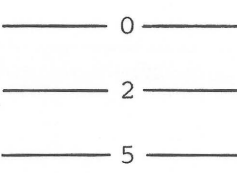
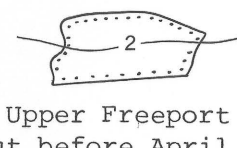


EXPLANATION

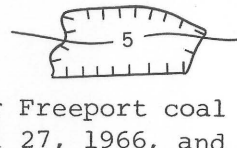
NOTE: All boundaries are approximately located and are shown with solid lines.



Zero line coincides with outcrop of coal bed; bottoms of index numbers 2 and 5 are on the side of thicker overburden. Locally lines coincide, reflecting nearly vertical slopes.



Overburden-thickness lines are paralleled with dots in mined-out areas.



Overburden-thickness lines are ticked in mined-out areas.

Approximate western limit of Upper Freeport coal bed likely to be mined under current conditions

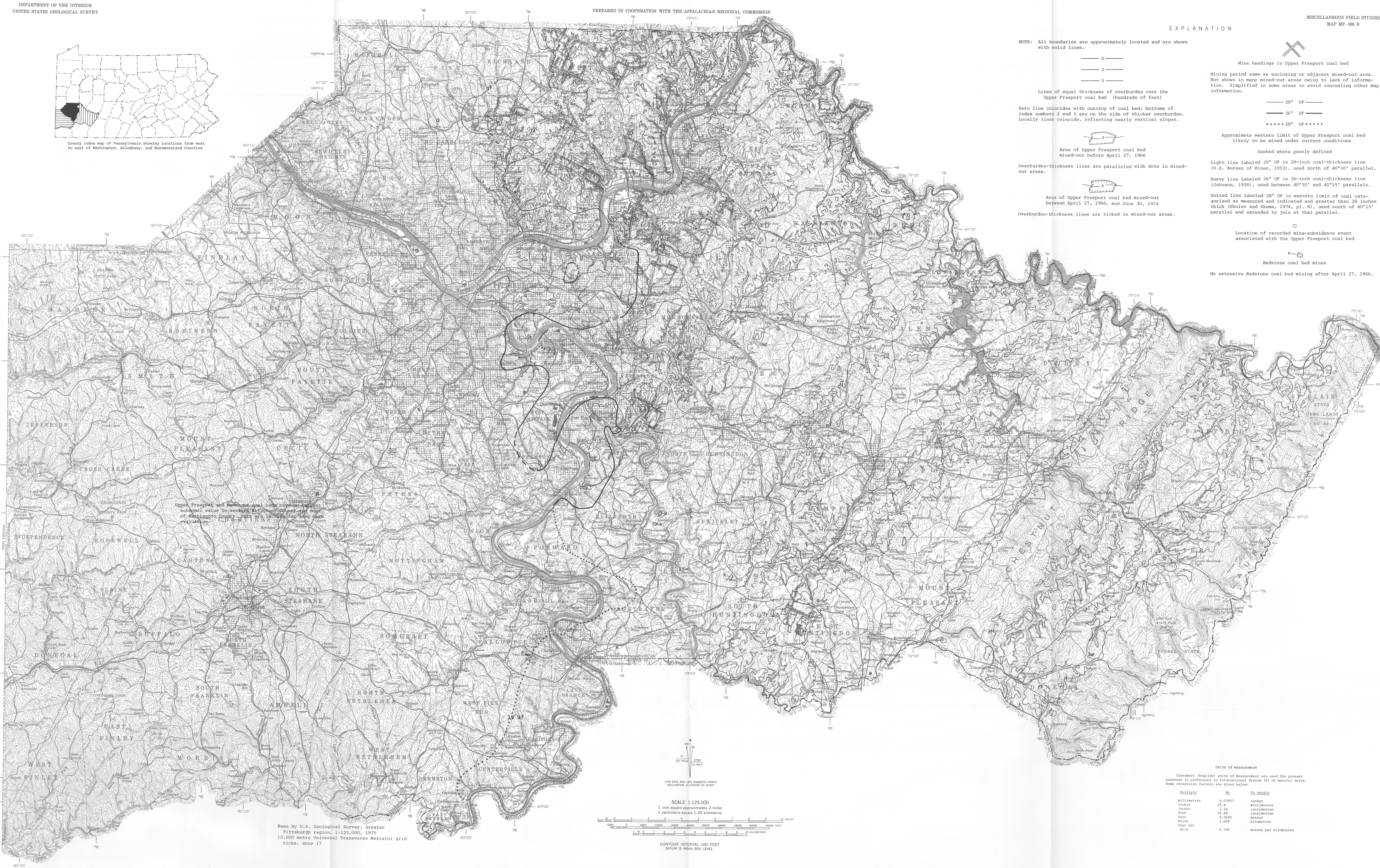
Dashed where poorly defined

Light line labeled 28° UP is 28-inch coal-thickness line (U.S. Bureau of Mines, 1953), used north of 40°30' parallel. Heavy line labeled 36° UP is 36-inch coal-thickness line (Johnson, 1929), used between 40°30' and 40°15' parallels. Dotted line labeled 28° UP is western limit of coal categorized as measured and indicated and greater than 38 inches thick (Sholes and Skema, 1974, pl. 8), used south of 40°15' parallel and extended to join at that parallel.

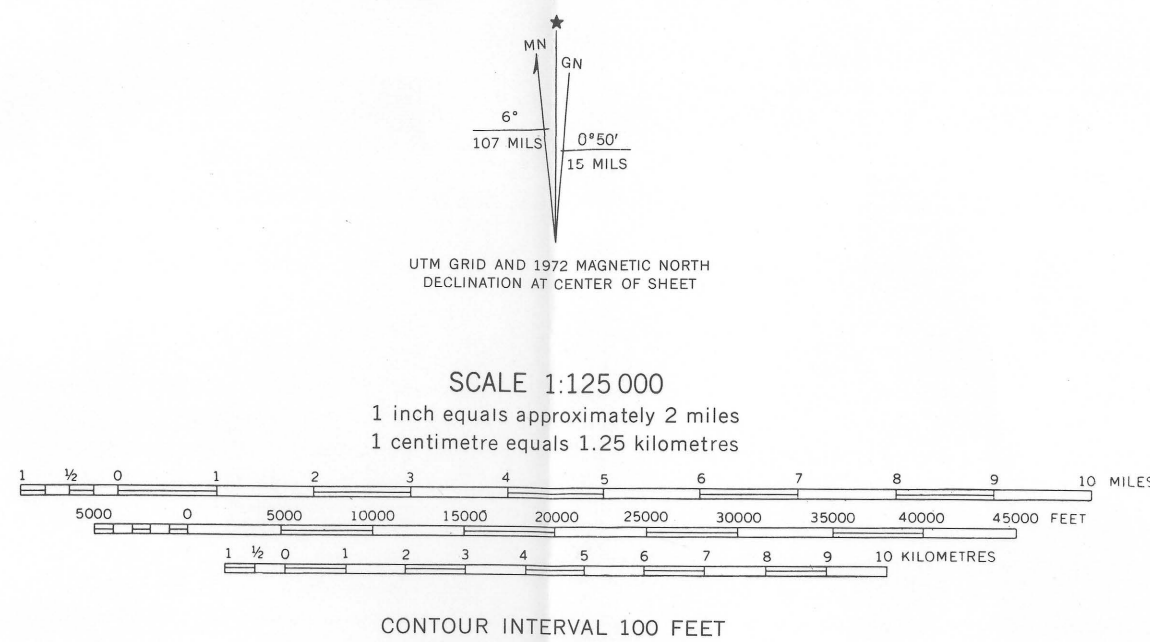
Location of recorded mine-subsidence event associated with the Upper Freeport coal bed

Redstone coal bed mines

No extensive Redstone coal bed mining after April 27, 1966.



Base by U.S. Geological Survey, Greater Pittsburgh region, 1:125,000, 1975
10,000 metre Universal Transverse Mercator grid ticks, zone 17



INTRODUCTION

This map was prepared as part of a study of underground coal mining activity as it relates to surface subsidence. The premise of the study was that geologic and other mappable factors would correlate with known subsidence events and thereby either increase the predictability of subsidence events or, at the least, enable a general classification of land relative to its potential for subsidence. This map and another (Bushnell, 1975a) combine published and newly developed information from which was made an interpretive classification showing areas that correlate with high, moderate, and minor numbers of subsidence events (Bushnell, 1975b). The sources of information used in compiling the map are indicated by asterisks in the list of selected references.

The Division of Mine Subsidence Regulation, Pennsylvania Department of Environmental Resources, provided access to mine maps and related information. A. W. Martin Associates, Inc., King of Prussia, Penn. (W. W. Beck, Jr., written commun., 1974) furnished locations of sites where one or more structures were damaged by mine subsidence. Their compilation is from insurance claims, newspaper articles, the Allegheny County government, and the Division of Mine Subsidence Regulation. This record probably is very incomplete, for only in the last few years have there been regulatory safeguards that yield records of most subsidence events. In earlier times only relatively spectacular events received notice and were recorded in the press or elsewhere. Because of the varied sources of map information, some detailed but others very general, as well as the relatively small map scale, this map is intended for general planning purposes and not as a basis for decisions on the use of specific tracts.

The study was sponsored by the Appalachian Regional Commission as one element of a regional program of environmental analysis conducted by the U.S. Geological Survey.

MINING ACTIVITY

The Upper Freeport coal bed lies at the top of the Freeport Formation, the uppermost formation of the Allegheny Group of Pennsylvanian age (Wagner and others, 1970, p. 46, fig. 25). It has now replaced the Pittsburgh as the most valuable coal reserve in Allegheny and Westmoreland Counties with seven mines active in Allegheny and three in Westmoreland Counties. The Upper Freeport is not mined in Washington County.

Unlike the Pittsburgh coal, the Upper Freeport is variable in thickness and in quality, ranging from only a few inches to ten feet of minable coal with high to low sulfur, ash, and clay content (Heyman, 1929, p. 108-111, 1970). Locally it is replaced by many small and some large but not well defined "washouts". These are the result of scour and channel fill by Pennsylvanian age streams, after the coal material was deposited. Normally washouts of any size are avoided in mining. The coal bed is especially thick (and commonly is labeled the "thick Freeport") along the Allegheny River between Allegheny and Westmoreland Counties, where it has been mined extensively.

The Upper Freeport coal horizon extends southward into Washington County where it lies under 500 to 1,500 feet of overburden. On the map, the 28-inch coal-thickness line north of the 40°30' parallel (U.S. Bureau of Mines, 1953), the 36-inch coal-thickness line between the 40°30' and 40°15' parallels (Johnson, 1929, sheet 27), and the dotted 28-inch coal-thickness line south of the 40°15' parallel (Sholes and Skema, 1974, pl. 8) define approximately the western limits of Upper Freeport coal that is mineable with the techniques and equipment presently employed in "thick Freeport" mines. It is a reasonable speculation that Upper Freeport coal may be mined in the future in some parts of Allegheny and Washington Counties that are west of the limits shown and where data currently available are inadequate for accurate assessment.

SURFACE SUBSIDENCE

The extensive mining has created a serious mine subsidence problem. "Mine subsidence" is a customary and useful term, equivalent in Pennsylvania to subsidence of the ground surface as a result of underground mining. The Commonwealth of Pennsylvania responded to this situation with the passage of the Bituminous Mine Subsidence and Land Conservation Act of 1966. This act required that mine operators leave coal in place beneath certain structures in existence on the effective date of the Act, April 27, 1966; also protected are cemeteries. In addition, structures that predate the act may be protected by the purchase of unmined coal, which is then left in place to support the surface. Details of this act and its operation may be acquired from:

Division of Mine Subsidence Regulation
Department of Environmental Resources
Donaldson Crossroads
203 South Washington Road
McKeesport, Penn. 15137

Surface subsidence is controlled by the nature of the coal and its enclosing rocks, the nature of the mining operations, the depth of mining (that is, thickness of overburden), cultural development of the ground surface, the ground-water regime, and the period of mining operations—before or after April 27, 1966. Locally, subsidence has occurred long (30 or more years) after cessation of mining. This suggests that the old coal pillars are failing as the results of ground-water action, weathering, surface loading, or plastic failure of the mine floor, with accompanying overextension of the bridging capacity of the mine roof and overburden. Overburden data and the time of mining are most amenable for map presentation, considering available information.

Table 1 summarizes the few recorded damaging events associated with subsidence caused by mining of the Upper Freeport. Their distribution does not have the same striking correlation with overburden thickness as do those events caused by mining of the Pittsburgh coal bed (Bushnell, 1975a, table 1). In fact, the Upper Freeport events suggest that overburden thickness is not an important factor. The difference between the Upper Freeport and Pittsburgh distributions may possibly reflect the fact that much of the Upper Freeport mining underlies many residential areas and is largely under a thicker cover than is mining of the Pittsburgh seam. The one post-1966 event listed in table 1 damaged many "protected" homes in a local area and is reported to have been related to a roof fall of sandstone in a collapsed mine room.

The location of one mine subsidence event plots outside the limit of mined-out Freeport coal as shown on the map. This locality in northwestern Allegheny County may overlie an area in which another coal bed was mined many decades ago, for Munn (1911, p. 15) records that a relatively thick local development of a coal bed in the Conemaugh Group was mined nearby. An alternative explanation is that Upper Freeport mining, no longer active in the area, may have extended beyond the recorded limit. Also, the cause of this anomalous event may have been identified incorrectly, for slope failure, which is common in the region, and faulty foundations can produce distress features in structures similar to features resulting from mine subsidence.

Table 2 is a summary of the relationships of undermined Upper Freeport coal, density of housing units, and subsidence events. The 65 percent of the undermined area with more than 100 housing units per square mile contains 73 percent of the subsidence events. Unlike the data of the Pittsburgh coal study (Bushnell, 1975a, table 2), it

appears that, statistically, structures in rural areas stand the greatest chance of damage from Upper Freeport mine subsidence. Realistically, because the number of subsidence events is small compared to those associated with the Pittsburgh coal bed, the Upper Freeport figures, though useful as a general summary, are not an adequate basis for detailed interpretation.

REDSTONE COAL BED MINES

The Redstone coal bed lies in the Pittsburgh Formation, Monongahela Group, about 65 feet above the Pittsburgh coal bed (Wagner and others, 1970, p. 46, fig. 25). Those mines in the Redstone recorded at the Pennsylvania Division of Mine Subsidence Regulation are shown on the map. Although they are not associated with any recorded subsidence events, nevertheless, any underground void is a potential site of surface subsidence. No claim is made that these are all the mines in the Redstone, for this coal is known to have been mined underground for local use at many places in southern Allegheny County and western Westmoreland County. No records of this small-scale mining were available. In addition, it has been mined widely at the surface. Although appreciable areas of reasonably thick Redstone probably remain, large-scale underground mining of the Redstone is unlikely in the foreseeable future. It is not of consistent thickness, and largely it has been broken up by collapse caused by mining of the Pittsburgh coal bed just beneath.

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Table 1: Number of recorded subsidence events^{1/} and claims of damage from subsidence, related to period of underground mining and overburden thickness of the Upper Freeport coal bed, Allegheny and Westmoreland Counties, Pennsylvania.

| Overburden thickness | Period of mining | |
|----------------------|------------------|-----------|
| | Pre-1966 | Post-1966 |
| 0 to 200 ft | 6 | 0 |
| 200 to 500 ft | 5 | 1 |
| Greater than 500 ft | 3 | 0 |

^{1/} Some events include damage to more than one, but adjacent structures.

Table 2: Relationships between the area undermined of Upper Freeport coal, housing density, and recorded subsidence events, Allegheny and Westmoreland Counties, Pennsylvania.

| Housing density in units per square mile ^{1/2} | Area undermined with given housing density in square miles (approx.) | Percent of total undermined | Average no. of units per square mile | Approximate total units in undermined area with given density | Subsidence events in undermined area with given density | Percent of total events | Approximate ratio of subsidence events to total units |
|---|--|-----------------------------|--------------------------------------|---|---|-------------------------|---|
| Less than 100 | 28 | 25 | 50 | 1,400 | 4 | 27 | 1/150 |
| 100 - 500 | 42 | 52 | 300 | 12,600 | 2 | 13 | 1/6300 |
| 500 - 1000 | 6 | 8 | 750 | 4,500 | 2 | 13 | 1/2250 |
| 1000 - 2000 | 3 | 4 | 1500 | 4,500 | 7 | 47 | 1/643 |
| More than 2000 | 1 | 1 | 3000 | 3,000 | 0 | 0 | - |
| Total | 103 ^{1/2} | 100 | - | 26,000 | 15 ^{1/2} | 100 | 1/1733 |

^{1/2} Data from the Southwestern Pennsylvania Regional Planning Commission, Housing unit density map, 1967.

^{2/} 1 square mile equals 2.59 square kilometers.

^{3/} Approximate overall averages: 5.3 square miles/subsidence event; 0.19 subsidence events/square mile.

MAP SHOWING DEPTHS TO THE UPPER FREEPORT COAL BED, MINING ACTIVITY, AND RELATED SURFACE SUBSIDENCE, AND THE REDSTONE COAL BED MINES, ALLEGHENY, WASHINGTON, AND WESTMORELAND COUNTIES, PENNSYLVANIA

By
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1975