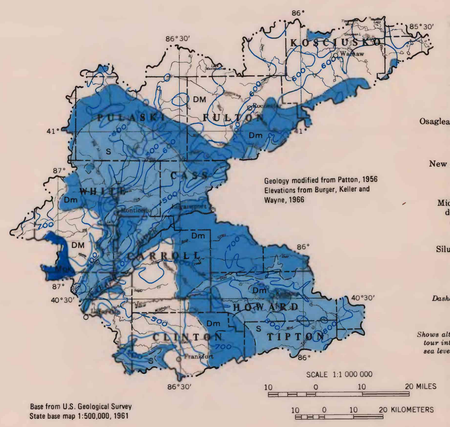
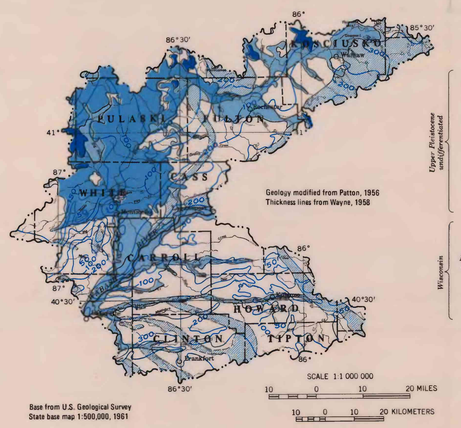
PREPARED IN COOPERATION WITH THE
INDIANA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATER

THE GEOLOGIC ENVIRONMENT



BEDROCK UNDERLYING THE BASIN RANGES IN AGE FROM SILURIAN TO MISSISSIPPIAN.—*Silurian and Middle Devonian limestones and dolomites are the principal bedrock aquifers.*



UNCONSOLIDATED GLACIAL DEPOSITS UNDERLIE MOST OF THE BASIN.—*In the northeastern part and in the deeper preglacial valleys, these deposits are about 350 feet thick. Sand and gravel units within the unconsolidated section are the major sources of ground water.*

QUALITY OF GROUND WATER

All samples of fresh ground water analyzed from the basin were of the calcium magnesium bicarbonate type, very hard – greater than 180 mg/l (milligrams per liter), and had a high iron content – generally above 0.3 mg/l. The selected analyses indicated in the table and located on the map at the right are typical for the principal aquifers. The significance of the major constituents are outlined below with the two primary quality problems, iron and hardness, emphasized.

CHEMICAL ANALYSES OF RAW WATER FROM SELECTED PUBLIC SUPPLY SYSTEMS.
[Indiana State Board of Health, 1968]

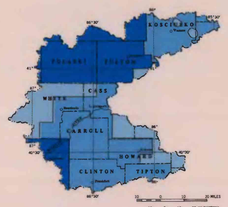
Community	Depth (feet)*	Aquifer**	Constituents, in milligrams per liter												
			Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Hardness as ($CaCO_3$)	pH	Color
Delphi	152	L	0.6	108	47	13	5	100	14	0.4	3.6	447	7.2	<5
Flora	53	G	1.8	94	27	4	1	57	8	.1	.1	346	7.4	5
Frankfort	276	G	1.5	71	27	16	1	30	3	.6	.7	290	7.8	<5
Galveston	465	L	1.3	81	31	10	2	32	5	.4	.2	328	7.7	5
Kawanna	133	G	1.4	64	24	10	1	41	6	.1	.1	258	7.6	5
Kokomo	160	L	2.3	137	2.2	9	1	9	.6	.6	.7	351	7.8	5
Lafayette	100	G	.4	120	39	18	4	103	28	.3	3.5	462	7.8	0
Montezuma	104	G	1.0	70	21	12	1	23	2	.5	.2	263	7.2	5
Monon	325	L	.2	73	27	33	3	59	36	.4	.2	292	7.8	<5
Purdue	154	G	1.8	73	27	15	2	22	9	.6	.3	290	7.6	<5
Rochester	106	G	1.6	83	20	6	2	38	8	.1	.7	291	7.8	10
Roseville	100	G	2.2	92	28	13	5	20	21	.2	.2	342	7.6	5
Windfall	151	L	1.3	92	37	24	2	35	13	.5	.5	384	7.6	<5

*Deepest well reported for well field
**G–Gravel
L–Limestone

CHEMICAL CONSTITUENTS IN WATER, THEIR SIGNIFICANCE, AND RECOMMENDED LIMITS FOR PUBLIC WATER SUPPLIES*

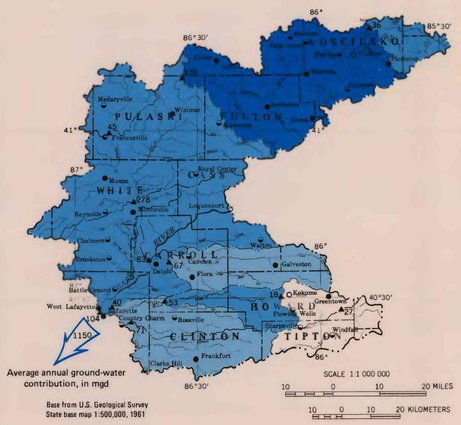
Constituent or property	Recommended maximum limit	Significance
Iron (Fe)	0.3 mg/l	Imparts a taste if in large amounts. Causes rusty or brownish stains on porcelain, fabrics, and other products.
Calcium (Ca) and magnesium (Mg)	(**)	Not harmful for human consumption. Causes most of the hardness, scale forming, and soap-consuming properties. (See "hardness.")
Sodium (Na)	(**)	Significant in human consumption only where a sodium-free diet must be maintained.
Sulfate (SO_4)	250 mg/l	May impart a bitter taste. Large amounts have a cathartic effect.
Chloride (Cl)	250 mg/l	Causes salty taste when combined with sodium. Large quantities cause metals to corrode. Some plants are sensitive to high concentrations.
Fluoride (F)	1.3 mg/l	In Middle Wabash Basin, concentrations exceeding 1.3 mg/l may cause mottling of tooth enamel of children.
Nitrate (NO_3)	45 mg/l	Higher concentrations may cause infant cyanosis ("blue baby" disease).
Total solids	500 mg/l	Larger quantities (exceeding 1,000 mg/l) generally affect taste and make the water unsuitable for many uses.
Hardness	(**)	Consumes soap before a lather will form; deposits a soap curd; and forms a scale in water heaters, boilers, and pipes. U.S. Geological Survey classification: Soft, 0-60 mg/l; moderately hard, 61-120 mg/l; hard, 121-180 mg/l; and very hard, over 180 mg/l.
Color	15 units	Not known to be harmful to humans, but color is undesirable in water. Color of less than 15 units cannot be seen by most people.
pH	(**)	Measure of the hydrogen-ion activity of a solution. A value of 7.0 is neutral; below 7.0 is acid; above 7.0 is basic.

*U.S. Public Health Service, 1962.
**No limit set.



THE DATA SHOWN ON THE PRINCIPAL MAPS OF THIS SHEET HAVE THE RELATIVE ACCURACY INDICATED ABOVE.

GROUND-WATER AVAILABILITY AND FUTURE DEMANDS



COMBINED 1960 MUNICIPAL AND INDUSTRIAL WATER PLANT CAPABILITIES AND PROJECTED FUTURE WATER NEEDS

[Data from Wabash River Coordinating Committee, 1971 Wabash River Basin Comprehensive Study: U.S. Army Corps of Engineers.]

Community		Projected demands in million gallons per day				1960 Water supply, in mgd
		1970	1980	2000	2020	G W
Akron	*	0.13	0.24	0.48	0.96	
	AVG	.11	.20	.40	.80	0.34
Culver	*	.43	.47	.53	.60	
	AVG	.36	.39	.44	.50	.67
Delphi	*	.47	.79	1.90	2.9	
	AVG	.39	.66	1.50	2.4	2.3
Flora	*	.30	.50	1.10	1.7	
	AVG	.25	.42	.92	1.4	1.2
Frankfort	*	3.7	4.6	7.2	11.3	
	AVG	3.1	3.9	6.0	9.4	8.5
Galveston	*	.32	.41	.67	.96	
	AVG	.27	.34	.56	.80	.66
Greentown	*	.35	.38	.49	.65	
	AVG	.29	.32	.41	.54	.14
Lafayette Area	*	31.7	39.4	63.4	102.1	
	AVG	26.4	32.8	52.9	85.1	43.5
Mentone	*	.19	.30	.59	.85	
	AVG	.16	.25	.49	.71	.70
Monon	*	.22	.32	.64	.82	
	AVG	.18	.27	.53	.68	.50
Monticello	*	1.2	1.7	2.7	3.7	
	AVG	1.0	1.4	2.3	3.1	2.0
Pierceton	*	.20	.29	.56	.78	
	AVG	.17	.24	.47	.65	.80
Rochester	*	1.1	1.6	3.1	4.6	
	AVG	.90	1.30	2.60	3.80	3.10
Winamac	*	.58	.80	2.5	4.0	
	AVG	.48	.67	2.1	3.3	1.00

Note: "AVG" is average daily, "*" is average day of maximum month.

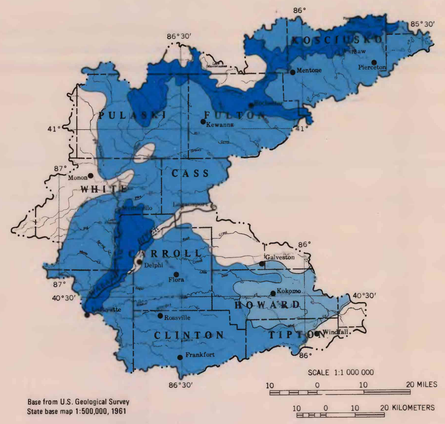
GROUND WATER NEEDED TO SATISFY FUTURE DEMANDS IS AVAILABLE FROM SOURCES WITHIN THE BASIN

On the average, about 1,150 million gallons of ground water is entering the streams each day from naturally overflowing aquifers underlying the middle Wabash River basin. In addition to this amount about 6,000,000 million gallons of fresh water is in storage within the aquifers underlying the basin.

In contrast, an average of about 33 million gallons per day is being pumped from these aquifers, which is less than 3 percent of the amount that is naturally discharging into the streams. By the year 2020, it is estimated that only about 10 percent of the amount now being naturally discharged will be pumped from the aquifers on an average day.

Even though the amount of water being pumped is a small percentage of the total amount available, many problems arise when large amounts of water are withdrawn from small areas, such as well fields used for municipal and industrial supplies. Many new problems will arise as more and more water is withdrawn in the future. The keys to solving these problems and to providing the water when and where it is needed in the future are farsighted planning, wise management, and efficient design of production wells and well fields.

GROUND WATER AS A SOURCE OF SUPPLY



PRODUCTIVE AQUIFERS UNDERLIE MOST OF THE BASIN.—*The valley-train and outwash sand and gravel aquifers near the major streams provide consistently high well yields, generally about 1,000 gpm. Most communities in the area of these aquifers have municipal-supply wells completed within them. Bedrock aquifers underlying the basin generally provide good yields; however, yields are highly variable from well to well even within a small area. Yields from wells completed in the bedrock in the eastern part of the basin are generally higher than in the other areas where bedrock is the principal aquifer.*

GROUND WATER AS A SOURCE OF SUPPLY

The information presented in the various sections of this sheet are the basic facts needed to estimate the quantity and quality of ground water available for short pumping periods (24 hours or less in any 48-hour period) from the principal (best known) aquifer underlying any part of the basin.

Much additional information is required to design wells or well fields or to predict the effects of sustained pumping and extreme development on the ground-water resources of the basin.

ESTIMATING SHORT-TERM WELL YIELDS

Estimates can be made of the short-term well yields that might be expected from the principal aquifer underlying any area of the basin by using the specific capacity and available drawdown values shown on the maps at right. The relationship between well yield and these values is:

WELL YIELD = SPECIFIC CAPACITY × AVAILABLE DRAWDOWN
(Q_w, in gpm) (C_w, in gpm/foot of drawdown) (S_w, in feet)

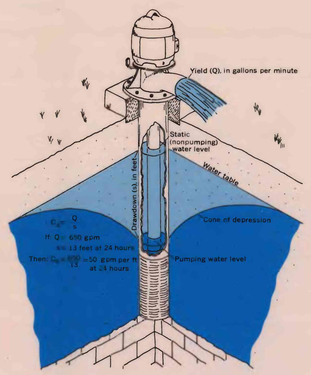
The well yields obtained using this method are only preliminary estimates and as such should not be considered as firm obtainable yields or as well-design criteria. No data are provided to make allowances for mutual interference between neighboring wells, for drawdown effects caused by aquifer boundaries, or for sustained pumping. These data can only be obtained at individual sites by well-aquifer tests. Even so, estimates of well yields based on specific capacities and available drawdowns can be made in the basin based on the idealized assumptions presented.

EXAMPLE: Estimate the anticipated short-term well yield available from the principal aquifer just east of Rochester (sec. 5, T. 30 N., R. 3 E.), Fulton County.

The range of specific capacity in this area is 61 to 80 gpm per foot of drawdown. The average available drawdown is 21 to 30 feet. Therefore, the estimated anticipated range in well yield is:

$Q = C_w \times S_w$
(61–80) (21–30) =1,280 to 2,400 gpm

No wells have been constructed at Rochester with a yield within this range; however, a city well in section 8 yields 1,000 gpm with a drawdown of only 15 feet and is screened for less than half of the aquifer thickness. The average available drawdown at the well is 35 feet, indicating that this well as installed could possibly yield over 2,000 gpm if it were equipped with a suitable pump.

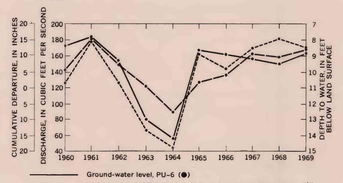


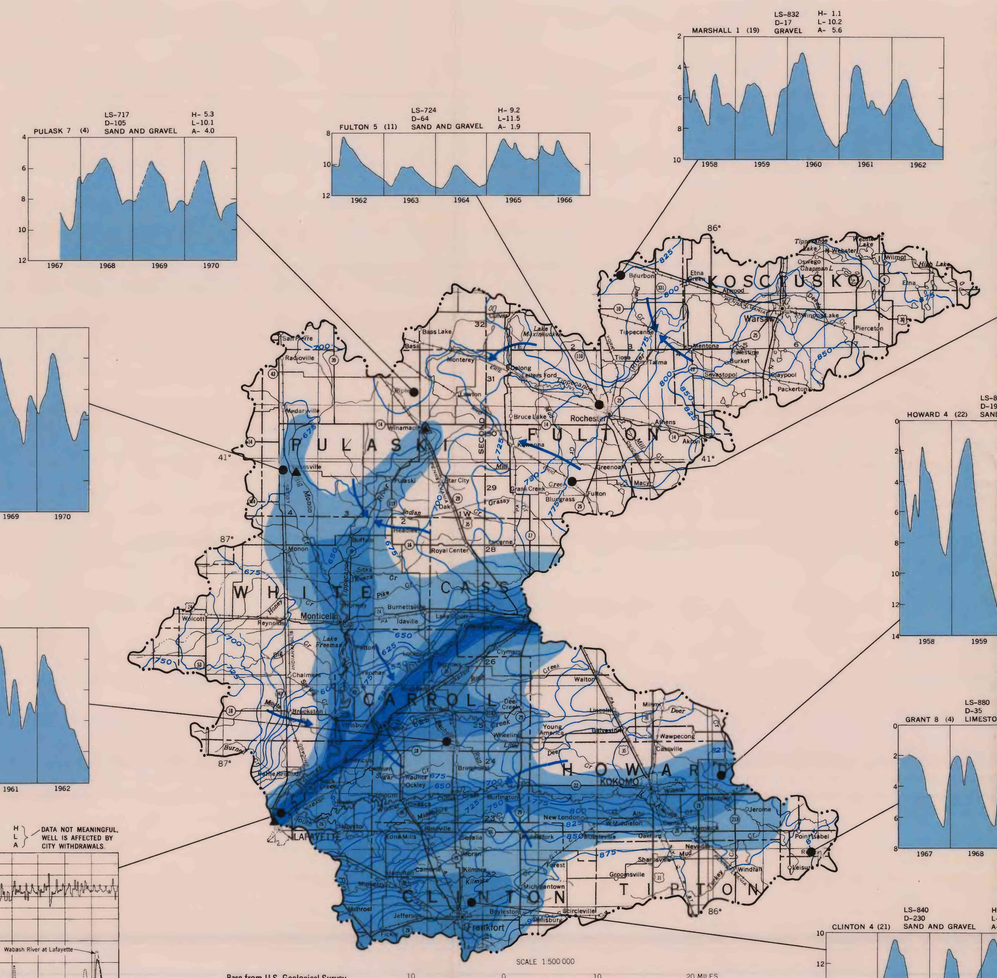
THE SPECIFIC CAPACITY OF A WELL IS A MEASURE OF THE PRACTICAL EFFICIENCY OF THAT WELL RELATIVE TO THE AMOUNT OF WATER ACTUALLY AVAILABLE FROM THE AQUIFER IN WHICH THE WELL IS DEVELOPED.—*Specific capacity (C_w) is equal to the yield (Q) divided by the drawdown (s) and is expressed as the number of gallons a minute the well will yield for each foot of drawdown of the water level measured at a specific time (generally 24 hours) after pumping began. Where no detailed aquifer-test data are available, specific capacities may be used to indicate an aquifer's capability to yield water to wells.*

GROUND WATER

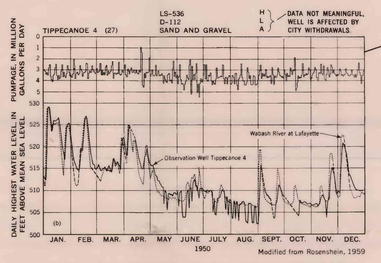
FLUCTUATIONS OF GROUND-WATER LEVELS

THE GRAPH BELOW ILLUSTRATES THE RELATION BETWEEN CHANGES IN GROUND-WATER LEVEL, AMOUNT OF PRECIPITATION, AND STREAM DISCHARGE





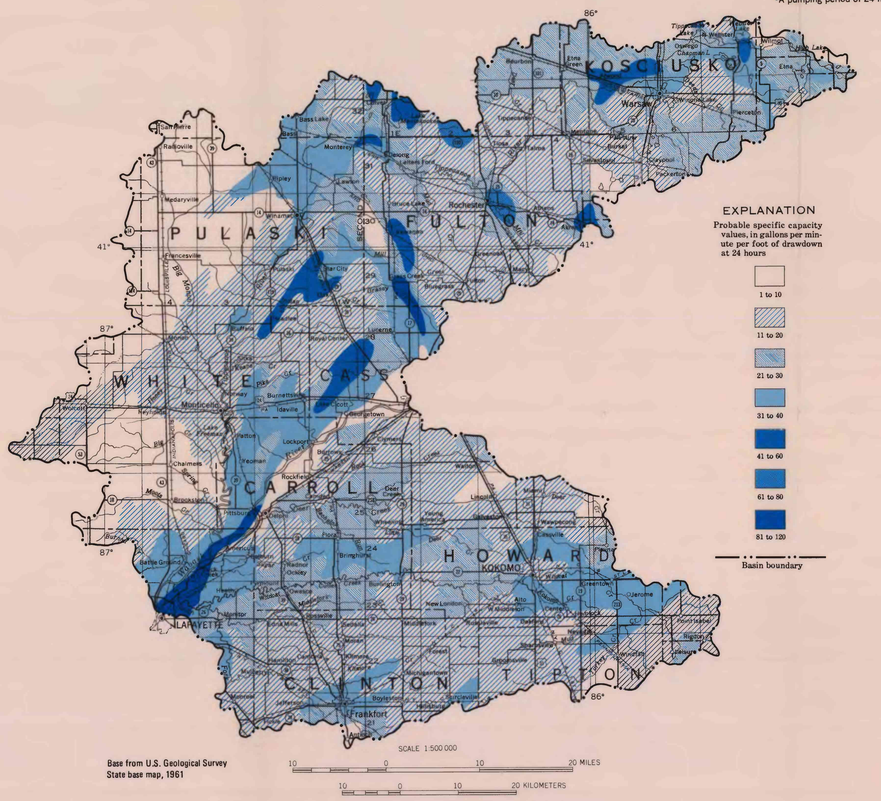
THE GROUND-WATER LEVELS IN THE BASIN ARE CONTINUALLY FLUCTUATING IN RESPONSE TO RECHARGE TO AND DISCHARGE FROM THE AQUIFERS.—*Under natural conditions, the fluctuations during the year range from an average of less than 2 feet in the north-central part of the basin to more than 25 feet along the Wabash River. In areas of large withdrawals, the natural fluctuations may be increased locally by as much as 20 feet. The well hydrographs illustrate typical fluctuations above and below the average water-level surface depicted by contours on the map.*



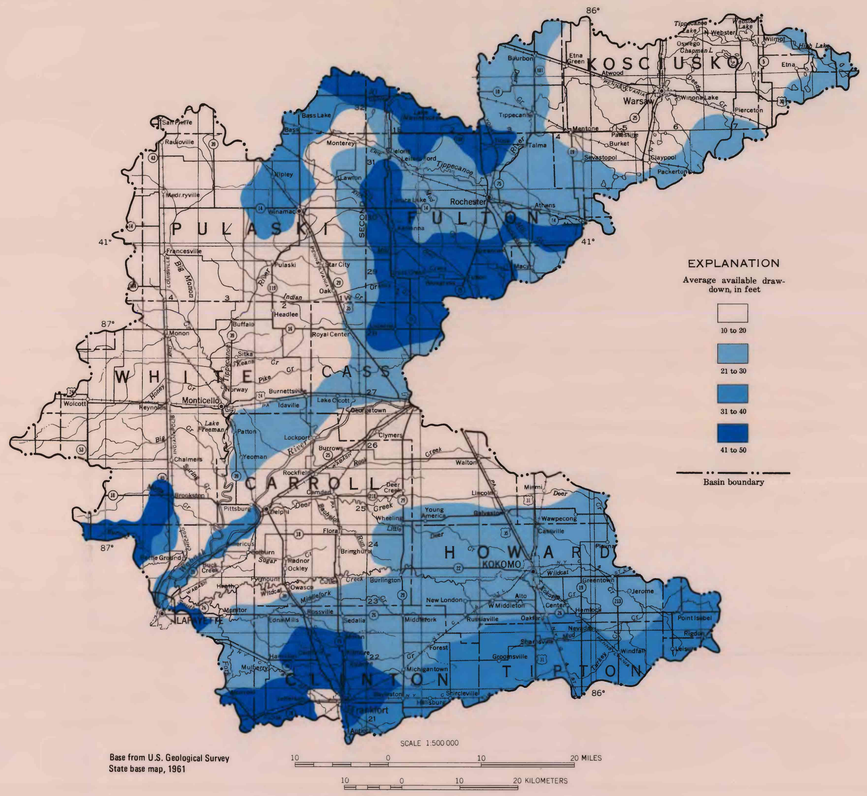
THE WATER-LEVEL FLUCTUATIONS RECORDED IN OBSERVATION WELL TIPPECANOE 4 ILLUSTRATE HOW GROUND-WATER LEVELS RESPOND TO CHANGES IN STAGE OF NEARBY STREAMS AND TO LOCAL GROUND-WATER WITHDRAWALS

SHORT-TERM* YIELDS AVAILABLE FROM PRINCIPAL AQUIFERS

*A pumping period of 24 hours or less in any 48 hour period.



SPECIFIC CAPACITY VALUES SHOWN ARE THE ANTICIPATED RANGES FOR IDEALIZED WELLS COMPLETED IN THE PRINCIPAL AQUIFERS UNDERLAIN THE BASIN.—*The idealized wells are assumed to be 100-percent efficient, 12 inches in diameter, open to the entire thickness of the aquifer, screened if completed in a sand and (or) gravel aquifer, and properly developed. Lateral continuity of aquifer zones within the geologic section was assumed in order to facilitate areal definition of principal aquifers. The specific capacity values have all been adjusted for a 24-hour period of continuous pumping.*



VALUES SHOWN ARE THE ANTICIPATED RANGES OF THE DRAWDOWN AVAILABLE TO WELLS DEVELOPED IN THE PRINCIPAL AQUIFERS.—*In water-table aquifers, the indicated drawdown is equivalent to two-thirds of the minimum observed saturated thickness of the aquifer. In artesian aquifers, the drawdown is equivalent to the distance from the lowest observed water level to the top of the artesian aquifer.*

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1974—W71054

WATER RESOURCES OF THE MIDDLE WABASH RIVER BASIN, INDIANA

By
James R. Marie and L. G. Davis

1974