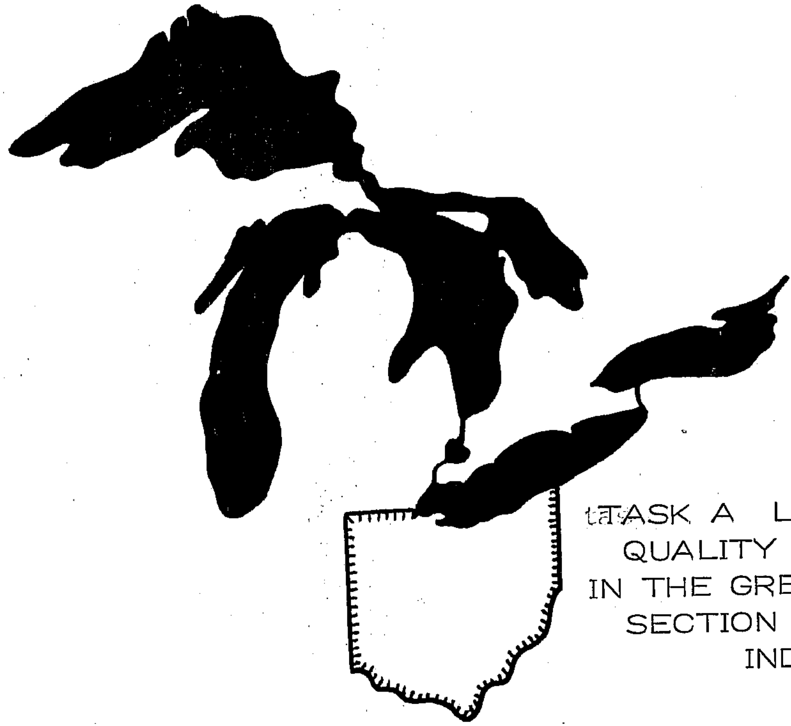

TASK A LAND USE/WATER QUALITY RELATIONSHIPS IN THE GREAT LAKES BASIN SECTION 4 EXTRACTIVE INDUSTRIES

CLEAR TECHNICAL REPORT NO. 29

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Section 2

SUPPORTING MATERIAL

2.1 Introduction

In this report we discuss the effect on the quality of surface and underground waters of the extraction of earth materials from pits, quarries, mines, and well fields. The materials discussed include seven "industrial minerals," namely sand and gravel, stone, clay, peat, gypsum, rock salt, and brines; and the ores of two metals, iron and copper. Although the production of these materials in the Great Lakes region is very large, both by tonnage and by value, of more significance to this study are the number and distribution of extractive sites. As shown in Table 1, sand, gravel, and stone are produced commercially at more than 1,200 localities. No single deposit accounts for more than a fraction of one percent of the total. Clay and peat are similarly dispersed, though on a far smaller scale. Gypsum, rock salt, brine, and the two metals are more limited in geological occurrence and therefore in number of extractive operations.

2.2 Scope of the Study

Information for the report was obtained from the state geological surveys of Minnesota, Wisconsin, Michigan, Indiana, Ohio, and New York. For Michigan -- the only state entirely within the Great Lakes Basin -- this contact was exceptionally valuable, because the Geological Survey Division of the Natural Resources Department is the administering agency of the state's Mine Reclamation Act and Mineral Well Act. We also received publications, letters, or telephone assistance from the Ohio EPA, the Water Resources Division of the U.S. Geological Survey, the New York State Department of Environmental Conservation, the Genesee - Finger Lakes Regional Planning Board, the Minnesota Pollution Control Agency, and the Robert S. Kerr Water Research Center of the U.S. EPA. A prime source of information on the nature and distribution of the mineral industry was the Minerals Yearbook (U.S. Bureau of Mines, 1972).

2.3 Study Procedure

The work was divided among the five members of the study group, with coordination and report-writing being handled by the principal investigator. Contacts with personnel of state and Federal organizations were made by phone, and a number of the persons called then furnished us with pertinent reports, both published and unpublished. In general, literature sources reviewed were those already known to the study group or suggested to them by those interviewed. The assumption was made that, for a rapid overview such as the present report, such procedure would be adequate.

Section 1

SUMMARY

1.1 Introduction

The land-use category discussed in this report includes pits and open cuts, mainly for extraction of sand and gravel but also for clay and peat; quarries for removal of bedrock as crushed stone; open-cut mines for extraction of iron ore; underground mines for extraction of copper ore, gypsum, and rock salt; well fields, where brines are pumped for their content of dissolved salts; and oil fields, where brine is produced as an unwanted byproduct of oil production. Sand and gravel are produced in all eight of the Great Lakes states, crushed stone and peat in seven, and clay in five. Gypsum, salt, and brines are produced in Michigan, Ohio, and New York. Iron ore is mined chiefly in Minnesota and copper ore exclusively in Michigan.

Pollutants from these activities include suspended solids, or sediment, which may enter surface waters, and dissolved salts, which may enter both surface and ground waters. Of the two, dissolved salts appear to be the more serious problem.

1.2 Summary

Sand and gravel are recovered at more than 1,000 pits, and crushed stone at over 170 quarries, distributed throughout the Great Lakes region. Although some pollution of surface waters undoubtedly occurs, we have found no reference to the gravel or stone industries as polluters in any of the eight states.

Production of salt from mines, and of oil and salines from wells, in Michigan, Ohio, and New York has resulted in local contamination by chlorides. The most serious and long-range effects are found in ground waters. In general, sources of pollution of this type are known, and state regulations are either in effect or pending.

1.3 Recommendations

We recommend a preliminary survey of the gravel and stone industries, aimed at determining their seriousness as pollutants. Perhaps a random "spot check" of a few score of pits and quarries would indicate whether a wide-ranging system of monitoring ought to be established.

We also recommend continuing study of the problem of how to dispose of unwanted brines. This problem, serious now, will become more so in the future, when the production of salt and salt-derived chemicals will increase greatly. All possible methods of disposal should be evaluated.

Section 3

REVIEW OF FINDINGS OF PREVIOUS STUDIES

3.1 General Description of Land-Use Category

3.1.1 Extractive Industries Other Than Salt and Brines

In terms of tonnage, gross value, and number of extractive operations, by far the most important mineral resource of the Great Lakes Basin is sand and gravel. These materials are used solely as aggregate in concrete. Because they command only a low price per ton, sand and gravel will not bear high transportation costs and must be produced close to their point of use. Thus there are hundreds of pits, scattered throughout the region, each supplying a local market (Table 1).

A close second in gross tonnage is crushed stone. In the Great Lakes region, nearly all this stone is limestone or its close relative, dolomite. Much is used as aggregate in concrete, but large tonnages also go into the manufacture of cement, lime, refractories, and steel. The clay that occurs in the region is common clay; no high-quality china clays or other premium varieties are known. Between 80 and 90 percent of the clay produced in Michigan and in the northward-draining counties of Ohio -- the major producing states -- went into the manufacture of portland cement, and was thus captive production of cement companies. Most of the remainder was used for ordinary brick and tile, and for expanded or lightweight aggregate. Peat -- nominally a fuel, but used in this country as a soil conditioner and potting medium -- is produced in small operations in seven of the eight Great Lakes states.

Gypsum is produced at two mines and two quarries in Michigan, the nation's leading state in gypsum production; at one mine and one quarry in Ohio; and at three mines in New York. Wallboard-manufacturing plants are located adjacent to most of the mines and quarries. The gypsum is taken directly to the plant, where it is crushed, ground, and calcined. A little gypsum is used as a retarder in portland cement.

Surface mining for iron has long taken place in Minnesota (Vermilion and Mesabi ranges), Wisconsin (Gogebic), and Michigan (Menominee, Marquette). The Mesabi Range today produces about 75 percent of U.S. iron ore, the other ranges being relatively inactive. Copper mining is confined to one underground mine on the Upper Peninsula of Michigan.

TABLE 1 - EXTRACTIVE INDUSTRIES OF THE GREAT LAKES BASIN, 1970[1/]
(Exclusive of Oil and Gas)

Commodity	MINN.	WIS.	ILL.	MICH.	IND.	OHIO	PA.	N.Y.	Total
Sand-and-gravel pits	61	230	13	453	57+	109	1	113+	1038+
Crushed-stone quarries...	1	88	3	27c[2/]	9c	27		16c	171+
Clay pits....		2	2	16	2	5			27
Peat bogs....	2c	1c	2c	11c		4c	1	3c	24+
Gypsum mines or quarries				4		2		3	9
Salt mines...				1		2		2	5
Brine fields.				6c		2c		3c	11+
Iron mines (open-pit).	1c								1c
Copper mine..				1					1

1/ Data are only for those counties in each state that are wholly or partly in the Great Lakes Basin.

2/ For some states, only the number of counties can be tabulated. Numbers designating counties are followed by the letter c.

Source: Minerals Yearbook 1970 (U.S. Bur. Mines, 1972).

3.1.2 Salt and Brines

Thick beds of rock salt underlie the southern peninsula of Michigan, the northeastern counties of Ohio, much of western Pennsylvania, and New York south of a line approximately from Syracuse via Rochester to the southwestern corner of the state. These salt beds constitute a valuable mineral resource, which is mined in underground workings at one locality in Michigan, two in Ohio, and two in New York. The salt produced is used for ice control on streets and highways, and in the chemical and food industries.

As geologic time has passed, waters have come into underground contact with the salt beds and have dissolved salt, forming brines. These brines are valuable mineral resources. Naturally occurring brines are pumped to the surface in an area of central Michigan centering around Midland, and in Mason and Manistee counties on the western edge of the state. At these places the brines yield not only sodium and chlorine, the constituents of common salt, but also numerous other elements, such as bromine, iodine, magnesium. At other localities, notably Painesville in northeastern Ohio, and at the south end of Seneca Lake, New York, wells are drilled to the rock salt, water is pumped down to dissolve it, and the resulting "artificial brine" is brought to the surface. Here it is evaporated to yield salt, or it may be pumped directly into a manufacturing complex, where it forms the raw material for production of sodium chemicals and chlorine chemicals.

Much brine is also brought to the surface as an unwanted byproduct in the production of oil, in the oil fields of Michigan, Ohio, and New York. These brines have been locally sprayed on rural roads for dust control, but most of them constitute a waste that must be disposed of.

3.2 Historical Development of Extractive Industries

Large-scale production of sand and gravel began after the introduction of steel-frame construction in 1885, which brought with it a demand for concrete. Extraction of crushed stone started somewhat later, after development of such equipment as crushing machinery, the steam drill, and dependable explosives. Tremendous expansion of the aggregates industry has taken place since World War II, as a result of the boom in housing, commercial and industrial building, construction of highways and airports, and similar uses of concrete.

By contrast, clay, gypsum, and salt have uses that go far back into antiquity, and all have been extracted since shortly after the first white men came into the Great Lakes region. Clay yielded brick and tile, and gypsum gave plaster and mortar, for the early builders. The Onondaga salt springs, near Syracuse, New York, were known in 1788, and soon thereafter salt was being produced by evaporating the brine in kettles over fires. Wells were later dug for the brine. By the mid-1800s, 140,960,000 litres (4 million bushels) of salt was being produced annually. Natural brines at Saginaw, Michigan, were tapped in 1860; they were especially well situated for the meat-packing industry of Chicago. Production of salt and brines in Ohio has a similarly long history.

From the mid-1800s to about 1953, the Lake Superior region produced the bulk of the iron ore used in the nation's steel industry. In 1953, the peak year, production reached 97 million metric tons; by 1968, it was 57.5 million. The decline can be traced to three factors: depletion of high-grade reserves, the "direct-shipping" ores; imports of foreign ores; and the technological revolution that allowed production of highly desirable concentrates from previously unusable low-grade ores (taconite). Future production will be of taconite and similar ores on a very large scale, using production-line techniques. It is expected that about one-half of total U.S. needs for iron ore will be met by Lake Superior production; of this amount, Minnesota will produce 75 to 80 percent.

By 1880, Upper Michigan was the nation's leading producer of copper. Output declined steadily through 1954, except for temporary increases in the late 1920s and World War II. A new mine in Ontonagon County doubled the state's copper output, and by 1962 it was 74,000 tons, or 6.0 percent of national production. Activity at this mine remains strong, but the future of the world copper market is beset with uncertainty.

The history of iron and copper mining in the Lake Superior region is summarized by Deshpande and Dworsky (1973, p. 2-6 - 2-13).

3.3 Pollution Resulting from the Extractive Industries

3.3.1 Nonmetallic Extractive Industries Other Than Salt and Brines

In the average sand and gravel operation, pit-run material is washed, screened, and stockpiled in several sizes, from pebbles 3 inches or more in diameter down to fine sand. The effluent from washing may contain unwanted sand (grains larger than 1/16 mm in diameter) or silt (1/16-1/256 mm), but is seldom burdened with clay (finer than 1/256 mm). Little clay occurs with sand and gravel, because the water currents that originally deposited these materials -- meltwater from the ice sheets of the Pleistocene age -- were too swift to allow clay-size material to settle out. The effluent can be readily cleared of its sand or silt by settling in a pond, and this is commonly done, so that the water can be used over again. (People in the sand and gravel business say, "We use the water till we wear it out.") Such waters carry little dissolved material, other than what they originally had, as the constituents of sand and gravel are by their very nature resistant to chemical attack and thus unlikely to yield a solution load to waters that come into contact with them. Nearly all the waters used at sand and gravel pits are surface waters. At some deposits, the desired material lies below the water table, and is extracted from under water by dragline or clamshell bucket. The bodies of water that are left in worked-out pits constitute park lakes, waterways for residential development, or ground-water recharge basins. Pre-planning toward these goals is standard procedure at many of the larger pits. Constraints on the industry are imposed chiefly by (1) competition with urban expansion for close-in sites of production; (2) community objections to noise, traffic, and unsightliness; and (3) necessity for reclamation of mined-out areas.

The following paragraphs are quoted from a letter of March 14, 1974, from E. K. Davison, Director of Environmental Affairs of the National Sand and Gravel Association. In cooperation with a man from the EPA, Mr. Davison "solicited information on discharges from a number of our member companies around the country."

> I found in my limited survey that in about one-fourth of those operations which discharge into a public watercourse the discharge is simply a pump-down to keep a pit dry or, more usually, to evacuate excess water, rather than a discharge of wash-water from the screening plant. Such pumps appear to be well removed from portions of pits used for receiving screening plant washwater.
>
> The few analyses of pump-down discharges that I received indicated that suspended solids contents exceeding about 12 to 15 mg/1 would be unusual. Analyses furnished me for discharges involving settling ponds for process water (as distinguished from pump-down discharges) showed a median suspended solids content of 139 mg/1. These were mostly "one-shot" samples taken for filling out the permit applications under the Refuse Act Program. One of the EPA Regional Offices in a study of both sand and gravel and crushed stone operations found a median of 55 mg/1 for suspended solids. This particular report corroborated the observation of both the EPA Effluent Guidelines man and this Association office that volumes of discharges related to tons of production vary so widely that only the pollutant concentration method, as distinguished from loading per unit of production, is practical. Suspended solids and pH are the usual parameters of concern. The pH is no problem in discharges from sand and gravel operations.
>
> I have never heard of any concern or contamination of underground water provided the pits or ponds are receiving only process water from sand and gravel handling.

Pollution of waters by the sand and gravel industry may be appreciable, but if so it is largely unrecognized. In the sources consulted for this report, we have found hardly any mention of this subject. It seems to have given rise to little if any regulatory legislation.

Water may enter into the crushed-stone operation if the stone is naturally muddy or shaly, but this is an undesirable condition and at most quarries the quality of the stone is such that washing is not necessary. Water may be clarified by settling in ponds, but it is probable that some mud and silt goes into adjacent waters. At a limestone quarry on Kelleys Island, Ohio, for example, silty water was discharged for some years into Lake Erie, where it produced a little delta. Slight chemical effect is generally made on waters that come into contact with limestone or dolomite for a few minutes during washing.

Production of clay consists simply of extraction from a pit and removal to the plant. The industry is relatively small in the Great Lakes area and little effect on quality of waters is to be expected. Much the same is true of peat. This substance is dug up, shredded or otherwise dry-processed, packed, and shipped.

Between 16.3 and 19.7 million liters (4.3 and 5.2 million gallons) of water are pumped every day from a gypsum mine on the Port Clinton peninsula on the south side of Lake Erie (L. Purcell, U.S. Gypsum Co., personal communication). This exceptionally large quantity of water is explained by the presence of fractures through which lake water is entering the mine. (Variation in the above figures reflects water level in the lake, which in turn depends on prevailing winds.) In May, 1974, the water had a pH of 7.72, an average sulfate content of about 1,380 mg/1, and total dissolved solids averaging about 2,400 mg/1 (R. Sturtz, Ohio EPA, personal communication). Some of the water is used in the sink-float process of upgrading the gypsum in the mill; the rest is discharged into Sandusky Bay, an arm of Lake Erie. The state EPA does not consider this discharge as a serious source of pollution, owing to the great dilution that it immediately undergoes. However, the Ohio EPA does not have standards that apply to lakes and bays, only to streams. It is not possible to generalize from one gypsum mine to others, as the amount and nature of water will vary with the local conditions. Water pumped from a gypsum mine in western New York, for an example, is pure enough to be diverted, by contract with the state, into a stream at a guaranteed rate of 5,677 liters (1500 gallons) per minute (R. Runvik, U.S. Gypsum Co., personal communication).

> Coal was at one time mined by underground methods in Bay, Genesee, Huron, Midland, Saginaw, and Tuscola counties [Michigan] from the Saginaw Formation of the Pennsylvanian System. Coal production ceased due to the thinness of the coal beds, the low grade and high sulphur content of the coal, and the high cost of underground mining. No future coal production is anticipated (U.S. Bureau of Mines, 1971, p. 5-127).

Effects, if any, of the discontinued mines on the quality of waters is not known. Deleterious effects of exploratory drill holes are discussed in Section 3.5.

3.3.2 Extraction of Salt and Brines

Unlike sand, gravel, and the other relatively inert substances discussed in the preceding section, salt is readily dissolved in the earth's waters, and the resulting brines are chemically active. When discharged on the ground surface, they sterilize the soil and kill vegetation; if discharged into a water supply, they give an undesirable salty taste to drinking water. Thus "chloride contamination" is a serious and continuing problem in brine fields, and also at salt mines where mine seepage must be disposed of. Waste brines have traditionally been flushed into streams or lakes. For example, brine has been discharged into the south end of Seneca Lake, New York, for nearly 100 years; in addition, operational leakages, spillages, and the former practice of stockpiling salt have undoubtedly contributed chlorides to the lake.

> Seneca Lake had an average chloride content of about 100 mg/1 from about 1920, when first analyzed, to 1960. From 1960 to 1970, chlorides increased to about 200 mg/l. Since 1970 there has been a levelling off or slight decline in chloride. Salt-plant operations (possibly including leaky abandoned salt wells) are suspected causes (R. M. Waller, U.S. Geol. Survey, personal communication).

Newly established standards controlling stream pollution in New York, discussed in Section 3.9.3, will eliminate disposal of brines into streams in that state.

Waste brines may be pumped into ponds, in the hope that the water fraction will evaporate and the salts remain as precipitates. This practice, however, is successful only in arid or semi-arid regions, where evaporation exceeds rainfall (U.S. EPA Rept. EPA-430/9-73-011, p. 94). Under the Great Lakes climate, evaporation is slow and much of the brine infiltrates into the ground-water supply. Leakage and filtration through the dikes at evaporation ponds is also a hazard. A third method of disposal is to pump the brine back into the ground. It may be pumped into an oil-bearing zone, where it may help to repressure the reservoir and act as a water-flood to move more oil toward well bores; needless to say, this is a technique that requires considerable specialized knowledge. Or, the brine may be pumped into a deep porous and permeable bed or rock that will absorb and hold it. Much remains to be learned about this technique.

In sum, the production of salt and brines appears to be the most damaging extractive industry to the quality of the water supply in the Great Lakes region.

3.3.3 Mining of Iron and Copper Ores

Crushing, screening, washing, and gravity beneficiation are the chief processes that iron ore goes through at the mine. The wash water, much of which used to run off and produce "red water" in the streams draining the Mesabi and other ranges, is now clarified in settling ponds and is re-used. The development of closed-water systems in the tailings-disposal areas has been notably successful in reducing pollution (R. K. Hogberg, Minnesota Geological Survey, personal communication). The St. Louis River at Duluth shows the lowest longtime average annual sediment yield of any large river system in the Great Lakes Basin: 1 metric ton per km^2. (The Cuyahoga River south of Cleveland shows 88 metric tons per km^2.) The St. Louis River drains a large part of the Minnesota iron ranges. Planning subareas 1.1 and 1.2 of the GLBC, which contain the iron and copper mines, have the lowest gross erosion rate of all subareas in the Basin, as indicated in Table 2. The effects of mining are not mentioned in a study of suspended sediment in streams tributary to Lake Superior (Callahan, 1973).

3.4 Assessing and Quantifying the Problems

To assess the extent of pollution by the region's extractive industries other than salt and brines would involve visiting and inspecting 1,000 to 2,000 separate pits, quarries, and mines. Most of the pollution would be in the form of sediment in water. Quantifying the observations would involve measuring the discharge and determining the concentration of suspended solids at each occurrence. To be of value for purposes of comparison and totalling, such measurements should be taken at times of average or "normal" discharge and pollution. It is doubtful whether the results would be reliable and significant enough to warrant the effort and expense.

Determining a water's chloride content is a relatively simple process of titration and is done on a routine basis. It gives quantitative results that are comparable with a large body of similarly expressed data from waters at many localities. Standards of comparison are generally known and accepted. For example, the U.S. Public Health Service recommends that drinking water contain no more than 250 mg/1 of chloride. Thus chloride contamination may be readily assessed and quantified.

TABLE 2 - GROSS EROSION RATE, SUBAREAS 1.1 AND 1.2

Subarea	Tons per Acre per Year Current	1980	2020
1.1	0.33	0.34	0.32
1.2	0.24	0.23	0.22

Source: Great Lakes Basin Framework Study, Appendix 18, Table 4, 1970.

3.5 Mobility of Pollutants

The mobility of sediment discharged into water bodies, as from washing plants at gravel or crushed-stone operations, depends on (1) the coarseness of the material, and (2) the kinetic energy, if any, of the water body. Sand and silt discharged into a pond or other standing water will settle promptly. Clay may remain in suspension for a long time. If the discharge is into a stream, natural sorting will take place: coarse sand will settle nearest the point of inflow, and silt farther away; clay will very likely not come to rest until the stream reaches a body of quiet water where energy is at a minimum and settling can take place. Sources of severe pollution by suspended solids should be relatively easy to spot because of the above-described method of dispersal.

Brines are highly mobile. Those brines that seep into streams or lakes may cause contamination, or they may undergo such great dilution by fresh waters that the stream or lake waters show only slight effects. The chloride concentration of streams during low flow throughout Michigan rarely exceeds 35 mg/l, even though brines are present in the shallow subsurface of much of the state.

Waters that remain underground can hardly purge themselves. If fresh waters become contaminated with chloride, they may remain contaminated indefinitely. Under natural conditions, underground waters generally move very slowly; but when man enters the picture he may upset the hydrostatic equilibrium, causing rapid migration of brines into fresh-water zones. From 1860 on, hundreds of wells were drilled in the Saginaw Valley of Michigan, in the search for coal and valuable brines. Few if any of these wells were lined with casing, with the result that they served as conduits through which highly mineralized brines from deep in the rocks rose and mixed with near-surface fresh waters. Deterioration of ground-water quality was noticed at Saginaw as early as 1906 (Bowman, 1906); it was attributed to abandoned brine wells. At Lowell, near Grand Rapids, Kent County, the chloride content in a municipal well increased from a trace in 1933 to 925 mg/l in 1941. The major cause was leakage of brine through abandoned oil and gas wells (Deutsch, 1963). A well drilled in Lansing in 1956 contained less than 100 mg/l, but after two months of operation the chloride content had risen to about 900 mg/l. The probable source of contamination was an abandoned brine well (4,575 mg/l of sodium chloride), which had been drilled in 1867. Smith (1944) has described the deleterious effects of brine migration on overlying fresh-water aquifers in Michigan, and Smith and Frye (1945) have reported on the history of brine contamination in the Saginaw Valley.

Many thousands of shallow shot-holes are drilled each year in Michigan by oil companies for geophysical testing; borings are made for foundation work; and holes are drilled by cement companies or others to test the limestone bedrock. All these holes are uncased, and many have acted as pipes through which mobile brines move upward. The result has been chloride contamination of water supplies that continues even today.

The gross areal extent of ground-water contamination in southern Michigan is not known. Probably most individual areas do not exceed a few acres. In districts where ground water is pumped, the resulting decrease in hydrostatic head might lead to more widespread contamination, through open holes and inter-aquifer leakage.

In considerable areas of Wood and Hancock Counties, northwestern Ohio, surface and ground waters have a higher-than-normal salinity. Near Portage, Wood County, the Portage River at periods of low flow commonly contains more than 150 mg/l of chloride. It seems very likely that contamination is the result of leakage of brines from the old Lima oil and gas field. This field was discovered in 1884, reached its peak of production in 1896, and is nearly exhausted today. According to Orton (1888), oil seeps into wells and excavations in the Findlay area antedated discovery by 50 years. No doubt deep brines have been moving upward for scores of years, in large part via old oil and gas wells which were never cased or in which the casing has long since rusted away.

Another situation is exemplified by the artificial-brine industry near Syracuse, New York. The wells are at Tully, 27.3 km (17 miles) to the south; the brine is pumped to a plant near the west shore of Onondaga Lake, where caustic soda and soda ash are produced. Lagoon effluent and leachate from stock piles contribute high chloride content to Ninemile Creek and Onondage Lake. The situation is discussed in two reports (Kantrowitz, 1970; Shampine, 1973).

3.6 Natural Renovative Mechanisms

Water that is contaminated only by suspended solids, as at a gravel or crushed-stone plant or taconite mine, undergoes renovation if these solids are allowed to settle out. Water thus clarified may be re-used in the plant or discharged into water bodies without deleterious effects.

There is essentially only one natural mechanism for renovation of chloride-contaminated waters. This is dilution by fresh waters. Unless the pollution load is very heavy and the water body is small, such dilution ordinarily reduces the chloride level to acceptable values. Where underground waters have been invaded by brines, there is no natural means of renovation.

3.7 Probable Changes in Extractive Industries with Time

It will be seen from Table 3 that all the commodities discussed in this report are expected to increase markedly in production well into the next century. Salt, the major source of water pollution, was first produced for food seasoning and preservative, but the salt industry has long since become a mainstay of the chemical complex, and the bulk of today's production goes into the sodium and the chlorine families of basic chemicals. This being the case, there is little doubt that demand for salt will continue to rise. It is expected to more than quintuple by the year 2020.

Production of both iron and copper is expected to increase moderately in the coming decades. Deleterious effects on water quality may increase proportionately, although it seems entirely within reason to believe they might be held to present levels or even made to decrease, as more is learned and applied to control of tailings accumulations and the drainage from them.

3.8 Seriousness of Future Pollution Problems

For mineral resources other than salt and brines, there is little basis for prediction. A reasonable assumption seems to be that pollution will increase in roughly the same proportion as production increases. We believe the over-all effects will continue to be slight.

As for salt and brines, it is hard to avoid the conclusion that chloride contamination will increase markedly unless firm governmental controls on extractive and manufacturing processes are imposed. Hazards to be expected are exemplified at a New York site, where a company started mining rock salt about 2 years ago. While working on a deep-well disposal system, they have stored mine seepage and plant wastes in holding ponds. There has been leakage, dike failure, and production of a fine saline dust, all of which have caused problems to the water supply (R. M. Waller, U.S. Gel. Survey, personal communication). With five times as much salt being produced in 2020 as is being produced today, it is clear that drastic controls and monitoring systems will be necessary.

3.9 Review of Programs of Controlling Pollution

A comprehensive description of methods for controlling pollution from extractive operations of all types is given in two reports of the U.S. Environmental Protection Agency (1973).

TABLE 3 - PROJECTED MINERAL PRODUCTION, GREAT LAKES REGION,
BY SELECTED COMMODITIES
(Thousands of Metric Tons)

Commodity	1968[1]	1980	2020
Sand and gravel...	116,981	155,276	464,876
Crushed stone.....	100,298	130,151	387,537
Iron ore..........	57,548	66,605	126,748
Salt..............	W[2]	20,993	94,911
Clay..............	3,755	4,600	11,663
Gypsum............	W	2,005	3,692
Peat..............	237	262	427
Copper ore........	68	91	299

1/ Actual.

2/ Withheld to avoid disclosing individual company data.

Source: Great Lakes Basin Framework Study, Table 5-103 (1971).

3.9.1 Michigan

Michigan's Mine Reclamation Act (Act 92, 1970, amended by Act 123, 1972) provides for the reclamation of lands subjected to the mining of coal, gypsum, stone, and metallic ore (but not sand and gravel, clay, or peat). The effects of mining on water pollution is one of the objectives of a comprehensive survey mandated by the act. This survey is currently under way and is expected to result in promulgation of rules governing (among other things) pollution of public waters. Supervisor of the Act is the chief of the Geological Survey Division of the Department of Natural Resources. Completion of the comprehensive survey is hoped for in 1974.

The Water Resources Commission Act (Act 245, 1929, as amended, effective April 15, 1973) creates a Water Resources Commission "to protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the Great Lakes . . ." etc. Mining operators must obtain permits to discharge wastes into public waters.

Michigan's Mineral Well Act (Act 315, 1969) is intended "to provide control of the drilling, operating and abandoning of mineral wells to prevent surface and underground waste; . . . to provide for inspecting, repairing and plugging of mineral wells; . . ." etc. Supervisor of the Act is the chief of the Geological Survey Division. Full enforcement of this Act should go far toward controlling pollution from mineral wells.

Material in this and the following paragraph is taken from Deshpande and Dworsky (1973). Official Michigan policy states, "The business of mining and beneficiating low grade iron ore . . . is declared to be in the public interest and necessary to the public welfare, and the acquisition of private property for development of an adequate water supply, the necessary storage, processing and treatment of liquid and solid wastes . . . is declared to be for a public purpose." The Michigan Department of Natural Resources is authorized to acquire by condemnation land for settling ponds, storage basins and treatment, transportation and other facilities -- this land to be leased to the mine operator if he has already secured 75 percent of the necessary land (Michigan Statutes 425.171, P. A. 1968, no. 314).

"It is the policy of the State to develop and continue mining in the Upper Peninsula. It is in the public interest and for the public welfare." Because beneficiation needs water, the use of water in the processing of low grade iron ore is declared to be in the public interest (Michigan Statutes 323.251, sec. 1, P. A. 1959, no. 143).

3.9.2 Ohio

The surface waters of Ohio are protected under Regulation EP-1 of the Ohio Environmental Protection Agency, effective July 27, 1973, entitled "Water Quality Standards." Sources of water pollution are regulated by applying effluent standards and issuing permits, under the general style of the Federal Water Pollution Control Act, Section 402, "National Pollution Discharge Elimination System."

Regulations under Ohio's oil and gas law (Revised Code Chapter 1509) prohibit the contamination of surface or ground waters by disposal of oil-field brines, but drilling operations are so numerous and state regulatory agencies so undermanned that adequate control is not exercised.

Ohio has no other pollution-control program for its subsurface waters.

3.9.3 New York

New standards to control stream pollution became effective in New York on March 27, 1974. These are set forth in the State Department of Environmental Conservation's "Classifications and Standards Governing the Quality and Purity of Waters of New York State." Title 6, Official Compilation of Codes, Rules and Regulations, Part 702.1, refers to "Class A-Special (International Boundary Waters) (Great Lakes Water Quality Agreement of 1972)." Quality standards include, among other items, requirements that total dissolved solids shall not exceed 200 mg/1, and that suspended solids that will be deleterious for any best usage will not be allowed. Legislation to support these measures comes under Article 17 of the Environmental Conservation Law (formerly Article 12 of the Public Health Law) (W. E. Loveridge, NYSDEC, personal communication and enclosures).

It may be significant that a comprehensive survey by a regional planning agency, with full attention to major sources of pollution, especially of ground water, does not mention deleterious effects of any extractive industries. This report is listed in the references under Genesee-Finger Lakes Regional Planning Board.

3.9.4 Wisconsin

In Wisconsin, according to Wirth et al. (1973), "current state laws are adequate to control water pollution related to mineral resources." Deshpande and Dworsky (1973), on the other hand, find that the state lags behind Michigan and Minnesota in creating formal policies and safeguards against environmental damage that might be caused by mining. If mining operators are to divert waters for their use, they must secure a permit from the Department of Natural Resources. "The Department shall impose such conditions in the permit as it finds are reasonably necessary in the public interest for the restoration of waters after completing of the mining operations or cancellation of the permit, for the orderly disposal of waste or tailings . . ." (Statute 107.05, sec. 9). Statute 144.01 subjects "unnecessary siltation" from quarries and gravel pits to regulation. Statute 29.29(3) prohibits discharge of deleterious substances into the state's waters. But all these regulations apply only if the mining operation requires diversion of water for its use. The regulations do not apply to ground water.

3.9.5 Minnesota

All state agencies in Minnesota are directed to cooperate with and assist the Pollution Control Agency, which was formed in 1967. The Division of Water, Soil and Minerals of the state's Department of Natural Resources is in charge of mining regulation. The commissioner of the Department may grant permits for drainage diversion and control or use of water where necessary for mining of iron ore, taconite, or copper -- if it is necessary and there is no other alternative, if it will not substantially impair the interests of the public, and if it will not endanger health or safety (Deshpande and Dworsky, 1973). If a permit is granted, the Commissioner will also prescribe the requirements for restoration of the waters to their former condition. This may require the mining operator to post a bond (Statute 105.64). Mine dewatering is monitored by the state's Conservation Department.

3.9.6 Other States

Only three Illinois counties drain into Lake Michigan. The state is currently limiting all discharges into the lake, and no new ones are to be allowed.

There are large sources of pollution in northern Indiana, but these are industrial plants rather than extractive industries. Urban runoff, industrial wastes, and waste-treatment processes are the significant sources of pollution of Lake Michigan and the streams tributary to it.

Only Crawford and Erie counties in Pennsylvania are tributary to Lake Erie. The state's "Clean Streams Act" and other legislation should be more than sufficient to control pollution from the single sand and gravel pit and the one peat bog reported to be active in this area.

Section 4

SUMMARY OF RESEARCH PROGRAMS

4.1 Nature of Studies

In the limited time available, it has not been possible to make a study of "current or proposed research, demonstration, or monitoring programs that may help answer basic questions." Such a study is desirable and should be made.

State-of-the-art studies of pollution produced by certain extractive industries are currently under way at the Robert S. Kerr Water Research Center of the U. S. Environmental Protection Agency, in Ada, Oklahoma. Reports are soon to be published on the significance of water pollution associated with the sand and gravel, uranium, and oil-shale mining industries. Research is also being done on sealants for mine-tailing sedimentation ponds. Studies bearing more directly on the extractive industries of concern in this review are in the discussion stage at the Center.

With a grant from the Federal Water Pollution Control Agency, researchers at the University of Minnesota and their associates have made a study of the role that peat might play in combating water pollution (U.S. Bur. Mines, 1972, p. 389).

The following news item appeared in the magazine Rock Products, July 1974.

> The Environmental Protection Agency finally is moving ahead with its previously announced study of mining effluents prior to establishing guidelines and new source performance standards. The consulting firm Versar, Inc., has been awarded the contract; it will meet with the trade associations to identify critical factors and review control methods currently in use. $3.5 million has been released to EPA by the Office of Management and Budget to participate in the joint U.S.-Canadian investigations set up by the Great Lakes Water Quality Agreement of 1972.

Section 5

NATURE AND AVAILABILITY OF TECHNOLOGY TO COPE WITH PROBLEMS

5.1 Nature of Technology

There is abundant published material on techniques of controlling pollution from mining activities (e.g., U.S. EPA Rept. EPA-430/9-73-011, 1973). Most of it deals either with acid-mine drainage and other problems of coal-mine areas, or with the treatment of waters laden with suspended solids from the milling of metallic ores. The former subject is of little significance in the Great Lakes region. The latter is applicable to the Minnesota iron-ore mines, to which indeed it has been intensively applied (Baillod et al., 1970, 1972). This technology, i.e. use of tailings ponds and related features, can be readily modified for use at gravel pits and stone quarries throughout the region if it is determined that the need exists.

When and if it is decided how best to dispose of unwanted brines, it will probably be found that existing techniques will do the job. Know-how is available to evaporate brines in order to recover their salts; to pump them into deeply buried strata via disposal wells (U. S. EPA Rept. EPA-430/9-73-012, p. 31-100); and to return them to oil-bearing strata to aid in repressuring and total ultimate recovery of oil. What is needed is fundamental research on alternative methods of disposal, especially on the long-range effects of deep-well injection.

Section 6

NEED FOR NEW PROGRAMS

6.1 Gaps in Knowledge

By far the largest extractive industries in the Great Lakes region are those that produce sand, gravel, and crushed stone. Large quantities of water are used in these operations, yet little information seems to exist on the extent of this use or on the degree to which contaminated waters are released. A systematic study, perhaps undertaken with the aid of the various states, would yield much-needed data on this subject. Such a study should be undertaken in the light of the expected expansion of these industries in the coming decades, as indicated on Table 3, page 15.

As previously indicated, there are appreciable gaps in our knowledge of the best way in which to dispose of waste brines. One aspect of the problem that should receive attention is a systematic inventory of those geologic formations beneath Michigan, Ohio, and New York that might act as large-scale receptors of brines. The rate at which these formations can accept introduced brines, and their ultimate storage capacity compared with the volume of brine expected to be produced over the next 40 to 50 years, are other topics on which information is needed.

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