

STATE OF MICHIGAN
THE DEPARTMENT OF
NATURAL RESOURCES



TWENTY-SEVENTH BIENNIAL REPORT
1973-1974



LETTER OF TRANSMITTAL

To the Governor and Members of the Seventy-Eighth
Legislature:

Sir and Gentlemen:

In accordance with provisions of Section Four, Act No.
17, Public Acts of 1921, I am transmitting herewith the
Twenty-Seventh Biennial Report, Department of Natural
Resources, for the fiscal years, 1972-73 and 1973-74.

I am pleased to submit this summary of the activities and
progress of this Department.

Respectfully,
HOWARD A. TANNER, *Director*

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GEOLOGICAL SURVEY DIVISION

ARTHUR E. SLAUGHTER, *State Geologist*

During the biennium, changes were made to Act 61,
Public Acts of 1939, as amended, to designate the
Director of the Department of Natural Resources as also
Supervisor of Wells with authority to ameliorate conflicts
between oil industry activities and Departmental concern
for environmental quality. The State Geologist and Chief
of the Geological Survey Division, previously titled by the
Act as Supervisor of Wells, became assistant supervisor.

Division field personnel engaged in oil and gas activities
were brought under the line organizational structure of
the Department. Regulatory Control and Production-
Proration units in appropriate districts of Regions II and
III came under the jurisdiction and supervision of newly
appointed regional Geologists, regional Managers, and
the Field Bureau Chief, rather than the Supervisor of the
Division's Oil and Gas Section. The restructuring of field
functions as distinct from staff duties was not fully
accomplished during the biennium. The overall objective
of this reorganization was the efficient conservation,
recovery, and use of all oil and gas resources of the
State through more effective administration of Act 61,
Public Acts of 1939, as amended, and Act 197, Public
Acts of 1959.

Oil and gas exploration and drilling activities continued at
a record pace around the periphery of the Michigan
Basin during the biennium. A record number of new
Salina-Niagaran oil and gas fields was discovered.
Record drilling and production activities, however,
brought numerous associated problems and concerns to
both industry and Department personnel, resulting in
more hearings before the Oil and Gas Advisory Board.
Most exceptions sought by producing companies called
for modifications of spacing orders to take maximum
advantage of drilling locations on area-restricted Salina-
Niagaran reefs. Five injunctive directional holes drilled
to protect esthetic or environmentally sensitive locations
were completed.

Mid-1973 ushered in full implementation of the Mineral
Well Act, Act 315, Public Acts of 1969, with its rules,

permits, fees and bonding requirements. This ended interim handling of deep-well disposal, solution mining, and test-well activities. Also in early 1973, the much-needed Mine Reclamation Act, Act 92, Public Acts of 1970, as amended, became effective. A new Mine Reclamation Unit was set up to work with open pit mine and quarry operators in "reclaiming lands subject to mining of minerals, controlling adverse effects of mining, preserving natural resources, encouraging planning for future land use, promoting orderly development of mining, encouraging good mining practices, and recognizing and identifying the beneficial aspects of mining." All minerals operations except sand, gravel, peat, marl, and clay—if extracted by open-pit mining—come under the new unit's review and evaluation. The Mine Reclamation Unit helped coordinate reclamation-revegetation research under contract with Michigan Technological University (MTU).

Also in cooperation with MTU's Institute of Minerals Research, the Division initiated evaluation of the State's mineral potential with a core-drilled mapping and sampling program to assess high quality dolomite in Chippewa, Mackinac, and Schoolcraft Counties. Dolomite of good chemical quality is an essential commodity in the chemical and steel-making industries of the State. Prospecting and exploration for all nonferrous metals in the western Upper Peninsula achieved new levels of attention and interest as vigorous demands created deficit supplies of these essential raw materials.

Consultation services performed for the Bureau of Water Management, Department of Public Health, Office of Land Use, Office of Planning Services, Forestry Division, and Solid Waste Management Division continued to be of major consequence in forwarding numerous state programs. Counsel offered to the Mineral Lands Subcommittee of the State Essential and Unique Lands Committee contributed to adaption of the sequential land-use concept. Expertise in state mapping progress was instrumental in accelerating high-priority mapping programs by the State Mapping Advisory Committee. Early in 1974, responsibility for geologic evaluation of potential landfill sites was transferred from this Division to the Solid Waste Management Division for more efficient assessment and monitoring of this important environmental function. Safeguarding the ground waters of the State continued to be an important cooperative effort with the Bureau of Water Management and the Department of Public Health.

OIL AND GAS SECTION

Division work groups engaged in oil and gas activities were again restructured and re-titled. Field operations of the Regulatory Control and Production-Proration units, previously outside the line organizational structure of the Department, came under direct control of the Field Bureau. Staff units supervising and regulating various aspects of oil and gas activities became part of the Oil and Gas Section, previously titled the Oil and Gas

Conservation Group. The Section is made up of a Regulatory Control Unit, a Production and Proration Unit, and a Petroleum Geology Unit. It is headed by an Assistant State Geologist in charge of oil and gas matters.

The head of the Oil and Gas Section, schedules and presides at public hearings before the Supervisor of Wells and the Oil and Gas Advisory Board. The production and Proration Unit supervisor serves as secretary to the Advisory Board and assists in the issuance of orders relating to the causes heard. During the biennium, 16 public hearings covering 125 separate causes were heard before the Supervisor of Wells and Oil and Gas Advisory Board. In addition to these hearings, normally scheduled on a monthly basis, there were 12 administrative hearings, 3 show-cause hearings, 6 hearings involving unitization matters, 5 hearings involving special orders, and 2 involving emergency orders. As a result of the hearings the following numbers of orders were issued: 111 spacing orders, 41 proration orders, 5 exceptions to spacing orders, 5 approvals for directional drilling, 1 exception to the general rules, 2 exceptions to Special Order 2-73, 4 unitization orders, 4 special orders covering casing and no-flare matters, 2 emergency orders, and 1 no-flare order related to a show-cause hearing.

Oil production increased from 24,013,278 barrels for the 1971-72 biennium to 29,540,551 for this reporting period. Gas production for the biennium amounted to 90,840,984 Mcf of which an estimated 44,408,300 Mcf was gas produced incidental to oil production. The upturn in oil and gas production reflects the increased number of new fields found during the past two bienniums.

During this biennium, 115 new fields, field extensions, or new pools were discovered. Of this total, 64 were classified as oil reservoirs and the balance as gas reservoirs. Most of these new discoveries were located in a belt extending from Mason County and arcing northeasterly to Alpena County. Another area of new discoveries was in the Ingham-Eaton-Calhoun County region of southern Michigan. In addition to the 115 mentioned discoveries, about 20 others were made during the latter part of the biennium but were not credited because the wells had not been officially completed. The geographic distribution of the new discoveries suggests continued development of the new pools around the entire periphery of the Michigan Basin.

Production and Proration Unit

Primary functions of this Unit are the acquisition and evaluation of engineering and geological data of Michigan's petroleum reservoirs. Other major duties are to carry out a surveillance and regulatory production control program, also directed toward the maximum ultimate recovery of Michigan's hydrocarbon resources.

There were 106 oil reservoirs and 864 wells being produced under State prorated control at the end of this

period. That compares to 22 reservoirs and 820 wells at the close of the last biennium. The notably large increase in oil reservoirs, as compared to the small advance in wells, stems from the active exploration and development of small (1 to 2 well) Salina-Niagaran reef reservoirs in northern Michigan. The latest daily oil production from prorated reservoirs represented about 70% of the 48,000 barrels of oil being produced daily in Michigan. In regulating these 106 reservoirs and new reservoirs being discovered at a rate of about three per month during the past year, this Section met its assigned regulatory program consisting of field surveillance, reservoir evaluation, processing and recording of production and engineering data. It also interpreted and utilized these data as they related to the Unit's responsibilities under the authority of the Supervisor of Wells.

During the biennium, this Unit participated in 16 public hearings covering 125 causes before the Supervisor of Wells and Oil Advisory Board. It also participated in all administrative hearings. Quarterly prorated production summaries, monthly development reports, and miscellaneous compilations of technical statistical data were submitted periodically to the Supervisor of Wells.

Observations were continued and data compiled and published annually on 20 oil reservoirs under State-approved secondary recovery programs. Perpetual records were maintained on Michigan's six oil refineries which process about 130,000 barrels of crude per day, 35 to 40,000 barrels of which are Michigan crude, with the balance made up of imported domestic and Canadian crude oil. Monthly records were maintained on the operations of 12 oil-well gas processing plants serving Michigan's major oil fields. Crude oil reserves studies were made jointly with the industry. These studies showed that Michigan's crude reserves increased from 58.7 million barrels as of December 31, 1971, to 72.4 million barrels as of December 31, 1973.

Petroleum Geology Unit

The major work of this Unit is the collection and maintenance of geological and engineering data on oil and gas wells drilled in Michigan; the processing and distribution of this information in the form of well logs, technical reports and maps; and serving as consultants to the Supervisor of Wells and other Division Units in matters of subsurface oil and gas geology. Service is also provided to other government agencies, universities, and the public. The Petroleum Geology Unit maintains a cartographic sub-unit for the drafting, maintenance and distribution of oil field maps and charts and the distribution of U. S. Geological Survey topographic maps. The Unit also maintains and manages libraries of well-sample sets, electric logs, and published well records for in-house and public use.

New well-sample sets were added to the library during the biennium but selection was again curtailed for lack of storage space and funds. The electric-log and well-

record libraries continued to expand as did the construction of new oil and gas field maps. These facilities continue to be widely used by oil-and-gas industry personnel, the public, and the Division's staff.

Information was given by phone and letter, and by personnel office contact to about 2,000 persons during the biennium. Persons seeking information or advice relating to oil and gas geology included landowners, industry personnel, consulting geologists, university professors and students, and personnel from various government agencies such as Public Service Commission Department of Highways and Transportation, U. S. Geological Survey, and agencies associated with the Atomic Energy Commission.

Members of the Petroleum Geology Unit again kept comprehensive statistics on oil and gas field activities. These and other types of data were published in Annual Statistical Summaries 18 and 20 covering calendar year's 1972 and 1973. Such summaries are widely used by the petroleum and natural gas industries as well as many governmental agencies. During the biennium, the Unit was charged with making special geological studies and a complete report on the Williamsburg gas eruptions in Grand Traverse County. In addition, Petroleum Geology staff members prepared reports for the American Association of Petroleum Geologists, Interstate Oil Compact Commission, and several industry-related periodicals. Unit personnel also delivered geological lectures, provided assistance in field mapping and the study of outcrop geology, served on several oil and gas industry committees, and participated in 16 public hearings and most administrative hearings.

A summary of the number of logs and records received, processed, published and distributed, and maps constructed and posted by the Unit follows:

Oil and Gas Logs		
New geological and driller's logs received	847	2400 logs distributed free to 3 universities and Michigan Elevation Service. Free distribution was discontinued January 1, 1973
Deepening and rework records received	320	
New logs published for distribution	621	Logs sold or distributed by special order to companies and public **26,151
New logs sold by subscription (estimated*)	28,157	**Total number of pages reproduced by Xerox for this number of logs amounted to 88,152
*The estimate includes about		
Electric Log Library		
New electric log sets received, processed and filed	869	
Well Sample Library		
New sample sets received, catalogued and filed	79	
Sample sets loaned or inspected:		
Companies	75	
Consultants	82	
University students	16	

Maps

During the biennium, the oil and gas cartographic sub-unit was reassigned to the Petroleum Geology Unit of the Geological Survey Division. Previously, oil-and-gas map operations were handled by Engineering Division.

A summary of activities follows:

New oil and gas maps constructed	14	Oil and gas maps available for use	299
Miscellaneous maps and charts constructed	1	Miscellaneous maps for sale	52

United States Topographic Maps

The cartographic sub-unit is also responsible for the maintenance of files, inventory, and distribution of U. S. Geological Survey topographic maps. Distribution of these maps was as follows:

Over-the-counter sales	5,455	Free Register	9,614
Mail order sales	3,047		

Regulatory Control Unit

This Unit issues permits to drill, deepen, rework, or plug any wells for oil and gas, for secondary recovery, or disposal wells for salt water brine or other fieldwastes produced in association with oil or gas operations or storage wells for liquid or gaseous hydrocarbons, as specified by oil and gas statutes of the State. The Unit controls the locating, spacing, drilling reworking, plugging, casing, and sealing of all wells and evaluates applications, well location survey records, and other pertinent data and records. It also evaluates environmental impact statements related to each permit application for well drilling.

Staffed largely with geologists who implement compliance with statutes and rules pertaining to oil and gas operations, the Unit maintains field offices in Region II at Mt. Pleasant, Cadillac, and Gaylord under supervision of the regional geologist located at Roscommon; and in Region III at Imlay City, Plainwell and Lansing (the latter operated from Geological Survey Division headquarters) under the supervision of the regional geologist located in the Regional Headquarters at Lansing. Each field office is assigned a geographic area throughout which attention is given to well site location, preparation and approval, evaluation of environmental impact statements, surveillance of drilling, plugging, brine disposal operations, production operations and conditions, and other matters relevant to oil and gas operations.

Record files are maintained on all wells for which permits are issued, on ownership, on well status, and on current well operations. Reports pertaining to the issuance of permits, the change of well ownership, status, condition, or abandonment are compiled and issued weekly, monthly, or on an annual basis.

During the biennium, the Unit issued 875 permits to drill wells for oil or gas, secondary recovery, salt water, or brine disposal in association with oil and gas operations and development of reservoirs for the storage of liquid or gaseous hydrocarbons. In addition, 52 permits were

issued to deepen wells. Permits were terminated for 85 wells after operators failed to begin drilling within six months of the date of issue. Applications were approved to rework 274 wells. Permits were issued resulting in the plugging or abandonment of 150 depleted wells or zones of completion and 394 newly drilled wells which failed to produce oil or gas. The Unit also approved and processed 604 transfers of ownership of individual wells plus blanket transfers for all wells of five companies. In addition, 16 permits to drill were cancelled and transferred to new drill sites; 108 corrections to permit files were recorded and published. Approximately 94,000,000 barrels of oil-well brine were disposed of under supervision of the Unit.

ECONOMIC AND ENVIRONMENTAL GEOLOGY SECTION

The Economic and Environmental Geology Section consists of the Mining and Economic Geology, Mineral Wells, Water and Environmental Geology, and General Geology units. New activities of the Section were primarily in the fields of mine reclamation and mineral wells.

Act 123, Public Acts of 1972, became effective during the first half of the biennium. It amended the Mine Reclamation Act (Act 92, Public Acts of 1970) to include, in addition to metallic minerals, the open pit mining of all types of stone. Field investigations of the State's stone quarries were made to determine the extent and type of regulation necessary in the public interest. Based upon these findings proposed rules were drafted.

Rules under the Mineral Well Act (Act 315, Public Acts of 1969) became effective early in the biennium. Staffing of the Unit permitted implementation of the Act and the rules. The head of the section served as secretary to the Mineral Well Advisory Board.

Mining and Economic Geology Unit

Mines Appraisal and Precambrian Geology

Although the number of properties appraised for general property tax purposes declined during each year of the biennium, this function continued to be an important one of the Unit. Approximately 45 iron ore and copper mines, mostly idle reserve properties, and other mineral properties were appraised during each year. Valuations were determined after review and study of drill hole records, mine maps and sections. Also involved was the examination of surface facilities and underground workings. Key consideration was given to the economics of individual properties, and to the metals commodity market. Total values of the properties reported to the Michigan Tax Commission were:

Type of Property	1973	1974
Iron Ore	\$ 1,207,000	\$ 1,102,000
Copper	33,665,000	37,760,000
Total	\$34,872,000	\$38,862,000

Increased product demand and favorable price stimulated copper mining activity with record production achieved at the White Pine Mine during 1973. The Centennial 3-6 Mine was dewatered and exploratory shaft-sinking began to evaluate reserves at this location.

Iron ore pellets from low-grade surface iron formation and underground ore continued to replace natural ore production. The first phase of the Tilden Mine and Empire Mine expansion neared completion at the end of the biennium.

These additions will increase iron-ore pellet capacity to more than 16 million tons annually. The Sherwood Mine commenced sinking an incline to a lower level, from 1650 down to 1875 feet.

Beneficiation and agglomeration operations are subject to a specific tax in lieu of general property taxes. The annual determination of these taxes, and especially their allocation to the assessing districts involved, is an increasingly important activity of this Section. Total specific taxes determined by the appraisers were:

Type of Property	1973	1974
Low-grade ore	\$1,640,889.74	\$1,899,976.16
Underground (agglomerated)	476,123.29	478,175.39
	\$2,117,013.03	\$2,378,151.55

Geologic mapping of the Precambrian rocks of the western Upper Peninsula, in cooperation with the U. S. Geological Survey, continued at a modest pace. Preliminary geologic maps of the Negaunee SW, Wakefield NE, Marenisco and Witch Lake quadrangles, the Ironwood-Ramsay area, and Porcupine Mountains area were made available in open-file. These maps cover an area of approximately 385 square miles. Three reports on the geology of Isle Royale were published and a multi-colored geologic map neared completion.

In addition to the cooperative program, field mapping of exposed Precambrian rocks in Menominee County was completed. After the petrographic study has been accomplished on the numerous rock specimens collected, a geological report on the area will be prepared. The objective of this study is to develop basic geologic data to help evaluate the general mineral potential of the area and to encourage further mineral exploration by the mineral companies.

Geologic consultation was given other divisions and state agencies; in particular, the Lands Division was assisted in appraising the mineral potential of lands involved in sales or exchanges, and in the sale of mineral rights to private surface owners. State-owned lands leased for copper, iron ore, and all-minerals exploration were inspected and annual reports of exploratory work were reviewed for conformance with lease requirements.

Geological information, primarily regarding Precambrian formations, was provided numerous interested parties including the general public and company

representatives concerned with the general geology and mineral potential of the western Upper Peninsula.

Mineral Statistics and Nonmetallic Minerals

Annual collection and publication of mineral statistics, along with the gathering and provision of information on the nonmetallic mineral resources of the State, are primary responsibilities of the Unit. Two separate canvasses of the State's mineral producers were made with the cooperation of the U. S. Bureau of Mines in order to compile the annual mineral statistics required by Michigan Statute (CL 48 S 319.202). Replies from over 500 mineral producers on production and value of over 900 individual pits, mines, quarries, and manufacturing plants were received. The production and value of three metallic minerals (iron ore, copper, and silver) and 12 nonmetallic building and industrial minerals (cement, lime, gypsum, stone, salt, sulfur, natural salines, peat, marl, clay, shale, and sand and gravel) were reported. Data on use, location, labor, and business trends were also provided by the canvass.

Data obtained from the canvasses were published in two Annual Statistical Summaries (17 and 19) and two Annual Directories of Michigan Mineral Producers (6 and 7). These mineral reports show that the value of the State's mineral production increased significantly during 1972 and 1973. The State's mineral valuation reached new record highs during the biennium totaling \$698,511,340 in 1972 and \$816,949,698 in 1973. The 1972 valuation increased \$42.8 million over 1971. The figure for 1973 was \$118.4 million over the previous year. The record-setting mineral valuation was attributed to an increase in demand for raw materials by the manufacturing and building industries. Iron ore continued to lead the way in value of minerals produced, followed by cement, natural salines, copper, petroleum, sand and gravel, and salt. The total value of nonmetallic minerals continued to exceed the combined value of both metals and petroleum by more than 56 percent. Michigan remained first in the production of gypsum and peat, and was the only producer of iodine. In addition, the State ranked second in production of bromine, iron ore, and sand and gravel.

In addition to the collection and publication of mineral statistics, the Unit was involved in geological research and various field studies. Late in the biennium, a study of the bedrock geology of Menominee County was initiated. It will eventually lead to a published report.

The Unit continued its mapping and sampling program in the investigation of high quality dolomite in the Engadine Dolostone belt of Chippewa, Mackinac, and Schoolcraft counties. Some 60 outcrop locations were visited with 66 samples being collected. The samples were sent to the Institute of Mineral Research (IMR) at Michigan Technological University where they were to be analyzed for their chemical quality to measure their potential use in the chemical and flux-stone industry. A new investigation of the Hendricks Limestone member of the Burnt Bluff Group was initiated for Chippewa,

Mackinac, and Schoolcraft counties. The purpose of the study is to locate and define potential reserves of high quality limestone. The project is in cooperation with IMR at Michigan Technological University. As of the end of the biennium, six of 15 planned locations had been core drilled. With the prospects of having chemical analysis made through the U. S. Bureau of Mines, an investigation of the Traverse group of limestones was initiated in Cheboygan and Presque Isle counties. During 1973, some 34 localities were visited and 25 sites were found suitable for the collection of 30 samples. Eventual chemical analyses of the samples will indicate whether these prospects are potential sources of high calcium limestone for the chemical and flux industries or for the manufacturing of Portland cement.

The Unit co-authored a geological report entitled "Devonian Strata of Emmet and Charlevoix counties, Michigan" by R. V. Kesling, R. T. Segall, and H. O. Sorensen which was published by The University of Michigan Museum of Paleontology as Papers on Paleontology No. 7, 1974. The report should be a valuable aid to land planners, builders, aggregate and cement industries, rock hounds, and geologists interested in the Traverse Group in the Charlevoix-Petoskey area. The photographic plates of fossils in the book should be useful to paleontologists and fossil collectors by showing the varieties found and their identity.

Upon request of the Michigan Basin Geological Society, the Unit led a geologic excursion into the Grand Traverse region. The published guidebook included a discussion, road log, and descriptions of the various glacial-geologic features and the bedrock-geology outcrops that were examined on the trip.

A sampling and chemical analysis program of the natural-brine resources of the Lower Peninsula was planned and carried out to define and locate high-quality brine. The project resulted in collection of 105 samples of oilfield brines, representing 19 different brine-bearing horizons, in 40 counties of the Michigan Basin. The brine analysis was done in cooperation with the U. S. Bureau of Mines. As a result of the study, two papers on the natural brines of the Detroit River group were presented at the 1973 International Symposium on Salt at Houston, Texas, and at the 1973 meeting of the Michigan Academy of Science, Arts, and Letters annual meeting at East Lansing.

Preliminary field trips were made to stone quarries and open-pit mines in the state mainly to gather information for formulating rules for administration of the Mine Reclamation Act 123 of 1972. The Unit supplied advice and recommendations to Forestry Division for revision of its mineral-disposal policy. In addition, gravel pit-mining plans were supplied when requested by Forestry Division. Assistance was given to Region II geologists in directing exploratory work for an evaluation of state-owned gravel properties in Clare and Presque Isle counties, property in Presque Isle County for land-exchange purposes, and a gravel pit in Cheboygan

County involving a mineral trespass on state-owned mineral rights.

Supplies of 24 rocks and minerals were collected by the Unit to provide over 2,000 rock and mineral kits to meet the growing demand for educational material in the earth and environmental sciences. The kits are sold to students, teachers, rock hounds, and other interested parties.

The Unit continued to gather information for the preparation and revision of maps and charts dealing with the mineral industry. Correspondence and discussion with the public and representatives of industry on the mineral resources of Michigan was a prominent activity. This included the identification of rocks, minerals, and fossils brought or sent in by individuals; directing industrialists to supplies of sand and gravel, stone, and other mineral resources; evaluation and appraisal of state and private owned lands subject to sales or land exchanges; and the answering of inquiries on all phases of geology.

Mine Reclamation Unit

The Mine Reclamation Act (Act 92, Public Acts of 1970, as amended by Act 123, Public Acts of 1972) became effective on March 29, 1973. The Mine Reclamation Unit was established in January, 1974. In the interim, staff of the Mineral and Mining Economics Unit conducted a comprehensive survey and study of open pit operations to determine the extent and type of regulations of mining areas deemed necessary in the public interest. As a result of their suggestions and conclusions, proposed rules were drafted for submission to the Natural Resources Commission for tentative approval before going to public hearings.

The annual plan-maps submitted for 41 operating properties were reviewed and evaluated. Since January, 1974, several open-pit iron ore, gypsum, and limestone mining areas were examined to observe progress of reclamation activities and associated problems. In lieu of the promulgation of rules, this Unit actively encouraged open-pit operators to incorporate an end-use or multiple land-use strategy in their plan of operations.

This Unit acted as coordinator in research activities relating to reclamation of mining areas conducted under contract by Michigan Technological University. The research included: 1) Revegetation research on dam berms and rock piles resulting from mining and milling operations; 2) Fundamental research on the nature and characteristics of mine tailings as they affect plant growth; 3) Revegetation research on tailings areas subject to wind erosion and subsequent air pollution; 4) Development of equipment suitable for operation in tailings basins; 5) Research on application of soil-mechanics principles in the use of tailings for construction of dikes and roads and in the control of erosion of tailings basins by wind or water; and 6)

Control and treatment of effluent water from mine plants and tailings basins.

Mineral Wells Unit

The Mineral Well Act provides for control of the drilling, operation, and abandoning of mineral wells to prevent surface and underground waste. During this biennium, the program was fully implemented with respect to lees, permits, and bond system, effective May 1, 1973.

Although there was insufficient surveillance of some activities, a majority of the operators concerned attempted to comply with the permit-bond requirements.

Disposal and Storage Wells: The State disposal- and storage-well program was approved by the federal Environmental Protection Agency as meeting federal standards for regulating storage and disposal wells. Since implementation, 78 permits were issued as follows: 68 for previously existing wells; 5 for conversion of old wells for disposal; and 6 for new disposal wells, one of which was completed.

Natural Brine and Solution Mining: Minimum regulatory standards were met, largely due to excellent cooperation on the part of the salt and chemical industry. Since implementation, some 63 brine- and solution-mining wells were permitted for operation, or drilling and operation. Assessment of subsidence programs associated with solution-mining operations continued. Companies subject to this portion of the law made concerted attempts to upgrade the quality of their leveling and other operations in compliance with instructions embodied in the Solution Mining Guidelines. These guidelines were prepared in 1972 by the Solution Mining Research Institute for companies operating in Michigan.

Test Wells: The test well program was primarily handled on a complaint basis. It is believed that the majority of companies utilizing test wells met the permit-bond requirements for those programs. A summary of the permit activity and test of records is presented in the following table.

Test Well Activity May 1, 1973-June 30, 1974		
Test Well Program	No. Permits	Holes Drilled on Record
Foundation Borings	1,106	3,293 ¹
Geophysical Testing Holes	63	109,000 ²
Mineral Exploration	90	357 ³
Miscellaneous	14	19
Total	1,273	112,669

¹Does not include holes less than 25 feet in depth.

²Average depth 1,584 feet. Does not include over 400,000 shot holes under 25 feet in depth.

³Includes borings from areas excluded from permit requirements.

Water and Environmental Geology Unit

The Unit continued to serve as geologic consultant to the Bureau of Water Management, Department of Public Health, several other DNR divisions, and the general public in evaluating and protecting ground waters of the State. Service was provided in appraising waste-disposal sites, public ground-water supplies, ground-

water contamination, and area hydrologic investigations in the pursuit of ground-water quality and environmental excellence. Nearly 80 percent of staff time was devoted to liquid and solid waste contamination studies. This involved more than 2,650 man hours of field work. An additional 1,450 hours were focused upon waste-disposal conferences and various departmental, organizational, and professional meetings.

Geohydrology

The staff served as a consultant to various state agencies, municipalities, industrial organizations, and interested individuals in matters relating to the occurrence, availability, quantity, and quality of ground-water supplies. To assist in performing this duty, the Unit maintains a file of over 150,000 well records. Copies of 16,523 water-well records were sold to various parties seeking geologic and hydrologic information.

As part of its normal public service in water resources matters, the Unit responded to 261 information requests from the general public; 337 requests from industry, representatives, ground-water consultants, and water-well drillers; plus 206 requests from federal, state, and local agencies.

Ground Water. The Unit assisted the Bureau of Water Management in investigation and evaluation of 103 proposed sites for disposal of liquid wastes to the ground waters to prevent pollution and other health hazards.

The Unit provided field supervision for 25 wells drilled at state parks, fish hatcheries, and other Department installations for the Engineering Division. Reports on drilling, completion, and well capacities were submitted to the Engineering Division in addition to recommendations on contractual bid items for an additional 30 proposed wells.

The Unit investigated and prepared reports on 16 water-supply and sewage-disposal projects for the Department of Public Health and the DNR's Municipal Wastewater Division. Seven of these projects were investigations of spray irrigation and other types of land sewage-disposal projects; 3 were municipal aquifer evaluations; and the remaining 6 were evaluations of on-site, water-supply and sewage-disposal proposals for new subdivisions.

Advice and information on the geohydrology of 100 miscellaneous well problems were provided to the Department of Public Health's Ground Water Quality Control Unit.

Surface Water. The Unit provided information and geologic advice to the DNR's Bureau of Water Management and the public for 53 surface-water problems, including dredging in or near inland lakes, proposed impoundments of surface water, and problems related to lake levels. Federal agencies received information and consultation service on 4 surface-water problems.

U. S. Geological Survey Cooperative Program.

Several cooperative programs with the Water Resources Division of the U. S. Geological Survey were continued. This work involved gaging streams, monitoring groundwater levels and water quality, and detailed investigations of local and regional water quality. Most of these studies were published as Water Investigations and Water Information Series reports. Additional material is available as open file reports. The Baraga County report was published during the biennium and environmental geologic reports for Delta and Washtenaw Counties were nearing completion at the end of the two-year period.

Geographic Names. The Unit served as a clearinghouse for information and procedures on selecting and revising geographic names. New and proposed geographic names were reviewed and processed through the U. S. Board of Geographic Names. Over 60 requests were handled by the Unit in 42 formal name changes for clarification purposes.

During the biennium, the Livingston County Board of Commissioners initiated a project of replacing with new names all of the duplicated lake names in its county. This project, now completed, involved 15 lakes. At the end of the biennium all requests had been cleared through the U. S. Board of Geographic Names.

Glacial and Environmental Geology

Activities were almost entirely devoted to the geologic evaluation of solid-waste disposal sites for ground- and surface-water pollution possibilities. During the biennium, 102 such requests were handled for the Department's Solid Waste Management Division.

Criteria and guidelines for solid-waste disposal in Michigan were formalized. Numerous inquiries relating to waste disposal, environmental geology and glacial geology received responses. A U. S. Geological Survey cooperative study of the Muskegon County wastewater treatment facility was initiated with Unit participation. Surface- and bedrock-geologic maps of Marquette County were 95 percent completed during the biennium as part of a cooperative study with the U. S. Geological Survey.

Special Studies

A three-year environmental study of Houghton Lake was completed and published as part of a seven-volume report co-sponsored by the Upper Great Lakes Commission and the DNR's Bureau of Water Management. Fourteen lectures were presented at various universities, DNR in-service training sessions, the 22nd Annual Suburban Sewage Disposal Conference, the Department of Public Health's Basic and Advanced Soils courses, the Michigan Academy of Science, Arts, and Letters, and local health department seminars. Papers were published in the Michigan Basin Geological Society Fieldtrip Guidebook for 1973; in Agronomy (co-authored abstracts) and in Titles and

Abstracts for the 1973 meeting of the Michigan Academy of Science, Arts, and Letters.

Upper Peninsula Office

The ground-water evaluation and protection function of the Upper Peninsula office is similar to the Geohydrology Unit of the Lansing office. The Staff spent more than 3,200 man-hours in the field and more than 700 hours in conferences and meetings. Twenty-one talks were presented to a variety of organizations. Information was supplied or investigations were made in response to about 100 requests for assistance in ground-water related problems. About 250 man-hours were spent in the field, in addition to office work, assisting local municipalities and public schools with their water-well problems. Supervisory assistance in the drilling of 25 state water wells was undertaken. Eighty man-hours were spent in the field, on evaluations of the possible effects of waste effluents on ground-water supplies for sewage lagoon sites; 200 man-hours for trailer park sites, 256 man-hours for new subdivisions; and 176 man-hours for other projects. Eighteen requests involving surface water were investigated in addition to 3 gravel pit and quarry investigations. Six hundred man-hours were spent in the field investigating sanitary landfills. Lengthy problems handled during the biennium were an acid mine-water study in the Village of Stambaugh, the Osborn Subdivision salt water contamination case, and the Republic-Mine dike leakage problem.

General Geology Unit

Principal activities of this Unit were the acquisition of general geologic, geographic, physiographic, and historic information; responding to inquiries relating to the geology, geography, mineralogy, geologic history, mineral development history, physiography, topographic mapping, state boundary problems, publications and activities of the Geological Survey Division; providing consultation services to other state agencies, particularly the Office of Land Use and the Office of Planning Services. Other main functions covered editing, lay-out, and distribution of Division publications, in particular those produced in cooperation with the U. S. Geological Survey's Water Resources Branch. This Unit also served as liaison in coordinating the cooperative topographic mapping program; maintained a reference library; assisted in occasional field investigation, and coordinated the Division's training program.

Geoscience Information

A substantial part of the Unit's services continued to be the dissemination of basic information on the geology, geography, mineralogy, geologic history, mineral development history, physiography, mapping, state boundary, publications, and activities of the Division in general.

During the biennium, over 2,400 letters were written, 3,400 publication requests filled, and over 900 people

visited the office for information and assistance. Over 1,000 telephone contacts were handled by the Unit.

More than 4,000 Geological Survey publications were distributed by the Unit for use in answering inquiries and filling requests. In addition, 800 publications issued by other agencies were distributed and 1,100 items were reproduced from material in Unit files.

Geologic Resource Center

More than 1,500 books, reports, and papers were incorporated into the Division library and files. The acquisition of these new items stems largely from cooperative exchange programs with other state geological agencies, the U. S. Geological Survey, U. S. Bureau of Mines, and other state, federal, and private agencies. The Unit maintained subscriptions to over 70 periodicals and journals on geology and related topics published by scientific and resource organizations.

Consultation Services

The Unit provided geologic background information for the Office of Planning Service's Boardman River study after inspecting a large portion of the river. This was preparatory to seeking Wild River designation for this relatively unspoiled stream.

Technical assistance for topographic mapping and other mapping considerations was provided to the Office of Land Use and its State Mapping Advisory Committee. This material contributed to completion of the cooperative topographic mapping program and strong support of other basic mapping programs essential to land use planning. A 21-page report on the status and needs of mapping in Michigan was produced for the Committee in cooperation with the Office of Land Use.

Employment

A dozen new professional people were added to the staff to handle new and increased responsibilities in Oil and Gas Regulatory and Mineral Wells mandates. Two new clerical positions were also added to assist in these functions. One professional geologist transferred to the Solid Waste Management Division as that unit assumed major responsibility for geological evaluation of the pollution potential of this environmentally-sensitive activity.

Personnel Changes 1972-74

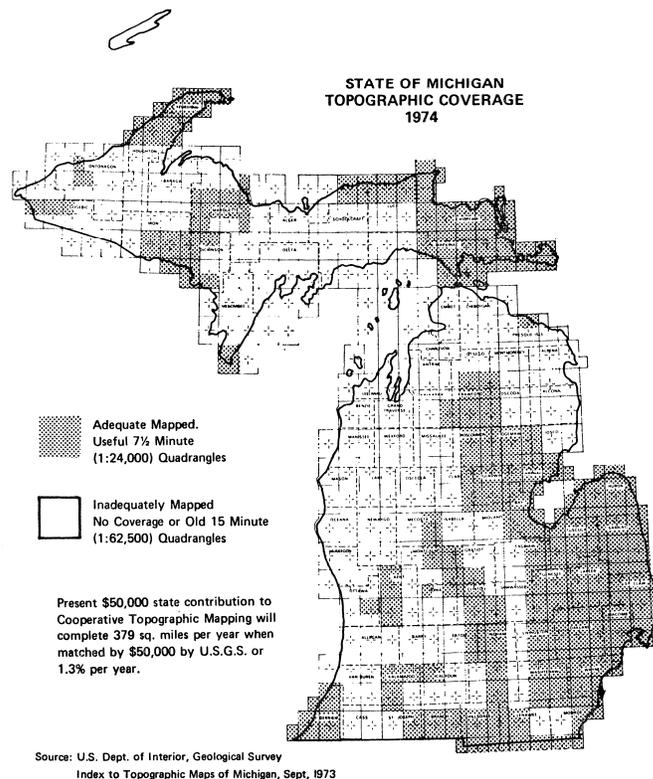
	Professional	Technical	Student Assistants	Clerical
Hired	12	—	11	5
Transferred from other state agencies	2	6	—	3
Transferred to other state agencies	14	7	—	5
Retired	—	1	—	2
Separated	1	—	8	1

The unit processed 1,319 employment contacts. Fifty-five formal interviews were held jointly with various Unit supervisors. Interest in employment with the Geological Survey Division by newly graduated geology majors reflected, in large measure, the poor job market in exploratory and extractive industries brought on by declining profit potential in the early seventies.

Topographic Mapping

The Unit continued to monitor the state cooperative topographic mapping program with the U. S. Geological Survey. Fifty-six newly published topographic quadrangle maps, 93 advance prints, and 40 advance proofs of maps in progress were distributed by the Unit. Less than half of these maps were produced under the cooperative program. Most were completed in response to requests for adequate basic mapping to support various federally financed development and resource management projects in the state. In addition, 27 quadrangle maps were photorevised by the U. S. Geological Survey and distributed by the Unit. This is part of a Topographic Mapping Branch program to keep all urban area maps up to date to meet the demand for basic information in such rapidly-growing sectors. The total number of sheets distributed during the biennium exceeded 16,000.

Newly published maps accounted for 2,300 square miles of previously unmapped or inadequately mapped territory. This brought the total of adequately mapped land area up to 41.7 percent at the 7½ minute, or 1:24,000 scale. These maps provide basic land use information for all land resource planning and management endeavors. At the end of the biennium, mapping of 6,000 square miles of the state was in progress and another 11,000 square miles were authorized for mapping in the near future. This figure includes 9,500 square miles for which orthophotoquads, interim scale corrected photo mosaics, were authorized. These interim maps will provide basic land-use information for selected areas until standard line maps can be produced under the cooperative program.



TOPOGRAPHIC MAPS RECEIVED DURING THE 1972-74 BIENNIUM.

Advance prints (before field check):

Three Rivers NE, NW, SE, SW

Advance prints (after field check):

Alpena NE, NW, SE, SW	Manistique River NE, NW, SE, SW
Black River NE, NW, SE, SW	McKinley NE, NW, SW
Blaney NE, NW, SE, SW	Mio NE, NW, SE, SW
Blissfield NE, NW, SE, SW	*Muskegon NE, NW, SE, SW
Bolton NE, NW, SE, SW	Niles SE, SW
Corunna NE, NW, SE, SW	Posen NW, SE, SW
Driggs Lake NE, NW, SE, SW	Presque Isle SW
Dundee NW, SW	Rogers NE, NW, SE, SW
*Fenwick NE, NW, SE, SW	Samaria
Hubbard Lake NE, NW, SE, SW	Seney NE, NW, SE, SW
Ida	Seul Choix Point NE, NW
Klein NE, NW, SE, SW	*Smyrna NE, NW, SE, SW
Laingsburg NE, NW, SE, SW	Three Rivers NE, NW, SE, SW
*Lake Harbor NE	Thunder Bay Island
Manistique NE, NW	

Advance proofs (provisional designation in parentheses)

Adams Point (Posen NW)	Middle Island (Alpena NE)
Alpena (Alpena SW)	Moltke (Rogers NW)
Bath (Laingsburg SW)	*Niles West (Niles SE)
*Belding (Fenwick SW)	North Point (Alpena SE)
*Berrien Springs (Niles NE)	Ossineke (Black River NW)
Black River (Black River SE)	Polaski (Bolton NW)
*Cannonsburg (Smyrna SW)	Posen (Posen SW)
Constantine (Three Rivers SW)	Presque Isle (Presque Isle SW)
*Evans (Smyrna NW)	Price (Laingsburg NW)
*Galien (Niles SW)	Rogers City (Rogers NE)
*Greenville East (Fenwick NW)	Shaftsbury (Laingsburg SE)
*Greenville West (Smyrna NE)	*Sheridan (Fenwick NE)
Hawks (Rogers SW)	*Shiloh (Fenwick SE)
Klingner Lake (Three Rivers SE)	Smyrna (Smyrna SE)
Lachine (Bolton SW)	South Point (Black River NE)
Laingsburg (Laingsburg NE)	Spruce (Black River SW)
Lake Winyah (Bolton SE)	Thompsons Harbor (Posen SE)
Long Lake East (Alpena NW)	Three Rivers East (Three Rivers NE)
Long Lake West (Bolton NE)	Three Rivers West (Three Rivers NW)
Metz (Rogers SE)	Thunder Bay Island

Final published maps

Assumption	*Bridgman
Augusta	*Caseville

*Bad Axe East	Cement City
*Bad Axe SE	*Charity Island
*Bad Axe West	Chicago (1:250,000)—revision
*Baroda	*Coloma
Bath	Dansville
*Bay Port East	East Lansing
*Bay Port West	*Elkton
*Belding	Fayette
*Benton Harbor	Fort Wayne (1:250,000)—revision
*Benton Heights	Gilletts Lake
*Berrien Springs	Grandville
*Harbor Beach	Pleasant Lake
*Huron City	*Port Austin East
Jackson North	*Port Austin West
Jackson South	*Port Hope
*Kinde East	Price
*Kinde West	*Redman
Laingsburg	Rogers City
Leslie	*Rush Lake
Long Lake NE	*Sand Point
Lyons	Shaftsbury
Mason	*Sodus
Michigan Center	Somerset Center
Moltke	*Three Oaks
Morenci	Tipler
*New Buffalo East	Toledo (1:250,000)—revision
*New Buffalo West	Williamston
*Niles West	
<i>Interim revisions</i>	
Allendale	Fairgrove
Alvordton	Fish Point
Banfield	Frankenmuth
Battle Creek	Grand Rapids East
Bedford	Grand Rapids West
Bellevue	Nettle Lake
Birch Run North	Pinconning
Bridgeport	Quanicassee
Caledonia	Reese
Cedar Springs	Rockford
Cedar Springs SW	Saginaw NE
Cutlerville	Sparta
Delton	Willard
Essexville	

**Produced cooperatively by the U. S. Geological Survey, Department of Interior, and the State of Michigan. All other maps produced under Systems-Investigations-Research program by the U. S. Geological Survey in support of various federally financed projects.*

State appropriations to the cooperative topographic mapping program, contributed through the Highways Trunkline Fund, continued on a \$50,000 annual basis, with matching funds provided by the U. S. Geological Survey.

Publications

Eighteen new Geological Survey publications were released during the biennium along with reprints of seven previously published reports.

Over 5,000 Geological Survey publications were exchanged with comparable organizations throughout the country and deposited in libraries in more than 60 states, provinces, and nations. Nearly 4,000 publications were distributed by the Unit in answering inquiries and filling requests supplemented by other material.

Publications released during the biennium are listed below.

GEOLOGICAL SURVEY PUBLICATIONS

(* indicates reprint)

Report of Investigation 9—Geology and Magnetic Data for Southern Crystal Falls Area, Michigan (U. S. Geological Survey cooperative).

Report of Investigation 14—Gravity and Aeromagnetic Anomaly Maps of the Southern Peninsula of Michigan (Michigan State University cooperative).

**Water Investigation 3*—Water Resources of Van Buren County, Michigan (U. S. Geological Survey cooperative).

Water Investigation 11—Ground Water and Geology of Baraga County, Michigan (U. S. Geological Survey cooperative).

**Water Information Series Report 1*—Upper Rifle River Basin, Northeastern Lower Michigan (U. S. Geological Survey cooperative).

Water Information Series Report 3—Hydrology and Recreation on the Coldwater Rivers of Michigan's Southern Peninsula (U. S. Geological Survey cooperative).

Water Information Series Report 4—Hydrology and Recreation on the Coldwater Rivers of Michigan's Upper Peninsula (U. S. Geological Survey cooperative).

Annual Statistical Summary 15—Mineral Industry of Michigan, 1970 (U. S. Bureau of Mines cooperative).

Annual Statistical Summary 16—Michigan's Oil and Gas Fields, 1971.

Annual Statistical Summary 17—Mineral Industry of Michigan, 1971 (U. S. Bureau of Mines cooperative).

Annual Statistical Summary 18—Michigan's Oil and Gas Fields, 1972.

Annual Directory 6—Michigan Mineral Producers, 1972.

Annual Directory 7—Michigan Mineral Producers, 1973.

Circular 10—Mineral Well Act and General Rules Governing Mineral Well Operations in Michigan.

**Pamphlet 4*—Collecting Minerals in Michigan.

**Pamphlet 5*—Geologic Sketch of Michigan Sand Dunes.

**Michigan Conservation Reprint*—Michigan Beach Stones.

**Michigan Conservation Reprint*—Michigan's Colorful Minerals.

Price List 14—Available Publications of the Geological Survey (1973).

Price List 15—Available Maps of the Geological Survey (1973)

Price List 16—Available Publications of the Geological Survey (1974).

**Chart 1*—Stratigraphic Succession in Michigan.

Ground-water Publications List (1973).

Ground-water Publications List (1974).
26th Biennial Report, 1970-1972.

Publications in Press

Bulletin 6—Mineralogy of Michigan.

Water Information Series Report 2—Flowing Wells of Michigan (U. S. Geological Survey cooperative).

Water Information Series Report 5—Compilation of Miscellaneous Stream Flow Measurements for Michigan Streams through September 1970 (U. S. Geological Survey cooperative).

Annual Statistical Summary 19—Mineral Industry of Michigan, 1972 (U. S. Bureau of Mines cooperative).

Annual Statistical Summary 20—Michigan's Oil and Gas Fields, 1973.

Annual Directory 8—Michigan Mineral Producers, 1974.

Price List 17—Available Maps of the Geological Survey (1974).

**Rock and mineral kit*—collection of 24 rocks and minerals of Michigan.

Environmental Series Report 1—Geology and Hydrology for Environmental Planning in Washtenaw County, Michigan (U. S. Geological Survey cooperative).

U. S. GEOLOGICAL SURVEY PUBLICATIONS

(prepared in cooperation with the Geological Survey Division)

Published Reports and Maps

Geophysical Investigations Map GP-894—Aeromagnetic Map of Michigan and the Adjacent Great Lakes.

Hydrologic Investigations Atlas HA-432—Water Resources of the Wisconsin-Lake Michigan Basin.

Hydrologic Investigations Atlas HA-436—Reconnaissance of the Manistee River, a Cold-Water River in the Northwestern Part of Michigan's Southern Peninsula.

Water Resources Data for Michigan 1971—Part 1, Surface Water Records.

Water Resources Data for Michigan 1970—Part 2, Water Quality Records.

Water Resources Data for Michigan 1972—Part 1, Surface Water Records.

Water Resources Data for Michigan 1971—Part 2, Water Quality Records.

Water Resources Investigations 8-73—Hydrology and Recreation of Selected Coldwater Rivers of the St. Lawrence River Basin in Michigan, New York, and Wisconsin.

Water-Supply Paper 2000—Water for a Rapidly-Growing Urban Community—Oakland County, Michigan.

Professional Paper 754-A—Glacial and Postglacial Geologic History of Isle Royale National Park, Michigan (National Park Service cooperative).

Professional Paper 754-B—The Copper Harbor Conglomerate (middle Keweenawan) on Isle Royale, Michigan, and its Regional Implications (National Park Service cooperative).

Professional Paper 754-C—The Portage Lake Volcanics (middle Keweenawan) on Isle Royale, Michigan (National Park Service cooperative).

Professional Paper 760—Paleomagnetism of some Lake Superior Keweenawan Rocks.

Index to Topographic Maps of Michigan (1972).

Index to Topographic Maps of Michigan (1973).

Open-File Reports and Maps

Regional Draft-Storage Relationships for Central and Western Upper Peninsula of Michigan.

Summary of Ground-Water Hydrological Data in Michigan, 1971.

Summary of Ground-Water Hydrological Data in Michigan, 1972.

Geology of the Precambrian Rocks in the Ironwood-Ramsey Area, Michigan.

Bedrock Geology of the Porcupine Mountains, Ontonagon County, Michigan.

Preliminary Geologic Map of the Marenisco Quadrangle, Michigan.

Preliminary Geologic Map of the Negaunee SW Quadrangle, Michigan.

Preliminary Geologic Map of the Wakefield NE Quadrangle, Michigan.

Preliminary Geologic Map of the Witch Lake Quadrangle, Michigan.