Waste Quantities	Volume	Weight
1. Estimated per capita daily waste quantities	266 yards	285 tons
2. Maximum daily volume or weight	935 yards	1,000 tons
3. Average daily volume or weight	266 yards	285 tons

4. Additional comments 1 yard=1.07 tons

APPENDIX C-12

C. Daily Customer Traffic **Number**

1. Estimate number of transfer vehicles ________
2. Estimated number of municipal collection vehicles ________
3. Estimated number of private collection vehicles ________
4. EStimated commercial/industrial/special trucks 5
5. Estimated residential pickup trucks/station wagons daily ________
6. Estimated residential cars ________
7. Additional comments ________

Part IV. GENERAL OPERATION

Please indicate any significant change, modification, addition or deletion in your general method of operation from that described in your original permit application (e.g. new equipment, road surfacing, installation of dust control sprinklers, noise control measures, traffic revision, blowing litter control, leachete collection, etc.):

As of 25 October, 1982, Industrial Mineral Products has changed the location of its Industrial Waste Landfill. The old pit has been phased out and is presently being capped with clay. The new landfill, the Dale Strip Pit, is now receiving the cement dust. The pit has been fenced and posted. A new road was constructed to accomodate tranker-truck delivery to this disposal site.

(Use additional sheets if necessary)

Prepared by Glenda M Lucas

Phone 432-3910

Date 12/20/82

APPENDIX C-12

Seattle-King County/**DEPARTMENT OF PUBLIC HEALTH**
400 Yesler Way Seattle, Washington 98104 (206) 587-4600

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

MEMORANDUM

December 23, 1983

TO: Industrial Mineral Products
Attn. Victor, Hoffman, President

FROM: John P. Nordin
Chief of Environmental Health Services

Please complete and return the enclosed renewal application with the appropriate fee for the following disposal site:

Special Waste Site - Industrial Mineral Products (Ravensdale Site)

Annual Permit Fee: $100.00

If you have questions concerning the renewal application please contact Greg Bishop at 228-2620.

JPN:rb
Enc.

District Service Centers:

CENTRAL
1500 Public Safety Bldg.
Seattle 98104
587-2755

Environmental Health Services
172 20th Ave.
Seattle 98122
587-4632

NORTH
10501 Meridian Ave. N.
Seattle 98133
363-4765

COLUMBIA HEALTH CENTER
3722 S. Hudson
Seattle 98118
587-4650

SOUTHWEST
10820 8th Ave. S.W.
Seattle 98146
244-6400

EAST
2424 156th Ave. N.E.
Bellevue 98007
885-1278

SOUTHEAST
Renton
3001 N.E. 4th St.
Renton 98056
228-2620

Auburn
20 Auburn Ave.
Auburn 98002
852-8400

APPENDIX C-12

INDUSTRIAL MINERAL PRODUCTS, INC.

P.O. BOX 95 RAVENSDALE, WASHINGTON 98051 (206) 432-1286

2 February, 1984

Seattle-King County Department of Public Health
400 Yesler Way
Seattle, WA 98104

Gentlemen:

Enclosed please find the completed renewal application for the Industrial Mineral Products Dale Strip Pit Industrial Waste Disposal Site. Accompanying the renewal application is a check (no. 20710) in the amount of $100.00 to satisfy the annual permit fee.

Sincerely,

Glennda McLucas, Geologist

APPENDIX C-12

SEATTLE-KING COUNTY
DEPARTMENT OF PUBLIC HEALTH

RENEWAL APPLICATION FOR 1984
ANNUAL DISPOSAL SITE PERMIT

Part I

Date of Application 1/31/84

Name of Site: DALE STRIP PIT INDUSTRIAL MINERAL PRODUCTS INDUSTRIAL WASTE SITE (RAVENSDALE)

Site Attendant/Manager G. McLUCAS

Address: P.O. BOX 95 RAVENSDALE, WA 98051

Phone (if any): 432-3910

Owner: BURLINGTON NORTHERN RAILROAD (MERIDIAN LAND

Address: AND MINERAL Co.) 1 BELLEVUE CENTER, 411 108th Ave N BELLEVUE, WA 98004

Phone: 451-7180

Type of Facility: (check)

Sanitary Landfill ___
Non-putrescible Landfill X
Transfer Station ___
Drop Box Facility ___

Sludge Utilization Site ___
Incinerator (Standard) ___
Incinerator (Steam Recovery) ___
Composting Facility ___
Reclamation Site X

Part II

GOVERNMENT APPROVAL

Health Department

1983 Solid Waste Permit Classification: Conforming _______ Non-Comforming _______

NOTE: If your 1983 permit included specific conditions, please describe status of compliance with each of the conditions that accompanied the permit and attach it to the application.

Other

The applicant has appropriate operating permits and follows guidelines established by other Department/Agencies (e.g. Puget Sound Air Pollution Control Agency, Zoning, Planning, Department of Ecology, etc.) Yes _______ No _______

NOTE: If no, indicate deficiency and measures taken to conform

APPENDIX C-12

Part III

SOLID WASTE CHARACTERISTICS

Please indicate any changes or updated information you may have in the following categories that would be different from that indicated in your original permit application:

DALE STRIP PIT ONLY

A. Source or Type:	Description (If necessary)	Present Volume (Tons)	Projected Volume (Ten Years) Tons
1. Garbage			
2. Rubbish			
3. Ashes			
4. Bulky Wastes			
5. Abandoned vehicles			
6. Construction and demolition wastes			PROJECTED LIFE OF LANDFILL
X 7. Industrial wastes	CEMENT KILN DUST	TO DATE 47,500 TONS	~~4 YEARS~~ 162,720
8. Hazardous waste			
9. Sewage treatment residues			
10. Street refuse			
11. Litter			
12. Agricultural waste			4 years
X 13. Mining wastes, BRICKS and CULLET FROM Customers		TO DATE 4500 TONS	15,000
14. Other			

B. Daily Waste Quantities

	Volume	Weight
1. Estimated per capita daily waste quantities N/A	15 YARDS	15 TONS
2. Maximum daily volume or weight	590 YARDS	295 TONS
3. Average daily volume or weight	308 YARDS (BEFORE COMPACTION)	154 TONS

4. Additional comments TONNAGES REPORTED FOR DALE STRIP PIT ONLY — OLD LANDFILL NOW COMPLETELY RECLAIMED DALE PIT OPERATIONAL SINCE 1 NOV. 1982. TONNAGES DETERMINED FROM RECORDS MAINTAIN FROM 11/82 to 10/83.

C. Daily Customer Traffic — Number

1. Estimate number of transfer vehicles 3
2. Estimated number of municipal collection vehicles
3. Estimated number of private collection vehicles
4. EStimated commercial/industrial/special trucks 1 (pneum
5. Estimated residential pickup trucks/station wagons daily
6. Estimated residential cars
7. Additional comments HAULING CONTRACTOR, Jerry Gee DELIVERS ALL DUST IN 1 truck; OTHER SOLID WASTE BACKHAULED IN COMPANY-owner 25-TON CAPACITY TRUCK-TRAILER Combos.

Part IV. GENERAL OPERATION

Please indicate any significant change, modification, addition or deletion in your general method of operation from that described in your original permit application (e.g. new equipment, road surfacing, installation of dust control sprinklers, noise control measures, traffic revision, blowing litter control, leachate collection, monitoring schedule, etc.):

In JANUARY 1984, IDEAL BASIC INDUSTRIES ENGINEERI STAFF DESIGNED AND INSTALLED A DUST ABATEMEN DEVICE that ATTACHES TO END OF PVC PIPE. THROUGH WHICH DUST IS BLOWN into LANDFILL. THIS CANVAS BAG, COMPLETE WITH INTERNAL BAFFLES SLOWS DOWN VELOCITY OF DUST AND FEEDS IT MORE SLOWLY INTO LANDFILL SO THAT FUGITIVE DUST IS GREATLY REDUCE MIDDLE PORTION OF FILL (UNDER BPA Powerlines) WILL BE COVERED OVER WITH SOIL in MID 1984, AN SEEDED.

(Use additional sheets if necessary)

Prepared by McLucas

Phone 432-3910

Date 2/2/84

APPENDIX C-13

Seattle-King County / **DEPARTMENT OF PUBLIC HEALTH**
400 Yesler Way Seattle, Washington 98104 (206) 587-4600

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

September 6, 1984

Victor Hoffman, President
Industrial Mineral Products
P.O. Box 95
Ravensdale, WA 98051

Dear Mr. Hoffman:

Re: Status of Solid Waste Disposal Site Permit
Renewal Application at Ravensdale Silica Sand Mine

We have completed our review of the above indicated Solid Waste Disposal Site Permit Application. Based on the information presented in the application and discussion with the Department of Ecology, this office cannot issue a Special Disposal Site Permit for your cement kiln dust operation.

Cement kiln dust is presently considered a Dangerous Waste by the Department of Ecology, and hence, cannot be regulated by this office as a solid waste. Due to this fact, the cement kiln dust disposal operation is now under the direct regulatory authority of the Department of Ecology.

Should you have questions pertaining to this matter, please contact me at 587-2722.

Sincerely,

Greg Bishop

Greg Bishop, Coordinator
SOLID WASTE PROGRAM

GB:rb

cc: Bob McCormick, Redmond D.O.E.
Avery Wells, Olympia D.O.E.
Jeff Everest, Southeast Health Office
Glenda McLucas, Industrial Mineral Products, Inc. ✓

District Service Centers:

CENTRAL
1500 Public Safety Bldg.
Seattle 98104
587-2755

Environmental Health Services
172 20th Ave.
Seattle 98122
587-4632

NORTH
10501 Meridian Ave. N.
Seattle 98133
363-4765

COLUMBIA HEALTH CENTER
3722 S. Hudson
Seattle 98118
587-4650

SOUTHWEST
10820 8th Ave. S.W.
Seattle 98146
244-6400

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Bellevue 98007
885-1278

SOUTHEAST
Renton
3001 N.E. 4th St
Renton 98056
228-2620

Auburn
20 Auburn Ave
Auburn 98002
852-8400

APPENDIX C-13

Seattle-King County / DEPARTMENT OF PUBLIC HEALTH
400 Yesler Way Seattle, Washington 98104 (206) 587-4600

September 20, 1984

JESSE W. TAPP, M.D., M.P.H.
Director of Public Health

James Knudson
Solid and Hazardous Waste
Management Division
Department of Ecology, MS PV-11
Olympia, WA 98504

Dear James:

Re: Industrial Mineral Product Kiln Dust Disposal

This letter is in response to your September 13, 1984 letter to this office concerning the above noted situation.

The Seattle-King County Department of Public Health is supportive of your recommendation for the interim storage of cement kiln dust at the Industrial Mineral Products' site. However, since the material in question is not presently classified as a solid waste, this office cannot issue an operation permit for Industrial Mineral Products' site.

In the interest of public health this office recommends that the interim storage of cement kiln dust at Industrial Mineral Products be:

1. Located within a fenced area or site otherwise secure from public entry;
2. Situated so as to preclude off side runoff.

It is the Seattle-King County Department of Public Health's understanding that Industrial Mineral Products has until November 18, 1984 to comply with interim status standards or terminate their acceptance of cement kiln dust waste.

Please keep the office informed of any relevant factors involved in this matter.

Sincerely,

Greg Bishop

Greg Bishop, Supervisor
Solid Waste Program

GB:mt

cc: Greg Gregory, Redmond DOE
Glenda McLucas
Industrial Mineral Products, Inc.
Wally Swofford, Technical Support

District Service Centers:

CENTRAL
1500 Public Safety Bldg.
Seattle 98104
587-2755

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587-4632

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Bellevue 98007
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SOUTHEAST
Renton
3001 N.E. 4th St
Renton 98056
226-2620

Auburn
20 Auburn Ave
Auburn 98002
852-8400

APPENDIX D

INFORMATION ON

CEMENT AND CONCRETE

IDEAL BASIC INDUSTRIES, 1984

APPENDIX D-1 Return To A. W. Ayers

CEMENT and CONCRETE

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ENCYCLOPAEDIA BRITANNICA
(Copyright 1963)

PORTLAND CEMENT ASSOCIATION
33 West Grand Avenue, Chicago, Illinois 60610

CEMENT. The word "cement" is from the Latin verb "to cut," and originally had reference to stone cuttings used in lime mortar. Thus, it is logical that in the middle ages the mortar itself was commonly called cement. In correct modern usage, cement generally means only the chemical binder, and the term may be used with respect to any material serving such a purpose.

Ranking, in volume of production, far above all other cements are the general construction cements—powdered inorganic cementitious materials that are mixed with water and sand to make mortar; and with water, sand and larger stone particles to make concrete.

Some modern organic plastics are attaining some use as cementitious building materials. When called cements they are often actually mortars, carrying inert filler. They are classed, in this article, among the adhesive cements.

Most construction cements are hydraulic cements; *i.e.,* ones that are not only mixed with water but will set and harden under water. They are composed of the commoner oxides of the earth's crust, and depend for their hydraulic property on chemical compounds of lime that react with water. Of the hydraulic cements, by far the most important is portland cement—the direct descendant of older types which it has largely supplanted. Portland-slag and portland-pozzolan cements are blends containing portland cement.

In the early 1960s, world production of hydraulic cement was over 350,000,000 short tons. The United States produced more than any other country, while the U.S.S.R., Federal Republic of Germany, Japan, China, Italy, France and Great Britain were other large producers.

Because of the great importance of portland cement, it is given major attention in this article; other cementitious materials are briefly discussed under *Other Cements.*

PORTLAND CEMENT

Portland cement is a finely ground powder, usually gray, which when mixed with water hardens and develops strength primarily because of a large content of anhydrous calcium silicates. These and other constituents react chemically with the water by hydration and hydrolysis. The most common raw materials are limestone and clay or shale. The raw mix is finely ground and heated to about 1,500° C. to decompose the calcium carbonate and recombine the calcium oxide; a partly fused clinker of marble size and larger is produced. The clinker is then ground, almost always with a small amount of calcium sulfate (gypsum), which retards set.

APPENDIX D-1

Portland cements with special properties are produced by varying the oxide composition, and also by adding small amounts of chemical agents at the clinker-grinding stage or later.

Early investigators advanced divergent theories as to why portland cement forms a rigid, strongly coherent mass when it reacts with water. It has since been established that a colloidal gel of high internal surface area is formed. Whatever the extent of direct chemical continuity, it is apparent that large internal surface forces may also be involved.

How Portland Cement Is Used.—A mixture of cement and water is called neat cement paste, whether fresh or hardened. In some grouting operations, including oil-well cementing, the paste is used as such. Generally, however, it constitutes the hardening ingredient in mortar or concrete. This use of sand and stone filler, called aggregate, is an economy, and also reduces shrinkage. The cement paste ordinarily amounts from 20% to 35% of the volume of the concrete. Since plain concrete is not nearly so strong in tension as in compression, steel reinforcement is embedded in structural concrete to provide greater strength in tension. (For information on the technology of concrete, *see* CONCRETE.) Another use of portland cement is in soil-cement mixtures, used as pavement base. Portland cement is also mixed with asbestos fibre and water, and processed to make special products.

In the United States, the annual tonnage of concrete made with portland cement greatly exceeds the combined tonnage of all other construction materials. Concrete is used in residential, farm and public building construction; in pavements, dams, bridges, silos, piping, tanks, reservoirs, revetments, swimming pools, ornamentation, etc. Like organic plastics, it derives much of its utility from the fact that it is readily cast or molded into shape.

Concrete is used extensively for shielding against nuclear radiation. It is used around reactors and particle accelerators, and for construction of radiation shelters. Sometimes special, heavy aggregates are used to reduce required thicknesses.

History.—The Egyptians used impure gypsum plaster as mortar in pyramid construction. Slaked lime was used by the Greeks, and the Romans probably learned of its utility from them. Both the Greeks and Romans made a pozzolanic mortar by mixing finely ground volcanic material with lime, sand and water. Pozzolana hardens by reacting chemically with the lime. The name derives from the Italian town Pozzuoli, where a suitable volcanic tuff was found. The Romans also used powdered pottery fragments as pozzolana. The pozzolanic cements made by mixing such materials with lime and water were found to be resistant if exposed to

water, and were for a long time the only cements known to be suitable for such exposure. Pozzolanic cement was used in such structures as the Roman Pantheon, and Colosseum. In the middle ages the quality of mortar declined. It was commonly a sand-lime mortar, and the lime was poorly burned.

In 1756 when John Smeaton was commissioned to rebuild the Eddystone lighthouse off Cornwall, Eng., a lime-pozzolana mortar was the recognized material for underwater construction, but it was not always satisfactory. Smeaton experimented and found that the better limes were those made from limestone containing considerable clay. He is thus credited with being the first to recognize what constitutes a hydraulic lime. In 1796, James Parker in England patented a hard-burned impure lime. His product, which he called Roman cement, attained wide use. It was essentially a natural cement (see *Other Cements*, below) in that it did not slake (absorb water and crumble) but required grinding. This was true of natural cements produced, from the late 1820s, in the United States from "cement rock." A considerable natural-cement industry developed.

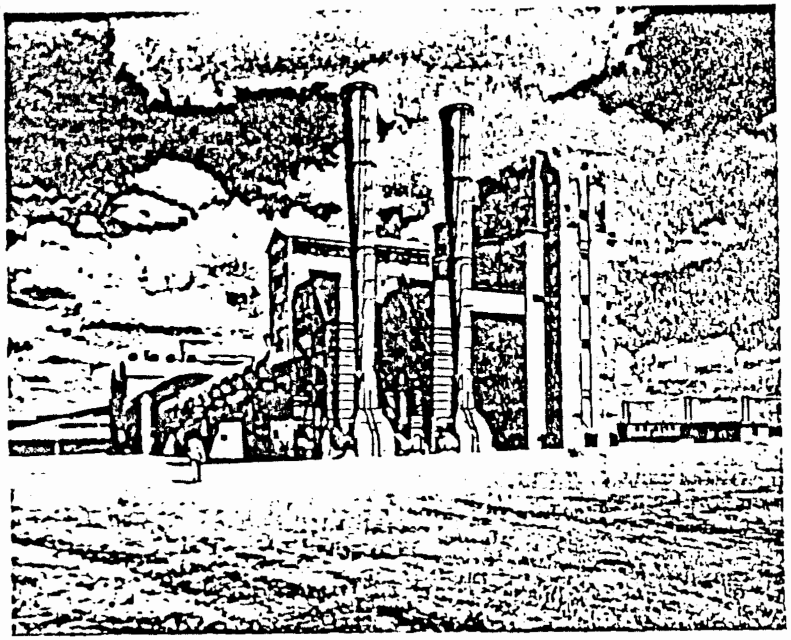
In 1824, a process for making "portland cement" was patented by Joseph Aspdin in England. He chose the name because of a fancied resemblance of the cement products to portland stone, a limestone quarried at Portland, Eng. Aspdin, by having conferred the name, is commonly considered to be the inventor of what has become the modern portland cement. Authorities recognize, however, that the matter is controversial because of other similar early developments. Modern portland cement is a logical scientific development from natural cement.

Methods of production have naturally changed greatly over the years. Early firing was in stationary, intermittently operated kilns. Production was on a small scale and the cement was ground with millstones. Kilns underwent various changes, but the most striking was the introduction of the rotary kiln. In 1877, T. R. Crampton obtained a British patent on a rotary kiln process for cement, but it was not a success. Frederick Ransome obtained British and U.S. patents in 1885 and 1886 for a process that achieved first success in the United States and led eventually to complete adoption of the rotary kiln for production of portland cement in that country. In Europe the continuously operating shaft kiln has remained a competitor.

MODERN PRODUCTION OF PORTLAND CEMENT

RAW MATERIALS

Cement raw materials may be divided into those essentially supplying the lime component (calcareous), the silica component



General view of a portland cement manufacturing plant

(siliceous), the alumina component (argillaceous) and the iron component (ferriferous). In the United States and Canada 30 different raw materials are used as listed in Table I. The oxide composition of various cement raw materials is given in Table II.

TABLE I.—*Raw Materials for the Production of Portland Cement*

Calcareous	Argillaceous	Siliceous	Ferriferous
Cement rock	Clay	Sand	Iron ore
Limestone	Shale	"Traprock"	Iron calcine
Marl	Slag	Calcium silicate	Iron dust
Alkali waste	Fly ash	Quartzite	Iron pyrite
Oyster shell	Copper slag	Fuller's earth	Iron sinters
Coquina shell	Aluminum ore refuse		Iron oxide
Chalk	Staurolite		Blast-furnace flue dust
Marble	Diaspore clay		
	Granodiorite		
	Kaolin		

Cement rock is a low-magnesium limestone containing clay. The Jacksonburg limestone of the Lehigh valley (Pa.) is a well-known example.

Limestones are composed essentially of calcium carbonate, varying minor percentages of magnesium carbonate and mechanically admixed impurities of clay and sand. Clay and sand are not objectionable impurities when the rock is used for the manufacture of portland cement. They supply the alumina, silica and iron oxide necessary for the formation of the desired silicates in the cement. The term "limestone" is used to include all carbonate rocks containing major quantities of calcium. However, because of its high magnesium content, dolomite (a carbonate of calcium and magnesium), cannot be used for the production of portland cement.

TABLE II.—*Per Cent Oxide Composition of Typical Cement Materials*

Type	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Ignition loss
Limestone . . .	1.2	0.5	0.4	54.0	0.6	43.2
Limestone . . .	5.6	1.0	0.5	50.7	0.8	41.2
Cement rock . .	14.2	4.8	1.6	40.2	2.8	34.2
Sand	89.7	2.4	0.7	0.6	0.7	5.9
Clay	67.8	14.3	4.5	0.9	1.2	8.0
Shale	63.0	20.0	5.5	0.7	2.7	6.0
Pyrite cinders . .	6.3	2.1	86.7	0.02	0.1	2.6
Slag	37.8	11.4	1.0	46.1	2.0	—
Sea shells (washed) .	1.5	0.4	1.2	52.28	0.7	41.8
Fly ash . . .	51.2	25.6	8.5	1.6	0.9	8.6

Marls are earthy, friable accumulations of calcareous material secreted by plants and animals in lakes and marshes. Over long periods of time the skeletal remains of plants mixed with shells of animals may form beds as much as 30-ft. thick, containing substantial tonnages of material suitable for cement manufacture.

Shell marls consist of mixtures of fossil shells, shell fragments and varying amounts of clay and sand.

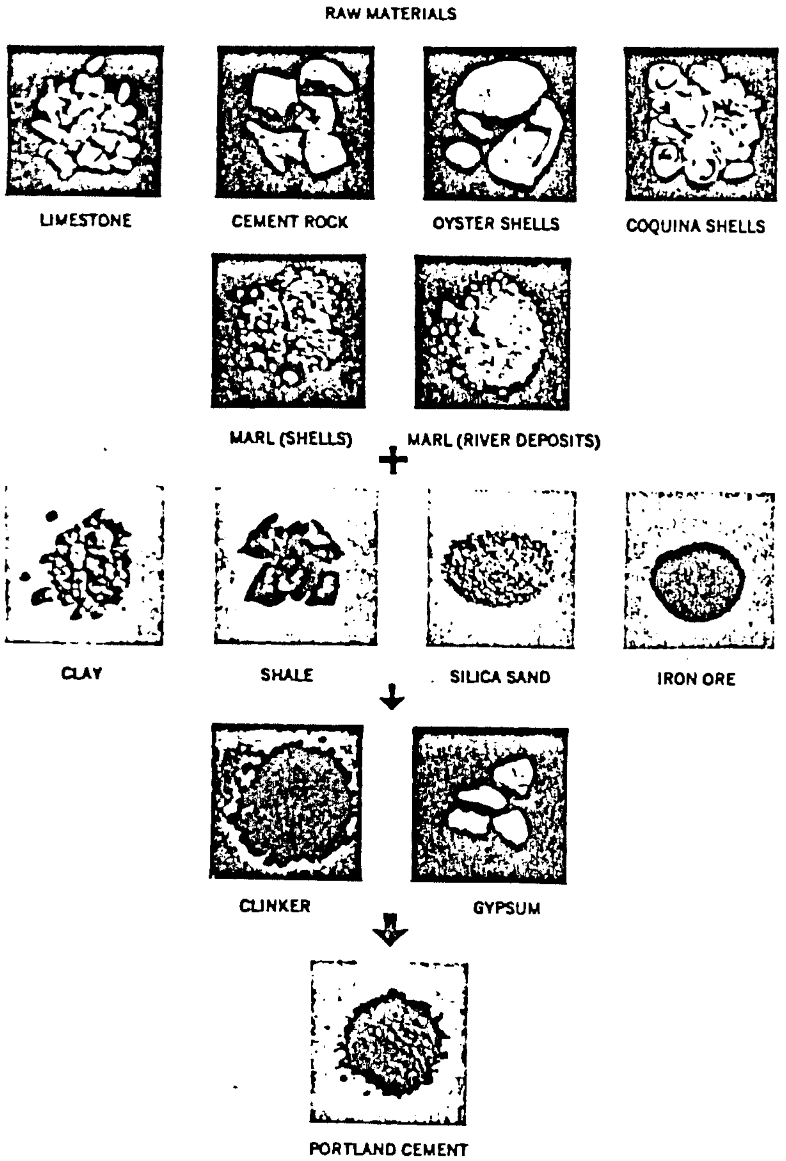
A process used in several places in England and France is based on simultaneous production of sulfuric acid and portland cement from gypsum with addition of argillaceous components.

Oyster and clam shells of recent origin have been collected and burned for lime from Nova Scotia to Texas. Tonnage adequate for cement manufacture, however, is not known on the Atlantic coast of North America. In San Francisco bay shells occur in brackish water deposits as much as 30-ft. thick, and are suitable for cement manufacture. Along the Gulf of Mexico, oyster shells are the principal source of lime for cement manufacturers at Corpus Christi and Houston, Tex., Baton Rouge, La., and Mobile, Ala.

Coquina shells, used in Florida, are excavated under water and cleaned completely or partially of their sand content by washing.

Chalk, a soft, friable form of calcium carbonate of high purity, is used for cement manufacture in Denmark, England, France and Belgium, where it occurs abundantly.

APPENDIX D-1



BY COURTESY OF PORTLAND CEMENT ASSOCIATION

FIG. 1.—RAW MATERIALS USED IN THE MANUFACTURE OF PORTLAND CEMENT

Clay and shale must be added where alumina and silica are not present in the limestone in sufficient amounts (and this is true for operations other than those based on cement rock). Clay is earthy, easily disintegrated and widely distributed; shales are composed of clay minerals deposited in water in thin layers and subjected to some pressure and cementation, with some lithification. Shales are weak rocks but do not disintegrate as readily as the unconsolidated clays and therefore require grinding.

Basic blast-furnace slag may be substituted in part for the raw materials used in the production of portland cement. The slag is mixed with limestone and serves to introduce a part of the lime, silica, alumina and iron oxide.

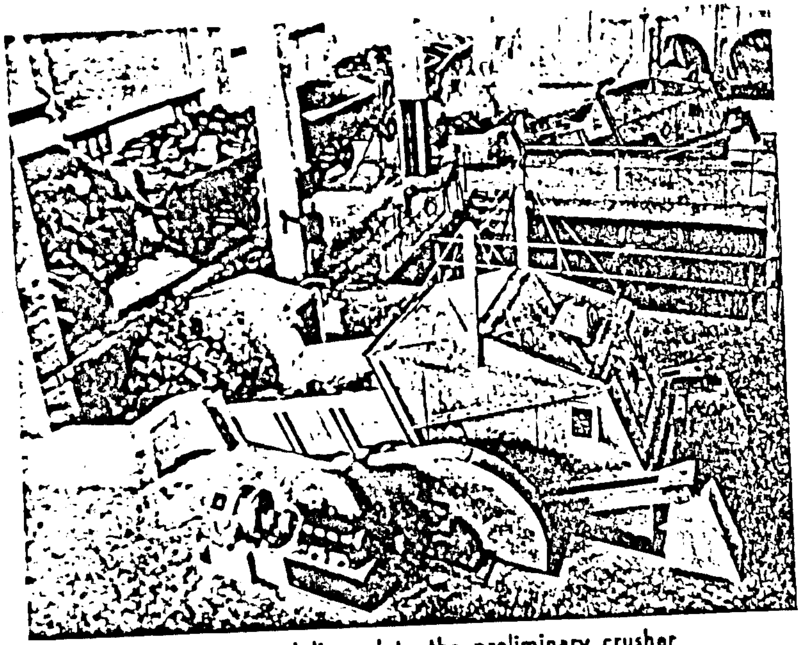
A raw material which was not used much in the first half of the 20th century but which showed promise of becoming important is fly ash from power stations employing direct-firing coal mills. Such fly ash has a composition fairly close to that of portland-cement argillaceous raw material.

Iron materials commonly used are iron ores, pyrite cinders (the product of the calcination of pyrite) and mill scale (from hot-rolling of steel).

PROCESSING

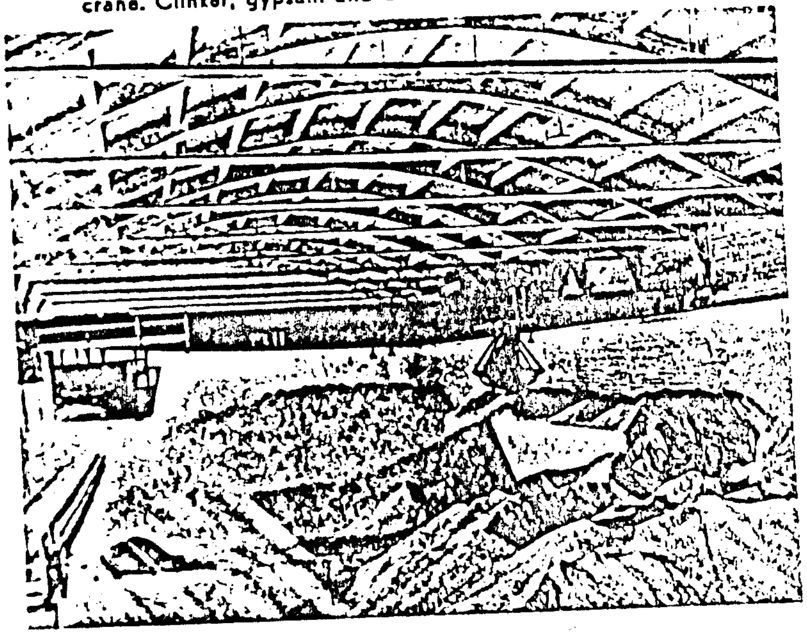
Processing of the raw materials into finished cement embraces four stages (*see* fig. 2): (1) size reduction (blasting, crushing, grinding) to obtain the fineness and surface which will permit the chemical reactions to take place between the components, and formation of the cement compounds during the subsequent pyroprocessing (burning); (2) blending, correction and homogenization of the raw mix to obtain exactly the desired composition and uniformity; (3) liberation of carbon dioxide (calcination) and burning to form new compounds; (4) fine pulverization of kiln product (clinker), with addition of gypsum.

Crushing.—Various types of crushers are used in the cement industry depending on the nature (hardness, lamination, quarry-product size) of the rock. These include gyratory crushers in which a steel cone moves eccentrically inside a cone-shaped housing; jaw crushers in which the rock is broken between breaker plates whose motion is substantially horizontal; roll crushers where the reduction takes place between two rolls or between one roll and a breaker plate, the rolls frequently being equipped with case-hardened steel teeth; hammer mills in which the rock is fractured by heavy hammers swung from a horizontal shaft and flung against the rock by centrifugal action; and impact mills, a variation of hammer mills where no internal grates are required and where the hammers bounce the pieces of rock against breaker plates. When



Rocks being delivered to the preliminary crusher

Crushed rock being emptied into storage bins by a travelling crane. Clinker, gypsum and crushed limestone are stored



hammer mills are used, the rock is sometimes screened ("scalped") for removal of pieces too large to be handled by the crusher.

Grinding.—The various components are usually moved from raw material storage by overhead crane and deposited in roughly the desired proportions in concrete bins above feed hoppers serving the grinding mills.

In the grinding of the raw materials, two processes are used: the dry process in which the materials are dried to less than 1% moisture and then ground to a fine powder; and the wet process in which the grinding takes place with addition of water to the mills to produce a pulp or "slurry."

The use of the two processes in the United States is distributed approximately as shown in Table III.

TABLE III.—*U.S. Use of Wet and Dry Processes in Grinding Cement*

Distribution	Per cent wet	Per cent dry
By production capacity	58	42
By plants	60	40
By number of kilns	41.5	58.5

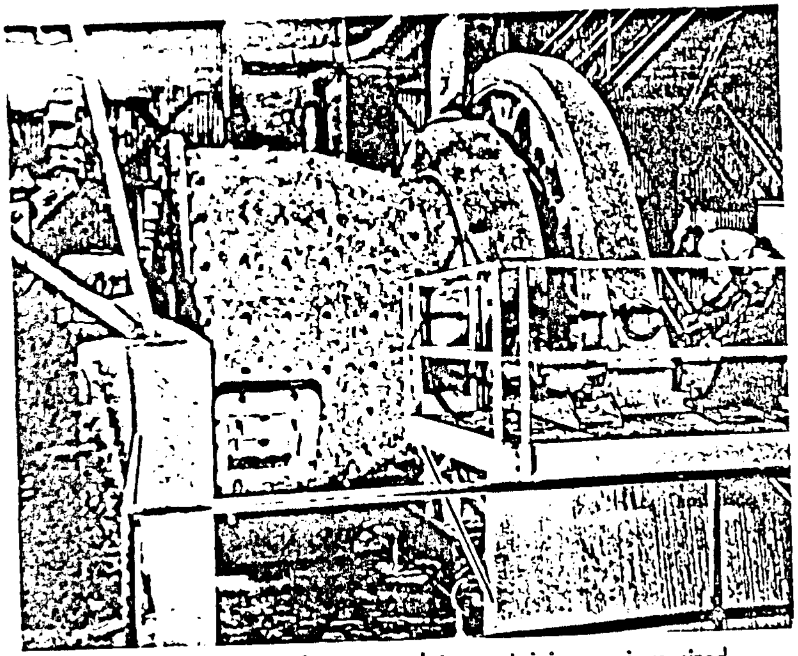
Dry Process.—The product is normally reduced from a size of 2 to $2\frac{1}{2}$ in. to a powder of from 75% to 90%, passing a 200-mesh sieve. The first stage, reducing the material size to approximately 20 mesh, may be done in vertical, roller or ball-race mills. Another type, the so-called ball mill, is a cylindrical machine equipped with heavy lining plates. It rotates at from 15 to 18 r.p.m. and is charged with 4–5 in. iron or steel grinding balls. The second stage is done in tube mills, which are similar to ball mills but are longer and of smaller diameter. Tube mills are charged with grinding balls of $\frac{3}{4}$ to 2 in. The tumbling, cascading and cataracting motions of the balls inside the mills reduce particle sizes by impact and attrition.

Frequently ball and tube mills are combined into a single machine consisting of two or three compartments, separated by perforated steel diaphragms and charged with grinding media of different sizes. This is called a compartment mill. In the process of grinding, an important relationship exists between the maximum size of the product being ground and the size of the grinding media.

Dry-process ball mills, compartment mills and tube mills may all be operated in closed circuit with air separators which separate the mill stream into coarse and fine fractions. The coarse fraction is returned to the mill for further grinding, whereas the fine fraction may pass on to another mill or to silos.

Before limestone, cement rock and shale can be ground to a fine powder it is frequently necessary to dry them to remove free water.

APPENDIX D-1.

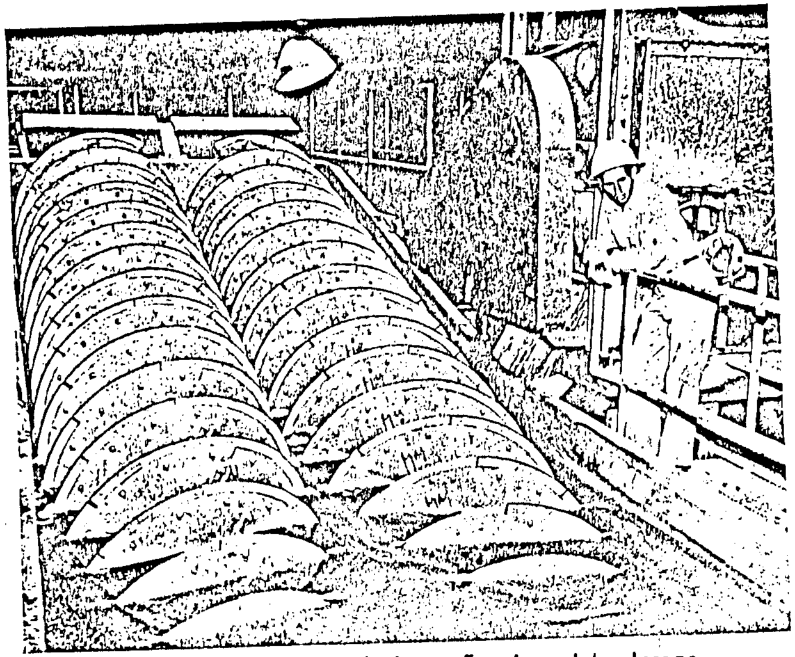


Revolving cylinder of armour plate containing various sized steel balls which pulverize rock to proper size

Such drying may take place in cylindrical dryers, typically 6 to 8 ft. in diameter and 60 to 150 ft. long. The heat is supplied from a combustion chamber. If coal is used for fuel, the chamber is stoker-fired to keep the flames from impinging directly on the material. In modern installations the drying and grinding operations are frequently combined by supplying hot air from an oil-, coal- or gas-fired furnace to the grinding system.

The finely ground raw meal is conveyed by pneumatic pumps, or by elevators and screw conveyors, to concrete silos. Frequent sampling of the finished product, followed by circulation, agitation and homogenization, enable the operators to arrive at the final blend by proportionate withdrawal from several silos. The final blend is again agitated and homogenized for one to two hours and is then ready to be conveyed to the kiln department.

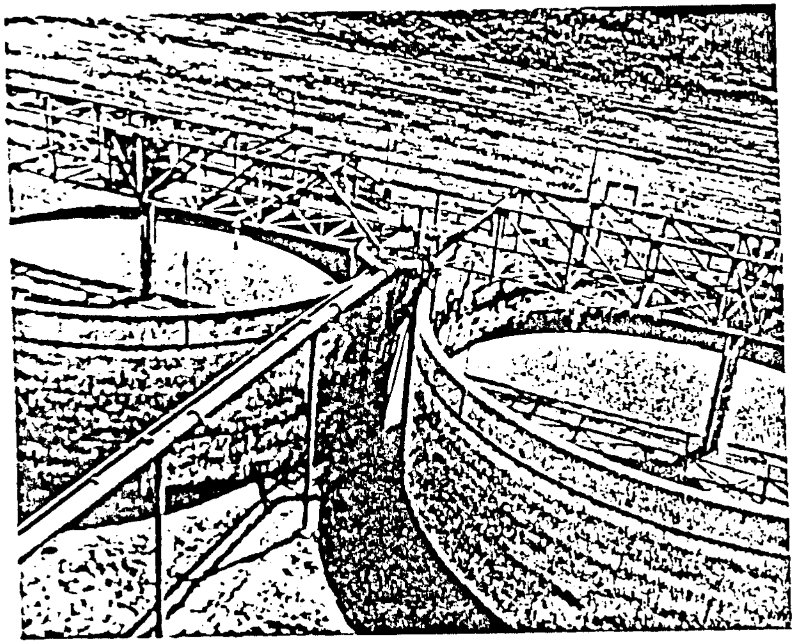
Wet Process.—Ball, tube and compartment mills of essentially the same construction as for the dry process are used for grinding. Water or clay slip is added at the feed end of the initial grinder together with the roughly proportioned amounts of limestone and other components. Vertical mills are rarely suitable for wet grinding. The closed circuit involves vibrating screens to remove oversize particles for return to the ball mill, and rake classifiers, hydroseparators and cyclones for the tube-mill product. In modern installations wet grinding is sometimes accomplished in ball mills alone, operating with excess water in closed circuit with classifiers, hydroseparators and thickeners.



Slurry classifier from which overflow is sent to storage tanks. Coarse particles are returned to mill for further grinding

Finished slurry is then conveyed by centrifugal pumps to slurry basins designated as mixing, correcting, blending and storage basins according to their functions. Sedimentation and segregation in all tanks are prevented by constant agitation, by either compressed air or mechanical agitators or both. When a correcting tank is full, a representative sample is analyzed, and desired amounts can be drawn from various tanks into one or several blending tanks for complete homogenization. The output of the blending tanks is pumped to an agitated storage tank, or a kiln basin, which holds a supply equivalent to three to seven days' production. In this manner any remaining small fluctuations in the slurry composition are further equalized, providing a uniform kiln feed.

Beneficiation.—Cement raw materials can almost always be proportioned to provide the correct chemical composition, but in some cases it has been found to be economically advantageous to



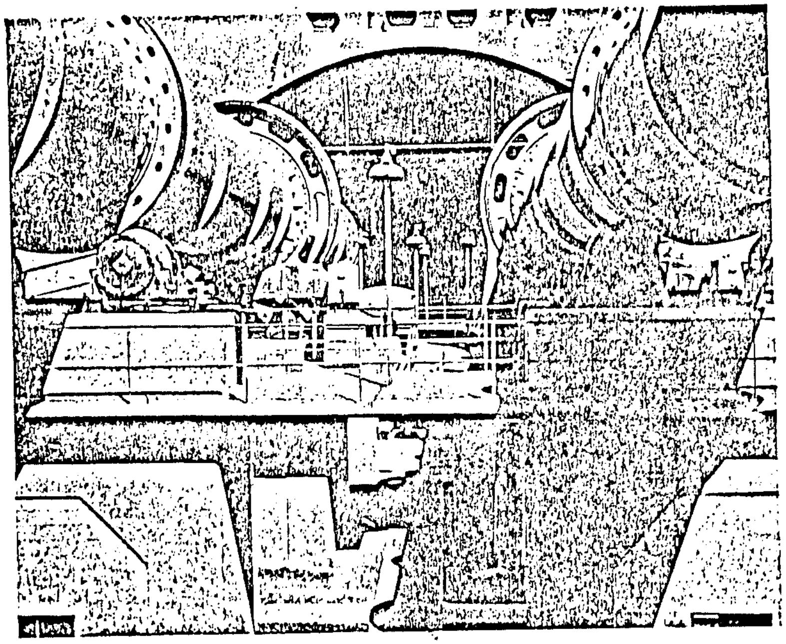
Slurry storage tanks

use froth flotation for removal of carbon and excess silica or alumina from quarry-run materials and thus avoid selective quarrying.

Burning.—The kiln department is especially important in a cement plant, since fuel consumption is a major item in the cost of manufacture and since the quality of the finished cement depends on the proper heat-treatment. Since raw- and finish-grinding departments most often are designed with higher capacities than those of the kiln department, a steady, high kiln output is also of the greatest importance for obtaining a low plant overhead.

Vertical kilns or shaft kilns, of the type used during the infancy of the cement industry, and still used in modernized versions in Europe, are not used in the United States and Canada for the production of portland cement, but in some locations are used for the burning of natural cement. The fuel economy of a shaft kiln is highly attractive, but it requires considerable labour for operation and the production capacity is relatively low.

The modern rotary kiln consists of a welded or riveted steel cylinder from 6 ft. in diameter and 60 ft. long (now rare) to 18½ ft. in diameter and 610 ft. long. These cylinders ride on steel tires

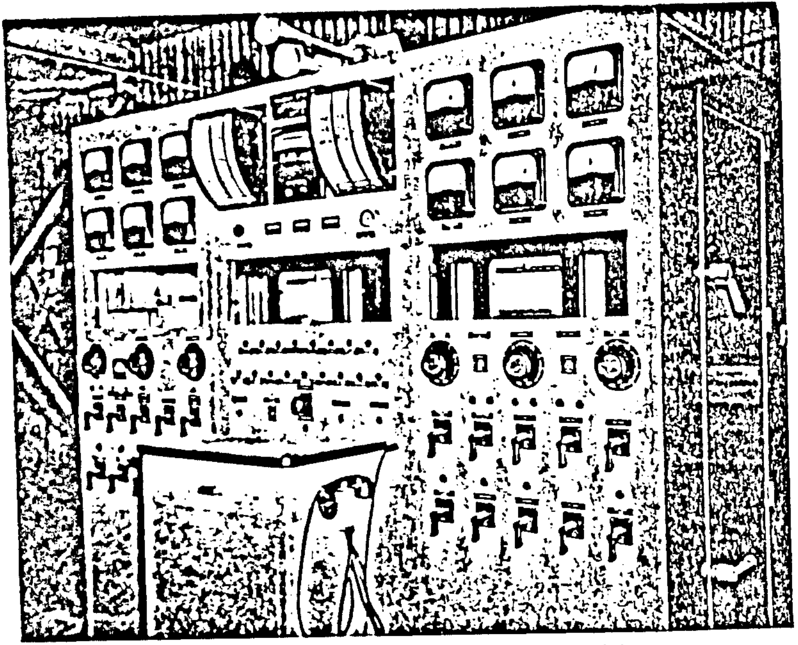


Twin kilns in which slurry is burned

and roller supports; they incline a few degrees, and rotate at a speed of between 50 and 90 revolutions per hour. The kiln feed or raw mix ("slurry" for wet-process kilns and "raw meal" for dry-process kilns), fed into the upper end, flows slowly through the kiln in a matter of hours, leaving the discharge end as clinker. Heat is supplied at the discharge end by combustion of coal, fuel oil or natural gas, providing a process temperature of 2,600° to 3,000° F. For protection of the steel shell and for conservation of heat, rotary kilns are lined with refractories. The combustion gases pass through the kiln in counterflow to the material and leave the kiln through its feed end at temperatures of 600° to 1,600° F. depending on kiln length and process used.

Fuel consumption in dry-process kilns can be kept to a minimum through the use of internal heat exchangers, consisting of steel or ceramic crosses and flights, and by preheaters. The so-called suspension-gas preheater lets the raw meal pass through a system of cyclones, in countercurrent with kiln exit gases. When entering the kiln the feed is highly preheated, improving fuel economy and increasing materially the capacity of the rotary kiln.

In still another system (which may be termed semi-dry) the



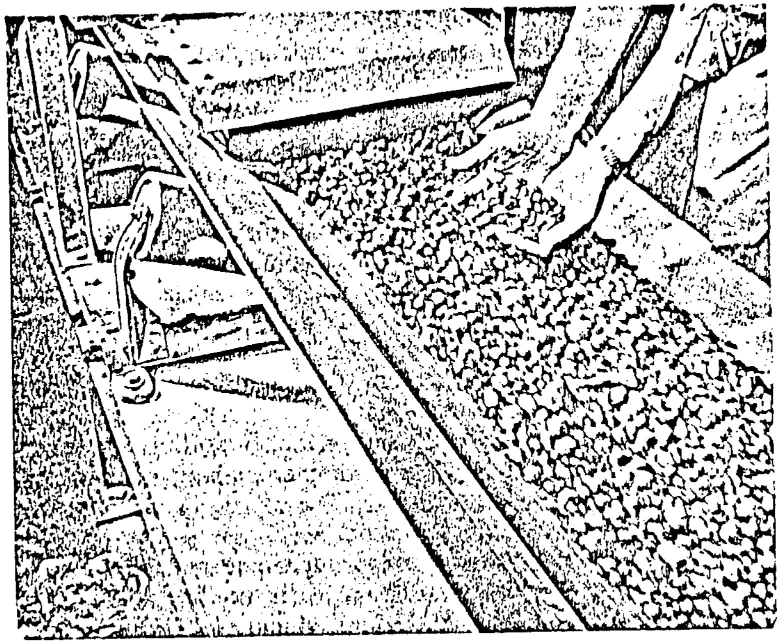
Control panel for a portland cement kiln

raw meal is mixed with 10% to 12% water and formed into pellets of one inch maximum size. These pellets are either dried and partially calcined on a slowly traveling grate through which the hot exit gases from the rotary kiln are passed, or are fed directly to the rotary kiln.

Wet-process kilns are somewhat longer than dry-process kilns inasmuch as a portion of the length (between $\frac{1}{4}$ and $\frac{1}{5}$) is used for evaporation of the slurry water. Such kilns are also equipped with elaborate heat exchangers consisting of heavy chains suspended in loops or curtains inside the kilns to increase the surface of slurry exposed to the gases and to facilitate the heat transfer from the gas stream to the material.

Hot clinker from the rotary kilns goes to clinker coolers which serve the dual purpose of reducing the temperature of the clinker before it is stored or ground and regaining the clinker heat for reuse inside the kiln as preheated secondary or primary combustion air.

Modern rotary kilns are equipped with intricate control systems. Visual inspection is also possible by means of openings at the discharge end. Using coloured glasses, a trained operator can



Belt conveyor transporting clinker from storage to finish mill

inspect for consistency of the semi-molten charge, size of clinker, place of the exothermic reaction, ring formation, colour and flame position.

Fuels.—The selection of kiln fuel is a matter of economics: the coal, oil or natural gas is selected which can be purchased at lowest cost per 1,000 B.Th.U., consistent with dependability of supply, uniformity and quality. In the United States and Canada, coal, oil and gas are used in cement plants, singly or in combination, or one fuel can be used as the main supply with another as a stand-by.

The manipulation of the combustion process in a cement kiln requires great skill and is of the highest importance to the quality of the clinker, fuel economy, production capacity of the kiln and preservation of the refractory lining.

Clinker Storage.—The cooled clinker is conveyed by drag chains, vibrating troughs or steel-band belt conveyors to storage. It is considered important to store the clinker under a roof, particularly in northern wet climates. This is true even though the exposed surface of clinker may be less than 1,000th of the exposed surface of finished cement of the same weight and though only a small amount of hydration would take place if the kiln clinker were wetted. At some plants, however, it has been found satisfactory to store large quantities of clinker outdoors, either unprotected or covered.

Finish Grinding.—The final stage in the manufacturing process involves grinding the clinker with a 4%–6% addition of gypsum. This product is the finished cement. The mills, essentially similar to the roller, race, ball, compartment and tube mills described under dry-process raw grinding, almost invariably use closed circuits with air separators. Cement fineness, formerly measured by the percentage passing certain screen sizes (*e.g.*, 96% passing a 200-mesh sieve and 90% passing a 325-mesh sieve), is now most frequently indicated in specific surface (surface area per gram). This measure can be determined by the Wagner (turbidity) method or the Blaine (air permeability) method. Both are relative indicators. The Blaine method lends itself to quick process control, whereas the Wagner method makes possible calculations of particle-size distribution. The average size of cement grains is about 10 microns (μ).

From the finish mill the cement is pumped pneumatically to silos and stored, ready for shipment. There it is again thoroughly tested for complete conformance to specifications. Total silo capacity for cement plants may be between 10% and 24% of annual production, depending on whether the plant is located in the southern part of the U.S., where the seasonal pattern of construction is fairly level, or in a northern climate where construction and cement shipments are interrupted by the winter months.

The finished product may be shipped in bulk or in paper bags. Specially designed hopper cars or trucks, railroad boxcars, and barges are used.

Packaging finished portland cement in self-sealing bags

Composition and Testing

In Great Britain, portland cement must meet specifications of the British Standards institution. In the United States, the specifications of the American Society for Testing and Materials (ASTM) are typical. Most countries place maximum limits on ignition loss, insoluble residue, magnesia (MgO) and sulfur trioxide (SO_3). Respective percentage limits of 3, 1, 5 and 2.5 are fairly typical. These respective limits protect against undue exposure, adulteration, delayed expansion and expansion from excess calcium sulfate. Where permitted, additions other than calcium sulfate and water are commonly limited to about 1%. Other chemical limitations are sometimes imposed concerning oxides, oxide ratios or calculated compounds. When certain reactive aggregates must be used, a maximum limit of 0.6% may be placed on alkali oxides.

Portland cements must meet physical requirements for fineness, setting time, soundness and strength. Because of the high fineness of modern cements, sieving tests are being supplemented and supplanted by determinations of specific surface by the sedimentation and air-permeability methods. By the latter method, the usual product in the United States has a specific surface of 2,800 sq.cm. per gram or better. British specifications do not require so high a value.

So-called initial and final setting times are determined by the increasing resistance of neat cement paste to weighted needles (Gillmore or Vicat). Initial set must generally not occur short of 30 to 60 min. Final setting time is generally limited to 10 hours.

Soundness is evaluated by expansion tests, generally involving heat-treatment of neat cement pastes previously cured for one day. In the Le Chatelier test, used in Great Britain and many other countries, a split cylindrical mold with projecting indicators gives the expansion of the specimen after a period in boiling water. The ASTM specifies an autoclave treatment of neat bars, which must not expand more than 0.8%.

Tensile- or compressive-strength tests, or both, may be required. Tension tests are made with small figure-eight-shaped mortar briquettes. Compression tests are made with mortar cubes or cylinders. Because of different test conditions, strength requirements of the various countries are usually not closely comparable. Mortar tensile strength requirements for general construction cement seldom exceed 400 lb. per square inch (p.s.i.), or 28 kg. per square centimetre, even after 28 days of moist curing. In contrast, compressive strength requirements run up to several thousand pounds per square inch. Strengths of mortar and concrete are greater the lower the water-cement ratio, and they continue to increase even for years under prolonged moist curing.

Composition and Its Effect on Properties.—The approximate oxide composition ranges—given in Table IV—are wide enough to cover most portland cements of practically all types.

TABLE IV.—*Composition Ranges of Portland Cement*

	Per cent
Lime, CaO	60 –67
Silica, SiO_2	17 –25
Alumina, Al_2O_3	3 – 8
Iron oxide, Fe_2O_3	0.5– 6
Magnesia, MgO	0.1– 5.5
Alkali oxides, Na_2O+K_2O	0.5– 1.3
Sulfuric anhydride, SO_3.	1 – 3

Source: F. M. Lea, *The Chemistry of Cement and Concrete*, revision of book by Lea and Desch, Edward Arnold Ltd., London (1956).

Tests made for free (uncombined) CaO generally show less than 2%, and often less than 1%. Compounds formed in the clinker are tricalcium silicate ($3CaO.SiO_2$), dicalcium silicate ($2CaO.SiO_2$), tricalcium aluminate ($3CaO.Al_2O_3$) and a ferrite phase commonly calculated as tetracalcium aluminoferrite ($4CaO.Al_2O_3.Fe_2O_3$). A shortened symbolism has developed which represents these solids as C_3S, C_2S, C_3A and C_4AF. The amounts of these compounds that can theoretically be formed can be calculated from the amounts of the four oxides of which they are composed.

In modern technology, the calculated amounts of these compounds provide a basis for estimating the properties of the cement. Early strength development is attributed largely to C_3S, whereas, with continued moist curing, C_2S causes increase in strength at the later ages. The need for retardation of set is attributed mainly to the C_3A, and the content of C_3A is related inversely to ability of the concrete to resist disintegration by sulfate-bearing water. Raising the amount of C_4AF, by raising the iron-oxide content of the mix without increasing the alumina content, is one means of reducing the amount of C_3A. The C_3A and C_3S are the compounds that release the most heat when the cement hydrates, or hardens.

Standard Types of Portland Cement.—The ASTM has defined five types of portland cement, identified in the specification (C150–61) by the Roman numerals I to V. These types, discussed below, serve to indicate variations in properties that can be brought about by varying composition and fineness.

Type I.—ASTM type I cement is intended for general concrete construction where special properties are not necessary. The British counterpart is "ordinary" portland cement. Type I is less restricted in chemical composition than the other types. A representative composition is 48% C_3S, 27% C_2S, 12% C_3A and 8% C_4AF.

Type II.—This cement is intended for use where concrete may be exposed to moderate sulfate action or where no more than moderate liberation of heat is advisable. The desired properties are obtained by placing moderate limits on C_3A and C_3S.

Type III.—Type III is high-early-strength portland cement, the British counterpart of which is called "rapid hardening." It is high in fineness, and at least moderately high in C_3S. It develops good strength within one day, and is used where concrete must be placed in service as soon as possible.

Type IV.—This is called low heat cement, and has a British counterpart with the same name. It is used where considerable thicknesses of concrete are required and temperature rise might be excessive, thus leading to excessive volume change and cracking. The British specification has direct limitations on heat evolution. The ASTM specification places limits on C_3A and C_3S. Type IV cement is generally produced only for special, large projects.

Type V.—This cement, which also is not always available, is for use where high sulfate resistance is required. It is low in C_3A. A sulfate-resistant portland cement known in Europe as Ferrari cement has a weight ratio of Al_2O_3 to Fe_2O_3 between about 0.6 and 1.0.

Air-Entraining Cement.—The ASTM adds "A" to its type numbers to indicate air-entraining cement. Various organic chemicals may be added in amounts up to a few hundredths of 1% (by weight of cement) to entrain fine bubbles in the mix. A concrete containing 4% to 7% by volume of these fine air bubbles has greatly increased resistance to scaling from frost action. The entrained air also produces a more workable mix.

Special Portlands.—Portland cements modified by small additions of chemical agents have acquired such names as oil-well, plastic, waterproofed and hydrophobic cement. Oil-well cement for use at the high temperatures in deep wells is prepared or treated to avoid quick set. The plastic cements have improved workability and may be used in stucco or exterior plaster. The waterproofed cements are treated to improve the resistance of the concrete to penetration by water. Hydrophobic cement is treated to minimize adsorption of water vapour during storage before use.

Coloured portland cements are made by adding pigment to either the white or gray cement. A white portland cement can be produced from materials very low in iron oxide.

Portland Blends.—Portland cement is sometimes ground with other material of cementitious value, gypsum being added as desired. The portland-slag and portland-pozzolan cements have already been mentioned. In these types, the portland cement and the other material are both substantial proportions of the whole, but the proportions are widely different in different instances.

In portland-pozzolan cement, the pozzolana—a siliceous material—reacts with lime liberated by hydrolysis of the portland cement. Natural pozzolanas are commonly of volcanic origin. Artificial ones include furnace fly ash and certain burned earths, clays and shales. The portland-pozzolans have a lower rate of heat liberation than type-I portlands. With proper curing they develop comparable eventual strengths if good pozzolana is used. Some of these cements protect against alkali-aggregate reaction.

In portland-slag cements a quick-cooled high-lime blast-furnace slag is used which is cementitious when activated by lime. Portland-slag cement has properties comparable with those of portland cement. It has relatively low heat evolution.

Expanding cements have been developed, for special purposes, in which portland cement is blended with expansive material. The original expansive cement, produced in France, relies for its expansion on formation of calcium sulfoaluminate hydrate.

Masonry cements are commonly made by finely grinding portland cement with limestone and an air-entraining agent. The entrained air improves workability, and the limestone, though not cementitious, is considered desirable as a filler.

Blends of portland cement with natural cement are sometimes made. Also portland cement and high alumina cement (*see* below) are sometimes mixed to obtain a quick-setting product.

OTHER CEMENTS

Other Hydraulic Cements.—The hydraulic limes and natural cements, made by calcining lumps of natural clayey limestone, are usually distinguished by the ability or lack of ability of the calcined lumps to slake in water. The hydraulic limes slake sufficiently to avoid the necessity of grinding, and are commonly sold as the screened, hydrated product. The natural cements require grinding. In both cases the firing temperatures are lower than for portland cement, but some recombination of lime occurs and is responsible for the hydraulic properties—which are, however, of relatively low order. Since the development of portland cement, the markets for these earlier products have dwindled.

Pozzolanic and slag cements, made by using hydrated lime with the pozzolana or slag, are employed in some countries but are of less general utility than their counterparts in which portland cement replaces the lime.

A superior type of slag cement, called supersulfated cement in Great Britain, is made by grinding slag with calcium sulfate. It develops good strength and shows sulfate resistance.

High alumina cement, also called aluminous cement, and in France *ciment fondu,* differs from portland cement in being dependent on calcium aluminates rather than calcium silicates for its strength development. It is manufactured by fusing a mixture of limestone and bauxite. The calcium aluminates formed are lower limed than C_3A. The cement gives high early strength, and has refractory qualities.

Other Construction Cements.—The limes produced by calcination of nonclayey limestones are not hydraulic, and are not ordinarily called cements. They are supplied both as quicklime (CaO) and hydrated lime. They are used in plasters and mortars that harden by drying out and reacting with carbon dioxide from the air. For stronger mortar, the lime may be partly replaced by portland cement.

Various gypsum plasters are made by partial or complete dehydration of gypsum (*q.v.*), $CaSO_4.2H_2O$, commonly with addition of special retarders or hardeners. They set and harden by recombining with water. Pure plaster of Paris, $CaSO_4.\frac{1}{2}H_2O$, sets very quickly. With added retarder it is called wall or hard wall plaster. For especially hard-finish plaster, the gypsum is completely dehydrated at high temperature, and chemicals such as alkali sulfate, alum or borax are added. Keene's, Mack's and Parian cements are hard-finish plasters. Hair or fibre and lime or clay may be added to the wall plasters during manufacture. Except for some finish coats, plaster coats are sanded.

Magnesium oxychloride cement, also called Sorel cement, is obtained in the hardened state by mixing magnesium oxide with a solution of magnesium chloride. Fibrous matter and sand are also incorporated. The cement is used mainly for flooring, but also for plaster, tile, decorations, etc. Prolonged contact with water is detrimental.

Refractory mortars are sometimes made with refractory aggregate, and clay as binder, and depend for strength development on vitrification of the clay as the temperature is raised. In other refractory mortars, high alumina cement may also be used. Other "air-setting" mortars consist of refractory aggregate, clay and sodium silicate solution. Additional chemicals may be used as binders or fluxes. Often the purpose is to produce only a temporary bond (as in making refractory brick) until vitrification can take over. For such a purpose, lime, hydraulic cement or organic materials such as tar may be used.

Pipe-sealing Cements.—In the gas and oil industries several kinds of jointing cements or pipe-sealing preparations are used. Among these are lead paints, graphite and oil, shellac in methyl alcohol, litharge and glycerin, iron filings and ammonium chloride, and various pasty materials.

Adhesive Cements.—The ancient water-soluble adhesives based on protein glues, vegetable gums and starches are now supplemented by both aqueous dispersions and organic solutions of synthetic plastics. Household rubber, pyroxylin and other cellulose cements are examples of adhesives that bond by the drying out of organic solvent.

Ancient waxes and pitches and the sulfur, asphalt and coal-tar cements are hot-melt cements similar in function to the modern polymeric thermoplastic solids that soften and become adhesive under the action of heat.

In contrast, thermo-setting plastics are generally low-molecular-weight chemicals or "pre-polymers" that are polymerized and set by heating or by chemical action of catalysts or curing agents. Of this nature are the phenolic, furan, epoxy, urea and melamine resins. All can act as adhesives.

Some adhesives, based on rubber or other elastomers, remain tacky and are used as removable pressure-sensitive tape, labels, etc.

Adhesives are often spoken of as cements even when used only to form thin films. Often, however, distinction is made between adhesives and cements, or mortar cements, that are based on adhesives but involve the use of a filler, or fine aggregate.

Catalyzed thermo-setting cements are used in special chemical-resistant masonry, and even for more general construction purposes. Epoxy resin cements bond strongly to concrete.

Bituminous, rubber and synthetic resin emulsions have been used integrally in concrete, along with portland cement, to confer special properties.

Silicate cements are generally based on aqueous sodium or potassium silicate solution as adhesive, usually with addition of graded silica as filler. The newer ones are mixed with a chemical agent at time of use, to obtain quicker set. Dental silicate cements, however, do not contain silicate solutions but glasses or fritted silicate reactive to phosphoric acid.

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APPENDIX D-1