STATE OF OHIO
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DEPARTMENT OF NATURAL RESOURCES
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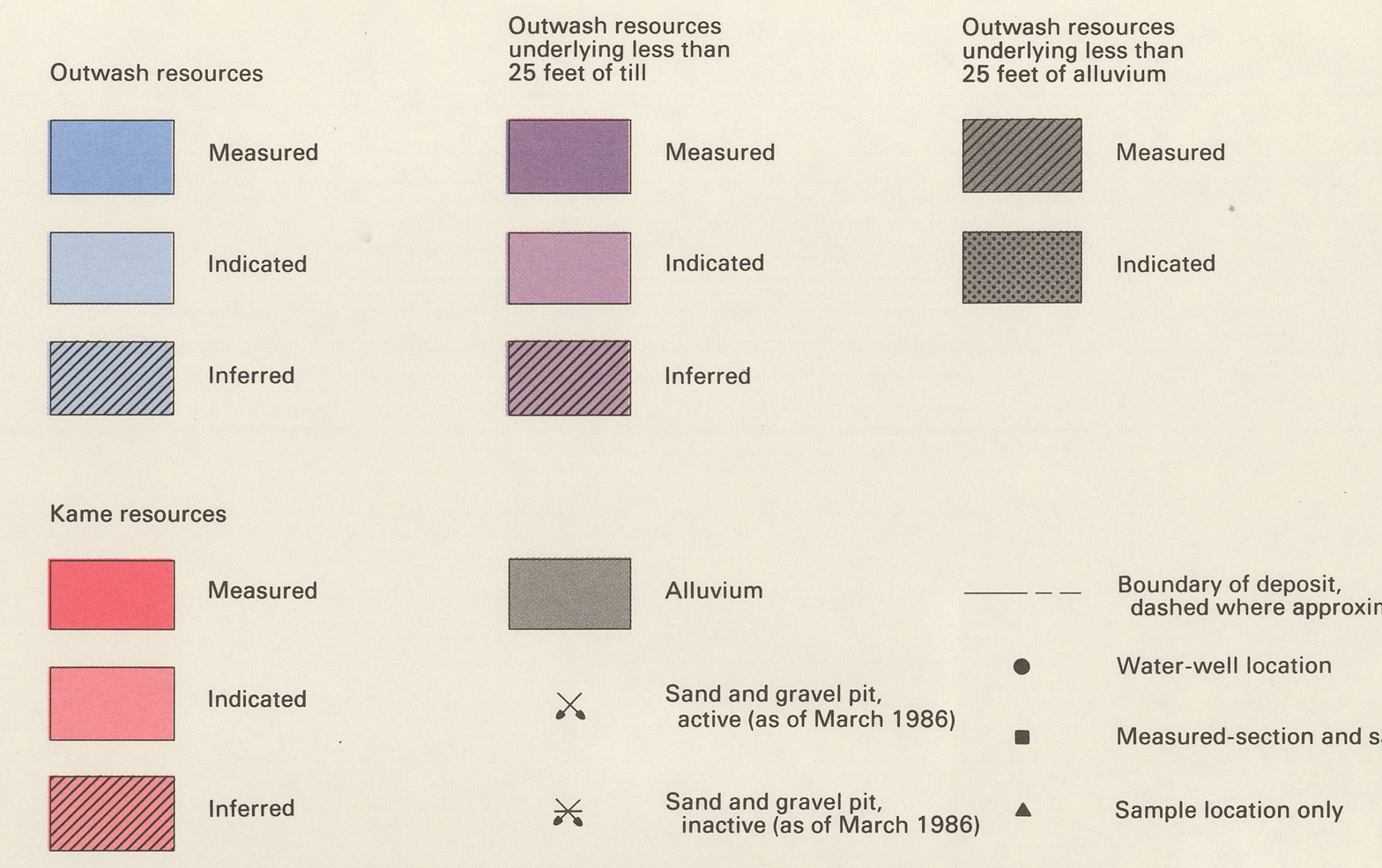
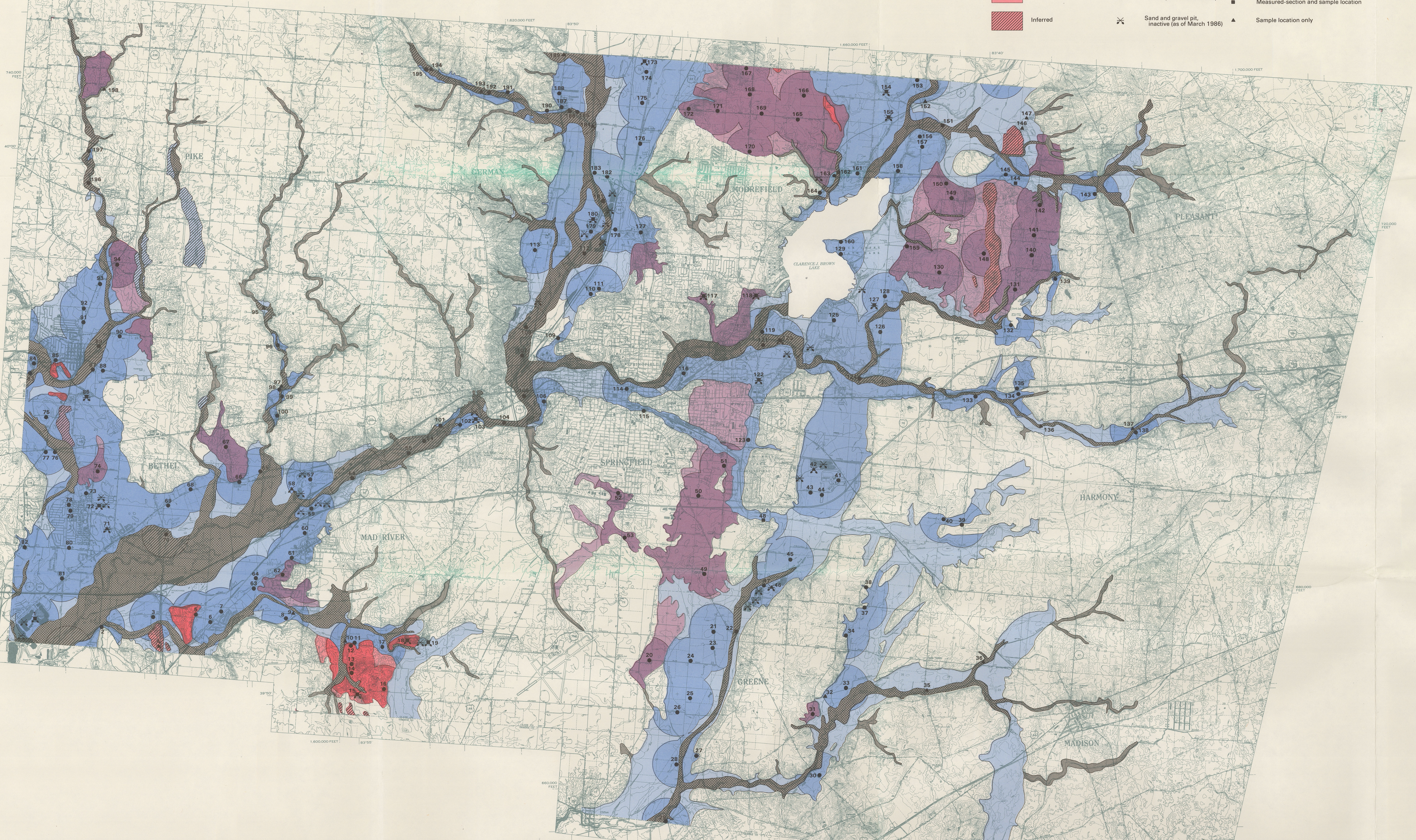
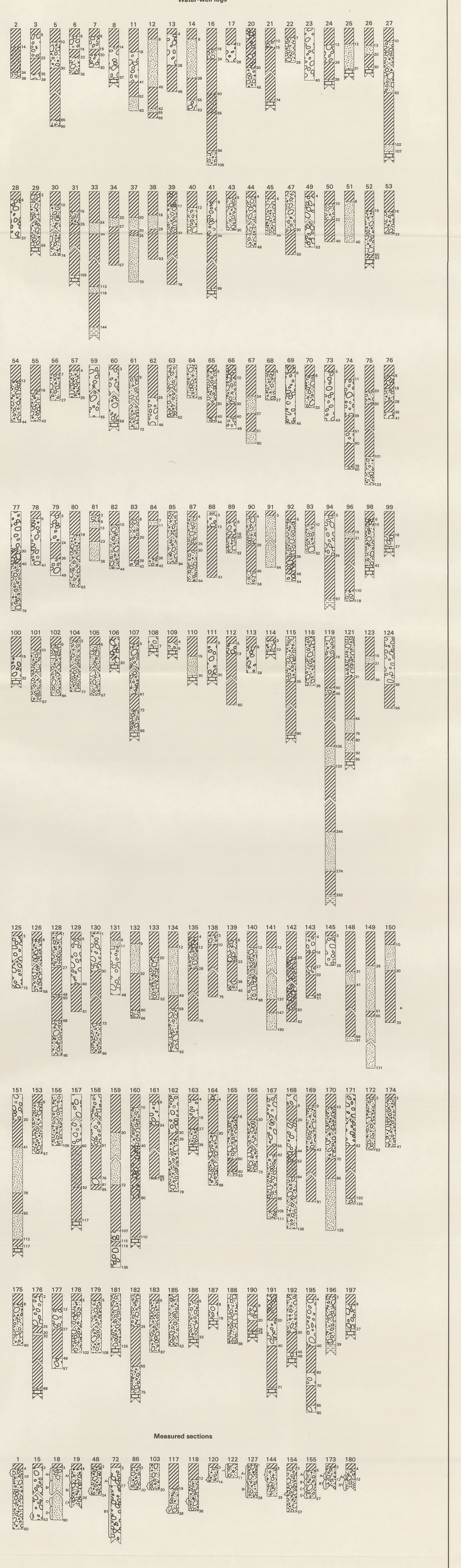
DIVISION OF GEOLOGICAL SURVEY
Horace R. Collins, Chief

SAND AND GRAVEL RESOURCES OF CLARK COUNTY, OHIO

By Richard A. Struble
1987







ABSTRACT

Sand and gravel resources of Clark County, Ohio, are estimated at approximately 5.7 billion tons. Cumulative sand and gravel production from 1950 through 1985 has been approximately 30 million tons. The remaining sand and gravel resources of Clark County appear adequate to meet the aggregate needs of the county for well into the next century. Analyses of samples collected from widely spaced deposits throughout the county indicate that most of the remaining undeveloped sand and gravel resources will meet most construction and material specifications.

INTRODUCTION

The occurrence of large quantities of good-quality sand and gravel in southwestern Ohio has played an important role in establishing this region of the state as an industrial and commercial center. The sand and gravel in Clark County are part of a larger resource of glacially derived sands and gravels which were deposited within the Great Miami River drainage area. The major portion of the resource is within outwash terraces confined to the valleys and tributaries of the Mad River and Buck Creek in Logan and Champaign Counties, the Mad River and the Little Miami River in Clark and Greene Counties, and the Great Miami River in Montgomery, Butler, and Hamilton Counties. This sand and gravel resource inventory of Clark County is one of a series of county reports intended to define the distribution, quantity, and quality of the sand and gravel deposits of Ohio.

Clark County is located in southwestern Ohio. Springfield, the largest city, is centrally located in the county and is approximately 45 miles west of Columbus, 25 miles northeast of Dayton, and 70 miles northeast of Cincinnati. The county covers approximately 400 square miles and is primarily agricultural except for the industrial and commercial area around Springfield.

Sand and gravel have been produced in Clark County since long before production data were recorded. The total original sand and gravel resource of Clark County is estimated at approximately 5.7 billion tons (table 1). Clark County ranked eighth in Ohio in overall sand and gravel production in 1985 (Ohio Division of Geological Survey, 1986). In southwestern Ohio it ranked fifth behind Hamilton, Butler, Montgomery, and Warren Counties. Annual production of sand and gravel in Clark County between 1950 and 1963 averaged approximately 445,000 tons. From 1964 to 1974, annual production averaged approximately 1,250,000 tons, peaking at 1,492,112 tons in 1971. This period of increased production resulted from commercial, residential, and industrial expansion and the construction of Ohio's interstate-highway network. From 1974 to the present, production has declined to an annual average of approximately 910,000 tons. If the forecast (Ohio Department of Development, 1983) of flat population growth and sluggish near-term industrial and commercial growth to the year 2000 proves correct, the annual production of sand and gravel in Clark County should be in the range of 950,000 tons for the remainder of this century.

Because much of the undeveloped sand and gravel resource in Clark County does not fall in or adjacent to densely populated areas, the land-use competition between the extractive industries and industrial and neighborhood developers has not been as intense in this county as in other counties in southwestern Ohio. To insure that the future development of the remaining resource is efficient and in the best interest of the citizenry of the county, it is essential that detailed maps and reports showing the distribution, quality, and quantity of sand and gravel resources be available to planners, municipal authorities, developers, and property owners in the county.

GEOLOGICAL OCCURRENCE

The landscape of Clark County is formed chiefly of unconsolidated glacial materials of Wisconsinan age. Wisconsinan-age ice spread southward from Michigan and Canada into Ohio approximately 50,000 years ago. Materials of older glaciations (Nebraskan, Kansan, and Illinoian) are found south of Clark County in Butler and Hamilton Counties, Ohio, in northern Kentucky, and in southeastern Indiana. These earlier glaciations played an important role in the evolution of the preglacial and interglacial drainage systems in Ohio, but deposits of the earlier glaciations in Clark County are either buried beneath younger Wisconsinan deposits or have been eroded by later glaciations.

The morphology of glacial features in western Ohio suggests that glaciers from the Erie basin advanced across central and western Ohio in two lobes, the Miami lobe on the west and the Scioto lobe on the east. The bedrock hills of Logan County to the north acted as a buttress to separate the ice sheet into the two lobes. Analyses of glacial materials from Clark County indicate that at times during the Wisconsinan the ice sheets of the two lobes were in north-south contact across the county and at other times were separated by interlobate areas of varying widths. During fluctuations at the ice margins, Miami-lobe materials were sometimes overrun by Scioto-lobe ice, or Scioto-lobe materials were overrun by Miami-lobe ice. The proximity of the two lobes in Clark County has resulted in much interbedding and overlapping of materials from the two lobes.

The glacial features at the surface in Clark County are considered to be the result of glacial processes associated with the retreat of the Wisconsinan ice sheet from the county. Except for a few outcrops of Silurian rocks in the Springfield, Limestone City, and Donnelsville areas, Clark County is covered with unconsolidated materials deposited by glacial ice or meltwaters. The glacial and postglacial landforms which dominate the Clark County landscape are: (1) end moraines, (2) ground moraine, (3) outwash (valley trains and outwash plains), (4) kames, and (5) alluvium on the floodplains of the primary and secondary streams of the county.

The end moraines and ground moraine in Clark County occur in a series of alternating north-south bands which are sometimes separated by outwash deposits. End moraines and ground moraine are composed of till, which is an unsorted mixture of clay, silt, sand, pebbles, cobbles, and boulders.

The end moraines of Clark County occupy approximately 33 percent of the surface of the county (Goldthwait, 1952). End moraines are hummocky ridges of till which mark the position of an ice sheet when the ice front remained relatively stationary or stagnant for substantial periods of time. The hummocky ridges develop as materials incorporated within or on top of the ice sheet are thrust forward and stacked along the ice margins. The end moraines in Clark County, which are commonly interbedded with lenses of sand and gravel, rise between 10 and 40 feet above the surrounding land surface.

Ground moraine, which occurs throughout Clark County, is characterized by a nearly level to slightly hummocky surface of low relief. In western Clark County the ground moraine generally averages less than 50 feet thick (Goldthwait, 1952). Ground moraine forms when materials carried within the base of the ice sheet are plastered on the land surface during glacial advances or when the materials are dropped to the ground as the ice melts or evaporates (ablation) during glacial recessions.

Ground moraine and end moraines, because of the generally clayey composition of till, have not been included in the resource inventory. However, many small pits have been developed in localized lenses of sand and gravel within the moraine to provide bank-run materials for use on farm roads and lanes. In some areas of Clark County, till was deposited over previously deposited outwash during fluctuations of the Miami-lobe and Scioto-lobe ice sheets. Where the thickness of the overlying till deposits is less than 25 feet, the outwash deposits have been included in the resource inventory. Areas where outwash underlies less than 25 feet of till are (1) Pike Township, 2 miles north of New Carlisle and 3 miles south of Christianburg; (2) Bethel Township, 2 miles northwest and 3 miles northeast of Medway; (3) Moorefield Township, 5 miles north of Springfield; (4) Springfield and Greene Townships, 1 to 5 miles south of Springfield; and (5) Pleasant Township, 2 miles east of Clarence Brown Lake. The resource of sand and gravel interpreted to lie beneath less than 25 feet of till in Clark County makes up approximately 22 percent of the total resource.

Outwash, which consists of well-graded, stratified sands, gravels, cobbles, and some boulders transported from glaciers by meltwaters, has been classified by geologists into two types of deposit, outwash plain and valley train. Valley-train deposits in Clark County are found in the valleys of the Mad River, Buck Creek, Mud Creek, and Beaver Creek. During recessions of the ice sheets, large quantities of materials within the glaciers were transported by meltwaters from the melting ice into established drainageways at the front of the glacier. Initially the valleys were partially filled with the outwash materials, but later, as the glacier receded from the drainage basin, the outwash materials were dissected by streams, and matched terraces developed along the margins of the valley.

Outwash-plain deposits occur in upland areas and consist of materials carried from the glacier by meltwaters unable to find access to a major drainageway leading away from the glacier. Outwash plains commonly are broadly sloping and form as materials transported by meltwaters are deposited in fans or coalescing fans at the front of the glacier. Outwash-plain deposits are generally thin and discontinuous and not considered as sources for commercial quantities of sand and gravel. However, the outwash-plain deposits of Clark County are thicker and have a wider distribution because of their unusual mode of deposition. The Clark County outwash-plain materials formed when the glacial meltwaters were confined between the distal margin of the Miami-lobe ice and the higher ground elevation in eastern Clark County. Other outwash plains were deposited by meltwaters confined between ice barriers which formed when the Miami-lobe and Scioto-lobe ice fronts stood only a short distance apart (Goldthwait, 1952). The major outwash-plain deposits are in eastern Clark County. One large band, continuous from the northern county boundary in Moorefield Township to the southern county boundary in Greene Township, is centered along a line through New Moorefield, eastern Springfield, and a point 1 mile east of Clifton. Smaller remnants occur 1 mile and 5 miles west of South Charleston in Madison and Greene Townships. Outwash-plain and valley-train deposits have not been differentiated on the resource inventory map but are mapped together as outwash. Approximately 58 percent of the total sand and gravel resource of Clark County is found within outwash deposits.

Kames are hills or mounds of stratified, water-laid, generally well-graded sands and gravels. Kames form when sediments carried from the apex of ice tongues are deposited between the ice edge and the valley walls or in crevasses at the margins of the wasting ice. In Clark County, kames cover only a small portion of the surface and rise from a few feet to 150 feet above the ground surface. Kames are located in Mad River Township in secs. 17 and 23 southwest of Enon and in secs. 22, 23, 28, 29, 34, and 35 southeast of Enon; in sec. 34, Bethel Township, south of New Carlisle; and in secs. 10, 11, and 17, Moorefield Township. A series of kames is inferred in western Pleasant Township in secs. 22, 23, 25, 26, 27, 28, and 29. Approximately 2 percent of the sand and gravel resource of Clark County occurs within kame deposits.

Another important source of sand and gravel in Clark County is outwash underlying alluvium within the floodplains of the primary and secondary streams. Alluvium, composed of stratified sands, silts, and clays, is generally a poor source of sand and gravel, but has been included on the resource map because some alluvium (river wash and bars) is extracted locally for use as construction aggregate. The alluvial deposits in Clark County average about 10 feet in thickness. Where the thickness of the alluvial overburden is less than 25 feet, the underlying outwash sands and gravels have been mapped and included in the resource inventory. Outwash underlying less than 25 feet of alluvium is found in valleys where valley-train deposits were entrenched by interglacial and postglacial streams and later covered by the alluvium of modern aggrading streams. Because land use is not as intense on the floodplains as in the upland areas, the extractive industries have concentrated on developing the aggregate resource within the floodplains. The resource of outwash underlying less than 25 feet of alluvium in Clark County makes up approximately 18 percent of the total resource of the county.

RESOURCES

The accompanying map shows the distribution of the sand and gravel resources of Clark County and identifies the resources by type of deposit. For mapping purposes, outwash includes both outwash-plain and valley-train deposits. The resource categories used in the sand and gravel inventory are defined below.

Measured resources include all sands and gravels within a specific deposit that are within a ½-mile radius of a control point. Control points are locations where information on the thickness of the sand and gravel resource has been determined from: (1) measured stratigraphic sections, (2) logs from water wells that have penetrated the deposit, or (3) verbal communications from pit or dragline operators. The thickness data are used to estimate the thickness of each mapped unit. Where there are multiple control points within a single deposit the average of the combined data is taken as the thickness of the unit.

Indicated resources are sands and gravels associated with and contiguous with measured resources but which occur farther than ½ mile from a control point. An indicated resource is assumed to have the same thickness as the associated contiguous measured deposit. Where an indicated resource is bounded by more than one measured resource, the thicknesses of the measured resources are averaged to define the thickness of the indicated resource.

Inferred resources are sand and gravel deposits which are not contiguous with a measured or indicated resource but which are interpreted to exist from analysis of air photos or soil surveys. Inferred outwash resources are assigned a thickness of 10 feet, and inferred kame resources are assigned a thickness of 20 feet.

The distribution of the sand and gravel resources of Clark County as shown on the map was determined from analysis of data derived from field examination, air-photo interpretation, soil surveys, and water-well logs. The 7½-minute (1:24,000) series of quadrangle maps was used as the mapping base for compiling field, water-well, and soil data. In each township the thickness of sand and gravel in each resource category was estimated from water-well log and measure-section data. The estimated thickness and the number of acres within each resource category provided the data needed to calculate the tonnage-per-township volume estimates (table 1). The tonnages shown in table 1 represent an estimate of the portion of the original resource of sand and gravel deposited in Clark County which now occurs at the surface or beneath less than 25 feet of till or alluvium and in no way reflect the quantities of sand and gravel currently available for extraction. Previously extracted sand and gravel and the amount of the resource lost to production because of zoning regulations and residential and industrial expansion have not been taken into consideration in the tonnage calculations.

This report provides general information regarding the distribution, quality, and thickness of sand and gravel resources of Clark County and should not be used as a substitute for the detailed site-specific investigations necessary to determine the potential of an area as a site for a commercial sand and gravel operation. However, fairly reliable thickness data are available from the water-well logs and measured sections included in the report.

ANALYSIS OF MATERIALS

Fifty-two samples of sand and gravel weighing 15 to 20 pounds were collected for laboratory analysis from stream cuts, roadcuts, all active gravel pits, and most semi-active and abandoned commercial sand and gravel pits in Clark County. Letter designations following location numbers indicate multiple samples taken from the face of the pit or stockpile samples dredged from different elevations below the water level in the pit. All samples were air dried at 105°F for 24 hours prior to splitting and subsequent sieve analysis. Material passing the No. 5 U.S. Sieve Series screen was sieved on a Ro-Tap mechanical shaker for 15 minutes. Material retained on the No. 5 U.S. Sieve Series screen was hand sieved for up to 10 minutes. Sieve-analysis results are given in table 2.

To determine the percentage of constituent rock types represented in the gravels, approximately 100 pebbles 1 to 2 inches in diameter were collected at 38 widely separated sampling locations (road and stream cuts and active and inactive gravel pits). These samples were washed, broken, and examined under a binocular microscope to determine the rock type of each. The percentage of constituent rock types for each site is shown in table 3. The stone-count and sieve-analysis data indicate that most of the sand and gravel resource of Clark County, with a minimum of preparation, can meet specifications for use in coarse and fine aggregate in concrete, mortar, and flexible pavements and as base and fill materials.

CONCLUSIONS

The undeveloped potential resource of sand and gravel in Clark County appears adequate to meet the demand of the region for many years if growth projections for the area are correct. The remaining extractable resource is located mostly in rural areas or on the floodplains of primary and secondary streams, so development of the resource will not be subject to the intense land-use competition encountered in other southwestern Ohio counties. The texture and composition of the sand and gravel in Clark County indicate that the deposits will provide good-quality materials for construction aggregate, base, and fill.

ACKNOWLEDGMENTS

The author expresses his appreciation to the sand and gravel operators and property owners of Clark County whose cooperation was essential for the completion of this study.

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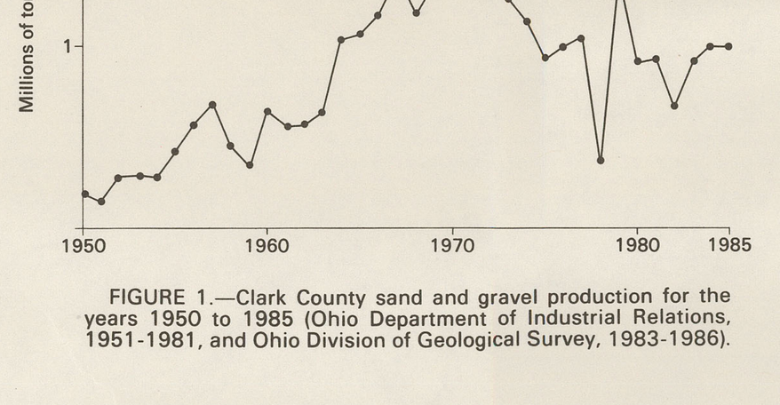


FIGURE 1.—Clark County sand and gravel production for the years 1950 to 1985 (Ohio Department of Industrial Relations, 1951-1981, and Ohio Division of Geological Survey, 1983-1986).

TABLE 1.—*Estimated sand and gravel resources, Clark County*

Township	Sand and gravel resources (tons): Outwash, Measured	Outwash, Indicated	Outwash, Inferred	Outwash underlying <25 feet of till, Measured	Outwash underlying <25 feet of till, Indicated	Outwash underlying <25 feet of till, Inferred	Outwash underlying <25 feet of alluvium, Measured	Outwash underlying <25 feet of alluvium, Indicated	Kames and eskers, Measured	Kames and eskers, Indicated	Kames and eskers, Inferred	Total
Bethel	536,896,700	88,008,600	631,600	39,511,100	792,800	6,229,000	64,688,800	113,310,500	4,277,600			854,346,700
German	253,388,500	58,178,700					131,932,400	52,535,500				496,035,100
Greene	198,311,300	178,415,200		11,240,700	14,340,000		2,123,600	26,841,700				431,272,500
Harmony	79,982,700	129,205,500						29,518,400				238,706,600
Madison	2,376,200	151,190,200						9,032,200				162,598,600
Mad River	217,784,800	113,876,700		19,915,600	3,998,800		21,000,300	181,969,700	67,796,800	9,583,200	4,619,200	640,545,100
Moorefield	507,678,700	138,762,600		378,028,900	83,530,700		33,650,100	48,610,800	2,587,500			1,192,849,300
Pike	33,595,700	14,742,900	16,195,600	44,784,000	9,938,200		10,611,200	30,461,500				160,329,100
Pleasant	31,868,500	83,667,900		283,967,500	94,233,300		5,534,300	33,750,300			22,041,400	555,063,200
Springfield	397,733,300	76,145,100		189,612,300	91,650,200		139,810,200	99,567,300				994,518,400
TOTAL	2,259,616,400	1,032,193,400	16,827,200	967,060,100	298,484,000	6,229,000	409,350,900	625,597,900	74,661,900	9,583,200	26,660,600	5,726,264,600

TABLE 2.—*Results of sieve analyses*

Grain size (% retained). ASTM scale: Boulders and cobbles; Gravel; Sand; Silt. Wentworth scale: Boulders and cobbles; Pebbles; Granules; Coarse to very coarse sand; Medium sand; Fine to very fine sand; Silt and clay.

Sample no.	Boulders and cobbles: -4.0"+3.0" U.S. Sieve Series[1] (3.0-4.0 inch diameter)	Boulders and cobbles: -3.0"+2.5" U.S. Sieve Series (2.5-3.0 inch diameter)	Pebbles: -2.5"+4 U.S. Sieve Series (0.187-2.5 inch diameter)	Pebbles: -4+5 U.S. Sieve Series (0.157-0.187 inch diameter)	Granules: -5+10 U.S. Sieve Series (0.0787-0.157 inch diameter)	Coarse to very coarse sand: -10+35 U.S. Sieve Series (0.0197-0.0787 inch diameter)	Medium sand: -35+60 U.S. Sieve Series (0.0098-0.0197 inch diameter)	Fine to very fine sand: -60+200 U.S. Sieve Series (0.0029-0.0098 inch diameter)	Fine to very fine sand: -200+230 U.S. Sieve Series (0.0025-0.0029 inch diameter)	Silt and clay: -230 U.S. Sieve Series (<0.0025 inch diameter)	Total
1			63.3	2.8	8.8	13.6	10.1	1.0	0.4	0.3	100.3
4		5.3	38.1	2.8	15.4	33.2	3.2	1.1	0.1	0.7	99.9
9			32.7	2.3	10.3	25.6	22.2	4.9	0.2	1.7	99.9
10			51.7	3.2	12.1	22.6	7.3	2.2	0.2	0.9	100.2
15		7.7	37.8	3.3	17.0	24.0	6.1	2.3	0.3	1.8	100.3
18A			46.6	2.8	14.1	24.9	8.5	2.3	0.1	0.5	99.8
18B			11.2	2.0	12.0	49.0	19.3	4.1	0.2	1.9	99.7
18C			2.7	0.4	2.2	7.4	9.3	49.3	7.3	21.2	99.8
18D			0.6		0.1	0.8	47.8	50.0	0.5	0.9	100.7
19A			50.0	5.4	21.2	15.6	2.7	1.9	0.3	2.8	99.9
19B			27.1	5.5	28.1	31.2	5.2	1.6	0.2	1.0	99.9
19C			7.0	1.0	6.6	35.6	28.2	20.1	0.4	1.0	99.9
32			42.1	4.3	17.1	23.5	4.1	3.9	0.8	4.0	99.8
35			68.3	2.2	8.4	15.6	4.5	0.6		0.3	99.9
36			53.8	3.3	12.7	17.8	7.1	2.8	0.3	2.0	99.8
42			43.0	3.7	15.6	31.6	5.4	0.7	0.1	0.2	100.3
46		8.7	38.5	3.5	13.6	23.7	6.5	3.4	0.3	1.7	99.9
48			52.1	2.6	11.1	18.3	8.4	4.5	0.4	2.7	100.1
58			54.9	2.4	7.8	21.7	12.0	1.0	0.1	0.2	100.1
71			44.2	2.8	11.6	26.7	11.2	2.6	0.1	0.8	100.0
72A		17.6	38.4	2.8	11.9	21.2	5.4	1.5	0.1	1.1	100.0
72B			51.6	3.6	10.9	21.5	9.2	2.0	0.2	1.2	100.2
86			58.0	3.3	10.8	22.5	3.6	1.1	0.1	0.7	100.1
95	10.2		39.5	2.1	8.7	18.6	9.7	6.6	0.7	4.1	100.2
97		6.2	64.7	2.2	7.5	10.3	4.9	2.9	0.2	1.1	100.0
103		7.3	55.6	2.4	7.7	15.8	8.9	1.4	0.1	0.9	100.1

Sample no.	Boulders and cobbles: -4.0"+3.0" U.S. Sieve Series[1] (3.0-4.0 inch diameter)	Boulders and cobbles: -3.0"+2.5" U.S. Sieve Series (2.5-3.0 inch diameter)	Pebbles: -2.5"+4 U.S. Sieve Series (0.187-2.5 inch diameter)	Pebbles: -4+5 U.S. Sieve Series (0.157-0.187 inch diameter)	Granules: -5+10 U.S. Sieve Series (0.0787-0.157 inch diameter)	Coarse to very coarse sand: -10+35 U.S. Sieve Series (0.0197-0.0787 inch diameter)	Medium sand: -35+60 U.S. Sieve Series (0.0098-0.0197 inch diameter)	Fine to very fine sand: -60+200 U.S. Sieve Series (0.0029-0.0098 inch diameter)	Fine to very fine sand: -200+230 U.S. Sieve Series (0.0025-0.0029 inch diameter)	Silt and clay: -230 U.S. Sieve Series (<0.0025 inch diameter)	Total
117			16.5	2.7	15.6	25.3	28.7	9.8	0.3	1.0	99.9
118		7.0	22.6	3.3	15.8	39.5	7.4	1.6	0.2	2.6	100.0
120		7.3	60.9	1.6	5.6	15.8	3.9	1.3	0.2	2.3	98.9
122			43.9	3.1	11.6	24.5	12.0	2.7	0.2	2.0	100.0
127A			49.2	3.5	13.1	22.9	7.0	1.9	0.2	2.2	100.0
127B		8.9	40.2	3.0	11.7	25.7	7.6	1.2	0.1	1.4	99.8
136			19.9	3.3	15.9	35.6	15.5	8.2	0.3	1.2	99.9
137			66.5	2.1	8.1	15.8	4.9	1.3	0.2	1.2	100.1
144			30.3	2.2	8.5	28.7	18.1	8.7	0.6	2.7	99.8
146			36.3	2.7	12.7	26.5	5.2	10.0	2.2	4.4	100.0
147			39.8	4.2	18.5	22.9	10.2	3.4	0.1	0.8	99.9
152		11.0	58.2	2.2	10.0	14.9	1.7	0.9	0.2	1.1	100.2
154			31.6	2.2	9.0	38.8	13.6	2.5	0.2	2.0	99.9
155A			52.6		14.1	10.8	17.5	3.4		2.6	101.0
155B			61.5		12.8	10.4	12.1	1.9		1.2	99.9
155C			30.0		6.7	9.4	50.9	3.9		0.1	101.0
155D			60.8		9.5	10.1	18.2	1.1		0.3	100.0
173A		11.3	55.9	2.2	7.0	14.2	6.7	1.7	0.1	0.9	100.0
173B		5.5	33.7	4.7	15.9	24.1	9.3	3.2	0.5	3.0	99.9
180A		5.4	55.2	1.9	6.6	18.1	10.0	1.4	0.1	1.3	100.0
180B			58.9	3.6	11.6	17.6	6.4	1.2	0.1	0.6	100.0
184			61.2	2.7	9.9	18.2	5.1	1.8	0.2	1.0	100.1
189			40.5	3.0	12.3	26.6	11.0	4.6	0.4	1.9	100.3
193		5.1	56.6	3.3	15.7	11.7	4.5	2.3	0.2	0.7	100.1
194		6.1	70.0	1.6	6.8	10.6	2.5	1.5	0.1	0.8	100.0
198			58.2	2.9	10.1	18.9	5.9	2.4	0.2	1.5	100.1

[1]- indicates particle passes through mesh; + indicates particle retained on mesh.

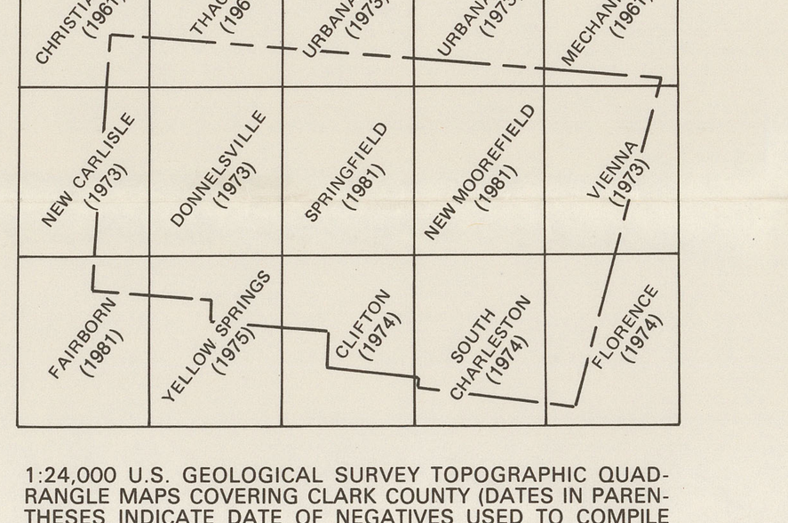
TABLE 3.—*Pebble counts*

Sample no.	Igneous and metamorphic: Count	Igneous and metamorphic: %	Carbonate: Count	Carbonate: %	Sandstone: Count	Sandstone: %	Siltstone: Count	Siltstone: %	Deleterious, Chert: Count	Chert: %	Deleterious, Ironstone: Count	Ironstone: %	Deleterious, Shale: Count	Shale: %	Deleterious, Clay clasts: Count	Clay clasts: %	Total: Count	Total: %
1	4	4	82	82	12	12			2	2							100	100
4	12	12	82	82	5	5			1	1							100	100
9	4	4	83	83	8	8			4	4			1	1			100	100
10	3	3	84	84	10	10			3	3							100	100
15	8	8	85	85	4	4			3	3							100	100
18	12	12	75	75	11	11							1	1	1	1	100	100
19	7	7	76	76	16	16									1	1	100	100
32	7	7	86	86	6	6			1	1							100	100
35	3	3	87	87	8	8			2	2							100	100
36	1	1	88	88	9	9			1	1			1	1			100	100
42	6	6	85	85	6	6			2	2					1	1	100	100
46	3	3	85	85	10	10			2	2							100	100
48	8	8	87	87	4	4	1	1									100	100
58	12	12	75	75	9	9			4	4							100	100
71	4	4	88	88	7	7			1	1							100	100
72	6	6	85	85	8	8			1	1							100	100
86	5	5	88	88	7	7											100	100
95	7	7	86	86	7	7											100	100
97	13	13	78	78	7	7	1	1	1	1							100	100
103	7	7	84	84	8	8			1	1							100	100
117	7	7	81	81	7	7			5	5							100	100
118	11	11	84	84	4	4			1	1							100	100
120	9	9	81	81	8	8			2	2							100	100
122	7	7	84	84	7	7	2	2									100	100
127	4	4	86	86	9	9			1	1							100	100
136	10	10	82	82	7	7			1	1							100	100
137	3	3	89	89	4	4	1	1			2	2	1	1			100	100
144	7	7	87	87	2	2	1	1	2	2	1	1					100	100
147	4	4	83	83	11	11			1	1			1	1			100	100
152	8	8	85	85	6	6			1	1							100	100
154	6	6	87	87	7	7											100	100
173	10	10	74	74	13	13			3	3							100	100
180	6	6	80	80	13	13			1	1							100	100
184	7	7	84	84	7	7									2	2	100	100
189	13	13	80	80	4	4			3	3							100	100
193	9	9	80	80	10	10			1	1							100	100
194	9	9	85	85	5	5	1	1									100	100
198	20	20	75	75	5	5											100	100

Area east of the Little Miami River lies within the Virginia Military District
Area west of the Little Miami River lies within the Between the Miamis
Land lines based on the Great Miami River Base

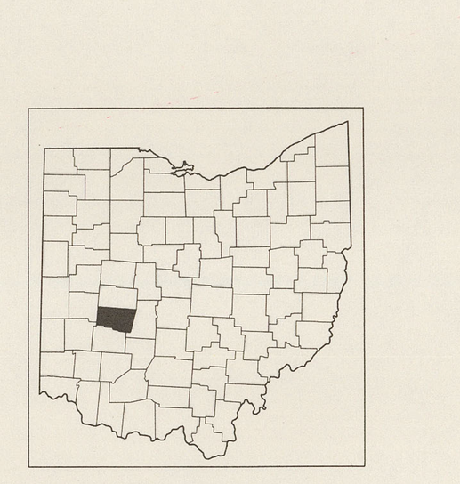
10,000-foot grid based on Ohio coordinate system, south zone

CONTOUR INTERVAL 5 AND 10 FEET
DATUM IS MEAN SEA LEVEL



1:24,000 U.S. GEOLOGICAL SURVEY TOPOGRAPHIC QUADRANGLE MAPS COVERING CLARK COUNTY (DATES IN PARENTHESES INDICATE DATE OF NEGATIVES USED TO COMPILE BASE)

UTM GRID AND 1987 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



LOCATION MAP

PHOTOTYPESETTING BY JEAN M. LESHER

CARTOGRAPHIC DRAFTING BY EDWARD V. KUEHNLE

VERTICAL SCALE

EXPLANATION

Clay
Sand
Gravel
Shale
Limestone
Water-well or measured-section number
Depth in feet to unit contact
Sample interval (measured sections only; asterisk indicates stockpile sample)
Water table (measured sections only; information not available for all sections)

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