ORBES

PENNSYLVANIA BASELINE

Part 2 - Impact Assessment Data Base

Chapter 1 - Characteristics and Human Utilization of Natural Ecosystems

Sections 1-3 - Geology, Climatology and Soils

PHASE II

OHIO RIVER BASIN ENERGY STUDY

June 1979

PENNSYLVANIA BASELINE

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Chapter 1 - Characteristics and Human Utilization of Natural Ecosystems

Sections 1-3 - Geology, Climatology and Soils

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Prepared for
Ohio River Basin Energy Study (ORBES)

Grant Number R805608-01-03

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

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2.1.1. TOPOGRAPHY AND GEOLOGY

2.1.1.1. TOPOGRAPHIC CHARACTERISTICS

A. Introduction

The ORBES Region of Pennsylvania lies in the Appalachian Plateaus Physiographic Province (Fig. 2.1.1.-1). This province is bound on the east by the "Allegheny Front," a topographic boundary between the plateau to the west and the Ridge and Valley Province to the east. The plateau is sub-divided into four sections: (1) the Pittsburgh Plateaus Section, (2) the Allegheny High Plateaus Section, (3) the Glaciated Section, and (4) the Allegheny Mountain Section.

B. Pittsburgh Plateaus Section

The major part of the ORBES Region is in the Pittsburgh Plateaus Section. This section includes all or part of the counties of Allegheny, Armstrong, Beaver, Butler, Cambria, Clarion, Clearfield, Fayette, Greene, Indiana, Jefferson, Venango, and Washington. It is well-dissected and hilly, with relief on the order of 300 to 500 feet. Steep slopes are common.

Dendritic drainage is prevalent. Major streams are the Monongahela and Allegheny Rivers which join at Pittsburgh to form the Ohio River (Fig. 2.1.1.-2). An important tributary of the Ohio River is the Beaver River. The Beaver is formed where the Mahoning River joins the Shenango River near New Castle in Lawrence County, and from there flows southerly to the Ohio River at Rochester about twenty miles downstream from Pittsburgh. A principal tributary of the Beaver is Slippery Rock Creek, a stream that drains much of northern Butler County in the Glaciated Section of the plateau. Slippery Rock Creek is joined by Connoquenessing Creek a few miles east of the Beaver River. Connoquenessing Creek and its tributaries drain most of the southern part of Butler County.

The Ohio River is a major stream of the area. From Pittsburgh it takes a northwesterly course for about 20 miles to Beaver where it turns southwesterly to form the Ohio-West Virginia boundary. The rather abrupt change in the flow direction of the Ohio River at Beaver is the result of diversion of the river in glacial time. Pre-glacially, the ancestral "Monongahela" flowed to Pittsburgh as it now does, and then on to Beaver where it continued northward along the course of what is now the southerly flowing Beaver River to the Lake Erie basin near Ashtabula, Ohio. When glacier ice blocked this northerly flow the stream was forced to seek another direction which was southwesterly along the course of the present Ohio River. A similar diversion occurred in the upper Allegheny River. Pre-glacially, the ancestral "upper Allegheny River" flowed through Olean, New York northwesterly to the Lake Erie basin, but because of ice-blocking was forced to take the southwesterly course that the present Allegheny now flows in flowing from Warren (Warren County) through Tionesta (Forest County) to Franklin in Venango County. French Creek, a tributary of the Allegheny, was also involved in a reversal of flow because of glaciation. French Creek now flows southeasterly through Meadville (Crawford County) and then to the Allegheny River at Franklin, but in pre-glacial time, French Creek was a northwesterly flowing stream that emptied into the Lake Erie basin. Thus, it is a stream whose flow direction has been reversed. From the Clarion River downstream the Allegheny River follows essentially the same course now that it did prior to glaciation. Neither the present Monongahela River nor its tributaries have realized any appreciable changes in flow direction because they occur south of the glaciated area and therefore were not directly affected by glacier ice.

C. Glaciated Section

The northwestern part of the Pennsylvania ORBES Region lies in the Glaciated Section of the Allegheny Plateau (Fig. 2.1.1.-1). This is mainly in Mercer and Lawrence Counties but also includes parts of Venango, Butler, and Beaver Counties. Glacial drift covers the bedrock in this section. The thickness of the drift ranges from a few feet in hilltop areas to several hundred feet where pre-glacial valleys have been filled or partly filled. Local relief in this section is moderate, on the order of 100 feet or so, and although some steep slopes occur, in general slopes are considerably more gentle than those in the Pittsburgh Plateaus Section. Various types of glacial landforms and deposits are present. They include ground moraines, end moraines, kames, kame terraces, kame moraines, eskers, and outwash deposits in valleys. Swampy, poorly drained terrain is common. The drainage pattern overall is dendritic but locally there are deranged patterns caused by glaciation. The dominant drainage direction in Mercer and Lawrence Counties is southerly by means of Shenango River, Neshannock Creek, and Beaver River. Slippery Rock Creek and its tributary, Wolf Creek, also drain a large segment of the glaciated terrain. Muddy Creek, a Slippery Rock Creek tributary, is of interest because it is in Muddy Creek valley that a man-made lake (Lake Arthur) was created in 1969 for recreational purposes in the same basin that contained a natural, glacial lake in Pleistocene time. Lake Arthur, the modern lake, has been reestablished at a somewhat lower water level than the ancient lake by the construction of an earth-fill dam near the site where glacier ice once blocked the flow of Muddy Creek. Other notable bodies of water occur just outside the boundaries of the ORBES Region but within the Ohio River drainage basin in Crawford County. These are Pymatuning Reservoir and Conneaut Lake. Pymatuning Reservoir is the result of the damming of Shenango River. This reservoir also extends into Ashtabula County, Ohio. Conneaut Lake is a natural glacial lake in a valley tributary to French Creek valley. Both bodies of water occur in valleys partly filled with glacial drift.

Notable tributaries entering the Ohio River from the south are Chartiers Creek and Raccoon Creek, both having their headwaters in Washington County. Chartiers Creek also flows through southern Allegheny County and joins the Ohio River downstream from Pittsburgh at McKees Rocks; Raccoon Creek flows through southern Beaver County to join the Ohio about 10 miles upstream from the Pennsylvania-Ohio boundary.

Allegheny River enters the Pennsylvania ORBES Region from the north. Its headwaters are in Potter County in the Coudersport drainage area. From there it flows northwesterly into New York through Olean where it turns and takes a southwesterly course to Pittsburgh. It is the main stream of the northern part of the ORBES Region. Principal tributaries of the Allegheny are the Kiskiminetas River (a stream formed by the joining of Loyalhanna Creek and the Conemaugh River), Crooked Creek, Mahoning Creek, Redbank Creek, and the Clarion River.

The Monongahela River, the major stream in the southern part of the ORBES Region, enters Pennsylvania from West Virginia and flows northerly, forming the boundary between Greene County and Fayette County, and also between Washington County and the southwest corner of Westmoreland County. From there it flows through southern Allegheny County to Pittsburgh. An important tributary of the Monongahela is the Youghiogheny River. This stream's headwaters are in western Maryland. From there the Youghiogheny flows northwesterly through the mountainous section of the Plateaus Province in Pennsylvania to join the Monongahela at McKeesport. Western tributaries of the Monongahela are Tenmile Creek in Washington County and Dunkard Creek in Greene County. An eastern tributary is Turtle Creek whose valley is heavily industrialized. Turtle Creek flows into the Monongahela at East Pittsburgh 11 miles upstream from the Point in Pittsburgh where the Monongahela joins the Allegheny to form the Ohio River.

D. Allegheny High Plateaus Section

The northern tier of counties in the Pennsylvania ORBES Region (Venango, Forest, Elk, and northern Clearfield) lie in the Allegheny High Plateaus Section. This section is characterized by hilly terrain and steep slopes. It is largely a forested area of fairly sparse population. Summit elevations of 1,900 to 2,000 feet are common as compared to ones in the 1,400- to 1,500-foot range in the Pittsburgh Plateaus Section. Also, local relief is relatively high in the High Plateaus Section, being on the order of 600 to 800 feet in areas adjacent to major stream valleys. The area of eastern Elk County and most of Clearfield County is part of the High Plateaus drained to the east by Sinnemahoning Creek and the West Branch of the Susquehanna River. The major part of Clearfield County, lying in the Pittsburgh Plateaus Section, is in the drainage basin of West Branch of Susquehanna River (note drainage divide Fig. 2.1.1.-2), and is not part of the Ohio drainage system.

E. Allegheny Mountain Section

The southeastern part of the region is located in the Allegheny Mountain Section of the Appalachian Plateaus Province. Terrain in the Mountain Section has a pronounced linear aspect not found in other sections. This linearity owes its presence to three parallel anticlinal mountains of northeast trend; Chestnut Ridge, Laurel Hill, and Negro Mountain; and one homoclinal mountain of the same trend known as Allegheny Mountain. Allegheny Mountain forms the "Allegheny Front" whose summit elevation is about 1,000 feet higher than elevations in the adjacent valley to the east at the western edge of the Ridge and Valley Province. Summit elevations of the Allegheny Front are highest in Somerset County (about 3,000 feet) and get progressively lower northeastward. At the Clearfield County-Cambria County boundary, the summit elevation is about 2,600 feet.

The Allegheny Front is a continuous feature along most of the east edge of the ORBES Region but the three anticlinal ridges die out as prominent topographic features to the northeast. Chestnut Ridge dies out as a conspicuous ridge in the vicinity of Blairsville although it is a noticeable feature beyond there into the Indiana-Clymer area of Indiana County. Laurel Hill also terminates as a prominent ridge in Cambria County in the vicinity of Nanty Glo. Negro Mountain is prominent only in southern Somerset County in the area of Mt. Davis, the highest point in Pennsylvania (3,213 feet). These anticlinal ridges become less evident to the northeast because the anticlines plunge in that direction. Although Chestnut Ridge anticline and Laurel Hill anticline are not manifested as such conspicuous ridges in the northeast part of the ORBES Region as in the southeast part, the structures do exist in Clearfield and Elk Counties where they impart a less noticeable linearity to the terrain of the High Plateaus Section of the Allegheny Plateau.

In southern Somerset County and adjacent Bedford County the Allegheny Front jogs to the east by about 10 miles, and the mountain forming the Front there is known as Little Allegheny Mountain. The Somerset County-Bedford County boundary line follows the summit of this mountain whose southern extension into Allegany County of western Maryland is known as Dans Mountain. Drainage in this extreme southeastern part of the ORBES Region is in the Potomac system. Wills Creek is one of the streams in this system. Little Allegheny Mountain and its southern extension, Dans Mountain, is a homoclinal ridge on the east flank of the Georges Creek syncline. The counterpart homoclinal ridge on the west flank is Savage Mountain. Because the syncline plunges to the southwest, these homoclinal ridges converge in the northeast direction and form a synclinal nose in southern Somerset County. It is at the site of this nose that the Allegheny Front makes the jog to the east.

Local relief in the Allegheny Mountain Section is in the 1,000- to 1,500-foot range where major streams have cut gorges through the anticlinal ridges. The Conemaugh River gorges through Laurel Hill west of Johnstown and through Chestnut Ridge east of Blairsville are notable. Other prominent gorges are the Loyalhanna Creek gorge through Chestnut Ridge east of Latrobe; Youghiogheny River gorge through Chestnut Ridge between Ohiopyle and Connellsville. Also, Casselman River, which is a Youghiogheny River tributary, flows through a gorge in Negro Mountain more than 500 feet deep. The highest point in Pennsylvania (3,213 feet) occurs about 5 miles south of this gorge at Mt. Davis, a slight local prominence on Negro mountain whose summit elevations in that area are generally in the 3,000- to 3,200-foot range.

Streams in this section in part follow the northeast-southwest trend of synclinal valleys and in part cut transversely across anticlinal ridges and synclinal valleys. The Conemaugh River whose headwaters are on the west slopes of Allegheny Mountain is a transverse stream that cuts across several folds in flowing to Blairsville. Youghiogheny River, in its upper reaches in western Maryland and Somerset-Fayette Counties, Pennsylvania follows the trend of the Youghiogheny syncline to Confluence, but from there turns northwesterly and becomes a transverse stream. Casselman River is unique in that it flows northeasterly along the trend of the Meyersdale syncline from western Maryland to Meyersdale, Pennsylvania where it turns northwesterly and crosses Negro Mountain anticline. At Rockwood, the stream turns southwesterly and roughly follows structural trend to its junction with the Youghiogheny River at Confluence, thus making a broad U-turn in its course of flow. Another stream that joins the Youghiogheny at Confluence is Laurel Hill Creek, a southerly flowing stream. Indian Creek is a stream in the Ligonier syncline as is Loyalhanna Creek before turning northwesterly at Ligonier to become a transverse stream.

There are several water impoundments in the Allegheny Mountain Section. The largest is Youghiogheny Reservoir, a combined flood-control and recreational facility in Somerset County, Pennsylvania and Garrett County, Maryland. The Youghiogheny dam is located near Confluence, Pennsylvania. Another reservoir is Quemahoning Reservoir in Somerset County on a tributary of the Conemaugh River south of Johnstown.

2.1.1.2 GEOLOGIC CHARACTERISTICS

A. Geologic Structure

In the ORBES Region of Pennsylvania the exposed bedrock ranges from Upper Devonian through Permian. The younger, Permian rocks occur in the southwest corner of the state. From there south-southeastward, older and older rocks crop out, down through the sequence of Pennsylvanian and Mississippian to the Devonian (Fig. 2.1.1.-3). This is because the strata are rising gently in the up-plunge direction of the Pittsburgh-Huntington basin. The most widely distributed surface rocks in this basin are the coal-bearing rocks of the Pennsylvanian System. Pleistocene glacial deposits cover the bedrock in the northwestern part of the area. The mineral resources of the area include coal, oil, gas, limestone, clay and shale, sandstone, sand and gravel, and ground water. Principal geologic hazards are landsliding, subsidence from coal-mining, and flooding. Seismic risk is minimal.

The Pennsylvania ORBES Region lies in a high trough known as the Pittsburgh-Huntington basin (Fig. 2.1.1.-4) whose axis trends southwesterly through Pittsburgh to Huntington, West Virginia and into eastern Kentucky. In Pennsylvania this basin has a southwesterly plunge causing rock strata to have an overall gentle inclination in that direction. This is why relatively young Permian strata are present in Greene and Washington Counties in the southwest corner of the state whereas older beds appear at the surface to the northeast (Fig. 2.1.1.-3). However, this regional southwesterly dip is dominated in the western counties by a southeasterly dip that extends from eastern Ohio into western Pennsylvania. Superimposed on the gentle southwesterly plunge of the Pittsburgh-Huntington basin are several northeast-trending folds that are most prominent in the southeastern, Allegheny Mountain Section of Appalachian Plateaus (Figs. 2.1.1.-3, 4, 5). Along the axial trends of these prominent anticlinal folds Mississippian strata crop out in rather extensive areas, and here and there Upper Devonian beds are also exposed along the same trends. West of Chestnut Ridge, the westernmost of these prominent anticlinal folds, there is a continued succession of northeast-trending anticlines and synclines as far west as Pittsburgh. These folds become ever more gentle to the west and do not exert any marked effect on either outcrop areas or topography west of Chestnut Ridge. Strata in much of the region are essentially flat-lying, that is they dip at an angle of less than one degree.

In Mercer, Venango, Clarion, Butler, Lawrence and Beaver Counties, and in most of Allegheny, Washington, and Greene Counties there is a southeasterly dip that averages about 60 feet per mile (a little more than ½ degree). This dip is locally modified by minor doming, particularly near the axis of the basin close to the more highly folded strata on the eastern limb. Map #9 (Appendix I) is a structure contour map that shows the structure of the entire ORBES Region. A more detailed structure contour map, Map #43 (Appendix I), shows the structure in six southwestern counties in the so-called Greater Pittsburgh Region which includes Allegheny, Armstrong, Beaver, Butler, Washington, and Westmoreland Counties.

The eastern limb of the Pittsburgh-Huntington basin is complicated by anticlinal and synclinal folds which are most prominent in the southeast part of the region in Somerset, Fayette, and Westmoreland Counties. These folds are depicted in the structure section, Figure 2.1.1.-5. The folds are also present in other eastern counties but are less intense there (Cambria, Indiana, Armstrong, Jefferson, Clearfield, and Elk Counties) and do not dominate the topography as much as in the southeast area. The amplitude or structural relief of the folds increases from west to east. In the vicinity of Pittsburgh, near the axis of the basin, folds have an amplitude on the order of 350 feet whereas Chestnut Ridge, Laurel Hill, and Negro Mountain anticlines to the east have an amplitude in the 2,000- to 3,000-foot range. Spacing of the axes of the major structures is from 10 to 15 miles apart. Axial traces of folds in the southeastern area are relatively straight, but become increasingly sinuous to the west.

Although the dominant structural trend by far is a northeasterly trend, "cross-structures" having a west-northwest orientation are recognized. An example is Cross Creek syncline in Washington County (see Map #43, Appendix I). Also, "lines of structural discontinuity" occur in Butler County as west-northwest-trending zones "along which fold axes terminate, diminish, or change direction." These have been referred to by Briggs and Kohl as "Wagner-Lytle Lines" which are thought to be indicators of oil and gas fields. There is speculation that these cross-structures may be "the expression of long-lived, very slowly and intermittently moving strike-slip faults in crystalline basement."

Faults are common, at least in the subsurface, in the eastern part of the region, but are virtually unknown in the western part. In the eastern area of folded rocks, faults are associated with the folds. Some faults are parallel or subparallel to the trend of the folds, and others are transverse. Generally speaking, surface evidence of faulting is not plentiful, but oil- and gas-well drilling provides subsurface evidence. There is surface evidence of faulting, however, in Clearfield County where a notable area of transcurrent (wrench) faulting occurs near the east edge of the Plateau. These faults are identified by recognizing offsets in surface coal beds and associated strata. Some faults that parallel the structural trend can be traced in the subsurface for a distance of 10 to 20 miles (see Map #9, Appendix I); others can be traced for less than a mile. Vertical displacements are not large. They are commonly on the order of 100 to 200 feet. Evidence of the horizontal displacement of transverse faults is generally lacking but it too is thought to be relatively small. In the ORBES Region there are no known major faults that extend for several tens of miles and have a displacement of thousands of feet as in some of the more tectonically disturbed areas of the United States.

B. Stratigraphy

Exposed bedrock strata in the ORBES Region range from Upper Devonian to Permian (see Fig. 2.1.1.-6). These strata are sedimentary rocks consisting mainly of shale, sandstone, siltstone, limestone, coal, and clay. Shale and sandstone are most abundant but other rocks that comprise only a small percentage of the total are of more economic value. These include certain coal, limestone, and clay beds. Various subsurface strata of Mississippian and Devonian age are reservoir rocks for oil and gas. They are primarily sandstones, but one cherty formation (Huntersville chert) is also a gas producer.

Considering the stratigraphic column as a whole and the occurrence of commercially important resources within it, the lower beds (Upper Devonian and Mississippian) contain the productive oil and gas reservoir rocks and the upper part of the Mississippian contains the siliceous Loyalhanna Limestone which is quarried extensively for aggregate stone in the Allegheny Mountain Section. The resistant Connoquenessing and Homewood sandstones of the Pottsville Group provide some of the more scenic terrain, for example, the gorge of Slippery Rock Creek at McConnell's Mill State Park in Lawrence County. The Allegheny Group has the Vanport limestone, the only source of flux stone for steel-making in western Pennsylvania. This group also contains several mineable coal seams. The Conemaugh Group has several claystone units that are landslide prone; the Monongahela Group has mineable coal beds including the famous Pittsburgh seam; and both the Monongahela and Dunkard Groups have shales, shaly limestones, and calcareous shales that are landslide prone.

Quaternary beds consist of unconsolidated Pleistocene glacial deposits plus recent alluvial deposits in stream valleys. These unconsolidated materials cover bedrock of different ages ranging from Upper Devonian to Pennsylvanian, depending on the locality within the region.

C. Coal Resources

The ORBES Region lies within the Main Bituminous Coal Field of Pennsylvania (see Fig. 2.1.1.-7). The Georges Creek Coal Field of Somerset County in the southeastern corner of the region is also included. A small, relatively unimportant part of the main field lies outside the ORBES Region, in Cameron, Clinton, and McKean Counties. Coal reserves in the latter three counties are small compared to those in other counties of the region.

Coal rank ranges from low-volatile bituminous in parts of Somerset and Cambria Counties through medium-volatile bituminous in other parts of Somerset and Cambria Counties and also in parts of Fayette, Westmoreland, and Clearfield Counties to high-volatile bituminous in all other counties of the region.

The higher rank coal occurs in the eastern part, the lower rank coal in the western part of the region. In the high-rank coal area of Somerset and Cambria Counties the fixed carbon content of coal on the dry, ash-free basis is up to 85%. This percentage decreases westerly to 57% at the Ohio border. In the Georges Creek Field the coal has a fixed carbon percentage of about 80%.

The heat value of the coal ranges from an average low of 14,700 Btu/lb in Beaver and Lawrence Counties to an average maximum of 15,800 Btu/lb in northern Somerset County, south Cambria County, and in the Georges Creek Field.

Coal seams of the Main Bituminous and Georges Creek Coal Fields are shown in Figure 2.1.1.-9. There are 12 principal mineable seams indicated in bold type. The areal distribution and thickness of these seams plus one other (Washington coal) are shown in Plates 1 through 13 (Appendix II). The major mineable seams occur in the Allegheny and Monongahela Groups which are widely distributed in the region. Mineable coal seams of lesser importance, in the Pottsville Group, occur principally in Lawrence and Mercer Counties whereas those of the Conemaugh Group are confined mainly to Somerset County, particularly in the relatively small Georges Creek basin.

Recoverable coal reserves in the Main Bituminous and Georges Creek Fields as of January 1, 1979 are shown by county on the coal fields map of Pennsylvania (Fig. 2.1.1.-7). These reserves are also presented in Table 2.1.1.-1 not only by county but also by thickness category and coal rank. Recoverable coal is defined as that which can be extracted and marketed. In these estimates it excludes coal less than 24 inches thick and coal that will be lost in mining (an estimated 37%). Counties having the largest in-place reserves as of June 1, 1970 are Washington, Greene, Indiana, Somerset, Fayette, Westmoreland, and Cambria Counties, in that order. The northern tier of counties (Mercer, Venango, Forest, Elk) has a comparatively small coal reserve.

The principal mining activity has been in Fayette, Allegheny, Westmoreland, Washington, and Cambria Counties (see Table 2.1.1.-2). Much of the mining in the first four of those counties was in the Pittsburgh coalbed, whereas in Cambria County mining has been mainly in Lower and Upper Kittanning and the Lower and Upper Freeport coalbeds. Remaining reserves in the Pittsburgh coalbed as of 1970 are shown in Table 2.1.1.-3.

Reserves of strip-mineable coal have been calculated for 16 of the 19 ORBES counties. In the other 3 counties (Elk, Forest, and Venango) reserves are very minor. The estimated strippable coal reserves are presented in Table 2.1.1.-4 and Figure 2.1.1.-8 which show county-by-county reserve estimates. These estimates are based on the amount of remaining coal having 120 feet or less overburden. It is notable that Butler County is the number one county with respect to reserves of strip-mineable coal. Reserves of strippable coal on an individual seam basis are presented in Table 2.1.1.-5. Table 2.1.1.-4 shows the reserves in each of 18 mineable beds and Table 2.1.1.-5 shows reserves for each of the 16 counties of southwestern Pennsylvania on a seam-by-seam basis. In general the coal beds of the Allegheny Group contain the largest reserves. These include the Brookville and Clarion coalbeds; the Lower, Middle, and Upper Kittanning; and the Lower and Upper Freeport seams. The Waynesburg coalbed of the Dunkard Group also has large reserves. Areas in which these coal seams are susceptible to strip-mining can be inferred in a general way from the "distribution and thickness" maps of Plates 1 through 13 (Appendix II). On those maps the outcrop trace of a given coal bed is represented by the boundary between a colored area and an uncolored area (white). Strip-mining will be done within the colored areas close to their boundary with uncolored areas. Mining will start at the outcrop and extend into the colored areas (into hillsides) until the overburden becomes prohibitively thick.

No coal seam in the Pennsylvania ORBES Region is known to have an average sulfur content of less than one percent without beneficiation (Edmunds, 1972) and thereby classify as "low sulfur" coal. However, some coal seams in some parts of the region are in the "medium-sulfur" category (1% to 2%). Other seams which contain more than 2 percent sulfur fall in the "high-sulfur" coal category. Table 2.1.1.-6 shows the sulfur content by seam of the strippable coal reserves of all ORBES counties except Elk, Forest, and Venango. It should be noted that the sulfur data in this table are based on average sulfur content of coal seams in each county and do not take into account local areas within which the sulfur percentage may be lower or higher than the reported value. No published sulfur data are available for deep-mine coal, but it is expected that the sulfur content of such coal largely conforms to that of strip-mine coal.

D. Oil and Gas Resources

The distribution of oil and gas fields in Pennsylvania is shown on Map #10 of the Pennsylvania Geological Survey (Fig. 2.1.1.-10). These fields appear in more detail on the Survey's Map #3 (in Appendix III) which also shows gas storage fields and principal gas pipelines in the region. The names of oil and gas fields and pools, including ones in which gas is stored, are all listed on Map #3. More than 50 gas-storage fields are located in the ORBES Region. These are fields from which gas has been previously extracted and are now being used for underground storage of pipeline gas from other producing areas mainly. Gas in these storage reservoirs is available on a demand basis particularly in winter months when domestic heating is at a maximum.

Reservoir rocks that contain oil and gas are shown in their stratigraphic position in Figure 2.1.1.-6. A distinction is made in Pennsylvania between deep production and shallow production of oil and gas. The so-called shallow production is from reservoir rocks of Middle Devonian age or younger. As can be seen on Map #3 and Figure 2.1.1.-10, deep-reservoir gas fields are in general located in the eastern part of the region, shallow-reservoir gas fields are in the central part, and shallow-reservoir oil fields are in the western part. There is a general northeast trend of oil- and gas-bearing areas. This trend is more pronounced in easterly areas than in westerly ones because anticlinal folds which are responsible for the trapping of gas in "pools" are more pronounced to the east.

Cumulative oil production in Pennsylvania through 1976 is 1,289,564,000 barrels (Lytle, 1977). In 1976 the production was 2,950,000 barrels (see Fig. 2.1.1.-11) about half of which came from the Bradford field in McKean County outside the ORBES Region. Reserves of oil in Pennsylvania (1976) are estimated at 50,563,000 barrels (see Table 2.1.1.-7). Much of this reserve probably occurs in McKean County.

Cumulative natural gas production in Pennsylvania through 1976 was 9,013,560 million cubic feet (Table 2.1.1.-7), a large part of which was from the ORBES Region. Figure 2.1.1.-12 shows that gas production in 1976 was not significantly different from that in 1946. Production was generally higher in the 1950's than in other decades; peak production in the period since 1946 occurred in 1954. Proved recoverable reserve estimates of "native" gas (exclusive of stored gas from other areas) are also shown in Figure 2.1.1.-12. Except for a decrease in the 1950's, these reserves increased in the period between 1948 and the end of 1967, and showed an overall decrease from 1967 to 1974. If both native gas and stored gas are considered together, Pennsylvania's total proved recoverable reserves showed an overall increase in the period from 1946 through 1975.

E. Other Mineral Resources

Mineral resources other than coal and oil and gas include limestone, clay and shale, sandstone, and sand and gravel. These are exploited principally by open-pit mining although there is some underground mining. A 1976 Mineral Producers Map of Pennsylvania by O'Neill (Plate 1 of Pa. Geological Survey Information Circular 54, 1977; in Appendix IV) shows the distribution of these operations and lists by county the mineral operations. There is a clustering of clay mines in Clearfield County and in the Beaver-Lawrence County area, a clustering of sand and gravel operations in Lawrence, Butler, Mercer, and Venango Counties (the glaciated area) and along the Allegheny River valley where glacial outwash deposits are present in the stream bed and also in both low-level and high-level terrace deposits. There are two principal areas of limestone mining. One is in Butler and Lawrence Counties where the high-calcium Vanport limestone (Pennsylvanian) is mined; the other is along Chestnut Ridge in Fayette and Westmoreland Counties where most of the siliceous Loyalhanna limestone (Mississippian) quarries are located. Sandstone operations, which are less abundant, show no particular concentration in any one area.

Each of these mineral resources is discussed more fully in the following paragraphs.

The principal limestone units exploited in the Pennsylvania ORBES Region are the Vanport limestone of the Pennsylvania Allegheny Group and the Loyalhanna limestone of the Mississippian System (see stratigraphic column, Fig. 2.1.1.-6). The Vanport is the only source of high-calcium limestone (90% to 96% $CaCO_3$) in western Pennsylvania. It is used as flux stone in the iron and steel industry, in making cement, and as agricultural limestone, aggregate stone, and roadstone. The Loyalhanna, on the other hand, is siliceous (sandy) limestone composed of about half-and-half calcium carbonate and quartz sand. It makes good quality aggregate stone that is used extensively as base or sub-base roadway material, in making concrete, and as railroad ballast. An overall view of areas in which the Vanport limestone and Loyalhanna limestone are worked is presented in Figure 2.1.1.-13 (Map #15 of the Pa. Geological Survey). The distribution and thickness of the Vanport limestone are shown in detail on Map #4 of Bulletin M 50, Part I of the Pennsylvania Geological Survey (in Appendix V). This is a map showing areas in which the limestone is either at the surface or close enough to it to be economically mined by open-pit or shallow underground methods. The limestone is also present in some areas south of that representing the mineable area, but is too deeply buried to be exploited. It does not exist to the north where it has been eroded away, leaving the older underlying rocks exposed. Typical thicknesses of the Vanport limestone in its workable area are in the 15- to 20-foot range. It attains an uncommon thickness on the order of 40 feet near Elliott Mills in Lawrence and Butler Counties. The principal reserves of Vanport limestone 15 feet or more thick are in Butler, Armstrong, Lawrence, Beaver, and Clarion Counties. Estimated reserves in these counties as of 1964 (O'Neill, 1964) were as follows:

County		Reserves (tons)
Butler		13,300,000,000
Armstrong		3,700,000,000
Lawrence		2,050,000,000
Beaver		30,000,000
Clarion		20,000,000
	Total	19,100,000,000

In 1976 there were 13 active limestone operations in the Vanport limestone, two of which were underground mines; the remaining 11 were quarries. One of the quarries is in Butler County, 3 in Lawrence County, 2 in Clarion County, and 1 in Armstrong County. There was no quarrying of Vanport limestone in Beaver County in 1976.

The Loyalhanna limestone is accessible for quarrying only in the southeastern part of the region where it crops out along Chestnut Ridge, Laurel Hill, and Negro Mountain anticlines in Fayette, Westmoreland, and Somerset Counties (Fig. 2.1.1.-13). There are 8 active quarries, all but two of which are on Chestnut Ridge; one of the others is on Laurel Hill (Somerset County) and the remaining quarry is on the breached crest of Negro Mountain anticline near Mt. Davis, the highest point in Pennsylvania (3,213 feet), in Somerset County. Three of the Chestnut Ridge quarries are in Fayette County and 3 are in Westmoreland County. The main reason for this concentration of Loyalhanna limestone quarries on Chestnut Ridge is because that area is closer to the primary markets for crushed stone to the west than are the Laurel Hill and Negro Mountain areas.

The thickness of the Loyalhanna in areas where it is quarried is approximately 50 feet. It is commonly referred to as "blue stone" because of its bluish-gray color. It is high quality stone for use in road construction, being classified by the Pennsylvania Department of Transportation (PennDOT) as Type A roadstone. Reserves of Loyalhanna limestone amenable to quarrying are estimated at 47 million tons in the Chestnut Ridge district and 85 million tons in the Laurel Hill district (O'Neill, 1964). No reserve estimates have been published for the Negro Mountain area.

Clay and shale are used in the Pennsylvania ORBES Region for making refractory products, stoneware, and cement. Clay used in refractories occurs as underclay of coal beds (fireclay) in the Allegheny and Pottsville Groups primarily. Some of this is plastic fireclay and some is flint fireclay. The more important clay beds are the Mercer clay (Pottsville) and the Brookville, Lower Kittanning, Bolivar, and Upper Freeport clay of the Allegheny Group (see stratigraphic section, Fig. 2.1.1.-6). Shale suitable for making common bricks, sewer pipe, tile, etc. occurs at several stratigraphic levels in the Allegheny and Conemaugh Groups. It is more widely distributed than fireclay, although shale operations are few in number compared to clay operations.

Clay and shale are mined chiefly by open-cut methods but the number of underground mines is substantial. The ratio of open-cut to underground mines is approximately 4 to 1. Clearfield County has about 25 open-pit clay mines where the Mercer and Clarion fireclays are the principal clay beds. Lawrence and Beaver Counties have about one-half that number of fireclay mines. The chief clay beds mined in that area occur in the Allegheny Group. The lower Kittanning clay is the most important of these clay beds.

Sandstone operations are not extensive in the Pennsylvania ORBES Region. There are about a dozen sites where sandstone is worked for the production of crushed stone and broken stone for uses such as aggregate, construction stone, sand blasting, foundry sand, engine sand, and riprap. The sites are scattered through the region. At one locality (West Winfield, Butler County) sandstone is produced from an underground mine along with the Vanport limestone but at other places it is produced from quarries. The main restriction on extensive exploitation of sandstone in the region is the lateral variability of sandstone units, both in quality and thickness. They are prone to change over fairly short distances from thick-bedded or massive sandstone to shaly sandstone. Also, their thickness may change locally from 40 to 50 feet to less than half that.

Sand and gravel for commercial use is found in several types of deposits. It occurs in the channels of the major rivers (the Allegheny, Ohio, and Beaver), as low-level terrace and high-level terrace deposits along those rivers, and in kame terraces, kame moraines, and eskers within the glaciated area. Rivers in the southern part of the region like the Monongahela, Youghiogheny, and Kiskiminetas are not sources of this material because they have never been the sites of glacial outwash deposition like rivers in the northern part of the region. Sand and gravel is used extensively in the ORBES Region in the construction industries, particularly in road-building where large quantities of concrete are used. Although sand and gravel is relatively plentiful, there are land-use conflicts that significantly reduce the areas in which this product can be exploited.

The location of sand and gravel operations is shown in Plate 1 of the Pennsylvania Geological Survey's Information Circular 54 (in Appendix IV), Numerous operations occur along the Allegheny River valley in Allegheny, Armstrong, Clarion, Venango, and Forest Counties. Others are present in the Ohio River valley in Beaver County, and the Beaver River valley of Beaver and Lawrence Counties. Sand and gravel is produced by dredging in some of these operations where deposits either in the present stream channel or on the "low-level" terraces are being worked. Where the "high-level" terrace deposits are worked, open-pit techniques are used. These high-level deposits occur on terraces about 200 feet above the present streams. The deposits are glacial outwash material laid down on the valley bottoms, presumably in Illinoisan glacial time before the valleys had been deepened to their present level. The deposits of the low-level terraces and stream beds are outwash material thought to have been deposited in Wisconsinan glacial time on bedrock valley bottoms that were on the order of 100 feet lower than present ones. The present streams, in other words, are flowing on alluvial deposits that accumulated to this depth as an abundance of glacial rock debris was being transported downstream away from glacial sources to the north. A common thickness of these glacial deposits is in the 50- to 85-foot range. Similar thickness is reported for the high-level terrace deposits. The quality of the sand and gravel in the low-level terraces and stream beds is better than that in the high-level deposits because the lower level (and younger) deposits are less weathered.

Another source of sand and gravel are the kames, kame terraces, kame moraines, and eskers distributed throughout several counties in the area once covered by glaciers. This area includes all of Mercer County, most of Lawrence County, and parts of Beaver, Butler, and Venango Counties. The distribution of these deposits is shown on the Glacial Deposits Map of Northwestern Pennsylvania by Shepps (Bulletin G32, Pa. Geol. Survey, in Appendix VI). Most of the places where the glacial deposits are being worked are in Lawrence and Mercer Counties, but several are in Butler and Venango Counties as well.

Ground water in the Pennsylvania ORBES Region occurs in both bedrock formations and in unconsolidated Pleistocene glacial deposits. The latter deposits occur not only within the glaciated area itself but also outside it in the form of outwash deposits along the Allegheny, Beaver, and Ohio River valleys. A generalized map of the Pa. Geological Survey (Fig. 2.1.1.-14) shows the water-yielding capabilities of bedrock formations in the region, but does not evaluate the surficial deposits within the glaciated area. The map indicates that throughout the largest part of the region there are bedrock aquifers capable of yielding 100 to 200 gallons per minute from wells. Lower yields, on the order of 25 to 50 gallons per minute, are common in two counties (Washington and Greene) in the southwestern corner of the state. Bedrock aquifers with the highest yields (200 to 850 gpm) are available in the northern tier of counties of the region (Mercer, Venango, Forest, Elk particularly) and in the Laurel Hill, Chestnut Ridge, Negro Mountain areas of Fayette, Westmoreland, and Somerset Counties. The highest water yields of all come from the permeable, unconsolidated glacial sands and gravels. Yields up to 2,000 gpm are reported from these.

Within the glaciated area (see Fig. 2.1.1.-14) and Glacial Deposits Map of General Geology Report G32 in Appendix VI) the thickness of glacial deposits ranges from a few feet to as much as 400 feet. The deposits are thickest where deep bedrock valleys have been filled, or partly filled, with glacial drift. Some of the drift is relatively impermeable till and some is very permeable sand and gravel. It is the sand and gravel beds that are the good aquifers. For the most part, sand and gravel deposits occur along valleys whose dominant orientation is northwest-southeast. The glacial map shows these deposits collectively as kames, kame moraines, kame terraces, and eskers of either Wisconsinan or Illinoisan age.

There are also outwash deposits that have been transported beyond the glacial boundary and deposited on the bedrock floor of the Allegheny, Ohio, and Beaver valleys. As explained in the section dealing with Sand and Gravel Resources, this type of deposition occurred at two different stages, first in Illinoisan glacial time and later in Wisconsinan glacial time so that these outwash deposits are now found at two different levels. The earlier deposits (Illinoisan) occur about 200 feet above the present streams and are known as the "high-level" terraces; the lower ones occur in the bottom of the present valleys and are known as the "low-level" terraces. The thickness of these deposits at both levels is on the order of 50 to 85 feet. The present streams are flowing on these deposits and not on a bedrock floor. Industrial plants along the Allegheny and Ohio valleys obtain ground water from wells drilled into the valley-bottom deposits. Some communities also obtain part of their water supply from that source. In the Pittsburgh area, this flow of ground water through the Wisconsinan outwash sand and gravel is popularly known as Pittsburgh's "underground river."

Bedrock aquifers are primarily sandstones in the 20- to 40-foot thickness range although locally they may be as thick as 80 to 100 feet, or even as much as 300 feet in the case of the Pocono Formation. The better aquifers occur in the upper part of the Mississippian System and in the Pottsville Group of the Pennsylvanian System. These aquifers include the Pocono sandstone (Mississippian) and the Connoquesnessing and Homewood sandstones of the Pottsville Group. There are also good aquifers in the Allegheny Group, particularly in the lower part. Areas in which a given aquifer is productive depend in part on its position with respect to depth below the surface. The optimum position is one below drainage level, that is, below the level of the deepest valley in the area but above the zone of brackish water and salt water. Another factor that governs the quality of an aquifer is its permeability. Sandstones in the Pennsylvanian System typically show lateral variations in permeability so that a given sandstone aquifer may yield quite different amounts of water from place to place.

A generalized evaluation of bedrock aquifers in the ORBES Region is as follows:

Bedrock Unit	Yield from Wells (gpm)		Counties where Aquifer Occurs
	Median	Range	
Dunkard Group			
Greene Formation	2	1 to 35	Washington and Greene
Washington and Waynesburg Formations	2	1 to 70	" "
Monongahela Group	1	1 to 50	Washington, Greene; parts of Allegheny, Fayette, Westmoreland
Conemaugh Group	10	2 to 200	Allegheny, Beaver, Butler, Armstrong, Westmoreland, Fayette, Jefferson, Indiana, Somerset, Clearfield, and Cambria
Allegheny Group	35	5 to 500	Beaver, Lawrence, Mercer, Butler, Clarion, Armstrong, Jefferson, Indiana, Somerset, Clearfield, and Cambria
Pottsville Group	35	5 to 500	Lawrence, Mercer, Venango, Forest, Clarion, Elk, Jefferson, Clearfield, Somerset, Fayette, and Westmoreland
Mississippian System Pocono Formation	?	? to 1,000	Mercer, Venango, Forest, Elk, Somerset, Fayette, and Westmoreland

(see Figure 2.1.1.-6 for stratigraphic positions)

It is noted that, in general, the better bedrock aquifers occur lower in the stratigraphic section and that they are present in the northern counties of the region at suitable depths for them to be good aquifers. It is the south-southwesterly dip of strata in the region that causes these more permeable formations to be too deep (in the salt-water zone) in the southern counties but at shallower depths and within the fresh-water zone in the northern counties. An exception is in the southeastern counties of Fayette, Somerset, and Westmoreland where anticlinal folds cause the aquifers to be shallow enough to be in the fresh-water zone.

The evaluation of bedrock aquifers on a stratigraphic basis as presented above can be related to water-yielding capabilities by area as Figure 2.1.1.-14 shows. Relatively low yields of 26 to 50 gallons per minute in areas depicted in purple color are found where aquifers occur principally in the

Dunkard and Monongahela Groups. Higher yields of 101 to 200 gpm in the widespread area of orange-red coloration occur mainly in Conemaugh Group aquifers, and the highest yields from bedrock aquifers of 201 to 859 gpm in the green areas are present where Pocono, Pottsville, and Allegheny aquifers occur. Water yielding capacity data in Figure 2.1.1.-14 and those in the above evaluation do not match because Figure 2.1.1.-14 shows the median-yield range of that formation within an area having highest yield whereas the above figures are those for all aquifers within the various stratigraphic units represented. It should also be pointed out that Figure 2.1.1.-14 does not show areas where the highest water yields of all occur (2,000 gpm or more), namely those where permeable, stratified glacial deposits are present.

Further information on ground water may be found in publications by Poth (1973, 1974), Newport (1973), Gallaher (1973), Schiner and Kimmel (1976), Carswell and Bennett (1963), Lohman (1938, 1939), Leggette (1936), and Piper (1933).

F. Seismicity

Seismic activity in eastern United States has been studied recently by the U.S. Geological Survey in cooperation with the U.S. Atomic Energy Commission. One result of the study is a seismotectonic map showing major tectonic features, the location of epicenters of earthquakes having an intensity of III or higher on the Modified Mercalli scale, and areas of seismic activity classified according to seismic activity level and structural control (Hadley and Devine, 1974). Figure 2.1.1.-15 is a portion of the tectonic map published in that study. It shows that western Pennsylvania lies within two tectonic provinces, the western part of the Central Appalachian Fold Belt and eastern part of the Findlay Arch which is the northeast branch of the Cincinnati Arch. There are no major faults shown in the ORBES Region of Pennsylvania, although faults of less than major extent do occur in the southeastern part where the most pronounced folds are located (Chestnut Ridge anticline, Laurel Hill anticline, and Negro Mountain anticline), and in the northeast (Clearfield County) where folding is less pronounced but minor faults are common. In the central and western part of the region faults are virtually unknown and folds are very gentle, particularly in the west where folds die out and a gentle, fairly uniform southeasterly dip away from the crest of the Findlay Arch prevails.

Figure 2.1.1.-16, also from the Hadley and Devine report, shows that two epicenters of earthquakes of MMIII or higher occurred in the Pennsylvania ORBES Region in the period from 1800 to 1972. Those earthquakes were minor ones in the MMIII to VI range. An earthquake of intensity III is so mild that many people do not recognize it whereas one of intensity VI is felt by all yet damage is slight, meaning that damage is restricted to such things as fallen plaster and broken chimneys. Figure 2.1.1.-16 has seismic frequency contours plotted on the basis of the total number of earthquakes of intensity greater than MMIII per 10,000 square kilometers. The contours are numbered 4, 8, 16, and 32, thus some areas are ones of low seismicity in which there have been between 0 and 4 earthquakes per $10^4 km^2$. Other areas have a frequency between 4 and 16, and between 16 and 32. The ORBES Region of Pennsylvania falls entirely within the 0 to 4 frequency category. Data on which

Figure 2.1.1.-16 is based were obtained from the Environmental Data Service of the National Oceanic and Atmospheric Administration, and from the Dominion Observatory, Ottawa, Canada.

Another result of the U.S. Geological Survey study was the delineation of seismic-activity areas. These areas were determined on the basis of (1) seismic frequency or areal density of epicenters, (2) maximum epicentral intensity, and (3) structural control of epicenter distribution. Five levels of seismic activity and three categories of structural control were used. The ORBES Region is categorized by activity level 1, the lowest level of seismic activity. At that level structural control is not relevant, meaning that there are no geologic structures (faults) with which seismic activity might be associated. The closest areas where more intensive activity is indicated are in northeast and southeast Ohio where areas of activity level 2 are present, meaning that earthquake frequency is in the 8 to 32 per $10^4 km^2$ range, but no earthquake of maximum epicentral intensity greater than VI has occurred. The closest area to the east where areas of seismic activity levels 2 and 3 occur is in southeastern Pennsylvania, western Maryland, and the eastern West Virginia panhandle. At level 3, earthquake frequency is from 8 to 32 per $10^4 km^2$ and at least one earthquake of epicentral intensity VII or VIII is recorded. An earthquake of intensity VII does considerable damage to poorly built or badly designed structures, and one of intensity VIII does great damage to poorly built structures and considerable damage to ordinary substantial buildings.

A geologic explanation of these two more seismic areas to the west and east that border the area of low seismicity in western Pennsylvania is given by King and Zietz (1978). They have identified a major northeast-trending lineament in the basement rocks under the Appalachian basin extending from New York to Alabama (Fig. 2.1.1.-17). This lineament was identified by aeromagnetic mapping principally, with additional data from regional gravity surveys. King and Zietz think that the lineament marks the southeast edge of a stable crustal block. The northwest edge of that stable block is marked by a parallel, seismically active zone extending from New Madrid, Missouri to the St. Lawrence River valley. The ORBES Region of Pennsylvania lies within the stable block, and the two seismic areas to the southeast and west lie within less stable zones that are probably related to deep-seated, geologically old strike-slip fault zones in the basement rocks. The only two areas of level 5 seismic activity in eastern United States include the New Madrid site in Missouri and the Charleston area in South Carolina. Those are areas that have experienced earthquakes of intensity IX or higher (great damage, buildings shifted off foundations) and in which seismic frequency is greater than 64. The Attica area of western New York (Fig. 2.1.1.-15) is one of seismic activity level 3 (earthquake frequency between 16 and 32 and at least one earthquake of intensity VII or VIII). Attica is considered part of the seismic belt that extends from New Madrid, Missouri to the St. Lawrence River valley.

There are 5 stations that monitor seismic activity in Pennsylvania, all operated by the Pennsylvania State University (Fig. 2.1.1.-18). Two are in western Pennsylvania at Erie and Beaver. The other three are at State College, Millersville, and Abington (near Philadelphia). These are part of a network of seismic stations that form the Northeastern U.S. Seismic Network. Quarterly bulletins of seismicity of northeastern United States have been issued since March, 1976. No Pennsylvania ORBES Region earthquakes are reported in these bulletins for the period from October, 1975 through December, 1977.

2.1.2. CLIMATOLOGY

2.1.2.1. CLIMATOLOGIC CHARACTERISTICS

A. General

The ORBES Region of Pennsylvania has a humid, continental-type climate. Prevailing westerly winds bring most of the weather disturbances from the interior of the continent, but coastal storms occasionally affect the weather of the region. The topography of the Allegheny Plateau locally influences the weather. Rugged terrain causes considerable variation in the freeze-free season, it being considerably shorter in northern counties than in southern counties. Latitudinal difference between the northern and southern sections has a climatic effect.

The climate of Pennsylvania is summarized in a publication by Daily (1971). Local climatological data are available from the Environmental Science Services Administration - Environmental Data Service at Asheville, North Carolina and from the National Oceanic and Atmospheric Administration Climatologist at the Pennsylvania State University.

B. Precipitation

Mean annual precipitation in the Pennsylvania ORBES Region is about 41 inches; the range is from 35 inches to 47 inches (see map, Fig. 2.1.2.-1). The greatest amount of precipitation occurs in the southeastern mountainous section in Somerset, Cambria, Westmoreland, and Indiana Counties; the least amount occurs in the central-west part, in the Ohio Valley area of Beaver County. Precipitation data for the 1941-1970 period from 36 weather stations throughout the region are presented in Tables 2.1.2.-1 and 2. At Pittsburgh, in the period from 1872 through 1976, the mean annual precipitation was 36.15 inches. At the same locality the mean annual precipitation ranged from a high of 43.38 inches (in 1950) to a low of 26.79 inches (in 1963) in the 40-year period from 1937 through 1976 (Figure 2.1.2.-3). Precipitation is fairly well distributed through the year, although larger amounts usually fall in the spring and summer than in other seasons. July is generally the wettest month and February the driest. Winter precipitation is ordinarily 3 to 4 inches less than that in summer. Mean monthly precipitation at Pittsburgh between 1872 and 1976 was at a maximum of 4 inches in July and minimum of 2.36 inches in November (Fig. 2.1.2.-2). At Ebensburg in Cambria County precipitation was 11.6 inches in June, 1972, the month in which Hurricane Agnes occurred.

Rainfall amounts of both one-hour duration and 24-hour duration that can be anticipated in a 2.33-year return period have been estimated (Pennsylvania Department of Environmental Resources, COWAMP report Study Areas 8 and 9, 1975). Figures 2.1.2.-4 and 5 show by means of rainfall lines (isopluvial lines) the expected amounts in the ORBES Region. On the basis of these maps the greatest rainfall of one-hour duration (between 1.4 and 1.5 inches) is likely to occur in Indiana and Armstrong Counties. Greatest rainfall of 24-hour duration in a 2.33-year return period is likely to occur in the southeastern section in Somerset, Fayette, Westmoreland, Cambria, Indiana, and Armstrong Counties where values range from 2.4 to more than 2.8 inches. Within these southeastern counties the greatest local concentration is indicated in southern Somerset County where the highest terrain of the region occurs. Maximum amounts of precipitation at various intervals (1, 2, 3, 12, and 24 hours) recorded at 23 different stations in the region are presented in Table 2.1.2.-3.

Occasional dry spells may persist for several months in the region. They are not confined to any particular season. During these spells monthly precipitation may be less than one-quarter inch.

Prior to industrialization, the pH of rainfall was governed primarily by the carbon dioxide content of the atmosphere (300 ppm). Based upon this concentration and the equilibrium of carbon dioxide dissolved in water, a pH of 5.7 can be "back-calculated" as the pH value of rain unaffected by man's activity. Acid rainfall is currently a "hot issue" in the Northeastern United States. Emissions of sulfur dioxide to the atmosphere are believed to be the reason for pH measurements less than 5.7. Kane (1974) measured a pH range of 4.1 to 5.8 on precipitation events seven miles north of downtown Pittsburgh. He reported, from a comparison of free H^+ content with total H^+ content, that Pittsburgh precipitation is a weak acid solution. Kane's calculated pK values, ranging from 4.39 to 7.58 with an average of 5.56, further support this conclusion. Gelburd (1977) measured the pH spectrum of individual raindrops from six precipitation events in Pittsburgh. He detected a pH range of 3.9 to 5.0 among the individual drops of all six events. The "drop average" for each of the six events was found to range from 4.3 to 4.7.

C. Temperature

The average annual temperature in Pennsylvania ranges from about 47° in the north-central Plateau to 57° in the southeastern part of the State. Although precise data for the ORBES Region are not available, the average annual temperature within it is probably about 50°. The average summer temperature in the region is near 70°; the average winter temperature about 30°. Figure 2.1.2.-19 shows for Pittsburgh the average monthly temperature, and also the average daily maximum and minimum temperature on a monthly basis. Temperatures above 90° occur on the average of 10 to 20 days per year in the region. Northern counties have fewer days with such temperatures than southern counties. Freezing temperatures occur on the average of about 100 days. Below 0° readings have been recorded from November through April. January mean minimum temperatures range from 15° to 25°; January mean maximum temperatures are in the 35° to 43° range. In July mean minimum temperatures are in the 52° to 65° range and mean maximums in the 80° to 87° range. The distribution of July and January mean maximum and minimum temperatures throughout the region is shown in Figures 2.1.2.-6, 7, 8, and 9. These isothermal maps show that the coldest areas are in the northeast (Elk, Forest, and Venango Counties) and the warmest areas are in the southwest (Greene, Washington, Allegheny, Beaver, Butler, and Lawrence Counties).

At Pittsburgh, in the period 1969-1976, the total heating degree days (based on a temperature of 65°) ranged from a high of 6,336 to a low of 5,282. The total cooling degree days in that same period ranged from 855 to 358.

D. Thunderstorms and Tornadoes

Thunderstorms average between 30 and 55 per year. They occur mostly in the summertime and account for most of the summer rainfall. At Pittsburgh there was a yearly average of 37 thunderstorms in the decade from 1968 to 1977 (Figure 2.1.2.-18). The greatest number in this period was 43 in 1974; the least number was 28 in 1969.

Although hurricanes rarely affect the area, tornadoes do occasionally occur. An average of 5 to 6 tornadoes are recorded annually in Pennsylvania. June is the month of highest frequency followed closely by July and August. The southwest plateau area is one of the three principal ones for such storms. The other two areas are the extreme northwest and the southeastern Piedmont. The most destructive tornado activity in the State occurred in the ORBES Region in southwestern Pennsylvania on June 23, 1944. On that date, there were three tornadoes that killed 45 persons, injured 362, and caused more than $2 million property damage. Figure 2.1.2.-20 is a map showing areas in eastern and southern United States affected by tropical storms that caused destruction between 1901 and 1955. It is noted that there is a northeasterly trending belt of such storms through West Virginia, Pennsylvania, and New York, and also a western "bulge" extending across Lake Erie and adjacent parts of northern Ohio, southeastern Michigan, and Ontario, Canada.

E. Flooding

Floods may occur in any month. They occur most frequently in March and April, but heavy rains may produce a flood in any season. In winter, heavy rains combined with snowmelt may cause flooding. Local flooding sometimes results from ice jams during a spring thaw, particularly along the Allegheny River. Localized thundershowers may also cause severe flash-flooding. Floods are expected at least once in most years. At Pittsburgh, flood stage is expected on the average of 1.3 times per year, based on the long-term record. Years in which major flooding occurred on the Allegheny River are 1865, 1889, 1892, 1905, 1907, 1910, 1913, 1936, 1942, 1947, and 1964; on the Monongahela River in 1888, 1907, 1918, and 1936; and on the Ohio River in 1907, 1936, 1942, and 1954 (Dailey, 1971). Hurricane Agnes which caused major flooding in eastern Pennsylvania in 1972 did not so affect the ORBES Region in the western part of the State. Construction of several flood-control dams in the Allegheny River and Monongahela River systems in the last two or three decades has alleviated damaging floods considerably although the threat still exists as evidenced by the Johnstown flood of 1977.

F. Snow

Winter storms most commonly move northeasterly through the area. When temperatures are low enough snowstorms of considerable magnitude may occur. Some storms drop as much as 30 inches of snow as did the November, 1950 storm at Pittsburgh. Annual snowfall has a wide range from one locality to another and from one year to another. Mountainous areas in the northern part of the region may receive more than 100 inches in a year whereas lower-lying and more southerly areas may receive less than 10 inches. A map of the average annual snowfall in the region is presented in Figure 2.1.2.-10. At Pittsburgh the mean annual snowfall in the 24-year period from 1953 to 1976 was 45.3 inches; the range was from a low of 16.6 inches in 1974-75 to a high of 82 inches in 1950 in the period between 1937-38 and 1975-76 (Figure 2.1.2.-12).

Measurable snow generally falls between November 20 and March 15 in the region, but snow has been recorded as early as the beginning of October and as late as May. The largest monthly amount usually occurs in December and January, but at Pittsburgh it occurred in January and February in the 1953 to 1956 time period (Figure 2.1.2.-13). The greatest amount of snow from a single storm usually comes in the month of March.

G. Growing Season (freeze-free season)

Altitude is an important control of the growing season. At the higher altitudes the growing season is shortened because of a greater potential for frost in the early fall and late spring. The growing season in the region ranges from a low of about 115 days in Elk County in the northeastern part to a high between 175 and 180 days in parts of Allegheny County in the southwestern part (Figure 2.1.2.-11). The southernmost parts of the region do not have the longest growing season nor does the most northerly part in general have the shortest growing season. This is because of the hilly terrain in the south where nocturnal cooling is effective in valleys, and the ameliorating influence of Lake Erie in the north, especially in the northwestern counties closest to the lake (Mercer and Venango). The average length of the growing season in various parts of the region as depicted by the "iso" lines in Figure 2.1.2.-11 can be misleading. At specific locations there may be considerable departure from the average. For example, at Somerset (Somerset County), in a 33-year period the growing season averaged 134 days, but the range was from 86 to 171 days.

H. Wind

Prevailing winds in the region are from the west-southwest. As cyclonic storms move through the area wind directions may change through the 360 degrees of a circle, but the direction of the wind that blows the greatest percentage of the time is west-southwest, i.e., it is the prevailing wind. Monthly wind data from the weather station at Greater Pittsburgh airport for the 10-year period 1968-1977 are plotted in Figures 2.1.2.-14, 15, and 16. In figure 2.1.2.-16 resultant wind direction for each month in that period is shown by means of directional arrows. Resultant wind is the vector sum of wind directions divided by the number of observations. There was a 35-degree variation in the direction of resultant monthly winds in the 10-year period, from 280 degrees (west-northwest) to 245 degrees (west-southwest). The prevailing direction, or the average of the resultant monthly winds, was 260 degrees (west-southwest). The more northerly resultant winds (276 and 280 degrees) occurred in February and May and the more southerly ones (245 to 266 degrees) occurred in the remaining months of the year.

The maximum wind speed at Pittsburgh since 1953 was 58 miles per hour in February, 1967. That, too, was a west-southwest wind (260 degrees). Maximum wind speeds represent the fastest one-minute value observed.

I. Fog

Heavy fog is defined as fog that reduces the visibility to one-quarter mile or less. The ORBES Region is subject to such fog. Cold air drainage down the slopes into valleys frequently leads to the forming of early morning fog; particularly during the cooler months.

Fog data from Pittsburgh (Greater Pittsburgh airport) are plotted for the period 1968-1977 in Figure 2.1.2.-18. The number of days of heavy fog ranged from a low of 9 to a high of 28. The average number of days per year of heavy fog in that 10-year period was between 20 and 21.

J. Clear Days

A clear day is one during which the sky cover is between 0 and 3 on a scale of 10. At a value of zero there are no clouds at all and at 10 the sky is completely overcast. At Pittsburgh in the 1968-1977 decade the number of clear days ranged from a mimimum of 47 to a maximum of 75. The average number of clear days was between 59 and 60 (Figure 2.1.2.-17).

2.1.2.2. AIR POLLUTION POTENTIAL

A. Basic Meteorology

Holzworth (1972) has made a study of the potential for air pollution in the United States, and has produced a map showing the total number of forecast-days of high meteorological potential for such in a 5-year period (Figure 2.1.2.-21). This map shows that in the ORBES Region of Western Pennsylvania the number of forecast-days is in the 15- to 25-day range.

B. Teknekron Data

Nieman and Mahan (1978) examined the impact of long-range transport of air pollutants from Ohio and West Virginia upon Pennsylvania's air quality. It was determined, by examination of meteorological data, that the first and second most frequently occurring persistent winds were directed toward Western Pennsylvania from Ohio and West Virginia. On the average, these wind conditions occur at most locations approximately thirty times or more per year. Analysis of June 1974 - August 1977 air quality data revealed that the 24-hr. TSP (total suspended particulates) standard was violated 33 times at the Sharon-Farrell Site (Mercer County) while the 24-hour sulfate standard was violated 7 times at the same location. Long-range transport conditions "...were either confirmed or deemed probable for 63% of the days on which either of these standards was exceeded. Long-range transport from the southwest and the south predominated, although dates were also found with transport from the north-northwest, the west, and the south-southwest." Analysis of air quality data from Monongahela Valley monitors #3 (Washington County) and #5 (Fayette County) revealed long-range transport conditions on 38% of the days when the secondary 24-hr. TSP standard was exceeded and 33% of the days on which the sulfate standard was exceeded. On the dates of standard-excursions 46% of the extremely persistent winds came from the southwest, 39% from the west, and 15% from the south.

2.1.3. SOILS

2.1.3.1. SOIL TYPES AND DISTRIBUTION

A. General

Soils are important from the standpoint of agriculture, vegetation, soaking up of rainfall and snowmelt, disposal of domestic wastewater by means of septic tanks and seepage beds, slope stability, and for the disposal of industrial and municipal wastewater by spray irrigation and ridge-and-furrow spreading.

Soil is composed principally of weathered rock material, organic matter, and water. It is derived from the physical and chemical alteration of parent bedrock, alluvium, and glacial deposits. Soil characteristics are determined by such factors as the nature of the parent material, topography, climate, plants and animals living on or in it, and time. Thin soil generally develops on steep slopes and thick soil on gentle or flat slopes including flood plains and flattish upland areas. Colluvial soil is that which has moved downslope to an "out-of-place" position.

B. Classification

Soils vary in color, texture, structure, and degree of compaction. Color is affected by the parent material, leaching and oxidation of minerals in the soil, organic matter, and vegetation types. Texture refers to the size, shape, and abundance of constituent particles. A textural classification delineates such types as sand, loam, and clay, and various combinations of those. Texture is an important property as it affects the permeability of soil. Soil structure refers to the manner in which discrete particles are arranged and held together as an aggregate. Different soil structures are described as crumb, granular, blocky, columnar, and platy.

Soils are generally classified in "soil series" according to their properties. They are placed in various series on the basis of profile characteristics determined from cores. Names applied to soil series are names of towns or physiographic features (such as the Monongahela Valley terraces).

Soil series are generally mapped at a scale of 1:20,000 or larger. Smaller scale regional mapping is done to show the distribution of "soil associations" which are groupings of soil series. The General Soil Map (Figure 2.1.3.-1) is a soil associations map of the region. It is adapted from an "Environmental Resources Inventory of the Pittsburgh District" of the U.S. Army Corps of Engineers. It is useful in making general comparisons of soils in the study area but not for planning specific land uses. Soil interpretations for wastewater disposal suitability are based almost entirely on the soil series category. Soil associations ordinarily contain one or more major soil series and at least one minor soil series. Soil series in a given soil association may also occur in another association, but commonly in a different pattern, that is, with different proportions of the series that compose the association.

C. Mapping

The accompanying General Soil Map (Figure 2.1.3.-1) produced by the U.S. Army Corps of Engineers (1976), shows soil associations that occur in a consistent, defined geographic pattern. Each association normally consists of a few major soils and several others that are less extensive. The name of an association is derived from the soil of greatest areal extent. As may be noted, major soils in one association may occur in one or several other associations.

Soils within one association are closely related geographically but may differ widely in their properties such as slope, depth, texture, or natural drainage. Because of such differences, the soils within the association may vary in their suitability for agriculture and/or non-agricultural use. A general soil map such as this is adequate only for the purpose of getting a broad, overall picture of relative conditions across a county or region but not for specific selection of sites or for design purposes.

The best and most recent state and regional soil maps were utilized in compiling the General Soil Map. The table, Soil Properties and Limitations Affecting Selected Land Uses (Table 2.1.3.-1) lists and describes major soils in each association. For the soils of the region, it summarizes their natural drainage and physiographic position, their texture and soil profile, slope range, depth to rock, and seasonal high-water table, permeability, engineering classification, and use limitations. The major soil limitations for most engineering and agricultural uses in the project area are steep slopes and seasonal wetness. The wetness problem is most often caused by fragipan which is a dense, firm layer at varied depths that in effect causes a high-water table, normally during the spring months. Shallow soils generally are associated with steep slopes. These two factors, steep slopes with their associated thin soils and seasonal wetness, combine to impose severe restrictions on most uses other than those associated with forestry recreation and wildlife.

Soil association maps are available for 12 of the 19 counties in the ORBES Region (Allegheny, Armstrong, Beaver, Butler, Clarion, Clearfield, Indiana, Jefferson, Lawrence, Mercer, Venango, and Westmoreland). Some maps are in color, some in black and white. Most of them are at a scale of about 4 miles to an inch. Others are at 3, approximately 5, and approximately 8 miles to an inch. Accompanying each map is a brief description of soil associations in the county. The available county soil maps and descriptions of soil associations are included in Appendix VII.

2.1.3.2 SOIL SUITABILITY FOR WASTE DISPOSAL

A. Methods

A Comprehensive Water Quality Management Plan (COWAMP) study of the Upper Allegheny River basin (Study Area 8) has been undertaken by the Pennsylvania Department of Environmental Resources. The following information on methods of disposal of wastewater, and on the evaluation of soil for wastewater disposal is from a preliminary draft copy of a 1975 report of that study.

The "no-discharge" policy of the Federal Water Pollution Control Act Amendments of 1972 has resulted in a great deal of recent interest in land disposal of wastewater and treatment process residues which may contain viruses, bacteria, antibiotics, hormones, nutrients, herbicides, fungicides, pesticides, heavy metals and toxic chemical compounds. Successful land disposal is dependent on the ability of the soil to remove these substances without contamination of ground and surface water.

Land disposal of wastes has been practiced for centuries through use of privies, cesspools and septic tanks. Basic elements of a standard septic tank - seepage bed system are depicted in Figure 2.1.3.-2. Waste effluent from the home enters the septic tank, a watertight steel or concrete container which removes solids from wastewater so that effluent from the tank will be transmitted more easily through soil. Suspended particulate matter in the sewage settles and accumulates as sludge in the bottom of the tank. Anaerobic biological decomposition of organic matter in the sludge reduces its volume and releases methane, carbon dioxide, ammonia and soluble organic compounds. A scum of solids also forms at the water surface; both sludge and scum accumulations should be removed from the tank periodically to prevent overflow into the disposal field. Effluent from the tank is disposed of in a seepage bed consisting of one or more trenches partially filled with gravel. Drain pipes are placed on top of gravel along the length of each trench, then earth is filled into the surface. Drain pipes allow effluent to flow into the gravel trenches where it discharges evenly into the soil.

Where physical conditions (i.e. slope, soil, etc.) are not conducive to a standard septic system, the Department of Environmental Resources will permit use of alternative methods such as an elevated sand mound, a sand-lined trench, an oversize area, or a method devised for shallow placement areas. These alternative methods must be designed by a registered professional engineer, and must be used with extreme caution.

Spray irrigation, a relatively new method of disposing of municipal sewage effluent in the United States, has been used in Europe for centuries; however, spray irrigation, (or a modification, ridge-and-furrow spreading) has a respectable history of use in the United States by the food processing industry for disposal of seasonal wastes.

In any system for renovating wastewater through spray irrigation, sewage generally is pretreated to remove suspended solids. The effluent is then pumped by pipeline to forested and agricultural areas where it is sprinkled onto land surface. In the forest, nutrients (predominantly nitrogen and phosphorus) from the wastewater are cycled and recycled through trees, leaves, other vegetation, and the forest floor. Nutrients from water sprayed on agricultural areas are taken up by plants which eventually are harvested. As remaining wastewater seeps through soil into the groundwater reservoir, a certain amount of renovation takes place, thus, plants and soil act as a natural filter for the effluent. If the system is properly designed and operated, high-quality water is recharged to the groundwater reservoir. This renovated water can then be drawn up through wells to supplement natural groundwater supply, or eventually be discharged to rivers and lakes.

Sludge is the solid phase by-product of physical, chemical or biological treatment of wastewater. As it comes from the treatment-plant processing stream, solids content is low (less than 5%), so sludge usually is dewatered to increase the solids content and reduce cost of ultimate disposal. Treated sludge may be landfilled, incinerated, or spread onto the land surface. Untreated sludge (under strict control) may be sprayed directly onto land surface in agricultural or forested areas similar to the spray irrigation of effluent.

The major residues of coal-fired power plants include: (a) fly ash, (b) bottom ash (defined as bottom ash and boiler slag), and (c) flue gas desulfurization (FGD) sludge resulting from the removal of sulfur dioxide from the combustion gases. In the Pennsylvania ORBES Region most coal ash disposal sites are located in ravines or basins with deposition depths ranging from 200 to 300 feet. The land consumed for disposal ranges from 240 acres (for a 1,000 MW plant with 10-yr. life, operating @ 70% l.f.) to 1,000 acres (for a similar plant with a 30-yr. life) (Bern, 1976). Perhaps the most outstanding disposal location within the study area is the Little Blue Run Valley site in Beaver County. This 8.2 million cubic yard, man-made impoundment accommodates the wastes of the Bruce Mansfield plant and was named one of ten outstanding engineering achievements of 1976 by the National Society of Professional Engineers. This site and other industrial waste disposal sites of the Pennsylvania ORBES Region are listed in Table 2.1.3.-2.

B. <u>Site Suitability</u>

Land disposal of municipal wastes is permitted through the Pennsylvania Department of Environmental Resources which sets standards for all sewage disposal facilities in the Commonwealth. Table 2.1.3.-3 summarizes important criteria and standards for land disposal of wastes as established by DER.

It has been determined in the COWAMP study that in 16 counties of the Pennsylvania ORBES Region a small percentage of the land is suitable for spray irrigation and sludge disposal (Table 2.1.3.-3). This is probably also true of the other three counties (Clearfield, Cambria, Somerset) for which such data are not yet available. Because of the low percentage of area suitable for conventional septic systems alone, areas suitable for septic tanks includes both alternate and standard systems (Table 2.1.3.-4). Areas suitable for only standard septic tank disposal systems closely coincide with those suitable for spray irrigation and sludge disposal.

The generally negative results of soil-suitability evaluation in the study area point out the need for thorough site evaluation before designing a land disposal system. In addition, if large-scale spray irrigation of treated effluent is considered as an alternative to other methods of wastewater treatment and disposal, a close look at current standards, controls, and criteria may be required.

Coal ash and FGD sludge disposal sites should include a stable foundation, control programs for groundwater and surface water contamination, and slope stabilization by revegetation. Fly ash and bottom ash sites may cover a wide variety of topographic situations. In some instances the residues may be pumped to the final disposal site without further processing. In ravine or slope site disposal the material must be handled as required to maintain the structural integrity of the area. In some ravine operations, fly ash and bottom ash are mixed to optimize the shear strength characteristics of the fill. Moisture content of this material is carefully controlled and vibratory compactors may be employed. Several proposed sites are considering mixing dry fly ash with FGD sludge in ratios needed to lower the resultant moisture content for the maintenance of structural stability.

TABLE 2.1.1.-1

Recoverable coal reserves of Pennsylvania over 24, 28, and 36 inches thick by counties and rank as of January 1, 1970 (millions of short tons).

FIELD COUNTY[1]	Recoverable reserves over 24 inches thick						Recoverable reserves over 28 inches thick						Recoverable reserves over 36 inches thick					
	Total > 24"	High-vol. bituminous	Med.-vol. bituminous	Low-vol. bituminous	Semi-anthracite	Anthracite	Total > 28"	High-vol. bituminous	Med.-vol. bituminous	Low-vol. bituminous	Semi-anthracite	Anthracite	Total > 36	High-vol. bituminous	Med.-vol. bituminous	Low-vol. bituminous	Semi-anthracite	Anthracite
MAIN BITUMINOUS AND GEORGES CREEK FIELDS																		
Allegheny	850	850	–	–	–	–	680	680	–	–	–	–	260	260	–	–	–	–
Armstrong	1,200	1,200	–	–	–	–	1,100	1,100	–	–	–	–	830	830	–	–	–	–
Beaver	680	680	–	–	–	–	350	350	–	–	–	–	200	200	–	–	–	–
Blair	11	–	8	3	–	–	9	–	7	2	–	–	3	–	2	1	–	–
Butler	1,100	1,100	–	–	–	–	860	860	–	–	–	–	370	370	–	–	–	–
Cambria	1,400	–	560	840	–	–	1,000	–	400	600	–	–	390	–	160	230	–	–
Cameron	18	12	6	–	–	–	13	9	4	–	–	–	0	0	0	–	–	–
Centre	120	–	120	–	–	–	83	–	83	–	–	–	3	–	3	–	–	–
Clarion	630	630	–	–	–	–	450	450	–	–	–	–	80	80	–	–	–	–
Clearfield	1,000	250	750	–	–	–	710	180	530	–	–	–	90	22	68	–	–	–
Clinton	15	–	15	–	–	–	9	–	9	–	–	–	6	–	6	–	–	–
Elk	140	140	–	–	–	–	110	110	–	–	–	–	46	46	–	–	–	–
Fayette	2,500	2,000	500	–	–	–	2,100	1,700	400	–	–	–	1,100	830	270	–	–	–
Greene	4,500	4,500	–	–	–	–	4,000	4,000	–	–	–	–	2,700	2,700	–	–	–	–
Indiana	2,100	1,600	500	–	–	–	1,700	1,300	400	–	–	–	630	470	160	–	–	–
Jefferson	1,100	1,100	–	–	–	–	880	880	–	–	–	–	260	260	–	–	–	–
Lawrence	160	160	–	–	–	–	150	150	–	–	–	–	77	77	–	–	–	–
McKean	130	130	–	–	–	–	98	98	–	–	–	–	5	5	–	–	–	–
Mercer	110	110	–	–	–	–	82	82	–	–	–	–	21	21	–	–	–	–
Somerset	2,000	–	1,000	1,000	–	–	1,600	–	800	800	–	–	670	–	340	330	–	–
Venango	120	120	–	–	–	–	81	81	–	–	–	–	7	7	–	–	–	–
Washington	4,300	4,300	–	–	–	–	3,800	3,800	–	–	–	–	2,600	2,600	–	–	–	–
Westmoreland	2,200	1,700	500	–	–	–	1,900	1,500	400	–	–	–	1,300	1,000	260	–	–	–
Field Totals	27,000	21,000	4,000	1,800	–	–	22,000	17,000	3,000	1,400	–	–	12,000	9,800	1,300	560	–	–

From Edmunds, 1972

TABLE 2.1.1.-2

In-place Coal Reserves of Pennsylvania by Counties as of January 1, 1970 (Millions of short tons)

Field County	Minimum thickness included	Mined out and lost to 1/1/70	Remaining in-place reserves 1/1/70
MAIN BITUMINOUS AND GEORGES CREEK FIELDS			
Allegheny	18"	1,800	1,400
Armstrong	"	430	3,300
Beaver	14"	34	2,500
Blair	18"	35	43
Butler	14"	230	3,400
Cambria	18"	1,500	3,900
Cameron	"	2	59
Centre	"	140	370
Clarion	"	190	1,900
Clearfield	"	680	3,300
Clinton	"	40	75
Elk	"	100	460
Fayette (not specified but 24" or less)		2,300	5,300
Greene	18"	610	8,900
Indiana	"	900	5,400
Jefferson	"	430	2,900
Lawrence	14"	44	740
McKean	18"	1	420
Mercer	"	110	390
Somerset	"	610	5,500
Venango	"	17	380
Washington	"	1,600	8,900
Westmoreland	"	1,800	4,600
Total	14" & 18"	14,000	64,000

TABLE 2.1.1.-3

In-place Reserves of the Pittsburgh Coal as of January 1, 1970 (Millions of tons)

County	Remaining in-place reserves over 14 in. (millions of tons)	Remaining in-place reserves over 28 in.* (millions of tons)
Allegheny	36	36
Armstrong	10	10
Beaver	Exhausted	Exhausted
Fayette	19	19
Greene	3,700	3,700
Indiana	5	5
Somerset	31	31
Washington	3,200	3,200
Westmoreland	140	140
Total for Pa.	7,100	7,100*

* Over 99% of the reserves over 28 inches thick are also over 42 inches thick.

Figures are rounded to first two digits (or first digit if 9 million or less). Figures do not add to total due to independent rounding.

From Edumunds, 1972

TABLE 2.1.1.-4

Estimated strippable coal reserves of 16 southwestern Pennsylvania counties, January 1, 1968, by seams (thousands of short tons).[1]

Coal Seam	Remaining coal in place with 0-120 feet of overburden	Remaining coal in place with 0-120 feet of overburden less 20% mining loss	Remaining coal in place with overburden = to 15X average seam thickness less 20% mining loss
Washington	76,100	60,900	34,700
Waynesburg	188,400	150,700	71,800
Sewickley	22,900	18,400	9,600
Redstone	65,200	52,200	20,100
Pittsburgh	72,000	57,600	37,900
Brush Creek	1,000	800	300
Mahoning	5,900	4,700	2,000
Upper Freeport	596,800	477,300	194,500
Lower Freeport	312,000	249,600	99,800
Upper Kittanning	154,300	123,500	46,700
Middle Kittanning	145,900	116,800	41,900
Lower Kittanning	306,000	244,800	89,900
Clarion[2]	95,900	76,400	30,200
Brookville[3]	142,700	114,200	46,100
Upper Mercer[4]	34,200	27,400	11,300
Lower Mercer	29,900	24,000	8,300
Quakertown	800	600	200
Sharon	22,900	18,300	7,000
Total	2,272,500	1,818,200	752,300

[1] Adapted from Table A62 of *The reserves of bituminous coal and lignite for strip mining in the United States*, U. S. Bureau of Mines, Information Circular 8531.

[2] Referred to as "Upper Clarion" in Table 59 of U. S. Bureau of Mines report.

[3] Revised from Table 59 of U. S. Bureau of Mines report by adding "Lower Clarion" tonnage from Clarion County and subtracting "Brookville" tonnage from Clarion County.

[4] Revised from Table 59 of U. S. Bureau of Mines report by adding "Brookville" tonnage from Clarion County and "Homewood" tonnage from Lawrence County.

From Edmunds, 1972

TABLE 2.1.1.-5

Estimated strippable coal reserves of 16 southwestern Pennsylvania counties, January 1, 1968, by counties and seams (thousands of short tons).[1]

County Seam	Ave. seam thickness (inches)	Remaining coal in place with 0-120 feet of overburden	Remaining coal in place with 0-120 feet of overburden less 20% mining loss	Remaining coal in place with overburden = to 15X average seam thickness, less 20% mining loss
Allegheny Co.				
Redstone	39	30,900	24,700	9,600
Pittsburgh	63	7,800	6,200	3,900
Upper Freeport ..	68	9,500	7,600	5,200
Total		48,200	38,500	18,700
Armstrong Co.				
Pittsburgh	66	5,000	4,000	2,600
Upper Freeport ..	38	94,400	75,500	28,700
Lower Freeport ..	41	42,900	34,300	14,100
Upper Kittanning	32	18,700	15,000	4,800
Lower Kittanning	36	55,900	44,700	16,100
Total		216,900	173,500	66,300
Beaver Co.				
Brush Creek	36	1,000	800	300
Mahoning	42	5,900	4,700	2,000
Upper Freeport ..	42	50,900	40,700	17,100
Lower Freeport ..	36	11,100	8,900	3,200
Middle Kittanning	36	4,200	3,400	1,200
Lower Kittanning	42	6,500	5,200	2,200
Total		79,600	63,700	26,000
Butler Co.				
Upper Freeport ..	41	125,300	100,200	41,100
Lower Freeport ..	43	52,000	41,600	17,900
Middle Kittanning	37	75,200	60,200	22,300
Clarion	45	54,400	43,500	18,700
Total		306,900	245,500	100,000
Cambria Co.				
Upper Freeport ..	36	22,000	17,600	6,300
Lower Freeport ..	35	19,300	15,400	5,400
Upper Kittanning	37	23,200	18,600	6,900
Middle Kittanning	35	1,400	1,100	400
Lower Kittanning	39	26,900	21,500	8,400
Total		92,800	74,200	27,400
Clarion Co.				
Upper Freeport ..	43	26,700	21,400	9,200
Lower Freeport ..	46	28,400	22,700	10,400
Middle Kittanning	35	6,500	5,200	1,800
Lower Kittanning	35	57,000	45,600	16,000
Clarion ("Upper Clarion")	35	41,100	32,900	11,500
Brookville ("Lower Clarion")	34	53,800	43,000	14,600
Upper Mercer ("Brookville")	41	23,200	18,600	7,600
Total		236,700	189,400	71,100

(continued)

Table 5 (continued)

County Seam	Ave. seam thick-ness (inches)	Remaining coal in place with 0-120 feet of overburden	Remaining coal in place with 0-120 feet of overburden less 20% mining loss	Remaining coal in place with overburden = to 15 X average seam thickness, less 20% mining loss
Clearfield Co.				
Upper Freeport ..	33	40,800	32,600	10,800
Lower Freeport ..	38	83,700	67,000	25,500
Upper Kittanning	36	47,400	37,900	13,700
Middle Kittanning	34	39,100	31,300	10,600
Lower Kittanning	37	70,300	56,200	20,800
Brookville	44	17,500	14,000	6,200
Total		298,800	239,000	87,600
Fayette Co.				
Waynesburg	44	41,200	33,000	14,500
Sewickley	51	14,200	11,400	5,800
Pittsburgh	85	4,100	3,300	2,800
Upper Freeport ..	42	62,600	50,100	21,000
Total		122,100	97,800	44,100
Greene Co.				
Waynesburg	62	53,400	42,700	26,500
Sewickley	54	8,700	7,000	3,800
Pittsburgh	76	8,200	6,600	5,000
Total		70,300	56,300	35,300
Indiana Co.				
Pittsburgh	62	700	600	400
Upper Freeport ..	44	52,000	41,600	18,300
Lower Freeport ..	40	22,000	17,900	7,200
Lower Kittanning	38	20,200	16,200	6,200
Total		93,300	76,300	32,100
Jefferson Co.				
Upper Freeport ..	37	43,300	34,600	12,800
Lower Freeport ..	40	29,100	23,300	9,300
Lower Kittanning	30	28,200	22,600	6,800
Brookville	39	29,200	23,400	9,100
Total		129,800	103,900	38,000
Lawrence Co.				
Upper Freeport ..	42	2,400	1,900	800
Lower Freeport ..	42	8,700	7,000	2,900
Middle Kittanning	36	19,500	15,600	5,600
Lower Kittanning	36	2,100	1,700	600
Homewood	42	9,000	7,200	3,000
Upper Mercer ...	42	2,000	1,600	700
Lower Mercer ...	42	1,700	1,400	600
Quakertown	36	800	600	200
Total		46,200	37,000	14,400

(continued)

Table 5 (concluded)

County Seam	Ave. seam thickness (inches)	Remaining coal in place with 0-120 feet of overburden	Remaining coal in place with 0-120 feet of overburden less 20% mining loss	Remaining coal in place with overburden = to 15 × average seam thickness, less 20% mining loss
Mercer Co.				
Brookville	48	42,200	33,800	16,200
Lower Mercer ...	34	28,200	22,600	7,700
Sharon	38	22,900	18,300	7,000
Total		93,300	74,700	30,900
Somerset Co.				
Redstone	41	9,600	7,700	3,200
Pittsburgh	41	9,500	7,600	3,100
Upper Freeport ..	40	38,100	30,500	12,200
Lower Freeport ..	34	14,400	11,500	3,900
Upper Kittanning	41	65,000	52,000	21,300
Lower Kittanning	41	38,900	31,100	12,800
Total		175,500	140,400	56,500
Washington Co.				
Washington	57	76,100	60,900	34,700
Waynesburg	41	93,800	75,000	30,800
Redstone	35	7,200	5,800	2,000
Pittsburgh	65	27,300	21,800	14,200
Total		204,400	163,500	81,700
Westmoreland Co.				
Redstone	38	11,700	14,000	5,300
Pittsburgh	79	9,400	7,500	5,900
Upper Freeport ..	48	28,800	23,000	11,000
Total		55,700	44,500	22,200
Grand Total		2,272,500	1,818,200	752,300

[1] Unpublished data from U. S. Bureau of Mines.

From Edmunds, 1972

TABLE 2.1.1.-6

Estimated strippable coal reserves of 16 southwestern Pennsylvania counties, January 1, 1968, by seam and sulfur content (thousands of short tons).[1,2]

Seam	Low Sulfur[2] (0-1%)	Medium Sulfur[2] (1-2%)	High Sulfur[2] (over 2%)
Washington	—	—	34,700
Waynesburg	—	—	71,800
Sewickley	—	—	9,600
Redstone	—	12,800[6]	7,500
Pittsburgh	—	32,500[7]	5,400
Brush Creek	—	—	300
Mahoning	—	—	2,000
Upper Freeport	—	52,800[8]	141,700
Lower Freeport	—	60,600[9]	38,400
Upper Kittanning	—	21,300[10]	25,400
Middle Kittanning	—	—	41,900
Lower Kittanning	—	23,400[11]	66,500
Clarion[3]	—	18,700[12]	11,200
Brookville[4]	—	—	46,100
Upper Mercer[5]	—	—	17,600
Lower Mercer	—	—	8,300
Quakertown	—	—	200
Sharon	—	7,000[13]	—
Total	—	229,100	523,200

[1] Adapted from Table A64 of *The reserves of bituminous coal and lignite for strip mining in the United States*, U. S. Bureau of Mines, Information Circular 8531.

[2] Based on the *average* "as received" sulfur content of each seam for each county. The *entire* tonnage of each seam for each county is assigned to the sulfur category corresponding to that seam's *average* sulfur content in that county.

[3] Referred to as "Upper Clarion" in Table 61 of U. S. Bureau of Mines report.

[4] Revised from Table 61 of U. S. Bureau of Mines report by adding "Lower Clarion" tonnage from Clarion County and subtracting "Brookville" tonnage from Clarion County.

[5] Revised from Table 61 of U. S. Bureau of Mines report by adding "Brookville" tonnage from Clarion County and "Homewood" tonnage from Lawrence County.

[6] Allegheny and Somerset Counties.

[7] Allegheny, Armstrong, Fayette, Somerset, Washington, and Westmoreland Counties.

[8] Allegheny, Cambria, Clearfield, Indiana, and Somerset Counties.

[9] Beaver, Butler, Clearfield, Indiana, Lawrence, and Somerset Counties.

[10] Somerset County.

[11] Beaver, Cambria, and Somerset Counties.

[12] Butler County.

[13] Mercer County.

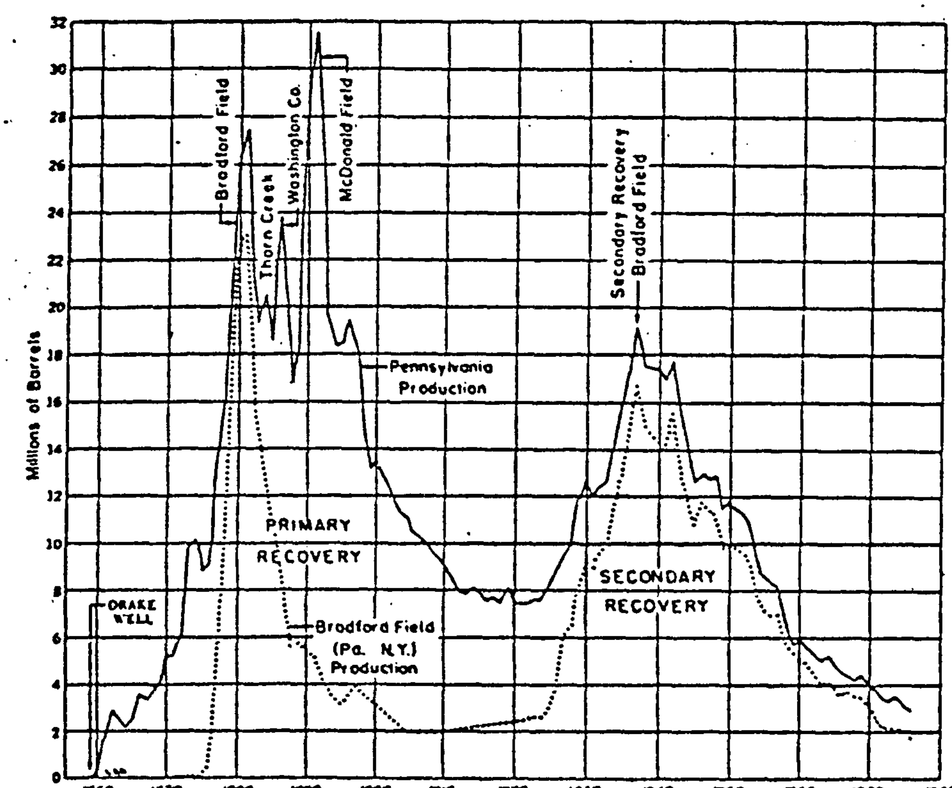
From Edmunds, 1972

		Production				Reserves		
		1976	1975	% Change	Cumulative to 12/31/76	1976	1975	% Change
Oil (1,000 bbls.)	Penna. Grade	2,887	3,132	- 8	1,288,944	49,975	47,377	+ 5
	Corning Grade	63	67	- 6	620	588	651	-10
	TOTAL OIL	2,950	3,199	- 8	1,289,564	50,563	48,028	+ 5
	Natural Gas Liquids (1,000 bbls.)	69	65	+ 6	---	446	515	-13
Gas (MMcf)	Shallow	76,632	72,620	+ 6	---	---	---	---
	Deep	13,342	12,152	+10	---	---	---	---
	TOTAL GAS	89,974	84,772	+ 6	9,013,560	1,651,898*	1,682,460*	- 2
	Stored Recoverable Gas					512,861	596,324	-14

*Stored Recoverable Gas Included

From Lytle, 1977

TABLE 2.1.1.-7 Production and reserves of oil and gas in Pennsylvania



From Lytle, 1977

FIGURE 2.1.1.-11 Annual production of crude oil in Pennsylvania

From Pennsylvania Department of Environmental Resources, COWAMP report, Study Area 9 (197

Weather Station	County	Monthly Mean Precipitation - Inches (Recorded 1941-1970)																Annual
		Jan.	Feb.	March	Winter Average	April	May	June	Spring Average	July	Aug.	Sept.	Summer Average	Oct.	Nov.	Dec.	Fall Average	
Pittsburgh AP WSO2	Allegheny	2.79	2.35	3.60	2.91	3.40	3.63	3.48	3.50	3.84	3.15	2.52	3.17	2.52	2.47	2.48	2.49	36.23
Pittsburgh City WSO	Allegheny	2.61	2.29	3.58	2.82	3.44	3.59	3.74	3.59	3.78	3.18	2.53	3.16	2.47	2.49	2.52	2.49	36.22
Acmetonia Lock 3	Allegheny	2.91	2.59	3.73	3.07	3.83	3.69	3.89	3.80	4.13	3.65	2.68	3.48	2.82	2.90	2.74	2.82	39.56
McKeesport	Allegheny	2.61	2.25	3.40	2.75	3.41	3.63	3.81	3.61	3.71	3.34	2.57	3.20	2.29	2.52	2.43	2.41	35.97
Bruceton	Allegheny	2.67	2.30	3.38	2.78	3.45	3.63	4.24	3.77	4.19	3.56	2.79	3.51	2.42	2.59	2.60	2.53	37.82
Putneyville 2SE DAM	Armstrong	3.05	2.78	3.72	3.18	4.09	4.27	3.76	4.04	4.43	3.75	3.32	3.83	3.22	3.25	2.96	3.14	42.60
Kittanning Lock 7	Armstrong	2.97	2.73	3.63	3.11	3.87	4.06	3.61	3.84	3.96	3.59	2.92	3.49	2.96	3.05	2.99	2.99	40.32
Sagamore 1S	Armstrong	3.14	2.59	3.82	3.18	3.91	4.47	3.73	4.03	4.30	3.73	3.25	3.76	3.21	3.33	3.06	3.20	42.56
Whitesburg	Armstrong	3.04	2.68	3.56	3.09	3.90	4.06	4.02	3.99	4.34	3.63	3.15	3.70	3.06	3.24	3.07	3.12	41.75
Ford City 4S DAM	Armstrong	2.74	2.48	3.46	2.89	3.70	4.04	3.74	3.82	4.26	3.81	2.98	3.68	2.98	2.89	2.66	2.84	39.74
Schenley Lock 5	Armstrong	2.88	2.65	4.01	3.18	3.87	3.92	3.71	3.83	3.96	3.56	2.86	3.46	2.74	2.90	2.80	2.81	35.86
Natrona Lock 4	Armstrong	2.78	2.47	3.61	2.95	3.81	3.73	3.81	3.80	4.20	3.67	2.70	3.52	2.74	2.79	2.64	2.72	39.00
Montgomery L & D	Beaver	2.64	2.26	3.43	2.77	3.60	3.71	3.37	3.56	4.01	3.16	2.70	3.29	2.62	2.64	2.42	2.56	36.56
Beaver Falls	Beaver	2.51	2.15	3.10	2.58	3.18	3.66	3.62	3.48	3.79	3.14	2.68	3.20	2.70	2.49	2.29	2.49	35.31
Newell	Fayette	2.82	2.32	3.55	3.89	3.76	3.99	3.83	3.86	4.17	3.53	3.07	3.59	2.45	2.84	2.68	2.65	39.01
Uniontown 1 NE	Fayette	2.96	2.43	3.65	3.01	3.62	4.24	4.25	4.03	3.97	3.63	3.05	3.55	2.63	2.91	2.71	2.75	40.05
Connellsville 3	Fayette	2.78	2.28	3.46	2.84	3.66	4.30	4.07	4.01	4.31	3.89	3.23	3.81	2.59	2.77	2.73	2.69	40.07
Confluence 1NW	Fayette	3.26	2.82	3.95	3.31	3.74	4.06	4.32	4.04	4.58	3.98	3.12	3.89	2.77	2.97	3.20	2.98	42.67
Waynesburg 1E	Greene	2.73	2.26	3.56	2.86	3.56	4.12	3.86	3.84	4.36	3.57	2.95	3.62	2.46	2.61	2.54	2.53	38.54
Greensboro Lock 7	Greene	2.77	2.35	3.54	2.88	3.46	3.76	3.95	3.73	4.45	3.93	3.00	3.79	2.40	2.65	2.56	2.53	38.80
Marion Center 2SE	Indiana	3.41	2.98	4.03	3.47	4.23	4.60	4.14	4.32	4.58	4.00	3.22	3.93	3.16	3.53	3.44	3.37	45.32
Creekside	Indiana	3.02	2.62	3.61	3.08	3.94	4.24	4.01	4.06	4.76	3.78	3.08	3.87	2.92	3.31	2.93	3.05	42.22
Blairsville 6ENE	Indiana	3.63	3.15	4.17	3.65	4.37	4.79	4.77	4.64	4.88	4.17	3.25	4.10	3.19	3.65	3.56	3.46	47.58
Claysville 3SE	Washington	2.83	2.38	3.57	2.92	3.64	4.12	3.68	3.81	4.25	3.48	3.08	3.60	2.59	2.73	2.54	2.62	38.89
Charleroi	Washington	2.79	2.35	3.72	2.95	3.66	3.83	3.41	3.63	3.94	3.45	2.91	3.43	2.47	2.79	2.63	2.63	37.93
Derry	Westmoreland	3.14	2.57	3.80	3.17	4.34	4.37	3.80	4.50	5.01	3.99	3.10	4.03	3.11	3.41	3.07	3.19	44.71
New Stanton	Westmoreland	3.10	2.64	3.63	3.12	3.51	4.10	3.81	3.80	4.04	4.00	3.16	3.73	2.84	2.79	2.87	2.83	40.49
Donora	Westmoreland	2.47	2.21	3.50	2.72	3.36	3.84	3.57	3.59	3.75	3.66	2.72	3.37	2.60	2.52	2.35	2.49	36.55
Vandergrift	Westmoreland	2.70	2.48	3.55	2.91	3.73	3.93	4.04	3.90	4.27	3.69	2.82	3.59	3.01	2.81	2.66	2.82	39.69
Average		2.78	2.49	3.63	3.00	3.72	4.01	3.90	3.88	4.21	3.64	2.95	3.60	2.76	2.89	2.76	2.80	39.84

Table 2.1.2.-1 Monthly mean precipitation at 30 weather stations in ORBES region

From Pennsylvania Department of Environmental Resources, COWAMP report, Study Area 8 (1975)

WEATHER STATION	COUNTY	MONTHLY MEAN PRECIPITATION-INCHES (RECORDED 1941-1970)																	ANNUAL
		JAN.	FEB.	MARCH	WINTER AVERAGE	APRIL	MAY	JUNE	SPRING AVERAGE	JULY	AUG.	SEPT.	SUMMER AVERAGE	OCT.	NOV.	DEC.	FALL AVERAGE	
BRADFORD 4W RES.	McKEAN	2.93	2.66	3.44	2.97	4.06	4.34	4.47	4.29	4.71	3.54	3.87	4.04	3.43	4.16	3.13	3.57	44.64
BRADFORD F.A.A. A.P.	McKEAN	3.17	2.85	3.45	3.15	3.79	4.20	3.85	3.94	4.29	3.36	3.46	3.70	3.16	3.56	3.01	3.24	42.15
KANE 1NE	McKEAN	3.25	2.81	3.67	3.24	4.14	4.71	4.17	4.34	4.93	3.78	3.94	4.21	3.44	3.78	3.16	3.45	45.76
WARREN	WARREN	2.71	2.40	3.333	2.81	3.70	4.22	4.40	4.10	4.46	3.63	3.58	3.89	3.42	3.83	3.01	3.42	42.69
MEADVILLE 1S	CRAWFORD	2.79	2.48	3.32	2.85	3.77	4.20	4.23	4.06	4.50	3.71	3.09	3.76	3.67	3.50	2.86	3.34	42.10
JAMESTOWN 2NW	CRAWFORD	2.55	2.16	3.06	2.59	3.76	4.08	3.93	3.92	3.88	3.23	3.04	3.38	3.12	3.15	2.47	2.91	38.42
* FRANKLIN	VENANGO	2.85	2.33	3.12	2.76	3.88	4.22	3.88	3.99	4.40	3.32	3.10	3.60	3.17	3.43	2.63	3.07	40.33
* TIONESTA 2SE DAM	FOREST	2.98	2.61	3.46	3.01	4.17	4.56	3.80	4.17	4.35	3.32	3.12	3.59	3.32	3.50	2.94	3.25	42.13
* CLARION 3SW	CLARION	3.02	2.67	3.58	3.09	4.06	4.33	3.88	4.09	4.57	3.47	2.98	3.67	3.12	3.34	2.91	3.12	41.93
* RIDGWAY	ELK	2.72	2.40	3.40	2.84	3.86	4.45	3.80	4.03	4.69	3.62	3.22	3.81	2.92	3.27	2.82	3.00	41.07
* GREENVILLE	MERCER	2.79	2.28	3.25	2.77	3.94	4.04	4.06	4.01	3.94	3.41	2.65	3.33	3.23	3.25	2.62	3.00	39.36
* FARRELL-SHARON	MERCER	2.64	2.16	2.95	2.58	3.41	3.85	3.63	3.63	3.55	3.47	2.43	3.15	2.62	2.87	2.46	2.65	36.04
* NEW CASTLE 1N	LAWRENCE	2.74	2.32	3.28	2.78	3.47	3.87	3.73	3.69	4.09	3.18	2.71	3.32	2.83	2.76	2.43	2.67	37.41
AVERAGE		2.86	2.46	3.33	2.88	3.85	4.24	3.99	4.02	4.33	3.46	3.17	3.65	3.19	3.41	2.80	3.13	41.07

* Stations in ORBES region

Table 2.1.2.-2 Monthly mean precipitation at 7 weather stations in ORBES region.

From Technical Paper No. 15, U.S. Weather Bureau, 1956
in Pa. DER, Cowamp report, Study Areas 8 and 9, 1975

Town	County	1 Hr	2 Hrs	3 Hrs	6 Hrs	12 Hrs	24 Hrs
Butler	Butler	1.80	2.70	2.85	3.11	3.17	3.86
Rochester	Beaver	1.53	1.80	2.32	3.03	3.21	3.21
Ford City Dam	Armstrong	1.69	1.97	2.14	2.39	2.96	3.92
Vandergrift	Westmoreland	1.89	1.89	1.89	1.92	2.07	2.90
Indiana	Indiana	2.12	2.22	2.40	2.83	2.87	4.12
Strongstown	Indiana	1.87	2.36	2.64	3.26	3.27	4.12
Murrysville	Westmoreland	1.30	1.84	2.18	2.37	2.46	3.24
Greensburg	Westmoreland	1.57	2.26	2.29	2.45	2.75	3.56
Boswell	Westmoreland	2.57	2.77	2.77	2.77	2.77	3.13
Pittsburgh City	Allegheny	2.09	2.29	2.35	2.53	2.53	3.76
Pittsburgh	Allegheny	1.71	2.12	2.14	2.45	2.93	3.14
Washington	Washington	1.80	2.45	3.12	3.48	3.55	4.16
Charleroi	Washington	1.30	1.53	1.81	2.27	2.44	2.53
Connellsville	Fayette	2.21	2.92	2.92	2.94	3.47	4.08
Confluence Dam	Fayette	1.75	1.76	1.84	2.22	3.09	3.22

Town	County	1 Hour	2 Hrs.	3 Hrs.	12 Hrs.	24 Hrs.
*Meadville	Crawford	2.21	2.23	3.23	3.39	4.38
*Titusville	Crawford	2.00	2.53	2.53	3.43	3.88
*Youngsville	Warren	1.75	1.87	1.93	2.55	3.13
*Scandia	Warren	1.40	2.34	2.55	2.83	2.83
*Sheffield	Warren	2.20	2.40	2.75	3.04	3.76
Franklin	Venango	1.74	2.41	2.62	2.87	3.37
Tionesta Dam	Forest	1.65	1.66	1.66	2.54	2.72
Marienville	Forest	2.10	2.17	2.21	3.20	3.41
*Kane	McKean	1.78	1.79	1.79	2.99	3.94
*Smethport	McKean	2.14	2.65	2.83	3.12	4.68
Ridgway	Elk	1.55	1.94	2.06	2.61	3.62
Clarion	Clarion	1.74	2.20	2.48	2.75	3.88
Parker's Landing	Clarion	1.78	2.40	2.48	2.75	3.88
Allens Mills	Jefferson	2.05	2.30	2.35	3.46	3.89
Punxsutawney	Jefferson	1.27	2.00	2.07	3.27	3.32

*Not in ORBES region

Table 2.1.2.-3 Maximum amount of precipitation at various intervals

TABLE 2.1.3.-1

SOIL PROPERTIES AND LIMITATIONS AFFECTING SELECTED LAND USES

SOIL SERIES NAME	NATURAL DRAINAGE AND PHYSIOGRAPHIC POSITION	TEXTURE AND/OR NATURE OF SOIL PROFILE: SURFACE	SUBSOIL	SUBSTRATUM	DOMINANT SLOPE RANGE 2/ (Percent)	DEPTH TO ROCK (Feet)	DEPTH TO SEASONAL HIGH WATER TABLE (Feet)	PERMEABILITY 3/ (inches per hour)	ENGINEERING 4/ CLASSIFICATION (Surface Layer only)	DEGREES AND MAJOR KINDS OF LIMITATIONS 5/: SEPTIC TANK FILTER FIELDS	SANITARY LAND FILL	DWELLINGS WITH BASEMENTS	INDUSTRIAL USE	LOCAL STREETS AND PARKING LOTS	AGRICULTURE (Cultivated crops)	REMARKS
CALVIN	Well drained (Uplands)	Silt loam (shaly)	Silt loam (very shaly)	Red shale and siltstone	3 - 20	1.5 - 3.0	6+	2.0 - 6.0	ML, CL or GM	Severe r,s	Severe r,s	Moderate s	Moderate s	Slight to moderate s	Moderate to severe r,s,d	Soils on favorable topography are in cropland, pasture and idle land. Shaly and steep soils mainly in woodland.
CANADICE	Poor (Lake plains)	Silt loam	Silty clay	Laminated silty clay and silty clay loam	0 - 5	10+	0 - 1 (Dec.-June)	0.06	CL, ML	Severe p,w	Severe w	Severe w	Severe w	Severe w,u,f	Severe w	Developed on sights of old, shallow glacial lakes.
CANANDAIGUA	Somewhat poor (Uplands)	Silt loam	Silty clay	Laminated silty clay and silty clay loam	2 - 8	10+	0.5 - 1.5 (perched, Dec.-May)	0.06 Below 12 in. depth	ML, CL or WH	Severe p,w	Severe w	Severe w,u	Severe w,u	Severe u,f	Moderate to severe w	Soils formed in lake plain deposits. Cleared areas mainly used for pasture and hay; some small grains, corn and grapes. Woodlots contain oak, sugar maple, etc.
CANFIELD	Moderately well (Uplands)	Silt loam	Loam to clay loam	Loam till	2 - 6	10+	1.5 - 3.0 (perched, Nov.-May)	0.06 - 2.0 (0.2-0.6 in the fragipan)	ML	Severe p,w	Severe w	Moderate w	Moderate w	Moderate u,f	Moderate w	Soil contains a strongly developed fragipan - a dense, very firm, brittle (when dry) layer that severely restricts penetration of roots and water.
CAVODE	Somewhat poor (Uplands)	Silt loam	Silty clay loam (somewhat shaly)	Shaly silty clay loam over clay shale	0 - 15	3 - 6	0.5 - 1.5 (perched, Oct.-May)	0.08 - 0.1	ML, CL	Severe p,w	Severe w	Severe w	Severe w,f,s	Severe w,f	Moderate w,s	Soil developed on broad, upland ridgetops and benches.
CHENANGO	Well drained (Uplands)	Gravelly silt loam	Very gravelly silt loam	Water-sorted sand and gravel	0 - 20	10+	6+	0.6 - 6.0	ML, SM or GM	Slight to moderate s	Severe (seepage)	Slight to moderate s	Slight to moderate s	Slight to moderate f	Slight to moderate s,d	Soils formed on glacial outwash plains.
CHILI	Well drained (Terraces and kames)	Loam	Gravelly sandy loam, clay loam	Gravel and sand with some fines	2 - 12	10+	4	2.0 - 0.6	ML, CL	Slight	Severe (seepage)	Slight	Slight	Slight to moderate s	Slight to moderate d,s	
COOKPORT	Well drained (Uplands)	Loam	Clay loam	Channery sandy loam over sandstone	0 - 12	3.5 - 4.0	1.0 - 2.5 (perched, Dec.-Apr.)	0.2 - 0.6 in the fragipan layer	ML, CL	Severe p,w	Severe w	Severe w	Moderate w,s	Slight to moderate w	Moderate w	Contains a fragipan layer at depths ranging from 20 to 35 inches.
CULLEOKA	Well drained (Uplands)	Silt loam	Silt loam (flaggy)	Very flaggy silty clay loam over siltstone or sandstone bedrock	3 - 20	1.5 - 3.0	None	2.0 - 6.0	ML, CL	Severe r,s	Slight to moderate s	Severe r,s	Moderate r,s	Moderate to severe r,s	Severe r,d,s	Surface may contain numerous rock fragments. The volume of fragments increases with depth.
DEKALB	Well drained (Uplands)	Fine sandy loam (stony)	Fine sandy loam (very stony)	Sandstone bedrock	5 - 50	2.5	6+	6.0 - 20.0	SM, GM, ML	Severe r,s	Severe s,p	Severe s,r	Severe s,r	Moderate to severe r,s	Severe s,r,d	
ERIE	Somewhat poor (Uplands)	Silt loam (channery)	Silt loam (very channery)	Channery glacial loam till	0 - 25	6+	0.5 - 1.5 (perched, Dec.-May)	0.06 - 0.2 in the fragipan layer	Gm, ML, or CL	Severe p,w	Severe w,s	Severe w,s	Severe w,s	Moderate to severe w,s	Severe c,w,s	Soil has fragipan.
ERNEST	Moderately well (Uplands)	Silt loam	Silty clay loam	Silty clay loam colluvium	0 - 15	5+	1.5 - 2.5 (perched, Dec.-Apr.)	0.06 - 0.6 in the fragipan layer	ML, CL	Severe p,w	Severe w,s	Severe w,s	Moderate to severe w,s	Moderate f	Slight to moderate s,w	Contains a fragipan of depths of 20 to 30 inches. Soils have formed in colluvial material
GILPIN	Well drained (Uplands)	Silt loam	Silty clay loam	Siltstone and shale bedrock	8 - 65	1.5 - 3.0	3	0.6 - 2.0	ML, CL, or GM	Severe r,s	Severe r,s	Severe r,s	Severe r,s	Moderate to severe r,s	Severe r,s,d	
GUERNSEY	Moderately well (Uplands)	Silt loam	Silty clay loam	Clay	12 - 35	5 - 10	1.5 - 4.0 (perched, Jan.-Apr.)	0.06 - 0.6 in the substrata	ML, ML-CL	Severe p,w,s	Moderate w,s	Severe u,s,w	Severe u,s,w	Severe u,s	Moderate to severe w,s	Soils developed from shale and limestone.
HANOVER	Well drained (Uplands)	Silt loam	Loam, silt loam	Loam till	5 - 30	10+	2.0 - 4.0 (perched, Nov.-Mar.)	0.02 - 0.6 in the fragipan layer	ML, ML-CL	Severe p,w,s	Moderate to severe w,s	Severe w,s	Moderate to severe w,s	Moderate to severe f,s	Moderate to severe w,s	Soil has fragipan at depth 14 to 30 inches. Developed on till plains, moraines and till-covered sandstones hills.
HAZLETON	Well drained (Uplands)	Sandy loam (stony)	Sandy loam (very stony)	Very stony sandy loam over sandstone bedrock	8 - 65	3 - 5	6+	2.0 - 6.0	ML, GW, or SW	Moderate to severe s,r	Severe (seepage)	Moderate to severe s,r	Moderate to severe s,r	Slight to severe s	Severe c,s	
HOWARD	Well drained (Uplands)	Gravelly loam	Very gravelly loam	Stratified sand and gravel	0 - 30	6+	None	0.6 - 2.0	SM, GM, or ML	Slight to severe s	Moderate to severe (seepage)	Slight to moderate s	Slight to severe s	Slight to moderate w	Moderate to severe d,s	Soils occur on outwash plains, kames and eskers. Trench walls unstable due to gravelly soils. Limitations for use primarily dependent on slope.
LANGFORD	Well drained and moderately well (Uplands)	Silt loam (channery)	Loam (channery)	Channery silt loam glacial till	3 - 20	6+	1.5 - 2.0 (perched, Mar.-May)	0.6 - 0.2 in the fragipan	ML, CL or GM	Severe p	Severe w	Slight to moderate w	Slight to moderate w	Severe w,u	Moderate to severe w,c,d	Soil contains a firm brittle fragipan from 20 to 48 inches.
LICKDALE	Very poor (upland flats and depressions)	Silt loam	Sandy clay loam	Loamy sand over sandstone bedrock	0 - 3	3.5 - 6	0.0 - 0.5	0.2	ML	Severe w,p	Severe w	Severe w	Severe w	Moderate to severe f,s	Severe w	Good wild life area. Artificial drainage required to overcome limitations for engineering use.
LORDSTOWN	Well drained (Uplands)	Silt loam (channery)	Silt loam (channery)	Very channery loam over sandstone or siltstone	3 - 30	1.5 - 3.0	6+	0.6 - 2.0	ML, CL, or GM	Severe r,s	Moderate to severe r,s	Severe r,s	Moderate to severe r,s	Moderate to severe r,s	Severe r,s,d	Occurs on very irregular glaciated topography. Use limitations mainly related to shallow soil and steep slopes.
MONONGAHELA	Moderately well (Terraces)	Silt loam	Silty clay loam, silt loam	Stratified sand, silt and clay	2 - 8	10+	1.5 - 3.0 (perched, Jan.-Apr.)	0.6 - 0.6	ML, SM	Severe p,w	Moderate w	Moderate w	Slight to moderate s	Moderate w	Slight to moderate w	Soil has a fragipan at depth of ranging from 18 to 30 inches.
OQUAGA	Well drained (Uplands)	Silt loam (channery)	Silt loam (channery)	Glacial loam (very channery)	3 - 45	1.5 - 3.0	None	0.6 - 2.0	ML, CL, or G	Severe r,s	Moderate to severe r,s	Severe r,s	Severe r,s	Severe r,s	Severe r,s,d	Most of this soil is forested.
PLATEA	Somewhat poor (Uplands)	Silt loam	Silty clay loam	Silt loam	1 - 12	5+	0.5 - 2.0	0.06	ML, ML-CL	Severe p	Moderate w	Severe w	Moderate w,f	Moderate w,f	Moderate to severe w,s	Soil has fragipan. Soils form in glacial till strongly influenced by clayey shales and siltstone.

Continued on next page.

TABLE 2.1.3.-1 (continued)

SOIL SERIES NAME	NATURAL DRAINAGE AND PHYSIOGRAPHIC POSITION	TEXTURE AND/OR NATURE OF SOIL PROFILE: SURFACE	SUBSOIL	SUBSTRATUM	DOMINANT SLOPE RANGE 2/ (Percent)	DEPTH TO ROCK (Feet)	DEPTH TO SEASONAL HIGH WATER TABLE (Feet	PERMEABILITY 3/ (Inches per hour)	ENGINEERING 4/ CLASSIFICATION (Surface Layer only)	DEGREES AND MAJOR KINDS OF LIMITATIONS 5/: SEPTIC TANK FILTER FIELDS	SANITARY LAND FILL	DWELLINGS WITH BASEMENTS	INDUSTRIAL USE	LOCAL STREETS AND PARKING LOTS	AGRICULTURE (Cultivated crops)	REMARKS
RAVENNA	Somewhat poor (Uplands)	Silt loam	Clay loam	Loam till	5 - 50	2.5	6+	6.0 - 20.0	ML, ML-CL	Severe w,p	Moderate w	Severe w	Moderate w	Moderate w,f	Slight	
RAYNE	Well drained (Uplands)	Silt loam	Silt loam or silty clay loam (channery)	Channery silty clay loam	5 - 15	5 - 6	5	0.6 - 2.0	ML, CL	Moderate r,s	Slight to moderate s	Moderate r,s	Moderate r,s	Moderate f,s	Moderate d,s	Formed in materials weathered from shale, siltstone and sandstone.
SHEFFIELD	Poor (Uplands)	Silt loam	Silt loam	Silt loam	0 - 2	5+	0 - 1 (perched, Jan.-Apr.)	0.06 in the fragipan	ML, ML-CL	Severe p,w	Severe w	Severe w	Severe w	Severe w,f	Moderate w	Soil has a fragipan. Developed in glacial till on large flats and upland depressions.
TYGART	Somewhat poor (Terraces)	Silt loam	Silty clay loam	Silty clay alluvium	1 - 8	5 - 10	1.0 - 1.5 (perched, Jan.-Apr.)	0.2 - 0.8 in the sub- soil	ML	Severe w,p	Severe w	Severe w	Moderate to severe w	Moderate to severe w,f	Moderate w	Soil developed in acid material washed from shale, sandstones and siltstone uplands.
UPSHUR	Well drained (Uplands)	Silt loam, silty clay	Silty clay, clay	Clay (stony)	6 - 35	3.5 - 6.0	3.5 - 6.0 (perched, Dec.-Apr.)	0.06 - 0.2 in the sub- soil	CL, MH, or CH	Severe s,p	Moderate to severe s	Severe z,s	Severe z,s	Severe z,s	Severe s,d	Formed in material weathered from shale, or siltstone.
VENANGO	Somewhat poor (Uplands)	Silt loam	Silt loam, silty clay loam	Loam or silt loam till	2 - 5	10+	0.5 - 1.5 (perched, Jan.-Apr.)	0.06 in the sub- soil	ML, CL-ML	Severe w,p	Moderate to severe w	Severe w	Severe w,f	Severe w,f	Moderate w	Soils developed in glacial till.
VOLUSIA	Somewhat poor (Uplands)	Silt loam (channery)	Silt loam, loam (channery)	Channery glacial loam till	0 - 15	6+	0.5 - 1.5 (perched, Dec.-May)	0.2 in the fragipan	ML, CL	Severe w,p	Severe w	Severe w	Severe w,f	Moderate w	Moderate to severe w,c	Contains a fragipan at depths ranging from 10 - 20 inches. Soils have developed in glacial till.
WAYLAND	Poor (Flood plains)	Silt loam	-	Silty clay alluvium	0 - 1	10+	0.0 - 0.5 (Nov.-June)	0.06 - 0.2 in the sub- strata	ML, CL	Severe w,p,x	Severe w,x	Severe w,x	Severe w,x,f	Severe w,x,f	Severe w,x	Soil frequently flooded.
WEIKERT	Well drained (Uplands)	Silt loam (shaly)	Silt loam (very channery)	Very shaly silt loam over shale bedruck	3 - 40	1 - 2	None	2.0 - 6.0	GM, ML	Severe r	Severe r,s	Severe r,s	Severe r,s	Severe r,s	Moderate to severe r,c,s	
WESTMORELAND	Well drained (Uplands)	Silt loam	Silty clay loam	Very channery silt loam over sandstone, shale and limestone	10 - 60	3 - 5	3 - 6 (Mar.-May)	0.6 - 2.0	ML, CL	Moderate to severe s,r	Moderate to severe s	Moderate s	Moderate s	Moderate s	Moderate to severe s	

1/ only the dominant soil (first named soil) of each soil association has been listed.

2/ percent dominant slope is the slope range within which 60 percent or more of this soil occurs.

3/ rating is given for the most restrictive (critical) horizon or layer. Other horizons in the same soil profile may have different ratings.

4/ the Unified Soil Classification System. *See Appendix.*

5/ DEFINITION OF RATING TERMS

Slight - relatively free of limitations or limitations easily overcome

Moderate - limitations can be overcome with good management and careful design

Severe - limitations are difficult to overcome

SOIL CHARACTERISTICS AFFECTING LIMITATIONS

c poor workability; stony or clayey surface and subsoil
d droughty
f high frost heave potential
p slow permeability
r shallow to bedrock
s slope
u low strength or unstable soils
w seasonal wetness
x flooding hazard
z high shrink-swell potential

Table 2.1.3.- 2

INDUSTRIAL WASTE DISPOSAL
SITES IN THE
PENNSYLVANIA ORBES REGION

ALLEGHENY COUNTY

Indiana Township Land Reclamation Area - Cheswick Power Indiana Township (Permit issued 3/2/73)	W. A. Conwell, Vice Pres. Duquesne Light Co. 435 Fifth Ave. Pittsburgh, PA 15219
Springdale Power Station Ash & Disposal Area Frazer & Springdale Twps. (Permit issued 4/18/79)	West Penn Power Co. 800 Cabin Hill Drive Greensburg, PA 15601
Phillips Ash Disposal Area Crescent Township (Permit issued 7/8/75)	Duquesne Light Co. 435 Sixth Street Pittsburgh, PA 15219

ARMSTRONG COUNTY

Rochester & Pittsburgh Coal Co. Incin. Plum Creek Township (Permit issued 1/7/75)	Rochester & Pittsburgh Coal Co. Cherry Run Plant Elderton, PA 15736
Armstrong Fly Ash Site Washington Twp. (Permit issued 3/22/76)	West Penn Power Co. 800 Cabin Hill Drive Greensburg, PA 15601
Quaker State Fly Ash Disposal Site Honey Township (Permit issued 7/14/76)	Quaker State Oil Refining Corp. Emlenton Plant Emlenton, PA 16373
PA. Electric Co. - Keystone Plant Plum Creek Township (Permit issued 12/5/77)	Pennsylvania Electric Co. 1001 Broad Street Johnstown, PA 15907

BEAVER COUNTY

St. Joe Minerals Corp. Fly Ash Ldf. Potter Township (Permit issued 7/1/76)	St. Joe Minerals Corporation Zinc Smelting Division Monaca, PA 15061
Stabilized Sludge Disposal Site Greene Township (Permit issued 7/26/74)	Carl Labovitz Dravo Corp. Neville Island 4800 Grand Ave. Pittsburgh, PA 15225

Little Blue Run Div. Area
Greene Twp.
(Permit issued 11/25/75)

Pennsylvania Power Co.
1 East Washington St.
New Castle, PA 16103

Cendrich Landfill
Industry Boro
(Permit issued 8/29/77)

George Cendrich Gen. Contracting, Inc
West Midland Ave.
Midland, PA 15059

Peggs Run Development Area
Greene Twp.
(Permit issued 10/27/77)

Pennsylvania Power Co.
1 East Washington Street
New Castle, PA 16103
c/o Ray E. Semmler, Pres.

BUTLER COUNTY

Winters Sludge Site
Penn Township
(Permit issued 9/10/75 Exp. 11/30/75)

E.H. Bilawich Construction, Inc.
19 Collins Ave.
Lyndvia, PA 16045

National Underground Storage, Incin.
Cherry Township
(Permit issued 11/4/76)

National Underground Storage, Inc.
Boyers, PA 16020

CLARION COUNTY

Glass Containers Corporation
Knox Plant Incinerator
Knox Boro
(Permit issued 7/19/72)

J. B. Myers
Project Engineer
Glass Container Corp.
Knox, PA 16232

CLEARFIELD COUNTY

Rockwell Plant #1 Incin.
City of DuBois
(Permit issued 1/18/74)

Roy Kiehl, Systems Engineer
Rockwell International Corp.
Liberty Boulevard
DuBois, PA 15801

ELK COUNTY

Airco Speer
Benzinger Township
(Permit issued 3/24/78)

Thomas Gery
Airco Speer
800 Theresia St.
St. Marys, PA

Cycle Mix Building Landfill Benzinger Township	Stackpole Carbon Company St. Mary, PA 15857 Att: W. L. Donahey
Benzinger Twp. Area B Incinerator Benzinger Twp. (Permit issued 3/3/76)	Stackpole Carbon Co. Eschbach Road St. Marys, PA 15857
Industrial Waste Landfill Benzinger Twp.	Stackpole Carbon Co. St. Marys, PA 15857

GREENE COUNTY

Delworth Mine Incin. Cumberland Twp. (Permit issued 6/13/77)	U. S. Steel Corp. P. O. Box 26 Pittsburgh, PA 15230

MERCER COUNTY

Greenville Steel Car Company Incin. Greenville (Permit issued 7/27/76)	Greenville Steel Car Company Foot of Union Street Greenville, PA 16125

VENANGO COUNTY

Continental Can Co., Inc., Incin. Oil City (Permit issued 6/5/73)	Continental Can Co., Inc. 15 Mineral Street Oil City, PA 16301
Chicago Pneumatic Tool Co., Incin. Franklin (Permit issued 3/24/77)	Chicago Pneumatic Tool Co., Equip.Div Howard Street Franklin, PA 16323

WASHINGTON COUNTY

Mitchell Power Station Ash Disposal Nottingham Township (Permit issued 12/9/74)	Mr. Benjamin Bennett West Penn Power Company 800 Cabin Hill Drive Greensburg, PA 15601
Elrama Fly Ash Disposal Area Union Township (Permit issued 1/16/75)	Duquesne Light Co. 435 Sixth Ave. Pittsburgh, PA 15219
Pitt Processing & Mfg. Co. Sludge Site Robinson Twp. (Permit issued 10/27/76)	Pitt Processing & Mfg. Co. 4314 Main Street Pittsburgh, PA 15224

Paris Fly Ash Site A Hanover Twp. (Permit issued 7/23/77)	Alex E. Paris Contracting Co., Inc. Route 18 Atlasburg, PA 15004

WESTMORELAND COUNTY

Gibson Electric Inc., Incin. Salem Township (Permit issued 6/12/74)	L. J. Maules, Vice-Pres. Gibson Electric, Inc. A Subsidiary of GTE Sylvania Old William Penn Highway Delmont, PA 15626
Wheeling-Pittsburgh Steel Slag Dump Rostraver Township (Permit issued 3/7/75) (Reissued 4/26/76)	W. P. Shane Wheeling-Pittsburgh Steel Corp. Duvall Center Wheeling, West Virginia 26003
Allegheny Ludlum Industrial Landfill Allegheny Township (Permit issued 7/27/78)	Allegheny Ludlum Steel Corp. River Road Brackenridge, PA 15014

TABLE 2.1.3.-3

SUMMARIZED CRITERIA AND STANDARDS
FOR LAND DISPOSAL OF WASTES
(Pennsylvania Department of Environmental Resources
Published and Unpublished Sources)

	System Type	Depth to Bedrock	Depth to Water Table	Slope	Soil Permeability (Drainage)
Septic	Standard	6' minimum	6' minimum	0-15%	6-60 minutes/inch (1)
	Alternate	-	20 inches (2)	0-25%	- (3)
Spray Irrigation	1-1/2 inch/week	3'-5' minimum	3'-5' minimum	0-15%	Well to moderately well drained
Sludge	-	2' minimum	10' minimum	0-10%	Well to moderately well drained (4)

(1) Average percolation rate

(2) Depth to soil mottling

(3) Not utilized on floodplain soils, or somewhat poorly, poorly, and very poorly drained soils

(4) Moderately well drained with at least 24 inches to mottling; well drained with at least 36 inches to mottling; flooding frequency less than once in 25 years

From Pennsylvania DER, COWAMP report, Study Area 8, 1975

TABLE 2.1.3.-4 Area Covered by Soils Suitable for Land Disposal of Wastes

From Pennsylvania DER, COWAMP reports, Study Areas 8 and 9, 1975

	Type of Disposal			
	Land available for spray irrigation and sludge disposal		Land available for septic tank disposal (alt. and std. systems)	
County	%	sq. mi.	%	sq. mi.
Allegheny	1.3	8.6	31.7	206.1
Armstrong	2.7	19.6	51.6	376.4
Beaver	5.2	23.0	55.2	243.2
Butler	6.5	51.6	50.8	404.1
Clarion	5.4	32.6	43.7	263.5
Elk **	9.6	54.4	46.7	264.5
Fayette	5.2	29.7	23.2	133.3
Forest **	7.4	31.4	35.7	151.7
Greene	1.0	8.6	21.1	175.0
Indiana	6.2	51.4	50.2	417.0
Jefferson	5.9	38.3	45.9	297.7
Lawrence **	2.5	9.1	39.6	144.8
Mercer	0.4	2.5	28.6	195.6
Venango	2.7	18.5	40.0	274.0
Washington	0.1	0.7	25.5	218.7
Westmoreland	0.9	9.1	52.5	545.7
TOTALS	63.0	389.1	642.0	4,311.3

* Based on County Soil Conservation Service soil interpretation and Table 11, "Summarized Criteria for Land Disposal of Wastes"

** Soil series maps for county not completed. Percentages estimated from available maps obtained from SCS Offices.

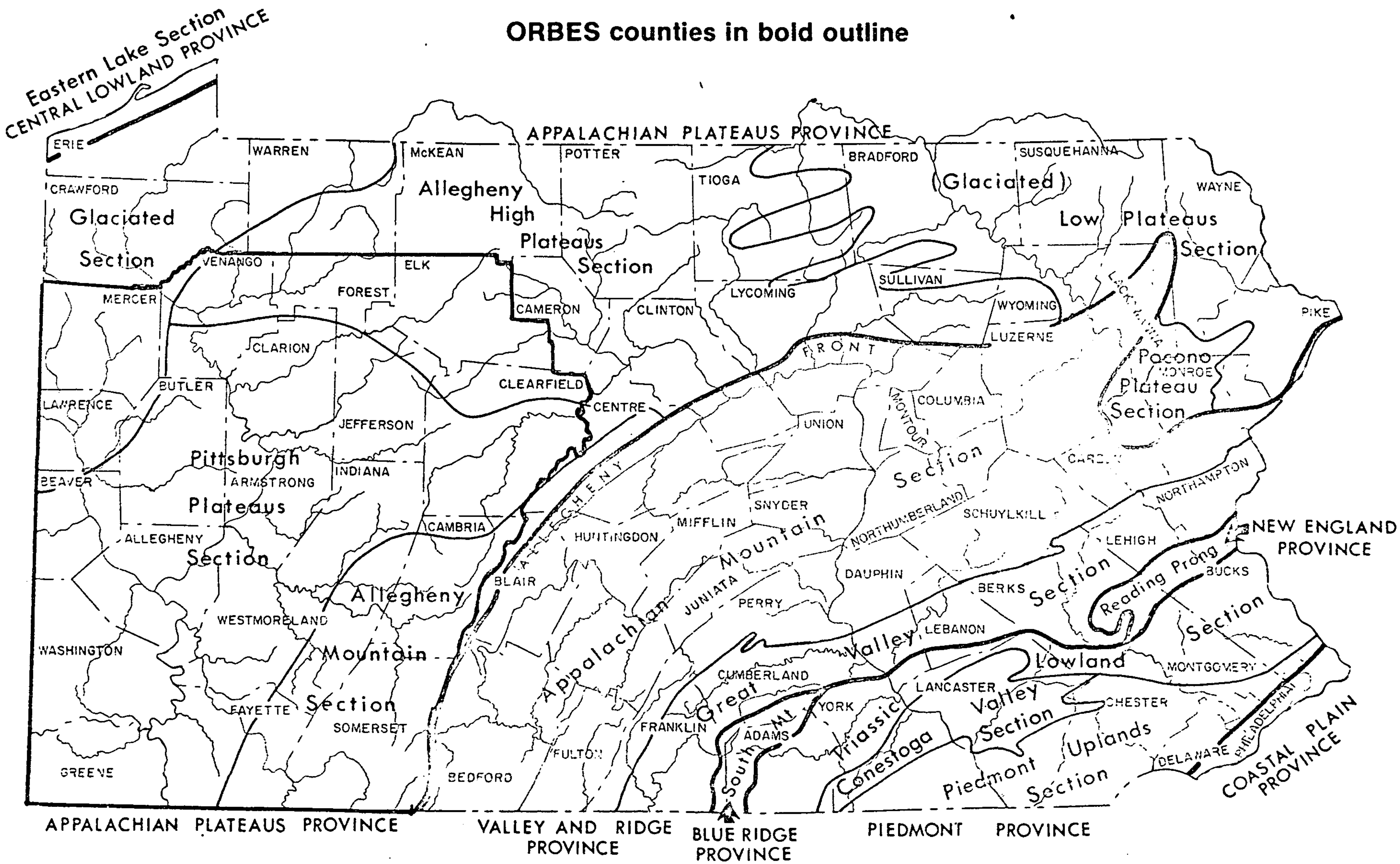
MAP 13

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, *State Geologist*

FIGURE 2.1.1. - 1

PHYSIOGRAPHIC PROVINCES OF PENNSYLVANIA

ORBES counties in bold outline



-47-

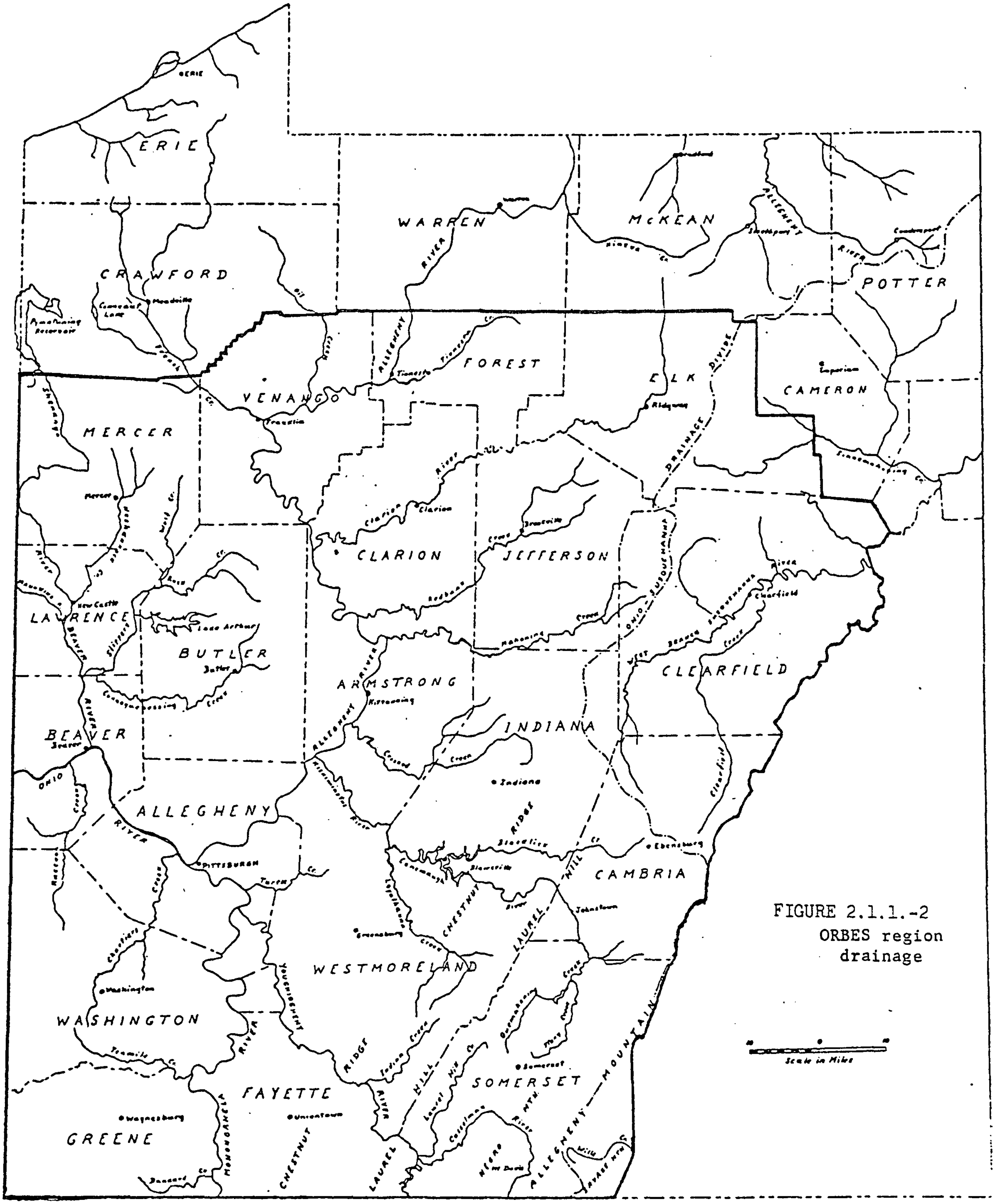


FIGURE 2.1.1.-2
ORBES region
drainage

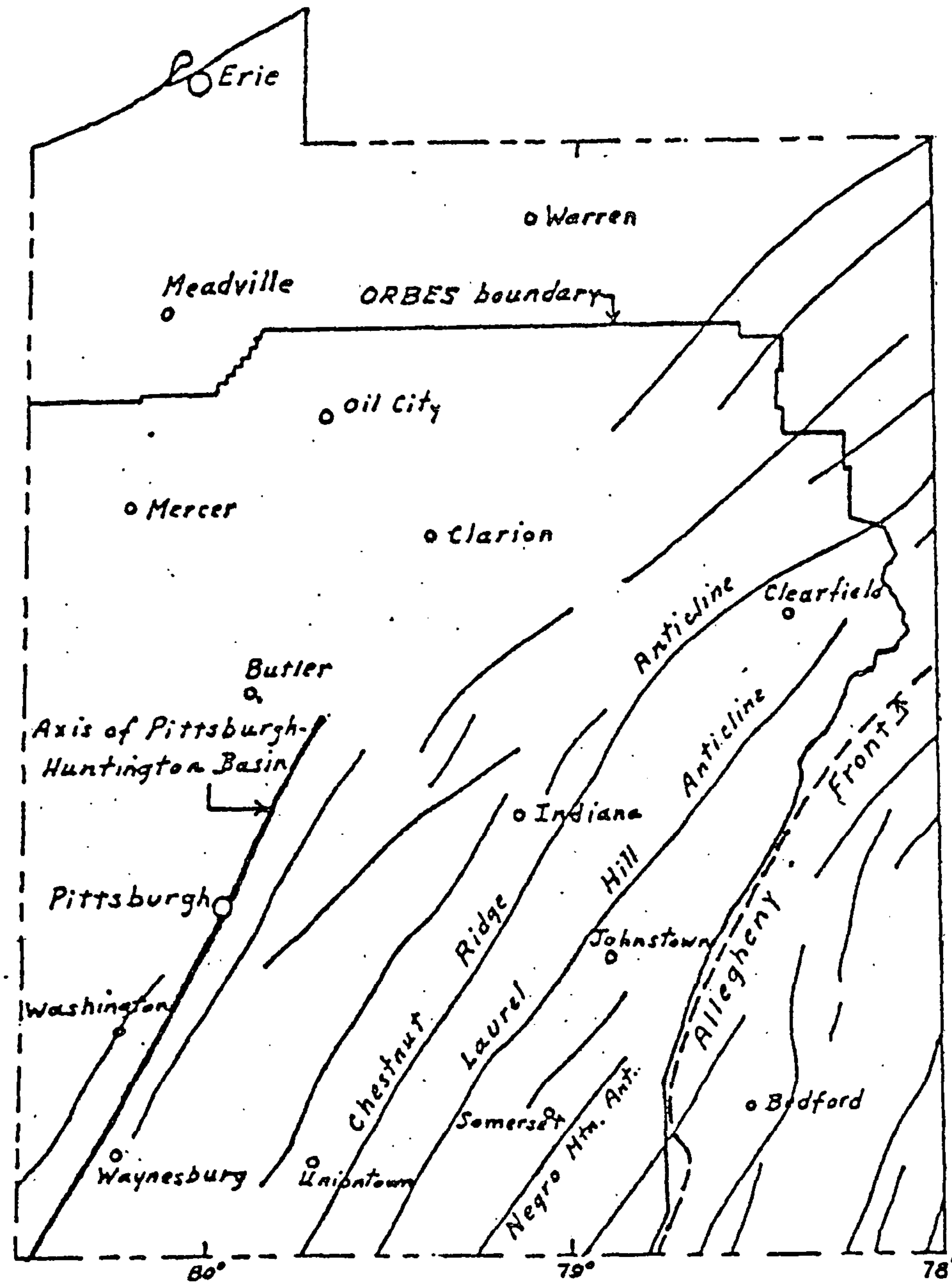


FIGURE 2.1.1.-4

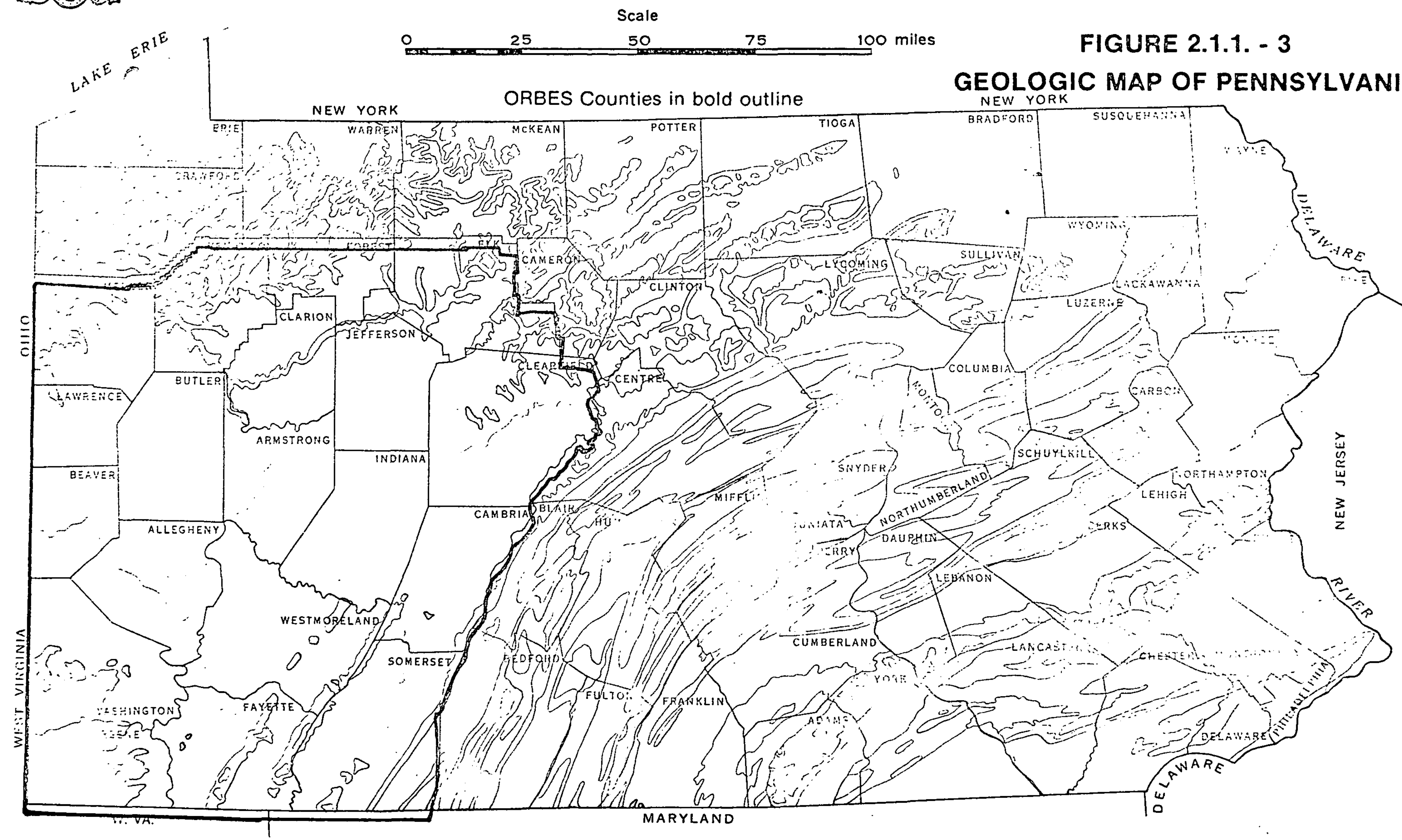
Axial trace of anticlinal structures in ORBES region

GEOLOGIC MAP OF PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC & GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

FIGURE 2.1.1. - 3

GEOLOGIC MAP OF PENNSYLVANIA



QUATERNARY (0-1 million yrs.) Sand and gravel. *sand and gravel.*

TRIASSIC (190-230 mil. yrs.) Shales and sandstones intruded by diabase. (red) *iron, building stone.*

PERMIAN (230-280 mil. yrs.) Cyclic sequences of sandstone, red beds, shale, limestone, and coal.

PENNSYLVANIAN (280-310 mil. yrs.) Cyclic sequences of sandstone, limestone, shale, clay, and coal. *coal, clay, lime.*

MISSISSIPPIAN (310-350 mil. yrs.) Red beds, shale, and sandstone.

DEVONIAN (350-400 mil. yrs.) Red beds, shale, sandstone, limestone and chert. *silica sand.*

SILURIAN (400-425 mil. yrs.) Sandstone, red beds, shale, and limestone. *gannister, lime.*

ORDOVICIAN (425-500 mil. yrs.) Shale, limestone, dolomite, sandstone. *slate, limestone, zinc.*

ORDOVICIAN and/or CAMBRIAN (425-600 mil. yrs.) Metamorphic rocks-schist, serpentine, gneiss and quartzite. *Building stone.*

CAMBRIAN (500-600 mil. yrs.) Limestone and dolomite; some sandstone and shale. *lime and gannister.*

PRECAMBRIAN (Older than 600 mil. yrs.) Gneiss, greenstone, serpentine and anorthosite. *zinc, building stone, graphite, serecite.*

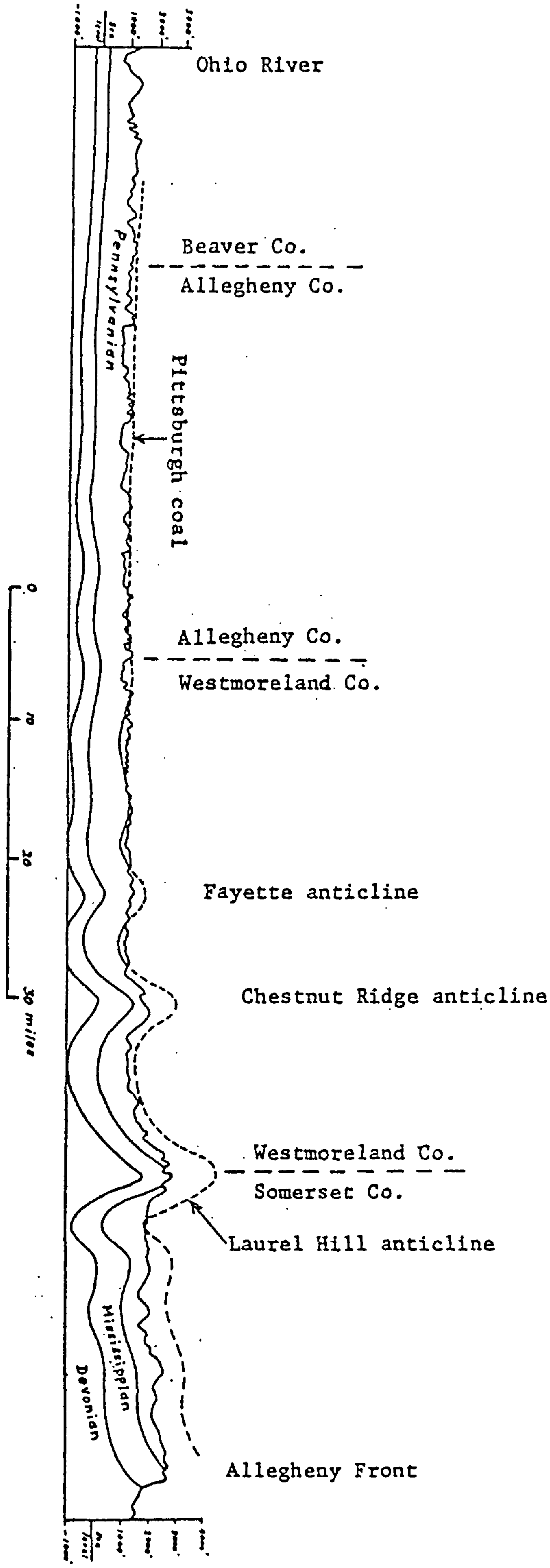
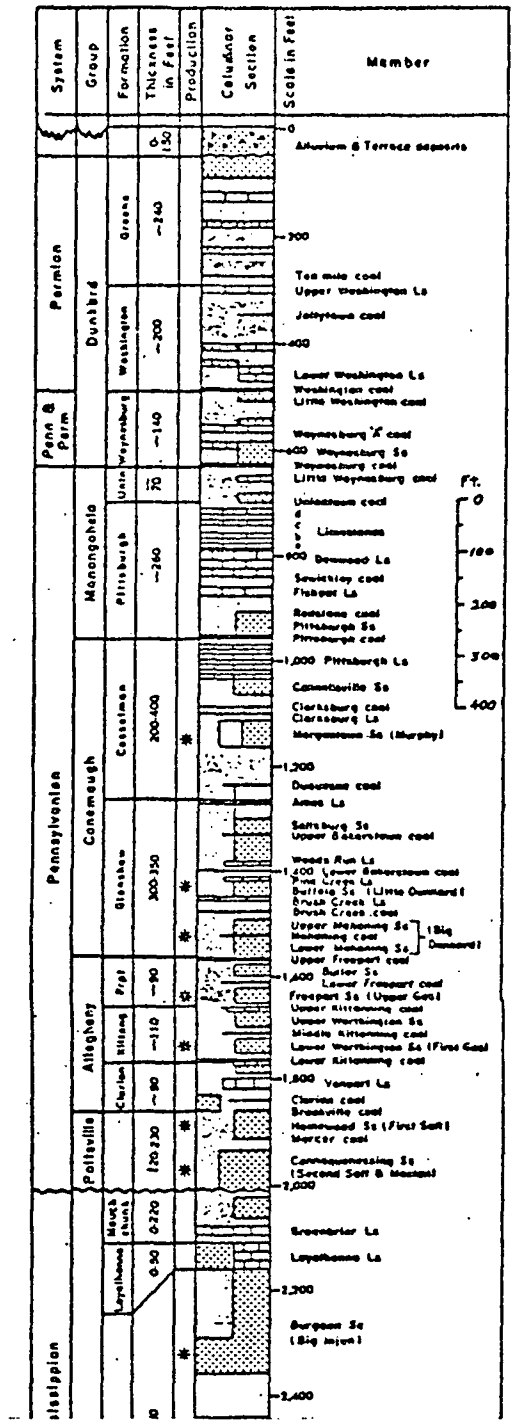


FIGURE 2.1.1.-5

Geologic structure section through Beaver, Allegheny, Westmoreland, and Somerset Counties from Ohio River to Allegheny Front



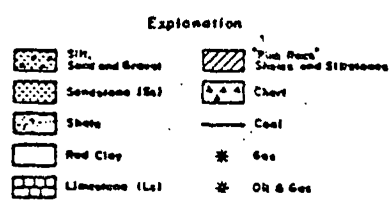


FIGURE 2.1.1.-6

Generalized Stratigraphic Section

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC & GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

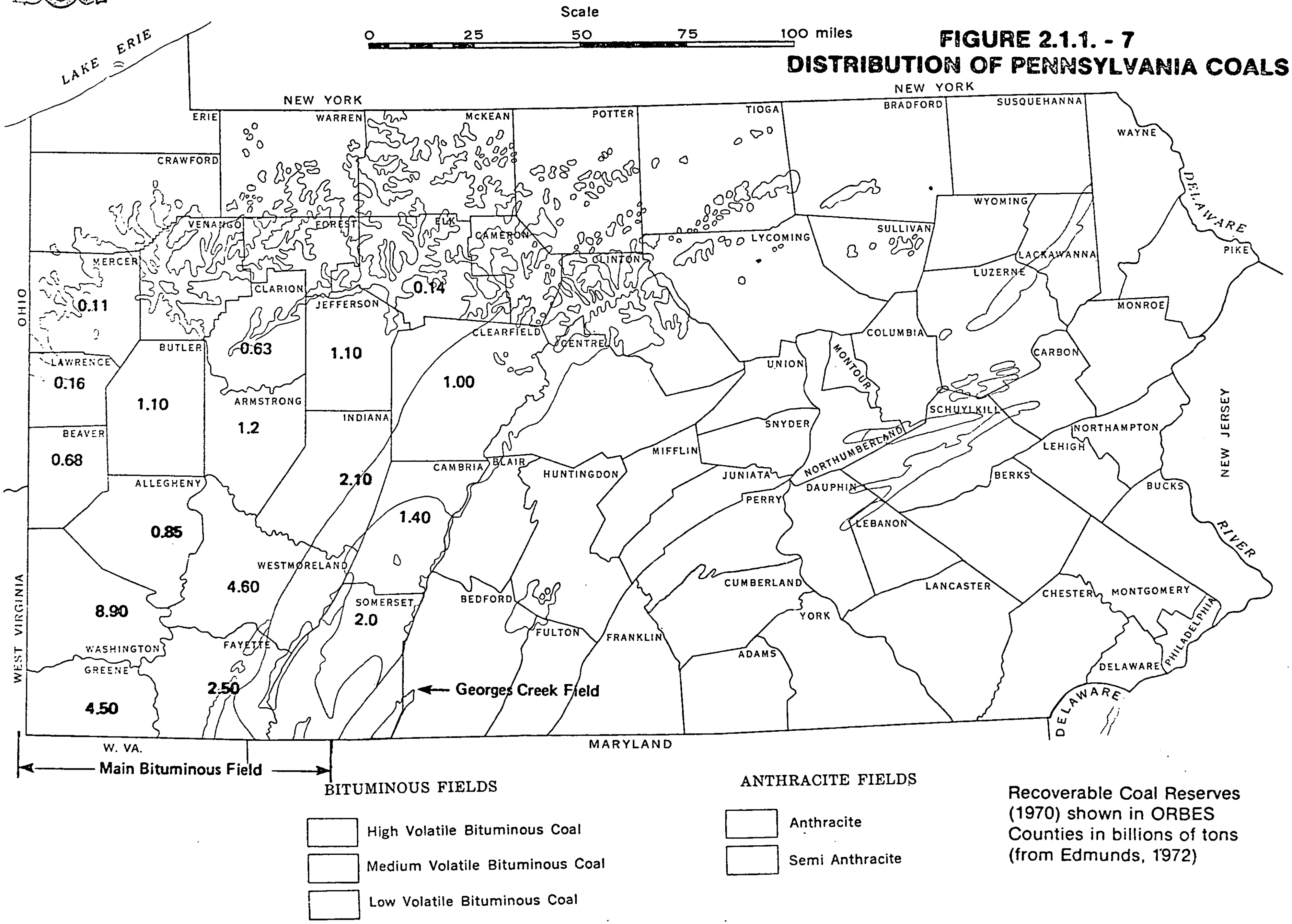
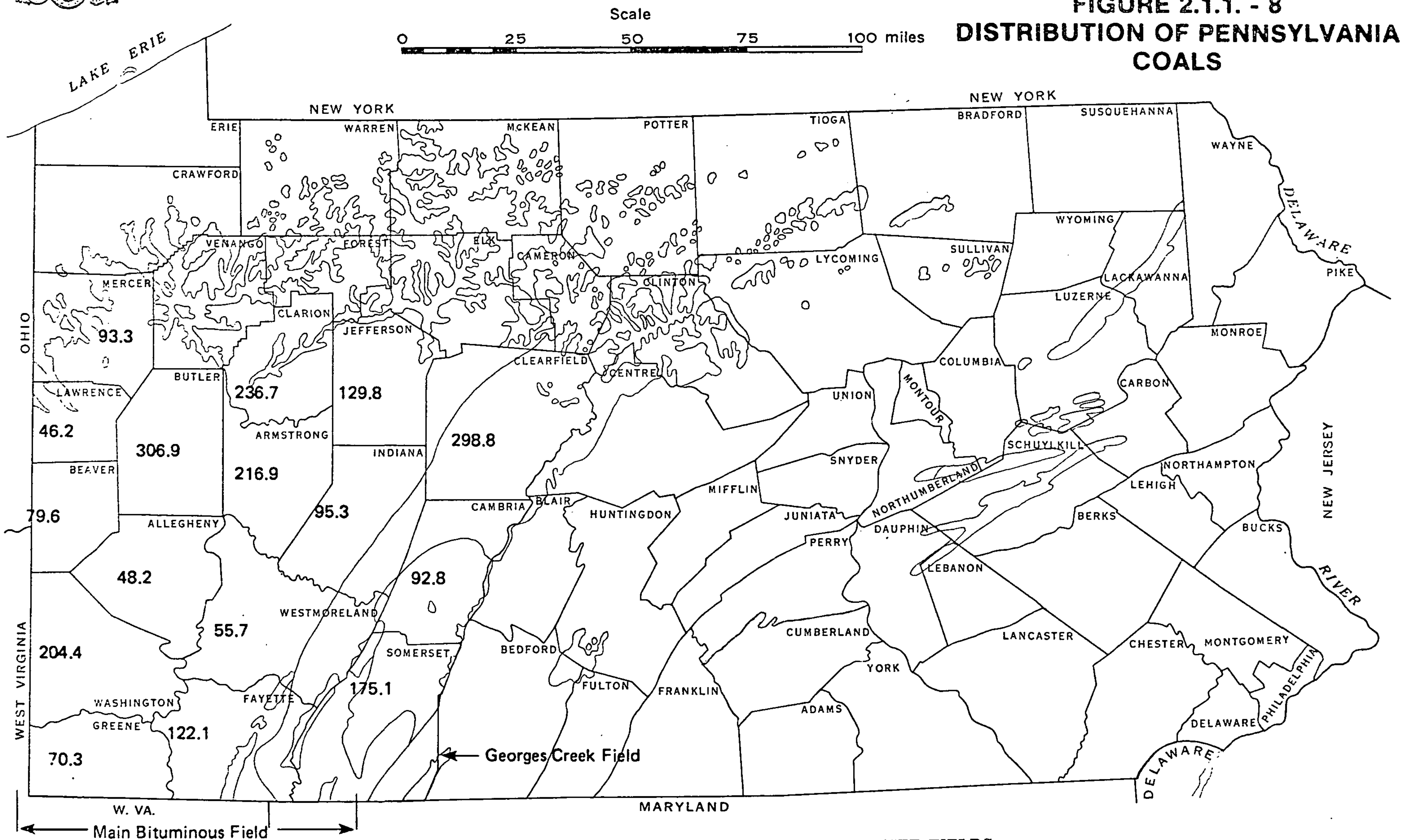


FIGURE 2.1.1. - 7
DISTRIBUTION OF PENNSYLVANIA COALS

DISTRIBUTION OF PENNSYLVANIA COALS

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC & GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

FIGURE 2.1.1. - 8
DISTRIBUTION OF PENNSYLVANIA COALS



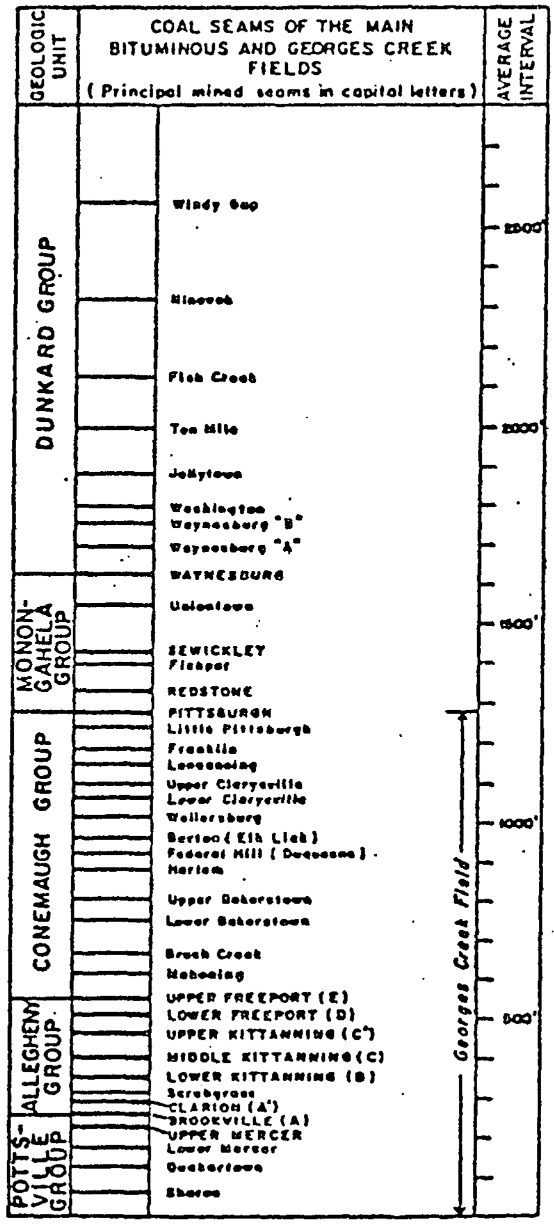
BITUMINOUS FIELDS

- High Volatile Bituminous Coal
- Medium Volatile Bituminous Coal
- Low Volatile Bituminous Coal

ANTHRACITE FIELDS

- Anthracite
- Semi Anthracite

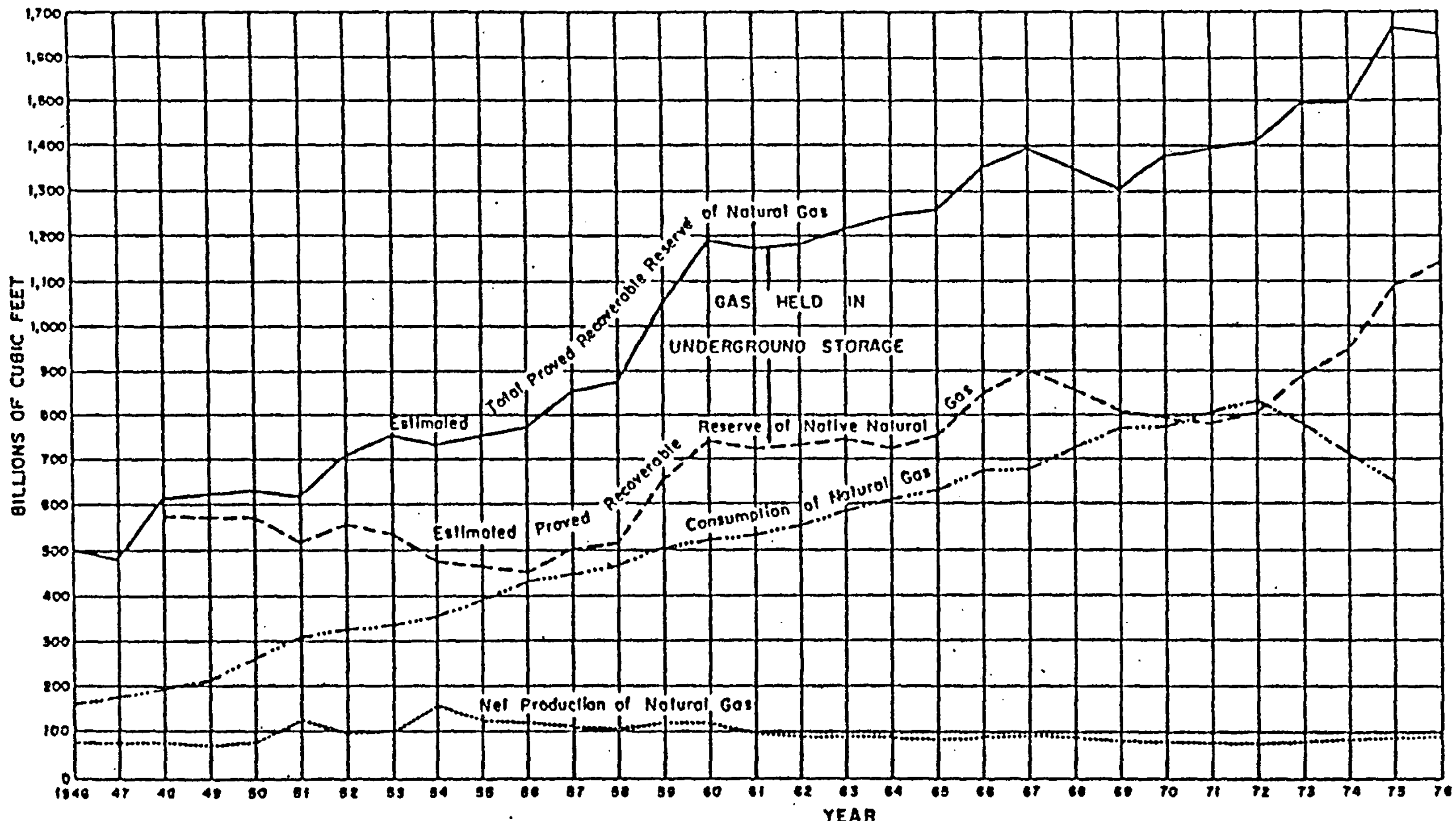
Strippable Coal reserves (1968) shown in ORBES Counties except Elk, Forest, Venango, in million of tons (from Edmunds, 1972)



Coal seams of the Main Bituminous and Georges Creek Fields.

From Edmunds, 1972

FIGURE 2.1.1.-9

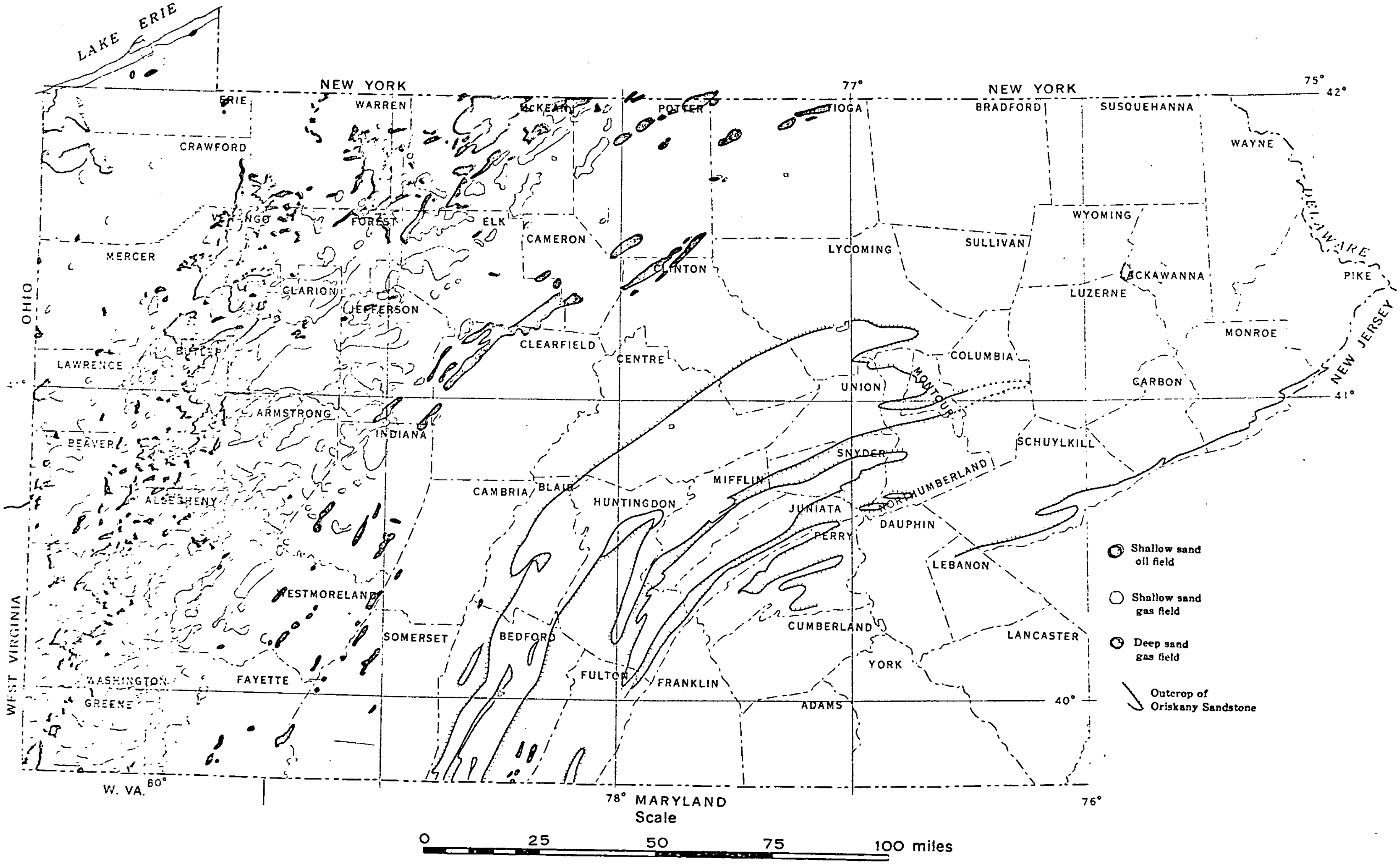


From Lytle, 1977

FIGURE 2.1.1.-12 Production, consumption, and reserves of natural gas in Pennsylvania

FIGURE 2.1.1. - 10
OIL AND GAS FIELDS MAP OF PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC & GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist



MAP 15

LIMESTONE AND DOLOMITE DISTRIBUTION IN PENNSYLVANIA

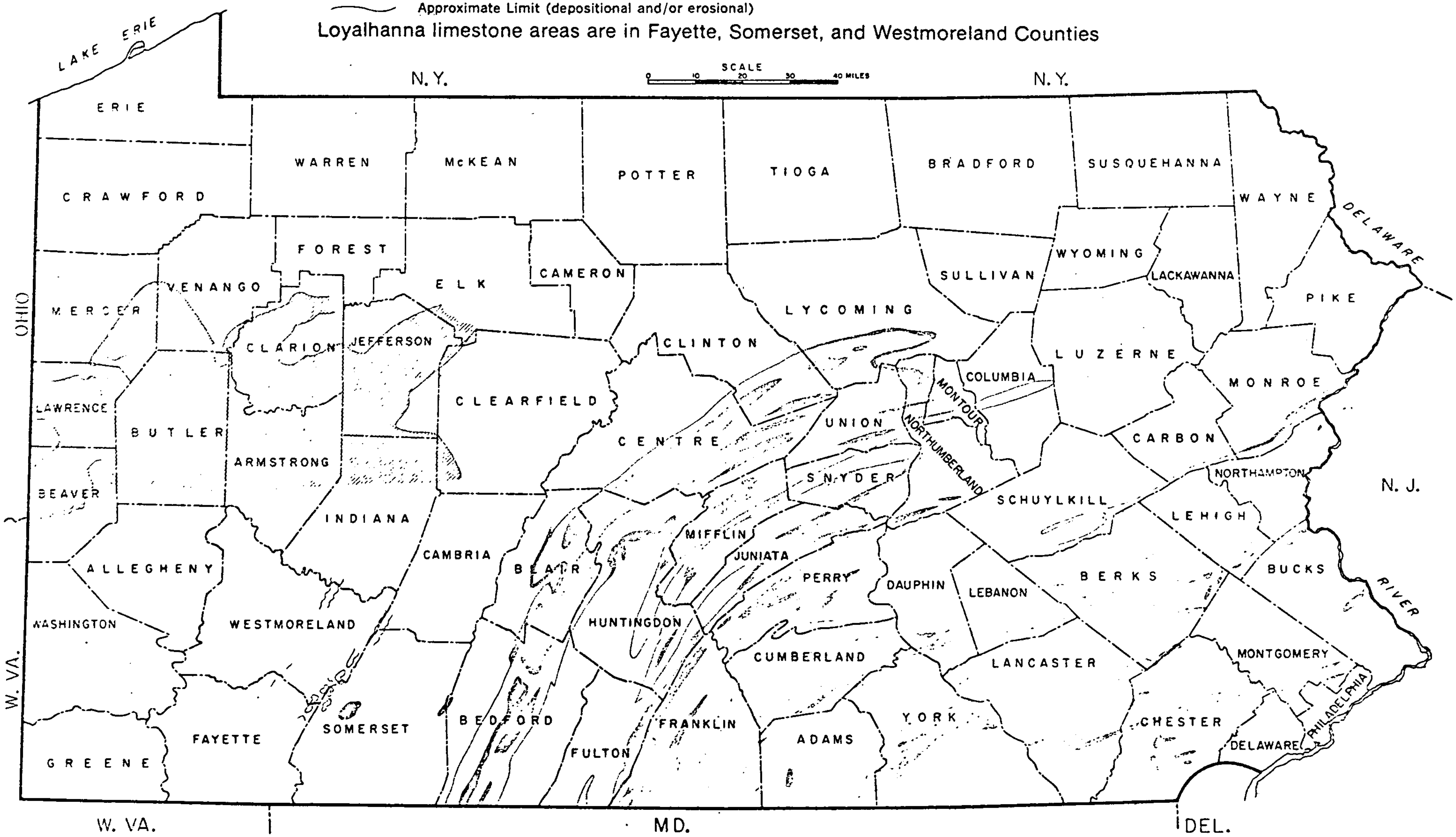
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, *State Geologist*

FIGURE 2.1.1. - 13

SURFACE AND SUBSURFACE (Vanport Ls.) SURFACE ONLY

Approximate Limit (depositional and/or erosional)

Loyalhanna limestone areas are in Fayette, Somerset, and Westmoreland Counties



LIMESTONE AND DOLOMITE DISTRIBUTION IN PENNSYLVANIA

Carbonate rocks, consisting of limestones and dolomites, are unique among the great variety of rock types in Pennsylvania. These rocks affect man's activities in three major ways: as hazards, as mineral resources, and as ground-water reservoirs. It is intended that this map will assist in planning and development of those areas in Pennsylvania underlain by limestones and dolomites.

HAZARDS–Carbonate rocks present hazards and construction problems due to the presence of solution cavities both in the surface and subsurface. These cavities are the result of gradual dissolving of the rock by water seeping through it. The solution cavities may become large enough to form tunnels, caves, and caverns, as well as surface sinkholes formed by the collapse of these cavities. The underground openings and their potential danger of collapse call for detailed planning studies prior to construction or development in limestone-dolomite areas. Studies should include local geologic mapping, borings, and other tests to establish foundation conditions for such structures as highways, dams, bridges, and large buildings.

RESOURCES–Limestone and dolomite rocks in Pennsylvania are extensively used as mineral resources for the production of (1) crushed stone for roads and railroads, (2) fluxstone for blast furnaces, (3) crushed rock for concrete, and (4) raw material for making cement and agricultural lime. Thus, the occurrence of limestone or dolomite in various parts of Pennsylvania should be recognized as a valuable mineral resource, and land-use decisions should take this into account.

WATER–Because of the development of solution cavities in carbonate rocks, these rock formations may contain and yield large quantities of underground water. Areas underlain by limestones and dolomites may supply the water needs of a community through the proper development of the subsurface water resources. The planning and development of any water supplies should recognize the existence of this valuable underground water source.

The very same porous nature of the carbonate rocks which makes available large ground-water resources may also permit the influx of sewage and surface wastes. Therefore, it is important to be particularly careful in planning sewage and waste disposal in limestone-dolomite areas so that contamination of the valuable ground-water resources will not occur.

STATEWIDE REFERENCES

Map 1	Geologic Map of Pennsylvania, 1960. Scale 1:250,000 (1" = 4 miles).	$3.75
M 20	Limestones of Pennsylvania, by B. L. Miller, 1934.	2.00
M 50	Atlas of Pennsylvania's mineral resources.	
	Part 1: Limestones and dolomites of Pennsylvania, by B. J. O'Neill, Jr., 1964.	2.75
	Part 1. Supplement, Limestones and dolomites of Pennsylvania, by G. Deasy and others, 1967.	1.00

OTHER PUBLICATIONS

This map is designed to acquaint the reader with the distribution of carbonate rocks in Pennsylvania. For other publications dealing in greater detail with limestones and dolomites in local areas of Pennsylvania, please refer to the Pennsylvania Geological Publications List, available upon request from the Pennsylvania Geological Survey, Department of Environmental Resources, Harrisburg, Pennsylvania, 17120.

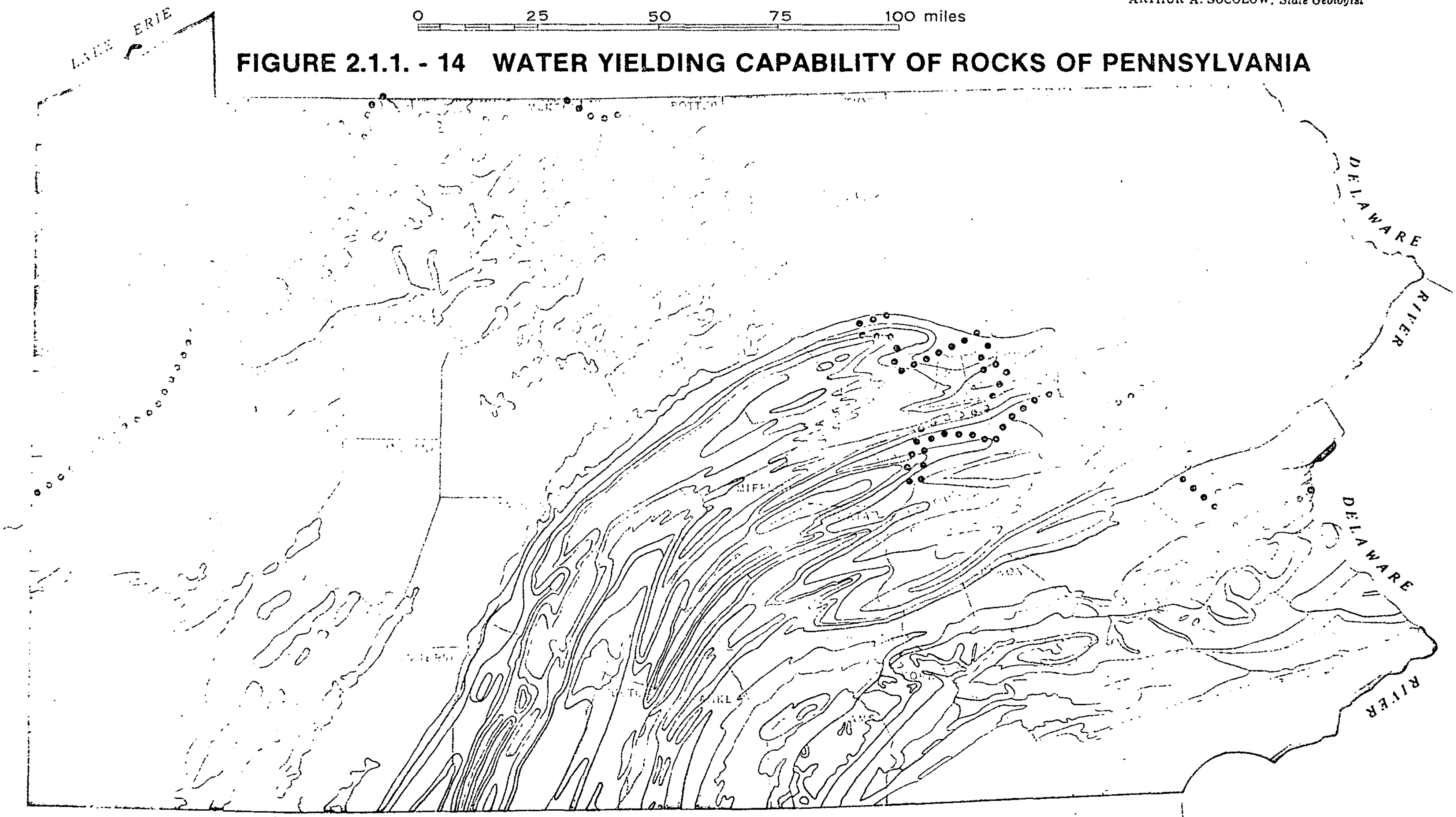
WATER YIELDING CAPABILITY OF ROCKS OF PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, *State Geologist*

Scale

0 25 50 75 100 miles

FIGURE 2.1.1. - 14 WATER YIELDING CAPABILITY OF ROCKS OF PENNSYLVANIA



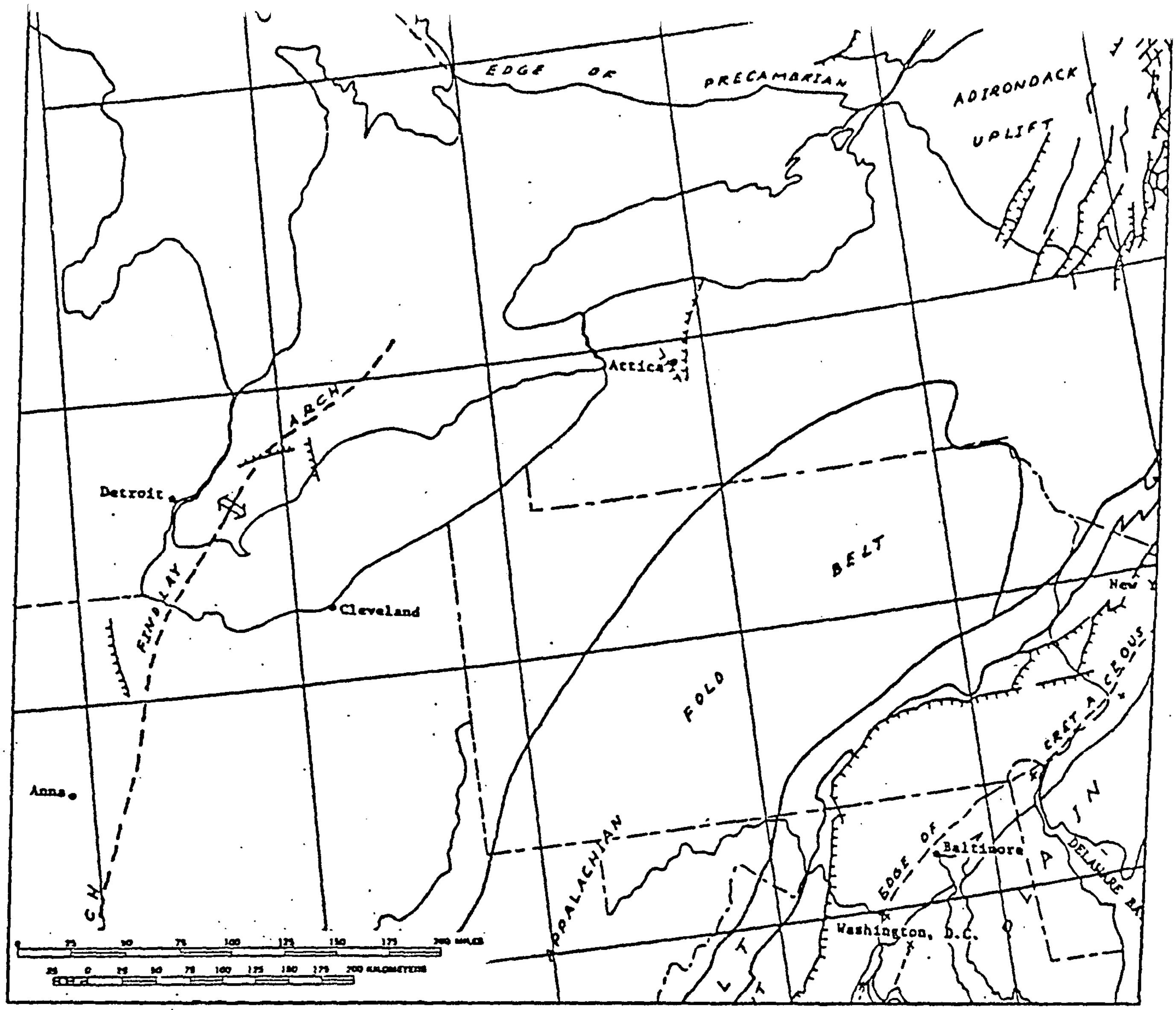
ESTIMATED MEDIAN YIELD (gpm) OF BEDROCK UNITS

Median yield is the yield in the middle of the range of yields of a rock formation. Each of the five colors on the map includes several formations, each with its own median yield figure. The range given for each color is from the formation with the highest median yield.

10 to 25 | 26 to 50 | 51 to 100 | 101 to 200 | 201 to 850

• • • • • • • • Southern limit of glacial deposits

Yields of wells in glacial and stream deposits of sand and gravel range from 20 to 2000 gpm.



EXPLANATION

From Hadley and Devine, 1974

Geologic boundary

Tectonic province boundary
Dashed where concealed by younger deposits

Major anticline or anticlinorium

Major syncline or synclinorium

Arch
Showing approximate location of axis

Dome

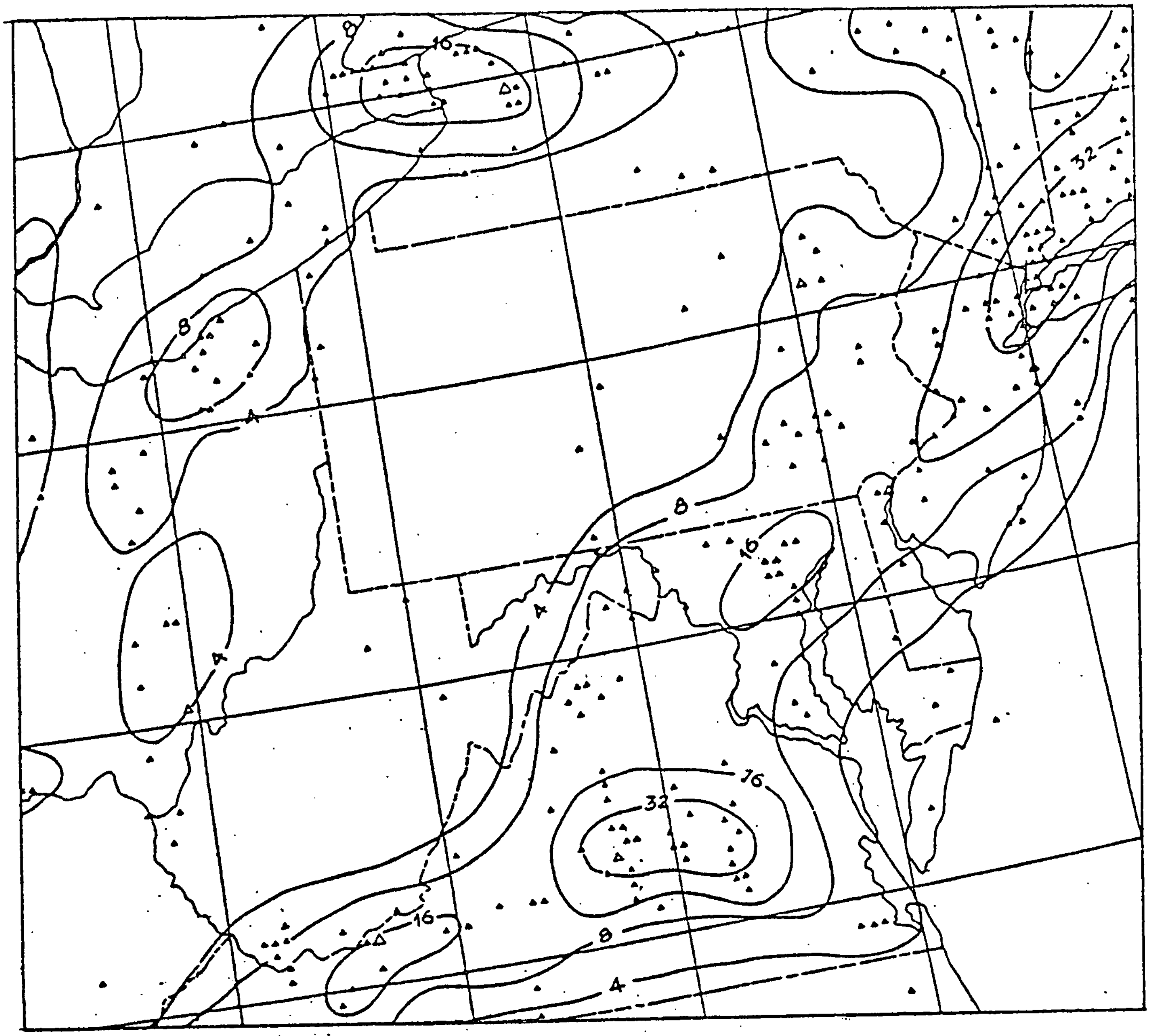
High-angle fault
Hachures on downthrown side where known; arrows show relative movement.
Dashed where approximately located or covered by younger deposits

Low-angle fault
Sawteeth on upper plate. Dashed where covered by younger deposits

Axis of embayment trough

x
Locally observed folds or faults in Coastal Plain rocks

FIGURE 2.1.1.-15
Tectonic Map



EXPLANATION

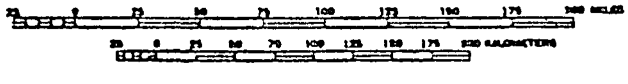
The center of each triangular symbol indicates the epicentral location of one or more seismic events, plotted to the nearest 0.1 degree of latitude and longitude. The intensity shown is maximum Modified Mercalli (MM) intensity in the epicentral area of the largest event at the plotted location. Most locations are based on observations of intensity rather than on instrumental records

—8—

Seismic frequency contour represents the areal distribution of earthquake epicenters with epicentral intensity of MM III and greater, as indicated by the total number per $10^4 km^2$ during the period 1800–1972. Contour intervals are 0–4, more than 4 but less than 8, more than 8 but less than 16, more than 16 but less than 32, more than 32 but less than 64, and more than 64. The contours are considerably generalized and are shown only as a guide for estimating regional seismicity. They have no value for precise location of seismic boundaries

Modified Mercalli Intensity

- ▲ III to VI
- △ VII
- △ VIII
- △ IX–X
- △ XII



From Hadley and Devine 1974

FIGURE 2.1.1.-16
Earthquake epicenters, 1800-1972

From King and Zietz, 1978

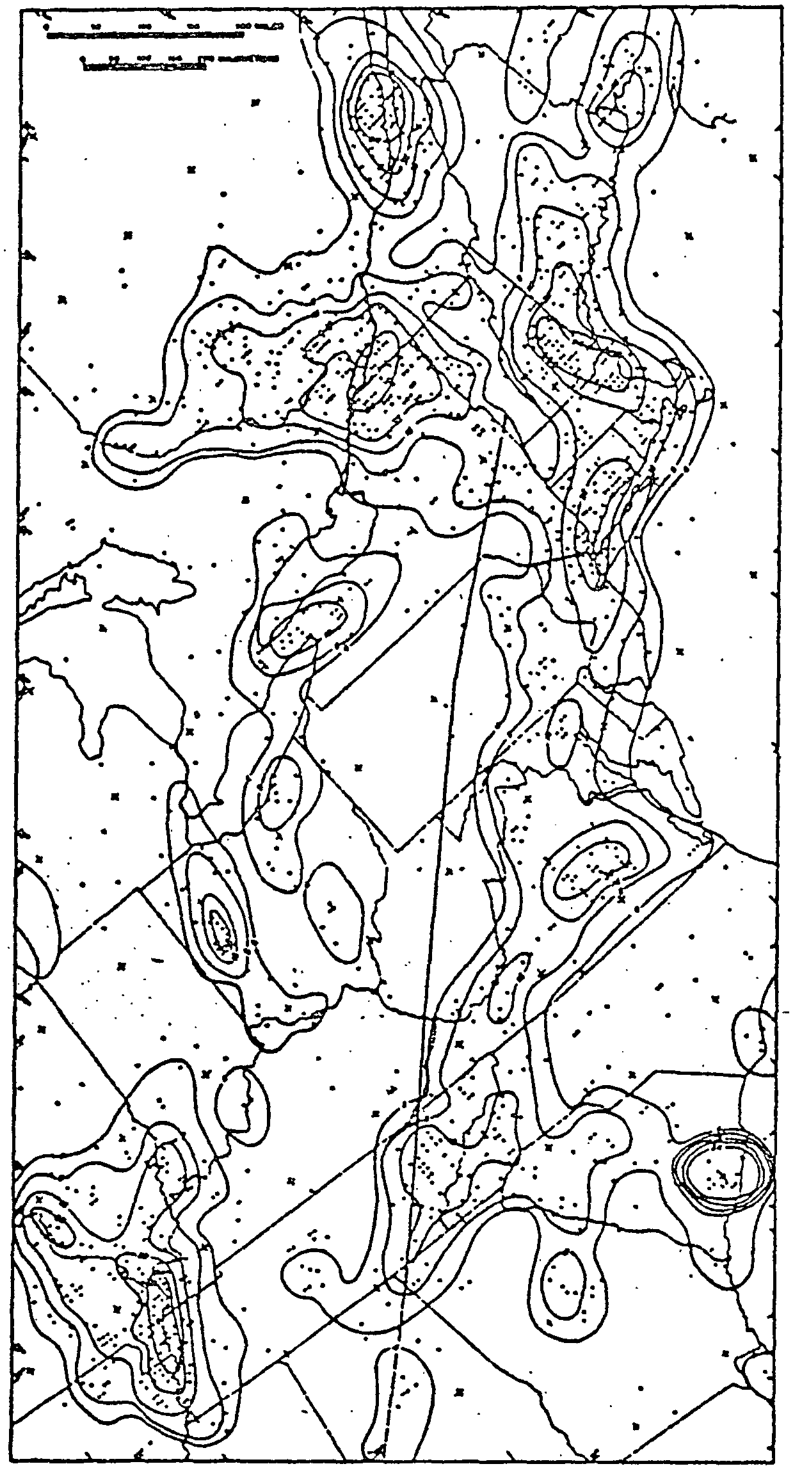


FIGURE 2.1.1.-17
New York - Alabama lineament plotted on seismotectonic map of eastern United States (Hadley and Devine, 1974) showing earthquake epicenters of modified Mercalli III or greater, recorded from 1800 to 1972. Contours show number of epicenters per 10,000 km.^{2}. Location of lineament is based on magnetic and gravity data.

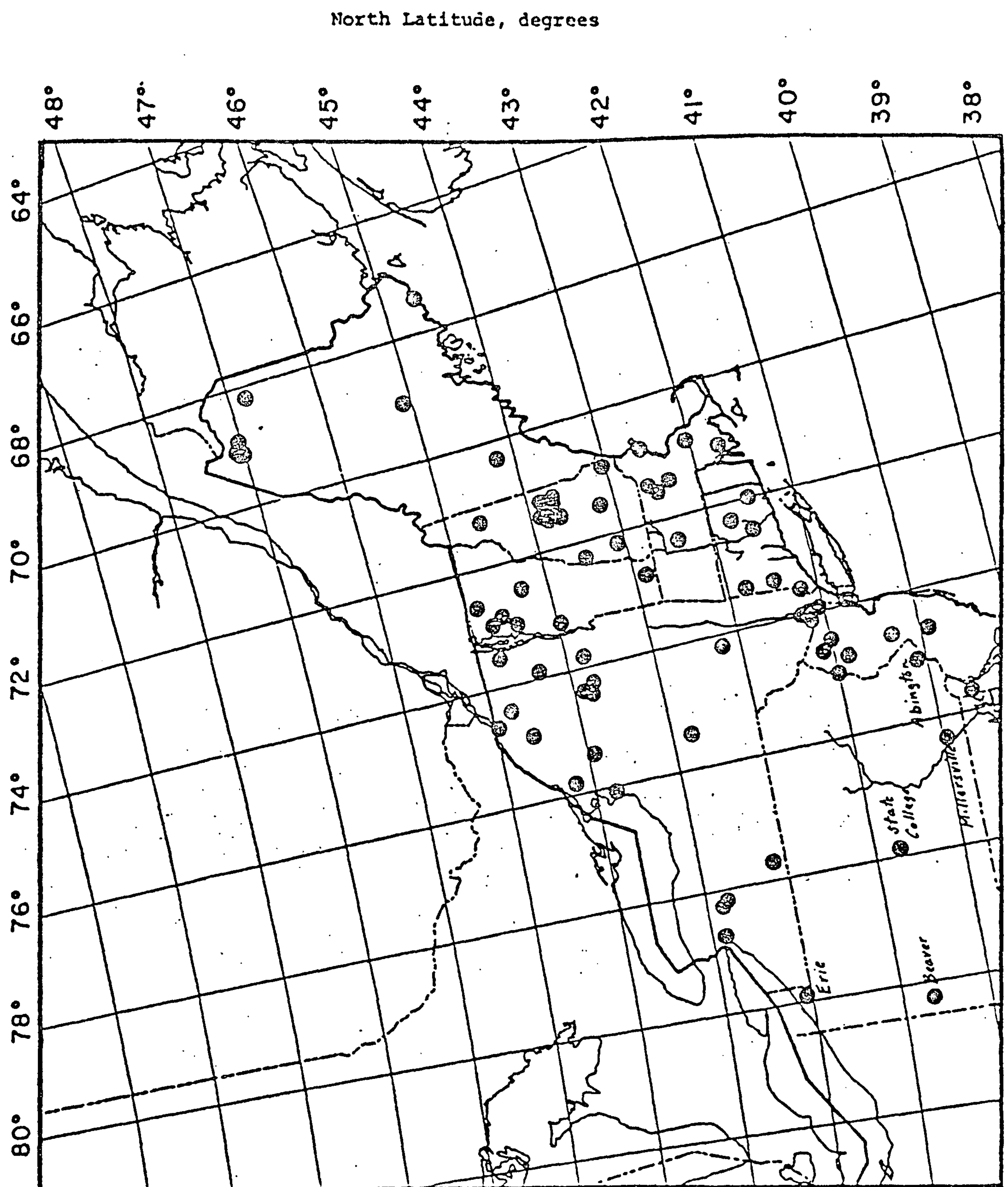
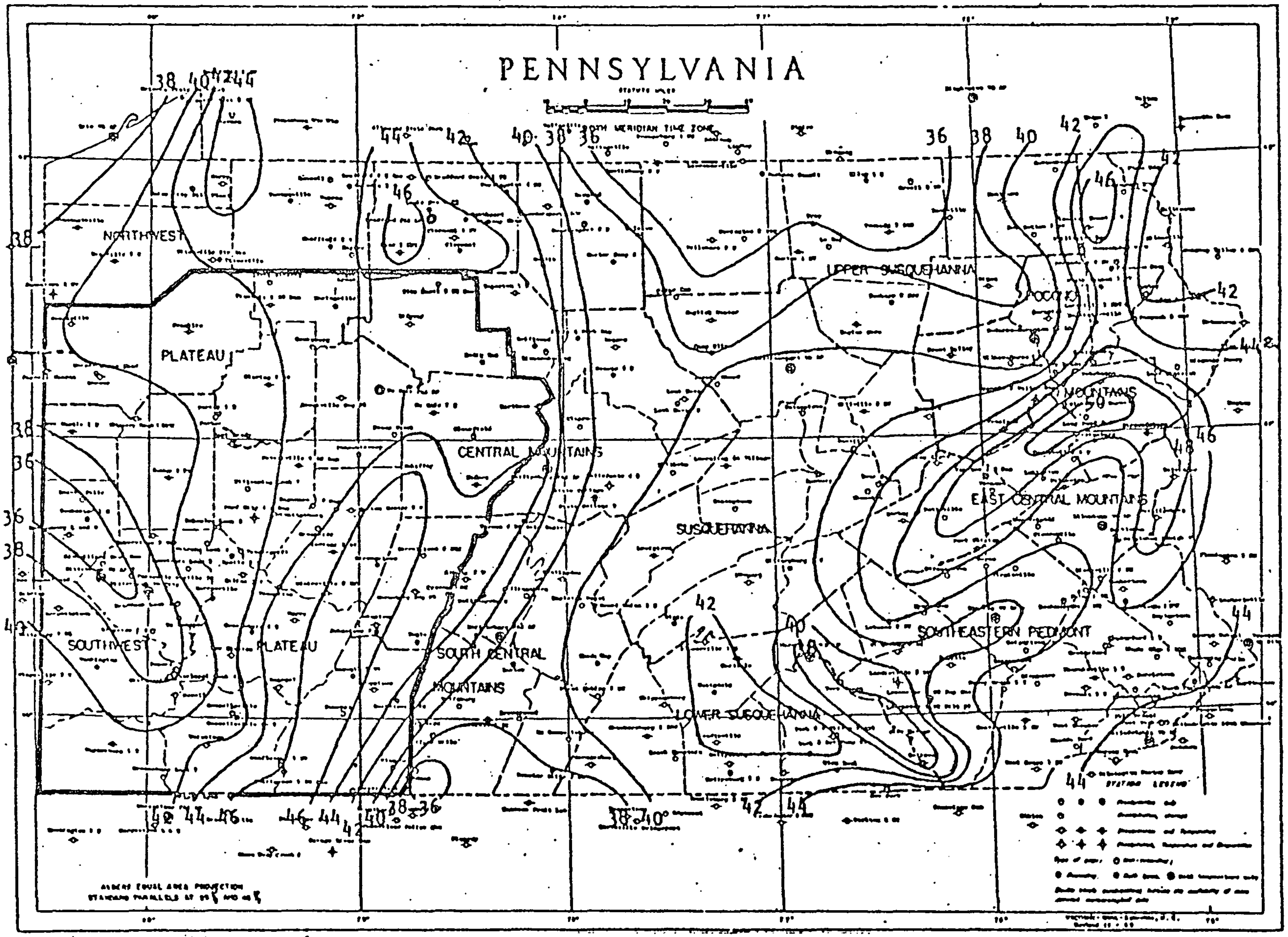


FIGURE 2.1.1.-18 Seismic stations operating during the period July - September 1977

Mean Annual Precipitation, Inches



Based on the period 1931-60

ORBES region in bold outline

Figure 2,1.2.-1

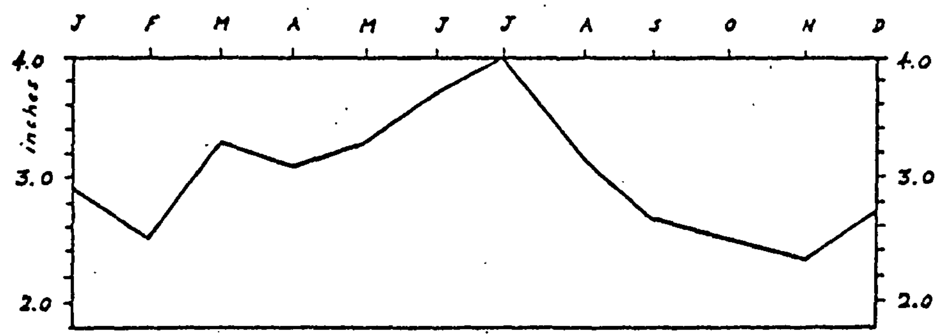


Figure 2.1.2.-2 Mean monthly precipitation
at Pittsburgh

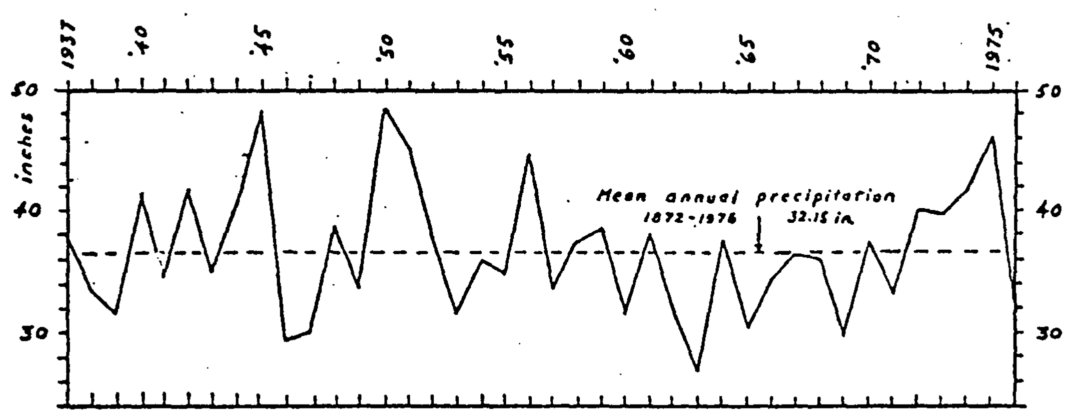
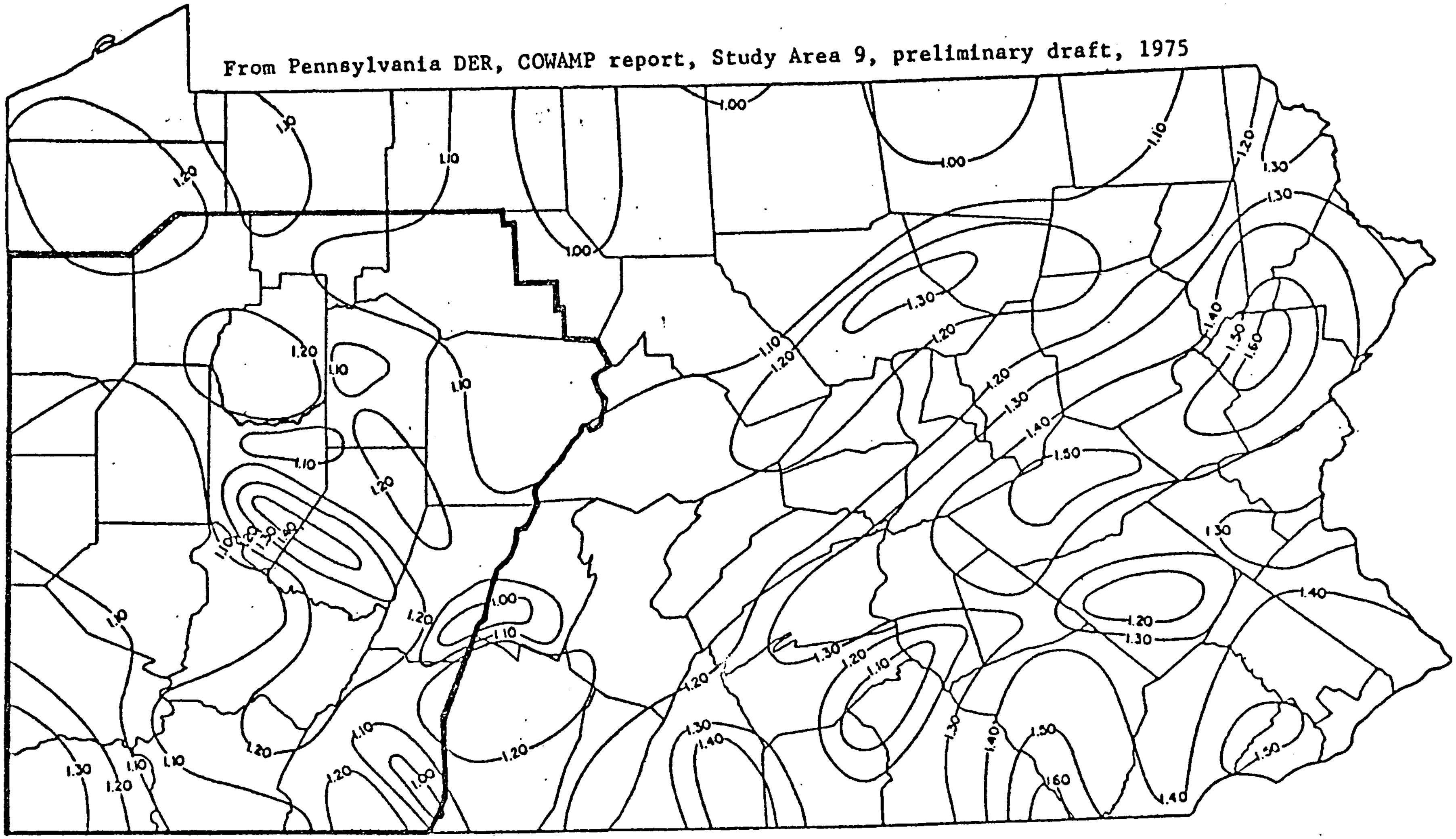


Figure 2.1.2.-3 Mean annual precipitation
at Pittsburgh

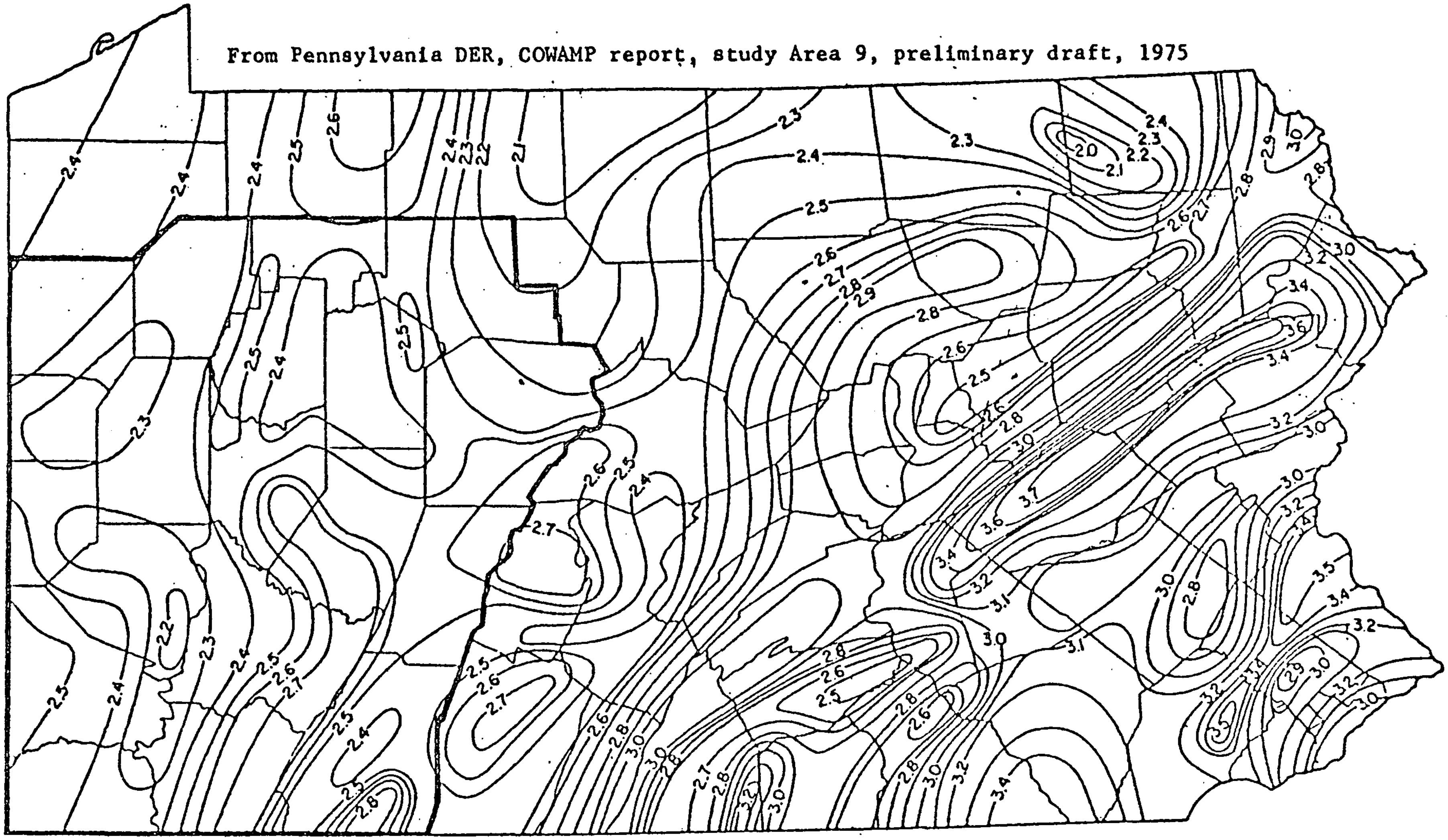
From Pennsylvania DER, COWAMP report, Study Area 9, preliminary draft, 1975



ORBES counties in bold outline

Figure 2.1.2.-4 Rainfall in inches for 1-hour duration and 2.33-year return period

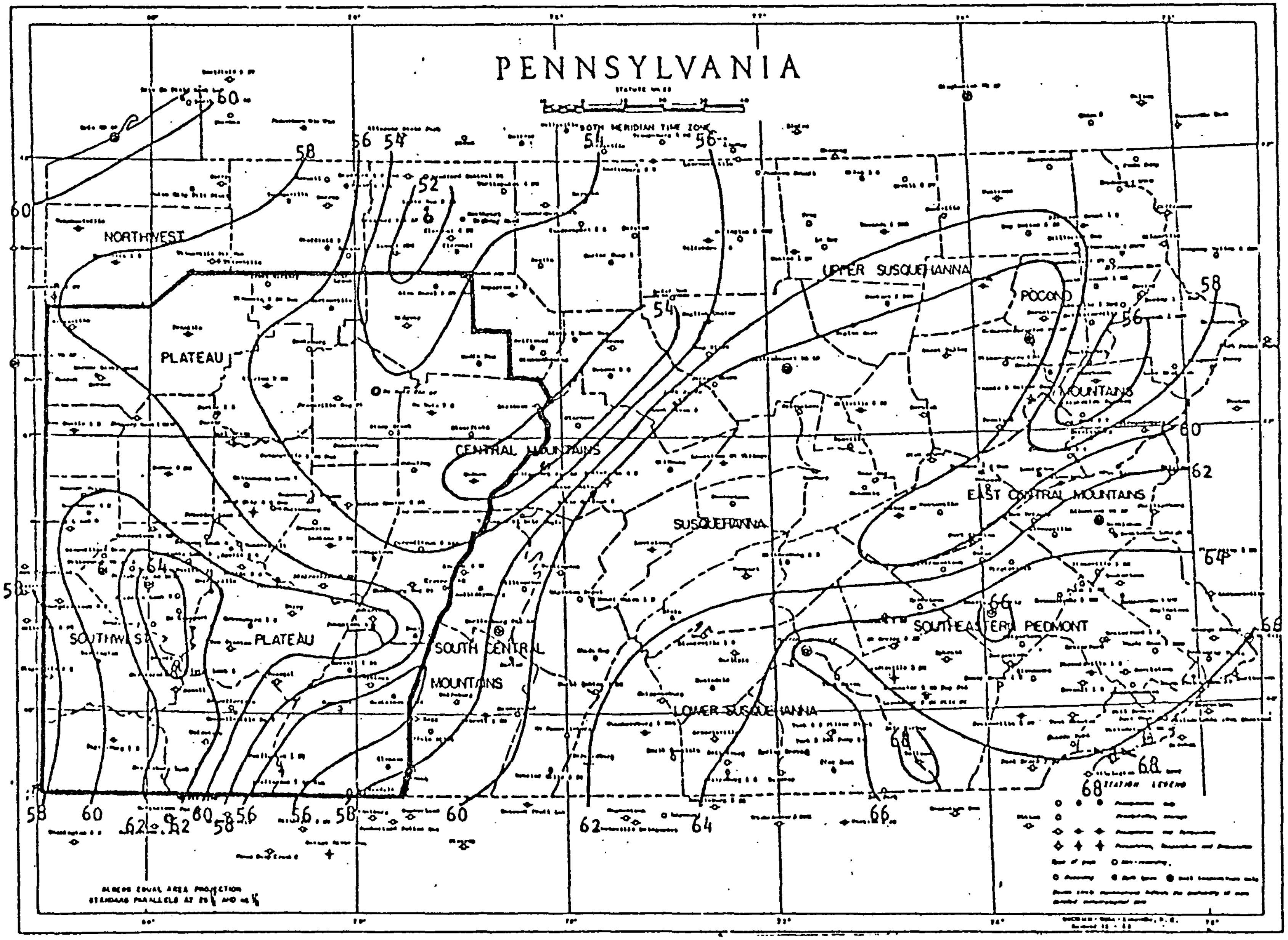
From Pennsylvania DER, COWAMP report, study Area 9, preliminary draft, 1975



ORBES counties in bold outline

Figure 2.1.2.-5. Rainfall in inches for 24-hour duration and 2.33-year return period

Mean Minimum Temperature (°F), July

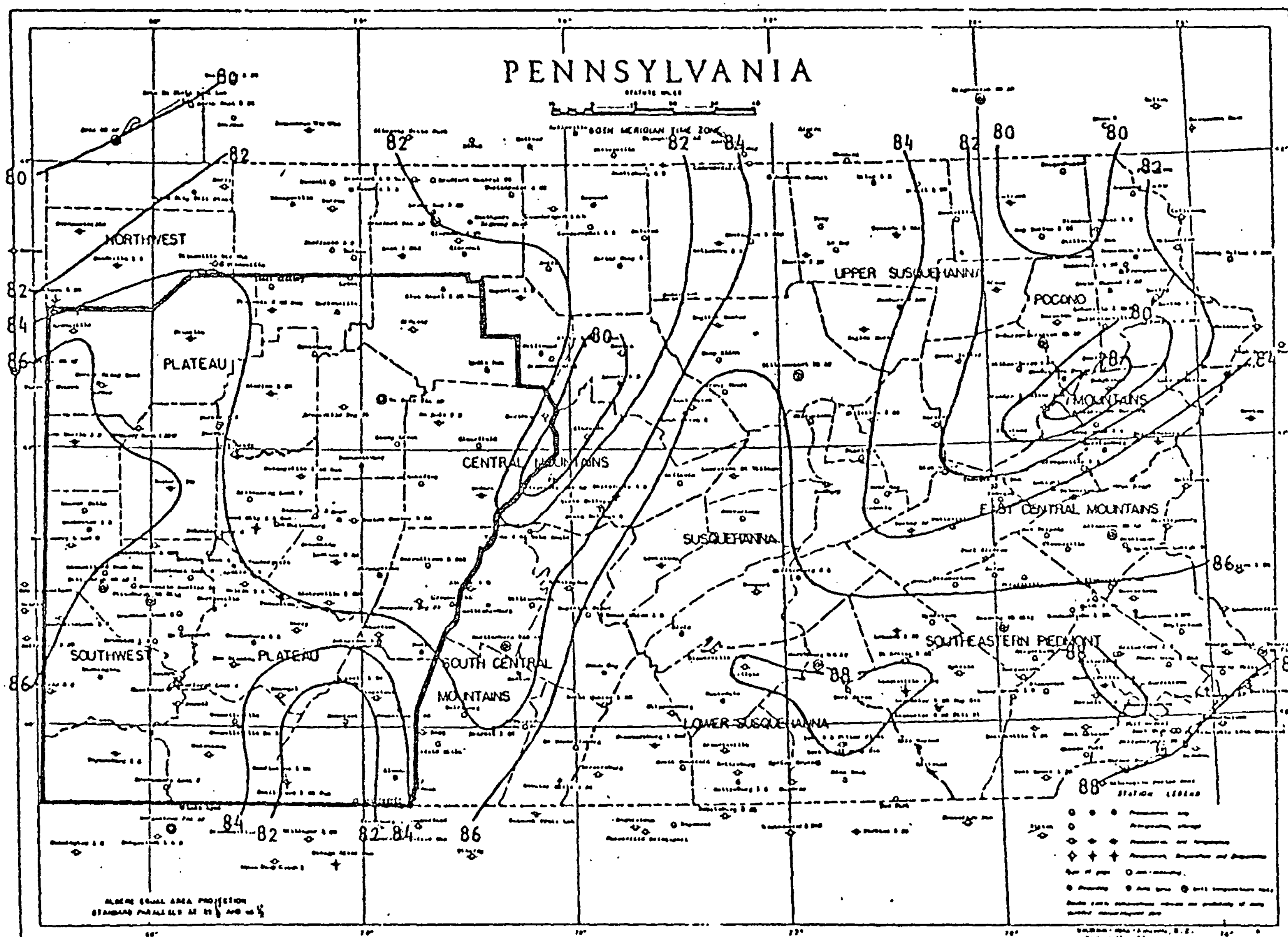


Based on the period 1931-60

ORBES counties in bold outline

Figure 2.1.2.-6

Mean Maximum Temperature (°F), July

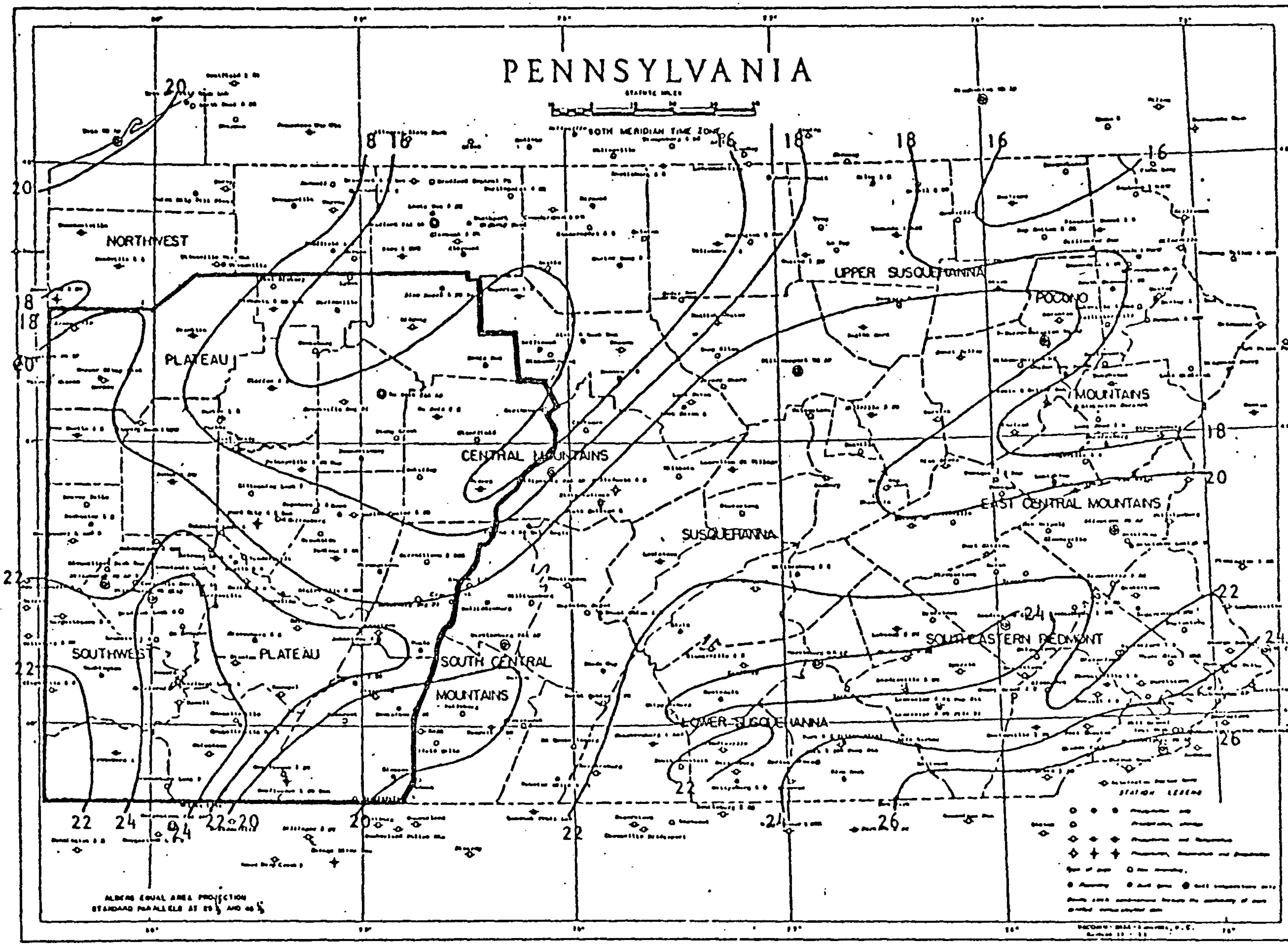


Based on the period 1931-60

ORBES counties in bold outline

Figure 2.1.2.-7

Mean Minimum Temperature (°F), January

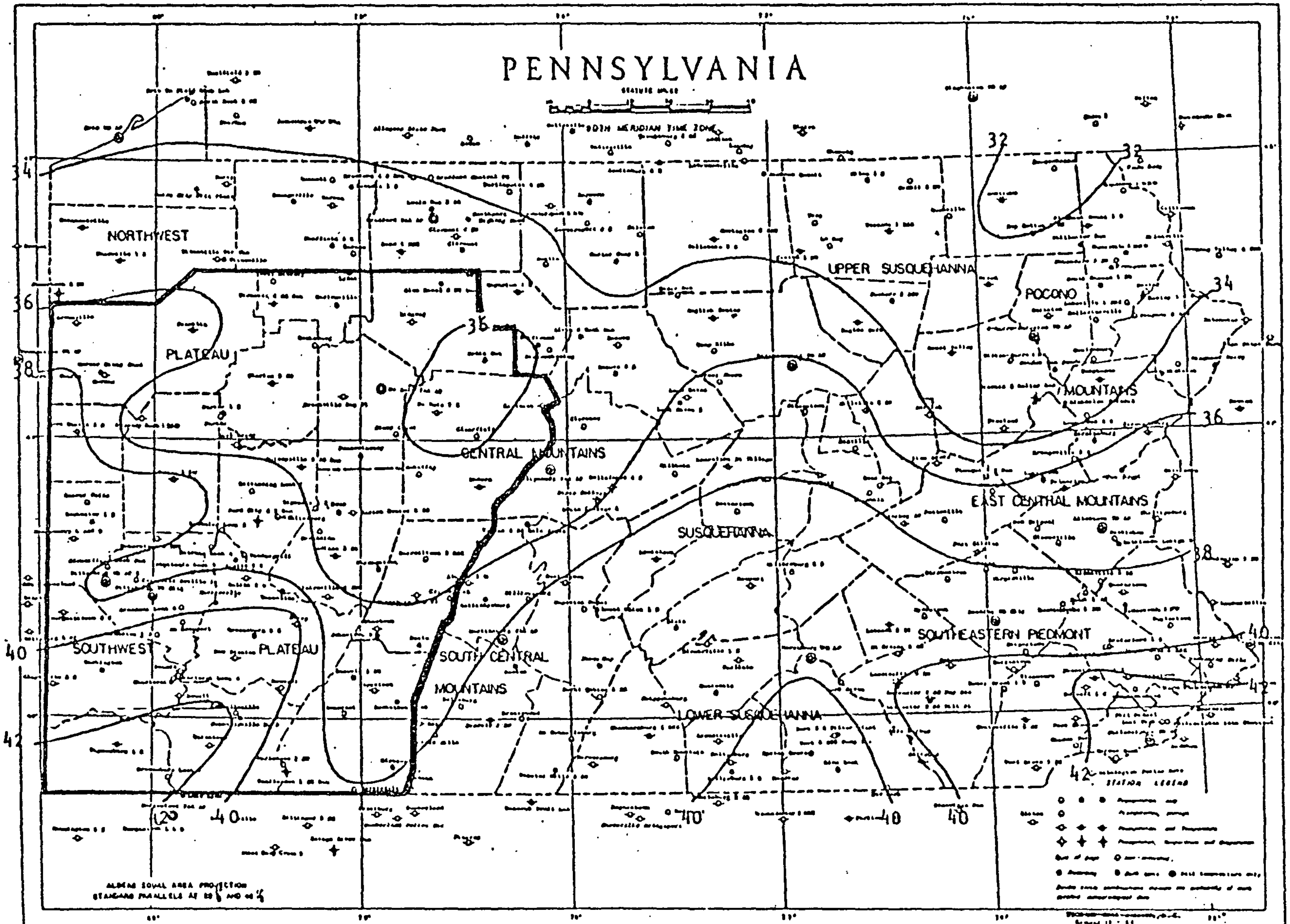


Based on the period 1931-60

ORBES counties in bold outline

Figure 2.1.2.-8

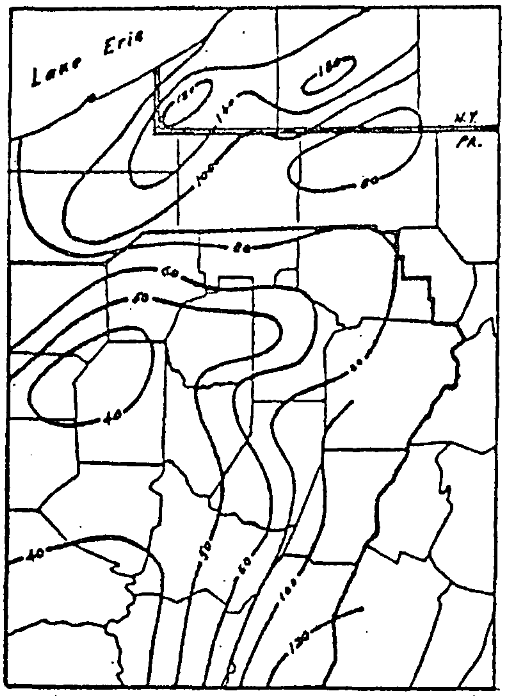
Mean Maximum Temperature (°F), January



Based on the period 1931-60

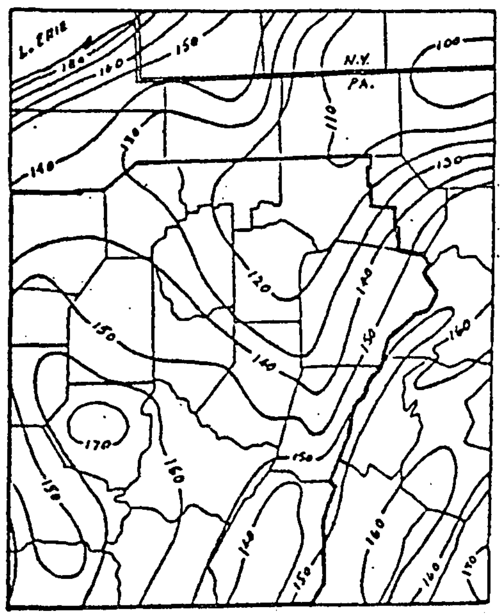
ORBES counties in bold outline

Figure 2.1.2.-9



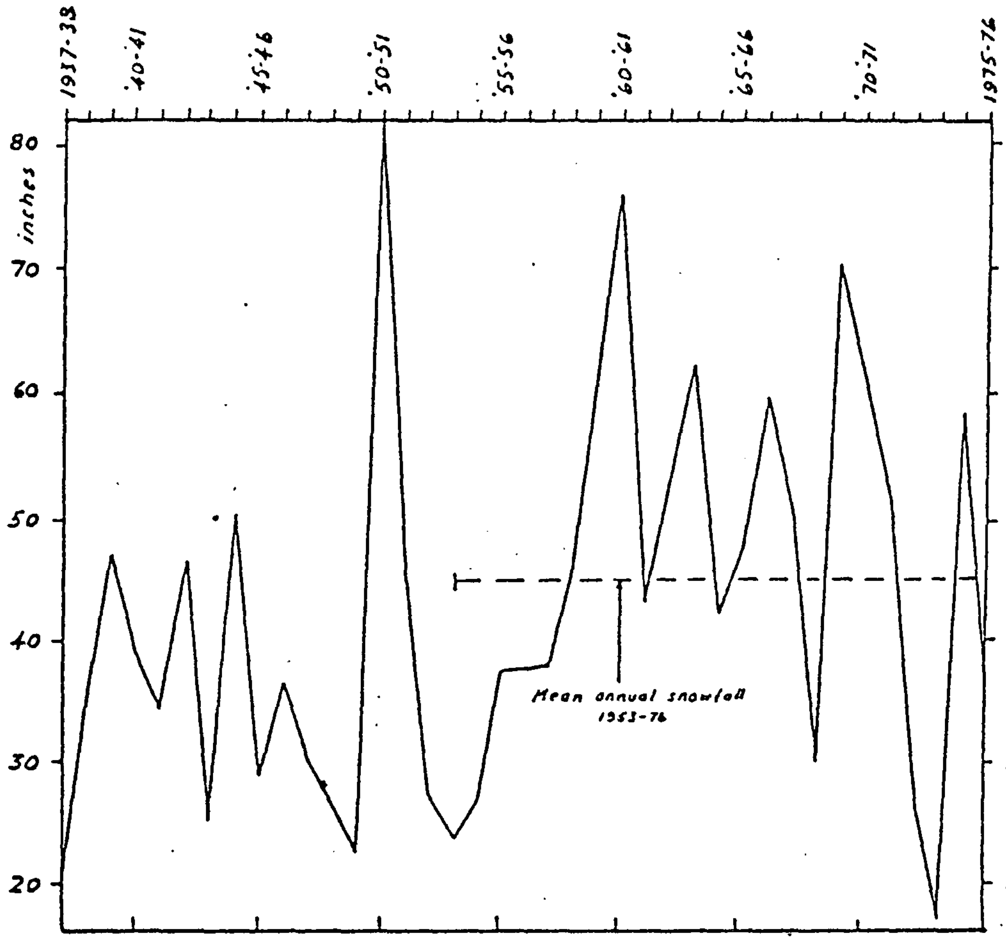
From U.S. Army Corps of Engineers, 1976

Figure 2.1.2.-10 Average annual snowfall 1962-72 (in inches)



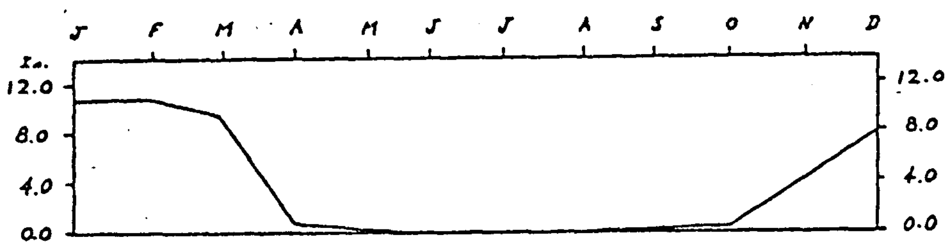
After Jennings, in Netting 1956

Figure 2.1.2.-11 Average length of growing season (in days)



Data from City station through 1951-52; from Greater Pgh. Airport from 1952-53 on

Figure 2.1.2.-12 Annual snowfall at Pittsburgh



Data from Greater Pgh. Airport station

Figure 2.1.2.-13 Mean monthly snowfall at Pittsburgh 1953-1976

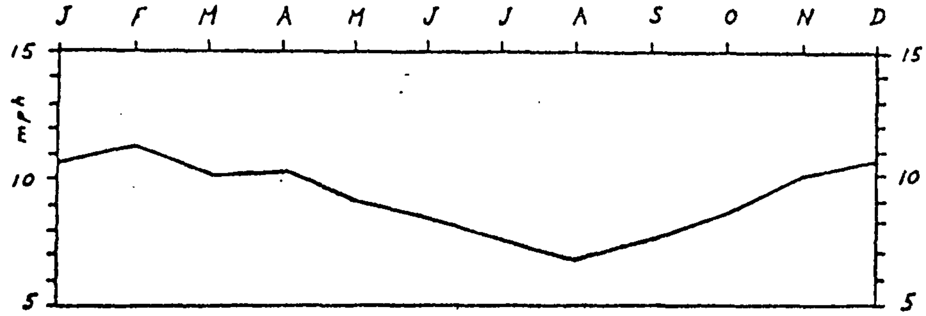


Figure 2.1.2.-14 Average monthly wind speed at Pittsburgh 1968-1977

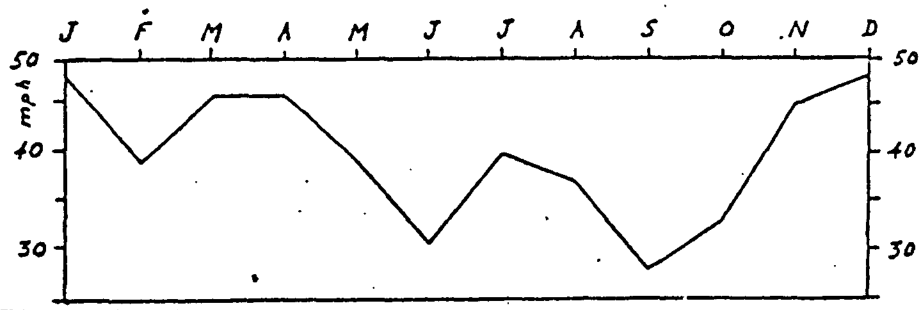


Figure 2.1.2.-15 Maximum monthly wind speed at Pittsburgh, 1968-1977

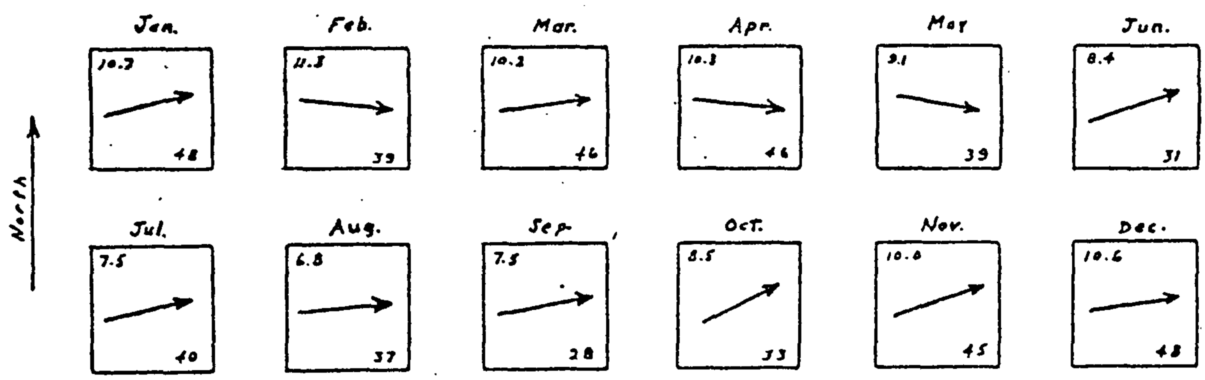


Figure 2.1.2.-16 Monthly wind at Pittsburgh, 1968-1977
Resultant wind*, average speed**, and maximum speed***

* Resultant wind shown by arrows; is vector sum of wind directions divided by number of observations

** Average speed (mph) in upper left corner of box

*** Maximum speed (mph) in lower right corner of box; is fastest mile in 1-minute interval

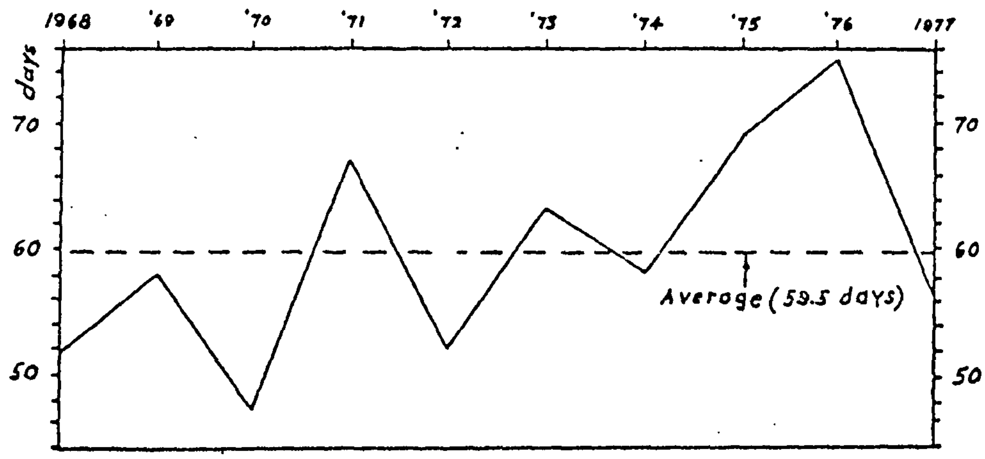


Figure 2.1.2.-17 Number of clear days at Pittsburgh

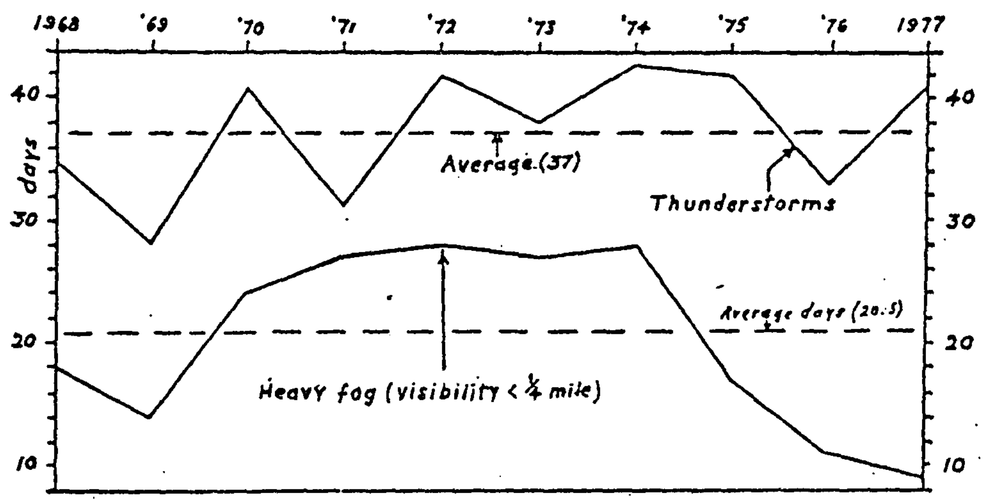


Figure 2.1.2.-18 Number of days of thunderstorms and heavy fog at Pittsburgh

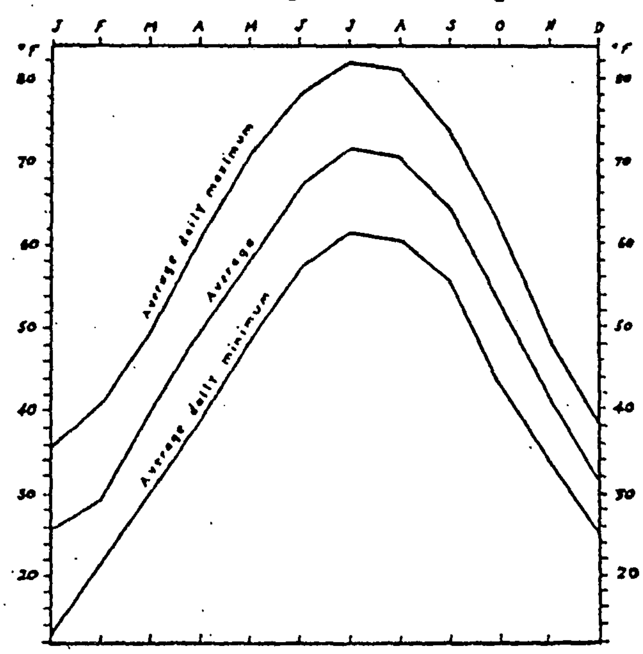
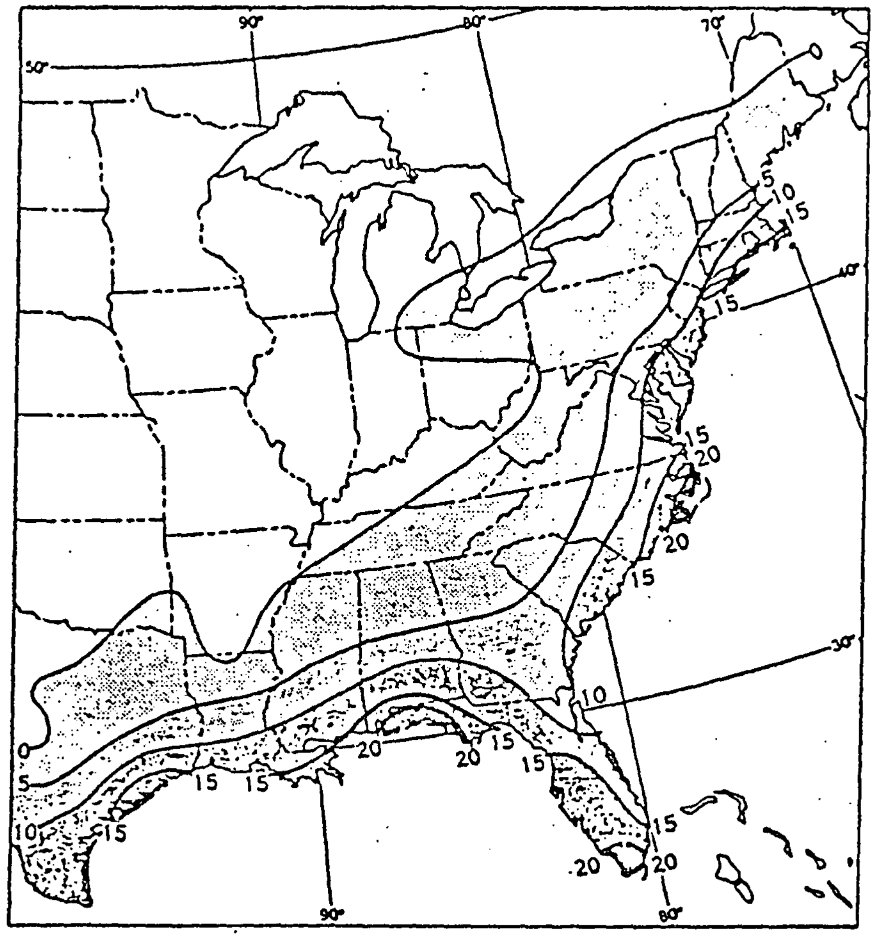


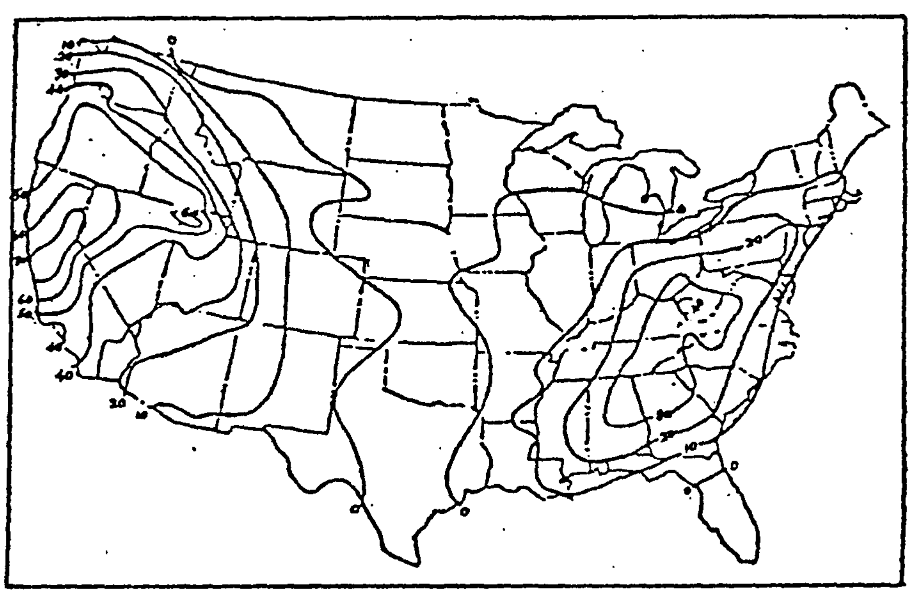
Figure 2.1.2.-19 Monthly temperature at Pittsburgh

Number of Times Destruction was Caused
by Tropical Storms, 1901-1955



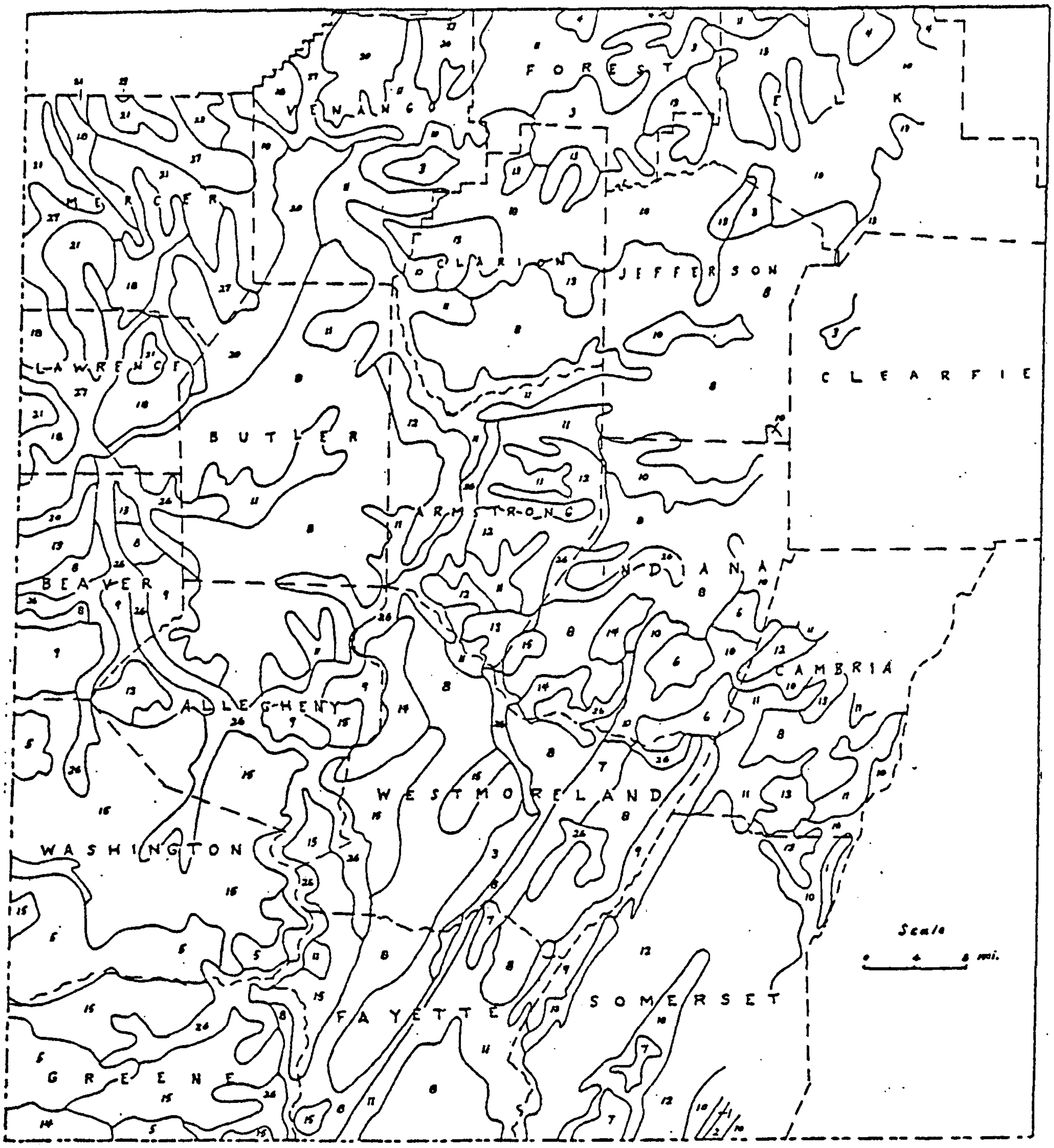
From USCOMM-ESSA

Figure 2.1.2.-20



From Holtzworth, 1972

Figure 2.1.2.-21 Total number of forecast-days of meteorological potential for air pollution expected in a 5-year period. Based on period Aug. 1, 1960-Apr. 13, 1970

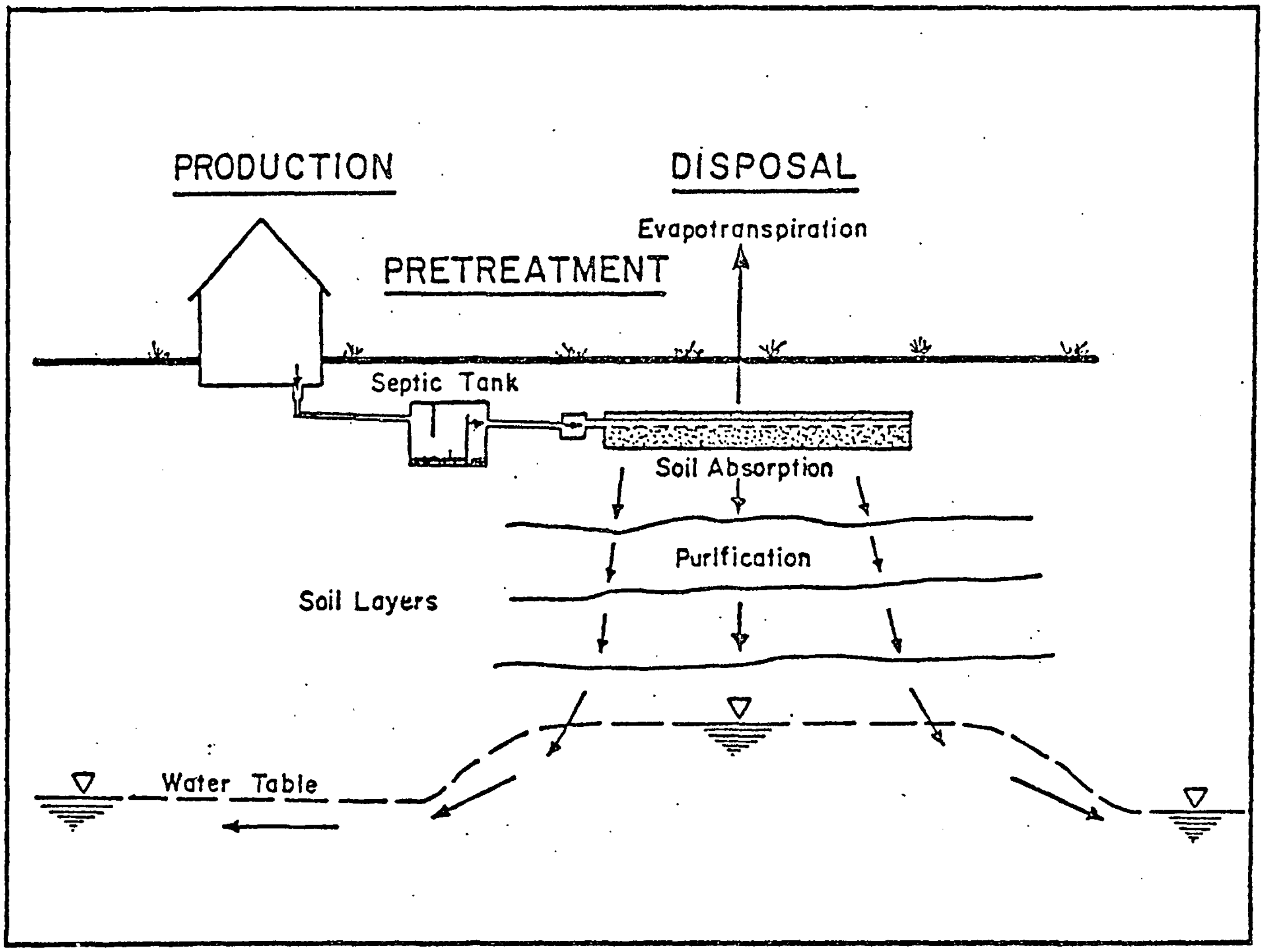


From U.S. Army Corps of Engineers Environmental Inventory of the Pittsburgh District, 1976

Figure 2.1.3.-1 General soil map
(see legend, following page)

General Soil Map Legend

Map Unit	Soil Associations
1	Calvin-Lock Mill-Meckesville
2	Berks-Weikert-Bedington
3	Cookport-Clymer-Hazleton
4	Cookport-Cavode-Wharton
5	Culleoka-Weikert
6	Gilpin-Clymer-Cookport
7	Gilpin-Hazleton-Calvin
8	Gilpin-Ernest-Wharton
9	Gilpin-Upshur-Weikert
10	Hazleton-Cookport
11	Hazleton-Gilpin-Ernest
12	Rayne-Wharton-Ernest
13	Cavode-Wharton-Gilpin
14	Upshur-Gilpin-Clarksburg
15	Guernsey-Culleoka
16	Oquaga-Lordstown
17	Oquaga-Wellsboro-Morris
18	Canfield-Ravenna
19	Erie-Langford
20	Hanover-Alvira
21	Ravenna-Frenchtown
22	Sheffield-Platea
23	Venango-Cambridge
24	Volusia-Mardin-Lordstown
25	Chenango-Howard-Pope
26	Monongahela-Philo-Melvin
27	Wayland-Chenango-Braceville
28	Canadice-Caneada



From Pennsylvania DER, COWAMP report, Study Area 8, 1975

Figure 2.1.3.-2 Standard septic tank-seepage bed system

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