THE PREPARATION OF SOIL-ENGINEERING MAPS FROM AGRICULTURAL REPORTS

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In most states possessing land of agricultural value, there is generally available a large amount of information about surface soils contained in county agricultural reports prepared by the State agricultural experiment stations and published jointly by the stations and the U.S. Department of Agriculture. A contribution to the field of soil engineering presenting the usefulness of these reports has been published by the Highway Research Board as Bulletin 22, "Engineering Use of Agricultural Soil Maps."

In spite of the availability of county agricultural reports, the state highway departments have, in general, neglected to utilize them. The reasons for this are readily apparent to any civil engineer who has ever consulted one.

Although the method of soil classification used in the reports is scientific, being the realm of pedology, the reports themselves are full of agricultural terms and interpret the soil conditions in the light of agricultural usage. Few highway engineers have the time to read through the extraneous information contained in these reports in order to find soil information which can be utilized for engineering purposes.

Nevertheless, the information is there and can be used to advantage, as is evidenced by such valuable publications as the "Field Manual of Soil Engineering," of the Michigan State Highway Department; "The Formation, Distribution and Engineering Characteristics of Soils" by Belcher, Gregg, and Woods; and the "Soils Manual" of the Missouri State Highway Commission. In a state where a large number of up-to-date agricultural reports are available these publications have their greatest usefulness. However, their overall value to highway engineers decreases with a decrease in the quality or quantity of county agricultural reports.

Up-to-date county reports usually contain maps showing much more detailed variations in soil type than is necessary for engineering purposes. Although this is no great disadvantage, the number of soil types mapped usually increases each year as new county reports are prepared. Furthermore, in states where mapping has been in progress for a period of 30 years or more there is a considerable difference between the nomenclature and mapping techniques used in the early reports as compared to those published in the last 10 to 15 years. This variation in quality of agricultural soil maps in a very real impediment to the use of pedologic information by the highway engineer.

All of the county agricultural reports for Illinois have been prepared and published by the University of Illinois Agricultural Experiment Station. Reports prepared during the period 1911 to 1929, of which there are about 45, use an old type of descriptive nomenclature for the soil profile which does not lend itself to interpretation for engineering purposes without considerable study. The 10 reports published in the period from 1930 to 1933 might be termed transitional reports, since the method of description and classification of the soil profile is better than the one used in the early reports but does not involve the use of soil-series names. The remainder of the reports published since 1933 use the most modern techniques of pedologic survey. These reports, about 20 in number, utilize soil-series names which could be directly correlated with engineering properties.

In order to utilize county agricultural reports for relating engineering properties to soil-series or type names, at least two

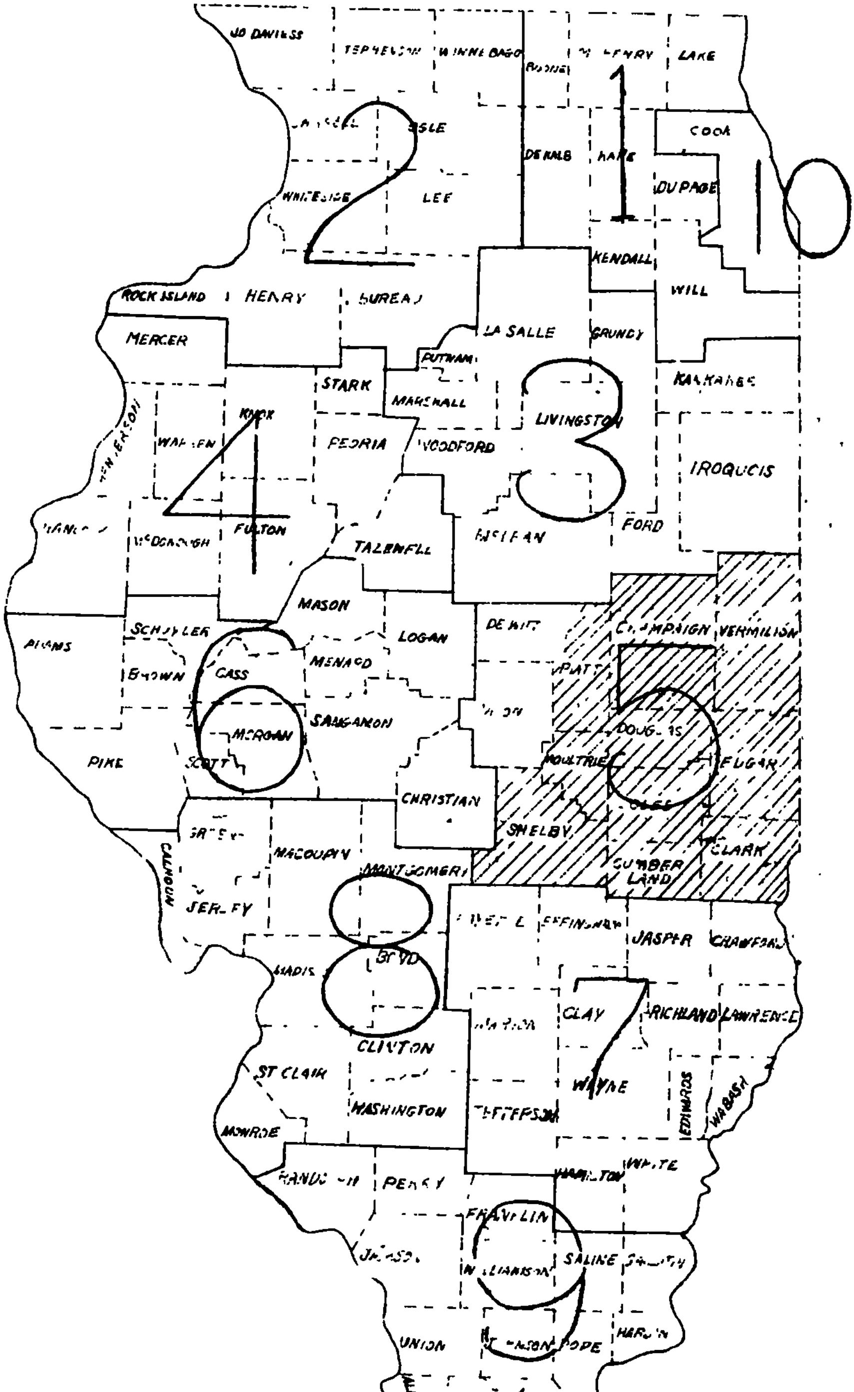


Figure 1. Highway Districts and Counties in Illinois

and possibly three different systems of correlation would have to be devised. On the other hand, if a soils manual of the type utilized so successfully by the Michigan State Highway Department were prepared, it could be used directly in only 20 of the 102 counties in Illinois. It would also require constant additions as new counties were mapped. In order to apply the available data to counties having no up-to-date reports it would be necessary to train the soils engineers of the Illinois Division of Highways in the techniques of pedologic survey. This would be a time-consuming operation, however desirable it might be.

In the spring of 1949 it was decided to inaugurate a project on the preparation of a soil manual for District 5, Illinois Division of Highways, as a part of the Cooperative Research Program on General Highway Problems. This program is directed by a joint committee representing the Illinois Division of Highways and the Department of Civil Engineering of the University of Illinois, Engineering Experiment Station. The program is sponsored by the Illinois Division of Highways and the work carried on by members of the university staff in the field and in laboratories.

District 5 comprises the 12 counties in east-central Illinois, indicated on Fig. 1. In this district up-to-date county reports were available for 4 counties, transitional reports for 1 county, and old-type reports for 6 counties. There was no published report for Clark County, but an old unpublished map was available.

It did not seem possible to reconcile the nomenclature used in the three different classes of reports in one soils manual. Consequently the decision was made to prepare new engineering soils maps for the district. Obviously, it would not be possible to remap on a strict pedologic basis each county for which only old-type reports existed without a tremendous amount of field work. Since time is an important factor in the preparation of the manual, this approach was ruled out. Furthermore, almost 300 different soil-type names have already been used in the preparation of the up-to-date county agricultural reports.

TABLE 1

ENGINEERING CLASSIFICATION OF THE PEDOLOGIC PROFILE

SYMBOL	SUBSURFACE PLASTICITY	SUBSOIL PLASTICITY
A	None to very slight	None to very slight
B	Slight to moderate	None to very slight
C	None to very slight	Slight to moderate
D	Slight to moderate	Slight to moderate
E	High	None to very slight
J	High	Slight to moderate
W	None to very slight	High
X	Slight to moderate	High
Z	High	High
O	Highly organic materials	

PARENT MATERIAL SYMBOLS

H	Highly Permeable materials (Granular terrace, alluvial or windblown sands and granular outwash)
M	Moderately Permeable Materials (Leached or permeable till, leached or sandy loess, alluvial silt, and local wash.)
S	Slowly permeable materials (Plastic till, modified loess or lacustrine clay)
R	Bedrock
O	Peat and Muck

TABLE 2

ILLINOIS SOIL TYPE DESCRIPTION SHEET

1. Number and Name - *146 Elliot Silt Loam*
2. Descriptive Name - *Brown silt loam on compact, medium plastic till*
3. Location in State - *East-central, north-central Illinois*
4. Rating: General Crops - 4 Pasture - Timber -
5. Topography - *Gently rolling to rolling - slopes 1 to 5 percent*
6. Drainage: Surface - *moderate* Under - *slow* Outlets - *good*
7. Native Vegetation - *Grass*
8. Parent Material - *Thin loess on compact, med. plastic Wisconsin till*

SOIL CHARACTERISTICS

SURFACE

1. Texture - *Silt loam* Structure - *Fine granular to crumb*
2. Color - *Brown to dark brown* Organic Content - *medium*
3. Thickness - *7 to 8 inches*
4. Reaction - *Medium acid* Available Phos. - *low* Nitrogen - *Medium to low*
   Available Potash - *medium*
5. Workability - *Fair but becoming poorer as organic matter decreases*

SUBSURFACE

1. Texture - *Heavy silt loam or silty clay loam* Structure - *Weakly coarse-granular*
2. Color - *Yellowish brown to dark grayish yellow*
3. Thickness - *6 to 12 inches*
4. Reaction - *Slight to medium acid* Available Phos - *low*

SUBSOIL

1. Texture - *Clay loam* Structure - *Subangular to angular aggregates*
2. Color - *Pale brownish yellow to dark grayish yellow with rusty brown spots*
3. Consistency - *Compact and plastic*
4. Thickness - *8 to 12 inches*
5. Reaction - *Slightly acid to neutral* Available Phos. - *Substrate* Nature and composition - *slowly pervious Wisconsin till, highly calcareous at 30 to 35 inches, igneous pebbles, not abundant*

For engineering purposes many of these soil types can be grouped together, since they have similar engineering characteristics. In order to utilize all of the pedologic information available and yet present it in a usable manner, the classification system shown in Table 1 was developed.

On the basis of this classification, each pedologic soil type mapped in a given area was assigned a two-letter group symbol. The first letter represents the plasticity of the subsurface and the subsoil; that is, the lower part of the A- and the B-horizon respectively of the pedologic profile. The classification was arranged so that letters at the beginning of the alphabet represents granular or slightly plastic materials, whereas those at the end of the alphabet represent highly plastic soil materials.

The second letter of the symbol designates the character of the parent material; for example, H represents highly permeable granular materials; M, moderately permeable, predominantly silty materials; S, slowly permeable clayey materials, and R, with a suitable subscript, represents bedrock, the subscript denoting whether it is shale, limestone, or sandstone.

The authors have no illusions that this system represents the acme of soil-classification systems but do feel it utilizes, to the best advantage, soils information already available. Furthermore, it provides a basic system with which engineering properties of soils in any part of the state may be directly correlated. Its form depends more upon the type of information available rather than upon the desirable ideal.

Table 2 is an illustration of a typical soil-type information sheet used by the Department of Agronomy of the University of Illinois in pedologic mapping. It can be seen that definite information in regard to the plasticity of the various horizons is not always given. In many instances it was necessary to deduce the plasticity characteristics from the information on tecture and permeability. The chart shown in Table 3 was used for this purpose.

In the mapping of District 5, 99 different pedologic soil types have been encountered. All of these have been classified into 13 engineering groups. The number of types in each group is indicated in Table 4 along with a brief description of the group. With the classification as presently devised it would be possible to have as many as 37 different groups, however it is expected that the actual number required to map the whole state will not exceed 20.

TABLE 3

CLASSIFICATION OF PLASTICITY FROM TEXTURAL CLASS

None to very slight plasticity
sand
clayey sand
silty sand
loamy sand
sandy loam
silt

Slight to moderate plasticity
loam
silt loam
sandy clay loam }
silty clay loam } - { moderate permeability slight to moderate plasticity
clay loam }

High plasticity
clay loam }
silty clay loam } - { slow permeability high plasticity
sandy clay loam }
silty clay
sandy clay
clay

TABLE 4

GROUPING OF PEDOLOGIC SOIL TYPES IN DISTRICT 5 ACCORDING TO ENGINEERING CLASSIFICATION

NUMBER OF PEDOLOGIC TYPES	GROUP SYMBOL	SUBSURFACE PLASTICITY	SUBSOIL PLASTICITY
7	AH	None to very slight	none to very slight
11	CH	none to very slight	slight to moderate
8	DH	slight to moderate	slight to moderate
4	XH	slight to moderate	high
1	CM	none to very slight	slight to moderate
26	DM	slight to moderate	slight to moderate
6	XM	slight to moderate	high
4	ZM	high	high
2	CS	none to very slight	slight to moderate
15	XS	slight to moderate	high
13	ZS	high	high
1	DR	slight to moderate	slight to moderate
1	OO	muck and peat	
99	13	total	

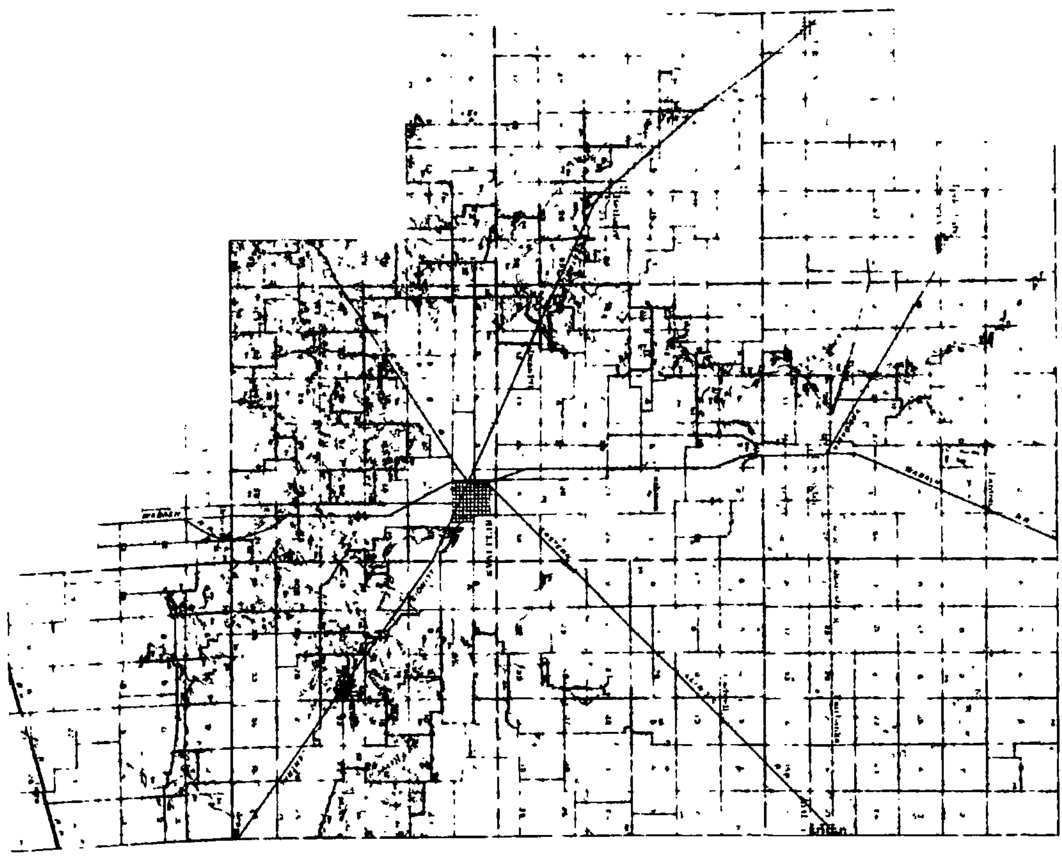


Figure 2. Agricultural map of Moultrie County

Once the new classification system had been worked out, the process of preparing an engineering soils map for counties having up-to-date agricultural reports was relatively simple and direct. It consisted of the following steps: (1) classification of each pedologic soil type mapped in the county according to the engineering symbols (Table 1) using the information contained in the soil information sheet (Table 2) and the plasticity-texture correlation (Table 3); (2) designation by a distinctive color of each engineering soil area on a photographic reproduction (scale: 1 in. equals 1 mi.) of the county agricultural map; (3) tracing of the boundries of each engineering soil area on a vandyke positive of the county highway planning map; (4) preparation of a vandyke negative of the completed soils map; and (5) reproduction of the engineering soils map.

In the counties where up-to-date agricultural reports were not available, the first step was preceded by a reclassification of the descriptive type names in terms of type names for which soil description sheets were available. This was frequently a time-consuming procedure and involved consultation with members of the agronomy department of the university; considerations of the correlation between topographic position, geology of the parent material and pedologic classification, and the use of aerial photographs to check soil boundries.

The relationship between the agricultural maps and the resulting engineering maps is illustrated in Figures 2 to 5.

In conjunction with the preparation of the basic maps, the soils engineer of District 5, assembled all reliable sampling and test data in the form shown in Figure 6. The location map was prepared on tracing

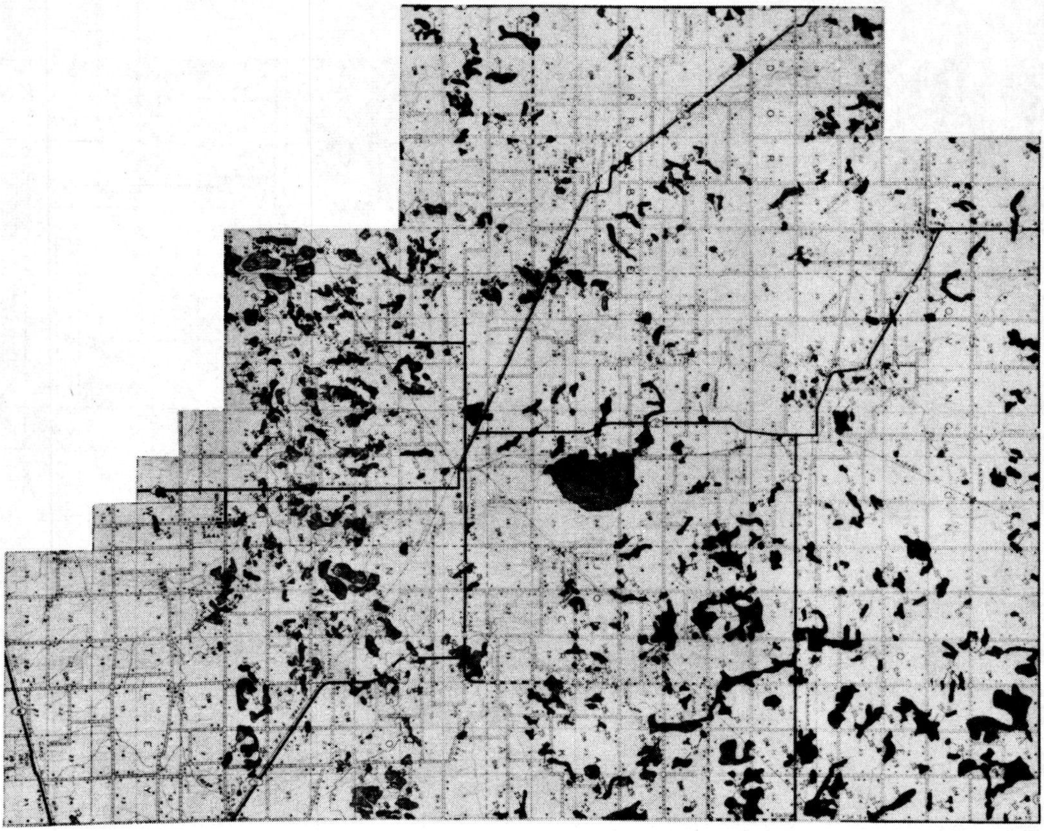


Figure 3. Engineering Soils Map of Moultrie County

cloth to the scale of 1 in. equals 1 mi., and the position of each exploratory boring was plotted as accurately as possible. The location could then be spotted readily on the preliminary soils map, and the test data used as a further check on the engineering classification. Unfortunately, the amount of reliable test data which could be correlated with a specific location and depth was found to be small. The data which are available will be, however, of further value in estimating the physical properties of each engineering soil group when a soils manual is prepared for the district.

At the present time basic engineering maps have been prepared for all 12 counties which comprise District 5, but only 4 have been reproduced in final form. This represents the effort of one staff member half-time during one academic year and full-time for three months. In addition, two undergraduate students have been employed about half-time for two months in preparing maps for reproduction. Now that the system has been formulated, it is felt that the average highway district comprising 10 to 12 counties could be mapped in a period of from 6 to 8 months using the same staff which has been available in the past.

The preparation of the engineering soil maps represents only the first phase of the project on the preparation of the soils manual. However, in order to make the maps of immediate use, each one will be accompanied by a brief summary of the geology, major soil types, and associated engineering problems of each type. In addition, a map showing the important geologic features of the district will be prepared for inclusion in the manual.

The authors wish to acknowledge the assistance received from the engineers of the Illinois Division of Highways, espec-

Figure 4. Agricultural map of Cumberland County

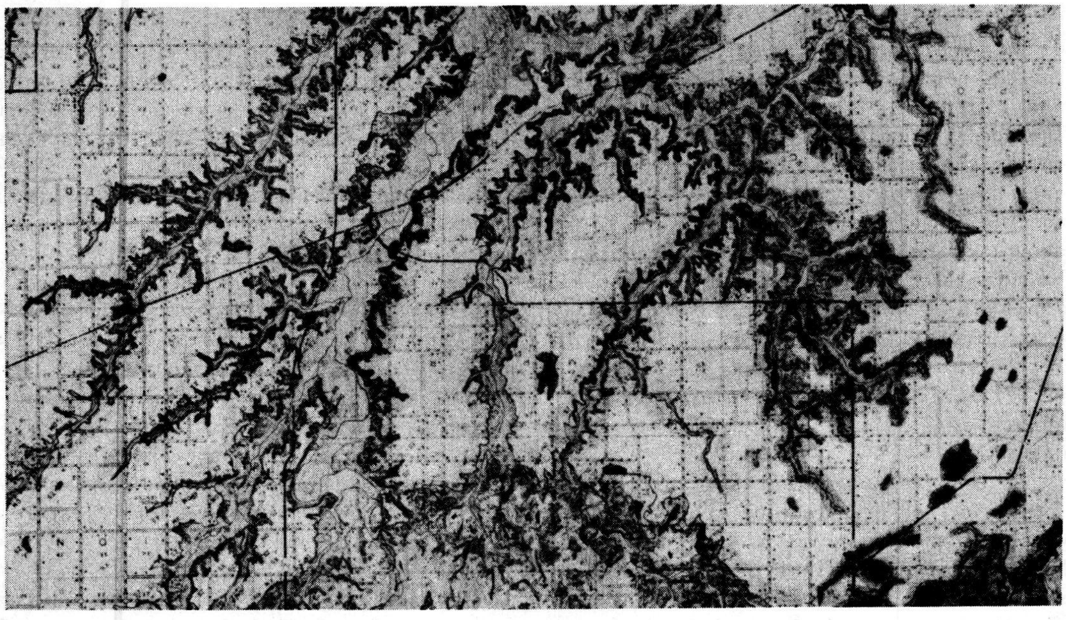
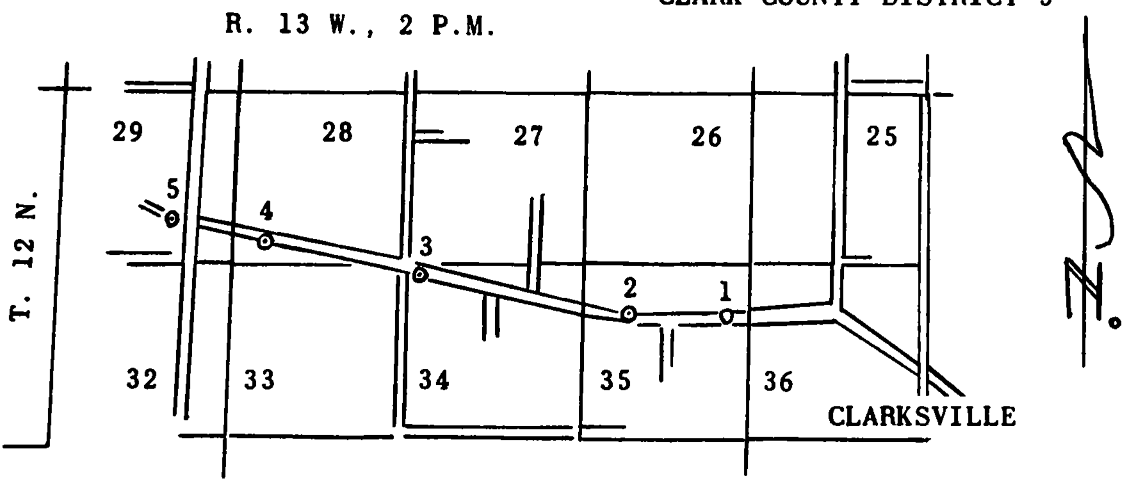


Figure 5. Engineering Soils Map of Cumberland County

ially from H. W. Russell, engineer of materials, who supervises the Cooperative Research Program on General Highway Problems for the sponsors; F. N. Barker, engineer of highway research, who furnished reproduction negatives of the highway planning maps; and Martin Zogg, engineer of materials, and Walter Lyon, soils engineer of District 5, who supplied much useful data and many helpful suggestions. The assistance provided by R. T. Odell, associate professor of soil physics, University of Illinois, in furnishing original county soil maps and in the interpretation of old county soil reports has been invaluable. Special acknowledgement is due to W. S. Pollard, Jr., instructor in civil engineering, University of Illinois, for his part in the preparation of the engineering maps and in the interpretation of aerial photographs.

CLARK COUNTY DISTRICT 5



NO.	DEPTH FEET	COLOR	SAND	SILT	CLAY	LL.	PL.
1	0-½	Gray	9	60	31	27	11
	½-3	Yellow	4	51	45	30	14
	3-5	Yellow	8	57	35	30	17
	5-10	Yellow	24	44	32	29	21
2	0-1½	Brown	8	59	33	34	15
	1½-3	Yellow	8	57	35	43	24
	3-4	Yellow	6	52	42	55	42
	4-5	Yellow	7	58	35	41	25
	5-5½	Yellow	4	54	42	52	38
3	0-1	Yw.-Bn.	10	55	35	32	12
	1-2½	Yellow	6	52	42	61	45
	2½-5	Yellow	16	49	35	43	31
	5-8	Yellow	25	43	12	35	22
4	0-1½	Gray	12	56	32	32	12
	1½-3½	Yellow	6	45	49	42	31
	3½-6	Yellow	13	49	38	32	18
5	0-½	Gray	32	48	20	26	8
	1/2-1½	Yellow	10	53	37	45	26
	1½-3½	Yellow	11	50	39	53	36
	3½-4½	Gray	10	50	40	46	30

Figure 6.

TOPOGRAPHIC MAP SYMBOLS

VARIATIONS WILL BE FOUND ON OLDER MAPS

ROADS

Hard surface, heavy duty, four or more lanes wide
Hard surface, heavy duty, two or three lanes wide
Hard surface, medium duty, four or more lanes wide
Hard surface, medium duty, two or three lanes wide
Loose surface, graded, and drained or hard surface less than 16 feet in width
Improved dirt
Unimproved dirt
Trail
Dual highway with dividing strip 25 feet or less in width
Dual highway with width of dividing strip exceeding 25 feet
Under construction–if classification is known appropriate width and red fill are shown
Private roads are sometimes labeled for clarity — PRIVATE
Traffic circle–Clover leaf

RAILROADS

U. S. Standard Gage

Single track
Multiple main line track If more than 2 tracks, number is shown by labeling
Abandoned track
Track under construction
Juxtaposition
Yards–Siding

Narrow Gage

Single track
Multiple track
Abandoned track

Miscellaneous

Carline
Railroad in street
Dismantled railroad or carline
Turntable and roundhouse

BRIDGES–TUNNELS–CROSSINGS

Bridge, road
Drawbridge, road
Footbridge
Tunnel, road
Bridge, railroad
Drawbridge, railroad
Tunnel, railroad
Overpass, underpass
Ford, road — Ford, Fd
Ferry — Fy, Ferry

DAMS–PIERS–BREAKWATERS

Important small masonry or earth dam
Large masonry dams
Dam with lock
Dam carrying road
Breakwater, jetty, pier, wharf
Covered pier or wharf
Seawall
Canal with lock

MISCELLANEOUS CULTURE SYMBOLS

Buildings (dwelling, place of employment, etc).
School–Church–Cemetery — Cem
Buildings (barn, warehouse, etc)
Cliff dwelling
Sewage disposal or filtration plant
Power transmission line
Telephone, telegraph, tramway, pipe line, etc (labeled as to type)
Wells other than water (labeled as to type) — Oil, Gas
Tanks, oil, water, etc (labeled as to type) — Water
Located or landmark object
Windmill–Gaging station — Windmill, Gaging Sta

BOUNDARIES

National
State
County, parish, municipio
Civil township, precinct, town, barrio
Incorporated city, village, town, hamlet
Reservation, national or state
Land grant
Small park, cemetery, airport, etc
U S land survey township or range line
Township or range line. location doubtful
U. S. land survey section line
Section line location doubtful
Township line (not U S. land survey)
Section line (not U S. land survey)
Found section corner–Land grant monument
Boundary monument–U.S mineral monument

MINE SYMBOLS

Open pit or quarry
Shaft–Tunnel entrance
Prospect

CONTROL DATA

Triangulation or transit traverse station
monumented with spirit level elev. — BM△1062
with vertical angle elevation — VABM△2240
with other checked elevation — △5675
Monumented bench mark with spirit level elev. — BM×958
with vertical angle elevation — VABM×1254
Less permanently marked bench mark with spirit level elevation — ×624
Checked spot elevation — ×5924
Unchecked spot elevation–Water elevation — ×5655 870

HYPSOGRAPHIC FEATURES

Index contour
Intermediate contour
Supplementary contour
Depression contours
Cut
Fill
Levee
Levee with road
Large earth dam or levee
Wash
Tailings
Tailings pond
Strip mine, waste area
Mine dump
Gravel beach
Distorted surface area
Sand area, sand dunes

FORESHORE–OFFSHORE FEATURES

Foreshore flat
Rock or coral reef
Piling, dolphin, stump, snag
Rock bare or awash at low tide
Rock bare or awash at low tide dangerous to navigation
Exposed wreck
Sunken wreck with masts exposed
Depth curve

HYDROGRAPHIC FEATURES

Perennial streams
Intermittent streams
Stream disappearing at definite point
Intermittent lake or pond
Dry lake or pond
Canal, flume, or aqueduct
Aqueduct tunnel
Elevated conduit
Water well–Spring
Large rapids
Small rapids
Large falls
Small falls
Channel in water area
Glacier or permanent snowfield
Marsh or swamp
Wooded marsh or swamp
Submerged marsh or swamp
Land subject to inundation
Mangrove

OVERPRINTED AREAS

Area in which only landmark buildings are shown
Woods–brushwood
Orchard
Vineyard
Scrub

LETTERING STYLES

Place, feature, boundary line, and area names
Richview, Union Sch, MADISON CO, C E D A R
Public works–Descriptive notes
ST LOUIS, ROAD, BELLE STREET, Tunnel - Golf Course, Radio Tower
Control data–Elevation figures–Contour numbers
Florey Knob, BM 1333, VABM 1217-*5806*-*5500*
Hypsographic names
Man Island, Burton Point, HEAD MOUNTAIN
Hydrographic names
Head Harbor, Wood River, NIAGARA RIVER

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TOPOGRAPHIC MAPS

The United States Geological Survey was created by an Act of Congress in 1879, for the purpose of making a systematic study of the geology and natural resources of the United States, and the classification of the public lands From the very beginning of this work it was evident that no adequate classification of lands or conclusive geologic determinations could be made without suitable base maps This led to the organization of the Topographic Division, which, since 1882, has been engaged in making a series of standard topographic maps to cover the United States, Alaska, Hawaii, and Puerto Rico

MAP SCALE

Under the general plan adopted each published map covers a quadrangle of area, bounded by parallels of latitude and meridians of longitude, and hence the maps are sometimes referred to as quadrangles, or quadrangle maps The map boundaries of parallels and meridians are based on the international system of latitude and longitude by which the location of any point on the surface of the earth is readily fixed The quadrangle maps are published on different scales, the map scale selected for each section of the country being, for economic reasons, the smallest scale adequate for general use in the development of each part of the country On the lower margin of each map are printed graphic scales showing distances in feet, miles, and kilometers In addition, the scale of the map is shown by a fraction expressing a fixed ratio between linear measurements on the map and corresponding distances on the ground For example, the scale of 1 62,500 means that one unit (such as 1 inch, 1 foot, or 1 meter) on the map represents 62,500 of the same units on the earth's surface The scale of "1 inch equals 1 mile" means that 1 inch on the published map corresponds exactly to 1 mile on the ground

Each quadrangle map is usually designated by the name of a city, town, or prominent natural feature within it, and on the margins of the map are printed the names of adjoining maps that have been published The adjoining maps are published at the same scale, unless otherwise noted.

FEATURES OF A TOPOGRAPHIC MAP

Topography is the configuration or shape of the land surface A topographic map is a graphic representation of the configuration or shape of a part of the earth's surface, and it is this distinctive feature that differentiates it from other maps Topography may be shown by several methods The most striking and realistic method is probably the familiar relief model formerly made of plaster or clay, now sometimes made of rubber or plastic. The ordinary topographic map is printed on a flat sheet of paper, and hence a symbol must be used to depict the topography There are several such symbols in use, including hachures, shading, and contours The contour method is used almost entirely by the Geological Survey, although a few maps have been published with relief shading overprinted on the contours Contours are superior to other topographic symbols for engineering needs, because they generally afford more precise information Contours make it practical to represent the form of the land surface with high precision The height of each hill, the depth of each valley, and, in fact, the elevation and slope of the ground at any point can be determined from a good contour map

A contour may be defined as an imaginary line on the ground, every part of which is at the same altitude, or elevation, above sea level. The shore line of any relatively stable body of water, as the sea or a lake, is, in effect, a contour If the level of the water rises or falls by any amount, the water's edge conforms to the shape of the land at the new level and traces out a new contour. Contour lines could be drawn at any elevation, but in practice only the contours at certain regular intervals of elevation are shown The contour interval, or the vertical distance between one contour and the next, is selected according to the steepness of the terrain in the area being mapped. In flat country it will usually be 5 feet, occasionally less In a mountainous region it may be as great as 50 feet, sometimes more. To make the contours easier to read and follow, every fifth one (usually) is made heavier than the others (accentuated), and is accompanied by figures showing the altitude of the contours above sea level The contour interval used on each map sheet is explained in a note printed in the bottom margin of the map

In addition to the contour lines and elevation numbers, the heights of many identifiable points, such as road intersections, summits, and surfaces of lakes, are shown on the map in printed figures giving altitudes to the nearest foot, except on the Puerto Rican maps, where contour intervals in meters are used, and individual heights are given to the nearest meter or tenth of meter These individual elevations are commonly called spot heights, or spot elevations.

The information shown on topographic maps may be divided into three general classes The first class includes all water features such as the ocean, lakes, rivers, glaciers, canals, swamps, and other bodies of water These are known as the hydrographic features, and are printed on the map in blue The second class of features includes all the works of man, such as roads, trails, dams, transmission lines, buildings, airports, railroads, bench marks, civil boundaries, and lettering. These are sometimes called the culture, or cultural features, and are shown on the map in black The third classification comprises the configuration and elevation of the terrain, including the mountains, hills, plateaus, valleys, and all other natural features that form the land surface These features, comprising the topography, are sometimes called the hypsographic features, signifying heights, and are printed on the map in brown

In addition to these general classifications, certain maps carry other information, printed in other colors Large bodies of water are usually shown with a light blue tint, or with the conventional blue water lining Several varieties of stipples, which are patterns of closely spaced dots, or hachure lines, printed in red, and simulating different shades of pink tint, are sometimes utilized in narrow strips for emphasis alongside such features as State, county, city, and Federal-reservation boundaries A light red or gray tint is sometimes overprinted on the closely built-up areas of cities, and indicates that only the landmark or other important buildings are shown within the tinted areas A solid red color has been used on recent maps for clarity and emphasis of certain cultural features, including the classification of the surfacings of higher-type roads, and the subdivision lines of the townships, ranges, square-mile sections, and land grants in the States subdivided by the public land surveys On the more recent maps, a green tint is used to show wooded areas, scrub, orchards, and vineyards The green overprinting is made only on a limited number of the published maps, because it is not required by all map users. In ordering maps "woodland" copies should be requested if they are desired, as they are furnished only upon specific request

Accompanying this text is a set of the symbols, printed in appropriate colors, most commonly used on modern topographic maps There is also shown a small sketch and map of a typical area, illustrating the use of contours in a variety of topographic forms.

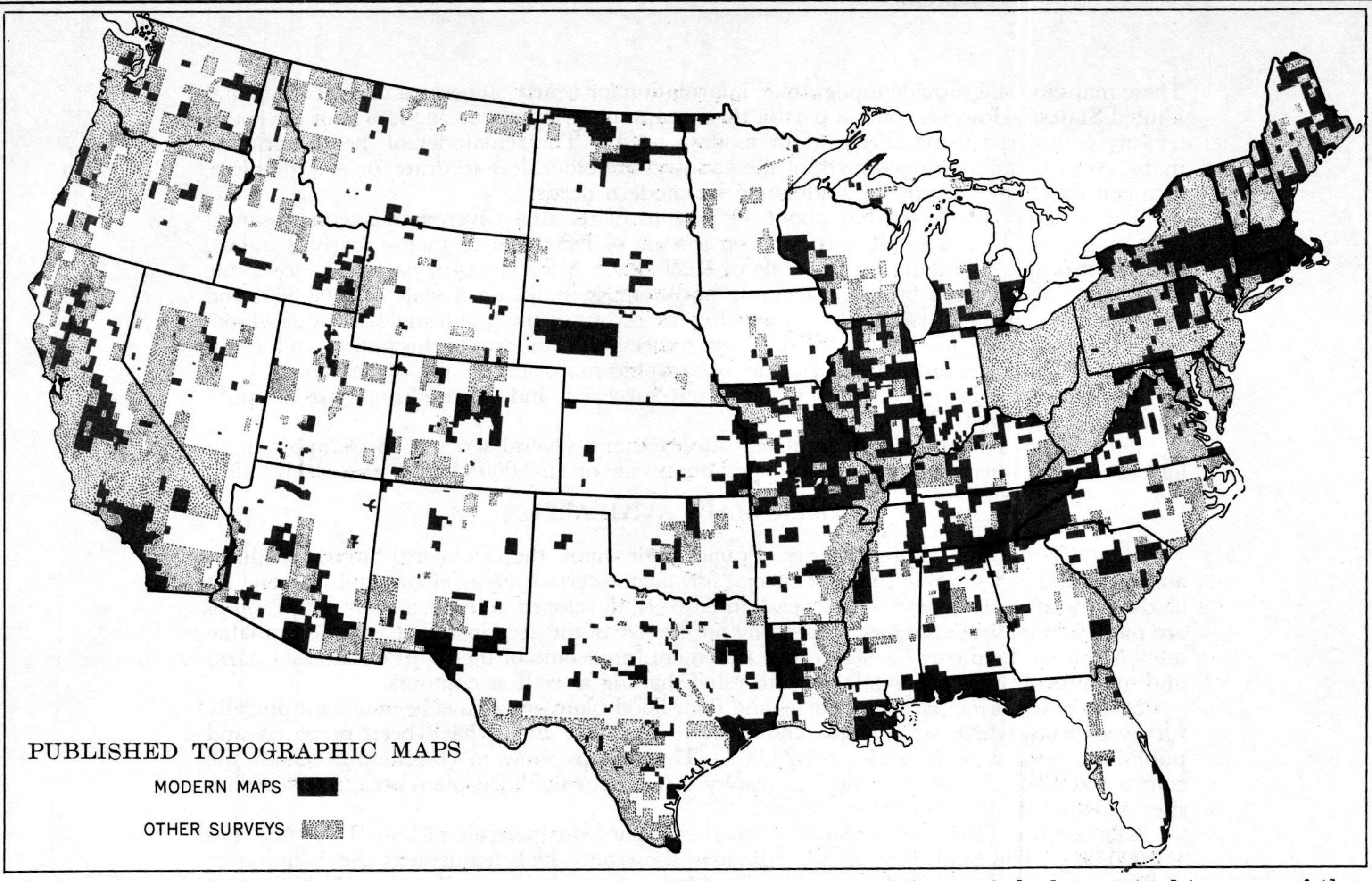
NATIONAL TOPOGRAPHIC MAP SERIES

Although some areas are surveyed and some maps are compiled and published on different scales for special purposes, the standard topographic surveys and the resulting maps of the continental United States have for many years been of three general types, differentiated as follows:

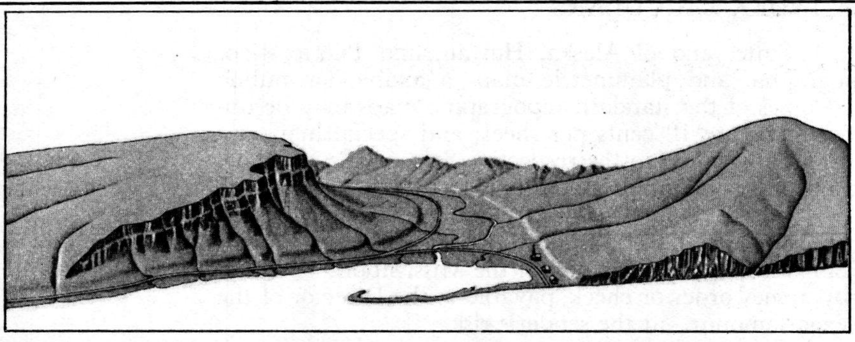
1. Surveys of areas in which there are problems of great public importance—relating, for example, to metropolitan and industrial areas, mineral development, dam and reservoir projects, irrigation, or reclamation of swamp areas—are made with sufficient detail to be used in the publication of maps on a scale of either 1:24,000 (1 inch = 2,000 feet) or 1:31,680 (1 inch = ½ mile), with a contour interval of 1 foot to 50 feet, the contour interval varying from area to area according to the steepness of the terrain. Quadrangle maps published on these scales measure 7½ minutes in both latitude (north-south) and longitude (east-west), and cover an area ranging from 49 square miles in the northern latitudes along the Canadian border, to 68 square miles in the southernmost latitudes of Texas and Florida The usual and preferred publication scale for the 7½-minute quadrangle maps is 1 24,000. The 1:31,680 scale will be continued temporarily only in a few localities where status of previously published maps or other local circumstances make the use of the 1:24,000 scale inadvisable for the time being

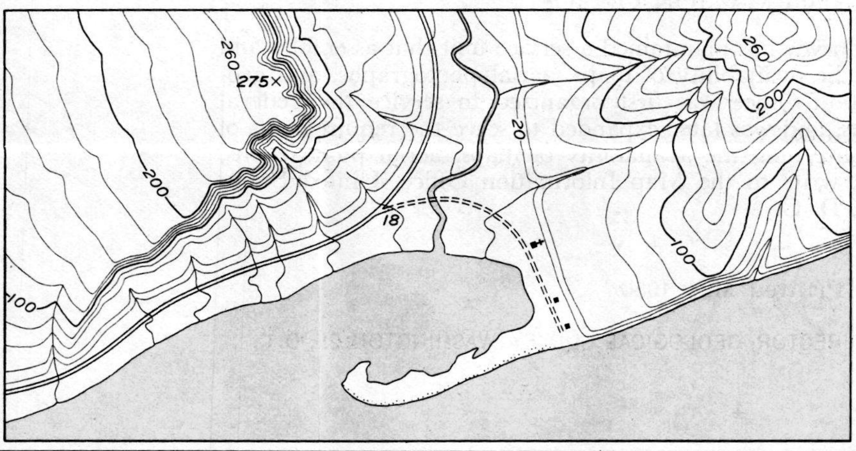
2 Surveys of areas in which there are problems of average public importance, as in much of the agricultural land of the Mississippi Basin, are made with sufficient detail to be used in the publication of maps on a scale of 1 62,500 (1 inch = nearly 1 mile), with a contour interval of 5 to 100 feet. Quadrangle maps published on this scale measure 15 minutes in both latitude and longitude, and each map covers an area of 195 to 271 square miles, the area depending on the latitude. One of the objectives of the Geological Survey is ultimately to supply a complete atlas of 15-minute topographic quadrangle maps, at the scale of 1 62,500, of the entire area of the continental United States

3 Surveys of areas in which the development problems are regarded as of less magnitude or urgency, such as certain of the desert regions of the West, were formerly made with only generalized detail, and the resulting maps were published on a scale of either 1:125,000 (1 inch = nearly 2 miles) or 1:250,000 (1 inch = nearly 4 miles), with a contour interval of 20 to 250 feet Quadrangle maps published on the scale of 1 125,000 measure 30 minutes in both latitude and longitude and each map covers an area of 790 to 1,084 square miles. Maps published on the scale of 1 250,000 measure 1 degree in each direction, and each map covers an area of 3,120 to 4,336 square miles.



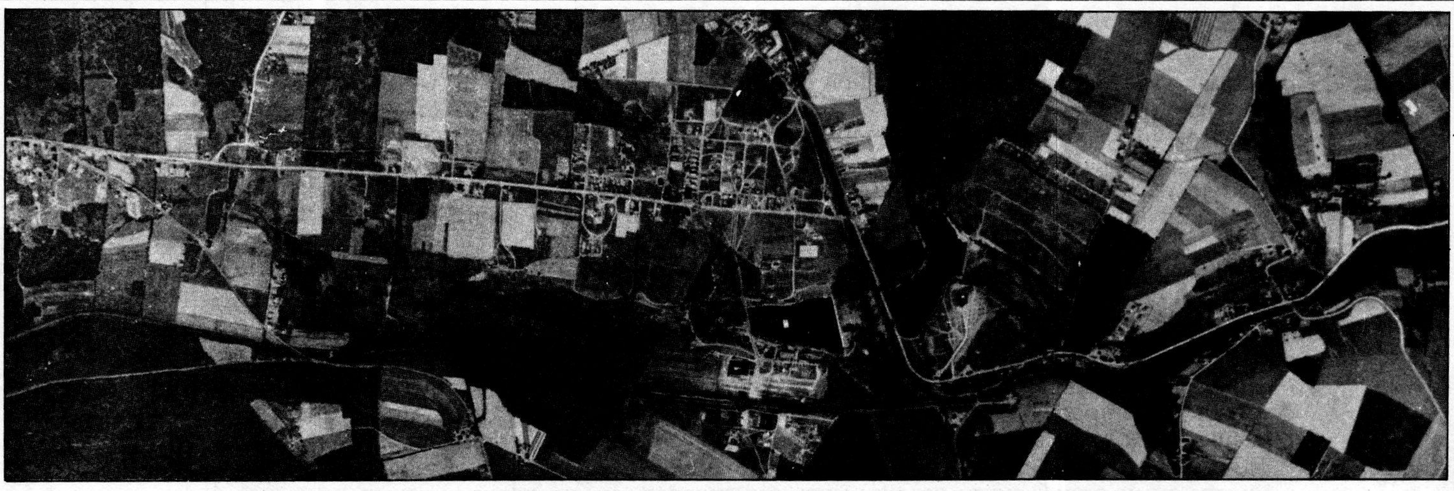
This small map is intended to give a general picture of the areas covered by published topographic maps of the U. S. Geological Survey and other government agencies. Some additional areas have been covered by old reconnaissance surveys which are now considered inadequate. Larger size status maps of the United States covering topographic mapping, aerial photography, aerial mosaics, vertical control, and horizontal control may be obtained on application to the U. S. Geological Survey, Washington 25, D. C. State index circulars showing the details of map coverage and the names of map sheets printed for distribution, are also available without charge.



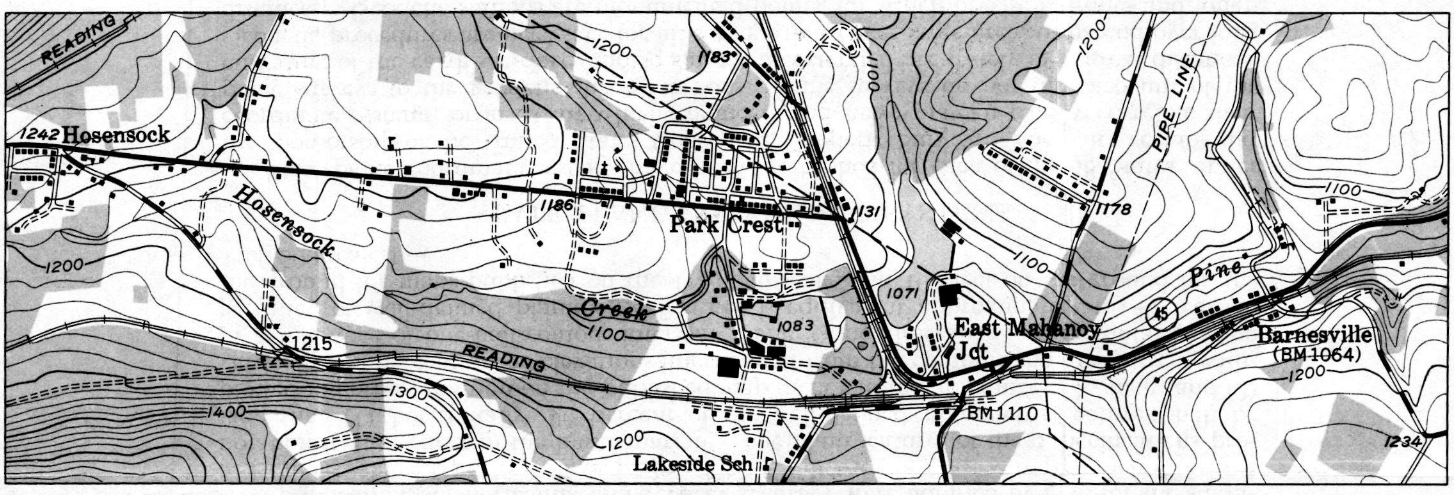


LAND FORMS AS SHOWN ON A TOPOGRAPHIC MAP

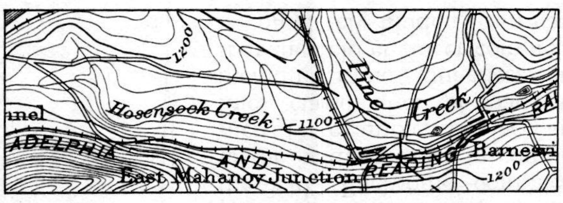
This illustration shows the manner in which relief, hydrographic, and cultural features are shown on a topographic map. The upper part of the illustration is a perspective view of a river valley that lies between two hills. In the foreground is the sea with a bay partly enclosed by a hooked sandbar. On each side of the valley are terraces through which streams have cut gullies. The hill on the right has a gradual slope with rounded forms while that on the left rises abruptly and ends in a sharp precipice from which it slopes gradually away forming an inclined tableland that is traversed by a few shallow gullies. The lower part of the illustration shows the same ground forms represented by contour lines. The contour interval used here is 20 feet, which means that the vertical distance between one contour and the next is 20 feet.



AERIAL PHOTOGRAPH USED IN THE PREPARATION OF MAP SHOWN BELOW.



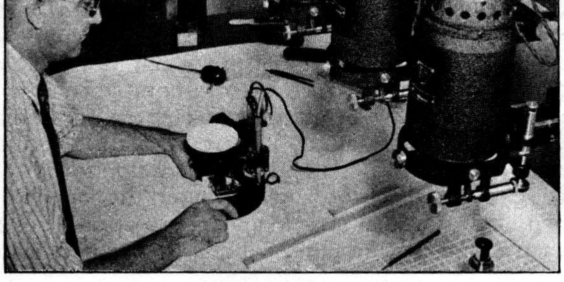
Portion of U. S. Geological Survey's Delano, Pa. 7.5′ quadrangle. Scale 1:24,000 (1″=2000′). Contour interval 20 feet. Topography from aerial photographs by multiplex methods. Surveyed in 1946.



Portion of U. S. Geological Survey's Mahanoy, Pa.15′ quadrangle. Scale 1:62,500 (1″=approximately 1 mile). Contour interval 20 feet. Surveyed in 1889.

The maps shown above cover the same ground area. A comparison of the two will show the extensive changes that have been made since the mapping of the Mahanoy quadrangle in 1889. They also illustrate the value of large scale mapping where culture is dense or where greater detail is needed. Older maps, such as the small one shown above, will be replaced with modern maps as funds become available.

BENCH MARK TABLET



MULTIPLEX

PLANE TABLE

Survey marker and some of the instruments used in the preparation of a topographic map

A new series of generalized topographic maps, planned to cover the entire area of the United States, on a scale of 1:250,000, with contour intervals ranging from 100 feet in the plains areas to 500 feet in the mountains, with relief emphasized by shading, is now in process of preparation and publication This series, which will require several years to complete, is intended primarily to meet military requirements, and original compilation is being done mainly by the Department of the Army An edition for civilian use is planned to follow the military edition of each of these maps, as such maps will be found useful for geographic information and for general planning on a regional basis.

All of the standard quadrangle maps of the United States areas are published on sheets about 16½ by 20 inches in size, except for the 1:24,000 scale maps, which are 22 by 27 inches.

AERIAL PHOTOGRAPHS USED IN MODERN MAPPING

The technical procedures of topographic mapping have undergone considerable change in recent years Aerial photographs, and precise plotting instruments for measuring and converting these photographs to standard maps, now perform a major function in nearly all topographic mapping operations The use of aerial photographs makes it economically practical to prepare the entire series of standard topographic map sheets in conformance with modern engineering standards of accuracy. Although in using aerial photographs each original map sheet is "compiled" in the office, extensive field surveys are still required—first for determining the latitude, longitude, and elevation of a number of control-survey points within each map-sheet area, and second, for checking and completing the map in the field Each office-compiled map sheet, if it is to be of standard quality, must be taken to the field, in order to complete all those features which the photographs do not show—such, for example, as place and feature names, political boundaries and land-subdivision lines, classification of roads and buildings, and numerous small but important features including mines, quarries, cemeteries, large springs, and oil wells It is also necessary that the field engineer complete the map by conventional surveys whenever the land surface is completely hidden from camera view by dense forest growth.

MAP ACCURACY SPECIFICATIONS

Specifications for horizontal and vertical accuracy were adopted in 1942 for the standard topographic maps, and those maps which fulfill these accuracy requirements carry a notation to that effect in the lower margin The main features of these specifications provide that (1) horizontally, 90 percent of the well-defined planimetric features shall be plotted in correct position on the published map sheet within a tolerance of $\frac{1}{50}$ inch, and (2) vertically, 90 percent of the elevations interpolated from the contours shall be correct within a tolerance of one-half contour interval (The $\frac{1}{50}$ inch tolerance for horizontal position accuracy of well-defined planimetric features is equivalent approximately to 40 feet on the ground for maps published on the 1:24,000 scale, and 100 feet on the ground for the 1:62,500 scale)

STATE PLANE COORDINATE SYSTEMS

State plane coordinate systems have been established for each of the 48 States, under the sponsorship of the United States Coast and Geodetic Survey These are rectangular coordinate systems, or grids, by which engineers and surveyors can readily correlate their plane surveys to the geodetic survey stations Plane surveys do not take account of the curvature of the earth's surface, and so cannot be extended accurately over great distances. Geodetic procedures are necessary for all surveys that cover large areas or extend over long distances. Geodetic stations are monumented points, for which precise latitudes and longitudes have been determined These geodetic positions, referred to the sphere of the earth, can be readily converted into plane, rectangular coordinates of any State system, and vice versa On all recent topographic maps certain of the grid lines of the State rectangular coordinate system may be drawn, by joining with straight lines the corresponding grid ticks, or short sections of lines, which extend at regular intervals just outside the map border, and which are labeled with appropriate north and east coordinate values in feet. In cases where State grid zones overlap, two or more systems will be shown on the map, in which case one zone will have its grid ticks indicated by dotted lines

EXTENT OF AREAS MAPPED

For the United States proper, nearly 10,000 topographic maps, and several hundred planimetric maps (maps that do not depict relief), have been published and are available to the public Some of these maps were originally prepared by other agencies, including the Tennessee Valley Authority, the Department of the Army, the United States Forest Service, and the Coast and Geodetic Survey. All of these maps are now distributed by the Geological Survey, and most of them have been edited and published by the Survey.

These maps in total provide topographic information for nearly 50 percent of the continental United States However, only a part of these maps, covering about one-fourth of the country, are considered to be adequate for modern needs. The remainder of the topographic maps, covering another one-fourth of the country, are older, less accurate, or less complete, so much that they are not fully adequate for modern needs.

The territory of Alaska has about 44 percent of its area covered by reconnaissance-type maps, of which a small portion is on a scale of 1:500,000 (1 inch = nearly 8 miles), with most of the remainder on the scale of 1:250,000 A few areas of particular economic importance are covered by more accurate and detailed maps on a scale of 1:62,500, and some are on larger scales. A new pattern for the layout of the quadrangle maps of Alaska was adopted in 1948, and all future Alaska map sheets will conform to this pattern in format, so as to provide a coordinated series of topographic maps for the entire territory

The Hawaiian Islands have been completely surveyed, and the resulting maps are published on a scale of 1:62,500

Puerto Rico has also been completely surveyed and several series of topographic maps have been published, the main series being on a scale of 1:30,000 (1 inch = nearly ½ mile).

OTHER MAPS AVAILABLE

In addition to the standard series of quadrangle maps, the Geological Survey produces and publishes topographic maps of special format for certain areas of unusual interest, including the national parks and several intensively developed mining areas These maps are published on various scales, depending on the size of the area included and the probable use. Many of them carry a descriptive statement, and some of the maps of national parks and monument areas are available with relief shading as well as contours

Many of the principal river courses and their flood-plain areas have been topographically surveyed, from which strip maps, known as river survey maps, have been prepared and published, usually at the scale of 1:24,000 These maps show in considerable detail the course and fall of the stream, the topography throughout the flood-plain area, selected dam sites, stream profiles, and other features.

Base maps of all of the States have been published on the scale of both 1:500,000 and 1:1,000,000. The State base maps ordinarily show only such features as the boundaries of States, counties, and Federal reservations; the principal cities, railroads, and highways; and the larger rivers and lakes In some States revisions are being prepared which will provide special editions with contours and relief shading. For Alaska, base maps at four different scales are available, the most popular of these being Alaska map E, on the scale of 1:2,500,000.

For the United States as a whole, there are available several series of base maps, contour maps, and relief maps, on different scales, and with varying amounts of information.

STATE INDEX CIRCULARS

Index maps and circulars of each State, and of Alaska, Hawaii, and Puerto Rico, showing the areas covered by topographic and planimetric maps available for public distribution, may be obtained free. Copies of the standard topographic maps may be obtained for 20 cents each; river survey maps are 10 cents per sheet; and special maps are available at different prices which are usually stated in the respective State index circulars. A discount of 20 percent is allowed on orders for maps amounting to $10 or more at the retail price.

Orders for maps should be addressed to the United States Geological Survey, Washington 25, D. C. (or to Denver 15, Colo., for maps of areas west of the Mississippi) Prepayment is required and may be made by money order or check, payable to the Director of the Geological Survey, or in cash—the exact amount—at the sender's risk.

MAP INFORMATION OFFICE

For some years the Geological Survey has maintained a service unit that assembles and distributes information concerning the availability of maps, aerial photographs, and geodetic control. The Map Information Office was first organized to service the Federal surveying and map-making agencies, and was later expanded to serve the requirements of all map users. For information concerning the availability of maps, aerial photographs, geodetic control, and related data, write to the Map Information Office, United States Geological Survey, Washington 25, D C.

Printed May 1950

FREE ON APPLICATION TO THE DIRECTOR, GEOLOGICAL SURVEY, WASHINGTON 25, D. C.