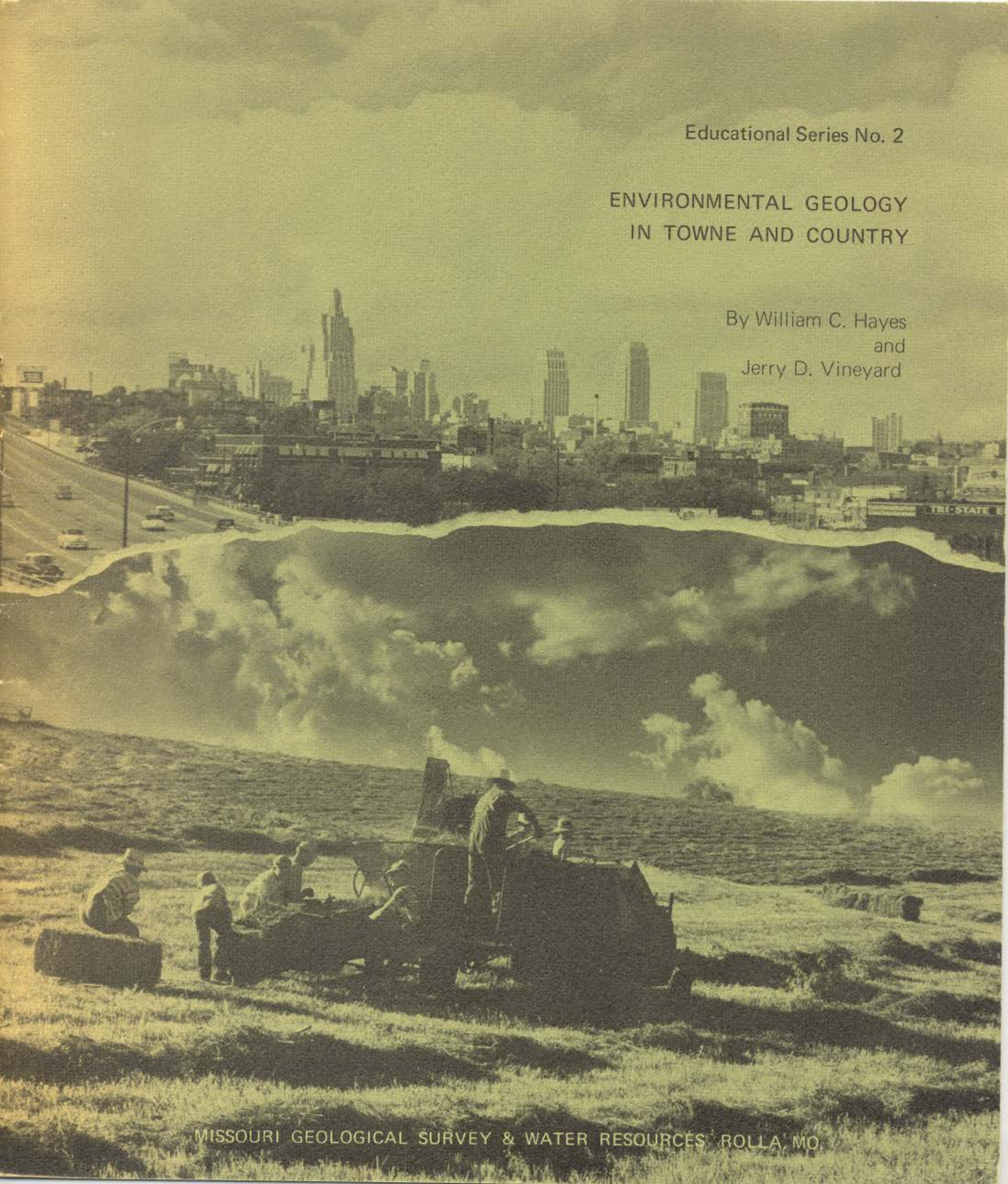
Educational Series No. 2

ENVIRONMENTAL GEOLOGY IN TOWNE AND COUNTRY

By William C. Hayes
and
Jerry D. Vineyard



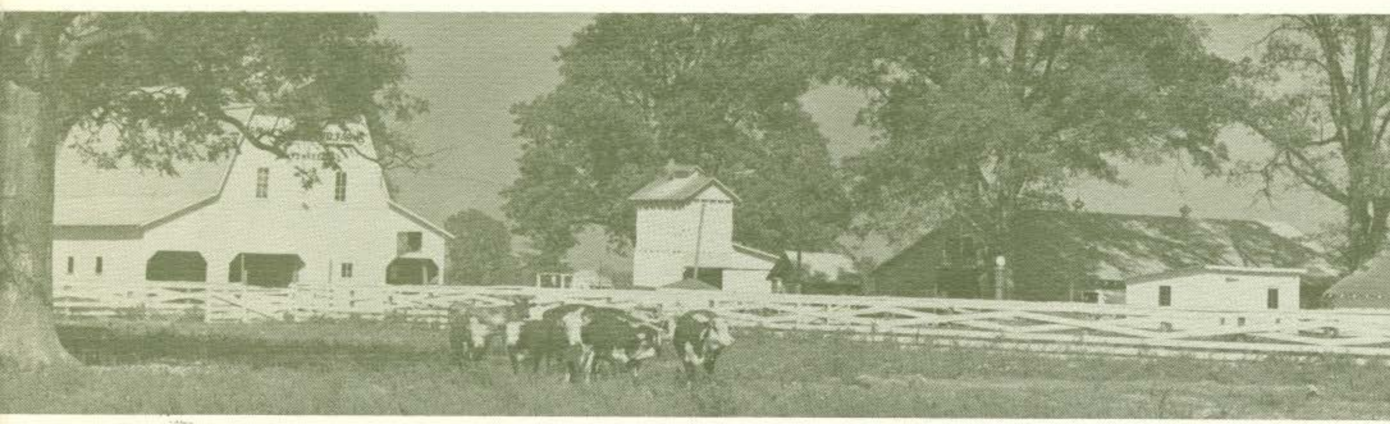
MISSOURI GEOLOGICAL SURVEY & WATER RESOURCES, ROLLA, MO

From metropolitan areas to the country. . . . .from the suburbs to undeveloped wilderness. . . . ."environmental geology" enables man to understand and improve his surroundings. By uniting the talents of the geologist with those of other specialists, every facet of man's environment can be considered.

Educational Series No. 2

ENVIRONMENTAL GEOLOGY IN TOWNE AND COUNTRY

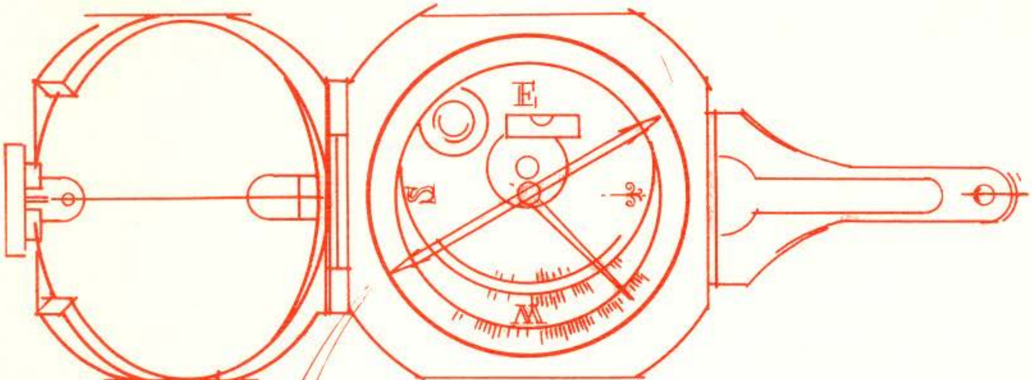
By William C. Hayes
Jerry D. Vineyard



August 1969

MISSOURI GEOLOGICAL SURVEY & WATER RESOURCES BOX 250 ROLLA, MO. 65401
WILLIAM C. HAYES STATE GEOLOGIST & DIRECTOR

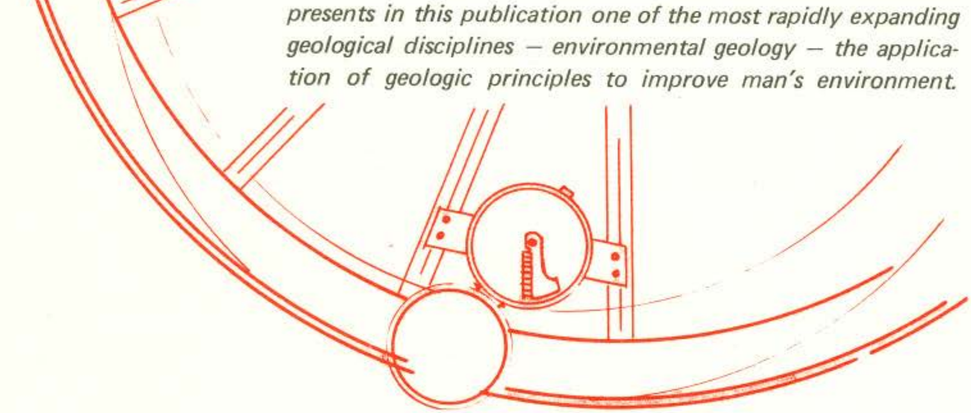
CONTENTS

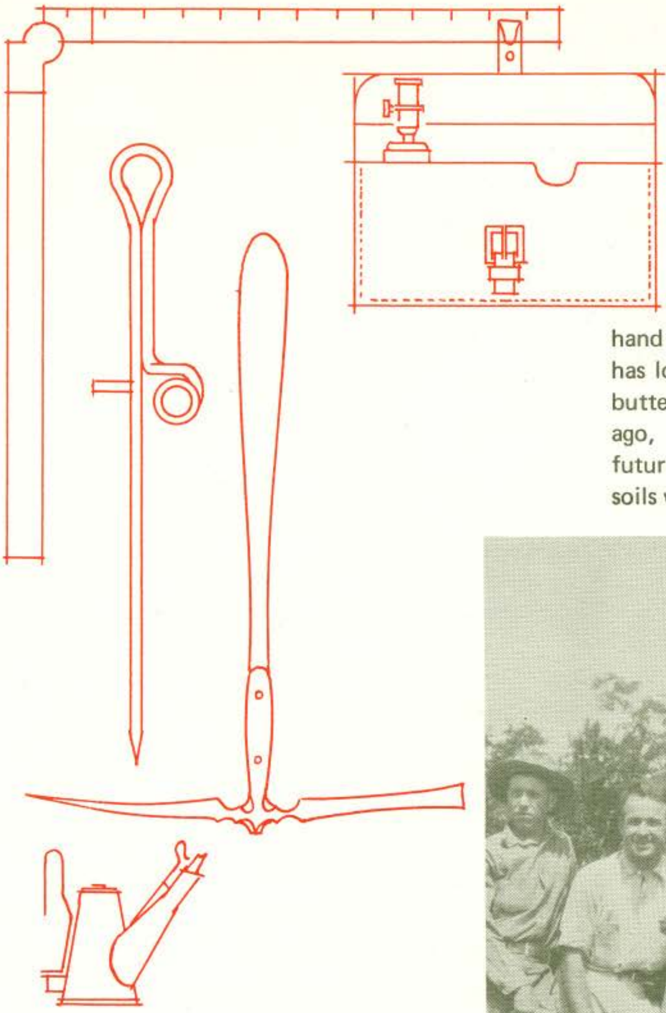


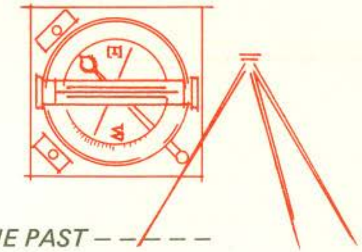
INTRODUCTION

The world is changing rapidly. . . . .from space exploration to preventive medicine. . . . .giant steps are being taken to conquer the unknown. Even the world of geology is evolving from a study of the "dead past" to practical application of mysteries revealed through such study.

The Missouri Geological Survey and Water Resources presents in this publication one of the most rapidly expanding geological disciplines — environmental geology — the application of geologic principles to improve man's environment.







THE PAST

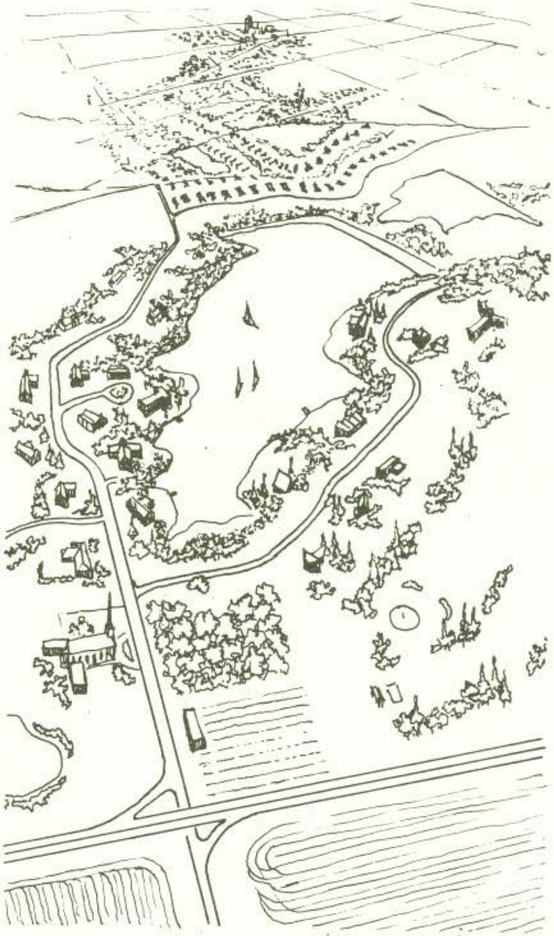
The geologist, with his rock hammer and hand lens peering at rocks exposed in a roadcut, has long been as stereotyped as a biologist with a butterfly net dashing through the fields. Years ago, geology was almost a science without a future — a study of the evolution of rocks and soils with little application to the "here and now".

EARLY GEOLOGISTS, such as these from the Missouri Survey, were noted for their concern with the chemical and physical properties of rocks.
(Photo: Mo. Geol. Survey, 1928)

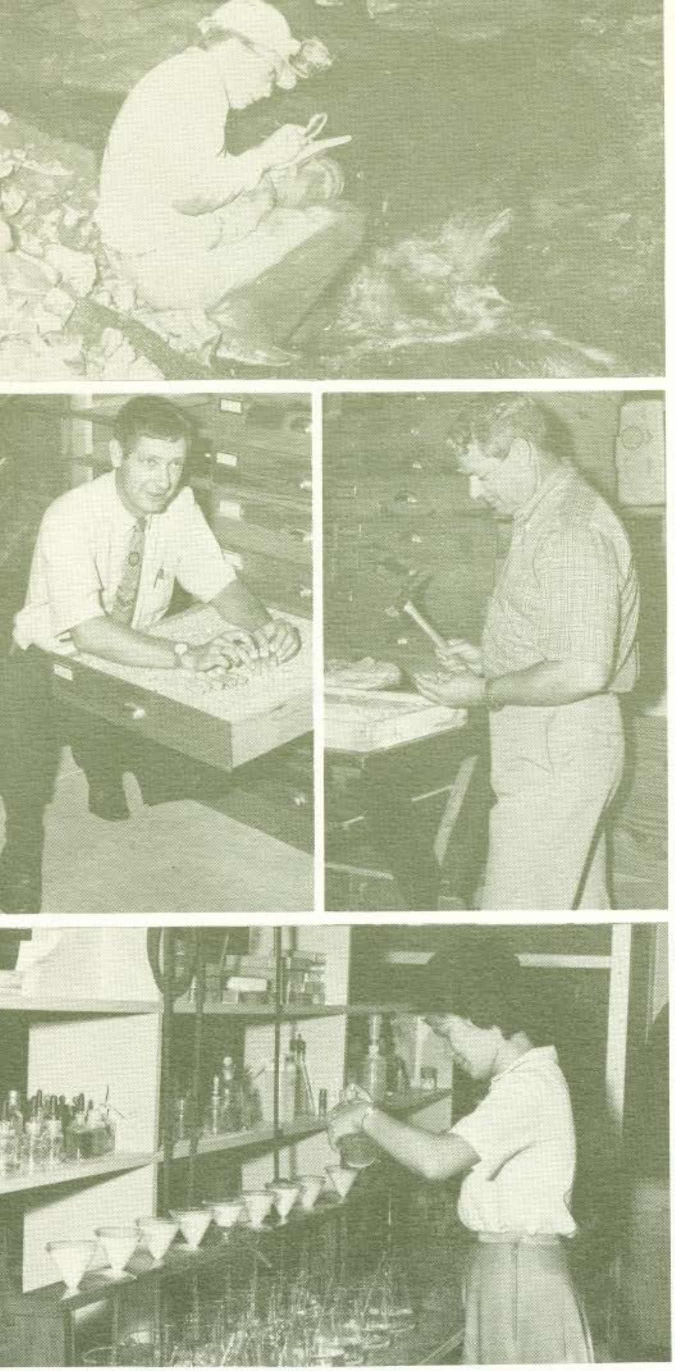
Gradually, however, the geologist became noted for his concern with the chemical and physical properties of rocks and minerals and for his interest in fossils. His most familiar early role, of course, was played in economic geology where he studied oil and mineral deposits and attempted to locate new sources of supply.

The original concept of "science for the sake of science" began to fade and geologists, as well as biologists, engineers, and other scientists tried to relate their fields and coordinate them to benefit man. As early as 1913, professional geologists, including those at the Missouri Geological Survey were making detailed studies of underground and surface water supplies. Everything in man's environment that affected or influenced him was being approached from a practical viewpoint. By the late 1920's and early 1930's, the discipline of "engineering geology" (use of geologic principles to solve engineering problems) had evolved.

The term "urban geology" became popular about 1960 for describing the somewhat unique applications of geologic principles in urban areas. With rapid and acute changes from rural to urban environment, the geologist took a new approach to the study of available mineral and water resources, landforms, and geologic processes affecting them. He concerned himself with urban geology—how best to utilize these natural resources in building a new community and providing for its basic needs.



ABOUT 1960 emphasis was being placed on the use of natural resources in building a new community – "urban geology" described the applications of geologic principles in urban areas.



TODAY — — — — —

The geologist is no longer pictured as someone who only peers at rocks and fossils. Today, he is regarded as a scientist with a considerable contribution to make, not only to engineering, urban planning, and related fields, but to the general over-all improvement of man's total surroundings. He has extended his horizons to include a new discipline—that of "environmental geology".

Indeed, environmental geology is so new that the dictionary doesn't include it. It defines environment as "the complex of climatic, edaphic, and biotic factors that act upon an organism or an ecological community. . ." and geology is termed "a science that deals with the history of the earth and its life especially as recorded in rocks. . ." but no comprehensive definition is given. The geologist of today is writing his own definition. He is applying geologic principles to improve man's environment through the wise use of available natural resources. He is making the new discipline—"environmental geology"—functional in metropolitan areas, the suburbs, rural areas, and the wilderness.

THE GEOLOGIST OF TODAY is no longer pictured as someone who only peers at rocks and fossils. Instead, he is regarded as a scientist who relies on modern equipment and methods in his application of geologic principles to solve practical problems.

WHAT IS ENVIRONMENTAL GEOLOGY?

TO AVOID MISTAKES– – – – –

The geologist's knowledge and recommendations have frequently been ignored in the planning effort, sometimes resulting in costly mistakes such as building on unstable hillslopes or on flood plains, urban construction over mineral deposits, and pollution of water supplies. Through the use of environmental geology—the study of surface and ground water, minerals, and other resources and their effect on the construction of a new community—the geologist is assuming an increasingly important role in avoiding mistakes such as these.

He is uniting his talents with those of the engineer, soil scientist, sociologist, architect, and businessman to build the best possible environment for living and working. He is assisting in the planning of new cities—from site selection through transportation, industrial development, residential complexes, and service facilities to educational and cultural provisions.

TO MEET GROWING NEEDS – – – – –

Two-thirds of the nation's population live in urban areas today, but it is predicted that by the year 2000 nearly five-sixths of the projected 350 million population will be urbanized. This will accelerate urban development and land utilization even more. The increasing people-to-land ratio will

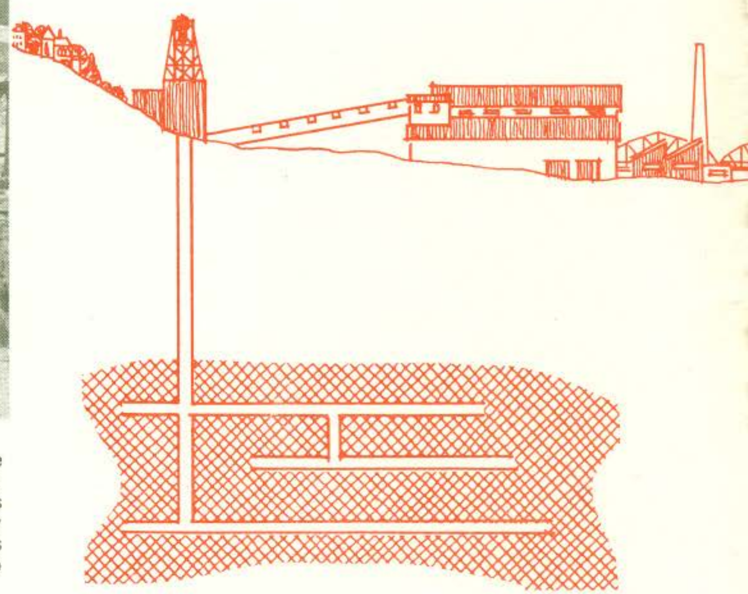
ROOF FAILURE in underground mines results in surface sinkholes like this one, where enormous sinks appeared in a housing development. This house was abandoned, as were numerous others in the area. A geologist can help avoid disasters such as this.

TO INSURE A STABLE EARTHEN DAM and successful lake, geologic information is needed in site selection and during the construction phase. A core trench (such as that pictured) is to key the dam into the subsoil and bedrock to prevent seepage.

continue to compound the problems of man and will greatly affect his use of natural resources.

More people will need more land for work and play, more food, and more water, and they will produce more wastes. Not from Confucious, but from James Russell Lowell: "There is no good in arguing with the inevitable. The only argument available against an east wind is to put on your overcoat." In analogy, the east wind is urban growth and changing environment; the overcoat — planning. Planning is needed now — before the environment becomes the adversary. Peaceful co-existence is possible for a growing population and the physical environment only if available resources are carefully evaluated and wisely used.

AN ORE DEPOSIT cannot be moved to a more desirable location. . . . .it must be mined where it is. A conveniently located mine such as this one poses few problems, but others may have to be wisely planned to counteract a poor site. If an ore deposit is situated in the middle of town, business may have to circumvent mining operations when necessary.



WHY IS ENVIRONMENTAL GEOLOGY IMPORTANT?

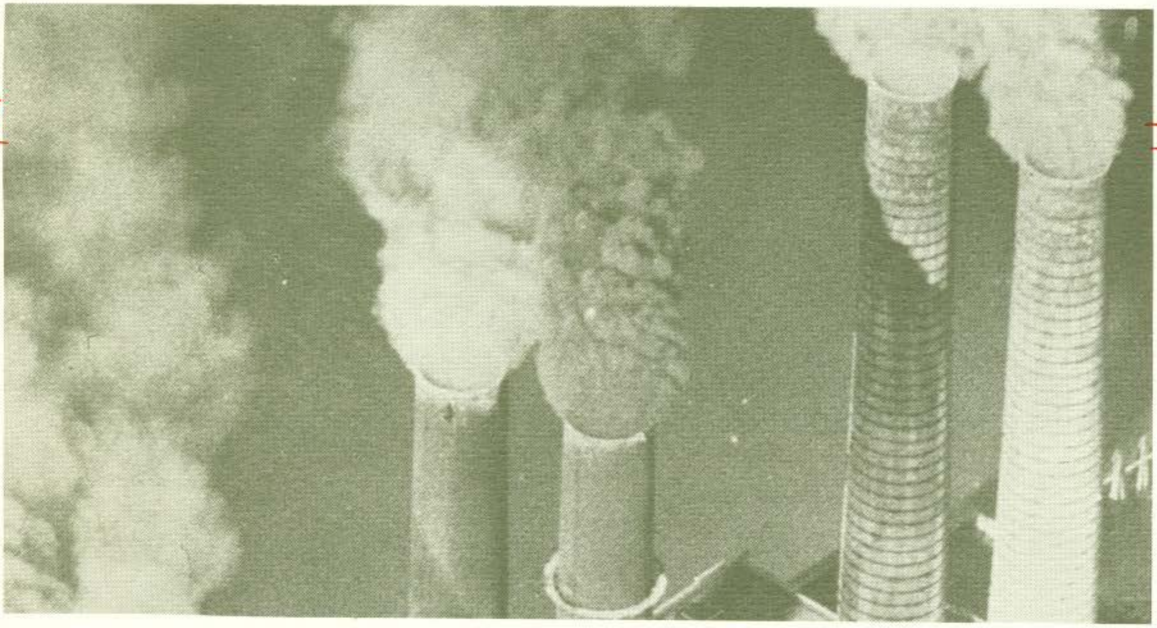
IN PHYSICAL PLANNING– – – – –

Physical facilities and needs of future generations are responsibilities of this generation. Man's comfort depends upon adequate recreational areas; desirable living conditions without poisons in the air, water, or food; and adequate water, food, fiber, and mineral supplies.

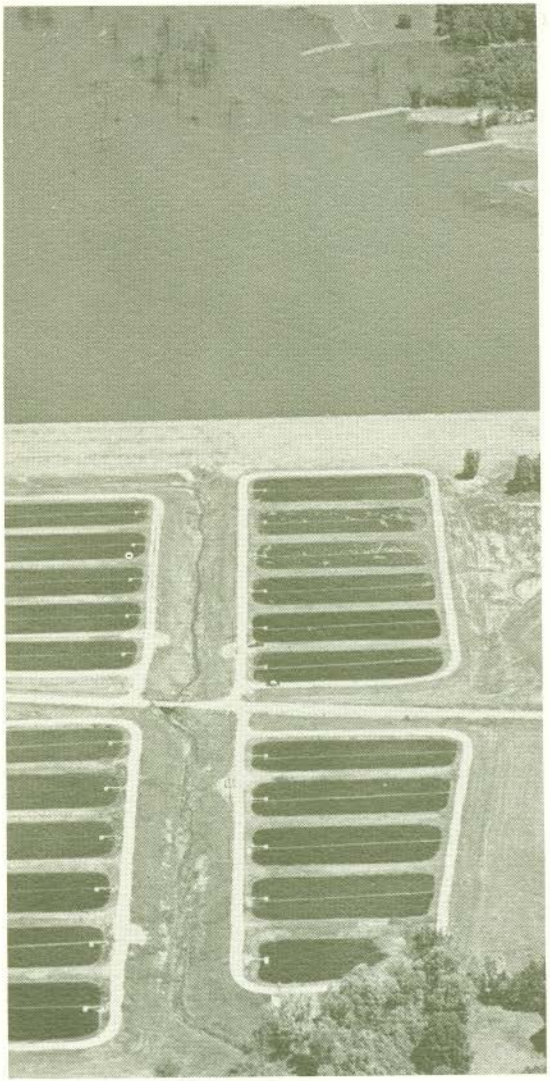
To provide these, physical planning has become essential at the national level–in the development of a defense system; interstate highways; and health, welfare, and related programs. Geologic factors affecting the physical environment are now being considered before defense plants are constructed, before bridges and highways are built, and before various other programs are carried out. Planning, based on environmental geology, is underway by agencies such as the Department of Housing and Urban Development, state and regional planning commissions, and county and city planning groups.

IN WISE LAND USE– – – – –

Development of a desirable environment may be limited by the physical features of the land. Mineral deposits, for instance, are where you find them. An ore deposit cannot be moved in order to mine it where labor and transportation are more readily available. The deposit must remain where it is. Locating and developing existing



Physical planning is essential to a pleasant environment – including planning for control of air pollution.



COMPREHENSIVE STUDIES of bedrock, soils, and water resources by a geologist should serve as a guide in locating lakes and reservoirs. Adequate pre-planning can eliminate lakes which won't hold water and other costly problems.

mineral deposits are, however, contributions of the geologist. He recognizes that, unfortunately, once a mineral is covered by a subdivision or an industrial park, it is inaccessible and is no longer available for man's use.

Streams, rivers, hills, and valleys are located in certain places because of geologic processes; they are affected by nature in different ways. For example, floods occur on the floodplains—not on hilltops. These physical features cannot be arbitrarily rearranged so that a home on a floodplain would escape all floods or a water well in a dry area wouldn't dry up. Problems must be anticipated because mistakes will not correct themselves. In some localities, a floodplain has been used as the site for a dense residential development or an industrial site. A geologist could have identified a flood zone or a groundwater recharge area such as this with little difficulty. He could have assisted in planning better utilization of the land by considering its physical limitations.

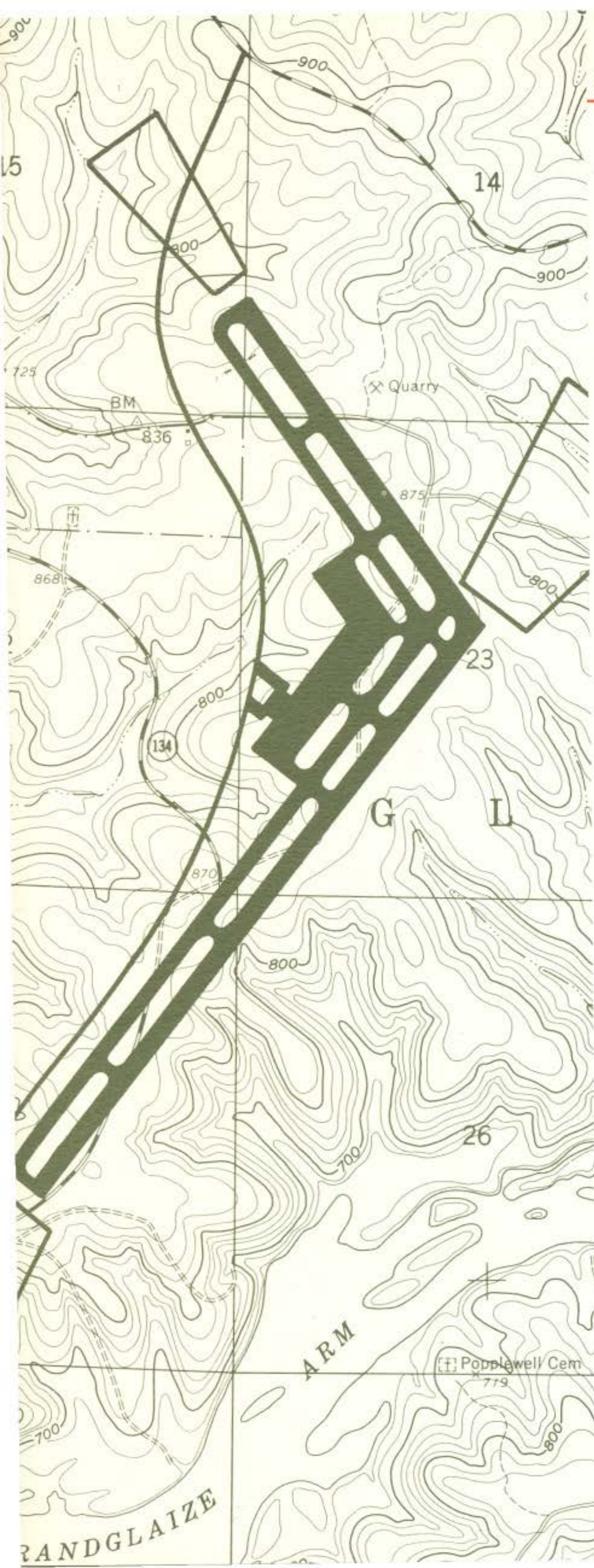
A satisfactory environment must have a water supply that is adequate for a growing population. What is best for a particular locality—deep wells, shallow wells in alluvium along a major river, or surface reservoirs? A geologist can help provide the answer based on comprehensive studies of bedrock, soils, and water resources of the area.

Wise land use will mean development of lakes and reservoirs only where the soils will hold water and residences will be built only on stable land. The geologist, working with other environmental experts, will answer such questions as: "What is the best way to dispose of waste here?" "Can land fill be used there?" "Is a housing development possible in a sinkhole area?"

PHYSICAL FEATURES cannot be arbitrarily rearranged so that urban development on a floodplain will escape flooding. Flood zones in most of Missouri have been identified and mapped and are valuable guides in wise environmental planning. Scenes such as this can be avoided. . . . .

PROBLEM: How to determine the best site for an airport on land already owned by the State Park Board in the rugged Ozarks area. SOLUTION: Location of the Lee C. Fine Memorial Airport was based on study of a topographic map. The landing strip was planned and constructed with the terrain (shown precisely on a topographic map) in mind.

SURFACE FEATURES can be an asset or a hindrance . . . . .at Florissant, Mo., an industrial and residential development has been planned to fit the karst (sinkhole) terrain. Roads were built around sinkholes; even vegetation and landscaping are determined by the topography.



FACTORS OF ENVIRONMENTAL GEOLOGY

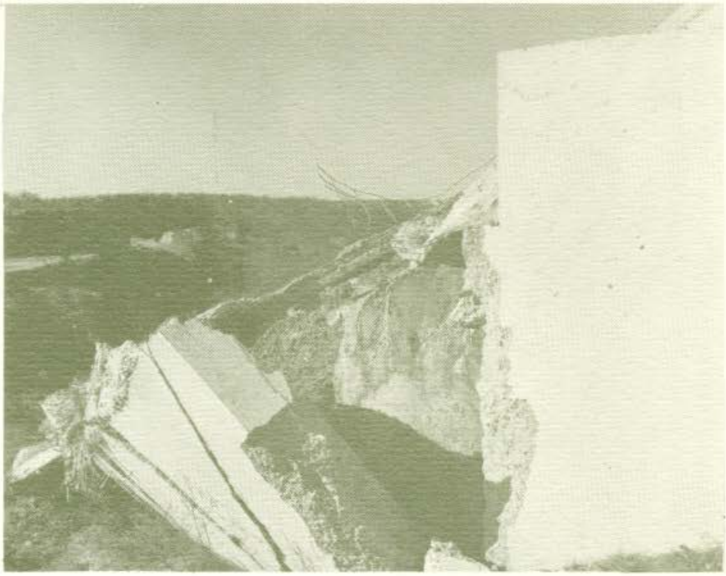
TOPOGRAPHY– – – – –

Since the earth's surface and the natural and man-made features thereon are a part of man's environment, he is affected by them. The topography—or landscape—influences his comfort and well-being in many ways. The ease with which he travels from place to place, the location of his home, and the site of recreational facilities may be partially determined by the surface features of an area. Certainly the planning of an airport would depend upon the topography as would the location of a lookout tower, a highway, a dam, communications facilities, or a railroad.

One of man's best tools for understanding and utilizing the topography to the best advantage is a topographic map. This is a detailed map showing cultural features, drainage, roads, and public land surveys in addition to the landforms. It shows the "lay of the land" by depicting the earth's surface as a third dimension relief through the use of variations in color or by contour lines.

About 52 percent of the state is covered by modern topographic quadrangle maps published by the U. S. Geological Survey in cooperation with the Missouri Geological Survey. Each quadrangle covers 7½ minutes of latitude and longitude for a total coverage of approximately 61 square miles. Less modern topographic maps at a smaller scale are available for nearly all of the rest of the state. (Index maps showing published topographic quadrangle maps may be obtained upon request from the Missouri Geological Survey.)

EVALUATION OF soils prior to building homes, roads, or bridges can help eliminate construction problems caused by swell-shrink characteristics, compaction qualities, or inadequate drainage.



SOILS— — — — —

Soils—the loose earth material above bedrock—are important in man's environment and must be carefully considered before major changes are made. Many health hazards and construction problems can be avoided if soils are evaluated prior to building homes, roads, bridges, or other structures. Evaluations are concerned with such things as moisture, swell-shrink characteristics, compaction qualities, porosity, permeability, and mineralogy.

Foundation designs and construction, for example, must be adapted to the soils or cracked foundations and other mishaps caused by excess moisture or adverse swell-shrink characteristics of soils will plague the builders. Waste disposal in dense suburban housing areas can become a real problem if soils do not permit adequate drainage. Transportation also may be affected if highways are constructed over sinkholes and unstable slide areas rather than on firm soils and bedrock.

Early recognition of soil problems can help eliminate unnecessary delays and expense. Of considerable value during early phases of planned development are soil maps published by the Soil Conservation Service. These give much data on drainage problems, slope characteristics, permeability, erosion, and related problems. Geologic maps such as those available at the Missouri Geological Survey can also be used in relating surface soils to underlying bedrock. Identification of these potential problems should be the first step in planning any change in man's natural environment.

WATER– – – – –

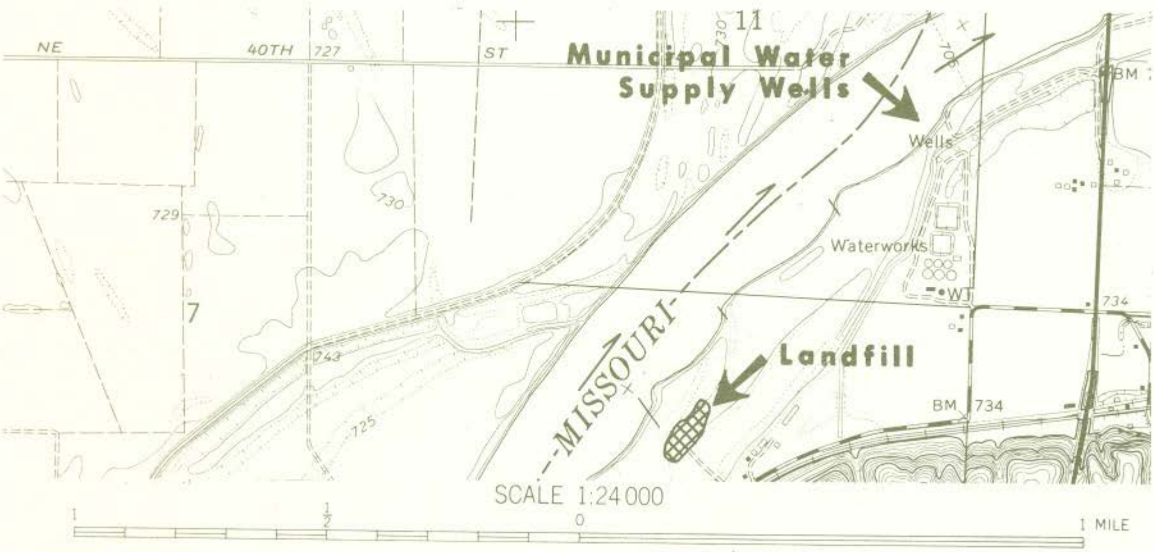
One of the world's most important natural resources—required to provide the necessary food and fiber for mankind—is water. It is a precious commodity because it must be available for man to live comfortably. Empires have been won or lost as the water table has risen or fallen, or as rivers have turned into mud flats and sand bars.

The supply seems inexhaustible when one considers that the average annual precipitation of 30 inches in the United States provides some 4,200 billion gallons of water per day. Of this quantity, approximately 600 billion gallons per day are available for man's domestic, industrial, municipal, and agricultural requirements. However, today's average daily use of about 350 billion gallons is predicted to double by 1980 and, by the year 2000, the demand is estimated to be one trillion gallons per day.

According to these estimates, demand will equal supply in a little over 10 years. The immensity of the water problem facing the nation is indicated by these projections, even though their validity may be somewhat dubious. As with many projections and extrapolations, circumstances alter the facts. For example:

1. A prediction was made in the last half of the 19th century that the growth of Manhattan would be limited by the island's capacity to transport grain as food for horses.

2. For the past 40 years, use of electricity has doubled every 10 years—it's doubtful that



A GOOD EXAMPLE of how ***not*** to plan a water supply. . . . .In this case, the municipal water supply is located downstream from a landfill. Contaminants from the landfill undoubtedly will filter down through the soil and eventually appear in the water wells.

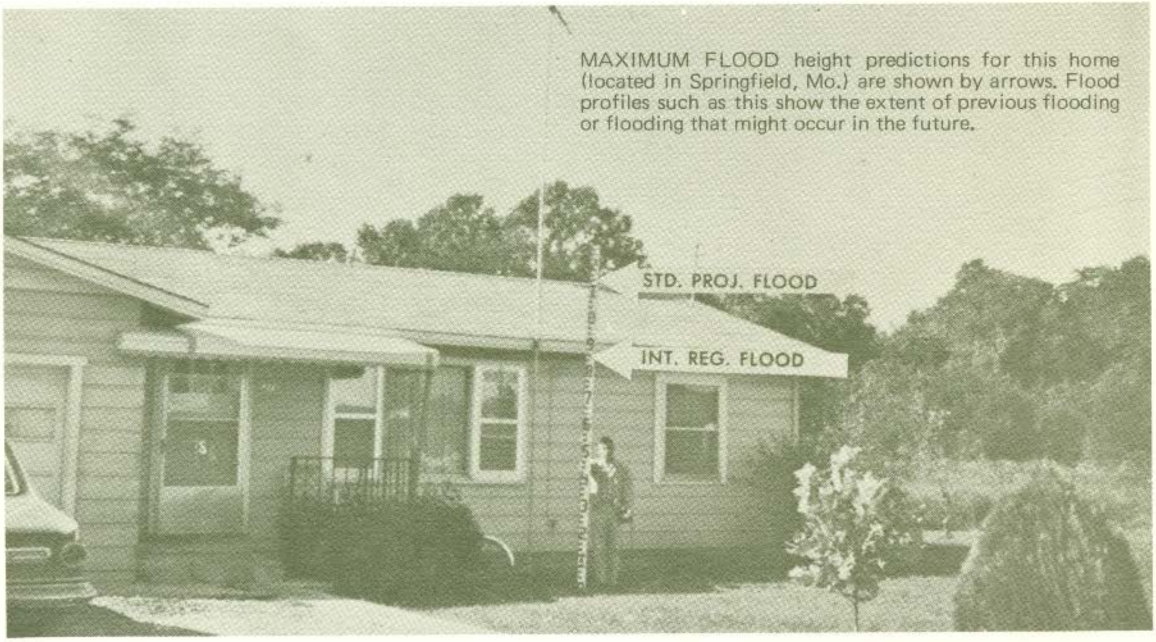
present technology can meet the challenge for continuing this rate of increase during the next 40 years.

The future is not as gloomy as intimated by the foregoing estimates; only a small amount of water is destroyed in use. Practically all water is non-consumptive and it is one of man's most inexpensive commodities. Compare the cost of a ton of dirt and a ton of water delivered to your home—water today is, truly, "cheaper than dirt"!

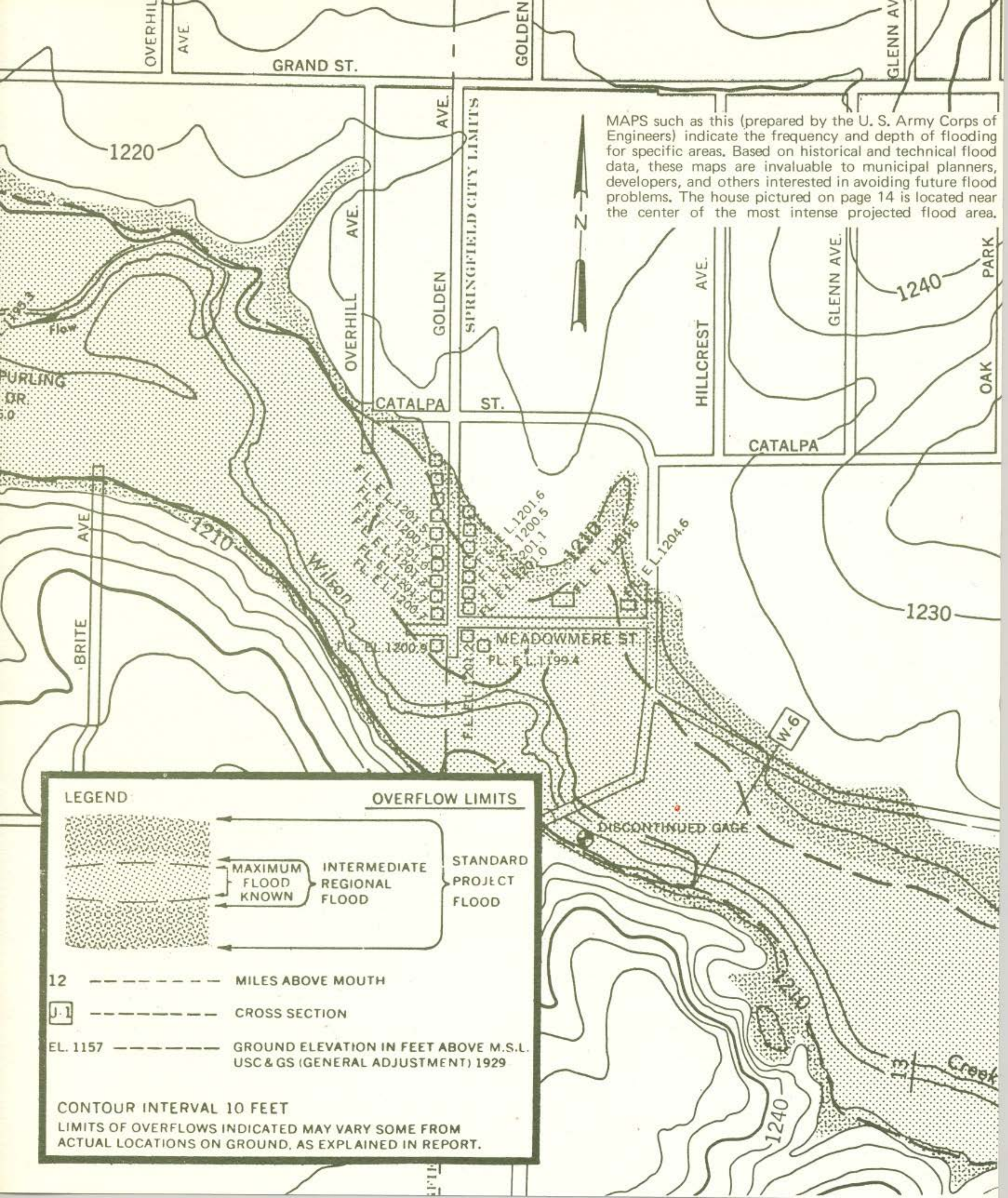
SURFACE WATER

The geologist classifies water that is on or in the earth in two categories: Surface water—water in lakes, ponds, streams, springs, or runoff; ground water—water beneath the earth's surface.

Surface water, an important factor in man's environment, has been studied since 1921 by the Missouri Geological Survey. Data collected by the Survey in cooperation with the U. S. Geological Survey from 137 stream gaging stations throughout the state provide a wealth of information on available surface water. This information is used for predicting maximum flood levels and low flow of streams in certain areas. It is a basis for planning sewage and industrial waste disposal; determining feasibility of surface water impoundment structures; and locating buildings, highways, and cities. Missouri Geological Survey Water Resources Report 20, a compilation of data from these gaging stations, is used by the Missouri Water Pollution Board for establishing surface water quality standards.



MAXIMUM FLOOD height predictions for this home (located in Springfield, Mo.) are shown by arrows. Flood profiles such as this show the extent of previous flooding or flooding that might occur in the future.



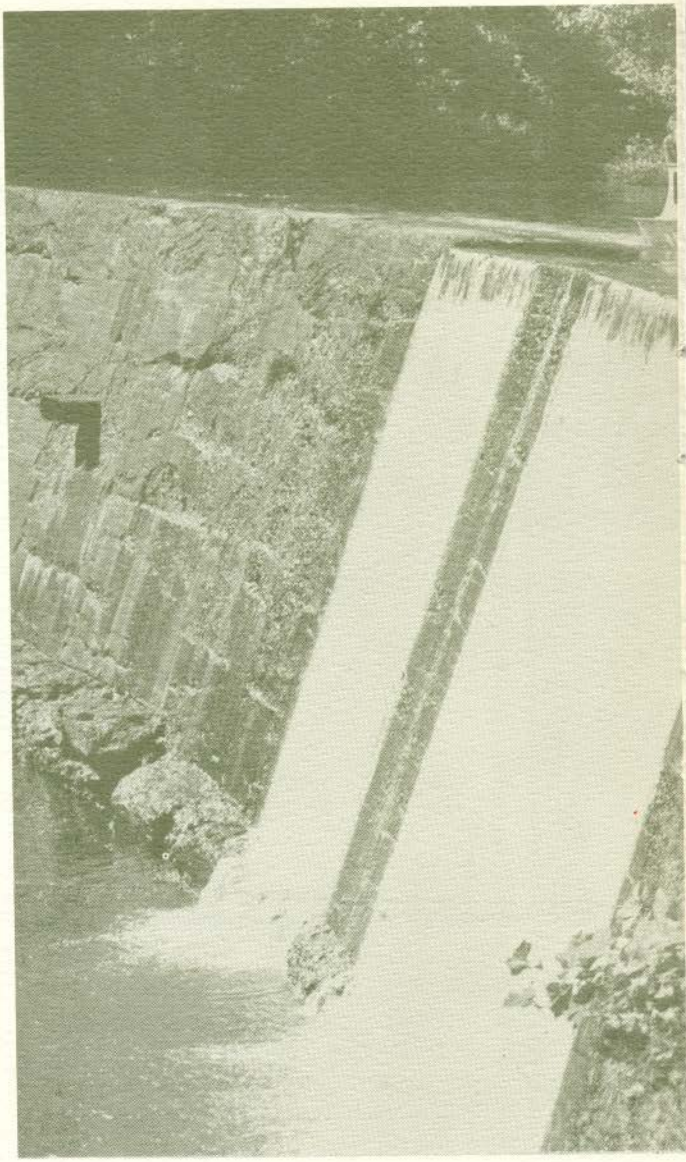
MAPS such as this (prepared by the U. S. Army Corps of Engineers) indicate the frequency and depth of flooding for specific areas. Based on historical and technical flood data, these maps are invaluable to municipal planners, developers, and others interested in avoiding future flood problems. The house pictured on page 14 is located near the center of the most intense projected flood area.

Environmental geology has proved helpful in regional recreation planning and in determining possible future water supplies. In line with this, the Missouri Geological Survey published a map in 1967 showing lakes with over 5 acres of water area throughout the state. The map also indicated the use of each lake as well as the ownership—whether federal, state, or local.

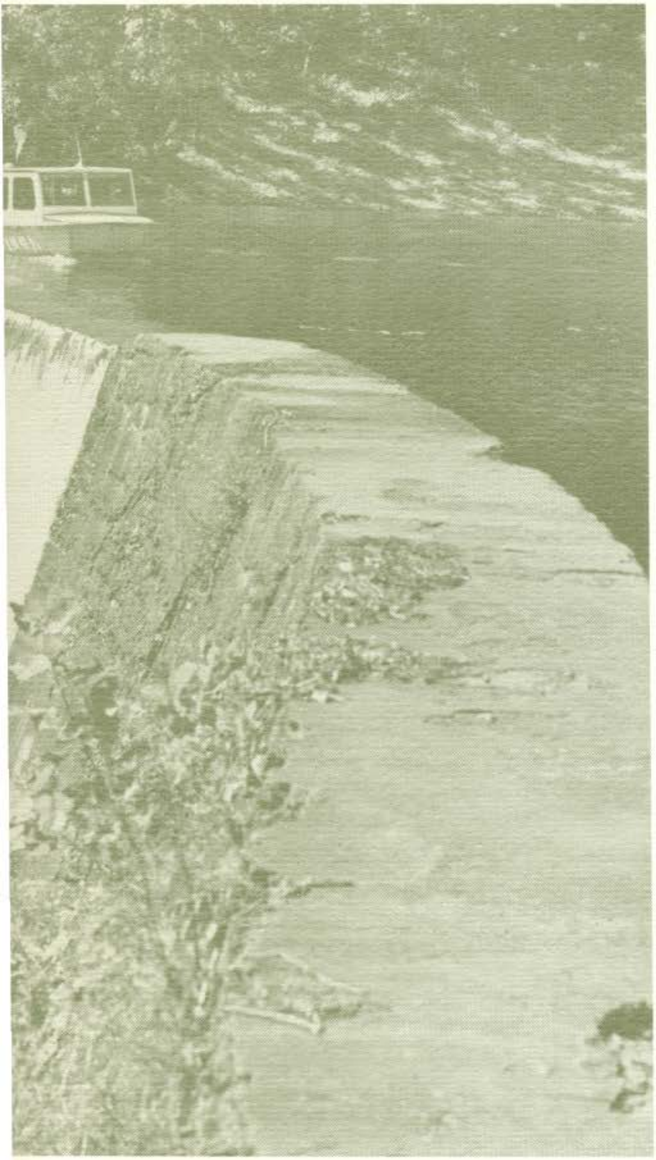
At the national level, a number of programs are concerned with surface water and floods along with their effects on cities and large communities. One of these is a three-stage program to delineate major flood hazard areas in communities with more than 2,500 population. Phase one, a compilation of a list of affected cities, was prepared by the U. S. Army Corps of Engineers. As phase two, the U. S. Geological Survey outlined areas on topographic quadrangle maps that have been "occasionally inundated". The 38 Missouri cities included are:

Bethany, Boonville, Brookfield, Canton Cape Girardeau, Carrollton, Carthage, Chillicothe, Columbia, Crystal City, Excelsior Springs, Fayette, Festus, Flat River, Hannibal, Hermann, Independence, Jefferson City, Joplin, Kansas City, Louisiana, Maryville, Mexico, Neosho, North Kansas City, Pacific, Pleasant Hill, Poplar Bluff, Ste. Genevieve, St. Charles, St. Joseph, St. Louis, Sugar Creek, Trenton, Union, Valley Park, Washington, and West Plains.

These quadrangles show maximum elevation of flooding for each affected city and are available without charge from the U.S. Geological Survey, Rolla, Mo. Phase three (detailed investigations and reports) has been completed for the Blue River valley and Pacific by the Corps of Engineers. Reports for Jefferson City and the



PRACTICAL MEASURES for reducing flood damage include control of the rivers through the use of dams and reservoirs. Detailed geologic examination of pro-



posed sites can many times mean the difference between successful flood control and unwanted water loss.

Springfield area are scheduled for completion by mid-1969, and studies are authorized next fiscal year for the Little Blue River and Cape Girardeau.

Programs such as this are but one aspect of man's consideration of geologic factors to improve his environment. When floodplains are identified by the geologist, continued construction of facilities in the path of expected floods is foolish because loss should be expected. Even when billions of dollars are spent on levees, dams, and channel improvements, heavy rains can still mean disaster in these floodplain areas.

Some flooding problems are caused by urbanization. With street construction, buildings with roofs shielding a lot of land, paved parking lots, and concrete patios, urbanization greatly increases the danger of flooding because rainwater cannot soak into the ground as it does in open areas. The water literally has no place to go except into the houses and other buildings. Potential flood losses, however, can become gains if imaginative planning provides for water retention structures which will attenuate peak runoff from floods in these urbanized areas. At the same time, they contribute to the esthetic qualities of urban living.

For example, low water retention structures (commonly formed where streets or roads cross valleys) can provide water storage to be used for periods of excess runoff. This will greatly decrease the threat of flooding in downstream areas and make the use of smaller stormwater drainage systems possible.

The best method for preventing flood damage is, of course, to avoid floodplains when building. Since this has not been done in many cases, three practical measures are suggested for reducing damage:

1. Control the rivers through the use of dams, reservoirs, levees, flood walls, channel improvement, or watershed treatment.

2. Control the land by designating floodways and encroachment lines, zoning, and passing subdivision regulations and building codes.

3. Use general controls such as flood proofing, temporary evacuation, open spaces, warning signs, and flood insurance.

GROUND WATER

The second classification of water made by the geologist–ground water– includes all water beneath the earth's surface. It is this water which man generally taps for his drinking water, which is significant in the productivity of an area.

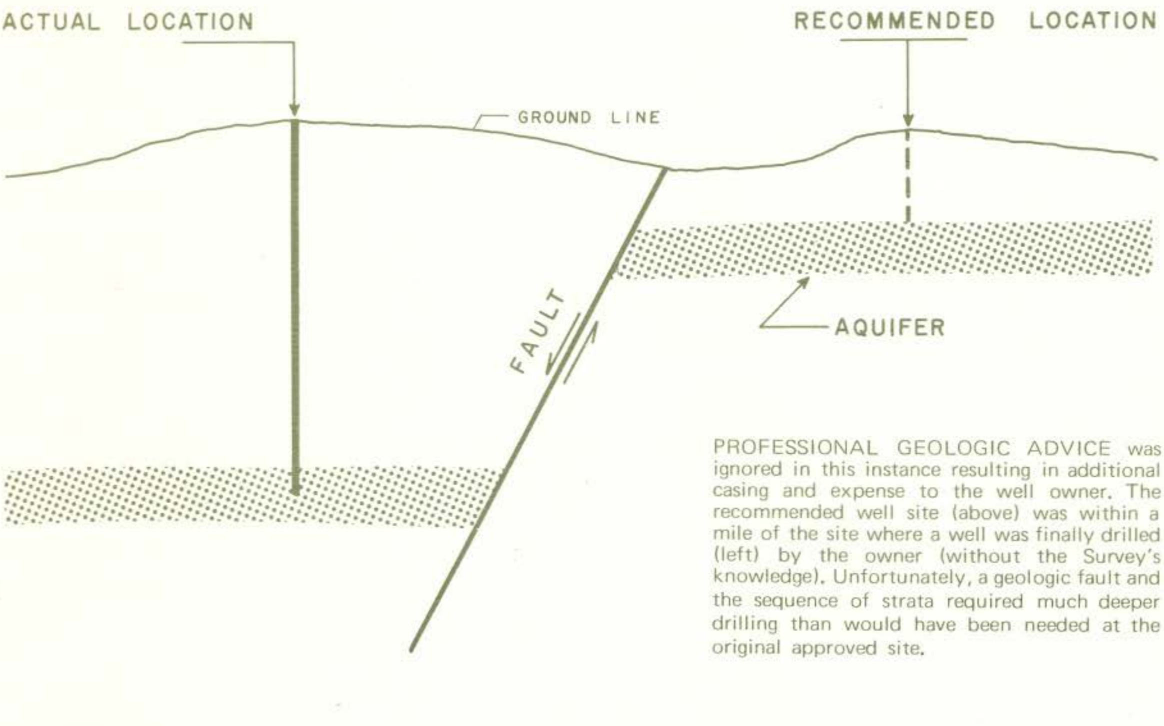
Finding adequate water supplies, however, is no easy job. The water witching techniques and "by guess and by golly" methods of bygone days just didn't work. Consequently, geology has become an indispensible tool in man's search for water. To find the best drilling site, geologic information such as that compiled by the Missouri Geological Survey is analyzed in detail. Survey files contain samples and over 27,000 logs of wells drilled in all parts of Missouri. Based on study of logs such as these, a geologist is generally quite successful in locating a good water supply.

While the Survey is not a water regulatory agency, many individuals, the State Division of Health, and other agencies rely on it for detailed subsurface geologic information for use in determining casing depths as well as for finding the best water supply. Survey geologists must consider a number of factors before making their recommendations since the geology varies from one part of Missouri to another. In the south and southeastern part of the state, for instance, a well may require as much as 1,000 feet of casing, whereas in other areas as little as 30 feet would be adequate.

A safe water supply is essential to man's health and must, therefore, be one of the prime concerns of environmental geology. Inexperienced well owners have ignored professional geologic advice on well locations in some instances, and have encountered problems with their water supplies. For example, an owner submitted a proposed well site location to the Survey for investigation and evaluation. After receiving the Survey's recommendations, the owner (without the Survey's knowledge), actually drilled the well at a location within a mile of the original site. Unfortunately, a geologic fault existed between the originally proposed location and the site where the well was finally drilled. Result–because of the sequence of strata encountered, the well had to be drilled much deeper requiring additional casing and expense than would have been needed at the approved site.

Numerous problems such as this exist in man's never-ending search for water supplies. He has come a long way in perfecting his methods of detecting water beneath the earth's surface–from the legendary divining rod and witching stick to modern geologic knowledge of which rock formations are the best aquifers. One of the most valuable "treasure maps" of the modern age is a special map which indicates the water yields that may be expected at certain depths in a particular locality and the general quality of the ground water. A packet of four of these maps depicting the ground water of Missouri is available from the Missouri Geological Survey. These are of considerable assistance to municipalities, industries, and private individuals interested in discovering the best possible site for a water supply system. They should be referred to early in the planning stage, however, before the final selection of a well site.

Other aids to Missouri's water consumers are the automatic water level recorders installed in a network of 37 wells throughout the state. These recorders provide the Survey with continuous water level measurements which, when compared with precipitation and stream flow, are the basis for predicting the stability of water levels and the movement of ground water throughout the state. These data are also used to indicate areas where



PROFESSIONAL GEOLOGIC ADVICE was ignored in this instance resulting in additional casing and expense to the well owner. The recommended well site (above) was within a mile of the site where a well was finally drilled (left) by the owner (without the Survey's knowledge). Unfortunately, a geologic fault and the sequence of strata required much deeper drilling than would have been needed at the original approved site.

possible "mining" (actual depletion) of ground water may occur.

MINERALS— — — — —

Minerals are one of the most important natural resources in man's environment. Cities cannot grow without them—homes cannot be built, streets cannot be put in, offices cannot be constructed. The proper materials: sand, gravel, crushed stone, clay, and shale must be used. These are the so-called "growth minerals" because they are necessary for the growth of urban areas. When adverse zoning or other conditions deprive a city of these growth minerals from a local source, the city's expansion falters.

How can a city grow when construction costs are too high? What happens to the growth and vitality of an area when industries cannot afford to locate there? Rising street construction expense caused by excessive cost of transporting growth minerals from another area may mean that money is not available for park lands or for upgrading the police department.

The economic significance of locally available growth minerals such as sand and crushed stone versus transportation of such materials from a distance is illustrated by table 1.

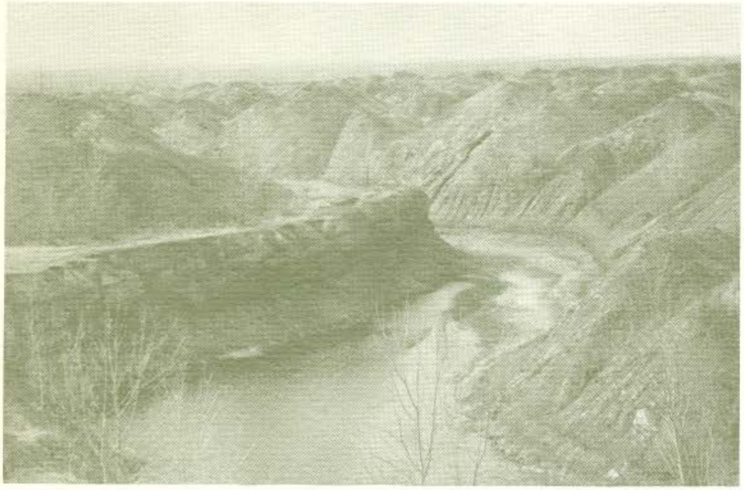
TABLE 1

Cost of Transportation of Growth Minerals

Area	Average price at scales	Haul 3 miles	Total Local Cost	Haul 20 miles	Total 20 mile cost	Percent increase for 20 mile load
Springfield, Mo.						
Crushed stone	$1.50	$0.65	$2.15	$1.14	$2.64	23%
Sand	1.30	0.65	1.95	1.14	2.44	25%
Kansas City, Mo.						
Crushed stone	1.50	0.45	1.95	1.30	2.80	44%
Sand	1.30	0.45	1.75	1.30	2.60	49%
St. Louis, Mo.						
Crushed stone	1.50	0.75	2.25	1.65	3.50	40%
Sand	1.30	0.75	2.05	1.65	2.95	44%

Yd^3 of 1: 2: 4 concrete uses 1133 lbs. sand
2100 lbs. aggregate

50,000 yd^3 concrete 28,325 ton sand save 90¢ = $25,492
52,500 ton agg. save 90¢ = $47,250
$72,742



UNFORTUNATELY, GROWTH MINERALS do not have the same emotional appeal as other resources. An unreclaimed coal strip mine is a desolate formidable sight.

Two economic factors should be carefully considered before any deposit of a low-unit-cost "growth mineral" such as clay, shale, sand, gravel, or limestone is covered up or made inaccessible by unplanned urbanization or development. The reasons:

1. Competitive prices for these raw materials may encourage a new industrial plant to locate nearby and thus influence the construction of related businesses, homes, and community utilities.

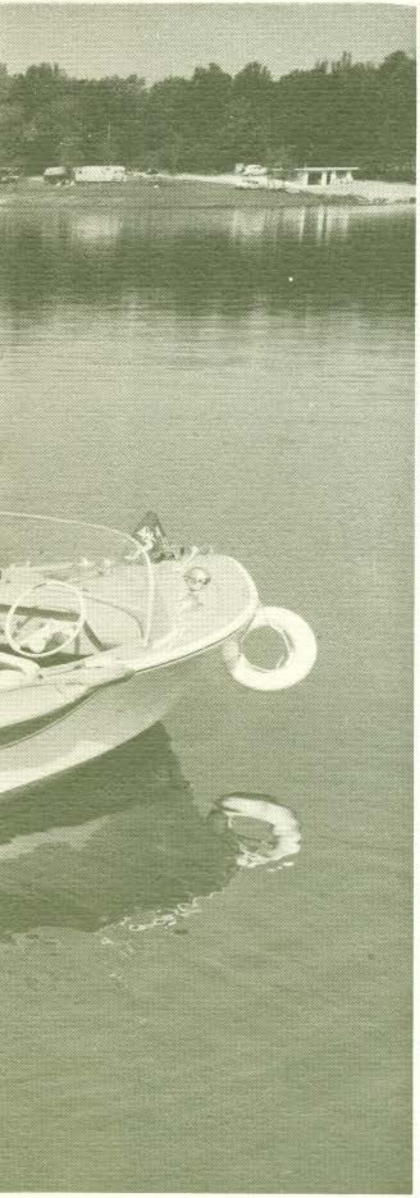
2. Properly planned use of the land may include the extraction of non-renewable mineral resources in urban and suburban areas while providing a business venture, employment, and local tax income.

Growth minerals should be extracted before an area is developed for housing, industrial, or other uses because of the potential economic impact on the new city or town. Why should sand and gravel, for example, cost an exorbitant amount because they have to be hauled a long way when, by delaying or relocating urban development, a local source of supply is readily available? Areas from which growth minerals are extracted can be restored for practical use with a little planning and ingenuity; urbanization can then proceed as scheduled with an added economic boost.

Unfortunately, growth minerals do not have the same emotional appeal as other resources in man's environment such as forests, water, and wildlife. These are clean, graceful, and appealing whereas coal mines and rock quarries are dirty and unsightly. Mineral production and processing installations generally have a poor public image. Man complains about noise, dust, trucks, and dangers from blasting. Yet, the technology is available to make mineral production and processing operations good neighbors—and many such operations are proving that they can. Admiral Hyman Rickover once said, "If people understood that

FROM AN UGLY STRIP MINE to an attractive recreation lake . . . technology has improved man's environment.

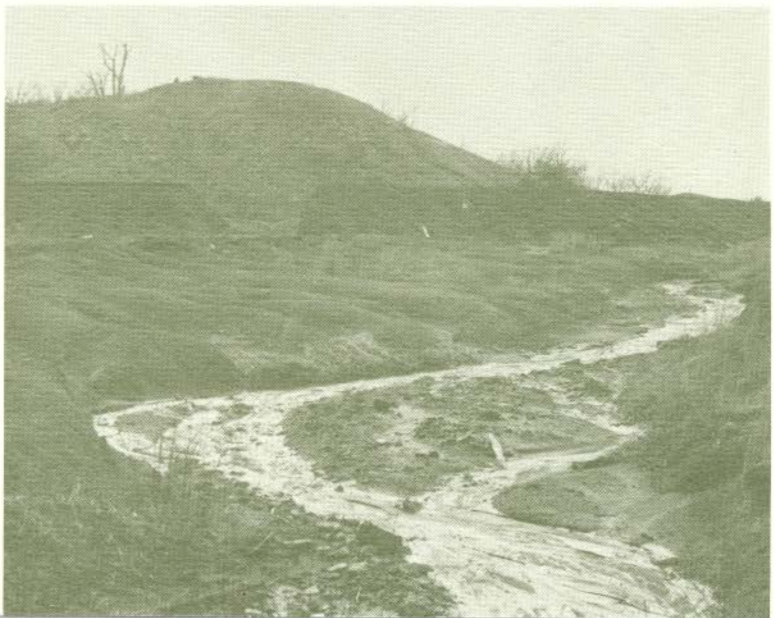
FACTORS OF ENVIRONMENTAL GEOLOGY



technology is the creation of man, therefore subject to human control, they would demand that it be used to produce maximum benefit and do minimum harm to individuals and to the values that make for civilized living."

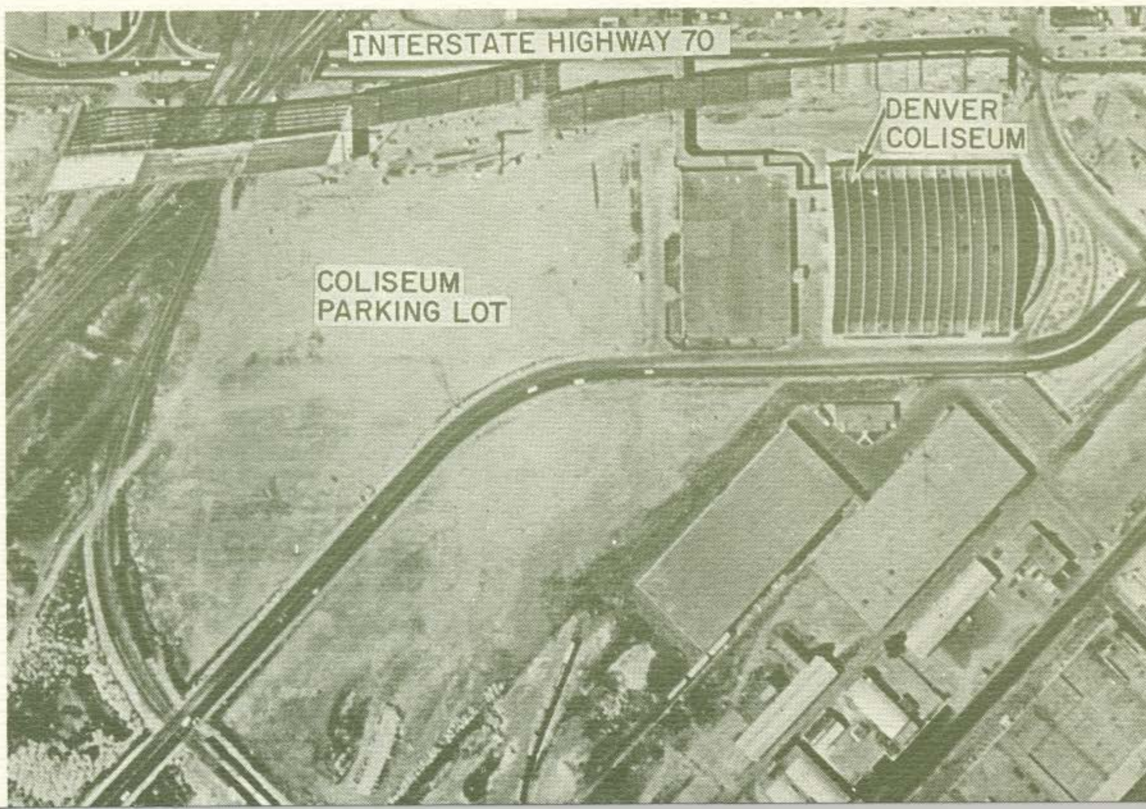
Therefore, since man initiates many of the undesirable aspects, he should be able to control them and turn them to a practical use. To illustrate this concept, a college in an eastern state wanted to expand, but found the way blocked by a large limestone hill. A local mineral firm offered to remove the hill for the limestone that it contained. Geologists assisted in locating the deposit and explosives experts advised the quarrymen on methods of breaking the stone with minimum blast damage and noise problems. When the work was completed, the college had an ideal site for expansion and the quarrying company profited from the sale of stone. The city reaped double benefits—a larger college and a ready supply of growth minerals.

WATER COLLECTING in abandoned strip mines, combines with sulfur deposits left behind to form sulfuric acid. Contour furrows, trees and shrubs will check erosion and reduce acid formation.



ABANDONED GRAVEL PITS (above) were used as sanitary landfill sites by the City of Denver as long ago as 1948. The growth minerals were removed and the space utilized.

TODAY, THE DENVER COLISEUM (below) and parking areas cover the landfill and former gravel pits. A good example of wise planning.

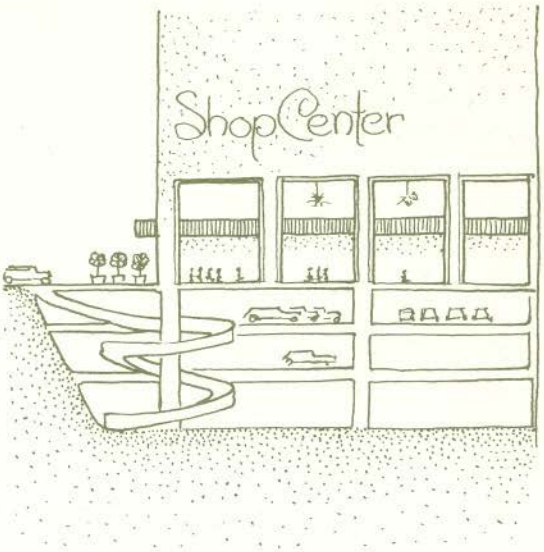


Profitable utilization of man's environment is well illustrated by a U. S. Bureau of Mines study of the aggregate resources in the Denver area. In 1960 the recoverable aggregates–within 15 miles of downtown Denver were estimated at 240 million tons; those which were inaccessible were believed to be 540 million tons. By 1966 losses to non-mineral land use plus sand and gravel production had diminished available reserves by approximately 90 million tons– a loss of over 1/3 the reserves in 6 years.

As far back as 1948, abandoned sand and gravel pits were being used by the City of Denver as sanitary landfill sites. Today, this same area which is adjacent to Interstate 70, is being utilized for parking and the Denver Coliseum is constructed upon it.

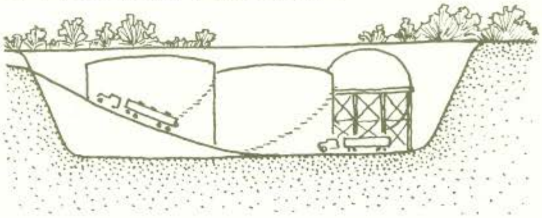
Enormous underground limestone mines in Kansas City, Springfield, and Neosho have been converted to profitable use for warehousing, cold storage, offices, and manufacturing plants. Underground facilities such as these offer many advantages, including controlled humidity and temperature, freedom from street vibrations and sonic booms, and lower fire risks. Today, many underground mining operations are designed so that underground space created by mining can be profitably utilized later. Uses to which mines can be put are endless, limited only by imaginative planning before mining begins. In fact, one individual wondered why some enterprising company hadn't opened an underground mortuary. The idea has a sure-fire slogan, he quipped, "You can't get buried any deeper any cheaper!"

SPACE CREATED BY SURFACE MINING can be profitably used in many ways– – –



CHEMICAL STORAGE

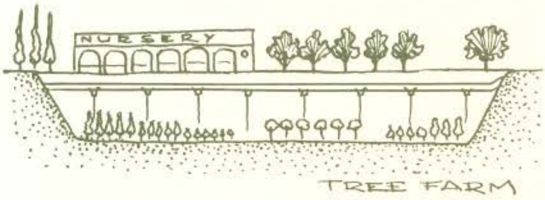
PETROLEUM STORAGE

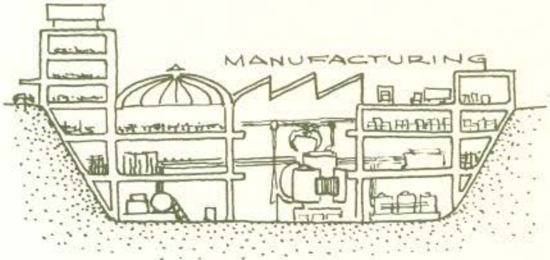


THE DIFFERENCE BETWEEN old-time haphazard underground mining and today's trend toward practical mine design is clearly illustrated by these Kansas City limestone mines. Once the mines were unplanned, with random pillar shape and arrangement (top). With the advent of the mined-space age, mine design evolved to a strict geometric configuration which gives more usable space.

Numerous open-pit quarries in Missouri have been labeled public nuisances and eyesores even though they are essential to the local construction industry. In years to come, however, cities may consider themselves fortunate to have quarries nearby because of a unique use currently being advocated for abandoned quarry pits. Since recent air pollution legislation banning open burning has placed man in danger of being engulfed by his own refuse, some experts are looking to large open pit quarries as possible solutions to the problem. They can be utilized for disposal of specific types of

OPEN PIT QUARRIES. . .





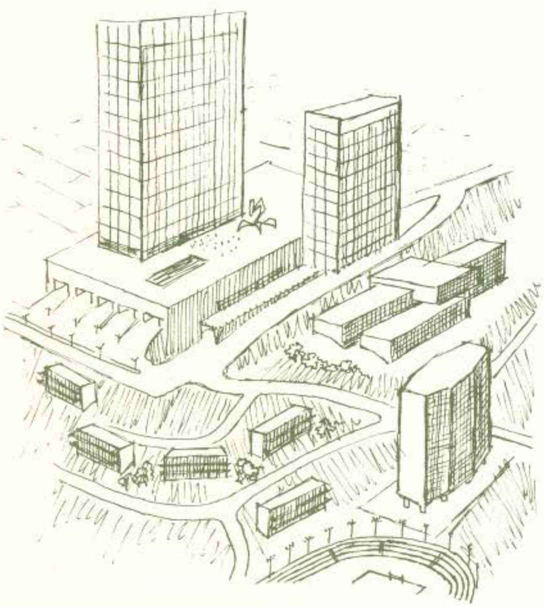
FACTORS OF ENVIRONMENTAL GEOLOGY

waste materials and then industrialization or urbanization can proceed over the former quarries.

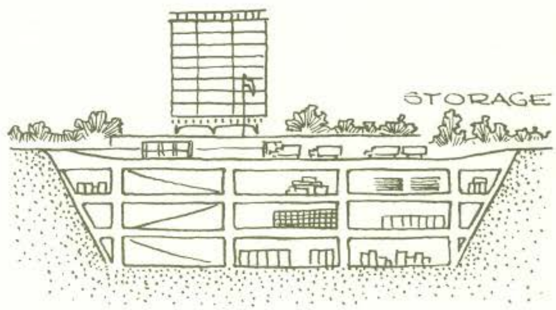
Companies such as A. P. Green Refractories Co. of Mexico, Mo. are mining clay from large open pits, which are refilled after mining with waste material from other excavations, providing attractive construction sites. Other pits are being developed as fishing and recreation lakes. St. Louis, for example, has an unusual residential area built around one end of a body of water created by open pit clay mining. At the other end of the pit, clay is still being produced. What was once an ugly clay pit has been transformed into an attractive subdivision featuring waterfront home sites. 'Clay pit" in this area has become a term of the past—when the growth minerals are mined out, the excavations become "lakes".

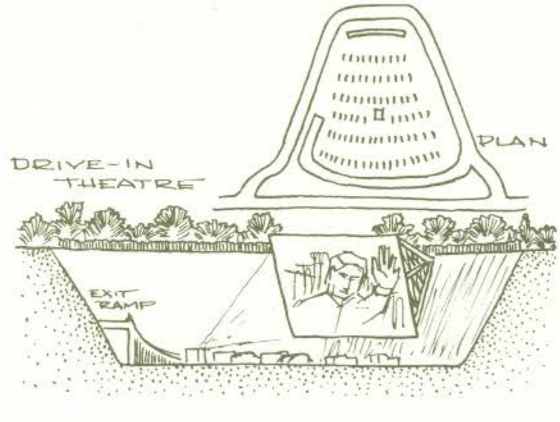
This idea is not new: Houk Stadium of Southeast Missouri State College in Cape Girardeau is built in an abandoned limestone quarry; Springfield is currently using several abandoned limestone quarries for disposal of "hard" wastes (brick,

. . .CAN BE VALUABLE



AN OPEN-PIT QUARRY can be an asset instead of an eyesore if imaginative planning is used. Some quarries can be filled with waste materials and then industrialization or urbanization can proceed over them. Others (such as those pictured) can be used without filling the excavation.



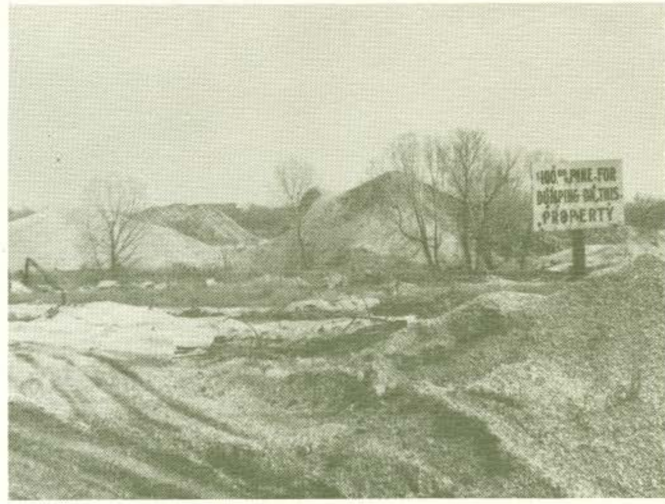


UNDERGROUND MINES, if wisely planned, can be profitably adapted to meet varied needs. (Top left) "Only the builder knows" – modern offices of Woodward, Clyde, and Sherrard in Kansas City are far underground. (Top right) General Warehouse Corporation of Springfield takes advantage of subsurface uniform temperatures in this well-planned cold storage facility. (Bottom left) Underground freight terminals such as this in Springfield (General Warehouse Corporation) are practical for limestone storage facilities. (Bottom right) Showplace of Kansas City's mined space developments is Brunson Instrument Company's underground plant. The company manufactures highly complex surveying and other instruments which require extremely close tolerances. Underground mine space is free from vibrations, traffic noises, weather changes, and other annoying problems characteristic of above-ground buildings.

concrete, rock, dirt, etc.) within the metropolitan area. These will eventually be filled and additional usable land will be available.

Strong attacks have been made against strip mining in recent years and, certainly, some parts of the industry have abused the land. But some companies, recognizing their responsibility to keep man's environment attractive,have reclaimed many acres of their mined land. A new mine-mouth power plant to be built by Empire Electric Company in southwestern Missouri will feature a large coal strip mine operated by Pittsburg and Midway Coal Mining Company. This company has announced that every acre of land disturbed by mining will be returned to its highest and best use through planned land reclamation. Peabody Coal Company's "Operation Green Earth" is likewise geared toward reclaiming strip mined lands for recreation areas and fishing lakes.

It is clear from these examples that reclamation of mined lands can be profitable and worthwhile. Man's surroundings—including the more than 66,000 acres desecrated by surface mining in Missouri—need not remain a wasteland. Joplin is almost surrounded by a lunar-like landscape of chat piles, yet it needs land for expansion and industrial development. Why not acquire wasted land such as this and return it to productivity? Golden opportunities await those with the courage and imagination to follow the lead of many of the enlightened mining companies in restoring man's environment to its original form or something comparable.

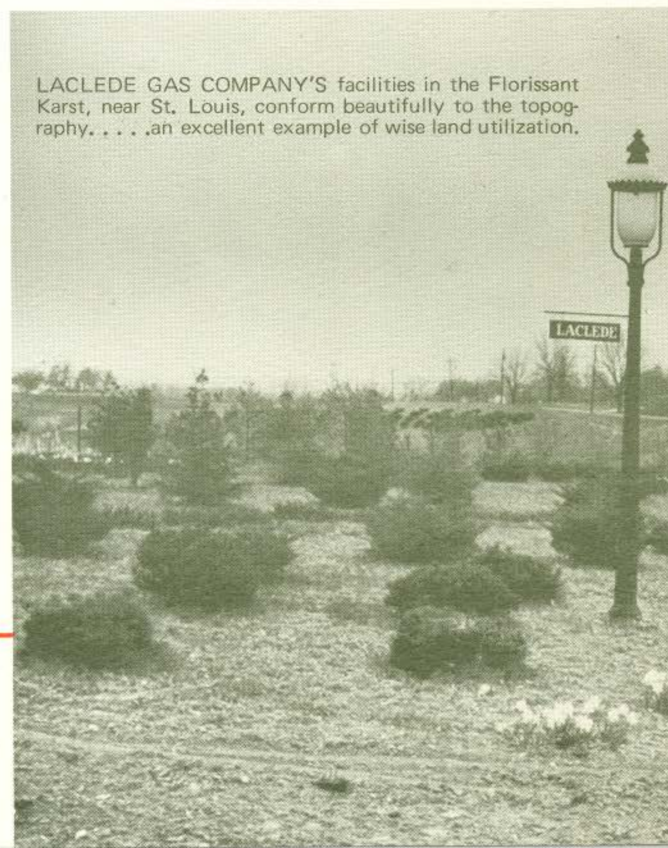


CHAT PILES in the Tri-State lead-zinc area near Joplin lend a "lunar-like" appearance to the landscape. . . . .Why not return it to productivity?

MODIFICATIONS BY MAN— — — — —

Another phase of environmental geology is concerned with modifications of the earth's surface by man. Such man-made structures as dams, reservoirs, houses, bridges, highways, and others can be drastically affected by certain geologic conditions. Missouri, with its widely varying geology, can particularly benefit from detailed studies such as these.

Many dry lake sites, faulty roadways and streets, contaminated streams and wells, and unsafe home foundations and dams can be directly attributed to natural geologic conditions. Potential problems, if not recognized before construction, can result in extremely costly repairs or construction. Because of the greater public risk and added expense involved in urbanization, geologic investigations should always be included in feasibility studies for large construction projects and in regional planning.



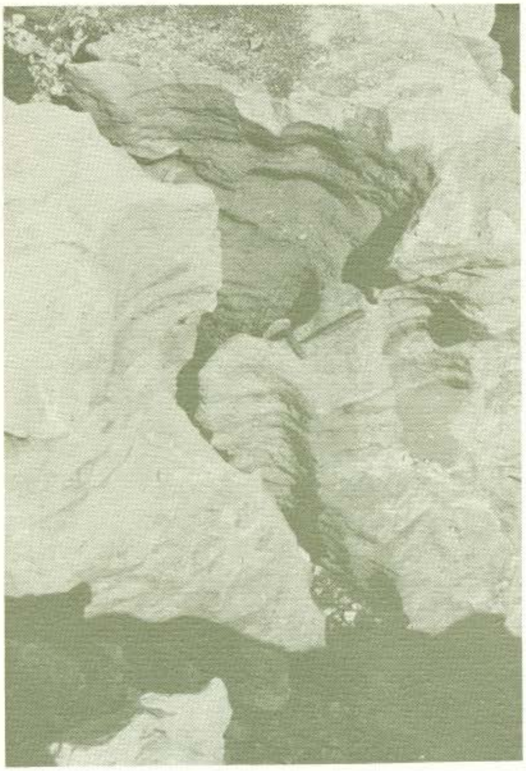
LACLEDE GAS COMPANY'S facilities in the Florissant Karst, near St. Louis, conform beautifully to the topography. . . . .an excellent example of wise land utilization.

FACTORS OF ENVIRONMENTAL GEOLOGY

Very often a planner may recognize an unusual or "hidden" natural resource which could be profitably developed and, with the aid of a geologist, he can plan for its wise utilization. For example, karst topography (meaning sinkhole lands) is often regarded as a poor choice for residential or industrial development. However, to visit Laclede Gas Company's facilities in the Florissant karst, near St. Louis, is to be impressed by their beauty and excellent qualities of livability. Housing, industrial, and transportation facilities are built on intersink areas, conforming to the topography; thus eliminating the strict geometric forms that frequently create monotony. Surprisingly enough, karst lands become homelands with imagination and little expense.

Natural or pre-existing drainage characteristics in such areas must not be overlooked, however. The city of Springfield, for example, is in a region underlain by highly cavernous limestone with many sinkholes. Some builders have neglected underground drainage considerations by filling all sinkholes in a given subdivision. Yet, sinkholes are important because they are in effect a part of nature's storm sewer system, channeling surface waters into underground drainageways which later reappear as springs in downstream areas. When the sinkholes are filled with no provision for surface drainage, wet basements and frequent flooding may be expected. However, karst lands developed with provisions for natural drainage into major sinkholes make highly desirable places to live. The

THIS SINKHOLE in a Springfield residential area acts as a natural unimproved storm sewer. It channels surface waters into underground drainageways and helps prevent wet basements and flooding.



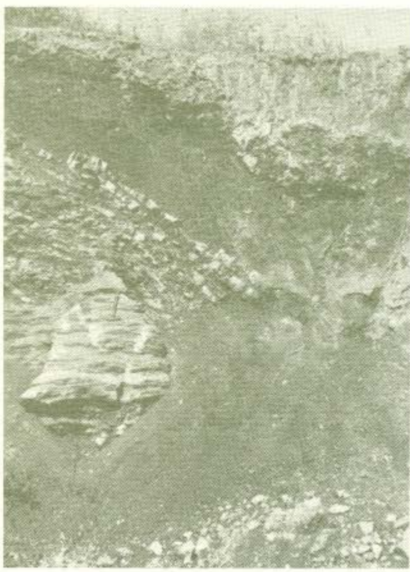
ROUGH ROCK SURFACES such as these in the Springfield area are a difficult engineering problem when constructing highways and buildings. Groundwater has dissolved the limestone and left the surface rough and uneven.

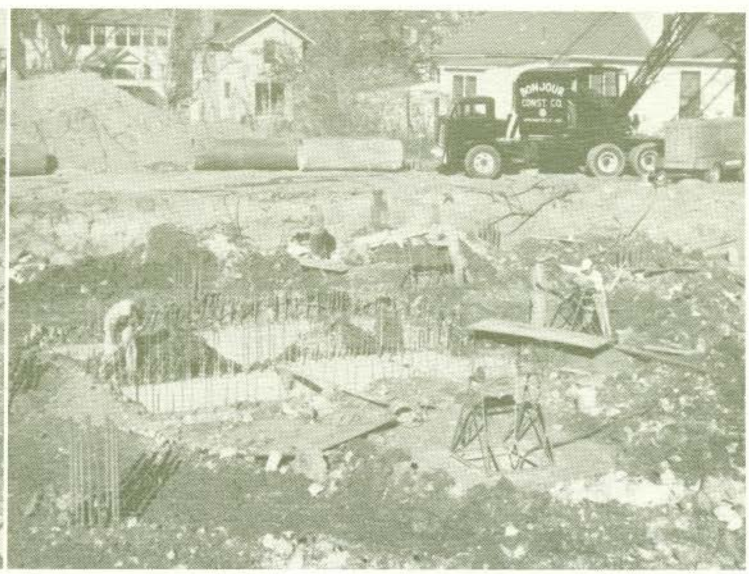
geologist often lends a hand in improving man's standard of living in this and many other ways.

Even carefully engineered highway construction may run afoul of unseen geologic factors. A good illustration is the new route for U. S. Highway 65 around the east edge of Springfield. The proposed route of the highway placed it over a prominent sinkhole and cave; the cave carries a large underground stream. Original plans were to seal the sinkhole completely with fill material. However, Missouri Survey geologists knew that the underground stream contributed to the flow of a large spring which had been dammed to form an attractive area—the focal point of an exclusive residential area with homes in the $100,000 class. Geologists warned that filling the sinkhole would intercept the spring flow and lower property values in the residential area, far from the problem sinkhole. Plans were formulated to provide proper surface drainage without affecting underground drainage. Problems such as this appear frequently, and trouble may often be avoided by drawing upon the talents of a geologist.

As a service to planners, builders, engineers, and others, the Missouri Geological Survey recently initiated a new series of quadrangle maps dealing with specific engineering geologic characteristics of the mapped area. These maps indicate by colors which rock and soil units might affect construction projects—whether a septic tank installation or construction of a high-rise apartment are appropriate in a certain location. They show areas which are particularly favorable for residential development and others which are underlain by rocks and soils that might be more suitable for industrial construction. The first map in the series,

DRILLING DOESN'T give a good picture of subsurface characteristics where pinnacles and cutters (gouged out places) are present. Irregular bedrock, unstable soils, and other unseen geologic factors can cause big building problems.





"Engineering Geology of the Maxville Quadrangle" has been published; others are planned for the suburban areas of St. Louis, Kansas City, and Springfield.

Any discussion of geologic features in recreational planning is likely to touch upon abuse of resources in Man's environment rather than upon wise use. A southwest Missouri city wanted a fall-out shelter and a tourist attraction several years ago, and someone remembered that a great cave lay directly beneath the city. The local newspaper ran a story on the cave featuring forgotten drawing and descriptions of the large and magnificent cave. But when the entrance was relocated, city officials found that short-sighted planning had directed the city's storm sewer system into the cave, and over the years it had filled with debris.

Unfortunately, this story is repeated in various forms throughout the state. To illustrate, a central Ozark town adjacent to Interstate 44 has an enormous spring within a few city blocks of the main street, yet allows the area to be littered and scarred with no effort being made to use what would be considered a wonder of nature in another region. Park lands can be developed almost anywhere, even in a busy metropolitan setting, but parks with geologic features such as this offer much more than playgrounds and picnic areas. Planners have a duty to seek out and capitalize on geologic features worthy of becoming focal points for parklands, residential areas, or for

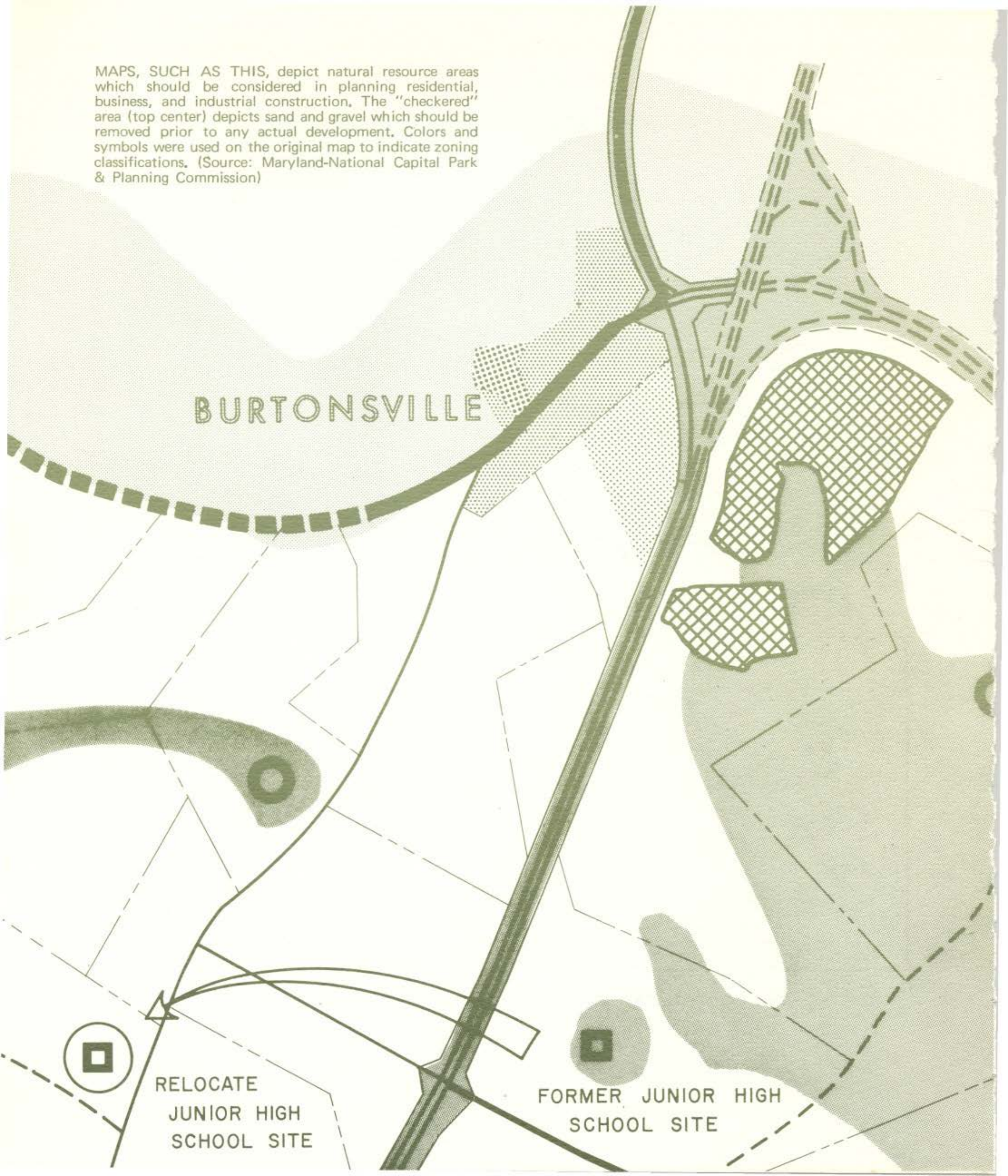
SPRINGS ARE SO ATTRACTIVE and the water quality so good that a number serve as the principal features of Missouri State Parks as well as providing favorable sites for fish hatcheries.

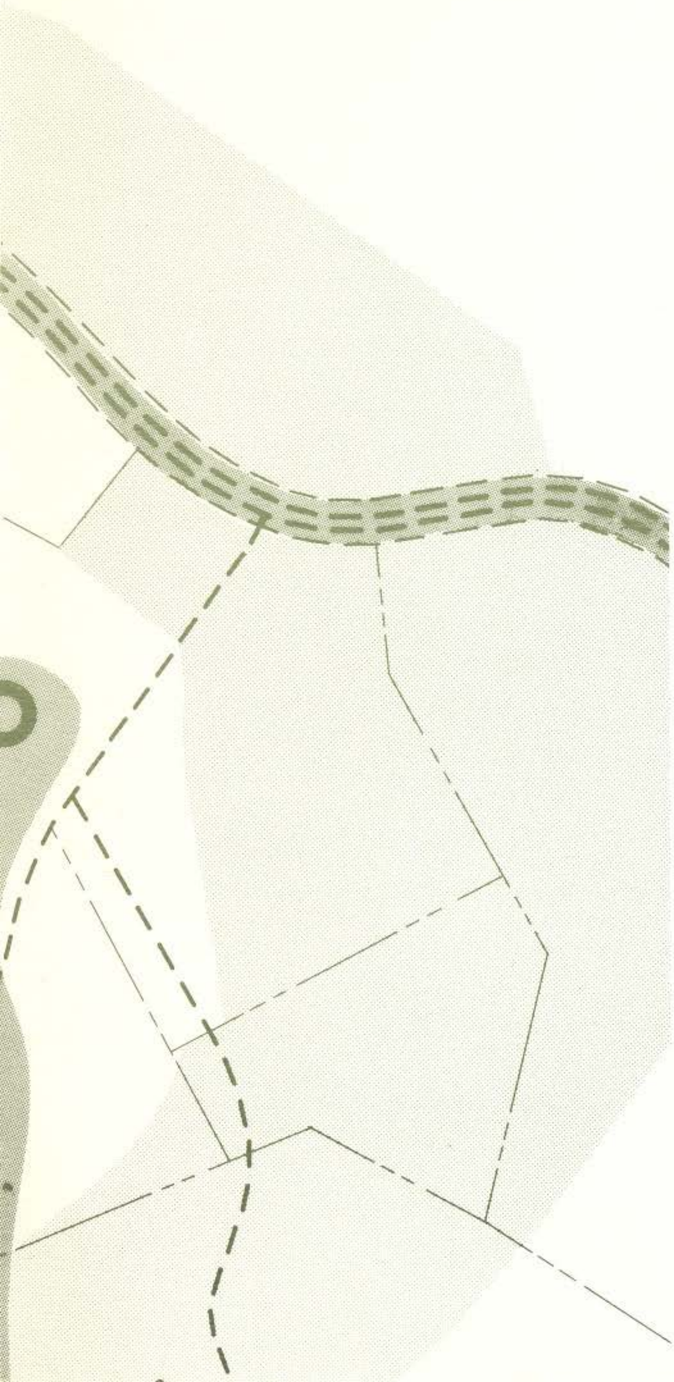
enhancement of public facilities. Such places abound throughout Missouri, generally where they are least expected. The Jefferson County Planning Commission recently discovered a splendid natural bridge in a beautiful setting that had previously gone unnoticed.

During the design and planning of Interstate 44 north of Springfield, the grotesquely weathered limestone bedrock pinnacles were purposely left exposed on the backslope. This use of rock in a natural setting is both pleasing to the traveler and required less rock removal by the contractor during construction.

GEOLOGIC FEATURES such as natural caves, (left) and other wonders of nature are ideal as focal points for parks, residential developments, or for public facilities. Such places abound throughout Missouri and may be incorporated in overall planning at little or no cost.

MAPS, SUCH AS THIS, depict natural resource areas which should be considered in planning residential, business, and industrial construction. The "checkered" area (top center) depicts sand and gravel which should be removed prior to any actual development. Colors and symbols were used on the original map to indicate zoning classifications. (Source: Maryland-National Capital Park & Planning Commission)





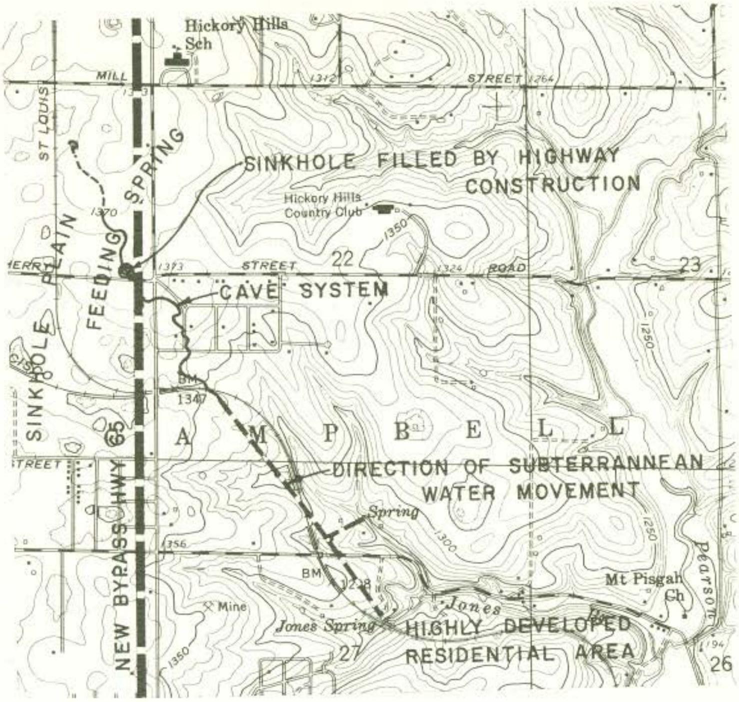
Great strides are being made in the world today and, as pointed out, the field of geology is no exception. Environmental geology has become a definite asset in many aspects of man's struggle to improve his surroundings. While it doesn't supply all the answers, it does help carry man a long way in his search for better living.

While today's interest in environmental geology may shift to place more emphasis on astrogeology (the application of geologic principles to a celestial body such as the moon or a planet), it is certain that the role of the geologist will be more important than ever. Already, detailed structural and geologic mapping of much of the moon has been completed. Geologists have, figuratively, been to the moon even before the astronauts!

Through analysis of data obtained by both manned and unmanned spacecraft, the geologist is in a sense already prospecting. One day, he may even help direct mining on the moon; he will certainly be on hand to aid in making an alien environment a pleasant place for man to live and work!

Whether man is on earth or among the stars, the new discipline—"environmental geology" will lead to the understanding and improvement of man's surroundings.

* * * * *



(left) THE PROBLEM: Study of the Springfield area before the construction of U.S. 65 bypass revealed that conventional filling of a deep sinkhole under the highway right-of-way would interrupt the flow of an underground stream feeding Jones Spring.

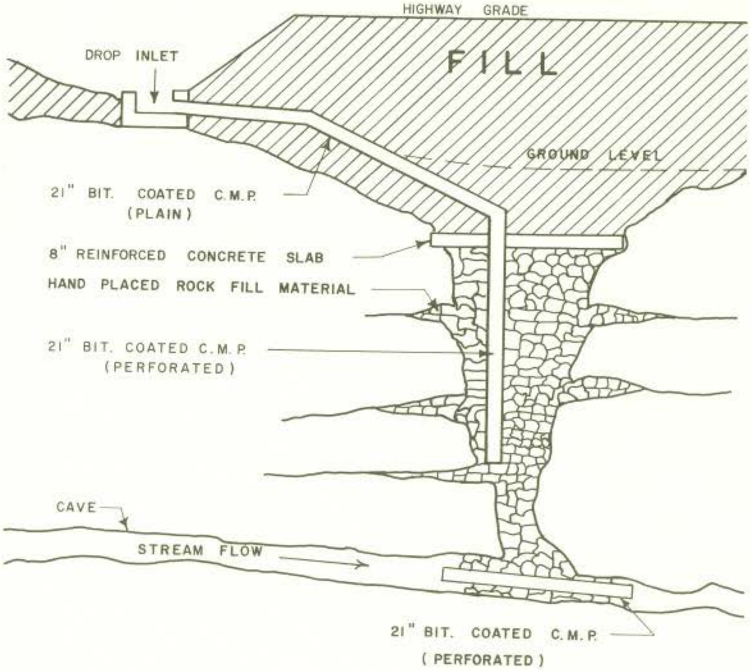
A PROBLEM AND

A practical example of the value of environmental geology is the solution to a problem relating to a large sinkhole under a major highway near Springfield. As strange as it may seem, the Missouri State Highway Department solved this problem by carefully filling the sinkhole well below the roadway pavement level and (by so doing) accomplishing outstanding beautification work miles away.

It all started with the construction of U.S. 65 bypass to the west of an exclusive residential area near Springfield. The area is quite attractive, greatly enhanced by several lakes and waterfalls formed by small dams below Jones Spring (a sizable spring flowing from a cave in the Burlington-Keokuk limestone).

The U. S. 65 right-of-way crosses a large sinkhole at Springfield's Cherry Street and Ingraham Mill Road. Flowing through a cave at the bottom of the sinkhole is an underground stream which may be followed downstream for several hundred feet before it disappears beneath debris which fills the passage.

Several years ago, Survey geologists, using fluorescein dye, traced this stream to Jones Spring. Conventional filling of the sinkhole, they felt, (right) THE SOLUTION: based on study of underground drainage by geologists, a large sinkhole east of Springfield received special consideration to permit construction of U.S. Highway 65 bypass and to safeguard the flow of beautiful Jones Spring. A bituminous-coated corrugated metal pipe and hand-placed rock fill provided stability, yet allowed water to pass.



A SOLUTION – – –

A practical example of the application of environmental geology to an "everyday" problem. . . . . .

would interrupt the flow of the underground stream feeding Jones Spring and would probably cause a constant maintenance problem because of subterranean washouts. The Survey notified the Highway Department, recommending that the underground drainage not be disturbed by construction. Plans were quickly drawn up to provide both for preservation of subterranean drainage and for a stable roadbed.

A corrugated metal pipe, strategic placement of rock fill, and an 8-inch reinforced concrete slab covered by earth fill were used in the sinkhole to keep surface and subsurface drainage much as they were before construction began. Passing motorists may never suspect that an unobtrusive roadside drain feeds a spring which beautifies one of Springfield's finest residential areas – thanks to the wise application of environmental geology!

FOR MORE INFORMATION

ON TOPOGRAPHY

Maryland-National Capital Park and Planning Comm., May 1967, Second preliminary plan for Fairland-Beltsville and Vicinity: 32 p., map.

ON SOILS

Cain, J. M., and Beatty, M. T., 1965, Disposal of septic tank effluent in soils: Jour. Soil & Water Cons., vol. 20, no. 3, May-June.

Elder, W. R., 1965, Urban geology of greater Waco, Part II, Soils: Baylor Univ., Waco, Texas, 66 p., map.

Klingebiel, H. A., 1967, Know the soil you build on: Soil Cons. Service, Agri. Info. Bull. 320, 13 p.

Legget, R. F., Dec. 1967, Soil: its geology and use: Geol. Soc. Am. Bull., vol. 78, no. 12, pp. 1433-1460.

ON WATER

Harvey, E. J., and Skelton, John, 1968, Hydrologic study of a waste disposal problem in a karst area at Springfield, Mo.: U. S. Geol. Survey Prof. Paper 600-C, pp. 217-220.

Hayes, W.C., 1968, Potential deep-well disposal of industrial wastes in Missouri, Missouri Mineral Industry News, vol. 8, no. 4, pp. 35-42.

Sheaffer, J. R., 1967, Introduction to floodproofing: Center for Urban Studies, Univ. of Chicago, Chicago, Ill., 61 p.

Spencer, Jean M., 1966, Urban geology of greater Waco, Part III, Water: Baylor Univ., Texas, 47 p.

U. S. Army, Corps of Engineers, 1967, Guidelines for reducing flood damages, 10 p.

Vineyard, Jerry D., Williams, James H., and others, 1969, Groundwater investigation, *in* James River–Wilson Creek study, Springfield, Missouri: Federal Water Pollution Control Admin., Ada, Oklahoma, vol. 2, App. D (in press).

ON MINERALS

Risser, H. E., and Major, R. L., 1967, Urban expansion — an opportunity and a challenge to industrial mineral producers: Ill. State Geol. Survey, Environmental Geology Notes no. 16, 19 p.

Schlicker, H. G., 1961, Gravel resources in relation to urban development in the Salem area: Oregon Dept. Geology and Mineral Industries and Mid-Willamette Valley Planning Council, 9 p.

Sheridan, M. J., 1967, Urbanization and its impact on the mineral aggregate industry in the Denver, Colo. area: U. S. Bur. Mines, Inf. Cir. 8320, 53 p.

Young, Eleanor, 1968, Urban planning for sand and gravel needs: Calif. Div. Mines and Geology, Mineral Information Service, vol. 21, no. 10, pp. 147-150.

ON GEOLOGY

Dobrovolny, E., and Schmoll, H.R., 1968, Geology as applied to urban planning: an example from the greater Anchorage area, Borough, Alaska: XIII Internatl. Geol. Congress, vol. 12, pp. 39-56.

Ehrlich, P.. R., 1967, Population, food and environment: Is the battle lost? Symposium on limitations of the earth – a compelling focus for geology: Univ. of Texas, Austin, Texas.

Flawn, Peter T., 1968, The environmental geologist and the body politic: Geotimes, vol. 13, no. 6, pp. 13-14.

_____, and Bucket, J. M., 1965, Urban geology of greater Waco, Part 1, Geology: Baylor Univ., Waco, Texas, 46 p., map.

Hackett, J. E., 1967, Geology and physical planning *in* Water, Geology and the Future: Water Resources Research Center, Indiana Univ., Bloomington, Ind., pp. 83-70.

Hayes, W. C., 1965, Engineering geology of Union Electric Co.'s Taum Sauk pumped storage project, Missouri: AIME Trans., 4 p.

_____, Oct. 1968, A growing discipline – engineering geology, *in* Jour. Eng. Club of St. Louis, Mo., vol. 68, no. 9, pp. 3-8.

_____, March 16, 1968, Environmental Geology, presented at Mo. Planning Assoc. Conf., Columbia, Mo.

_____, 1968, Potential deep-well disposal of industrial wastes in Missouri, Missouri Mineral Industry News, vol. 8, no. 4, pp. 35-42.

Hilpman, P. L., and Stewart, G. F., 1967, Environmental geology and urban land-use planning: presented at Geol. Soc. America ann. mtg., New Orleans, La., Nov. 22.

Landrum, J. D., 1964, A foundation investigation of Cherokee Cave under Route I-55, City of St. Louis: presented at Highway Geology Symposium, Rolla, Mo.

LeGrand, H. E., 1968, Urban geology and waste disposal: Geotimes, vol. 13, no. 6, p. 23.

McGill, J. T., 1964, Growing importance of urban geology: U. S. Geol. Survey, Cir. 487, 4 p.

Missouri Mineral Industry News, Feb. 1968, Hazardous dams in Missouri (editorial): vol. 8, no. 2, pp. 16-19, and vol. 8, no. 4, pp. 43-46.

Pittsburg Coal Co., 1957, Subsidence – its cause, effect and prevention, Library, Pa.

Scharon, L., Uhley, R., and Meidav, T., 1959, Subsurface investigations of a plant site (Madison Co.), Min. Eng., Feb., pp. 215-219.

Schlicker, H. G., and Deacon, R. J., 1968, Geology for the planner: presented at the Assoc. of Engineering Geologists, Seattle, Wash.

Smith, W. C., 1966, Geologic factors in dam and reservoir planning: Ill. State Geol. Survey, Environ. Geol. Notes, no. 13, 10 p.

Soil Conservation Society of America, 1968, Making rural and urban land use decisions: Ankery, Iowa, 40 p.

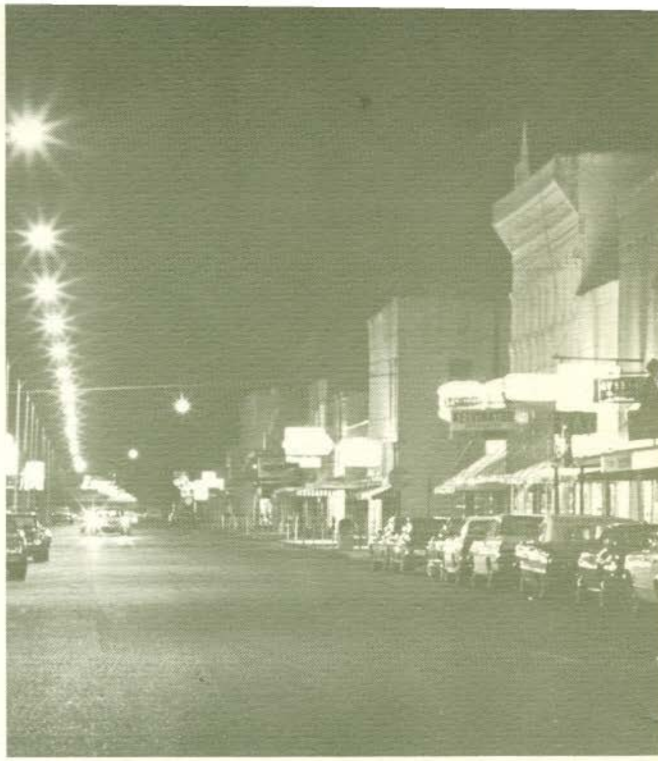
State Geological Survey of Kansas, Summer 1968, Environmental geology digest, vol. 1, no. 1, 43 p.

Vineyard, Jerry D., March 16, 1968, Natural resources and recreational planning: presented at the Mo. Planning Assoc. Conf., Columbia, Mo.

_____, 1969, Geologic report on the Ozark National Scenic Riverways: prepared for the Natl. Park Service, 56 p., illus.

ENVIRONMENTAL GEOLOGY IS USEFUL

IN TOWNE



* Locating highways
* Planning housing developments
* Disposing of domestic and industrial waste
* Finding municipal groundwater supplies
* Assuring foundation stability
* Selecting industrial sites
* Discovering growth minerals
* Providing adequate drainage
* Controlling floods
* Adapting buildings to topography

AND COUNTRY

* Finding domestic water supplies
* Selecting lake sites
* Building dams
* Developing recreational facilities
* Disposing of domestic and agricultural waste
* Avoiding pollution
* Controlling erosion
* Adapting buildings to topography
* Locating roads
* Discovering minerals

PHOTOGRAPHS – Bradford & Fitzsimmons
Brunson Instrument Co.
General Warehouse Corp.
Laclede Gas Co.
Missouri Div. of Commerce & Industrial Development
Peabody Coal Co.
St. Louis Post Dispatch
U. S. Army Corps of Engineers
Jerry D. Vineyard
James Williams
Woodward, Clyde & Sherrard

ILLUSTRATIONS – Douglas R. Stark

.....PUBLISHED BY THE MISSOURI GEOLOGICAL SURVEY

Created in 1853 by the State Legislature, the Missouri Geological Survey and Water Resources studies basic geology with a view toward determining resources available in the state; encouraging their wise use; and developing a data bank of useful geologic information for public use. It is charged by statute to conduct geological investigations in the state and to publish its findings.

Staff geologists answer inquiries about everything from mineral, oil, and gas production to geological hazards in construction and where to find underground water supplies. They aid people through field investigation and laboratory research. Services are available to Missourians and those interested in its geology. The offices, museum, and laboratories are located in Buehler Park, Rolla, Mo.

ENVIRONMENTAL GEOLOGY IN TOWNE AND COUNTRY August 1969

Educational Series No. 2 By William C. Hayes and Jerry D. Vineyard

MISSOURI GEOLOGICAL SURVEY & WATER RESOURCES

Box 250 Buehler Park Rolla, Mo.

William C. Hayes, State Geologist & Director