BuMines OFR 25-78

Final Report

Prepared for

UNITED STATES DEPARTMENT OF
THE INTERIOR
BUREAU OF MINES

by

GAI CONSULTANTS, INC.
570 BEATTY ROAD
MONROEVILLE, PENNSYLVANIA 15146

Bureau of Mines Open File Report 25-78

Text

Contract No. JO366047

STUDY AND ANALYSIS OF SURFACE SUBSIDENCE OVER THE MINED PITTSBURGH COALBED

JULY 1977

"The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or recommendations of the Interior Department's Bureau of Mines of the U. S. Government."

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. BuMines OFR 25-78	2.	PB 281 511

4. Title and Subtitle
Study and Analysis of Surface Subsidence Over the Mined Pittsburgh Coalbed

5. Report Date
July 1977

6.

7. Author(s)
R. E. Gray, R. W. Bruhn, and R. J. Turka

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
GAI Consultants, Inc.
570 Beatty Road
Monroeville, Pa. 15146

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C) J0366047
(G)

12. Sponsoring Organization Name and Address
Office of Assistant Director--Mining
Bureau of Mines
U.S. Department of the Interior
Washington, D.C. 20241

13. Type of Report & Period Covered
Contract research

14.

15. Supplementary Notes
Approved by the Director of the Bureau of Mines for placement on open file March 24, 1978.

16. Abstract (Limit: 200 words)
The purpose of this study is to investigate cases of subsidence over abandoned mined-out areas of the Pittsburgh coal identified from published and unpublished sources and to determine through a consideration of the geology, topography, climate, mining activity, and evidence at ground surface, what mechanisms control subsidence and under what circumstances it takes place. The study was performed in two phases, the first to identify all documented incidents of subsidence in mined-out areas of the Pittsburgh coal region; and the second, to study a particular portion of the region in detail, collecting pertinent data relative to the sites within, characterizing the nature of the subsidence and its economic consequences, and determining the applicability of the findings to other areas where similar problems with the collapse of abandoned mines have been encountered. The report identifies 354 incidents of subsidence in the 8,000-square-mile Pittsburgh coal region. One is located in Maryland, one is located in West Virginia, and the remainder are located in Pennsylvania. All were confined to the period 1955-76, an interval that was dictated by the availability of information. Data and locations of sites of subsidence are presented on graphs and tables and on U.S. Geological Survey 7.5-minute quadrangle topographic maps. Case histories of several incidents of subsidence above abandoned mines are presented and subsidence in southwestern Pennsylvania is discussed in detail.

17. Document Analysis a. Descriptors
Pittsburgh coal
Mine subsidence
Rock mechanics
Abandoned and active mines

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group 08I

REPRODUCED BY
NATIONAL TECHNICAL INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

18. Availability Statement
Release unlimited by NTIS.

19. Security Class (This Report)

20. Security Class (This Page)

21. No. of Pages

22. Price
A16-A01

DO NOT PRINT THESE INSTRUCTIONS AS A PAGE IN A REPORT

INSTRUCTIONS

Optional Form 272, Report Documentation Page is based on Guidelines for Format and Production of Scientific and Technical Reports, ANSI Z39.18–1974 available from American National Standards Institute, 1430 Broadway, New York, New York 10018. Each separately bound report—for example, each volume in a multivolume set—shall have its unique Report Documentation Page.

1. Report Number. Each individually bound report shall carry a unique alphanumeric designation assigned by the performing organization or provided by the sponsoring organization in accordance with American National Standard ANSI Z39.23–1974, Technical Report Number (STRN). For registration of report code, contact NTIS Report Number Clearinghouse, Springfield, VA 22161. Use uppercase letters, Arabic numerals, slashes, and hyphens only, as in the following examples: FASEB/NS–75/87 and FAA/RD–75/09.
2. Leave blank.
3. Recipient's Accession Number. Reserved for use by each report recipient.
4. Title and Subtitle. Title should indicate clearly and briefly the subject coverage of the report, subordinate subtitle to the main title. When a report is prepared in more than one volume, repeat the primary title, add volume number and include subtitle for the specific volume.
5. Report Date. Each report shall carry a date indicating at least month and year. Indicate the basis on which it was selected (e.g., date of issue, date of approval, date of preparation, date published).
6. Sponsoring Agency Code. Leave blank.
7. Author(s). Give name(s) in conventional order (e.g., John R. Doe, or J. Robert Doe). List author's affiliation if it differs from the performing organization.
8. Performing Organization Report Number. Insert if performing organization wishes to assign this number.
9. Performing Organization Name and Mailing Address. Give name, street, city, state, and ZIP code. List no more than two levels of an organizational hierarchy. Display the name of the organization exactly as it should appear in Government indexes such as Government Reports Announcements & Index (GRA & I).
10. Project/Task/Work Unit Number. Use the project, task and work unit numbers under which the report was prepared.
11. Contract/Grant Number. Insert contract or grant number under which report was prepared.
12. Sponsoring Agency Name and Mailing Address. Include ZIP code. Cite main sponsors.
13. Type of Report and Period Covered. State interim, final, etc., and, if applicable, inclusive dates.
14. Performing Organization Code. Leave blank.
15. Supplementary Notes. Enter information not included elsewhere but useful, such as: Prepared in cooperation with . . . Translation of . . . Presented at conference of . . . To be published in . . . When a report is revised, include a statement whether the new report supersedes or supplements the older report.
16. Abstract. Include a brief (200 words or less) factual summary of the most significant information contained in the report. If the report contains a significant bibliography or literature survey, mention it here.
17. Document Analysis. (a). Descriptors. Select from the Thesaurus of Engineering and Scientific Terms the proper authorized terms that identify the major concept of the research and are sufficiently specific and precise to be used as index entries for cataloging.

    (b). Identifiers and Open-Ended Terms. Use identifiers for project names, code names, equipment designators, etc. Use open-ended terms written in descriptor form for those subjects for which no descriptor exists.

    (c). COSATI Field/Group. Field and Group assignments are to be taken from the 1964 COSATI Subject Category List. Since the majority of documents are multidisciplinary in nature, the primary Field/Group assignment(s) will be the specific discipline, area of human endeavor, or type of physical object. The application(s) will be cross-referenced with secondary Field/Group assignments that will follow the primary posting(s).
18. Distribution Statement. Denote public releasability, for example "Release unlimited", or limitation for reasons other than security. Cite any availability to the public, with address, order number and price, if known.

19. & 20. Security Classification. Enter U.S. Security Classification in accordance with U.S. Security Regulations (i.e., UNCLASSIFIED).

21. Number of pages. Insert the total number of pages, including introductory pages, but excluding distribution list, if any.

22. Price. Enter price in paper copy (PC) and/or microfiche (MF) if known.

☆ U.S. GPO: 1977-0-241-530 2461

FOREWORD

This report was prepared by GAI Consultants, Inc., 570 Beatty Road, Monroeville, Pennsylvania 15146 under USBM Contract Number (J0366047). The contract was initiated under the Advancing Mining Technology/Coal Program. It was administered under the technical direction of Pittsburgh Mining and Safety Research Center with Mr. M. O. Magnuson acting as the Technical Project Officer. Mr. Joseph A. Gilchrist was the contract administrator for the Bureau of Mines.

This report is a summary of the work recently completed as part of this contract during the period June 30, 1976 to July 30, 1977. This report was submitted by the authors on July 30, 1977.

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	iii
1. INTRODUCTION	1
2. SUBSIDENCE--EXAMPLES AND GENERAL TRENDS	5
3. GEOLOGIC SETTING	38
4. MINING	48
5. SINKHOLES	66
6. TROUGHS	90
7. TROUGH SUBSIDENCE ASSOCIATED WITH PILLAR FAILURE	97
8. TROUGH SUBSIDENCE ASSOCIATED WITH PUNCHING OF PILLARS INTO THE MINE FLOOR	113
9. COSTS OF SUBSIDENCE TO THE PUBLIC	127
10. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	133
LIST OF REFERENCES	137
APPENDIX A - SOURCES OF SUBSIDENCE INFORMATION	A-1
APPENDIX B - TABLE A	

LIST OF TABLES

Table	Description	Page
1.1	U.S.G.S. Quadrangles in Which Sites of Subsidence are Located	4
2.1	Sites Above Abandoned Mines in the Pittsburgh Coal Region Where Recurrent Subsidence Has Been Reported	14
2.2	Distribution of Incidents of Subsidence Above Abandoned Mines in the Pittsburgh Coal Region by State and by County	17
4.1	Principal Types of Total Extraction Room and Pillar Mining Practiced in the Pittsburgh Coal Region	56
5.1	Conditions Conducive to the Development of Various Modes of Roof Failure	78
6.1	Documented Sites of Trough Subsidence Above Abandoned Mines in the Pittsburgh Coal Region	93
6.2	Ground Surveys Conducted Above Active Mines in the Pittsburgh Coal Region	94
7.1	Strength Relationships for Prismatic Pillars of Square Cross-Section--Pittsburgh Coal	106
8.1	Concepts Regarding Subsidence Due to Punching of Pillars into the Mine Floor	123
10.1	Classification of Subsidence Damage	136
A	Data Relative to Individual Sites of Subsidence Above Abandoned Mines in the Pittsburgh Coal Region	

LIST OF FIGURES

Figure	Title	Page
2.1	Ground Crack Associated with Mining 300 Feet Below Ground Surface	18
2.2	School Buttressed After Damage by Mining 280 Feet Below Ground Surface (Site 1200)	18
2.3	Three Homes Damaged by Subsidence (Site 101)	19
2.4	Subsidence Trough Near Almont Street in Carrick Section, City of Pittsburgh, Allegheny County, Pennsylvania (Site 101)	20
2.5	Apartment Complex Under Construction Damaged by Subsidence 140 Feet Above Abandoned Mine (Site 133)	21
2.6	Two Homes Damaged by Subsidence 30 Feet Above Abandoned Mine (Site 163)	21
2.7	Junior High School and Elementary School Damaged by Subsidence 125 Feet Above Abandoned Mine (Site 236)	22
2.8	Subsidence Trough in Washington Township, Fayette County, Pennsylvania (Site 236)	23
2.9	Sinkhole in Front Yard of Home on McCutcheon Lane, Penn Hills Township, Allegheny County, Pennsylvania (Site 64)	24
2.10	Section Through Abandoned Mine Entry Located Beneath Front Yards of Homes, Penn Hills Township, Allegheny County, Pennsylvania (Site 64)	25
2.11	Area of Recurrent Subsidence, California Borough, Washington County, Pennsylvania (Site 248)	26
2.12	Mean Diameters of Subsidence Features	27
2.13	Depths of Subsidence Features	28
2.14	Relationship of Diameter and Depth of Subsidence Feature to Overburden Thickness	29
2.15	Distribution of Periods of Undermining	30
2.16	Number of Subsidence Incidents Documented Above Individual Abandoned Mines	31

LIST OF FIGURES
(Continued)

Figure	Title	Page
2.17	Minimum Time Interval Between Mining and Subsidence	32
2.18	Distribution of Precipitation and Subsidence Incidents by Month and by Year for Period 1971-1975	33
2.19	Overburden Thickness at Subsidence Sites	34
2.20	Number of Structures Damaged per Subsidence Incident	35
2.21	Dollar Values of Insurance Settlements for Damages to Homes Above Abandoned Mines in the Pittsburgh Coal Region	36
2.22	Number of Documented Subsidence Incidents in Pittsburgh Coal Region by Year	37
3.1	Location of the Pittsburgh-Huntington Basin and the Appalachian Plateau	43
3.2	Geologic Column of Western Pennsylvania	44
3.3	Geologic Map of Western Pennsylvania	45
3.4	Variation of Roof Strata of the Pittsburgh Coal Over the Four-State Region	46
3.5	Selected Geologic Logs, Allegheny County, Pennsylvania	47
4.1	Generalized Map of the Pittsburgh Coal	58
4.2	An Early Partial Extraction Mine in Pittsburgh's Hill District, Allegheny County, Pennsylvania (Pittsburgh East Quadrangle)	59
4.3	Photostatic Copy of Map of Old Mine Located in Outlier of Pittsburgh Coal, Allegheny County, Pennsylvania	60
4.4	General Plan of Mine Development by Narrow Pillar Line Common in Allegheny County, Pennsylvania; Half Advance - Half Retreat Method of Pillar Extraction with Short Break Line	61

LIST OF FIGURES
(Continued)

Figure	Title	Page
4.5	General Plan of Mine Development by Narrow Pillar Line, Washington County, Pennsylvania; Full Retreat Method of Pillar Extraction with Long Break Line	62
4.6	General Plan of Mine Development by an Early Type of Block System Typical in Pennsylvania	63
4.7	An Early Total Extraction Mine Developed Using Long Pillar Lines, Allegheny County, Pennsylvania (Glassport Quadrangle)	64
4.8	Region of Pittsburgh Coal in Pennsylvania Mined Out Prior to 1935	65
5.1	Caving Failure Above Pittsburgh Coal Observed in Roadcut Along U. S. Route 22, Near Murrysville, Westmoreland County, Pennsylvania	79
5.2	Sinkhole Observed Near Haywood, Harrison County, West Virginia	79
5.3	Horizontal Borehole Photograph Showing Conditions in Abandoned Mine 20 Feet Beneath Proposed Construction Site in Allegheny County, Pennsylvania	80
5.4	Model Study Demonstrating Distribution of Overburden Load as a Function of Pillar Stiffness	81
5.5	Line Drawing Constructed from Photoelastic Observations Illustrating the Development of a Free-Hanging Wedge Over the Extracted Area as the Width of this Area Increases	82
5.6	Variation of Roof Stresses with Height of Caving	83
5.7	Relationship Between Frequency of Sinkhole Development and Distance from Outcrop	84
5.8	Relationship of Height and Width of Mine Opening and Angle of Break to Height of Caving	85

LIST OF FIGURES
(Continued)

Figure	Title	Page
5.9	Locations of Sinkholes Relative to Coal Outcrop and to Strata Located Above the Coal; Braddock, Glassport, McKeesport, Pittsburgh East Quadrangles, Allegheny County, Pennsylvania	86
5.10	Relationship Between Cumulative Precipitation and Subsidence	87
5.11	Conceptual Representation of the Frequency of Sinkhole Development Above a Particular Mine with Time	88
5.12	Inferred Rate of Caving of Mine Roof	89
6.1	Development of Trough 500 Feet Above Mine in Pittsburgh Coal, North Bethlehem Township, Washington County, Pennsylvania	95
6.2	Relationship of Depth of Subsidence Trough to Width of Mined Area	96
7.1	Probable Character of Overburden Failure Above Total Extraction Room-and-Pillar Mine in Pittsburgh Coal as Deduced from Field Observations	107
7.2	Relationship Between Trough Diameter, Overburden Thickness and Angles of Break and Draw for Trough Subsidence Above Abandoned Mine in Pittsburgh Coal Region Due to Pillar Failure	108
7.3	Comparative Strength of Cubes of Pittsburgh Coal as a Function of Cube Length; and Ratio of Prism to Cube Strength of Pittsburgh Coal as a Function of Width-Height Ratio of the Prism	109
7.4	Plan of Mine at Site 155	110
7.5	Municipal Building in Allegheny County, Pennsylvania, Damaged by Subsidence 120 Feet Above Abandoned Mine (Site 155)	111
7.6	Section Through Borings at Site 155	112

LIST OF FIGURES
(Continued)

Figure	Title	Page
8.1	Map of Mine Located Beneath Site 1200, Farmington, Marion County, West Virginia	125
8.2	Variation in Bearing Capacity of Mine Floor Relative to Shear Strength and Thickness of Underclay and Plan Dimensions of Coal Pillars	126
9.1	Number of Structures Damaged per Subsidence Incident Relative to Overburden Thickness	131
9.2	Documented Subsidence Sites in Allegheny County, Pennsylvania (1957-1976) Relative to Distribution of Total Dwelling Units	132
A.1	Index to U.S.G.S. Topographic Quadrangle Maps in the Pittsburgh Coal Region of Maryland	A-8
A.2	Index to U.S.G.S. Topographic Quadrangle Maps in the Pittsburgh Coal Region of Ohio	A-9
A.3	Index to U.S.G.S. Topographic Quadrangle Maps in the Pittsburgh Coal Region of Pennsylvania	A-10
A.4	Index to U.S.G.S. Topographic Quadrangle Maps in the Pittsburgh Coal Region of West Virginia	A-11

1. INTRODUCTION

This report summarizes the work performed for the U. S. Bureau of Mines by GAI Consultants, Inc., under Contract J0366047 carried out in the period July 1976 through June 1977.

Scope of the Study

The purpose of the study is to investigate cases of subsidence over abandoned mined-out areas of the Pittsburgh Coal identified from published and unpublished sources and to determine through a consideration of the geology, topography, climate, mining activity, and evidence at ground surface, what mechanisms control subsidence and under what circumstances it takes place.

The study was performed in two phases, the first to identify all documented incidents of subsidence in mined-out areas of the Pittsburgh Coal Region; and the second, to study a particular portion of the region in detail, collecting pertinent data relative to the sites within, characterizing the nature of the subsidence and its economic consequences, and determining the applicability of the findings to other areas where similar problems with collapse of abandoned mines have been encountered.

The Pittsburgh Coal Region encompasses portions of Maryland, Ohio, Pennsylvania, and West Virginia. Detailed study was conducted in southwestern Pennsylvania, an area that embraces approximately one-third of the coal region and includes nearly all sites of subsidence identified in the study. Over 60 percent of these sites were located in the Greater Pittsburgh area.

Data Collected

Within the 8,000-square mile[111] Pittsburgh Coal Region, a total of 354 incidents of subsidence above abandoned mines were identified at 302 different sites.

Identification was accomplished through an extensive three-month survey during which inquiries regarding subsidence information were made of coal and utility companies; of federal, state, and local government agencies concerned with mining, geology, and environmental affairs; and of other consultants in a four-state area. The details of the data collection program are presented in Appendix A.

The locations of the subsidence sites are shown on 32 U.S.G.S. 7-1/2 minute quadrangle topographic maps bound separately in the accompanying folio. The maps have been reduced to 11- by 17-inch size and are arranged alphabetically by state and by quadrangle. Quadrangle names are listed in Table 1.1. Quadrangle locations are shown on the four state quadrangle index maps, Figures A.1 through A.4.

Information gathered on individual sites is presented in Table A of Appendix B. The information for any particular site appears on two facing pages of the table. (Refer, for example, to the first section of Table A which pertains to Allegany County, Maryland.) The first entry for a site (appearing on the top page) provides basic information on site location, evidence of subsidence, and types and sources of available information. The second entry (appearing on the bottom page) presents some of the more detailed information on the physical character of the site--the dimensions and depths of the subsidence feature, the thickness of overburden, the nature of the rock above and below the mine, and available information on the history of mining beneath the site.

Subsidence listings in Table A are grouped by county. The listings for Pennsylvania are further subdivided into borough or township. The listings within each subdivision are arranged in chronological order according to reported date of occurrence. Site numbers are entirely arbitrary.

For purposes of discussion, data from 16 sites of subsidence above active mines in the Pittsburgh Coal are also included in Table A. Their site numbers are postscripted with the letter 'A'.

Sites whose exact locations could be determined--70 percent of all sites identified in the study--have been designated in Table A by an asterisk. The locations of these sites are shown on the U.S.G.S. quadrangle maps in the accompanying folio.

General Organization of the Report

Case histories of subsidence above active and abandoned mines in the Pittsburgh Coal are presented in Section 2. They illustrate the character of subsidence as it is commonly manifested and furnish an appreciation for how it has been experienced by residents of the area. In the same section, the data collected during the study are reviewed and general trends are presented relative to the geometry of the subsidence features, their location, time and frequency of occurrence, relationship to mining and topography, and damaging effects that have been reported during the period of documentation.

The geologic setting of the Pittsburgh Coal Region is discussed in Section 3, and mining practices of the region are discussed in Section 4, particularly in regard to the first decades of the Twentieth Century, when much of the mining in the presently subsiding areas was conducted.

The subsidence features themselves are discussed in Sections 5 through 8--sinkholes in Section 5, and troughs in Sections 6 through 8. Section 6 is devoted to a general discussion of trough subsidence in relation to active mining. Sections 7 and 8 are devoted to trough subsidence above abandoned mines--Section 7 in reference to pillar failure and Section 8 in reference to punching of pillars into the mine floor.

The costs to the public of subsidence above abandoned mines are discussed in Section 9, as documented by mine subsidence insurance sources and state agencies involved in abating and correcting subsidence problems.

Conclusions and recommendations are presented in Section 10.

Table 1.1

U.S.G.S. QUADRANGLES IN WHICH
SITES OF SUBSIDENCE ARE LOCATED

Avella	Latrobe
Braddock	Mannington (W. VA)
Bridgeville	Masontown
Burgettstown	Mather
California	McKeesport
Canonsburg	Midway
Carmichaels	Monongahela
Clinton	Murrysville
Connellsville	New Salem
Derry	Pittsburgh East
Donora	Pittsburgh West
Fayette City	Slickville
Frostburg (MD/PA)	Smithton
Glassport	South Connellsville
Greensburg	Washington East
Hackett	Waynesburg

Note: All quadrangles are in Pennsylvania unless otherwise designated.

2. SUBSIDENCE - EXAMPLES AND GENERAL TRENDS

Subsidence refers to movements of the ground surface that take place in response to readjustments of the overburden above a mine. Some movements take place during mining and some after. The movements may either be very local or may cover several acres, depending on the type of mining that has been practiced, the thickness and character of the overburden and mine floor, and other details of the site[16, 87, 114]. Figures 2.1 through 2.11 present several examples of subsidence observed in the Pittsburgh Coal Region that serve to illustrate the nature of its occurrence and the type of damage it can cause.

1. Figure 2.1 - A half mile long crack, intermittently 4 feet wide and more than 50 feet deep, opened in the ground surface as coal pillars were being extracted 300 feet underground. Several years later, an 1,800 pound farm horse fell into the crack and could not be extricated[71]. Ground cracks of a similar nature form in association with subsidence above abandoned mines but are almost never this wide.

2. Figure 2.2 - The two-story brick school building located 280 feet above mine level was fitted with the H-beam buttress after suffering substantial damage to its front wall as mining progressed beneath. Thirteen years later, after the mine had been closed, the building was damaged beyond repair when another episode of subsidence accompanied punching of the coal pillars into the mine floor. Subsidence movements continued for a period of four years when a federal and state sponsored program was undertaken to abate subsidence by injecting the mine with coal waste. A total of 43 homes and buildings were damaged by differential settlements and by increased earth pressures that accompanied subsidence. (This case is discussed in more detail in Section 8; Site 1200.)

3. Figure 2.3A shows a series of stair-step cracks that appeared across the front of a two-story ten-room masonry home as it subsided into a dish-shaped depression 150 feet long, 85 feet wide, and 8 inches deep one Saturday afternoon in May 1957 (Figure 2.4).

   Movements were first noticed shortly after noon when the resident of the home to the east became aware of a tapping sound like rain drops in one corner of her basement. She soon found that

the cellar door would not close and then observed a new crack in the floor of the basement.

Several hours later, the resident of the center home returned from work to find his kitchen and bathroom walls cracked top to bottom and "everything falling and cracking" in the basement.

Gas and electric service were shut off by 10 p.m., as "terrifying cracking noises" eminated from the two homes. Soon thereafter, the residents evacuated the premises at the recommendation of state officials.

A review of the sequence of events revealed that the initial movements, which had begun shortly after noon, continued until about midnight, and were then followed by larger movements that continued until about seven in the morning. These were followed again by lesser movements that continued for the next month.

Damage was most severe to the center home, where lateral differential movements at foundation level amounted to 3-1/2 inches and differential settlements amounted to eight inches (Figure 2.3B). Settlements averaged about one-quarter-inch per hour during the initial two-day period of subsidence, and brought about cracks in all ten rooms of the home.

In the home to the east, settlement of the basement floor opened a three-inch horizontal crack at mid-height across the full width of the basement wall (Figures 2.3C and 2.3D). The crack opened another three inches over the next 30 days. The first and second floors of the home were saved from potentially severe damage only by propping the basement floor joists with adjustable screw jacks.

The home on the west margin of the depression suffered only minor damage to its kitchen, which is located in one corner of the home (Figure 2.3E).

Damage to the $40,000 home in the center, 11 years old at the time, was assessed at $14,000. Although first considered to be a total loss, the home was eventually repaired, as were the two adjoining homes. The resident of the center home, who was also the builder of the three affected homes, expressed his dismay at the whole situation, "I can't understand it. We had to blast through

solid rock to lay the foundation. Something is sinking under the rock". The homes were located 70 feet above a mine abandoned 50 years earlier (Site 101).

4. Figure 2.5 - Construction of the $300,000, 24-unit apartment complex was nearing completion in August 1973, when minor cracks were observed in several of the interior walls. Two weeks later, settlements as great as nine inches took place across a nearly circular area 120 feet in diameter, accompanied by a wrenching and separation of walls from floors that necessitated the installation of props to prevent collapse. The 12 families that had already taken up residence in the building were moved to other quarters and construction activity ceased. The apartment building was subsequently razed. It had been constructed 140 feet above a mine abandoned in about 1925 (Site 133).

5. Figure 2.6 - Two $17,000 homes sustained considerable damage in June 1968, when an area about 80 feet in diameter began to subside between them (Site 163).

The resident of the home to the right was standing in his front yard when he heard a "crackling" sound and observed fissures appearing in the brickwork of his home. He quickly entered the home, shut off the utilities and fled. Within 20 minutes, one corner of the foundation dropped, causing a 2-foot gap to open in the wall between basement and first floor. In another 12 hours, the gap had widened to five feet and cracks also appeared in the street, 25 feet away.

While policemen and firemen patrolled the area and utility crews worked to uncover line breaks, residents within a 200-yard radius of the distressed homes were evacuated.

During this time, the garage and driveway of the home next door settled nearly a foot and experienced much the same cracking, misalignment of doors, and damage to brickwork as the home to the right.

Both homes are located about 30 feet above a mine worked more than 50 years earlier. The portion of mine underlying these two homes and ten others in the immediate area was subsequently filled with fly ash under a state subsidence abatement program.

This is but one of 49 subsidence incidents that have been documented in the borough of 30,000 in the past ten years. About 20 percent have damaged homes.

6. Figure 2.7A - In February 1976, the gymnasium and shop areas of a junior high school (right) began to experience distress as tension cracks as wide as two inches developed across the north end of one room; the base of one column cracked; and the top of an outside wall buckled. The northeast corner of the ten-year-old building settled about six inches. Note the sagging roof line and the boarded-up windows in Figure 2.7B. The subsiding area measured 160 by 190 feet and affected about one-third of the two-story brick building (Figure 2.8). Although most damage took place over the weekend when classes were not in session, movements continued sporadically for the next several months at a rate of about 0.021 foot per month. During this time, the depression gradually broadened, and after seven months, it reached the newly completed elementary school 75 feet east. Damage to the elementary school was not nearly as extensive as to the junior high school, although a four-inch crack opened in one wall, tile blocks separated and a number of tears appeared in the carpeting. Several rooms of the school were barricaded off, and adjustable props were installed to support joists and other points made critical by the outward rotation of the walls (Figure 2.7C).

   Adjacent to the subsiding school buildings stands the original school building constructed over the mined-out area 35 years earlier and undamaged by this episode of subsidence. Damage to the school buildings, all founded on shallow reinforced concrete footings, is estimated to be about $1.3 million. The school is located 125 feet above the Pittsburgh Coalbed, which was mined about 70 years before subsidence took place.

   Over a dozen homes in the general vicinity of the schools had been damaged by subsidence in years previous. The schools were built before the Pennsylvania Department of Environmental Resources was empowered to approve all proposed school sites (Site 236).

7. Figure 2.9 - The old doors lying against the hillslope cover an eight-foot-diameter sinkhole that developed as the natural cover of soil and weathered rock collapsed into the abandoned mine entry five to ten feet below ground surface. In profile, the sinkhole assumed the shape of an inverted cone (Figure 2.10).

   The entry parallels the front of the home. The owner contemplated erecting supports beneath

his home from within the mine to prevent its possible collapse, but was advised by Bureau of Mines officials to instead fill the void with granulated slag dumped into the mine from ground surface so that he would not subject himself to a possible roof fall or to the oxygen-defient atmosphere of the mine. The mine had been abandoned prior to 1930 (Site 64).

At another site several miles away, a sinkhole much the same as that shown in the preceding photo developed beneath a basement window well of a home at 9:30 in the morning one February day in 1956, forming a cone-shaped depression five feet wide and ten feet long at ground surface, and 25 feet in diameter at mine level. The distance from the base of the footing of the home to the roof of the mine was ten feet, and subsequent examination showed there was no solid coal beneath the entire northeast quarter of the home. The owner promptly filled the void to refusal with granulated slag to protect the home from possible damage. The mine had been abandoned prior to 1930 (Site 60).

8. Figure 2.11 shows a community in Washington County, Pennsylvania, that has experienced subsidence on at least four separate occasions in the past half century. Subsidence appears first to have taken place in the 1920's while mining was in progress. After abandonment of the mine, a long period of guiescence followed that was not broken until 1964, when three homes were damaged by subsidence of an area measuring 300 by 400 feet that overlapped part of the 1921 area. This was followed in mid-1972 by subsidence of seven homes 400 feet east of the 1964 area and in late 1972 by subsidence of six more homes in an area that partially coincided with the southerly part of the 1964 area. Subsidence abated for the next few months but resumed in April of 1973, affecting an area 450 by 800 feet and damaging 14 more homes. At nearly the same time in 1973, two other homes 1,100 feet east were similarly damaged by subsidence (Site 249).

The Pennsylvania Mine Subsidence Insurance Fund has thus far paid $139,000 in damage claims for homes in this community. The reason for the subsidence has not been determined. No mine maps are available, no subsurface investigations have been conducted, and no government agencies have made a study of the area. Available information is only fragmentary (Site 248).

Geometry of Subsidence Features

The preceding examples provide an overview of the types of subsidence features--sinkholes, troughs, and surface cracks--that have been observed above the Pittsburgh Coal.

Sinkholes, such as photographed in Figure 5.2 and sketched in Figure 2.10, are depressions in the ground surface that occur as a result of collapse of the overburden into an underlying mine void. Boundaries between ground surface and walls of the sinkhole are often abrupt, and because diameter often increases with depth, the profile of the sinkhole may resemble a bottle with the cap removed. Erosion of soil into the sinkhole may increase its diameter at ground surface so that eventually it assumes the profile of an hourglass.

When the overburden does not break to form a sinkhole, but settles to form a dish-shaped depression at ground surface, the subsidence feature is called a trough. Troughs are shown in plan in Figures 2.4 and 2.6. About 90 percent of the subsidence features identified in the present study were sinkholes and 10 percent were troughs.

Ground cracks such as pictured in Figure 2.1 mark distinct vertical or horizontal displacements in the overburden, but are often not as pronounced above abandoned mines as they are above active mines. These cracks roughly delineate the extent of the subsiding areas (Figures 2.4 and 2.6).

Most sinkholes and troughs are approximately circular in plan, though some are elongate. The ranges of diameters and depths of subsidence features identified in the present study are plotted in Figures 2.12, 2.13, and 2.14. Where the subsidence feature is elongate, the mean of the maximum and minimum diameters at ground surface is plotted. Examining the figures it will be observed that:

1. Over 84 percent of the subsidence features are 15 feet or less in diameter. One of the larger subsidence features approaches one-third mile in diameter.

2. Approximately 89 percent of the subsidence features are less than 25 feet deep. Some are as deep as 45 feet.

3. Approximately 66 percent of the subsidence features are deeper than they are broad. Deep subsidence features tend to be of rather small diameter, and virtually all subsidence features having depths of three feet or more are sinkholes. Those having

lesser depths are generally troughs. Some large troughs have been documented for which the depth is less than 1/500 the diameter.

By far the most prevalent subsidence feature observed above the Pittsburgh Coal is the sinkhole, and the most prominent mechanism responsible for sinkhole development appears to be caving of the mine roof. This will be discussed in Section 5. The most prominent mechanisms responsible for trough development appear to be pillar failure and bearing capacity failure of the mine floor. These are discussed in Sections 6, 7, and 8. Before dealing with these subjects in detail, several of the other data trends observed in this study are discussed. It should be recognized that documentation of subsidence incidents is generally confined to those that cause damage or constitute hazards, and therefore only they are represented in the trends that follow. Untold numbers of subsidence incidents that are of no consequence go unrecorded.

Mining

1. Most sites of subsidence were located above mines where mining with long narrow room pillars was practiced. Seventy-nine percent were undermined prior to 1935. The distribution of sites by period of undermining is shown in Figure 2.15.

2. Over 20 sinkhole incidents have been documented above two separate mines in Allegheny County, Pennsylvania, but generally only one or two have been documented above any particular mine (Figure 2.16).

3. As many as eight sinkhole incidents have been documented above a single mine in a particular year, but far more common are single incidents in a year.

Time and Frequency of Occurrence

1. More than half the subsidence incidents have taken place 50 or more years after mining, and a few have taken place more than a hundred years after mining. A few other incidents have taken place less than a decade after mining (Figure 2.17).

2. Recurrent subsidence has been documented at 34 sites, 11 percent of the total. Three incidents have been documented at nine sites and two have been documented at 24 sites. The period between successive incidents at a given site has ranged from one month to 14 years (Table 2.1).

3. Most subsidence incidents (36 percent) have taken place in spring, the three months March through May. Only 9 percent have taken place in late summer and autumn, the three months August through October (Figure 2.18). The relationship between sinkhole development and precipitation is discussed in Section 5.

Overburden Thickness

1. Nearly 81 percent of the subsidence incidents have taken place where the overburden (rock and soil) is less than 100 feet thick, and nearly 59 percent have taken place where the overburden is less than 50 feet thick.

2. No subsidence incident has been documented above an abandoned mine where overburden is greater than 450 feet thick. In southwestern Pennsylvania and West Virginia, the thickness of overburden ranges from 0 to approximately 1500 feet. The distribution of subsidence sites by overburden thickness is shown in Figure 2.19.

Damage Caused by Subsidence Above Abandoned Mines

1. Nearly one out of four documented subsidence incidents has resulted in damage to a structure or a roadway.

2. In the period 1957 through 1976, a total of 249 structures were damaged in 97 separate incidents. Damage to streets, roads or driveways was reported in 11 incidents apart from those in which damage to a structure was reported.

3. As many as 43 homes have been damaged in one incident, but single incidents have generally involved no more than one home. The distribution of damaged homes per incident is shown in Figure 2.20.

4. The Pennsylvania Mine Subsidence Insurance Fund, since its inception in 1962, has settled 39 claims for damage to homes above abandoned mines in the Pittsburgh Coal Region. The claims have totalled more than $231,000. The distribution of dollar amounts by claim is shown in Figure 2.21.

Locations of Subsidence Incidents

1. Of the 354 subsidence incidents identified in this study, 352 are located in Pennsylvania. One was

located in Maryland and one was located in West Virginia. None were located in Ohio. The distribution of incidents by state and by county is shown in Table 2.2.

2. Of the 352 documented incidents in Pennsylvania, 251 or 71 percent were located in Allegheny County, Pennsylvania. This area embraces the Greater Pittsburgh Area, and constitutes about six percent of the Pittsburgh Coal Region. It is one of the earliest undermined and most densely populated sectors of the region.

Data Base

The generalizations reported in the preceding paragraphs are based on data which cover the period 1955 to 1976, a 21-year span that was dictated by the availability of data. The earlier incidents--those from 1955 through 1970--were gleaned principally from newspaper accounts, records on file with the Pennsylvania Mine Subsidence Insurance Fund, and records on file with the U. S. Bureau of Mines in Bruceton, Pennsylvania. Records on file with the Pennsylvania Office of Resources Management were also available for the period following 1969.

The record for the period 1971 through 1975 is thought to include all incidents of subsidence above the Pittsburgh Coal documented by state and local authorities and by newspapers in that period. The 1976 record is not complete since data were collected before that year had ended.

During the 1971 - '75 period, the number of documented subsidence incidents per year ranged from 36 in 1971 to 65 in 1973, the mean in the five-year period being in excess of 45 incidents per year (Figure 2.22).

A complete description of data collection activities is presented in Appendix A.

GAI CONSULTANTS, INC.

Table 2.1

SITES ABOVE ABANDONED MINES IN THE PITTSBURGH COAL REGION WHERE RECURRENT SUBSIDENCE HAS BEEN REPORTED

Site No.	Overburden Thickness'	Subsidence Feature*	Number of Incidents	Date of First Incident	Elapsed Time (Years) Between Successive Incidents							
					1-2	2-3	3-4	4-5	5-6	6-7	7-8	Incident-Incident
6	90	-	3	-/67	0.5	3.75						
7	79	-	3	11/71	1	-						
21	40	-	2	6/72	2							
23	50	-/S	2	12/72	3							
46	-	S/S	2	1/71	4.5							
59	35	-	2	4/72	3.25							
67	<50	-/S	2	7/68	5.5							
70	12	S/S	2	4/71	0							
71	10	S/-	4	9/71	1.25	2.25	-					
76	15	S/S	2	5/72	2.75							
80	60	S/-	2	11/72	0.75							
102	39	S/-	2	1/60	14							
103	30	S/S	2	3/64	6							
109	50	-	3	7/70	1.5							

* S = Sinkhole; T = Trough

Table 2.1
(continued)

Site No.	Overburden Thickness'	Subsidence Feature*	Number of Incidents	Date of First Incident	Elapsed Time (Years) Between Successive Incidents							
					1-2	2-3	3-4	4-5	5-6	6-7	7-8	Incident-Incident
134	114	-	3	2/73	0.5	0.25						
148	105	-	3	12/71	0	0.25						
157	9	S/-	2	3/71	2.25							
162	-	-	2	3/68	6.25							
169	20	-	3	3/70	1	1.5						
179	60	S/S	2	8/72	1.5							
182	20	S/S/S	3	11/72	0.5	2						
189	50/40	S/S	2	12/73	0.08							
205	30	-/S	2	5/71	2.75							
214	45	-	3	4/70	3	0.75						
215	155	-	2	11/73	0.08							
248	220-244	T	8	-/64	<0.75	7.17	<0.5	<0.5	0.17	0.5	0.3	
249	210	T	3	-/69	4.25	0.25						
250	144	T	2	-/72	2.75							

* S = Sinkhole; T = Trough

Table 2.1
(continued)

Site No.	Overburden Thickness'	Subsidence Feature*	Number of Incidents	Date of First Incident	Elapsed Time (Years) Between Successive Incidents							
					1-2	2-3	3-4	4-5	5-6	6-7	7-8	Incident-Incident
251	-	-	2	10/71	0.5							
255	20	S/S	2	3/71	3							
260	60	-	2	5/72	0.08							
297	20	S/S	2	1/66	1.75							
302	12	S/S	2	4/69	2.25							
306	130	S/-	2	4/72	1.25							

* S = Sinkhole; T = Trough

Table 2.2

DISTRIBUTION OF INCIDENTS OF SUBSIDENCE ABOVE ABANDONED MINES IN THE PITTSBURGH COAL REGION BY STATE AND BY COUNTY

	Sites	Incidents
Pennsylvania - Allegheny County	213	248
- Fayette County	19	19
- Greene County	1	1
- Washington County	26	40
- Westmoreland County	41	44
	300	352
Maryland - Allegany County	1	1
	301	353
West Virginia - Marion County	1	1
	302	354

FIGURE 2.1 GROUND CRACK ASSOCIATED WITH MINING 300 FEET BELOW GROUND SURFACE

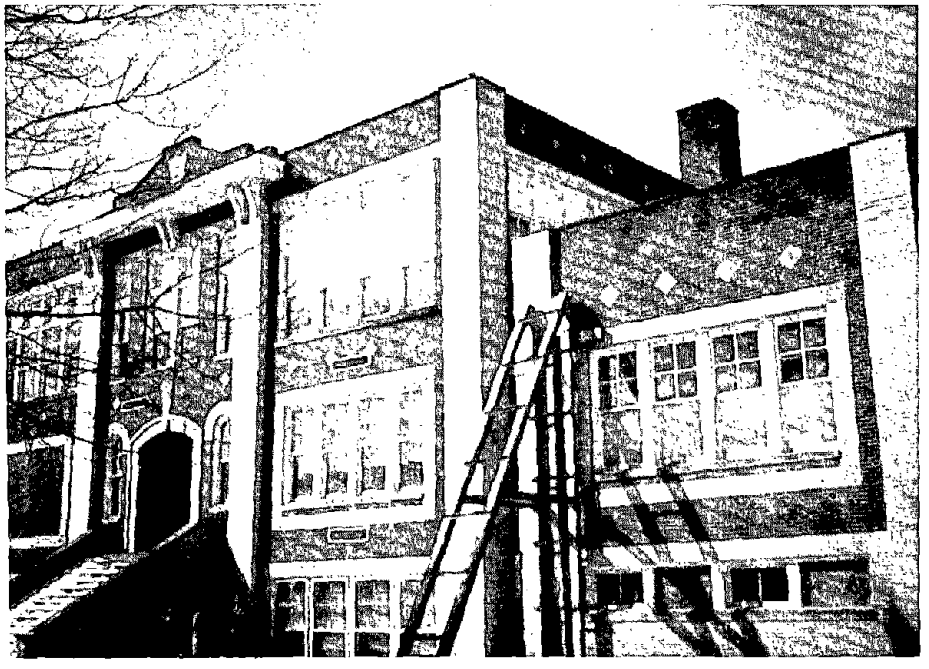


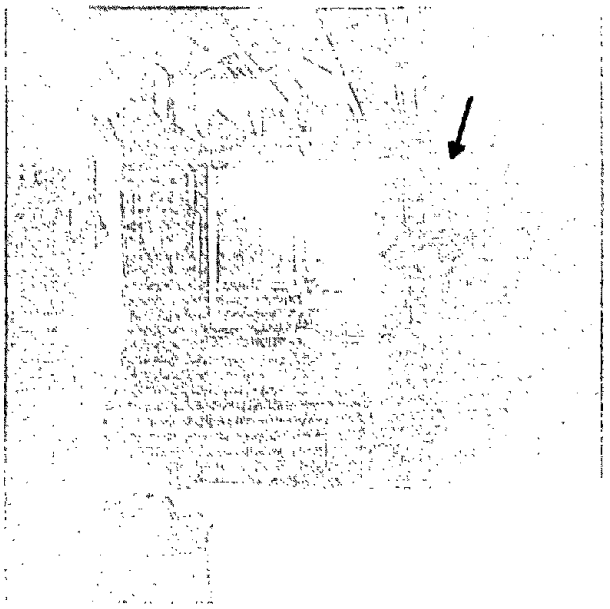
FIGURE 2.2 SCHOOL BUTTRESSED AFTER DAMAGE BY MINING 280 FEET BELOW GROUND SURFACE (SITE 1200)

A. Front View of Center Home

B. Rear View of Center Home

C. Side View of East Home

D. Interior View, Basement of East Home



E. Side View of West Home

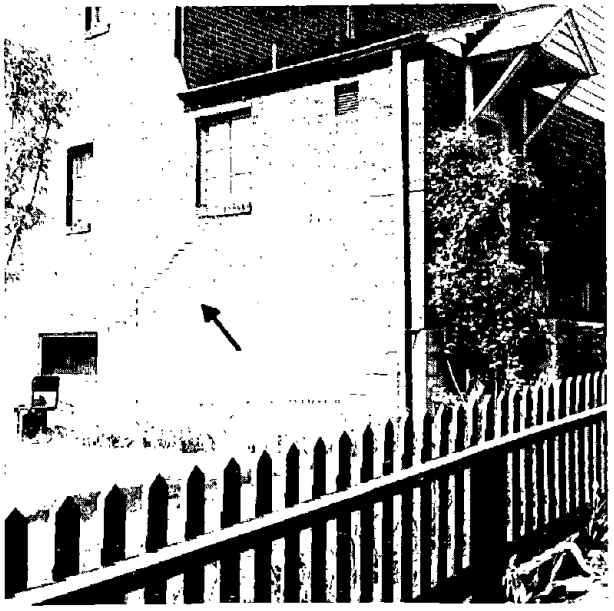


FIGURE 2.3 THREE HOMES DAMAGED BY SUBSIDENCE 70 FEET ABOVE ABANDONED MINE (SITE 101)
(COURTESY – U.S. BUREAU OF MINES, M.O. MAGNUSON)

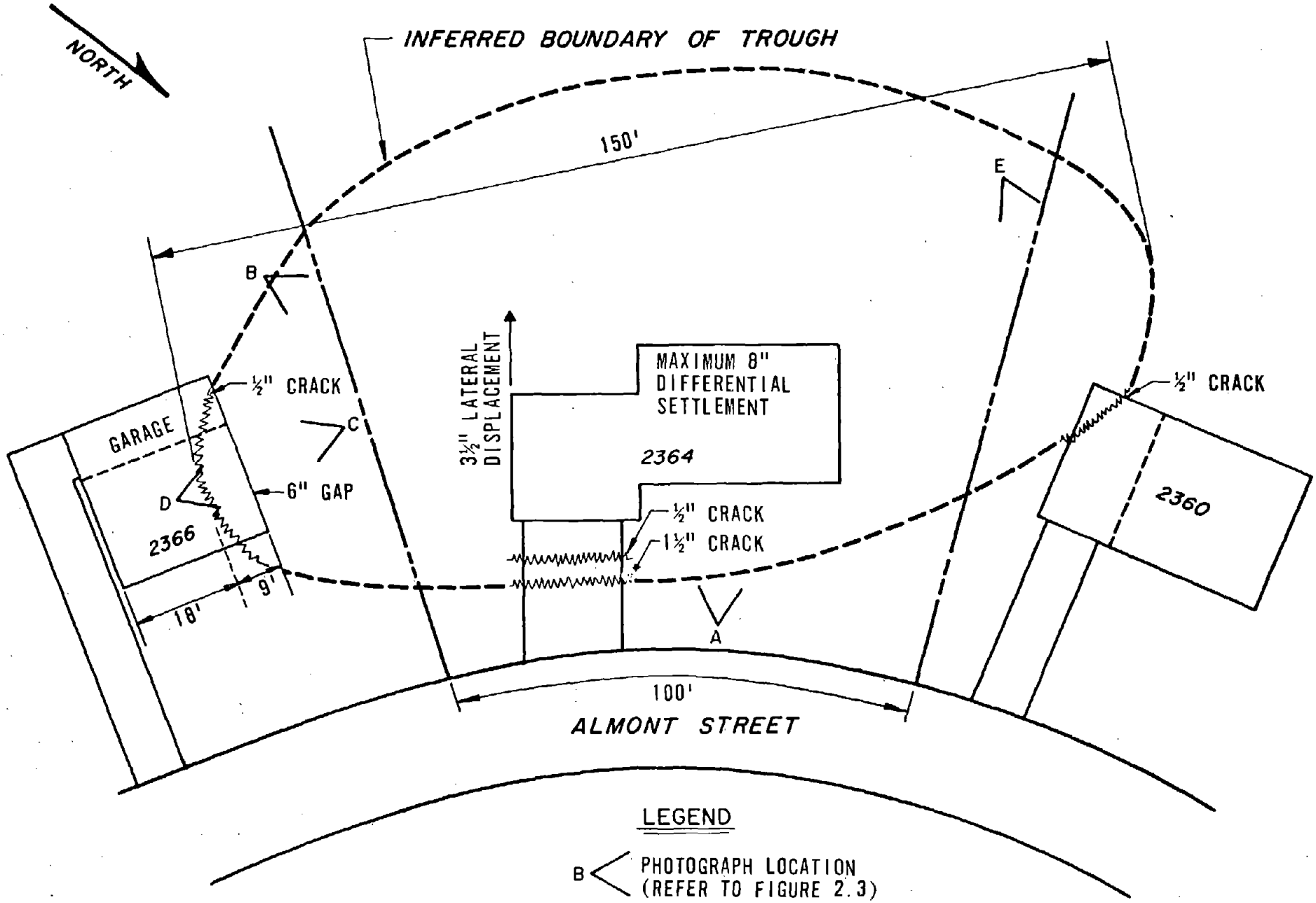
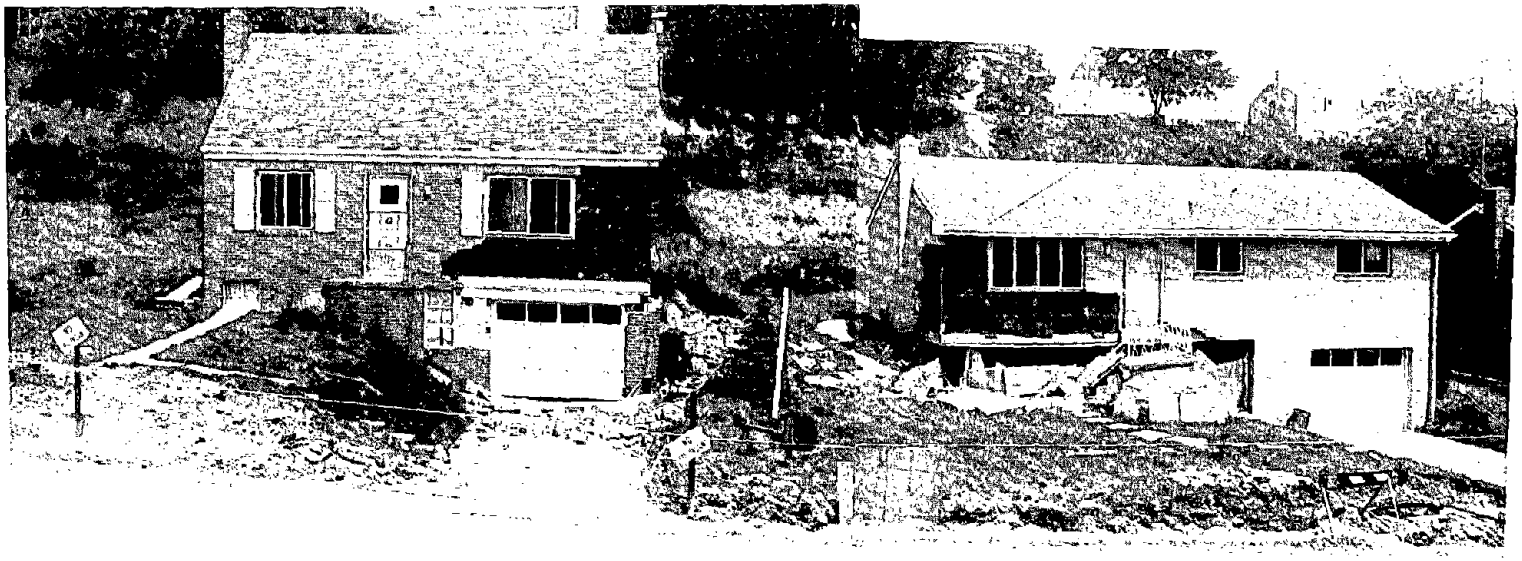


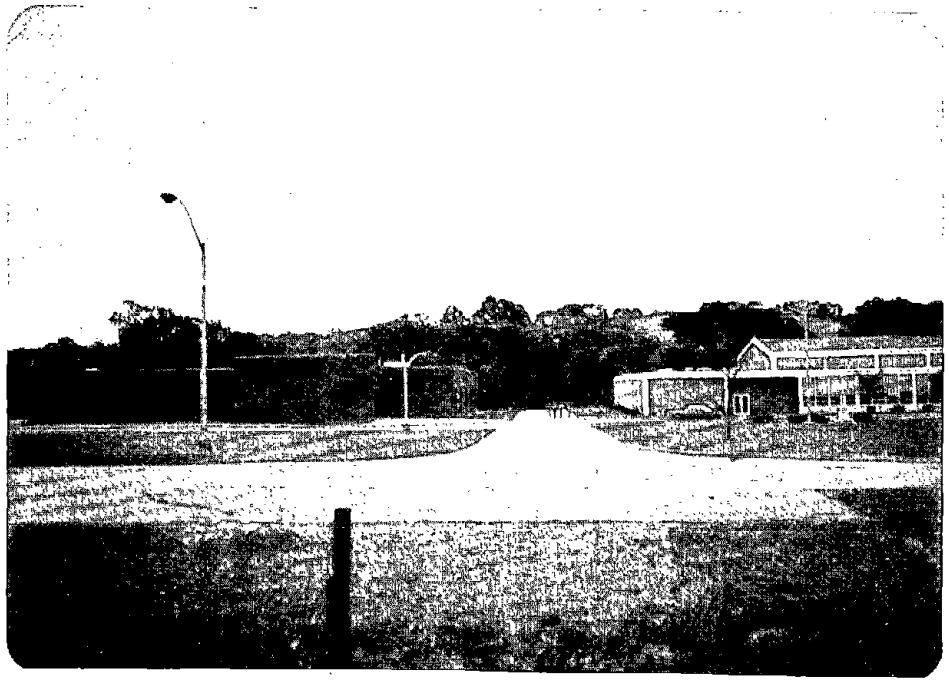
FIGURE 2.4 SUBSIDENCE TROUGH NEAR ALMONT ST. IN CARRICK SECTION, CITY OF PITTSBURGH, ALLEGHENY CO., PA. (SITE 101)

(AFTER U.S. BUREAU OF MINES, M.O. MAGNUSON)

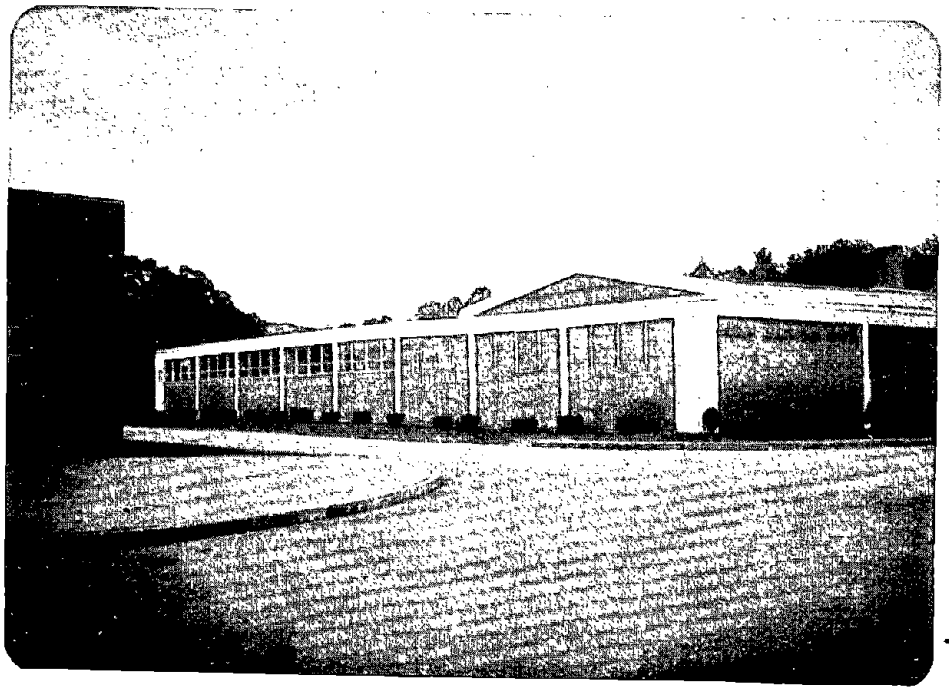
FIGURE 2.5
APARTMENT COMPLEX
UNDER CONSTRUCTION
DAMAGED BY SUBSIDENCE
140 FEET ABOVE ABAN-
DONED MINE (SITE 133)

FIGURE 2.6
TWO HOMES DAMAGED
BY SUBSIDENCE
30 FEET ABOVE
ABANDONED MINE
(SITE 163) (COURTESY-
U.S. BUREAU OF MINES,
M.O. MAGNUSON)

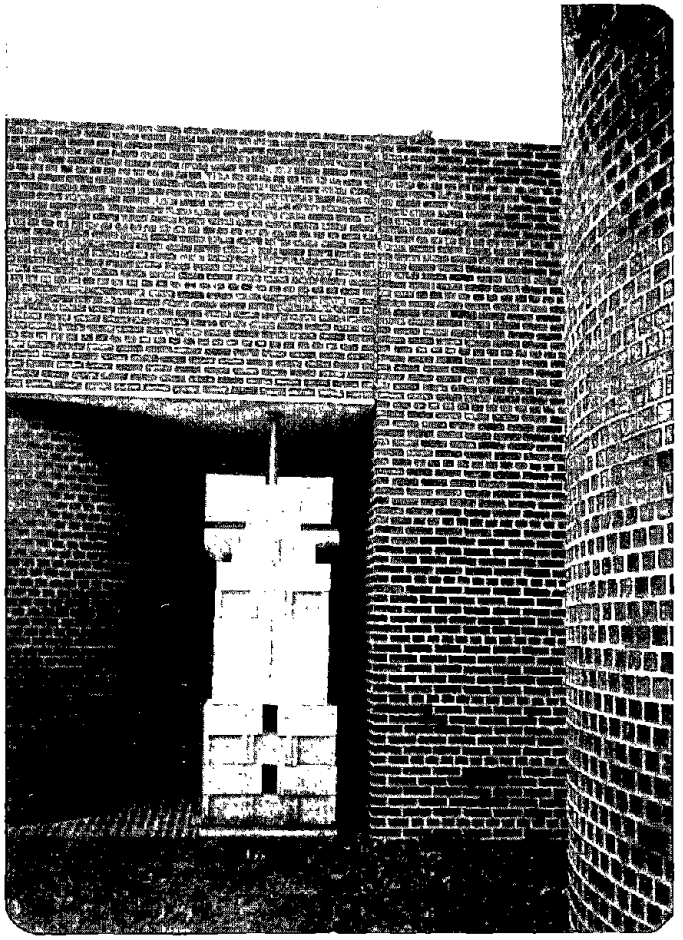




A. General View - Junior High School to Right, Elementary School to Left



B. Damaged Section of Junior High School



C. Adjustable Prop Installed At Elementary School

FIGURE 2.7 JUNIOR HIGH SCHOOL AND ELEMENTARY SCHOOL DAMAGED BY SUBSIDENCE 125 FEET ABOVE ABANDONED MINE

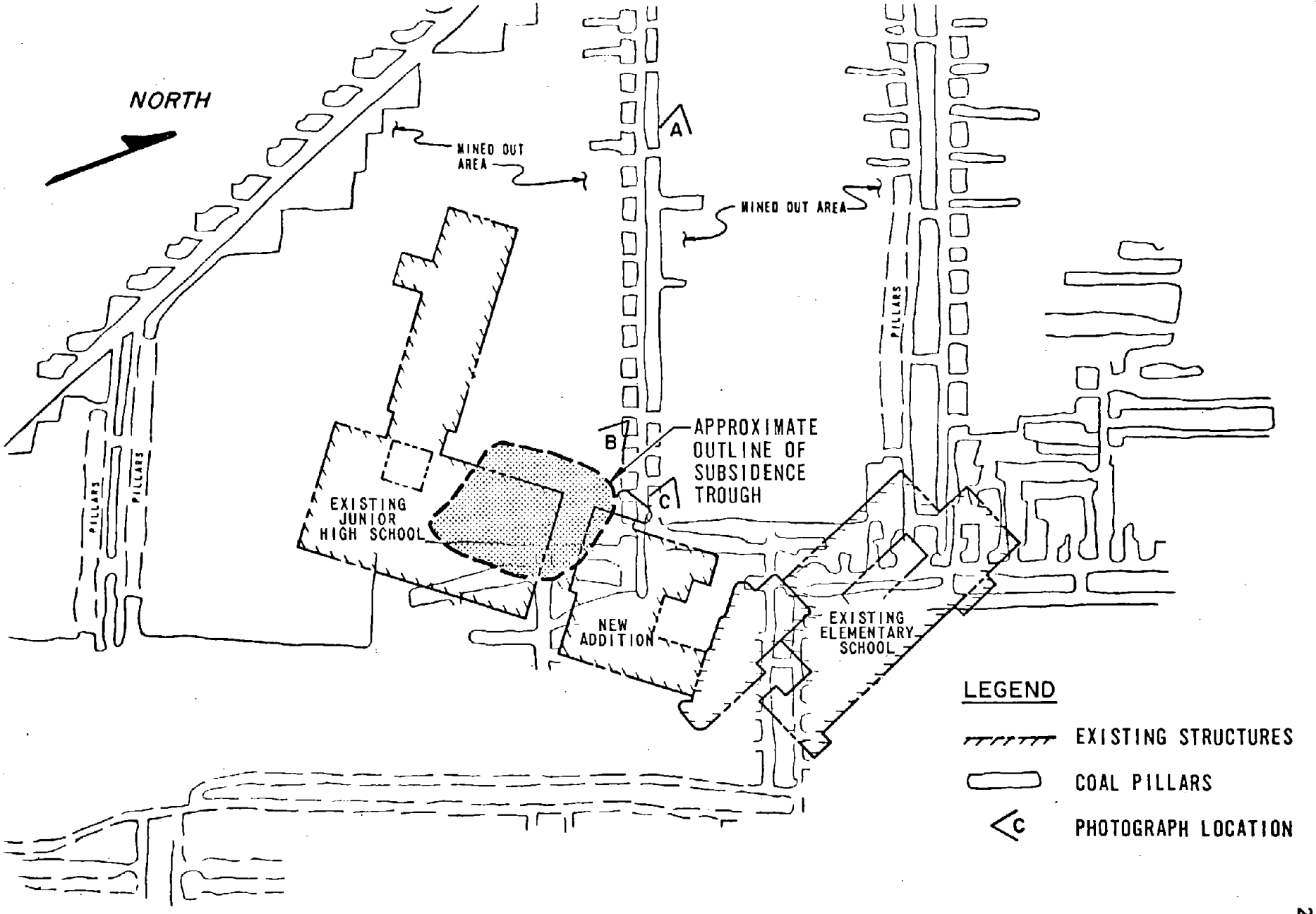


FIGURE 2.8 SUBSIDENCE TROUGH IN WASHINGTON TOWNSHIP, FAYETTE COUNTY, PENNSYLVANIA (SITE 236)

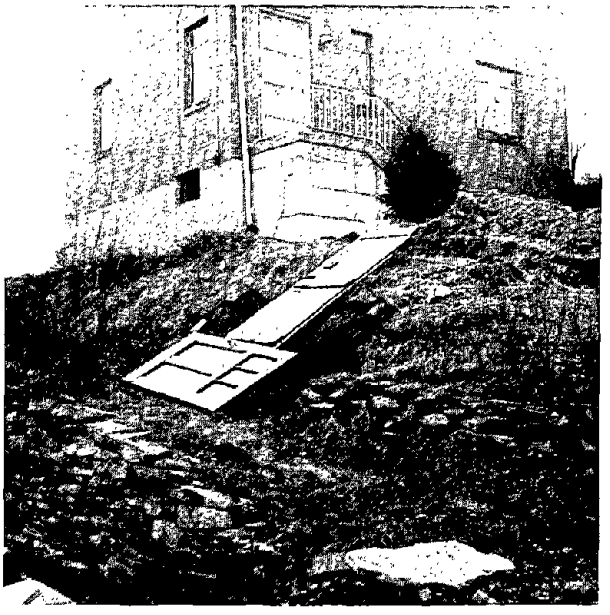


FIGURE 2.9 SUBSIDENCE SINKHOLE IN FRONT YARD OF HOME ON McCUTCHEON LANE, PENN HILLS TOWNSHIP, ALLEGHENY COUNTY, PENNSYLVANIA (SITE 64) (COURTESY- U.S. BUREAU OF MINES, M.O. MAGNUSON)

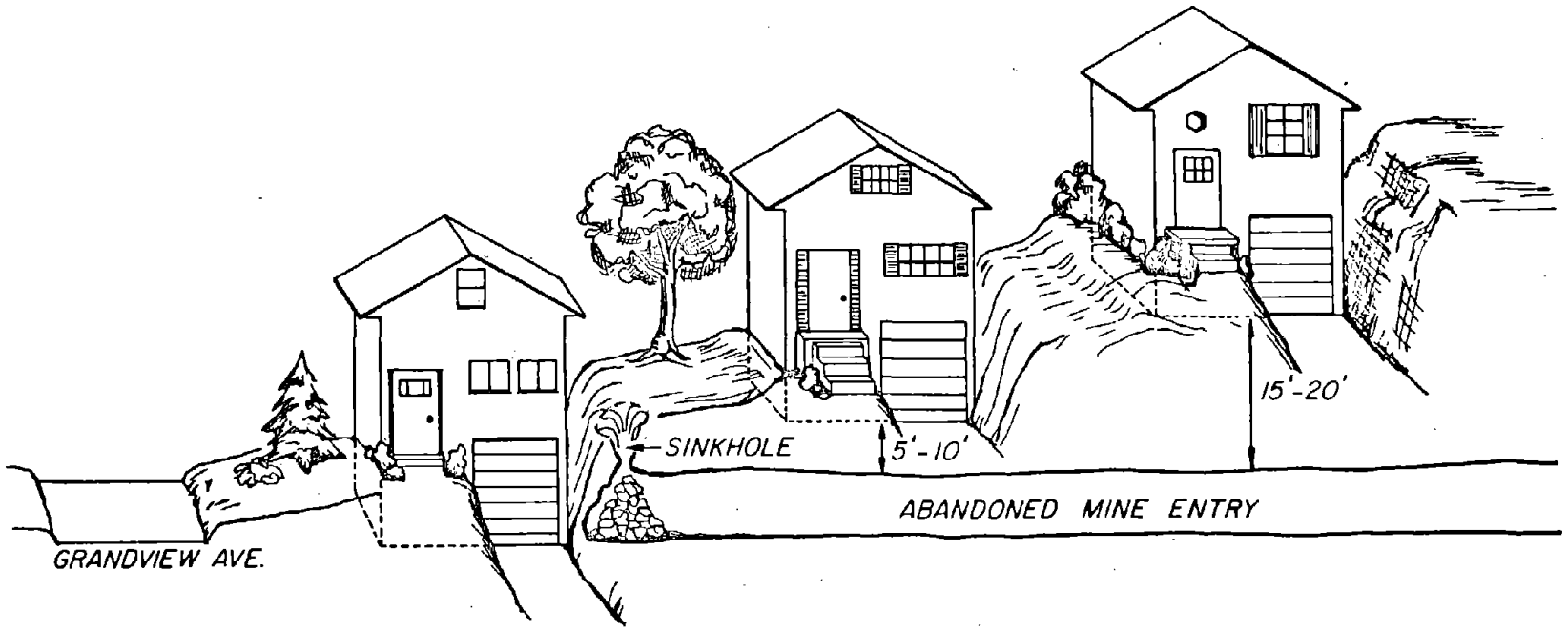


FIGURE 2.10 SECTION THROUGH ABANDONED MINE ENTRY LOCATED BENEATH FRONT YARDS OF HOMES, PENN HILLS TOWNSHIP, ALLEGHENY COUNTY PENNSYLVANIA (SITE 64), AFTER U.S. BUREAU OF MINES

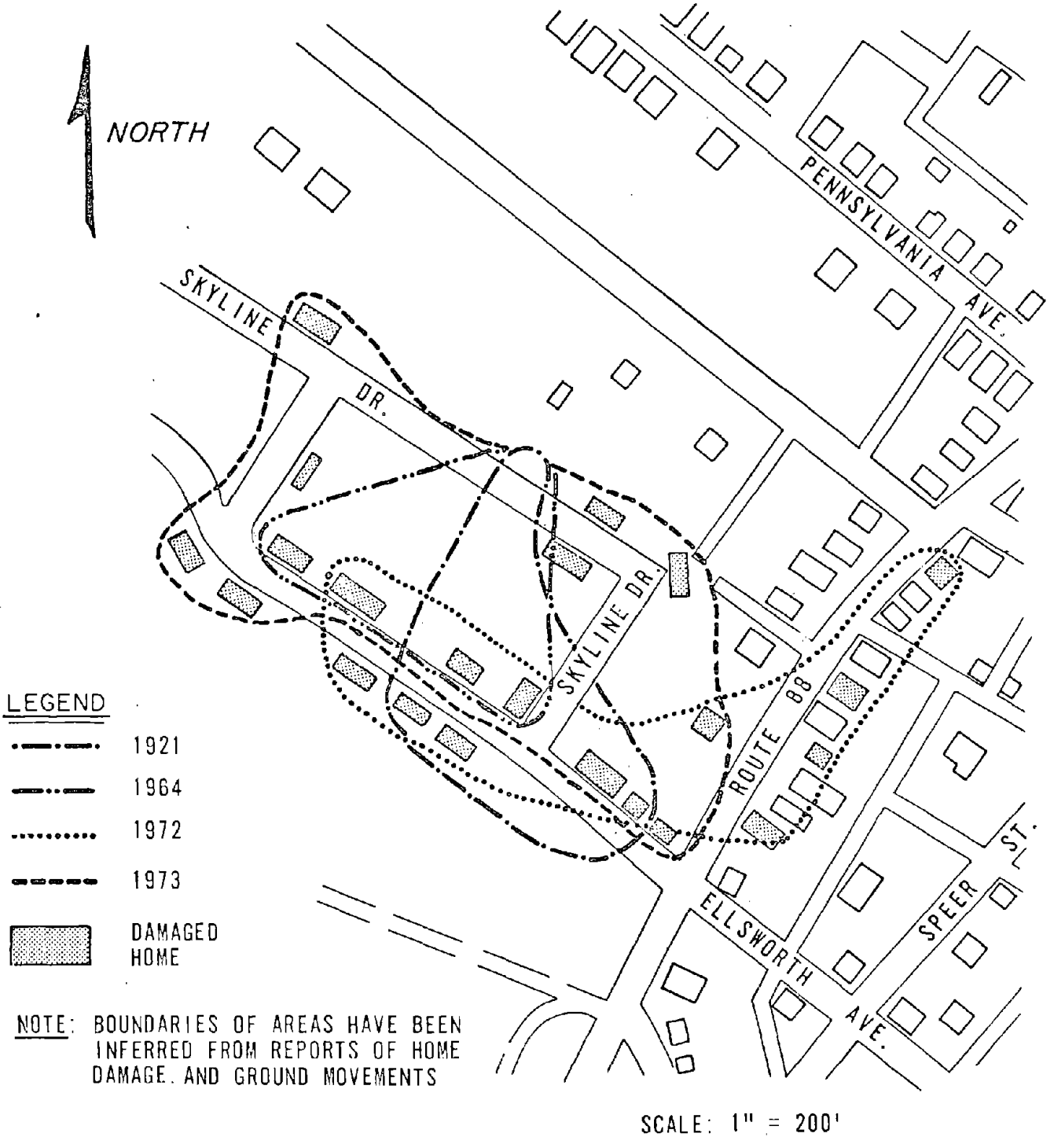


FIGURE 2.11 AREA OF RECURRENT SUBSIDENCE; CALIFORNIA BOROUGH, WASHINGTON COUNTY, PA. (SITE 248)

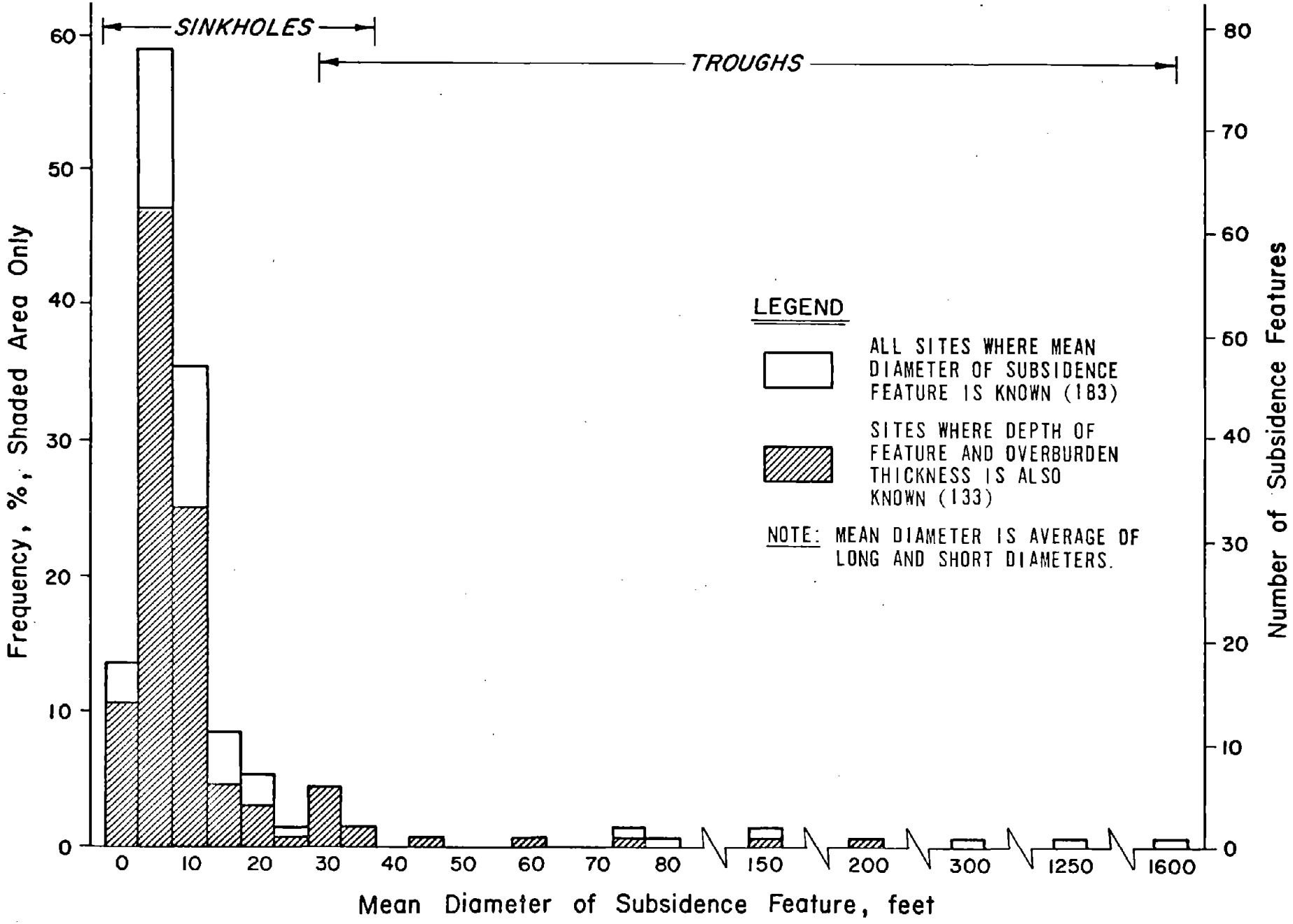


FIGURE 2.12 MEAN DIAMETERS OF SUBSIDENCE FEATURES

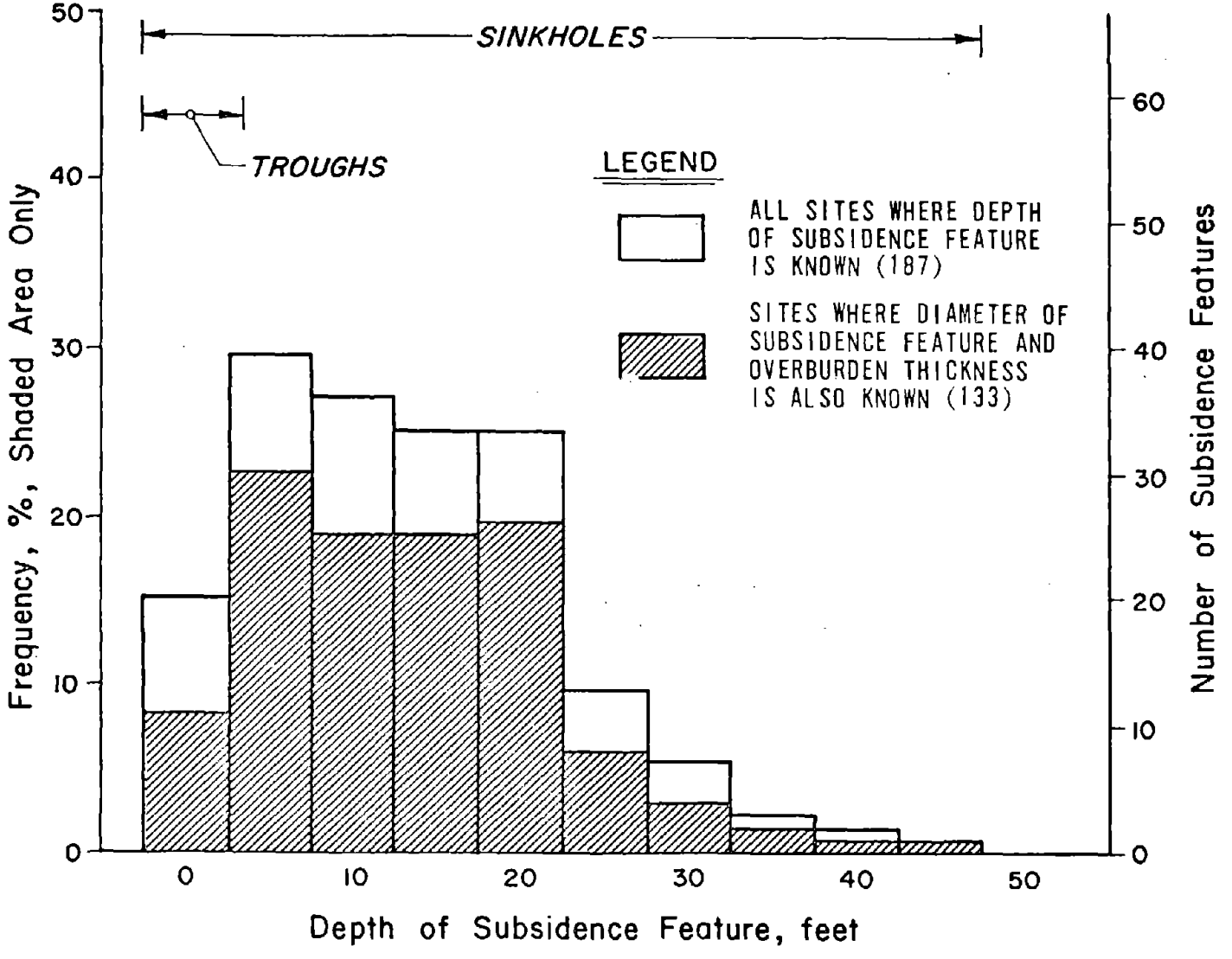


FIGURE 2.13 DEPTHS OF SUBSIDENCE FEATURES

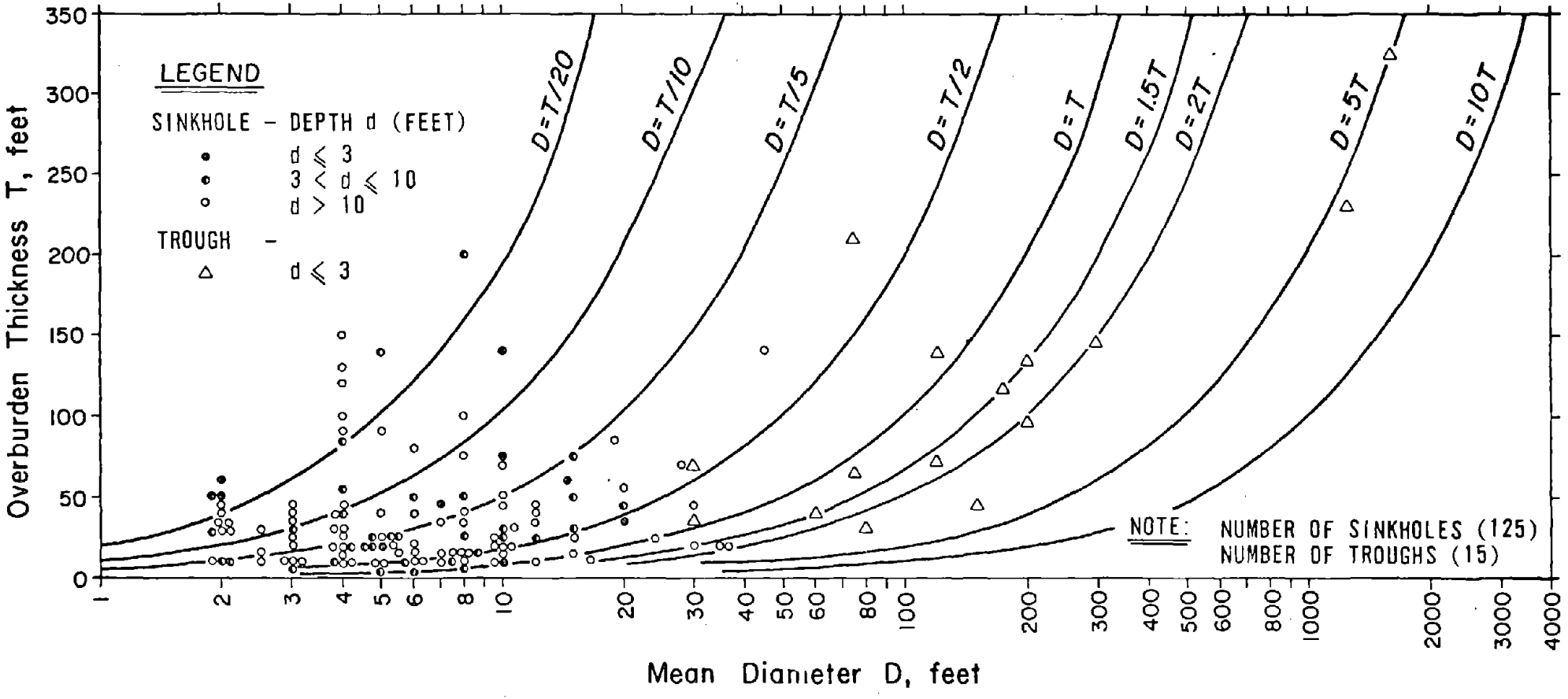


FIGURE 2.14 RELATIONSHIP OF DIAMETER AND DEPTH OF SUBSIDENCE FEATURE TO OVERBURDEN THICKNESS

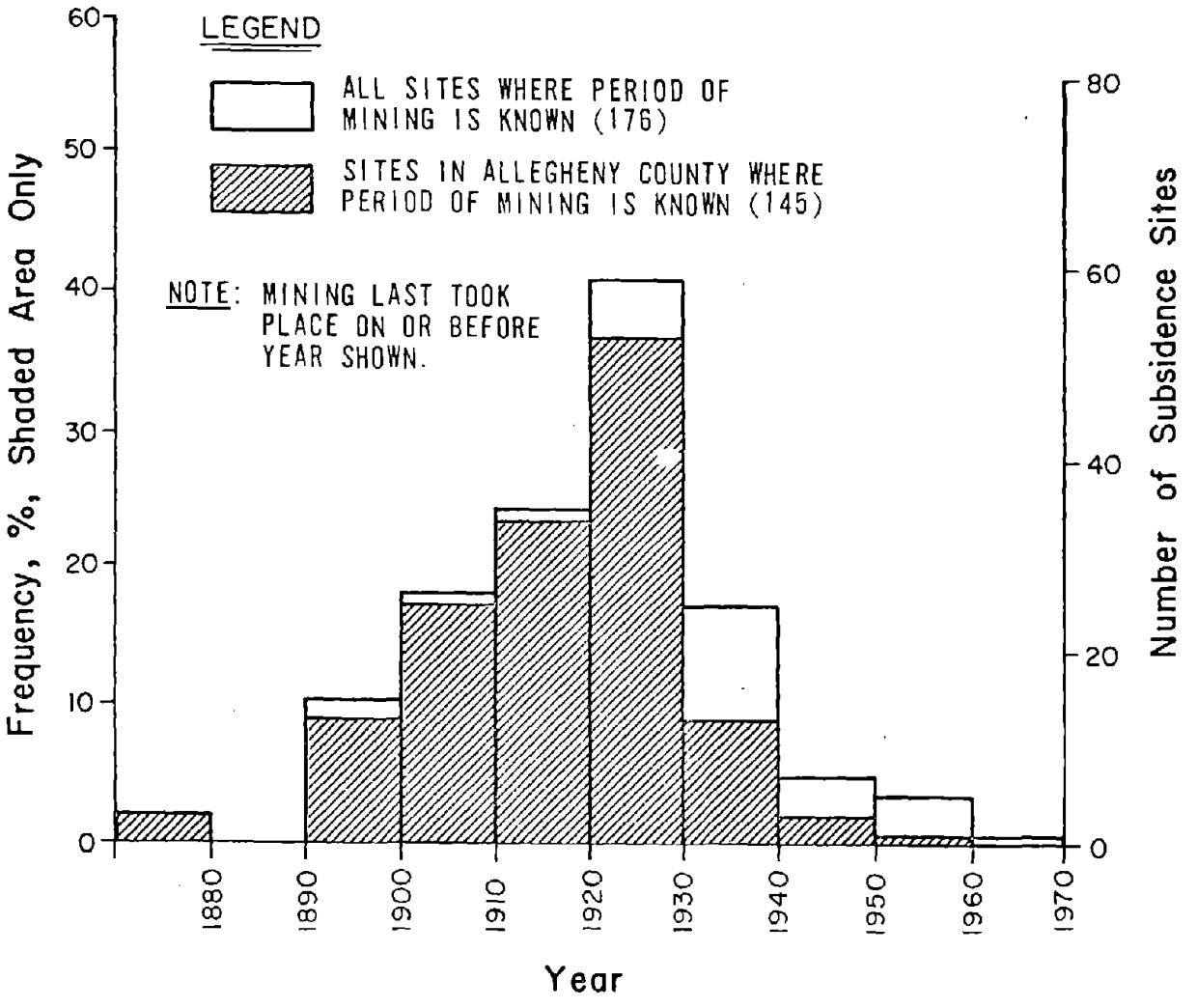


FIGURE 2.15 DISTRIBUTION OF PERIODS OF UNDERMINING

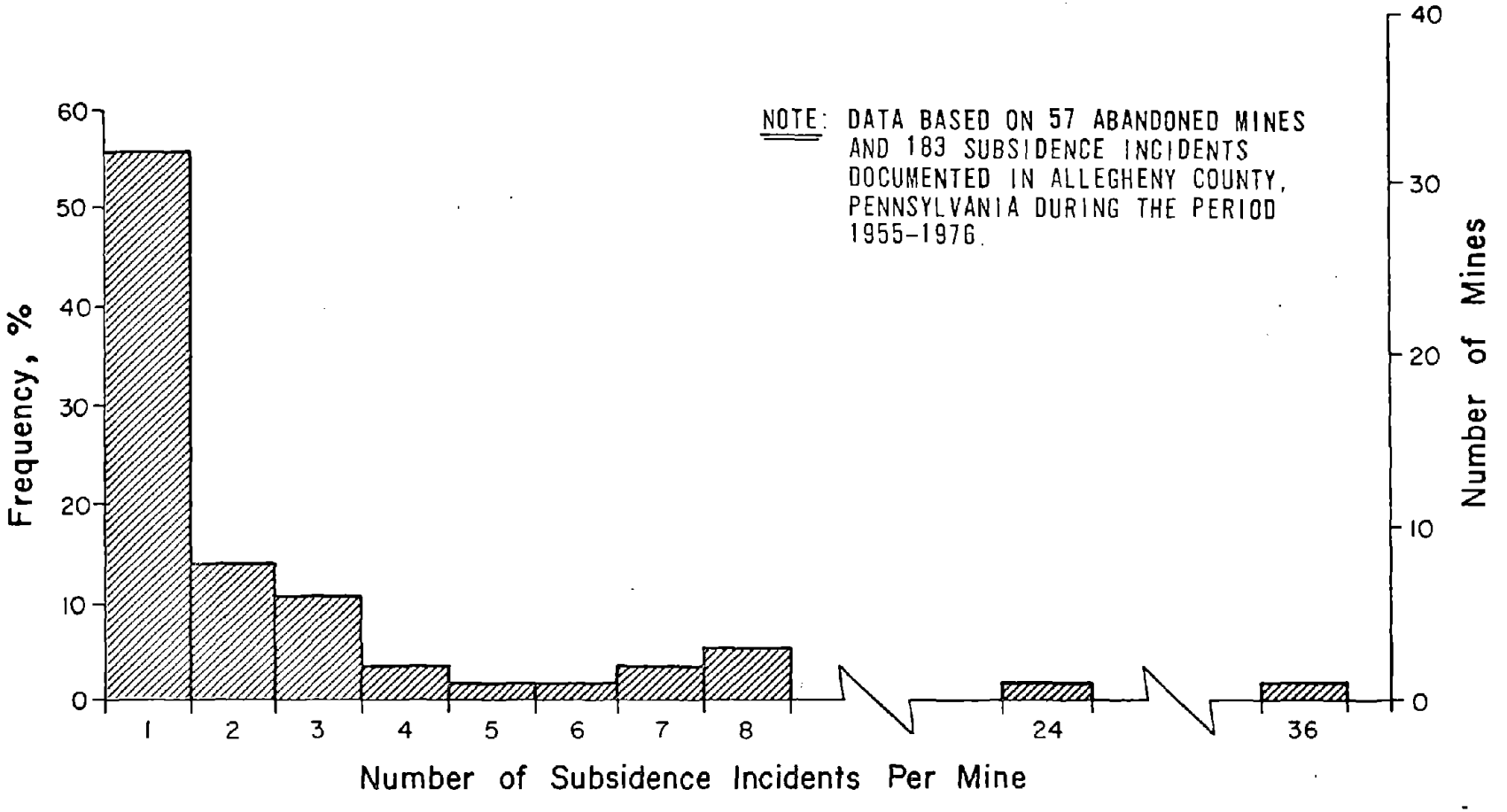


FIGURE 2.16 NUMBER OF SUBSIDENCE INCIDENTS DOCUMENTED ABOVE INDIVIDUAL ABANDONED MINES

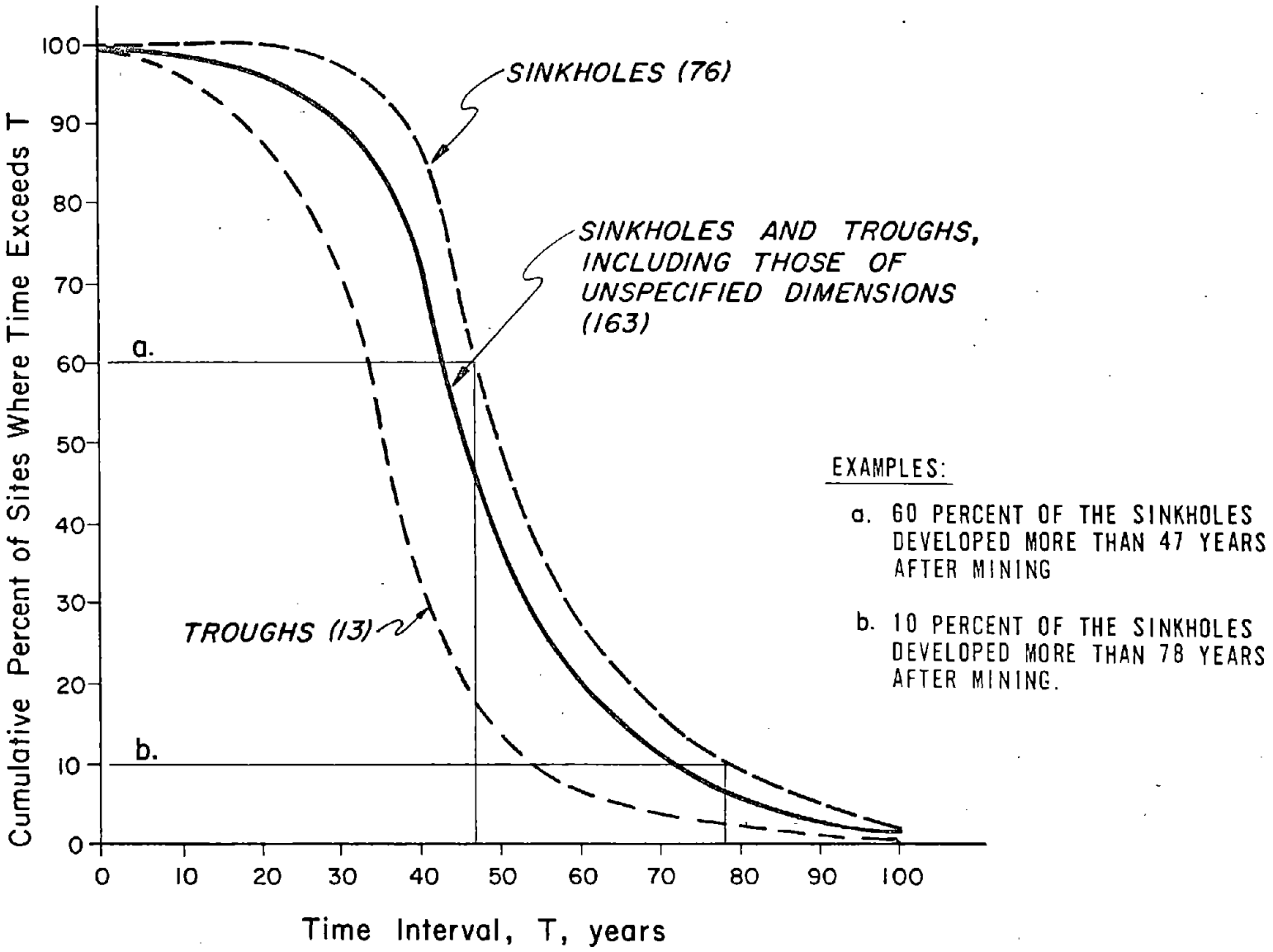


FIGURE 2.17 MINIMUM TIME INTERVAL BETWEEN MINING AND SUBSIDENCE

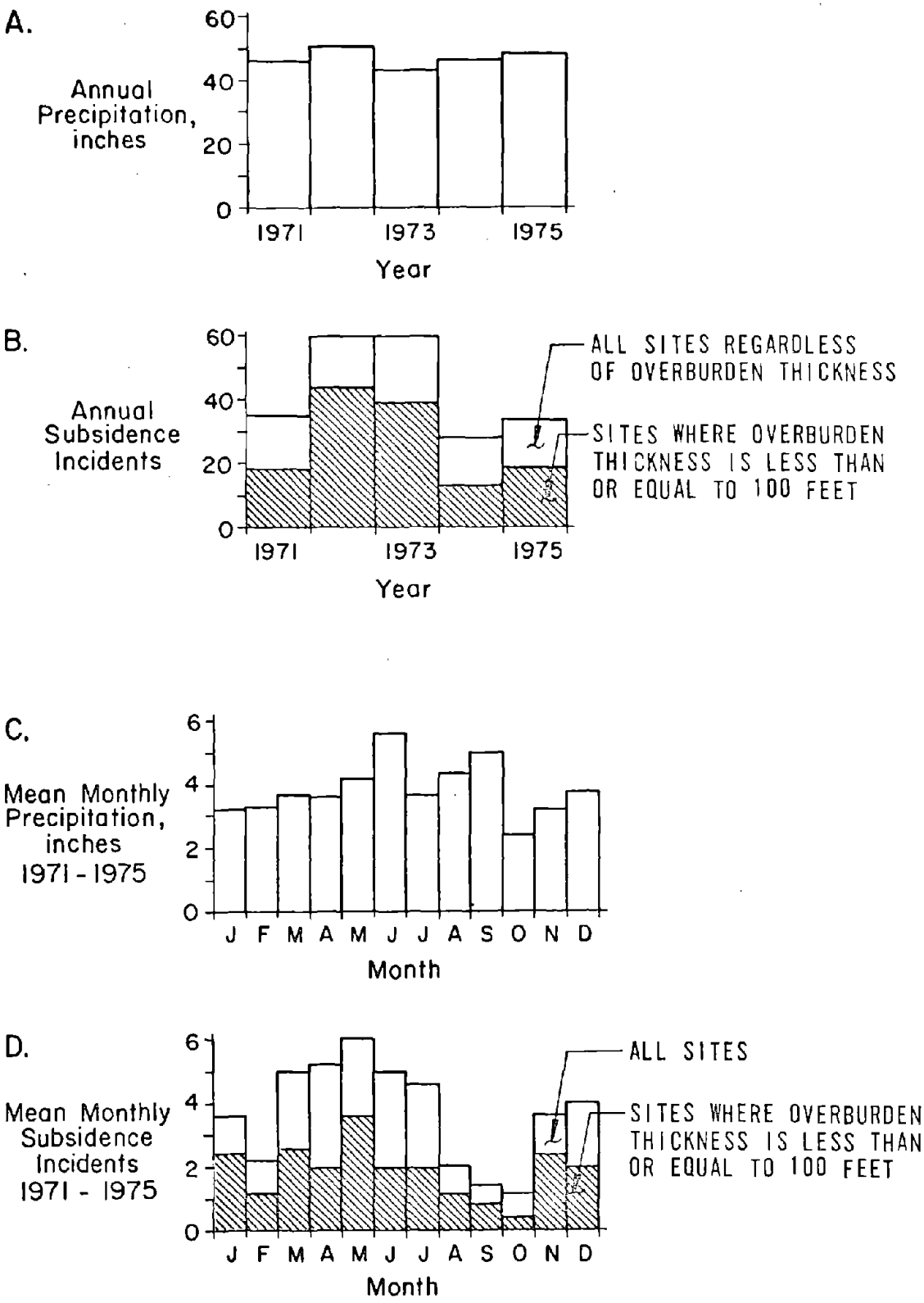


FIGURE 2.18 DISTRIBUTION OF PRECIPITATION AND SUBSIDENCE INCIDENTS BY MONTH AND BY YEAR FOR PERIOD 1971 - 1975

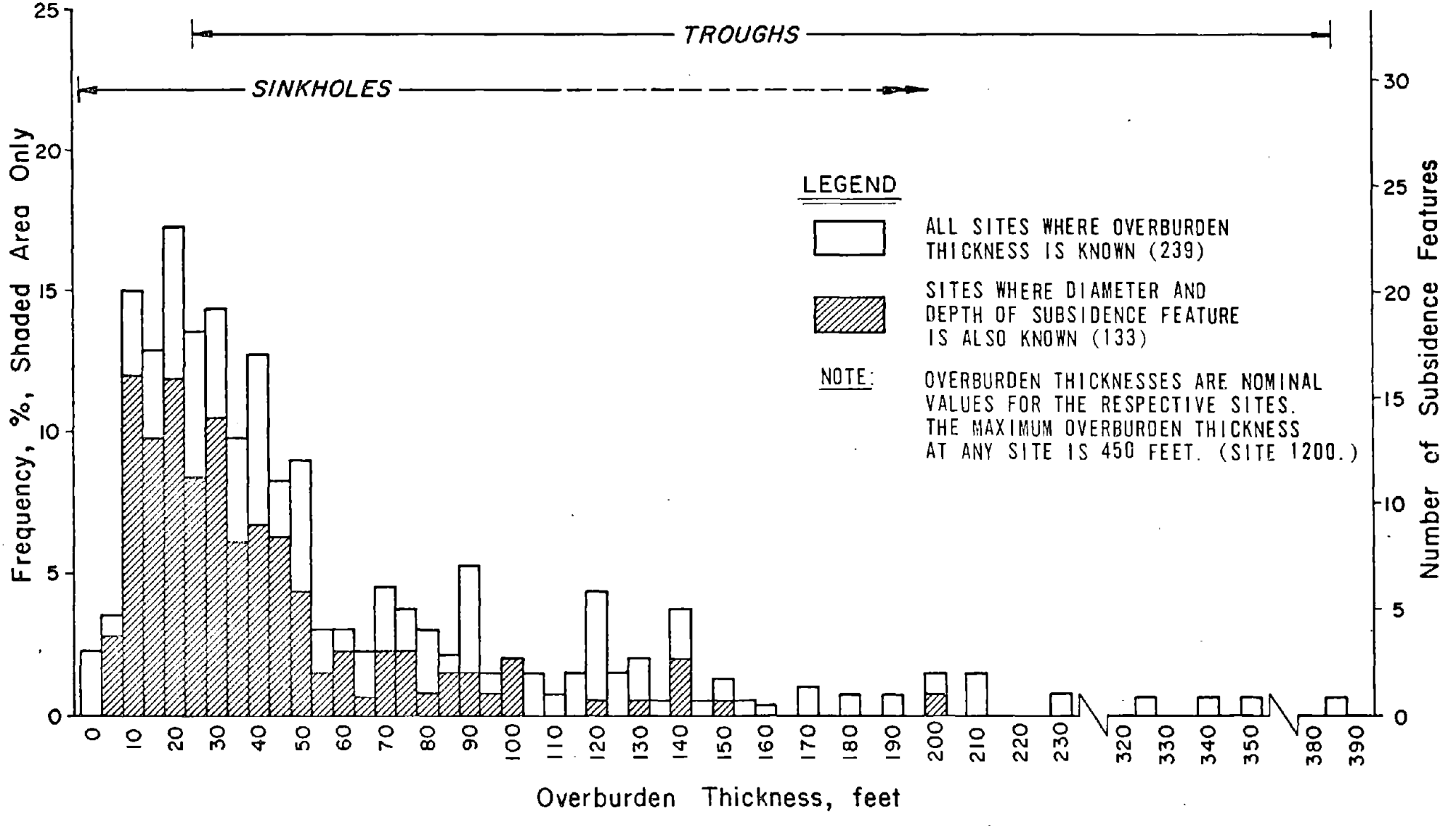


FIGURE 2.19 OVERBURDEN THICKNESS AT SUBSIDENCE SITES

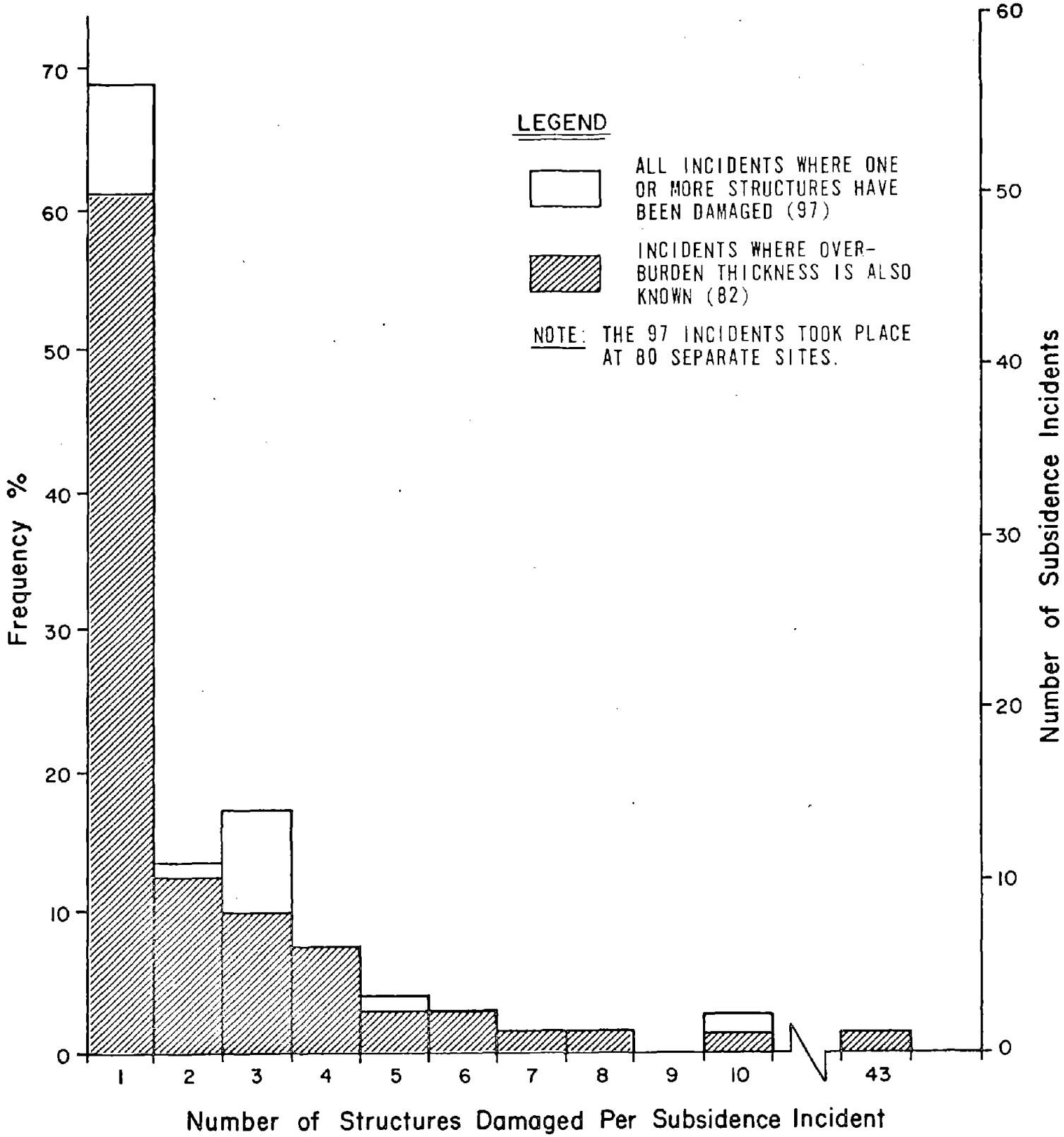


FIGURE 2.20 NUMBER OF STRUCTURES DAMAGED PER SUBSIDENCE INCIDENT - FREQUENCY

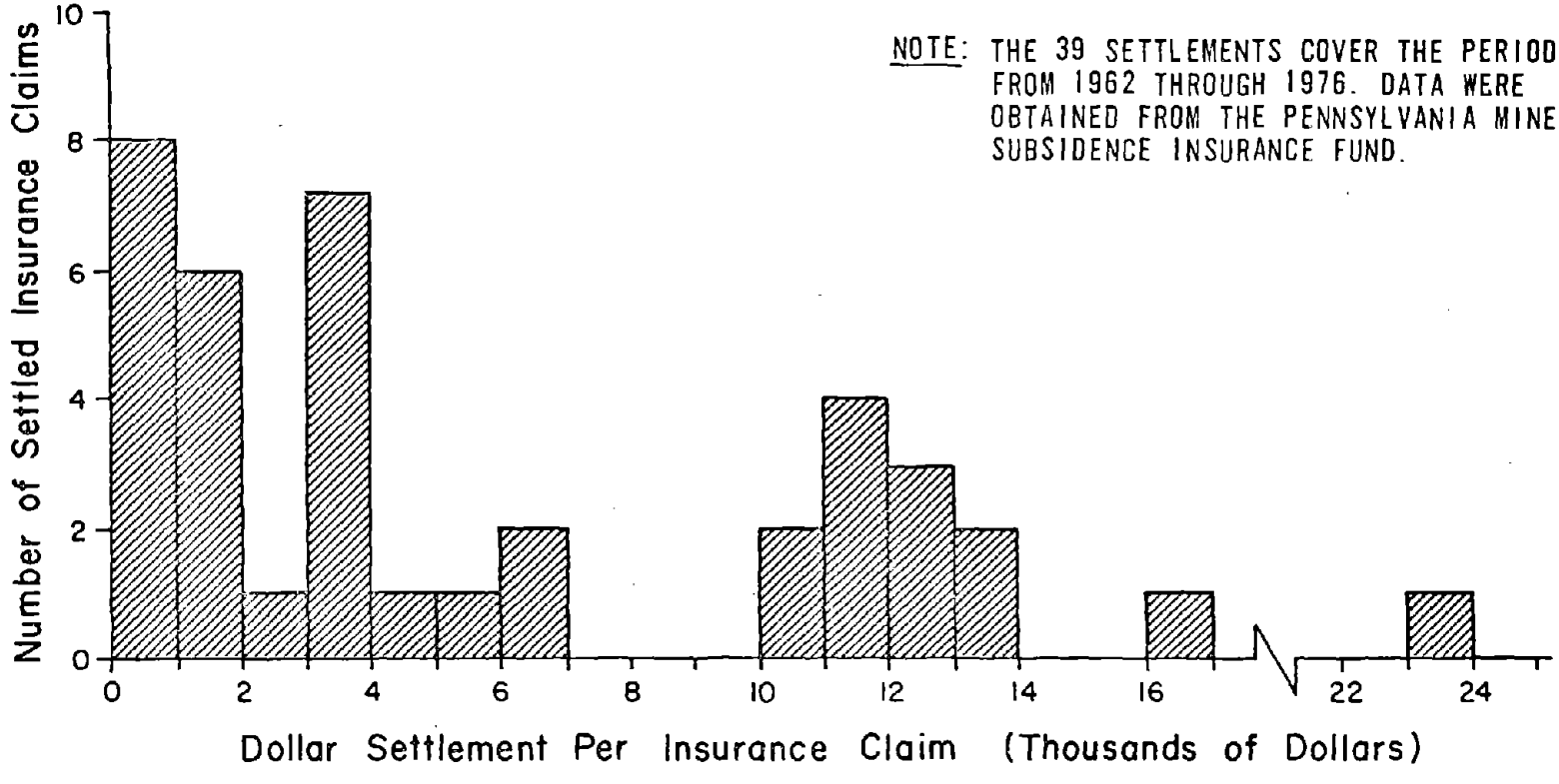


FIGURE 2.21 DOLLAR VALUES OF INSURANCE SETTLEMENTS FOR DAMAGES TO HOMES ABOVE ABANDONED MINES IN THE PITTSBURGH COAL

3. GEOLOGIC SETTING

Stratigraphy and Geologic Structure

Named in the 1840's by H. D. Rogers of the First Geological Survey of Pennsylvania in honor of the city where it was first mined[111], the Pittsburgh Coal is only one of more than 100 coalbeds found in the "Coal Measures" of the Appalachian Plateau and only one of 30 or more coalbeds in the Plateau that are thick enough to be mined commercially[65]. The Appalachian Plateau extends in a band 50 to 200 miles wide from New York to Alabama (Figure 3.1) and is characterized by nearly flat-lying sedimentary beds of Pennsylvanian and Permian age that alternate between claystones, shales, siltstones, sandstones, limestones, and coalbeds[101].

The Pittsburgh Coal occupies the Pittsburgh-Huntington Basin, a broad shallow synclinal trough in the central portion of the plateau, that is located between the Appalachian Mountains to the east and the Cincinnati Arch to the west. The axis of the trough bears northeast-southwest along a 200 mile line between Pittsburgh, Pennsylvania, and Huntington, West Virginia. The strata in the trough are divided into five Groups--the Pottsville, Allegheny, Conemaugh, Monongahela, and Dunkard (Figures 3.2 and 3.3). The Pittsburgh Coal is located at the base of the Monongahela Group.

The region in which the coal formed represents what was once a very extensive swamp slightly above sea level and covered with lush vegetation[27]. The swamp occupied considerable portions of Maryland, Pennsylvania, West Virginia, and Ohio, and was associated with a much larger body of water that extended as far west as Illinois. Located to the east of the swamp were the deltas and alluvial plains of a large Appalachian landmass that supplied sediment to the bay.

The 22-foot thickness of coal found in parts of West Virginia and Maryland attests to the long period that the swamp must have remained in the same general location[6, 7]. But the partings of silt and clay found within the coal demonstrate that at least for short periods of time the swamp was covered by deeper water permitting sediments from the adjoining landmass to be deposited directly on the decaying plant matter that would eventually become coal.

The recurring cycles of flooding and recession marked by sedimentary impurities in the Pittsburgh Coalbed are similarily reflected in the repetitive character of the strata overlying the Pittsburgh Coal--sequences of shale, siltstone, sandstone, and coal that may repeat themselves three or more times in a 100-foot interval in response to almost rhythmic changes in the size, shape, and depth of the basin of deposition[110]. Owing to the nearness of the Pittsburgh Coal Region to the parent landmass, these rhythmic

sequences of strata, or cyclothems[85] as they are sometimes called, are not so well developed as they are further west where the waters were generally deeper. As a consequence, the character of the overburden varies substantially across the Pittsburgh Coal Region and not always in a regular manner. Figure 3.4 shows this variation in a general way, as evidenced in the sequence of rock between the top of the Pittsburgh Coal and the base of the Redstone Coal, a 50- to 100-foot interval of the Monongahela Group known as the Lower Member of the Pittsburgh Formation. This interval exerts considerable influence of the behavior of the mine roof during mining and can influence later subsidence[27].

Pittsburgh Formation - Lower Member

Limestones and limy shales represent half to three quarters of this rock interval in an area that occupies the northern panhandle of West Virginia, portions of five Ohio counties to the west, and portions of Washington and Green Counties in Pennsylvania. The limestone interval often consists of alternately weak and strong shales in the first several feet above the coal, overlain by an irregularly bedded limestone, known as the Redstone Limestone. The Redstone Limestone occupies nearly the entire Pittsburgh to Redstone interval in parts of the area, but thins to one or two feet elsewhere. Where present in substantial thicknesses, the often hard, but impure limestone, poses roof control problems in mines and prevents the full extraction of coal. The Redstone Coal occurs above the limestone and is variable in thickness and quality, and is usually not mined.

Outside the limestone-rich portion of the Pittsburgh Coal Region, sandstone and shale predominate in the interval between the Pittsburgh and Redstone Coals. The Upper Pittsburgh sandstone lies immediately below the Redstone limestone and sometimes occupies nearly the full interval to the Redstone Coal in the eastern part of the Pittsburgh Coal field. In the Monongahela River area of southwestern Pennsylvania and northern West Virginia, the amount of sandstone in the interval varies as do the associated sediments. In some areas, the sandstone is massive with thicknesses up to 30 feet, while in other areas it displays cross-bedding and other characteristics of deltaic deposits. When massive, the sandstone exhibits the features of river channel deposits, cutting into underlying strata and occasionally cutting out part of the Pittsburgh Coal. Commonly, the sandstone becomes shaley and silty as it approaches the coal.

In the portion of the Pittsburgh Coal Basin that includes Fayette, Westmoreland, and Allegheny Counties in Pennsylvania, thick sequences of shale occupy most of the interval between the Pittsburgh and the Redstone Coals, and often include within them beds of siltstone, sandstone, and limestone.

The presence of the shale beds has promoted the development of mining methods that permit full extraction of coal by capitalizing on the ability of the strata to fracture in a controlled manner and thereby relieve the load from pillars still to be mined. This is quite different from the parts of Ohio and West Virginia where poorly breaking limestones require that coal pillars be left in place[83].

Rock strata can also influence subsidence. Competent limestone and sandstone strata can span between pillars more readily than can shale or claystone and can arrest caving of the mine roof that might otherwise lead to development of a sinkhole. Unfortunately, geologic data are insufficient at the sites of subsidence to draw any firm conclusions between frequency of subsidence and rock type. Although broad generalities regarding strata can be defined across the region, local variations not discernible on a regional scale create profound difficulties in extrapolating geologic information from one location to another except in the most general way and virtually prohibit the geologic interpretation of a subsidence incident unless a boring is drilled at the site. Some of the local variations in stratigraphy are apparent in the boring logs shown in Figure 3.5, which were selected from various subsurface investigations conducted in the Greater Pittsburgh Area. Distances between adjacent boring locations range from 1.5 to 4 miles and average about 2.5 miles. It will be noted that the two logs at Boring Site 4 show a change from mainly sandstone to mainly shale in a distance of only 200 feet, a not uncommon situation in the Pennsylvanian age rocks of the Appalachian Plateau. Problems with geologic interpretation are further discussed in subsequent sections.

Geologic Structure and Topography

The Pittsburgh Coal covers an area of 8,000 square miles and may once have extended far beyond its present boundaries to the Blue Ridge in eastern Pennsylvania and West Virginia. Some speculate that it may even have extended into the Anthracite Region of eastern Pennsylvania[111]. But natural forces prevailing in the 275 million year period since the coal formed have developed a series of secondary folds parallel to the main axis of the basin (bearing about north 25 degrees east) that have deflected the Pittsburgh Coal into a series of folds of several hundred foot amplitude with the result that much of the coal in the crests of the folds has been removed by erosion and only that in the low areas has been preserved. These low areas are recognized as the long fingers of coal that extend to the northeast through Westmoreland and Fayette Counties in Pennsylvania and Allegany County, Maryland. When compared to the intervening eroded areas, the low areas give some indication of the amount of coal that may have been lost, a loss all the more pronounced

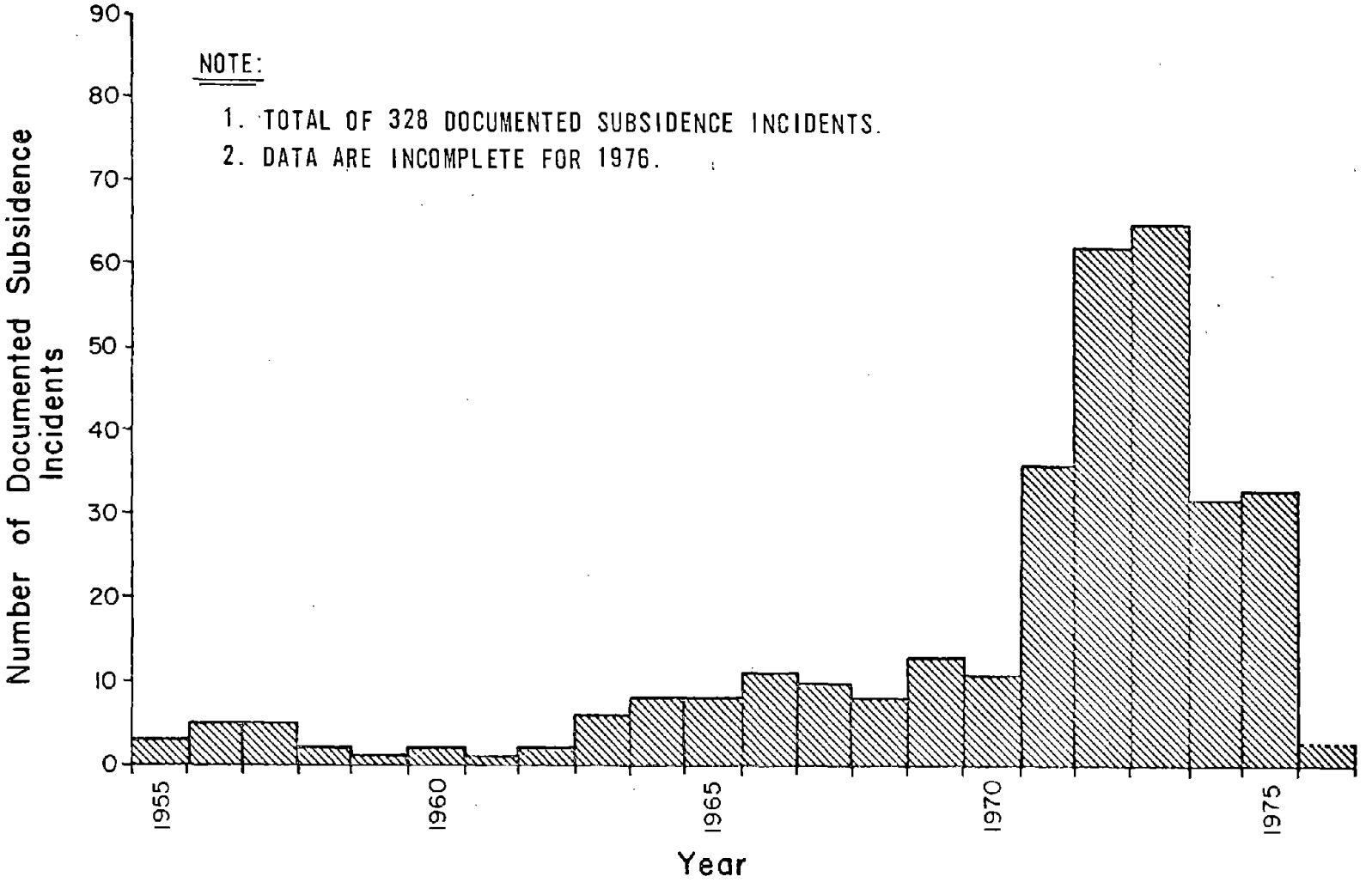


FIGURE 2.22 NUMBER OF DOCUMENTED SUBSIDENCE INCIDENTS IN PITTSBURGH COAL REGION BY YEAR

by the fact that the Pittsburgh Coal's 22 foot maximum thickness is found in the Georges Creek Field of Maryland, a relatively small erosional reminant located 100 miles east of the main coal field[7].

The erosion that has reduced the coal field to a fraction of its former size has also created a topography in the Pittsburgh Coal Region that is gently rolling for the most part, but is accentuated adjacent to major rivers and streams to create a mountainous area where the flat hilltops sometimes stand 500 or more feet above the valley bottoms[107].

Because of the shallow depth to the Pittsburgh Coal along the northern margin of the field near Pittsburgh, erosion has created a winding outcrop line whose length is over 600 miles in the six quadrangles that embrace the heart of the Greater Pittsburgh Area. The ready access to the coal afforded by the long outcrop line and Pittsburgh's strategic location at the confluence of the Allegheny, Monongahela, and Ohio Rivers, accounts for the early development of Pittsburgh as a center of industry and mining. Glass making, iron making, steam navigation, and later steel making all owe their development to the availability of coal. Beginning in 1759 with the informal collection of coal by British soldiers, mining progressed from the outcrop on the north face of Mount Washington overlooking the present city of Pittsburgh, to the east where the coal is at shallow depth and then to the south and west where the coal is deeper[33]. At the present time, nearly the entire Pittsburgh Coalbed in Allegheny, Westmoreland, and Washington Counties of Pennsylvania has been mined out and remaining reserves are principally pillars left in place from earlier mining[25]. Active deep mining of the Pittsburgh Coal is primarily confined to extreme southwestern Pennsylvania (Greene and Fayette Counties) and to adjoining parts of Ohio and West Virginia. In the Pittsburgh area, the Pittsburgh Coal has yielded to the Upper Freeport Coal, 600 feet below, as the principal producer[65].

Unfortunately, the long history of mining the Pittsburgh Coal has created a vast undermined area with considerable potential for subsidence, particularly where the coal was only partially recovered. It is sobering to realize that the mined out area created by extraction of the Pittsburgh Coal over the past 200 years extends over more than 1,200 square miles. Over the past several decades, however, total extraction methods that have been practiced in such counties in Pennsylvania as Washington, Fayette, and Greene, have sufficiently collapsed most of the mined out areas created in that period to permit safe construction of buildings at ground surface a year or two after mining with little danger of future subsidence[14, 23]. The remainder of the region, area, much of it located beneath the densely populated metropolitan Pittsburgh in Allegheny County,

is not fully collapsed, owing either to the inefficiency of the old mining methods or to mining methods where collapse of the void was never intended. Subsidence long after mining has been completed and long after the presence of the old mines has been forgotten is now causing difficulties for homeowners and businessmen, who, until the advent of mine subsidence insurance in Pennsylvania had no recourse but to accept damage due to subsidence as one of the unavoidable natural hazards of living in the region. With insurance or without, however, the psychological impact of subsidence on the individual is never positive, and with the decentralization of industry and the expansion of communities into undermined areas that were formerly used for agriculture, subsidence over abandoned mines will probably increase in the future.

Little has been done in the past to define where and when subsidence will occur and what mechanisms may be responsible. Subsequent sections of this report are devoted to a consideration of these topics.

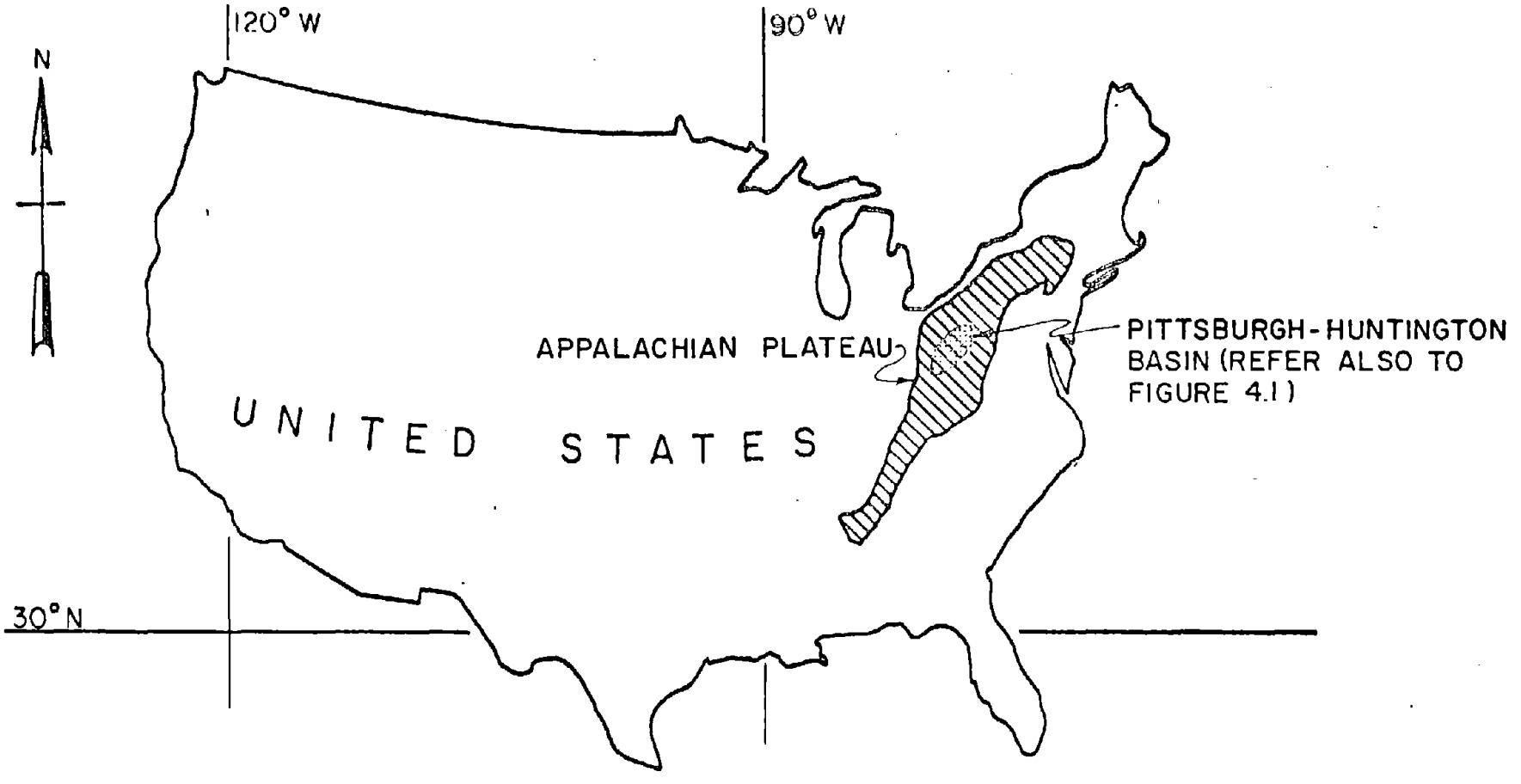
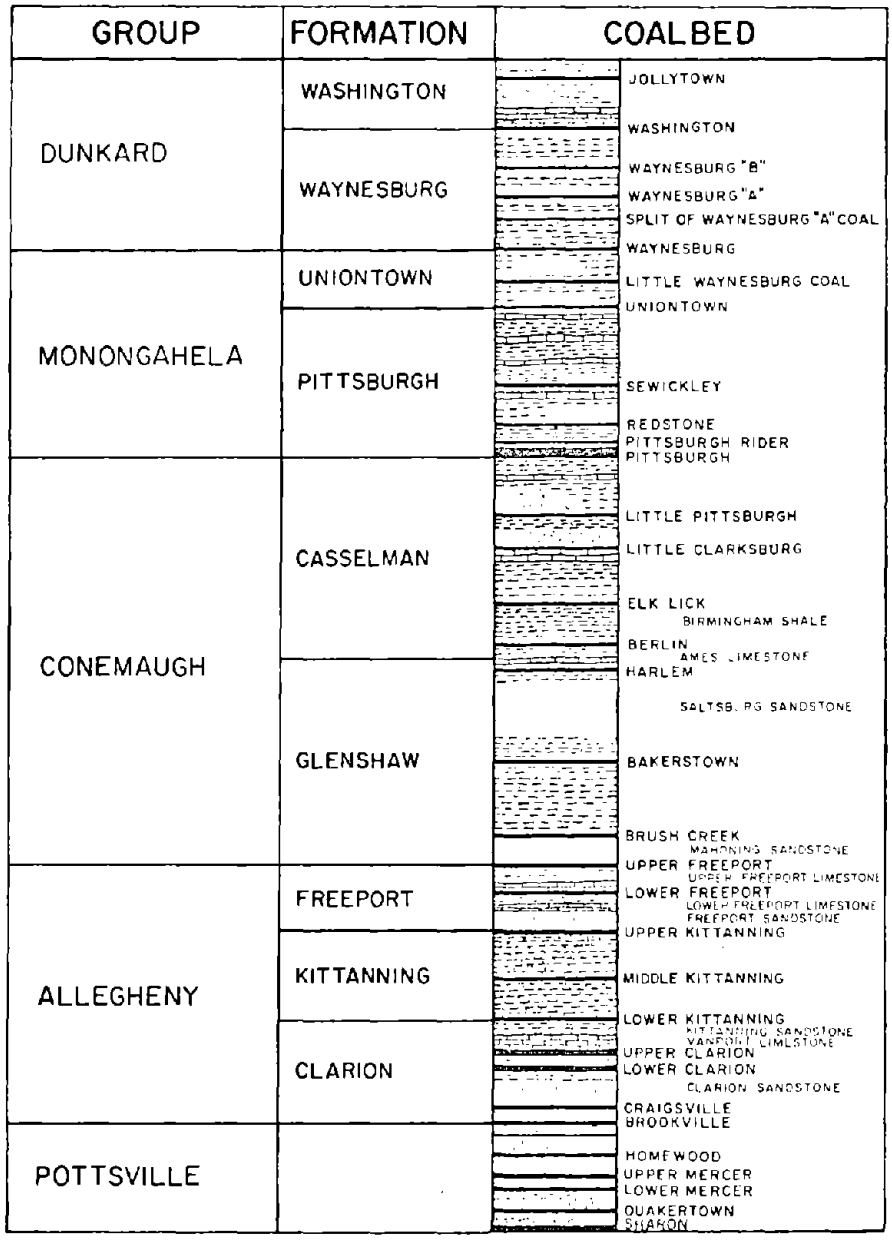


FIGURE 3.1 - LOCATION OF THE PITTSBURGH-HUNTINGTON BASIN AND THE APPALACHIAN PLATEAU



Coal Beds of Pennsylvania

FIGURE 3.2 GEOLOGIC COLUMN OF WESTERN PENNSYLVANIA

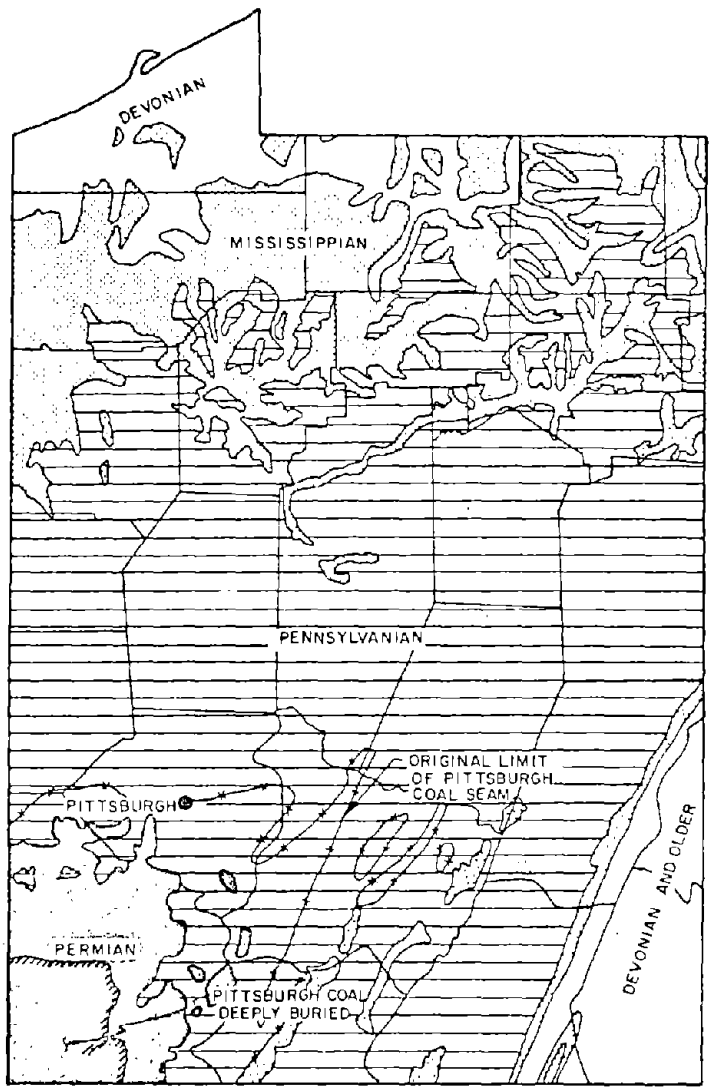


FIGURE 3.3 GEOLOGIC MAP OF WESTERN PENNSYLVANIA

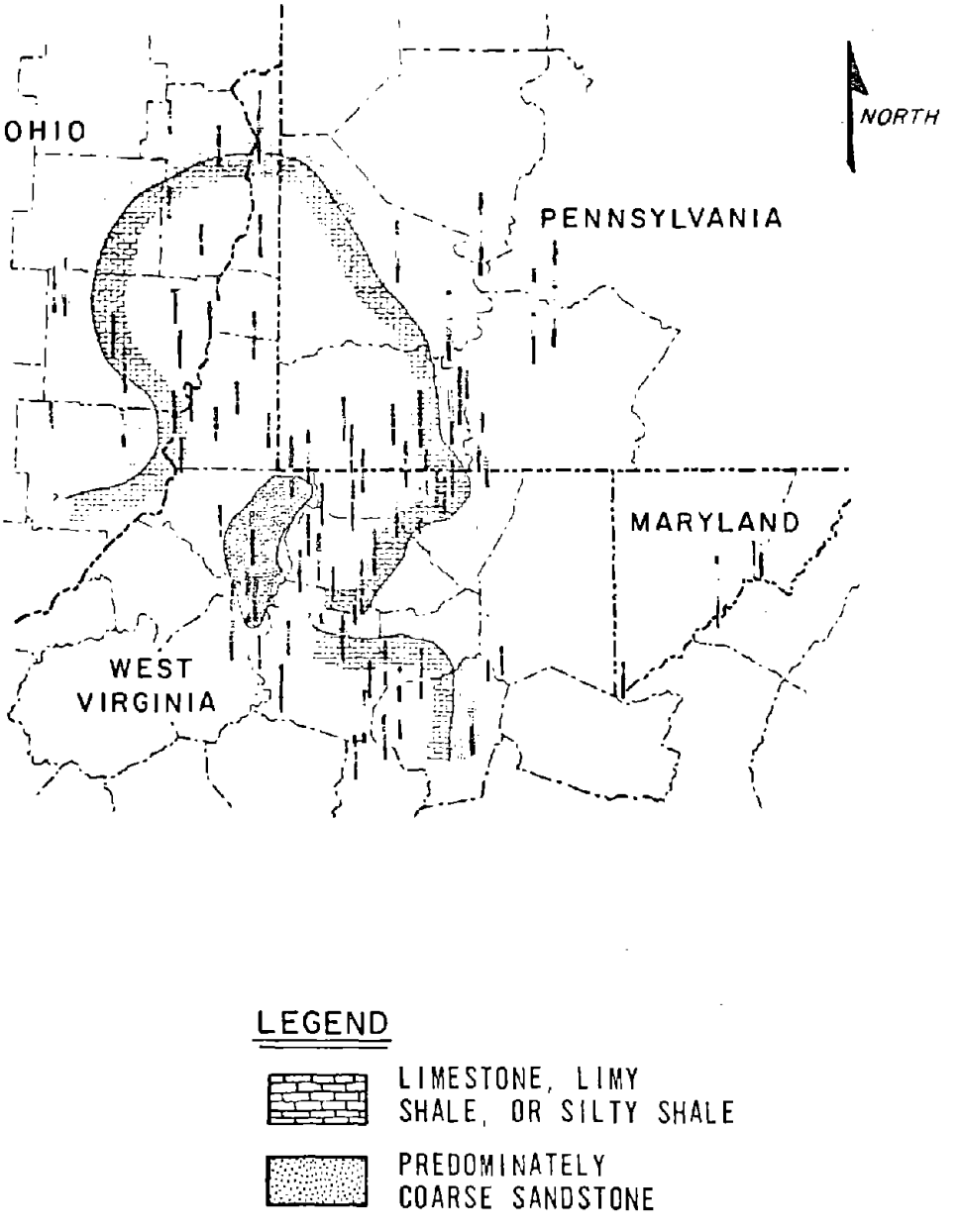


FIGURE 3.4 VARIATION OF ROOF STRATA OF THE PITTSBURGH COAL OVER THE FOUR-STATE REGION (AFTER A.T. CROSS, 1971)

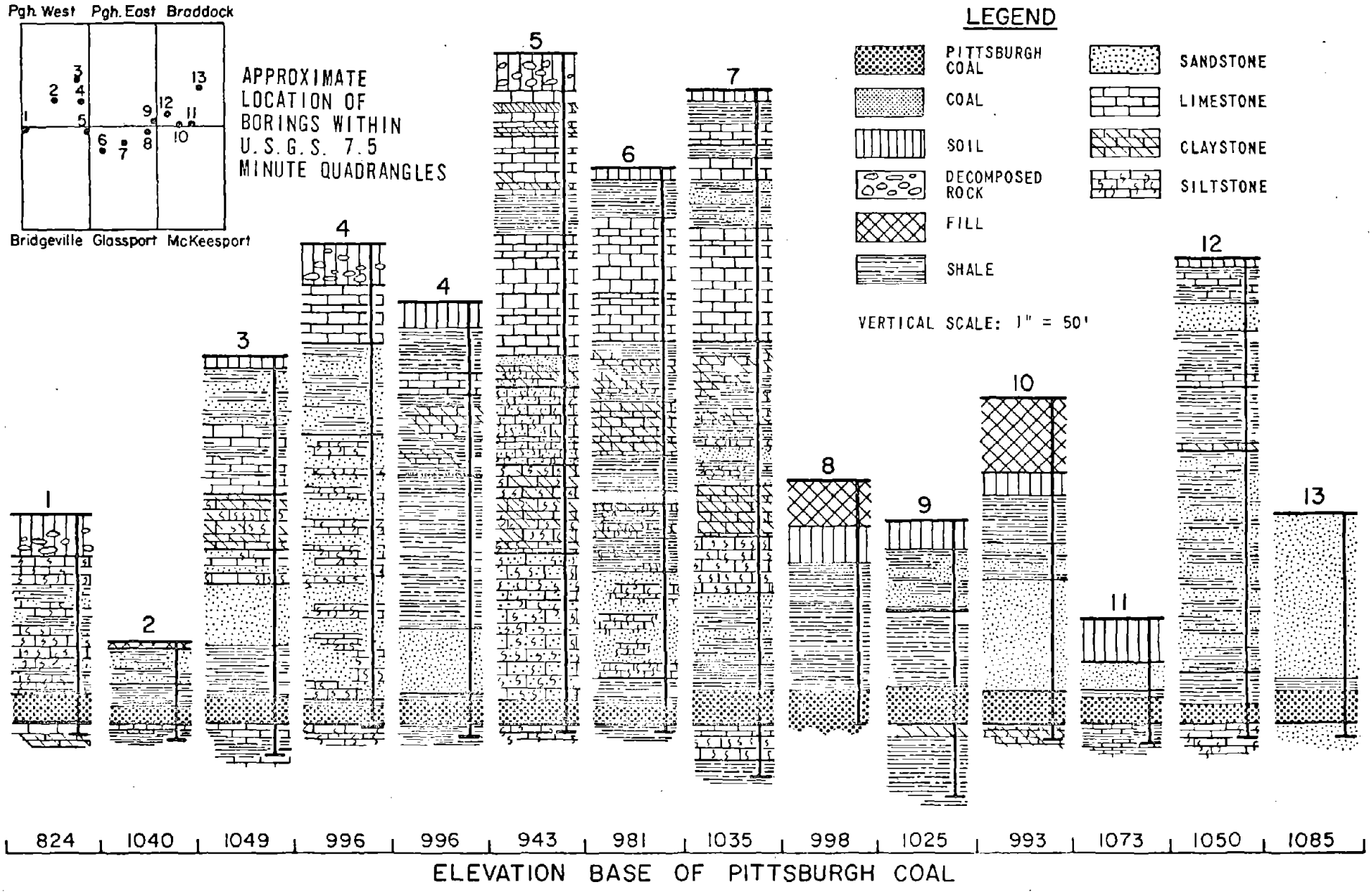


FIGURE 3.5 SELECTED GEOLOGIC LOGS, ALLEGHENY CO., PA.

4. MINING

General

The uniform quality, pervasive thickness, and excellent coking properties of the Pittsburgh Coal have made it one of the world's most valuable mineral resources. The Pittsburgh Coal underlies all or part of 43 counties in Maryland, Ohio, Pennsylvania, and West Virginia, and occupies a total area of approximately 8,000 square miles, nearly three-quarters of which is mineable (Figure 4.1). Although its production by deep mining has fluctuated through the years, the present level of about 49 million tons annually accounts for over 15 percent of the total U. S. coal production by deep mining[65]; and production levels over the past 200 years have yielded more than eight billion tons of Pittsburgh Coal[7, 65, 111], a total which has accounted for almost 35 percent of the cumulative production of the Appalachian bituminous coal region and over 20 percent of the cumulative production of the United States[74].

Nearly all of the Pittsburgh Coal has been mined by room and pillar methods. These have ranged from simple partial extraction operations to sophisticated total extraction operations. But whatever the method, in those locations where pillars have been left underground through the dictates of mining or economy, the potential for subsidence exists long after mining has ceased . The mining methods employed in the Pittsburgh Coal Region are reviewed in the following pages in order to describe the origin of the areas that are now exhibiting subsidence.

Partial Extraction

Seventy years ago, some form of total extraction room and pillar mining was being practiced in the major mines in the Pittsburgh Coal Region, with the exception noted before of mines in the West Virginia Panhandle and the Ohio districts, where roof control problems prevented total extraction[83].

During the 18th and 19th Centuries, partial extraction mining was the rule rather than the exception[33]. Coal pillars were left in place as a matter of convenience and safety regardless of the character of the roof. Because the earliest mines were small operations under shallow cover, decisions as to spacing and regularity of pillars were often arbitrary, and acceptable pillar sizes were probably determined at some point during mining by robbing a pillar to the point of failure.

Increased production by the mid- to late-19th Century brought mechanization to mining that necessitated a regular arrangement of pillars. Some of the earliest air driven and electric driven cutting machines were developed in the late 1870's and 1880's, about the time that electric locomotives were first produced for use in mines[61]. (Cutting machines were used to cut horizontal slots in the coal face top or bottom to facilitate break out of the coal during blasting.)

As the demand for coal increased, mining spread from the hills along the Monongahela River near Pittsburgh to the hills between the Allegheny and Monongahela Rivers a few miles east. Although not as large a reserve as that south of the Monongahela River, these outliers of coal were, a hundred years ago, the most convenient source of coal to the market.

Pittsburgh's Hill District located two miles east of Pittsburgh's central business district lies above one of these outliers. Mining began there about 1795 and continued to about 1870 [38]. The coal pits, as mines were then known, penetrated the coal from the outcrops on the hillsides. After digging some distance into the hill, rooms were formed on each side, with coal pillars being left at intervals to support the roof. The hilly terrain provided ample outcrops from which to reach the coal.

Mine maps from this era are few and difficult to locate. However, an excavation to mine level made a few years ago as part of an urban renewal project in the Hill District provided a unique opportunity to inspect a portion of one of these old mines. The excavated area measured 80 by 150 feet and revealed an orderly pattern of pillars and openings, with rooms five to six feet wide alternating with pillars of equal width (Figure 4.2)[38]. Such a pattern did not permit extraction much in excess of 50 percent. Most mining in that era was done by hand, with coal being taken out by pick, shoveled into a wheel borrow, carried to the mouth of the pit, dumped onto a platform, and finally loaded into freight wagons for shipment.

Figure 4.3 presents the map of another partial extraction mine, this one located in an outlier of coal in the Braddock Quadrangle along the northeast fringe of the Pittsburgh Coal Region. The map shows the status of the mine some time around World War I, probably quite a few years after it had first opened. Note how the geometry of the mine had to be modified to accommodate the irregular outcrop of the coal seam, and how the extraction achieved in the mine is little more than 50 percent although the rooms and pillars were each about three times wider than those of the older mine discussed above. The rooms extend out to where the overburden is only 25 feet thick. Maximum cover at this mine was about 50 feet.

At some time possibly in the 1880's and 1890's, as suggested from available mine maps, extraction was increased by widening rooms to 20 to 24 feet and pillars to 10 to 18 feet, thereby increasing the coal retrieved from a given property by 10 to 20 percent. From this point onward until the advent of the block system of mining several decades later, rooms and pillars of this general size were one of the most pervasive characteristics of mines in the Pittsburgh Coal Region, a characteristic equalled only by the practice of driving the rooms on the face cleat to take advantage of the easier extraction in this direction[43, 83].

Total Extraction

At some point in the later part of the 19th Century or perhaps a little later--records of the Pittsburgh Coal Company and other sources seem to indicate a point at least as far back as the turn of the Century[14, 114]--total extraction mining was first practiced in the Pittsburgh Coal Region.

Total extraction was intended to achieve higher production from the increasingly valuable coalbeds and was first implemented in partial extraction mines of the day. The principal distinction between the partial extraction mines and total extraction mines was that the long narrow pillars left between rooms during first mining were now extracted in a second stage of mining. For a long while, wide rooms and narrow pillars were employed even in total extraction mines because it was believed that more lump coal (the preferred commodity) could be produced by room mining than by pillar mining (extracting the pillars left between rooms)[83].

In an extensive survey conducted nearly 50 years ago of mining practices current in the Pittsburgh Coal Region in that day, five principal types of total extraction room and pillar mining were recognized, with an equal number of subtypes[83]. The classification was based upon the development of the mine (the configuration of rooms and entries and the order of mining the property) and the technique employed to extract the pillars. The basic characteristics of these methods are presented in Table 4.1. Although differences existed between mines on the basis of size, property line constraints, and so on, most were developed in much the same manner. The following might be considered representative (Figure 4.4). Main entries (not shown), consisting of 4 to 9 parallel headings protected by chain pillars were advanced against the face cleat (N25°E) to the far boundary of the property. Main butt entries, consisting of three to five parallel headings also protected by chain pillars were then driven at right angles from the main entries at intervals of 2,000 to 3,000 feet and oriented N65°W. Both headings provided principal access to the mine property and were

further protected by barrier pillars 100 to 200 feet wide left immediately within the perimeter of the panel.

Face entries consisting of three parallel headings were driven at right angles from the main butt entries to block out panels of coal 50 to 100 acres in extent. These panels were subdivided, in turn, into smaller areas by entries driven parallel to the main butt entries at intervals of about 500 feet and connecting with the face entries at either end. Rooms, separated by pillars, were driven from these room entries to extract the coal within the panel.

To achieve total extraction, it was necessary to remove the pillars in a systematic fashion and at the same time collapse the roof over the newly mined area. Collapse of the roof was necessary so that the weight of overburden above the mined-out area would not transfer over the pillars still to be mined and crush them. The pattern of removing pillars was the point of departure between the various types of total extraction processes. The choice of process depended on production and development requirements, the thickness of the overburden, and the preferences of the operator.

The "full advance" method was the first and simplest technique. According to this method, rooms were driven in both directions off the butt entry as the entry advanced toward the opposite end of the panel. The rooms were 18 to 20 feet wide and 200 to 225 feet long, generally the same as in the partial extraction method, and the long narrow pillars separating them were broken every 80 to 100 feet by cross-cuts for ventilation. Pillars in these mines were sometimes left a few feet thicker than in similar partial extraction mines to enable easier removal, but generally did not exceed 10 feet in width. After the first four to seven rooms were mined full length, pillar extraction was begun, beginning at the far end of the first room driven. From this point, pillars were extracted in step so as to achieve a break line oriented across the rooms at an angle of approximately 45 degrees relative to the butt entry. (A break line is shown in Figure 4.4, as employed in a more refined mining pattern.) Pillar extraction was intended to follow closely behind room development to avoid delays that made pillars more difficult to extract. It was recognized that load transfer onto pillars increases with time. Extraction of the pillars was accomplished by cutting successive pockets into the lateral faces of the pillars, or alternatively, by cutting successive slabs off the end of the pillar facing the mined-out area. With either method, the pillars were extracted along a common front, so that when the temporary props set to support the roof were removed, the roof, which cantilevered out over the newly mined area, would fracture along the break line induced by the last line of pillars and collapse to the floor.

After extraction had been carried to the far end of the panel, the chain pillars and room stumps that protected the entries were removed. (This process was sometimes not accomplished until decades after first mining by smaller operators who could undertake the work economically.)

With thicker overburden, more refined techniques were developed for extracting pillars. In the "full retreat" method, rooms were driven only after the butt entry had advanced full length to the opposite face entry. Then rooms were driven on both sides of the butt entry beginning at the far end of the mine, followed by extraction of chain pillars and room pillars. Extraction was coordinated so that the two break lines each 150 to 200 feet long formed a chevron that moved from the far end of the panel to the near end.

By 1930, or thereabouts, many mines had accepted long break lines 1,000 to 1,500 feet long as preferable to short break lines of a few hundred feet, since the former provided superior roof control as well as concentration of haulage, trackwork, ventilation, and supervision (Figure 4.5). This fostered lower production costs and compensated for the advantages of quick production and minimum development offered by the other methods that had been developed originally for shallow cover.

By the 1920's, square pillar mining configurations were coming into favor, but were still far out numbered by older narrow pillar patterns (Figure 4.6). In these "block systems," pillars 60 to 100 feet on a side were separated by narrow rooms and entries 12 to 15 feet wide. The smaller rooms and entries allowed less roof deterioration, fewer roof falls and fewer support problems during pillar extraction. Pillars were extracted along an angled break line by methods similar to that described above.

In the period 1948 to 1952, continuous mining machines were introduced to the industry on a large scale[14, 23] and made the the long, narrow pillar pattern totally obsolete. Remaining mines of the old pattern were converted to the block system in the period of a few years. Subsequently, as "flat" break lines parallel to the pillar faces replaced angled break lines, the transition to the relatively efficient mining methods of today was essentially complete[95].

Shortcomings of Total Extraction Methods

Successful total extraction would result in a stable ground surface within a year or two after mining. But these total extraction methods were not always completely successful.

Figure 4.7 depicts a portion of an early total extraction mine in Allegheny County, Pennsylvania. The mine was operated just after the turn of the century, and as the dates on the map indicate, pillar extraction was conducted in the 1909 to 1910 period. The mine appears to have been worked according to the half advance, half retreat system, with room work and pillar extraction first progressing to the northwest along [A] toward a face entry not shown in the figure, and then returning to the southeast along [B]. In the portions of [A] and [B] shown, about 78 percent of the coal was extracted, including pillars; about 22 percent was lost. Roof falls, squeezes, or other complications brought about by factors no longer evident may have been responsible for the inability to extract the pillars. As a result of these factors, subsidence is a very real possibility many years after the mine has been abandoned, and this situation is made all the more precarious by the irregularity of the pillars still in place. It is probably for these reasons that the community located above the mine has experienced over 30 subsidence incidents in the past 10 years.

Incomplete extraction of coal seems not to have been uncommon in long pillar line mines. Some of the more prominent reasons for these pillar losses seem to have been the following[43, 49, 83]:

1. Faulty Planning. Situations resulting in local squeezes:

   a. Rooms too wide and pillars too narrow to support the overburden.

   b. Too many rooms driven off a heading before extraction of pillars was initiated. (Justification may have been to temporarily increase production.)

   c. Convergent extraction lines, preventing clean roof breaks.

2. Unsystematic or Poorly Supervised Mining. Situations resulting in local squeezes:

   a. Lack of uniformity in room and pillar sizes, sometimes as a result of mining without benefit of survey.

   b. Pillar gouging and unsystematic pulling of pillars.

   c. Irregular (unstraight) break lines.

3. Time Delays. Delays that have resulted in deterioration (rotted timbers, roof falls, flooding) too costly to clean up:

   a. Reductions in work force during economic downturns that slowed or stopped work in portions of the mine.

   b. Strikes, and union restrictions concerned with restationing miners from one work place to another where they may be needed more.

   c. Recommitting miners involved in pillar extraction to room work to maintain high production.

4. Problems due to Geology. Areas of difficult to control roof or floor that made pillar extraction hazardous or impossible. Sandstone channels in the roof are a common problem in this regard. (It might be noted that with the advent of continuous miners mining layout is no longer controlled by cleat orientation, as it was to such a great degree in the old mines, with the result that current mines can sometimes minimize the effects of difficult geologic conditions by reorientation of the rooms.)

5. Mine Accidents that resulted in closing off part of a mine.

6. Economics. Situations that rendered coal so cheap that pillars were not extracted even though the technology to do so existed.

Such areas of incomplete or faulty extraction are thought to be responsible for the frequency of subsidence that the Pittsburgh area has experienced in the past several years.

Delineation of these areas would aid homeowners and community planners in avoiding the most subsidence-prone locations or at least taking measures to counter potential subsidence effects. Unfortunately, this is not easily accomplished for the following reasons:

1. Maps are not available for many old mines. They may have been lost, may never have existed, or may not be available for inspection. Map coverage, for example, is available for only 30 percent of the six quadrangle area encompassing Greater Pittsburgh. (The maps produced during 1930's by the Works Projects Administration, W.P.A., show the locations and patterns of many old mines on a gross scale, but are not sufficiently detailed to be considered mine maps in the true sense.)

2. Available mine maps are only rarely annotated to show areas of incomplete extraction.

3. Wholly apart from the consideration of areas of "lost coal", available maps do not necessarily depict actual conditions at mine level at the time of mine abandonment. Many mine maps have been placed in public files long after the mines have closed and mining companies have ceased to exist. Outdated copies, or second copies, may be the only ones that find their way into these files. Furthermore, the detail and faithfulness of the maps is dependent to a degree on the time and inclination of the draftsman who prepared them and on the care with which the mine survey was performed. Also, mine properties closed by the principal mining company were occasionally leased to smaller operators who extracted coal that was uneconomical for the larger company to obtain. This second mining is often not recorded on available maps nor are the locations of operations conducted by small companies or individuals along crop lines--the "coal pit" or "country-bank" operations.

All of these factors taken together indicate the limitations of defining subsidence-prone areas by mine map information alone. For this reason, subsidence data collected during the present study (and that which will be collected in years to come) are probably the best indicators of areas particularly susceptible to subsidence. Several trends are already apparent.

1. Most subsidence incidents have taken place above mines operated prior to 1935, employing some form of long pillar line system. These types of mines are confined primarily to the area shown in Figure 4.8, which was established by inspection of maps on file with the State of Pennsylvania, the U. S. Bureau of Mines, and from W.P.A. maps.

2. Most subsidence has taken place through collapse of the overburden into the old rooms through progressive caving. A much smaller percentage, though equally as important from the standpoint of damage to structures at ground surface, has been the result of failure of old pillars or punching of pillars into the mine floor.

The mechanisms associated with the various forms of subsidence are discussed in subsequent sections of this report.

Table 4.1

PRINCIPAL TYPES OF TOTAL EXTRACTION ROOM AND PILLAR MINING PRACTICED IN THE PITTSBURGH COAL REGION
(After Paul and Plein, 1935)

Type	Locality	Range of Overburden (Avg. ft)	Percent Extraction	Room Length (ft)	Room Width (ft)	Pillar Width (ft)
FULL ADVANCE without PILLAR EXTRACTION All coal mined on the advance. Room pillars, room stumps, entry pillars and chain pillars are abandoned. Rooms are developed as butt entry is driven.	Ohio and W. Virginia Panhandle	0-800 (250)	55-65	200	24	8-9*
FULL ADVANCE with PILLAR EXTRACTION All or part of room pillars, room stumps, and chain pillars are extracted. Rooms are developed as butt entry is driven.	Pennsylvania Panhandle	0-300 (95)	70-80	238	23	8-9*
FULL RETREAT with SHORT BREAK LINES Rooms are driven after butt entry is developed. Room stumps and chain pillars are extracted in step with room pillars as mining retreats from far end of mine back to entry. Short break lines approximately 500 feet long.	Washington County, PA	0-600 (425)	80-85	250	17-21	13-25*
HALF ADVANCE-HALF RETREAT Rooms are turned off one heading as butt entries are driven. Room pillars off this heading are extracted in step during advance. After butt entry has reached its limit and mining along this heading is completed, rooms are driven off the other heading, beginning at the	Allegheny and Washington Counties, PA	25-600 (285)	72-90	270-350 220-100	18-24	12-27*

*Long, narrow pillars, rectangular in plan.

Table 4.1
(Continued)

Type	Locality	Range of Overburden (Avg. ft)	Percent Extraction	Room Length (ft)	Room Width (ft)	Pillar Width (ft)
far end and working back toward the entry. Room pillars, stumps, and chain pillars are extracted as the operation retreats back to the face entry. Rooms on the retreat side are 50 to 90 feet shorter than on advance side to permit quicker mining. Break lines are short.						
FULL RETREAT with LONG BREAK LINES Similar to full retreat with short break lines.	Westmoreland, Washington, Greene and Fayette Counties, PA					
LONG BREAK LINES 500 to 1500 feet long.	Marion County, W. VA					
a. Narrow Room Pillars		10-550 (240)	80-90	200-320	18-21	13-29*
b. Block System (including modification of (a.) where wide rectangular room pillars are employed)		10-900 (360)	85-87	200-550	10-18	40-111†

*Long, narrow pillars, rectangular in plan.

†Broad pillars, generally square in plan.

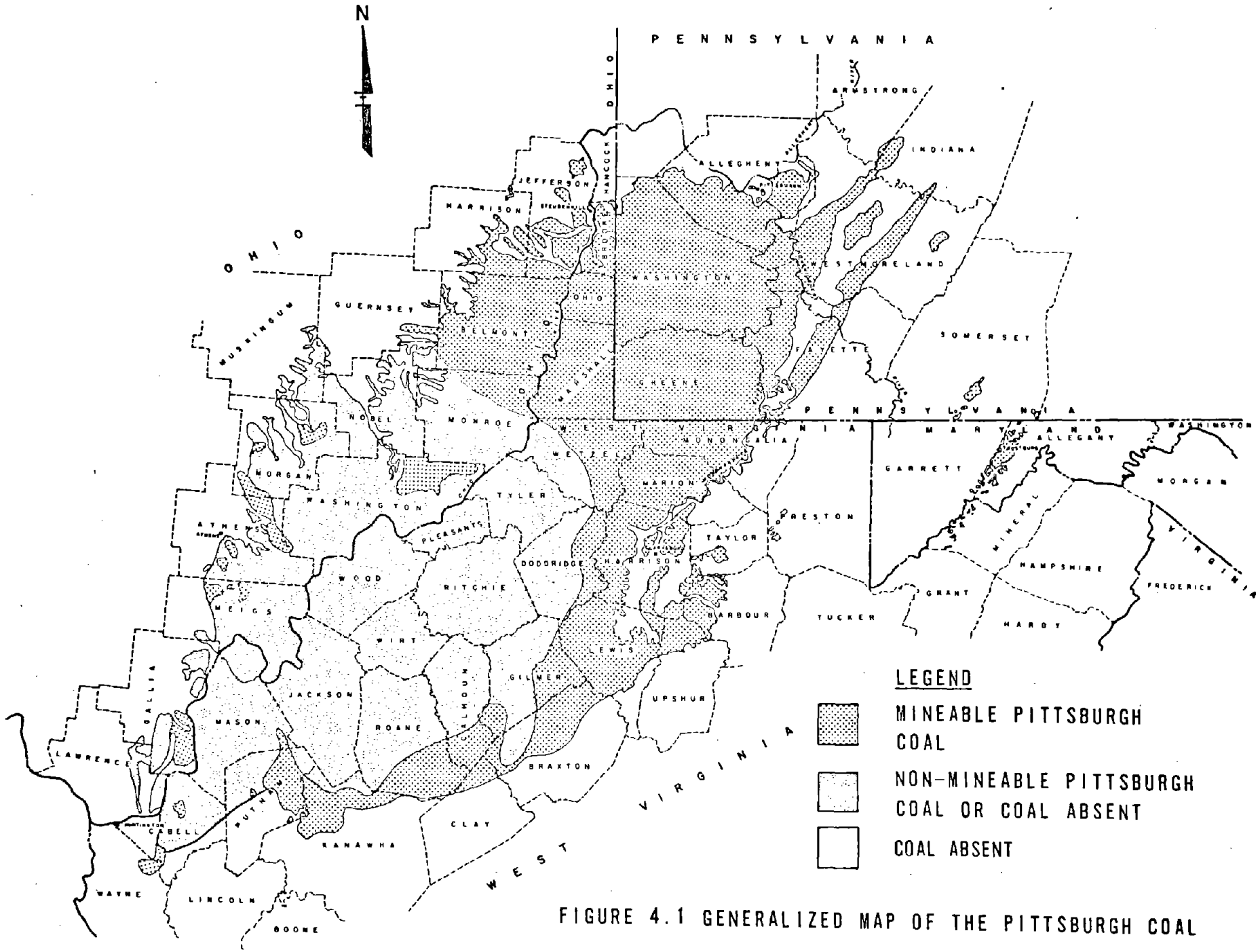


FIGURE 4.1 GENERALIZED MAP OF THE PITTSBURGH COAL

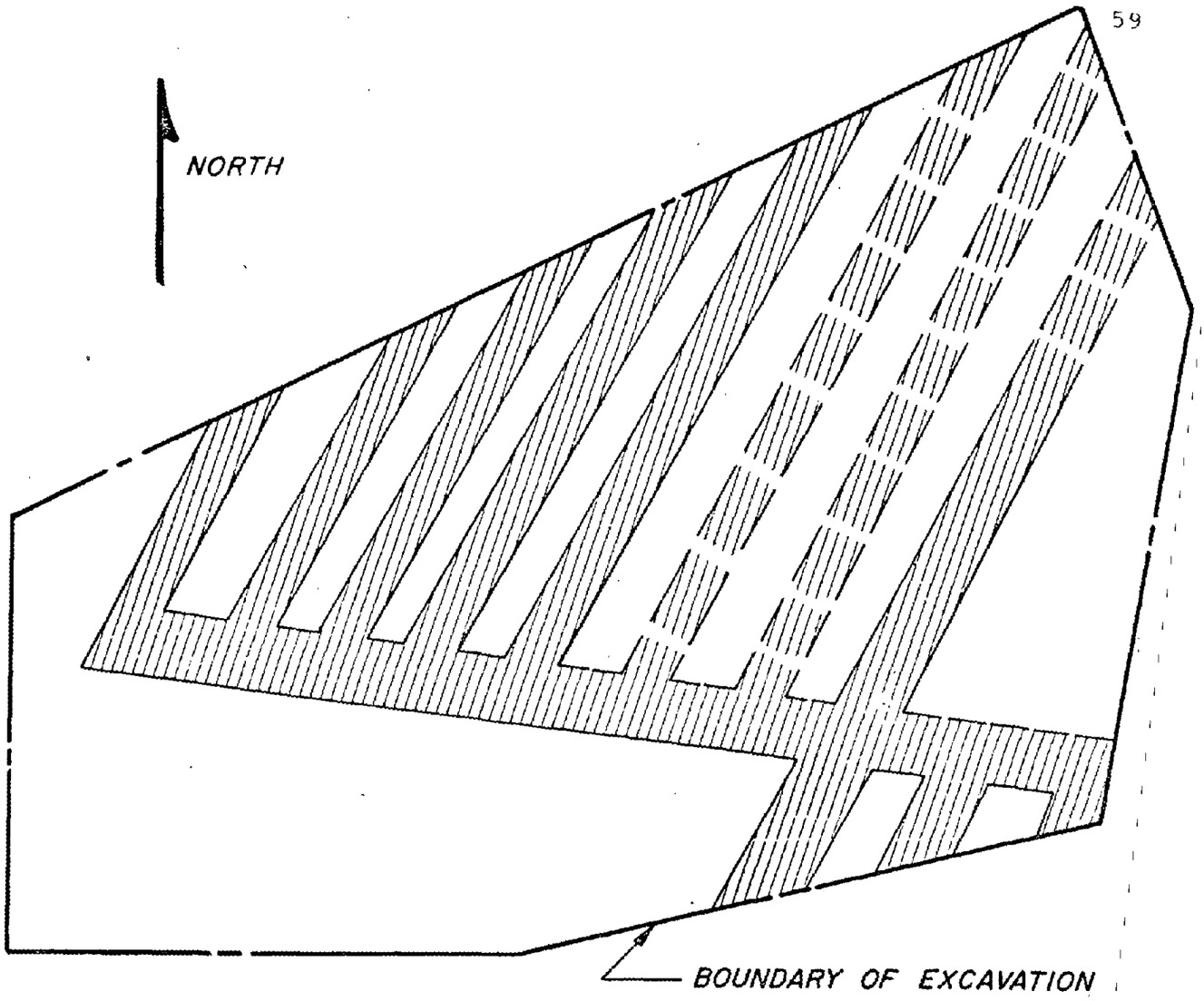


FIGURE 4.2 AN EARLY PARTIAL EXTRACTION MINE IN PITTSBURGH'S HILL DISTRICT, ALLEGHENY COU PENNSYLVANIA (PITTSBURGH EAST QUADRANGLE

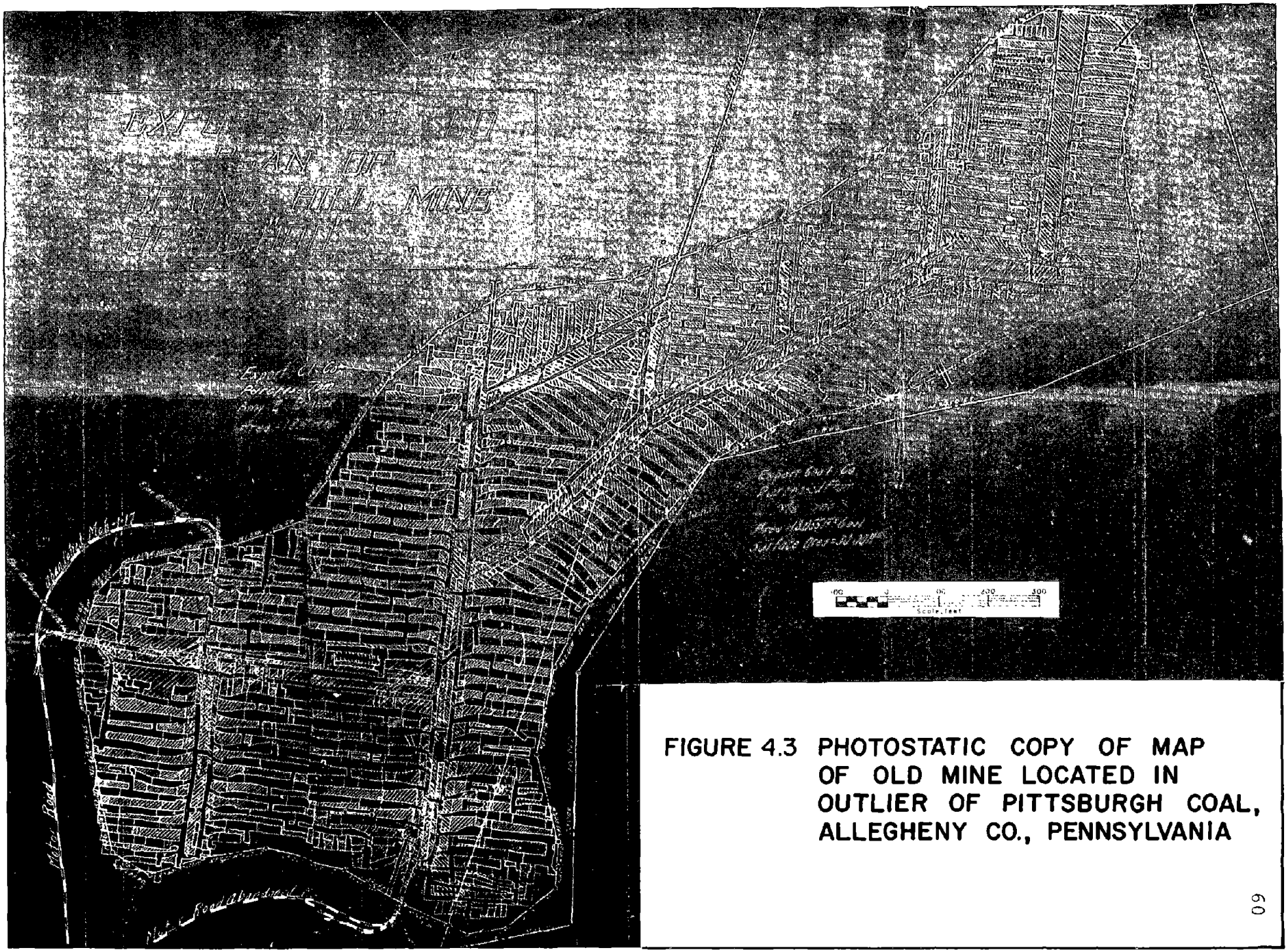


FIGURE 4.3 PHOTOSTATIC COPY OF MAP OF OLD MINE LOCATED IN OUTLIER OF PITTSBURGH COAL, ALLEGHENY CO., PENNSYLVANIA

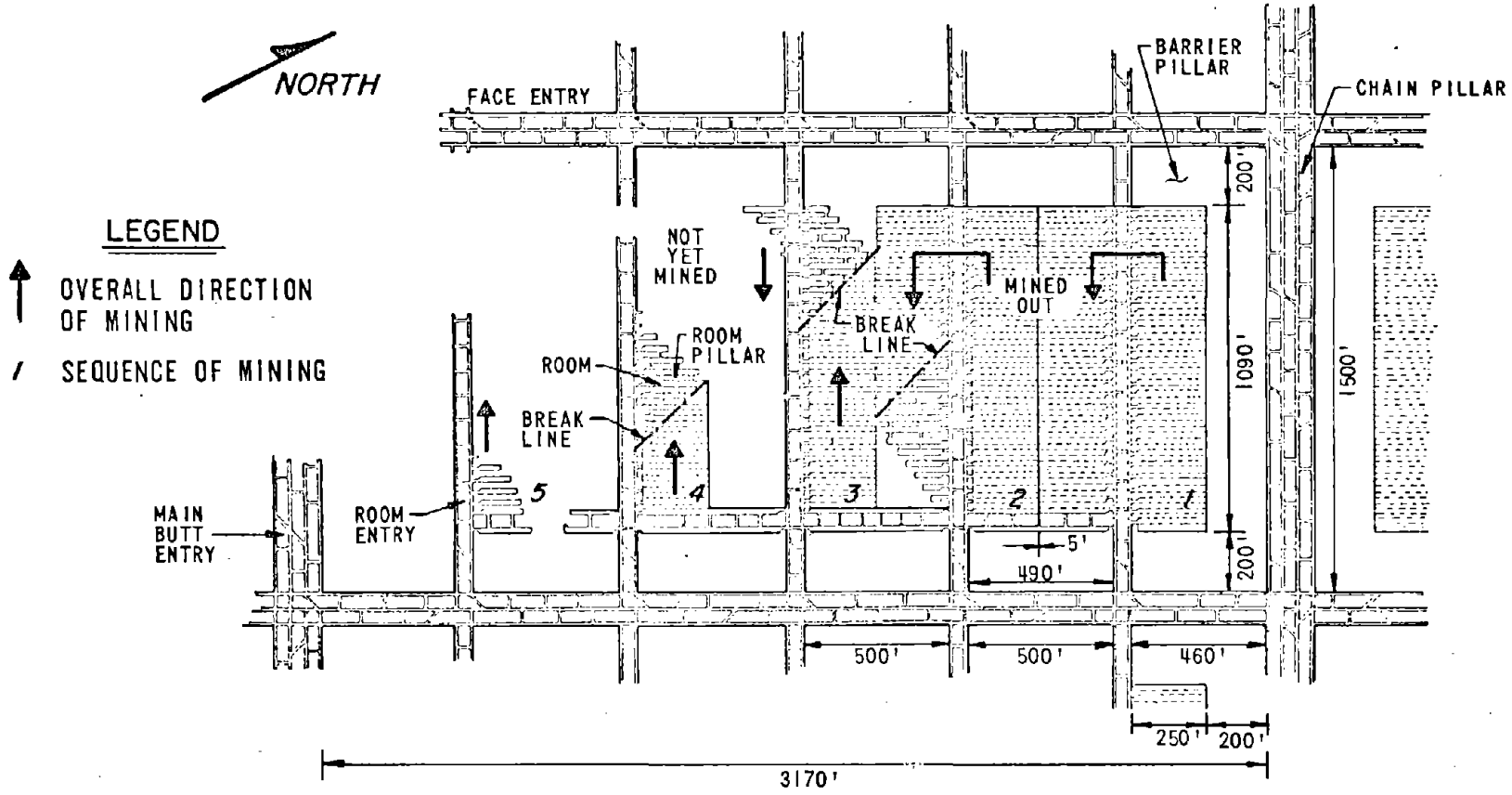


FIGURE 4.4 GENERAL PLAN OF MINE DEVELOPMENT BY NARROW PILLAR LINE COMMON IN ALLEGHENY COUNTY, PA.; HALF ADVANCE - HALF RETREAT METHOD OF PILLAR EXTRACTION WITH SHORT BREAK LINE (AFTER PAUL AND PLEIN, 1935)

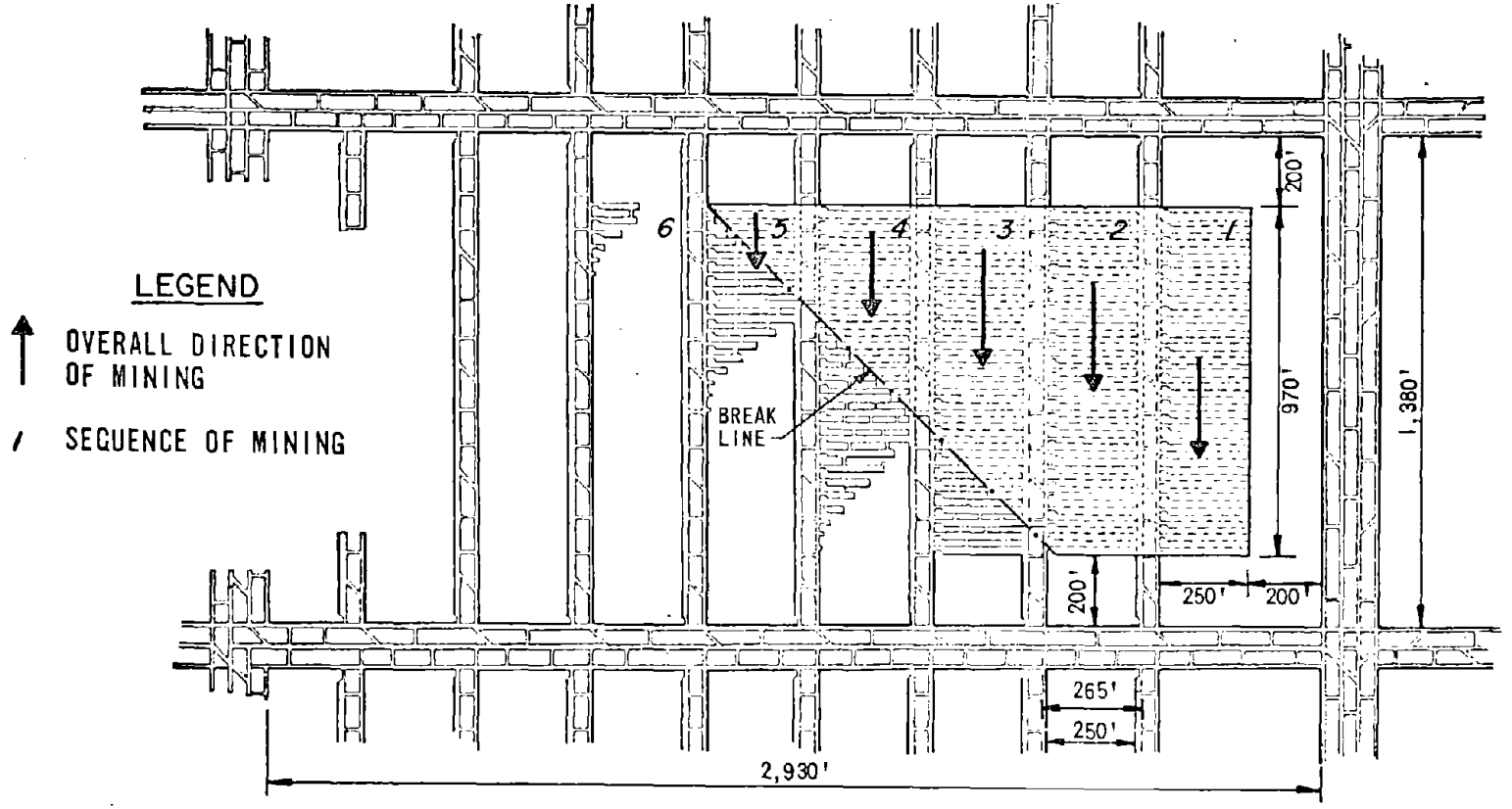


FIGURE 4.5 GENERAL PLAN OF MINE DEVELOPMENT BY NARROW PILLAR LINE, WASHINGTON COUNTY, PA.; FULL RETREAT METHOD OF PILLAR EXTRACTION WITH LONG BREAK LINE (AFTER PAUL AND PLEIN, 1935)

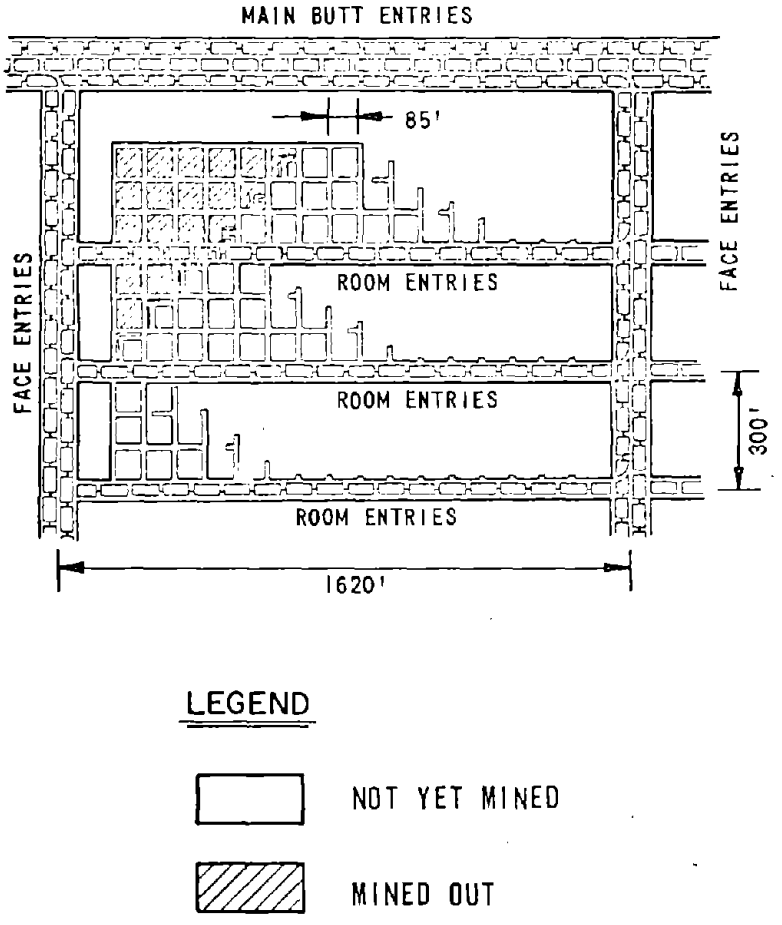
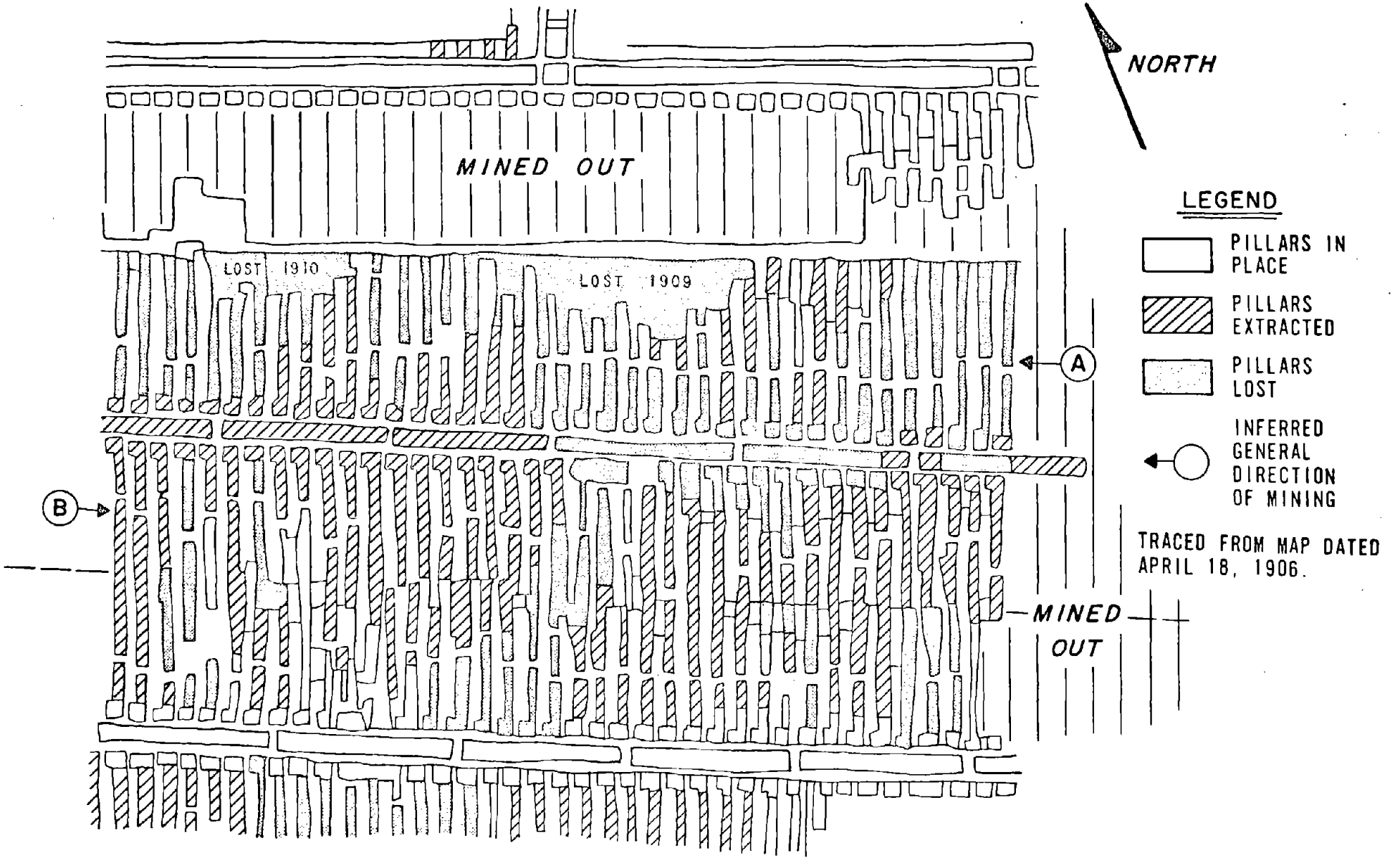


FIGURE 4.6 GENERAL PLAN OF MINE DEVELOPMENT BY AN EARLY TYPE OF BLOCK SYSTEM TYPICAL IN PENNSYLVANIA (AFTER PAUL AND PLEIN, 1935)



Section of Aliquippa Mine Operated by the M.R.C.C. & C. Co.

SCALE: 1" = 200'

FIGURE 4.7 AN EARLY TOTAL EXTRACTION MINE DEVELOPED USING LONG PILLAR LINES, ALLEGHENY COUNTY, PENNSYLVANIA (GLASSPORT QUADRANGLE)

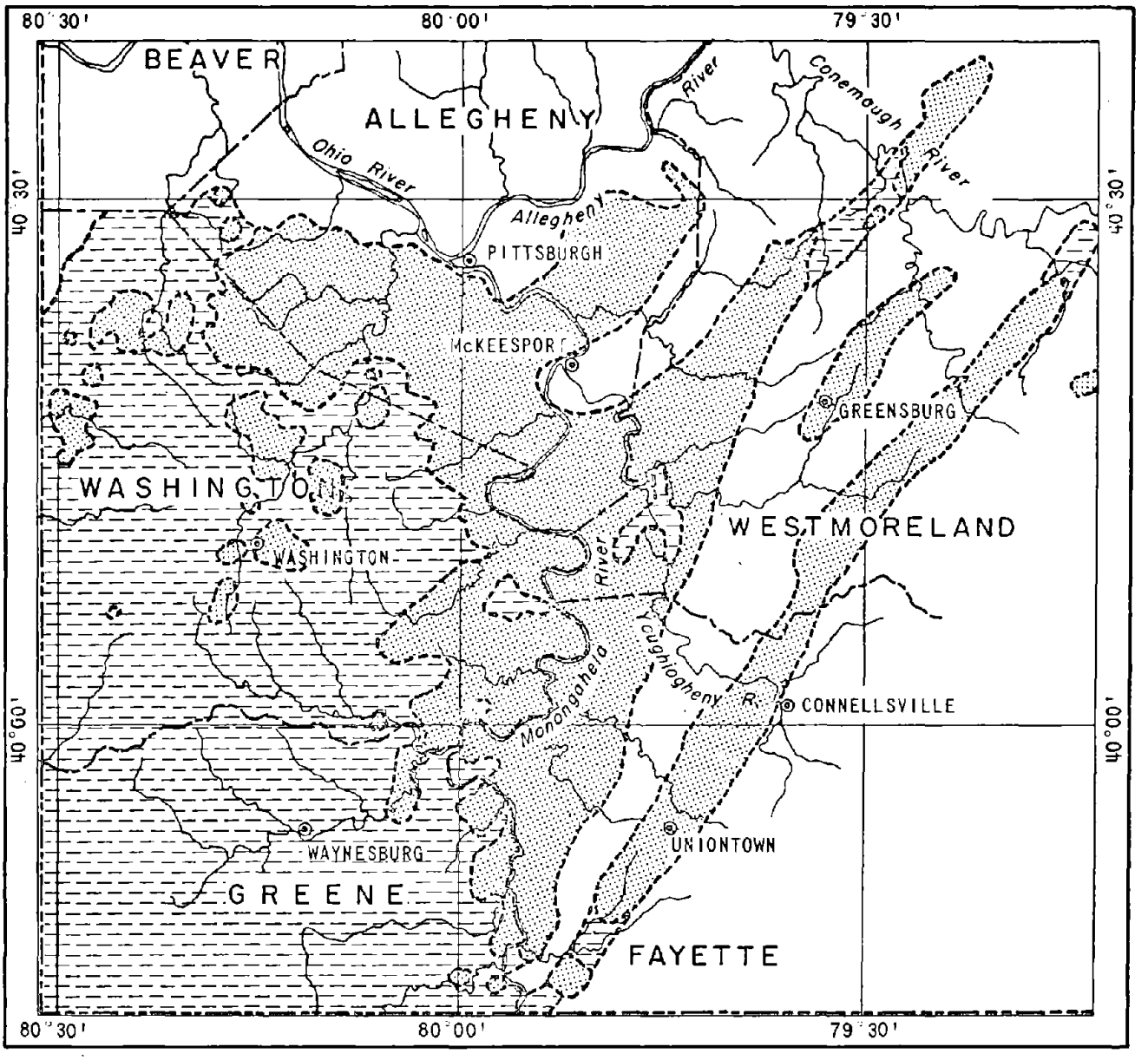


FIGURE 4.8 REGION OF PITTSBURGH COAL IN PENNSYLVANIA MINED OUT PRIOR TO 1935

5. SINKHOLES

Introduction

Figure 5.1 shows the type of caving failure common to rocks above the Pittsburgh Coal. Here, a 10-foot interval of shale directly above the coal has collapsed into the mine opening, followed by the stratum of sandstone immediately above it.

The collapse of the mine roof due to the removal of temporary roof support or by the natural deterioration of surrounding rock creates an irregular cavity above the mine. Despite initial stability the cavity will eventually work its way upward until a final equilibrium has been established[52]. Depending on circumstances, caving could be arrested by natural processes at some point in the overburden, but if not, will propagate to ground surface, with collapse of the final cap of soil and rock resulting in a sinkhole. Examples of sinkholes are shown in Figures 2.8 and 5.2.

Sinkholes constitute the most prevalent form of subsidence above the Pittsburgh Coal and one of the most costly to the homeowner and the taxpayer in terms of damage to personal property and creation of hazardous conditions.

Most sinkholes above the Pittsburgh Coal appear to be conical in profile with the apex upward. Most are 15 feet or less in diameter (Figure 2.12) and 20 feet or less in depth (Figure 2.13). Diameter to depth ratios vary from one-quarter to three-quarters, and most have developed above cover less than 50 feet thick (Figure 2.19). Much of this form of development is governed by the thickness and character of the overburden, the width and height of the mine opening and the in place state of stress in the rock.

Stability of Jointed Rock

The caving of the overburden that ultimately results in development of a sinkhole begins with collapse of the roof at mine level (Figure 5.3).

Two basic modes of roof failure have been recognized, shear failure and flexure failure[77]. The former often initiates as diagonal tension cracks near the face of the mine pillar, and the latter as tension cracks near midspan of the roof. Both result in vaults above mine level. Conditions that seem conducive to the development of each are presented in Table 5.1.

Arching and Geometric Influences on Sinkhole Development

Once a roof fall has begun, it will continue to propagate upward until the resulting vault has achieved a geometry compatible with existing gravitational and regional stresses and the properties of the strata composing the overburden[62]. As this progresses, the weight of the overburden is continually redistributed to either side of the opening through arching[35, 42] (Figure 5.4).

A model study conducted on horizontally stratified photoelastic material gives some indication of the nature of this arch and the zone of rock beneath it that is induced by gravity to fall from the roof (Figure 5.5). This study has shown that the height and to some extent the shape of the zone of overburden directly involved in the caving process changes in relation to the width of mine opening and thickness of overburden. The height of this caving zone has been found to bear an exponential relationship to the width of the opening. For the smaller widths of opening relative to thickness of overburden, the angle of break is such that the height of caving approximately equals the width of the opening. This corresponds to an angle of break of about 27 degrees. (Angle of break is defined graphically in Figure 5.8). With increase in width of the opening, the angle of break decreases to its limiting value, which, when the cavity pierces ground surface, is 10 to 14 degrees. As the width of opening increases still further, the profile of the caving zone transforms from an inverted wedge into an hour-glass shape, as if the apex of the wedge had spread out at ground surface. This evolution in caving profile is shown in Figure 5.5.

In practice, the height of caving for a particular width of opening is also dependent on rock type. In very blocky and seamy shale, the height of caving has been observed to equal or slightly exceed the width of the opening, while in a massive moderately jointed sandstone, it has been observed to be less than one-quarter the width of the opening[98]. Both of these estimates of cavity height are based on short-term observations made during underground construction. Because the ability of rock to stand unsupported diminishes with time, these estimates may not necessarily represent the height of caving over the decades or centuries required for sinkhole development. Over a period of time, stress relief, weathering, and other factors may reduce the strength of the rock to a level incompatible with existing stresses, and cause reinitiation of caving. With these periodic roof falls the cavity will gradually assume a configuration that is less susceptible to further modification.

The stresses most responsible for initiating the caving process are thought to be those near the crown of the roof and those at the upper corners of the rooms near the junction of the pillars and the roof[22] (Figure 5.6). Very low (perhaps even tensile) tangential stresses at the crown of the roof might initiate caving though flexural failure, while high compressive stresses, σ_c, at the upper corners of the rooms might initiate caving through shear failure. As the cavity works its way upward, both stresses assume levels more compatible with cavity geometry--the stresses at the crown of the span becoming more compressive; and the stresses at the corners gradually dropping from compressive values several times the major in place stress to near equality with this stress. Both changes tend toward increased stability of the arch and what might be called a limiting, or optimum, arch configuration.

Observations in active mines in the Pittsburgh Coal in West Virginia and far southwestern Pennsylvania indicate that there is a preferential tendency for roof falls to take place in north-south oriented mine openings[28]. These falls are due to shear failure of the roof and are attributed to a high east-west lateral stress field in the rock estimated to be two to three times the vertical in place stress. Under these stress conditions, the limiting height of caving may not exceed the width of the mine opening, since at that height, the compressive stresses at the corners of the rooms will have been reduced to levels less than the lateral in place stress and the possibility of shear failure of the roof will have been greatly reduced (Curves 2 in Figure 5.6).

In the northern part of the Pittsburgh Coal Region, near Pittsburgh, the thickness of overburden is only moderate, and erosion below the level of the coal has been extensive so that the high lateral stress field may no longer exist. Under these circumstances, the cavity may reach somewhat higher in the overburden than in the former case, perhaps as much as two or three times the width of the mine opening, before the tangential stresses in the crown of the cavity become sufficiently compressive to prohibit flexural failure of the roof, and the stresses at the corners are sufficiently low to withstand the shear stresses (Curves 1 in Figure 5.6).

Relationship of Sinkholes to Thickness of Overburden

While the foregoing is rather speculative, it still suggests that the optimum height of caving above a typical 20-foot wide room in the Pittsburgh Coal, even allowing for substantial variation of in place stresses, is probably somewhere between 20 and 60 feet. Since mine openings about 20 feet wide appear to predominate in the Pittsburgh Coal Region, it is not surprising that most sinkholes are found

where the overburden is less than 50 feet thick. (Refer to Figures 2.14 and 2.19).

Several sinkholes have been documented above cover considerably thicker than 50 to 60 feet--some at 80, 100, or 150 feet (Figure 2.19). Lacking certain specific details of these subsidence incidents, one might speculate that a chance coincidence of joints may have permitted roof falls to progress to greater than ordinary heights. While this cannot be discounted, it seems more likely that many if not most of these cases are associated with mine openings wider than the presumed 20 feet.

Such openings might exist at intersections of entries, at cross-cuts between rooms, at locations where props placed under the roof are now failing; or where pillar extraction was irregular or incomplete. (Recall Figure 4.7). By way of illustration, if the total span across two adjoining rooms and the intermediate pillar were 50 feet and the break angle were 15 degrees, caving of the two adjoining rooms around the old pillar might progress as much as 100 feet above mine level.

The presence of sinkholes at greater than expected elevations above the Pittsburgh Coal may also have other explanations. The thickness of soil at one or more of the sites may be greater than the typical 10 to 15 feet. Since soil is less capable of spanning a cavity than rock, a substantial thickness of soil would permit caving to reach higher into the overburden than is usual. Also, two coal seams, the Redstone and the Sewickley, lie within the first 100 feet above the Pittsburgh Coal. Although not of the same importance as the Pittsburgh Coal, they are mined locally. Development of a sinkhole above an unrecorded small mine in either of these coal seams is a possibility. Alternatively, some of these depressions may represent movements associated with local slope failures that have been mistaken for mine subsidence.

Regardless of these uncertainties, the data do indicate that the areas of the Pittsburgh Coal Region most prone to sinkhole development are those where the thickness of overburden is less than 50 feet. As shown in Figure 5.7, this constrains most sinkholes to a band 500 feet wide along the outcrop.

Relationship of Sinkholes to Height of Mine Void

For cavities to reach optimum size under any particular set of circumstances, it is necessary that the height of mine opening be large enough to accomodate the fallen material.

If the height of opening were less than the limiting value, caving would be arrested by filling of the void with broken rock. If the height of opening equalled or exceeded the limit, the height to which caving could progress would be governed by the width of opening and character of the overburden. These possibilities are sketched in Figure 5.8A.

Broken roof rock, it is estimated, bulks to a volume 10 to 12 percent greater than its in-place volume as it collects on the mine floor[114]. This bulking is due to disorientation of individual blocks of rock and results in a total volume of fallen rock V_b, which exceeds the in-place volume, V_o. For a cavity to reach optimum size, the volume of void at mine level, V_v, must be at least great enough to accommodate the added volume of material due to bulking. That is, V_v must equal at least $V_b - V_o$ [81].

This concept is depicted in Figure 5.8, which also presents a graphical representation of the thickness of overburden through which caving can progress for particular widths of opening and angles of break. Figure 5.8C indicates the minimum height of void required at mine level to accommodate the fallen material, and is based on a bulked volume 10 percent greater than the original volume. The vault is assumed to be shaped like a circular cone with apex upward. It is apparent from Figure 5.8B that the height of mine void required to accommodate fallen roof rock increases with width of opening and with lessening break angle, as would be expected. [Compare the cases shown by Points C and B in Figure 5.8B (same angles of break, different widths of opening), and the cases shown by Points B and A (same widths of opening, different angles of break).] Figure 5.8C shows that in a situation such as Case B where the roof span is 20 feet and the angle of break is 15 degrees, that caving would be arrested by filling of the mine opening if the opening were less than 15 inches high, while, all other things being equal, caving would be uninhibited if the opening exceeded 15 inches in height. If the overburden thickness were on the order of 38 feet thick, the latter case would result in a sinkhole, whereas the former would not. (A sinkhole could possibly form above a mine opening of lesser height if the fallen rock were periodically flushed away by mine water; if the fallen material were to consolidate to a lesser volume over a period of time; or, if the material were to fall from the roof as a unit and not bulk to greater volume as it collected.) Accepting the simplicifactions inherent in these estimates, it seems evident that the required height of opening to permit optimum caving is quite small, and it appears that the typical 4-1/2 to 6-foot mine opening in the Pittsburgh Coal in areas of partial extraction or incomplete total extraction far exceeds the minimum

height for optimum development of the cavity. It is interesting to note in this regard that where sinkholes have formed, their depths have generally exceeded four feet.

Depths of Sinkholes

The variation in depths of sinkholes from less than 3 feet to nearly 50 feet (Figure 2.13) reflects local site variations and the progressive nature of sinkhole development. Some sinkholes form suddenly with collapse of the ground surface; others form more gradually as if by slow yielding. The depths documented in this study are those existing when settlement had progressed to the point that the sinkhole caused damage to property or constituted a hazard sufficient to report to authorities. It seems probable from the considerable depths of a few of the sinkholes that previously fallen material had consolidated or been flushed away prior to final collapse. These same mechanisms could be deepening existing sinkholes.

Diameters of Sinkholes

The photoelastic study quoted previously[86] suggests that the zone of overburden directly involved in caving changes relative to the thickness of overburden (Figure 5.5). If the thickness of overburden were 55 to 60 feet, the volume of material induced to fall out of the roof might be a wedge whose apex just pierced the ground surface and the diameter of sinkhole at ground surface might be small.

If the thickness of overburden were only 30 or 40 feet, the volume of material induced to fall might resemble an hourglass with a much larger diameter at ground surface. With even less overburden, the zone might be nearly straight sided with an even greater diameter.

The data, however, only very roughly suggest such an inverse relationship between diameter and overburden thickness (Figure 2.14), and, indeed, diameters of sinkholes located above 20 feet of overburden are found to vary anywhere from one twentieth the overburden thickness to twice the overburden thickness. This variability is probably a reflection of local differences in weathering, jointing, erosion, and other geologic factors.

Stratigraphic Influences

The rock types overlying the Pittsburgh Coal were reviewed in Section 3. Limestone strata dominate in the

first 50 to 100 feet in the West Virginia Panhandle and adjoining portions of Ohio and Pennsylvania. Shaley rock, with layers of sandstone and limestone, dominate in the Pittsburgh area and other major portions of the region.

The geology of a part of the Pittsburgh area along the Monongahela River is shown on the map in Figure 5.9. Sinkhole locations are designated by black triangles. Hilltops are located 500 feet above river level.

The map area has been extensively dissected by streams and rivers, as has most of the area in the Pittsburgh Coal Region where sinkholes have been identified, and this erosion has exposed several alternating sequences of rock, most of it either interlayered shale, claystone, and limestone (ShL) or interlayered shale, claystone, and sandstone (ShS). These sequences may reach thicknesses of 100 feet to 200 feet, and in a broad sense represent the geologic interval in which most documented sinkholes have formed. On a location by location basis within the area, however, thicknesses and types of rock vary, often quite significantly, as has been shown in Section 3. (Refer to Figure 3.4, particularly to logs of Borings 6, 7, and 8, which pertain to the geologic map in Figure 5.9).

As a consequence, detailed geologic data are required for each sinkhole site if definitive statements regarding geologic controls on sinkhole development are to be made. Unfortunately, there are insufficient data for this purpose and all that can be concluded at this point is that shale and claystone appear to be prominent in areas where sinkholes have been observed and it is quite probable that the observed correlation (to be discussed subsequently) between quantity of precipitation and number of reported sinkholes reflects to a degree the sort of weatherability and strength losses of the rock strata that have been responsible for numerous landslides in the region[107].

Climate and the Effect of Precipitation on Subsidence

The Pittsburgh Coal Region possesses a humid continental climate that derives principally from polar sources located in the Hudson's Bay and Rocky Mountain regions of Canada, tempered to some extent by air intruding the region from the Gulf of Mexico[82].

March through August tend to be the wettest months and September through February tend to be the driest. In winter, about a quarter of the precipitation occurs as snow and snow covers the ground about 30 days each year.

Time Relationship between Precipitation and Subsidence

The distribution of precipitation by year and by month for the Southwest Plateau Climatological Division of Pennsylvania is shown in Figures 2.18A and C. This region extends south from Slippery Rock and west from Johnstown and includes the great majority of the Pittsburgh Coal Region in Pennsylvania[79].

The precipitation data represent the years 1971 through 1975, the period of most complete subsidence documentation. The distribution of subsidence incidents by year and by month for that same period is shown in Figures 2.18B and D.

The 1971 through 1975 monthly data suggest that:

1) When precipitation in a certain month exceeds that of the preceding month, the number of subsidence incidents tends to be higher that same month or the month following.

2) Conversely, when precipitation decreases in a certain month, the number of subsidence incidents tends to be lower that same month or the month following.

Both statements hold true 65 to 70 percent of the time for sites where overburden thickness is 100 feet or less and 50 to 60 percent of the time for all sites regardless of overburden thickness. These correlations appear to lend credence to the view that periods of increased rain are followed closely (within a period of days or weeks) by periods of increased subsidence activity. However, closer examination of the data shows there to be a substantially longer response time between precipitation and subsidence--a time that ranges from three to eight months.

This can be seen by graphically correlating two curves, one a curve of the cumulative number of subsidence incidents plotted by month for the period 1971 through 1975 and the other a curve of cumulative precipitation plotted by month for the same period (Figure 5.10). It is clear, first, that both curves are constituted of long, largely straight, segments of four- to eight-month duration separated by shorter segments of one- to two-month duration which are of different slope; second, that each change in slope of the cumulative precipitation curve is reflected by a corresponding change in slope of the cumulative subsidence incidents curve; and third, that corresponding nick points on the two curves (a nick point marking each break in slope of a curve) are separated by time intervals of three to eight months. (Note, for example, that Point F' on the cumulative subsidence incidents curve follows eight months after point F on the

cumulative precipitation curve.) These data seem to demonstrate that there is a definite cause-effect relationship between precipitation and subsidence.

Physical Relationship between Precipitation and Subsidence

In the Anthracite Region of Pennsylvania, it has been found that months of maximum subsidence have been preceded by months of maximum precipitation 93 percent of the time in the period 1950 to 1973. From this and other data concerning mine pool elevations, it has been deduced that high differential water pressures between mine and ground surface, brought about by ground water percolating down to the water table along the steeply dipping coalbeds, has been sufficient to burst through the side of a slope or the bottom of a river valley and cause subsidence by the in-rush of soil from above[2].

There is no indication in the Pittsburgh Coal Region that this is a prevalent mechanism of subsidence. Weather bureau records spanning the past five decades indicate that well over 2,000 inches of precipitation (almost 170 feet) have fallen in areas of high sinkhole density between the time of mining and subsidence[82], and miners have noted that rooms under less than 100 feet of cover tend to be wetter and more likely to experience roof falls than rooms under thicker cover[43]. This fact, and the observed relationship between quantity of precipitation and number of sinkholes recorded in a particular interval of time, suggest that water promotes sinkhole development in the Pittsburgh Coal Region chiefly in the following ways:

1) By increasing the moisture content of the soil and rock, decreasing their strength;

2) By promoting slaking, swelling and shrinkage of soil and rock and oxidation of minerals, particularly by alternate wetting and drying; and

3) By developing seepage pressures in the overburden that reduce the frictional resistance between rock blocks.

While only a fraction of any precipitation actually passes through to mine level, the continued percolation of water through the overburden over a period of decades is apparently significant.

The Element of Time in Sinkhole Development

The development of sinkholes has been described as an incremental caving process, depending on such factors as geology, mine configuration, and climate. It is to be

expected, therefore, that the rate of the caving as well as the time lapse between mining and development of the sinkhole can vary from place to place. The following two examples seem to indicate this.

Borehole photographs made during a subsurface investigation at a site on Mt. Washington in Allegheny County, Pennsylvania[40], revealed the presence of subsidence-induced fractures and disturbed zones throughout the entire 125-foot thickness of overburden. Several one- and two-foot voids were also observed within the loose fallen material at mine level. Although some areas of the ground surface had evidently settled, subsidence was apparently not yet complete, having probably been inhibited by the coal pillars still in place in the mine. About 30 percent of the coal remained. Details of the mining history at the site are not clear, but the nearness of the mine to the outcrop and its rather haphazard configuration show that it was mined by primitive methods long ago, possibly as far back as the 18th century when several mining operations occurred in the area.

This experience indicated that eventhough mining at a site may have been conducted well over 100 years earlier, voids still may be present that are capable of eventually damaging a structure by subsidence. The implication of this is that it should never be concluded that an area where old methods of mining were practiced is free from further collapse, regardless of the time that has elapsed since mining, unless such a conclusion is based on a thorough subsurface investigation by direct methods such as drilling, etc.

In contrast to the preceding situation are other experiences in the Pittsburgh Coal Region that have shown that it should not be assumed that appreciable periods of time must elapse after mining before a sinkhole might appear. This is exemplified by the 12-foot diameter sinkhole that developed at ground surface in Washington County, 300 feet above mine level within a week after second mining had been completed[102]. That situation, although rare, attests not only to the occasional rapidity of the caving process but also to the extraordinary thickness of overburden above which sinkholes might form if local conditions permit.

Rate of Caving

Because the caving process is so complex, one could not hope, given a particular set of circumstances, to make any sort of accurate computation of the time required for a roof fall at mine level to evolve into a sinkhole at ground surface.

However, some appreciation of this rate can be obtained from the data shown in Figure 2.17, where the time interval between mining and development of the sinkhole is presented. In some cases, it was possible to determine only that mining had been conducted prior to a particular date, so the curve actually represents the minimum possible time interval between mining and appearance of the sinkhole. Examining Figure 2.17, it is seen that in the majority of the cases documented in the study, over 50 years have been required for development of most sinkholes.

A rough estimate of the rate of caving can be made based on these time intervals and on known overburden thicknesses. Computed rates are shown in the histogram appearing in Figure 5.11. The inferred rate of caving is seen to range between 1/2 and 4 feet per year, with a preferred tendency for the 1/2 to 1-1/2 feet per year interval. Naturally, in any particular caving situation, the actual rate of caving may deviate considerably from the inferred value due to variations in precipitation, differences in integrity of the individual strata that the vault is passing through, and other factors.

Urbanization has probably accelerated sinkhole development in some areas. The terrain around Pittsburgh is hilly and residential lots are commonly created by cutting benches into the hillslopes. Ten or twenty feet of material may be removed at the rear of a lot. This not only decreases the thickness of overburden above the mine and lessens the time required for caving to reach ground surface, but may also permit caving to reach ground surface in areas where it could not before. In addition, excavation may alter site drainage and increase percolation of surface water to mine level. Indiscriminant discharge of water from rain gutter downspouts has been linked to a few cases of sinkhole development[76].

It should be recognized that the estimated rates of caving as well as the time intervals for sinkhole development indicated above are based on a limited period of sampling. This prevents accurate estimation of the rate of caving and the frequency of sinkhole development that may be experienced by future generations. It is envisioned that the frequency of sinkhole development above a particular mine can be represented by a curve of the type shown in Figure 5.12. In the period encompassing the first several decades after mining (Interval A), the curve possesses a low to moderate slope. Adjustments within the overburden are still in their early stages and little caving has had the opportunity to reach ground surface. After several decades, the curve steepens as caving nears ground surface over a wide area and sinkholes form more frequently (Interval B). Finally, the curve assumes a low, nearly horizontal slope as a final

equilibrium is reached and the possibility for further sinkhole development approaches zero (Interval C). Each mine probably possesses a curve somewhat of this type, reflecting individual geologic and mining factors and periods of mining, with some mines apparently being more inclined to sinkhole development at the present time than others. (Recall Figure 2.16, which shows the number of sinkholes documented per mine, and Table 2.1, which lists the number of recurrences of subsidence at particular sites.) Currently over 40 sinkholes are reported each year and probably several times that number go unreported. Whether this current rate of sinkhole development reflects Interval A, B, or C of a composite curve representing all mines in the region is uncertain, and it must, therefore, be assumed that sinkhole development will continue for a long time to come, perhaps many more centuries.

Table 5.1

CONDITIONS CONDUCIVE TO THE DEVELOPMENT OF VARIOUS MODES OF ROOF FAILURE
(After Morgan, 1973)

Conditions conducive to shear failure are:

1. A mine roof dissected by planes of weakness--joints, clay veins with slickensides, and so on--oriented so as to permit blocks of rock to slip out of place;
2. A great overburden thickness or high vertical stresses transferred from adjoining areas of the mine;
3. High horizontal stresses;
4. Wide spans;
5. Pillars and floor that are stiff compared to the roof; and
6. Soft shale located above a comparatively rigid mine roof.

Conditions conducive to flexural failure by loading in a vertical plane are:

1. Low ratio of horizontal to vertical stresses;
2. Thinly bedded layers or layers that have separated along horizontal planes;
3. Wide spans;
4. Jointing in the roof or coal;
5. Pillars and/or floor of low stiffness; and
6. Roof layers of low stiffness.

Conditions conducive to flexural failure by buckling are similar to those for flexural failure above, except that the ratio of horizontal to vertical stresses is higher.

FIGURE 5.1 CAVING FAILURE ABOVE PITTSBURGH COAL OBSERVED IN ROADCUT ALONG U.S. ROUTE 22, NEAR MURRYSVILLE, WESTMORELAND COUNTY, PENNSYLVANIA

FIGURE 5.2 SINKHOLE OBSERVED NEAR HAYWOOD, HARRISON COUNTY, WEST VIRGINIA

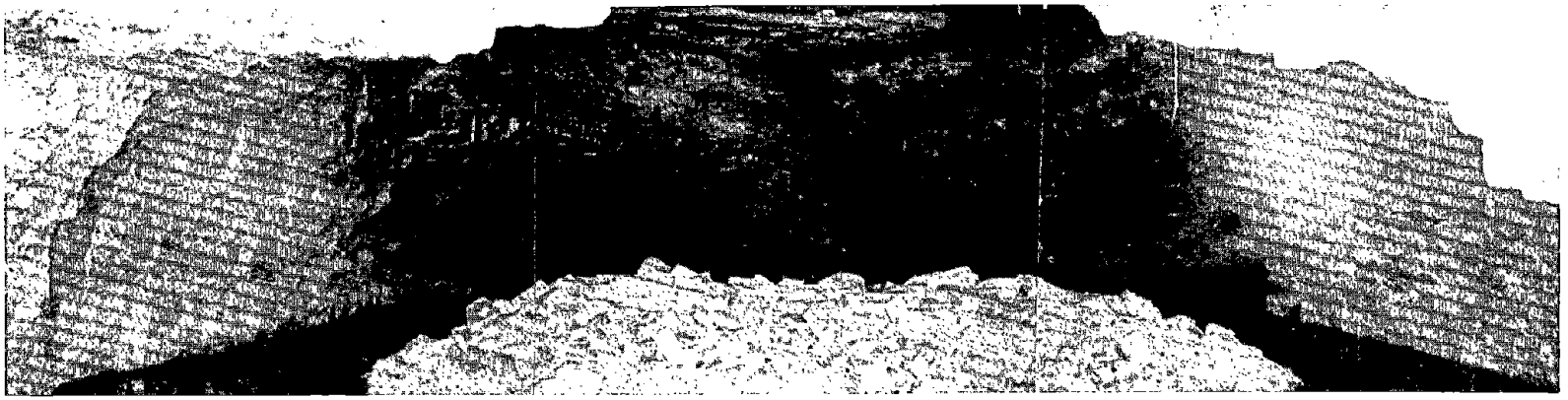
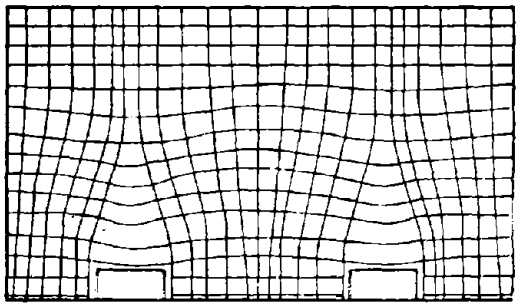
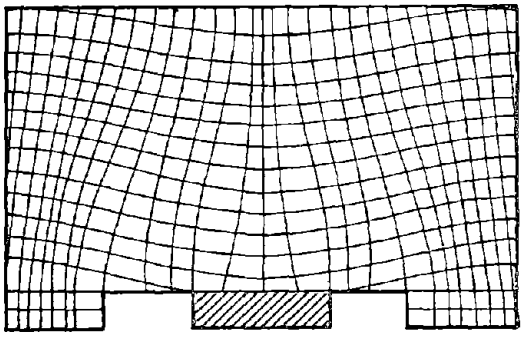


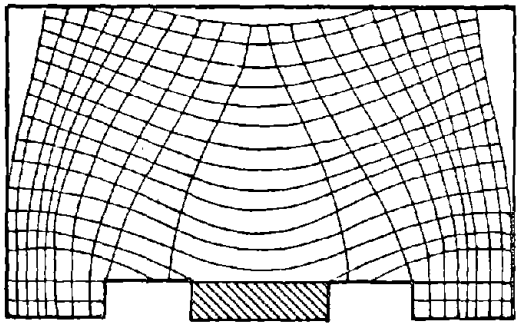
FIGURE 5.3 HORIZONTAL BOREHOLE PHOTOGRAPHS SHOWING CONDITIONS IN ABANDONED MINE 20 FEET BENEATH PROPOSED CONSTRUCTION SITE IN ALLEGHENY COUNTY, PENNSYLVANIA. NOTE ROOF FALL MATERIAL IN CENTER FOREGROUND, OLD ROOF SUPPORT POSTS IN CENTER REAR, AND WATER ON MINE FLOOR. MINE OPENING IS SIX FEET HIGH.



All Pillars Equally Stiff,
Each Carries Same Load



'Soft' Center Pillar
Carries Less Load



'Softer' Center Pillar,
Carries Even Less Load

FIGURE 5.4 MODEL STUDY DEMONSTRATING DISTRIBUTION OF OVERBURDEN LOAD AS A FUNCTION OF PILLAR STIFFNESS (AFTER ADLER, 1951)

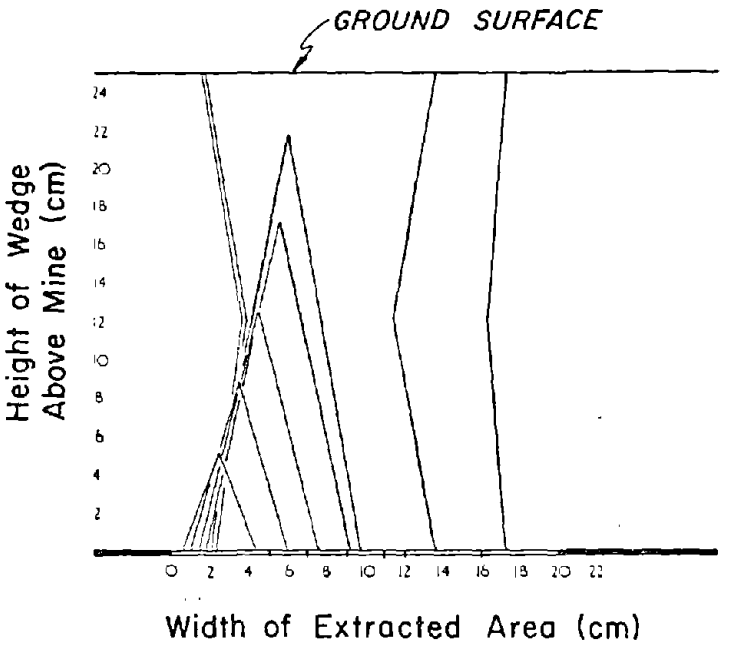


FIGURE 5.5 LINE DRAWING CONSTRUCTED FROM PHOTO-ELASTIC OBSERVATIONS ILLUSTRATING THE DEVELOPMENT OF A FREE-HANGING WEDGE OVER THE EXTRACTED AREA AS THE WIDTH OF THIS AREA INCREASED (AFTER P.R.RANKILOR, 1970)

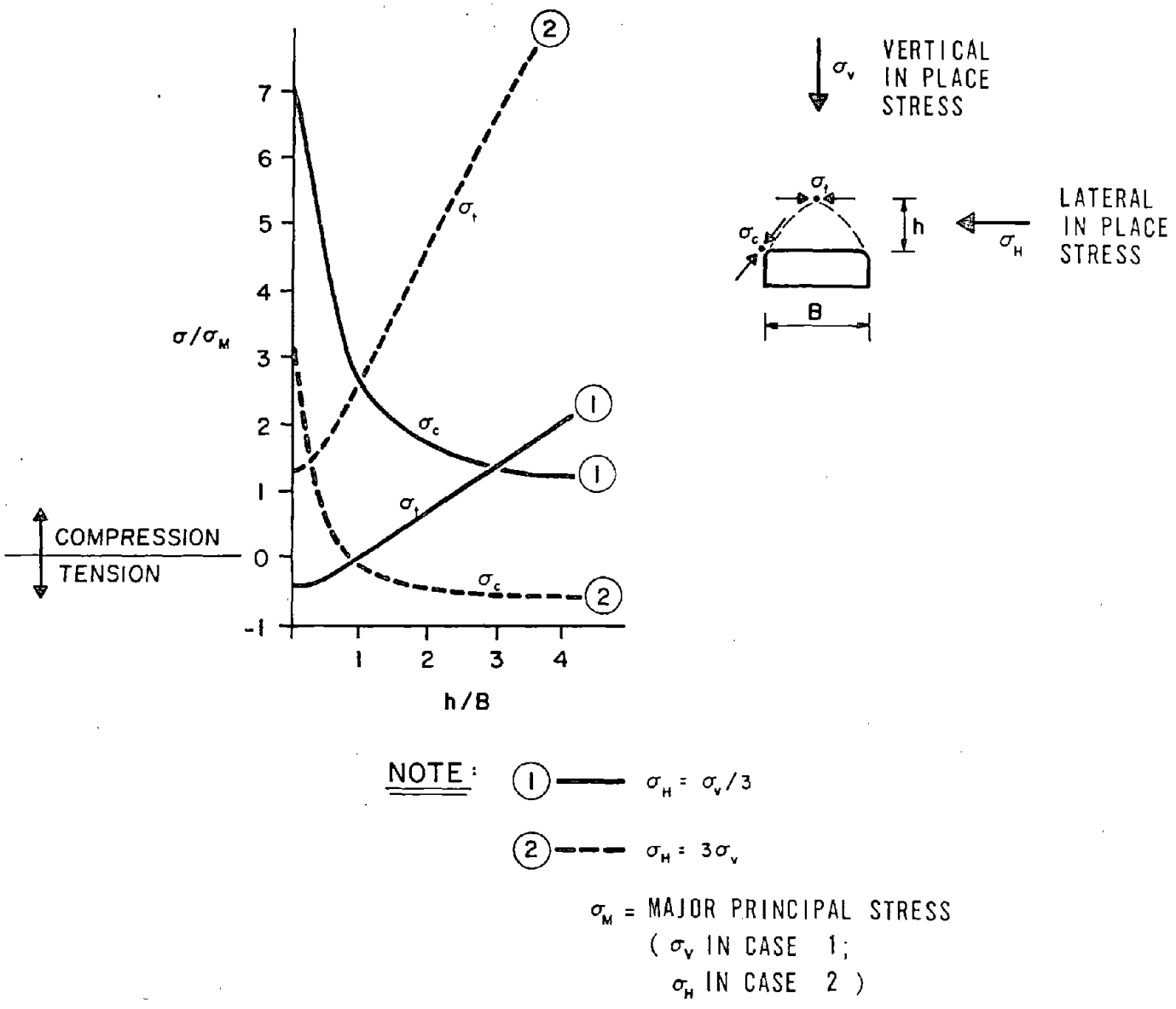


FIGURE 5.6 VARIATION OF ROOF STRESSES WITH HEIGHT OF CAVING (AFTER COATES, 1967)

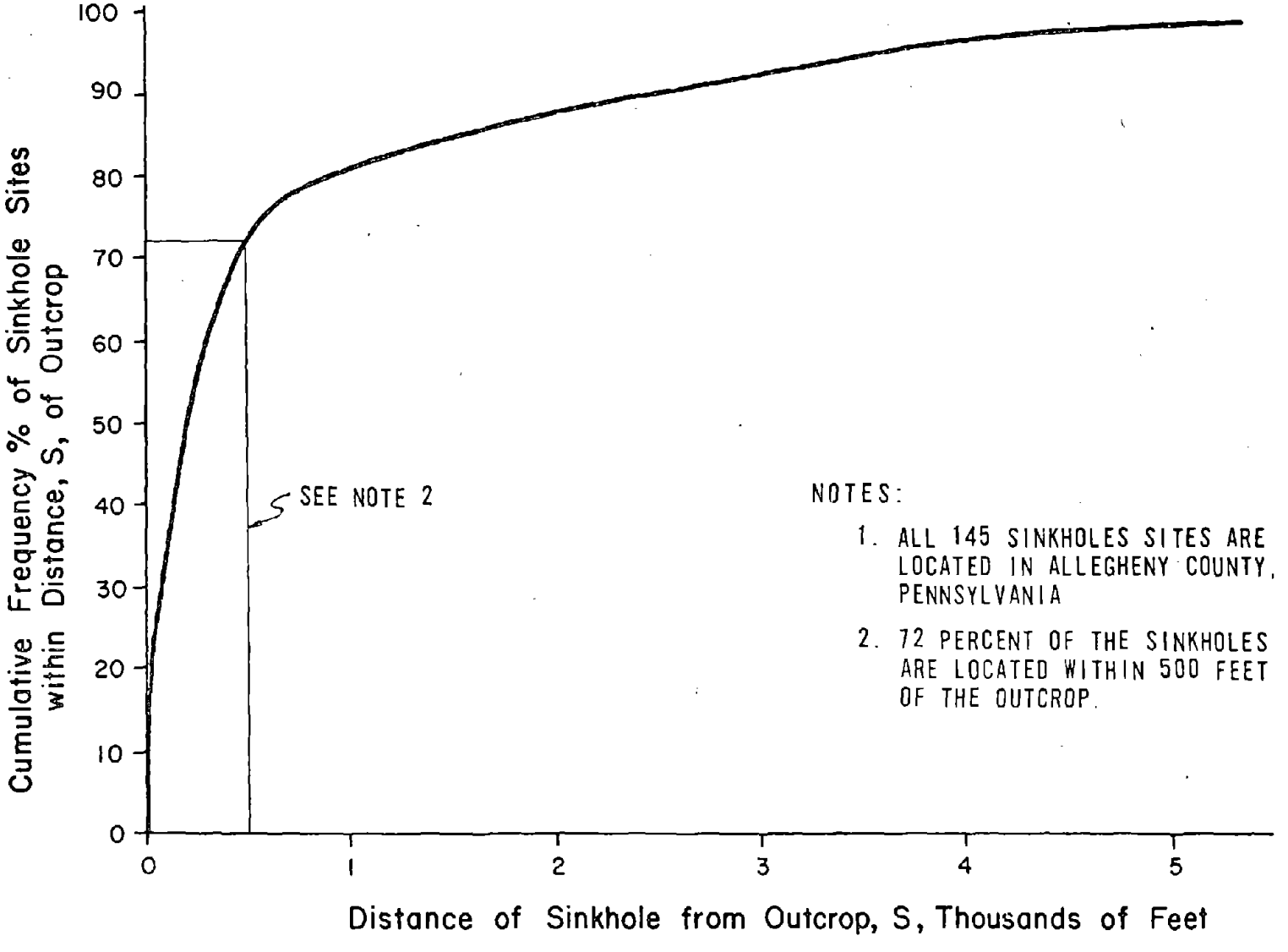
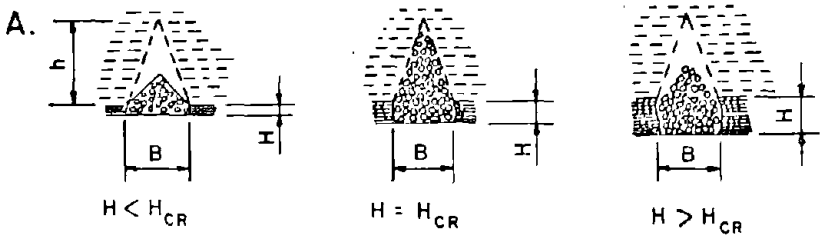
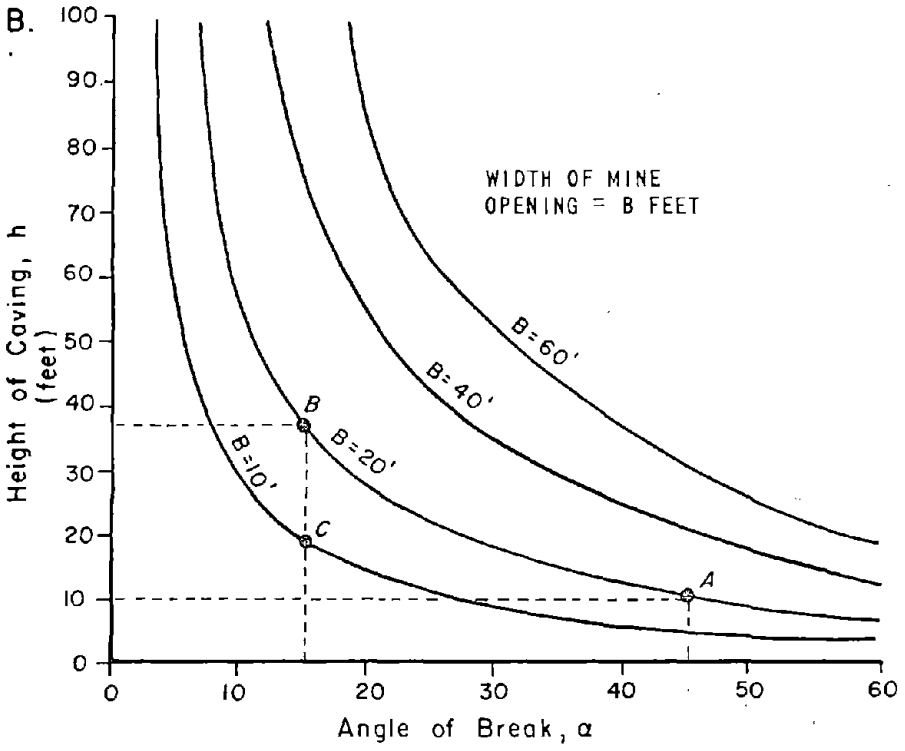
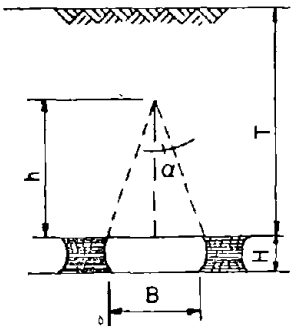


FIGURE 5.7 RELATIONSHIP BETWEEN FREQUENCY OF SINKHOLE DEVELOPMENT AND DISTANCE FROM OUTCROP







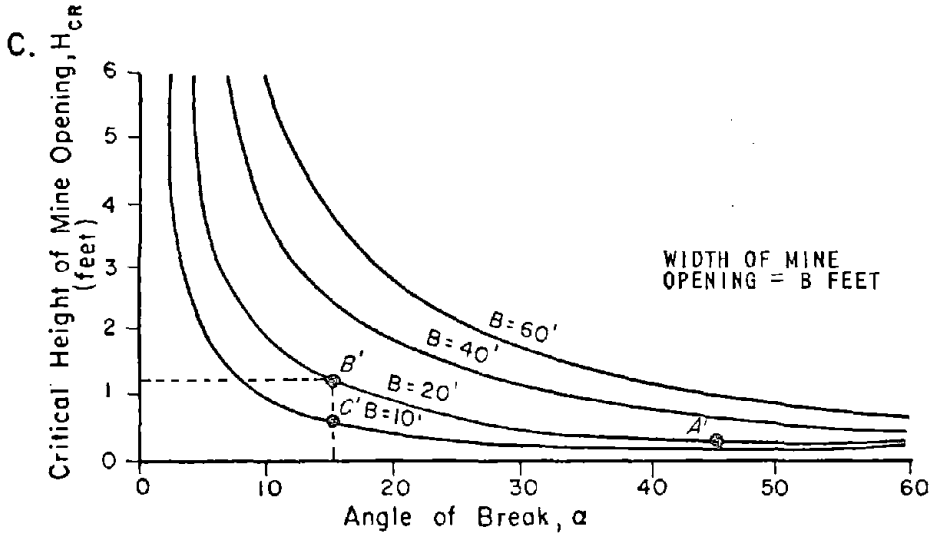


FIGURE 5.8 RELATIONSHIP OF HEIGHT AND WIDTH OF MINE OPENING AND ANGLE OF BREAK TO HEIGHT OF CAVING

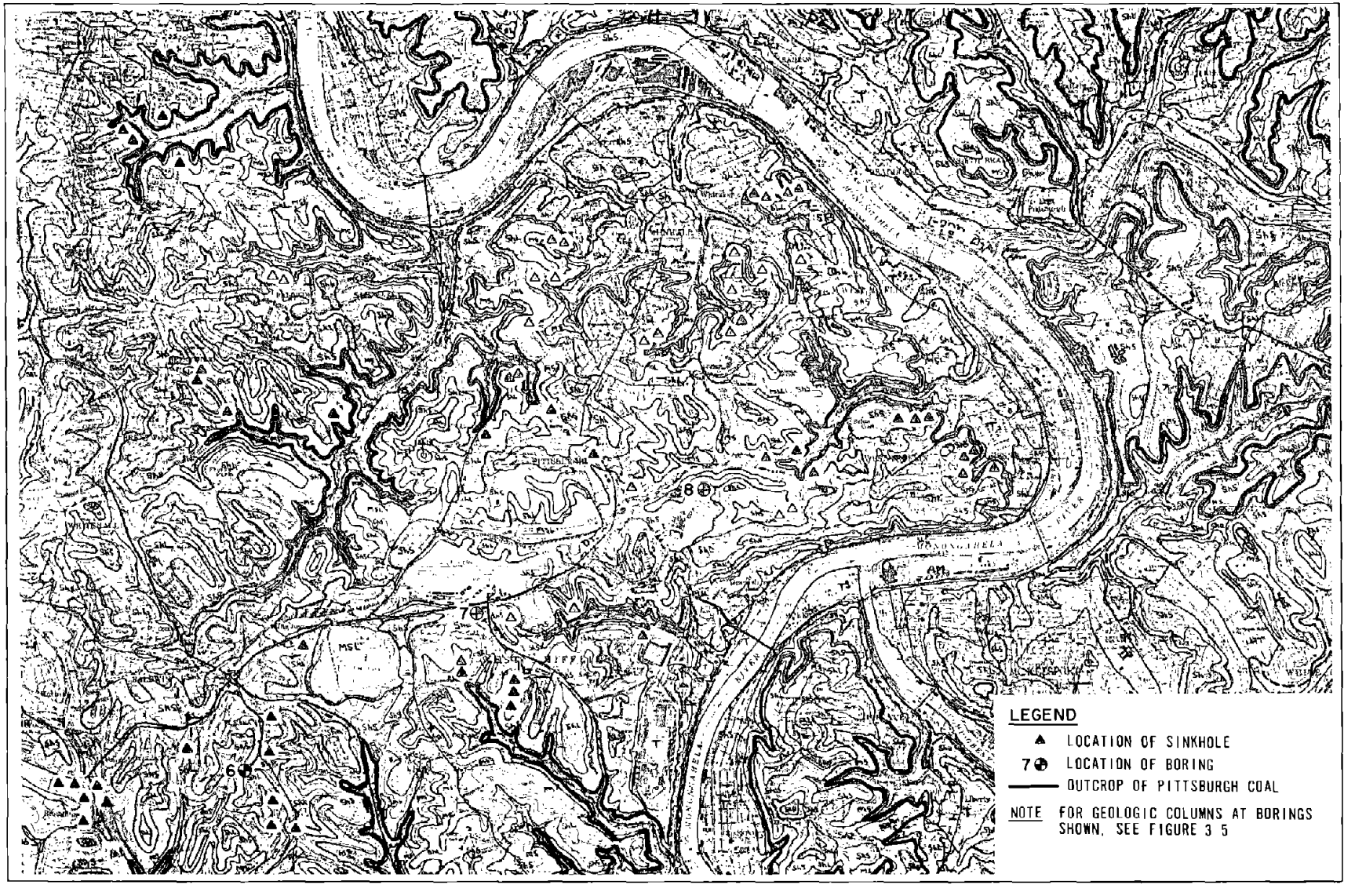


FIGURE 5.9 LOCATION OF SINKHOLES RELATIVE TO COAL OUTCROP AND TO STRATA LOCATED ABOVE THE COAL; BRADDOCK, GLASSPORT, McKEESPORT, PITTSBURGH EAST QUADRANGLES, ALLEGHENY COUNTY, PENNSYLVANIA

Reproduced from best available copy.

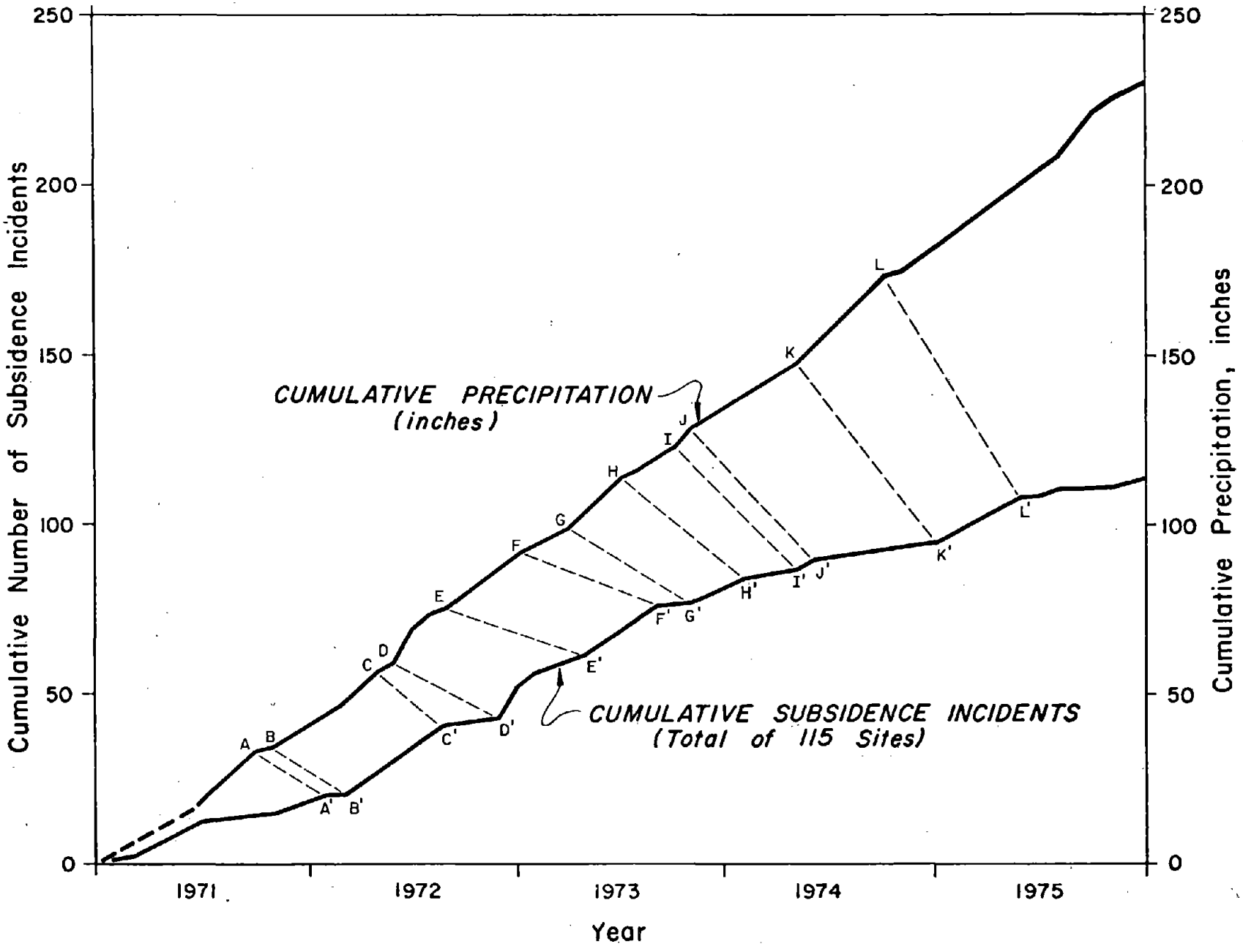


FIGURE 5.10 RELATIONSHIP BETWEEN CUMULATIVE PRECIPITATION AND SUBSIDENCE

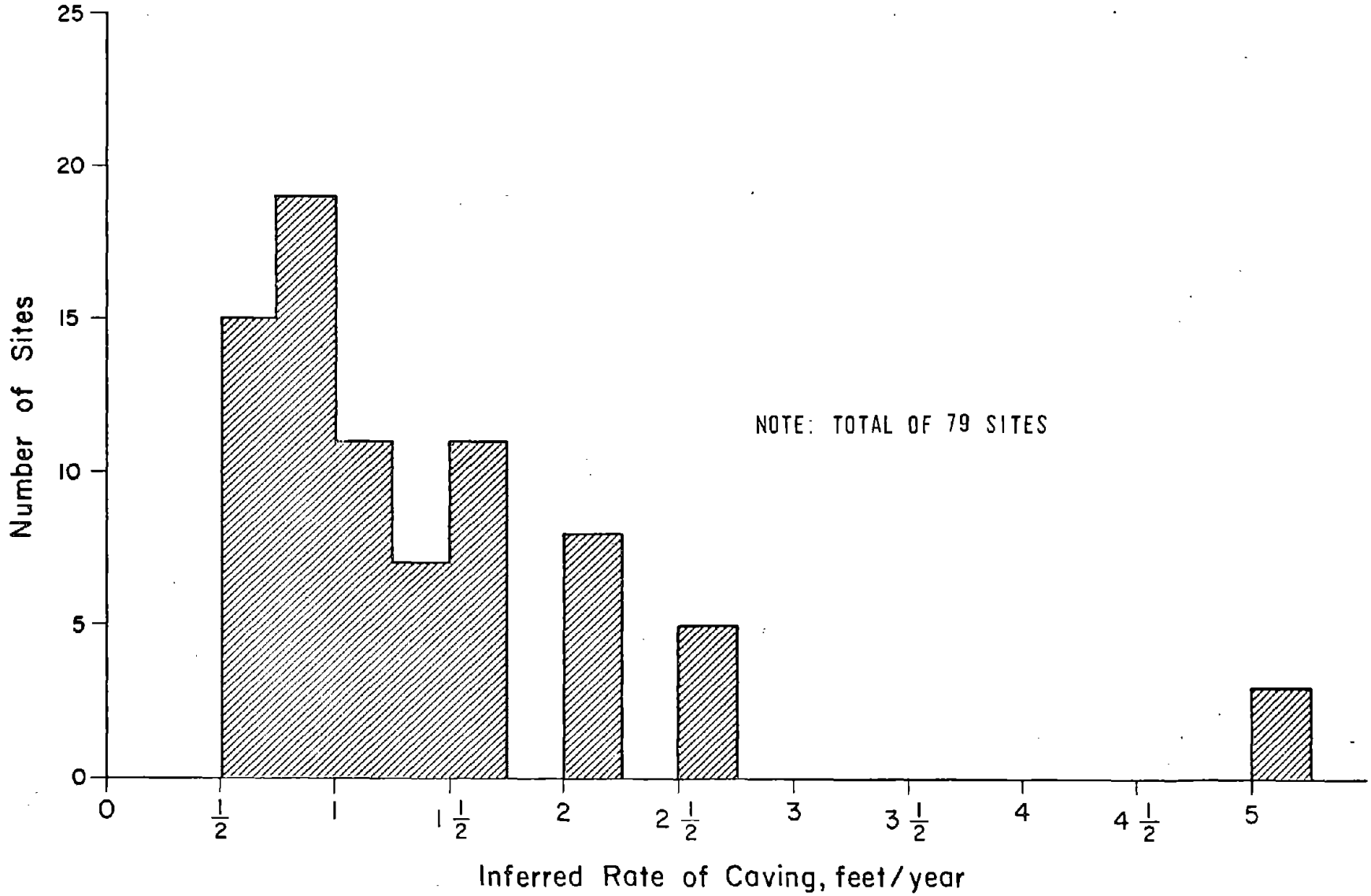


FIGURE 5.11 INFERRED RATE OF CAVING OF MINE ROOF

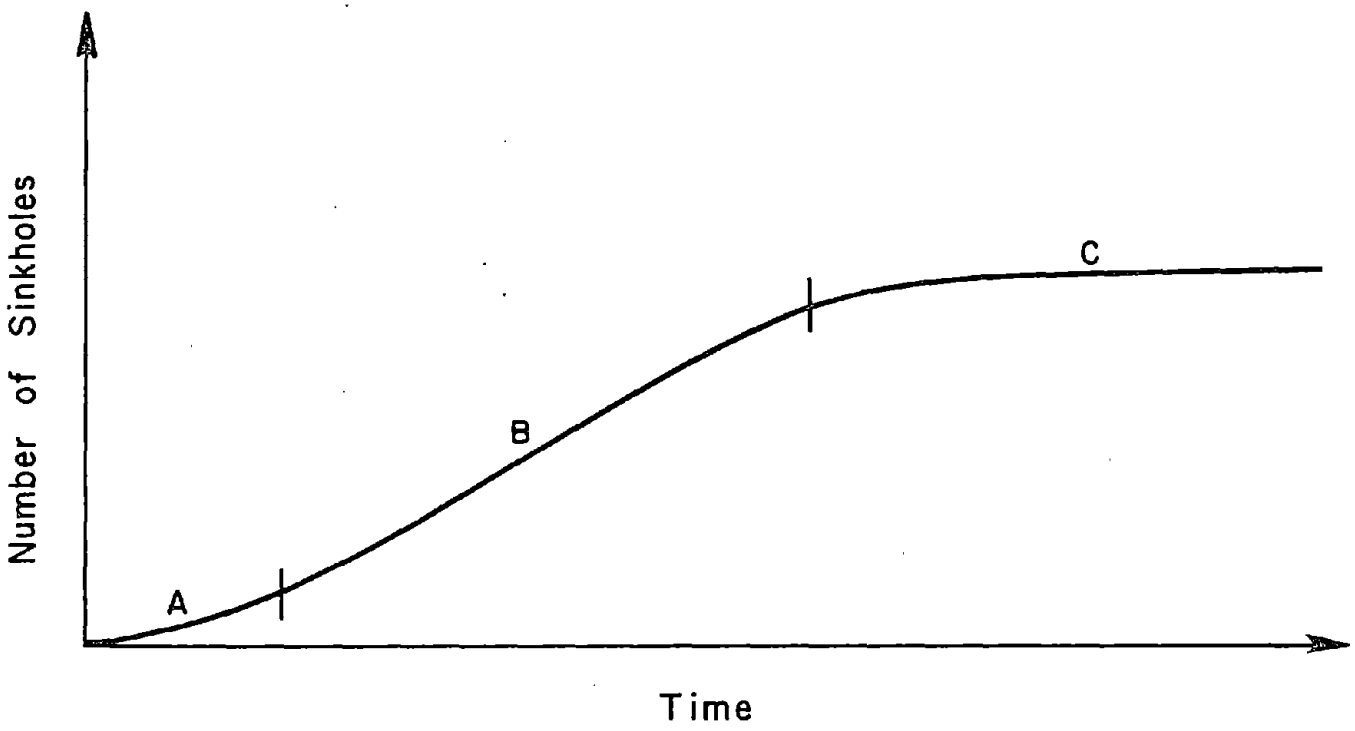


FIGURE 5.12 CONCEPTUAL REPRESENTATION OF THE FREQUENCY OF SINKHOLE DEVELOPMENT ABOVE A PARTICULAR MINE WITH TIME

6. TROUGHS

Introduction

Troughs are gentle depressions in the ground surface formed by sagging of the overburden into a mined-out area. Vertical displacements associated with troughs above abandoned mines in the Pittsburgh Coal Region are generally less than 3 feet, and diameters range from 30 feet to more than a third of a mile (Figure 2.12). Some troughs are about twice as wide as they are long, but most seem to be roughly circular. Diameter-depth ratios range from 10 to over 500. Plan views of troughs are shown in Figures 2.4 and 2.8. Profiles of troughs above abandoned mines resemble those above active mines (e.g. Figure 6.1). None of the troughs identified in the present study have been profiled by transit survey, however.

Documented instances of troughs are far fewer than sinkholes, and it is probable that unless a trough extends beneath a structure and causes damage, it generally goes unnoticed. All 15 troughs tabulated in the present study have been associated with damage to homes or property. These troughs were observed where the overburden ranged from 30 to 450 feet. A listing of these sites is given in Table 6.1.

Troughs may originate in any one of three ways--by caving of the mine roof between pillars, by crushing of pillars, or by punching of the pillars into the mine floor (a bearing capacity failure in foundation engineering terms).

In the first instance, the overburden may merely sag downward into a vault that has worked its way very near ground surface. With time, the trough may break through to form a sinkhole. Note that several of the 30-foot diameter troughs shown in Figure 2.14 plot adjacent to 30-foot diameter sinkholes more than 10 feet deep, defining a zone of overlap between sinkholes and troughs in the range of diameters from 30 to 40 feet. Above this range, subsidence features tend to be troughs, while below it, they tend to be sinkholes.

Of the larger diameter troughs--those 30 feet or more in diameter that have developed where cover over the mine is greater than 50 to 60 feet--pillar failure and punching of pillars into the mine floor are thought to be the predominant mechanisms of subsidence. Competent mine floors and unflooded conditions tend to favor the former, while weak mine floors and flooded mine conditions tend to favor the latter. Lack of detailed information at each site of trough subsidence does not permit a definitive means of differentiating troughs

according to mechanism. But tentatively, two characteristics seem to set troughs of each origin apart--the time between mining and subsidence, and the diameter of the trough relative to overburden thickness.

As will be explained subsequently, troughs deriving from pillar failure are thought generally to develop several decades after mining and to develop in such a way that the diameter of the trough is related to overburden thickness in a regular way. Troughs deriving from punching of pillars into the mine floor are thought generally to develop within a rather short time after mining--perhaps within 10 to 15 years after the operator has abandoned the mine and ceased dewatering--and their diameters appear not to bear a regular relation to overburden thickness.

Available data regarding trough subsidence (admittedly incomplete in many cases) will be examined in subsequent sections of this report--troughs deriving from pillar failure in Section 7 and troughs deriving from bearing capacity failure in Section 8. Before doing so, the nature of subsidence above active mines is briefly reviewed to introduce the parameters commonly used to describe trough subsidence and to provide a basis of comparison between troughs above active mines and those above abandoned mines.

Troughs Above Active Mines in the Pittsburgh Coal

Extraction of coal over a sufficiently broad area results in subsidence of the ground surface. This is true regardless of the depth of the seam, and subsidence has been experienced even when the mined coal is more than 1,000 feet below ground surface[78].

Where total extraction is practiced, the amount of subsidence is expressed as the ratio of settlement to extracted thickness of the seam. In western Pennsylvania, total extraction mining of the Pittsburgh Coal has resulted in subsidence amounting to two or three feet, corresponding to 40 to 60 percent of the extracted thickness of the coal-bed. (Some post-mining geological evidence suggests that subsidence may occasionally reach 75 percent of the seam thickness[46].) Most subsidence information pertaining to active mining in the Pittsburgh Coal has come through a series of ground surveys conducted over the past 40 years by the U. S. Bureau of Mines and the past 10 years by the Commonwealth of Pennsylvania. These are listed in Table 6.2.

The vertical displacement, or settlement, due to subsidence--the depth of the subsidence trough--can reach the 2 to 3 foot maximum only if the area over which coal is extracted equals

or exceeds a certain minimum[77]. The width of this minimum area--the "critical width"--is estimated in western Pennsylvania to be 1.5 to 1.6 the thickness of the overburden, based on the rather limited data provided by the studies listed in Table 6.2. The critical length of this area is estimated to be about the same. (The National Coal Board of Britain has established, through a compilation of surveys conducted at 157 collieries in the United Kingdom, that the average critical width and length for total extraction mining in that country are each about 1.4 [78]. It should be noted that long wall mining is prevalent in Britain, whereas room-and-pillar mining is prevalent in the Pittsburgh Coal Region, but the general character of the subsidence troughs produced by each is thought to be rather similar[104].)

As subsidence takes place, a zone of overburden outside the limits of mining is drawn by gravity toward the mined area. As a consequence, the area of subsiding ground surface is greater than the area being mined. The two areas are related to one another by the angle of draw, which denotes the inclination to the vertical of a line connecting a point on the edge of the mined area with a similar point on the edge of the subsided area (Figure 6.2). The angle of draw is governed principally by the strength properties of the overburden and is generally greater for soil than for rock. Prevailing rules of thumb and the surveys quoted earlier (again, rather limited data) suggest that the angle of draw for rock in the Pittsburgh Coal Region ranges from 15 to 27°. (The angle of draw in Britain commonly falls in the range of 25° to 35° [78].) The angle of draw for soil is generally on the order of 30° to 45°, the larger angles pertaining primarily to coarse grained granular soils and the smaller angles to fine grained soils.

Table 6.1

DOCUMENTED SITES OF TROUGH SUBSIDENCE ABOVE
ABANDONED MINES IN THE PITTSBURGH COAL REGION

Site	Location	Date of Subsidence	Period of Mining	Dimensions, feet		Overburden Thickness T, feet	D/T
				Diameter, D	Depth, d		
	Allegheny County, Pa.						
16	Carnegie Boro	11/55	1900-1930	30	1.2	35	0.9
72	Penn Hills Township	3/72	<1875	50x100	3	66	1.2
101	Pittsburgh	5/57	1907	120	1	70	1.7
115	Pittsburgh	4/72	<1920	30	0.5-2	70	0.4
133	Pleasant Hills Boro	8/73	1915-1925	120	0.8	140	0.9
145	South Park Township	1/58	1905-1910	60	0.2-1	40	1.5
171	West Mifflin Boro	7/70	<1930	80	(<3)	35	2.3
	Fayette County, Pa.						
236	Washington Township	2/76	<1907	160x190	1.5	125	1.4
	Washington County, Pa.						
248	California Boro	4/73	<1935	600x1900	(<3)	220-244	5.4
249	California Boro	-/69	<1935	50x100	(<3)	210	0.4
250	California Boro	-/72	<1935	200x400	(<3)	144	2.1
	Westmoreland County, Pa.						
289	Monessen	5/56	<1930	200	1	94	2.1
290	Monessen	1/63	1930-1935	200	(<3)	135	1.5
318	Unity Township	5/65	--	100x200	(<3)	44	3.4
	Marion County, W.Va.						
1200	Lincoln Township	10/73	1961	1400x1800	(<3)	230-450	4.7
				Mean (all 15 sites)			2.0
				(excluding sites 248 and 1200)			1.5

Table 6.2

GROUND SURVEYS CONDUCTED ABOVE ACTIVE MINES IN THE PITTSBURGH COAL REGION

ROOM-AND-PILLAR MINING

1. Clyde Mine (Republic Steel Corporation), Washington Township, Greene County, Pennsylvania. Date of Survey: 1968-69. Source: Pennsylvania DER-MSR.

2. Crucible Mine (Crucible Fuel Company), Cumberland Township, Greene County, Pennsylvania. Date of Survey: 1937-38. Source: U. S. Bureau of Mines RI 3452, 1939.

3. Maple Creek Mine (U. S. Steel Corporation), Somerset Township, Washington County, Pennsylvania. Date of Survey: 1970-74. Source: Pennsylvania DER-MSR.

4. Mathies Mine (Mathies Coal Company), North Strabane Township, Washington County, Pennsylvania. Date of Survey: 1969-72. Source: Pennsylvania DER-MSR.

5. Montour No. 10 Mine (Pittsburgh Coal Company), South Park Township, Allegheny County, Pennsylvania. Date of Survey: 1936. Source: Bureau of Mines RI 3355, 1937.

6. Nemacolin Mine (Buckeye Coal Company), Cumberland Township, Greene County, Pennsylvania. Date of Survey: 1938-40. Source: U. S. Bureau of Mines RI 3562, 1941.

7. Republic Mine (Republic Steel Corporation), Redstone Township, Fayette County, Pennsylvania. Date of Survey: 1931-32. Source: Transactions AIME, Volume 110, pp. 58-94, 1936.

LONGWALL MINING

1. Gateway Mine (Jones and Laughlin Steel Corporation), Morgan Township, Greene County, Pennsylvania. Date of Survey: 1972-75. Source: Pennsylvania DER-MSR.

SHORTWALL MINING

1. Valley Camp No. 3 Mine (Valley Camp Coal Company), West Finley Township, Washington County, Pennsylvania. Date of Survey: 1973-75. Source: Pennsylvania DER-MSR.

Reproduced from best available copy.

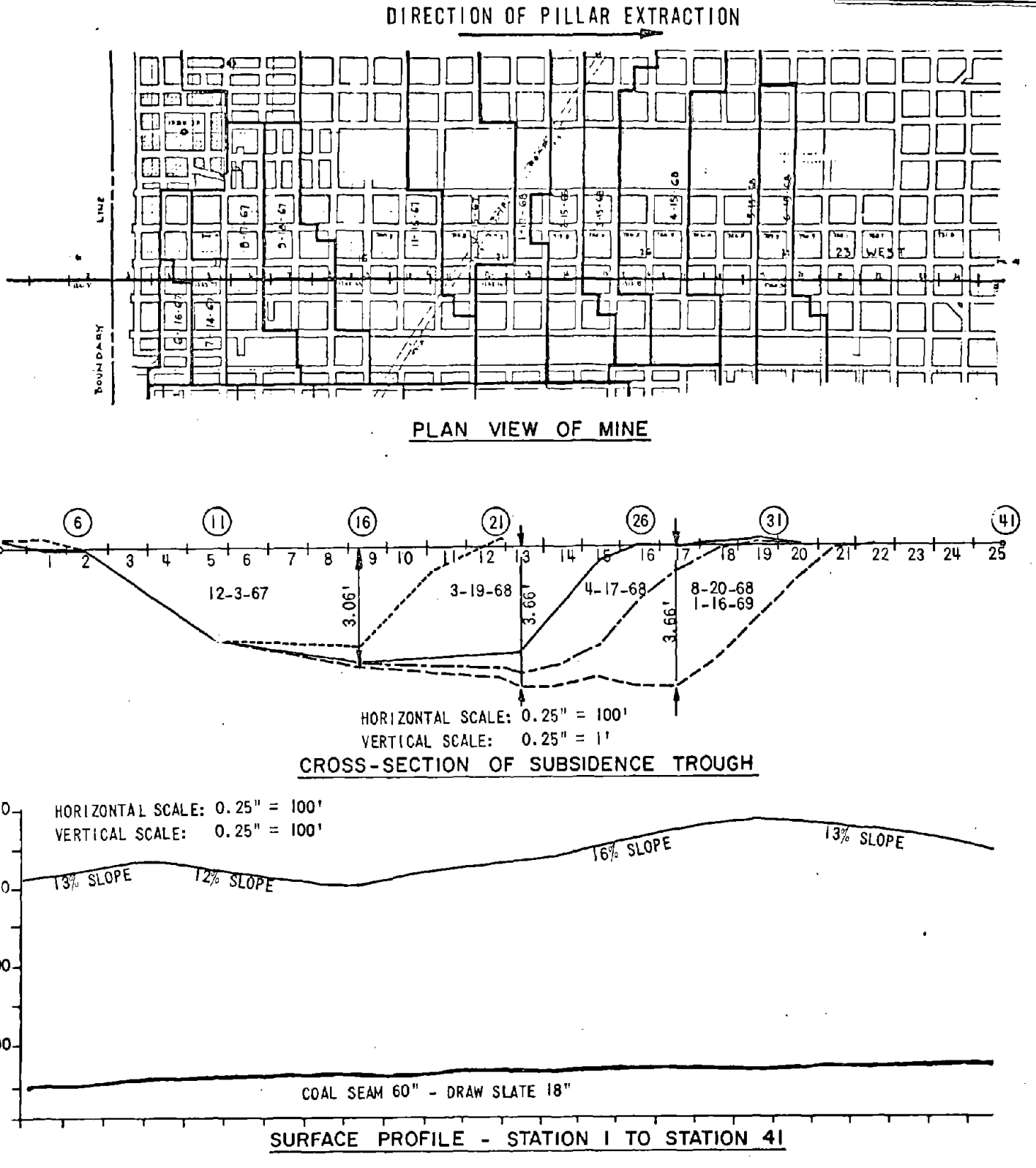


FIGURE 6.1 DEVELOPMENT OF TROUGH 500 FEET ABOVE MINE IN PITTSBURGH COAL, NORTH BETHLEHEM TWP., WASHINGTON CO., PA. COAL IS TOTALLY EXTRACTED BY THE BLOCK SYSTEM. (AFTER PA. DEPT. OF ENVIRONMENTAL RESOURCES, OFFICE OF MINE SUBSIDENCE REGULATION)

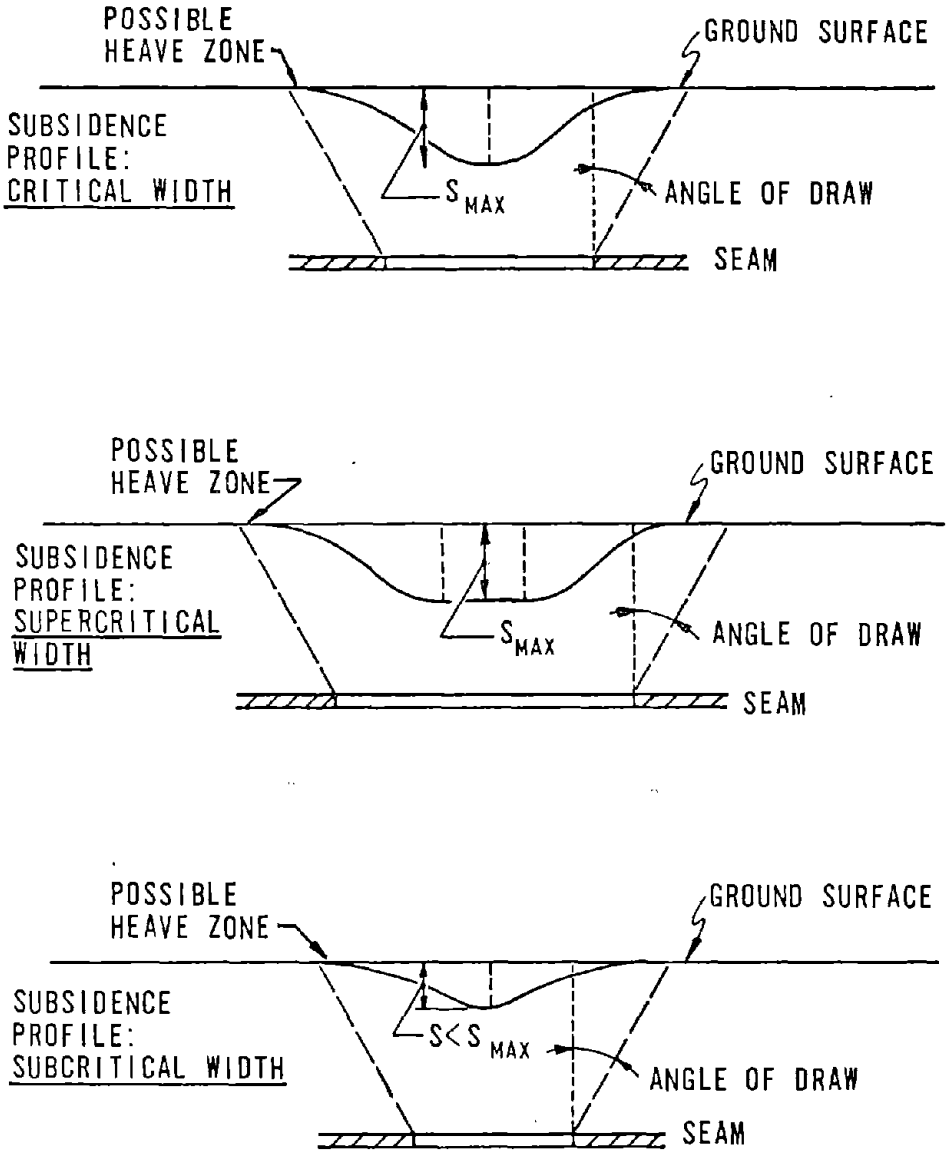


FIGURE 6.2 RELATIONSHIP OF DEPTH OF SUBSIDENCE TROUGH TO WIDTH OF MINED AREA (FROM GRAY ET. AL, 1974)

7. TROUGH SUBSIDENCE ASSOCIATED WITH PILLAR FAILURE

Introduction

Troughs above abandoned mines, whatever their origin, exhibit geometries much like those above active mines. Data are insufficient to determine whether or not there is a critical area at mine level over which pillar failure must occur before a subsidence trough above an abandoned mine achieves its maximum depth. The data do suggest there is a limit to the depths of troughs formed above abandoned mines, and that there is an optimum diameter that at least roughly defines the areal extent of the trough for any particular overburden thickness.

Depths of Troughs

The depths (vertical displacements) of troughs above abandoned mines in the Pittsburgh Coal are not often measured, but seem from written and verbal accounts as well as personal observation to be quite modest and not more than a foot or two.

Since vertical displacements above mines where pillars are extracted seldom exceed half the thickness of the coal seam, it is not suprising that vertical displacements above areas of pillar crushing are less than the displacements where pillars have been mined out.

Diameters of Troughs

The diameters of troughs above abandoned mines have been found to vary from several tens of feet to several thousands of feet, and appear, when pillar failure is the causative factor, to bear a relationship to thickness of overburden. The ratio of trough diameter to overburden thickness varies from one-half to as much as five times the overburden thickness, but seems to center about a value near one and one-half (Figure 2.14 and Table 6.1). (The relationship of trough diameter to overburden thickness for situations where punching of pillars into the mine floor is the causative factor is discussed in Section 8.)

As indicated earlier, much potentially useful information is lacking at most sites of subsidence and consequently, it is possible only to speculate as to the general sequence of events that leads to trough subsidence where failure of pillars is involved. This sequence is envisioned as follows:

The subsidence process is initiated by the failure of a single pillar, the first pillar whose strength drops below the level of the imposed stress. Failure may come either by slow yielding or by outright collapse, but in either case a portion of the load the pillar has been carrying is transferred to adjoining pillars by arching within the overburden (Figure 5.4). If the magnitude of the transferred load is sufficiently high, the adjoining pillars will also fail, causing still another redistribution of load. Successive pillar failure and repositioning of the arch continues until the overburden is no longer able to span the distressed mine zone and fails either by shear at the periphery of the distressed zone or by flexure.

Direct observation of the manner in which each stratum behaves during subsidence is impossible, but careful observations made at mine level and at ground surface during pillar extraction in active mines in the Pittsburgh Coal Region has shed some light on how the overburden probably behaves as pillars fail.

When a mine is developed and rooms are created, the strata in the mine roof act as a series of beams spanning between pillars. With the extraction of pillars the strata break, creating a loosened wedge of rock above the mined out area. Extraction of each successive line of pillars causes the zone of loosened strata to reach higher and higher into the overburden until it eventually reaches ground surface.

This type of progressive failure of the overburden was described in relation to the Pittsburgh Coal as early as the turn of the century, when field studies were conducted in the Georges Creek Basin of Maryland[88]. Quoting from that early study,".....

> In the George's Creek Region, Maryland, the coal seam varies from 6 feet 6 inches to 9 feet 10 inches in thickness and, when the pillar coal is removed, falls occur which extend to the surface. Figure [7.1] indicates the supposed effect of the removal of the pillars under the overlying strata where the surface is 250 feet above the coal seam. Subsidence extends to the surface in such a case after the pillars have been drawn back 220 feet. After the first break occurs at B due to drawing the pillar at A, the entire block of roof sinks and causes the cavity C. The distance from A to B horizontally is 40 feet or 40 feet of pillar have been taken out when the first fall occurs. The second fall occurs at D and the fracture line extends to the space E at the Redstone seam. This break occurs after 60 feet of pillar has been taken out and the break extends almost 40 feet above the floor of the Pittsburgh seam.

> This third fall extends to F and the fourth to G, the line of fracture in the latter case extending to the space H in the Lower Sewickley seam, 85 feet above the floor of the Pittsburgh seam, the total length of pillars drawn up to this stage being 100 feet. The next break occurs when pillars have been drawn for 160 feet to K and the break extends to L. When the pillars are drawn back a distance of 220 feet to M the fracture extends to the surface at N, a height of 250 feet above the bottom of the Pittsburgh seam. This fracture line is approximately correct as shown in Figure [7.1] and is based on actual survey and observation of a large number of surface breaks in relation to the mine working".

The angle of break from the vertical at the above site is about 24 degrees. At another site in the same study, several measurements of the angle of break averaged 22°30'. The overburden thickness was 170 feet.

Quoting further from this early study,".....

> The conclusion drawn from concepts as these is that until a pillar fall extends to the surface, the fracture is conical in shape, but as the pillar line extends down the rooms beyond the first surface break, the strata fracture on a nearly vertical line".

It will be recognized that this description of the character of failure of the overburden is quite compatible with the photoelastic study described in Section 5 (Figure 5.5), particularly in regard to the conical shape of the fracture zone. These and other studies indicate that the foregoing description reasonably represents the mode of failure of the overburden above an active mine.

Because the loss of roof support by pillar crushing is similar to pillar extraction in the sense that a failed pillar is much less rigid than the adjoining unfailed pillars and forces a redistribution of the load by arching[4], then the mode of failure described above is probably also a fair representation of the subsidence of the overburden above an abandoned mine.

Assuming this to be true, it would be expected that successive failure of adjoining pillars in an abandoned mine would continue only until the conical fractured zone of rock reaches ground surface, since once this has happened, the continuity of the arch is broken and there is no further impetus for pillar failure and broadening of the distressed zone at mine level. But even so, movements at ground surface do not stop at this point, because while the fractured zone

works its way upward, the downward movements of the blocks of rock within this fractured zone tend to reduce the lateral restraint on the surrounding overburden material. As a consequence, this surrounding material tends to move downward and inward toward the center of the subsiding area, much as would the material on a slope if the toe were cut away[53]. The inclined surface bounding this zone of radially moving material slopes at the angle of draw, which, in turn, is governed by the joints in the rock and the shear resistance along these joints[26].

The combination of these two phenomena--the downward movement of the fractured material and the radial and downward movement of the surrounding material--creates a trough whose diameter D is related to overburden thickness T according to the following expression:

$$D = 2T\ (\tan \alpha + \tan \beta),$$

where

α = the angle of break, and

β = the angle of draw.

Since in the Pittsburgh Coal Region α is on the order of 22° to 24°, as observed in the Maryland and other studies, and β is on the order of 20°, as noted earlier, then the diameter of a trough created by pillar failure in an abandoned mine in the Pittsburgh Coal Region can be expected to be approximately one and one-half times the thickness of overburden (Figure 7.2). The data in Figure 2.14 and Table 6.1 show this to be true on the average, supporting observations made independently by others[70].

Deviations from the average can probably be attributed to local geological and mining details, inaccuracies in measuring the actual bounds of the subsiding area, and to the fact that trough development is often progressive. (Recall, for example, the case history of the junior high school, described in Section 2.)

Mine Pillars

The ultimate cause of trough subsidence described in the foregoing paragraphs is the failure of one or more coal pillars.

As can be appreciated from the discussion of mining in Section 4, there are several categories of pillars:

1) Permanent pillars intended to support surface structures for indefinite periods of time;

2) Moderate term pillars intended to protect entries, haulage ways and air shafts for periods of several months to several years; and

3) Short-term pillars intended to support the overburden above rooms only until extracted during retreat mining or until the mine is worked out.

The strength of a coal pillar depends upon its size and geometry, weaknesses in the pillar (fractures, bedding planes, clay veins and stringers), and the inherent strength of the coal itself[100].

Since the turn of the century, investigators have attempted to evaluate pillar strength by relating it to representative samples of coal tested in the laboratory and in the field. The Pittsburgh Coal was among the first to be investigated, prompted to some extent by the advent of pillar extraction methods that made use of thin pillars between the working space and mined out area, which were sometimes less in width than the thickness of the coalbed[48]. Several of the more important strength relationships defined for the Pittsburgh Coal are summarized in Table 7.1 and Figure 7.3.

The formulas in Table 7.1 represent the strengths of pillars of square cross-section. Many pillars, particularly those developed in the 1930's and earlier, are elongate in plan with one dimension differing from the other by as much as a factor of ten. Some rather preliminary data (not pertaining specifically to the Pittsburgh Coal) indicate that the strength of a pillar of rectangular cross-section whose plan dimensions are $W_1 \times W_2$ is equivalent to that of a pillar of square cross-section whose plan dimensions are each $(W_1 + W_2)/2$ [92].

Although these formulas provide insight into the capacity of coal pillars to support loads, it is often difficult, if not impossible, to use them quantitatively to determine the capacity of pillars in abandoned mines due to the frequent lack of accurate information regarding the geometry and pattern of pillars as they now exist. But in that rare instance when such information is known reasonably well and the geometry of the pillars is fairly regular, then at least a rough estimate of the factor of safety against pillar failure can be made.

One such case is shown in Figure 7.4, which depicts a site located in Allegheny County, Pennsylvania[45] (Site 155). Mining at that site was conducted during a four-month interval in 1943, during which time about 75 percent of the coal was extracted in a mining pattern that consisted of 25-foot wide rooms alternating with 10-foot wide pillars broken by cross-cuts at intervals of 90 feet or less. The strengths of the pillars probably ranged from 850 to 1750 psi, the lesser strength corresponding to the smallest pillar in the pattern (10 feet by 18 feet in plan), and the greater strength corresponding to the largest pillar (10 feet by 90 feet in plan). Pillar height was about 6 feet. Vertical stresses acting on the pillars probably ranged from 450 to 700 psi, the higher stress corresponding to the smallest pillar and the lower stress to the largest pillar. It is assumed that each pillar carried the weight of the overburden directly above itself plus half the weight of the overburden above each adjoining entry[55]. The stress on the coal before mining was probably about 120 psi--approximately 1 psi per foot of overburden[81].

Based on these strengths and stresses, the factor of safety against pillar failure in this portion of the mine is estimated to be somewhere between 1.2 and 3.9, the smaller factor of safety corresponding to the smallest pillar. This is to say that the ultimate strengths of the pillars are 20 to 290 percent higher than the stresses imposed on them. Current practice generally considers an adequate factor of safety for long-term stability to be no less than 2.0 [57].

Pillar failure took place at the site in 1959, 16 years after mining, causing the ground surface to subside and severely damaging the east wing of the building shown in Figure 7.5. A cross-section through four borings made at the site following subsidence are shown in Figure 7.6. The strata above the mine are largely shale, broken throughout and containing small voids that indicate that differential downward movements of strata had taken place. The 15-foot layer of limestone in the upper portion of the overburden is also quite broken and is weakened by limy shale seams, making it incapable of competently spanning the failed pillars.

As far as can be determined, no mining investigation was conducted at the site before the structure was erected. Had such an investigation been conducted, it might have been decided to stabilize the mine by filling it with mine waste prior to construction, or by taking some alternate measures to prevent subsidence.

Precisely what caused the pillars to fail at this site is not known. It is presumed that natural deterioration in the years following mining simply reduced pillar dimensions

until at least one pillar was no longer capable of bearing its load. This is a common presumption made by those in subsidence engineering. In most cases, the ultimate cause of pillar failure never is learned. At a few sites, individuals who in various ways have been associated with subsidence incidents have attempted single out specific factors as the probable cause of pillar failure. These are presented in the following paragraphs. (For reasons of liability, identifying details have been omitted in some cases):

1. Accident. A mine fire in Allegheny County, Pennsylvania, burned the pillars in an abandoned mine beneath Site 44, causing severe subsidence damage to one home while threatening several others. The fire was a remnant of one that had been extinguished by overexcavation during construction of a nearby shopping center in the early 1960's. The burning mine area that ultimately caused subsidence had was been not extinguished because it extended beyond the property line of the construction site. Although efforts were made at the time to prevent propagation of the fire by sealing the coal outcrop with soil, the fire continued to burn and five years later broke out on the hillslope, followed shortly thereafter by subsidence of a home 100 feet behind the coal outcrop. The mine, located 25 feet below ground surface, was subsequently filled with fly ash.

   Elsewhere, the installation of a new sewer line is reported to have caused at least one incident of subsidence. In that community, sewage is disposed of by flushing it into old mines through pipes installed from individual homes. At the site in question, the sewage disposal hole intercepted a coal pillar at mine level. Rather than drill another hole, the contractor chose to split apart the pillar using explosives. Soon after he did so the ground surface subsided, damaging three homes located 220 feet above the mine.

2. Dewatering. Many mines in the Pittsburgh Coal are above natural drainage and are essentially free of water. Some are not, and are at least partially flooded.

   It is reported that the increased price of coal prompted a mining company to dewater one of its old mines to extract coal that had been too costly to mine earlier. While dewatering was underway, several homes located 200 feet above an

adjoining abandoned mine subsided. As a consequence, the dewatering program was discontinued and the proposed mining program was aborted.

Complete details surrounding this incident are not available, but it is speculated that draining the mine may have withdrawn the buoyant support furnished the overburden by the water, causing the weight of the overburden to be transferred back onto the pillars. If the pillars had weakened since mining, this increased load may have been sufficient to cause one or more of them to fail. Pressures exerted on the overburden by the draining water may also have contributed to the failure.

3. Mining. Mining the Upper Freeport Coal was judged to have induced movements in an abandoned mine in the Pittsburgh Coal at Site 50, causing subsidence of the ground surface and damage to a home located 65 feet above the abandoned mine. The operating mine was located 640 feet below the abandoned mine. Whether subsidence was due to pillar failure or caving of the overburden in the old mine is not known. (This is the only documented incident of subsidence due to this cause. The area of overlap between the mined Pittsburgh Coal and mineable Upper Freeport Coal is rather small and is confined to an area of about 75 square miles in the eastern part of Allegheny County and the western part of Westmoreland County, Pennsylvania[32, 108, 109].)

Subsidence at another site is thought to have been caused by pillar extraction in an adjoining portion of the mine. The site had been undermined earlier, but the area mined may not have been of critical dimensions and therefore subsided further when broadened by mining alongside. Several homes were damaged.

Subsidence at still another site was initiated by extracting chain pillars and other available coal in a mine abandoned 50 years earlier that was located 35 feet below ground surface (Site 228A). (Second mining has been speculated to be a contributing factor to subsidence above abandoned mines at a number of sites, but not often confirmed. This type of mining is not as common today as it was during World Wars I and II and the Depression, but is still practiced by a few operators who purchased leases from the mine owner.)

While the subsidence-producing factors presented in the foregoing paragraphs are to some extent conjectural, they indicate that activities by man subsequent to first mining can occasionally be the immediate cause for subsidence, and can hasten what natural deterioration would require a much longer time to accomplish.

The foregoing discussion also indicates that the subsiding area during any incident is generally quite small compared to the total mine area and this suggests that small localized details in a mine most probably dictate where subsidence will take place and when. It will be recalled from Figure 2.12 that most troughs measure less than 200 feet in diameter. Taking into account the angle of draw, the distressed area at mine level may be only about half the diameter of the trough at ground surface--about 100 feet for a trough 200 feet in diameter. This is an area small enough to encompass perhaps only two or three pillars in a typical mine. Whether a carefully executed subsurface investigation is sensitive enough to delineate potentially critical mine conditions on such a small scale is doubtful. It is necessary, therefore, to consider most areas above old abandoned mines to be susceptible to eventual subsidence unless some measures are taken to prevent it or unless it can be determined that a competent stratum exists in the overburden that is capable of spanning a series of failed pillars.

In the next section, trough subsidence due to punching of pillars into the mine floor is examined, beginning with a consideration of the rock types that constitute mine floors in the Pittsburgh Coal Region.

Table 7.1

STRENGTH RELATIONSHIPS FOR PRISMATIC PILLARS OF SQUARE CROSS-SECTION--PITTSBURGH COAL

Strength of a cube of Pittsburgh Coal (Figure 7.3A)

	Reference
$\sigma_c = K/\sqrt{H}$	Gaddy, 1956

Strength of a square prismatic pillar of Pittsburgh Coal (Figure 7.3B)

	Reference
$\sigma_p = 2800\sqrt{W} / \sqrt[6]{H^5}$	Greenwald (in-place tests), 1939
$\sigma_p = \sigma_c\sqrt{W/H}$	Holland, 1964
$\sigma_p = \sigma_c\ (0.778 + 0.222\ W/H)$	Bauschinger, 1876; Hustrulid, 1976

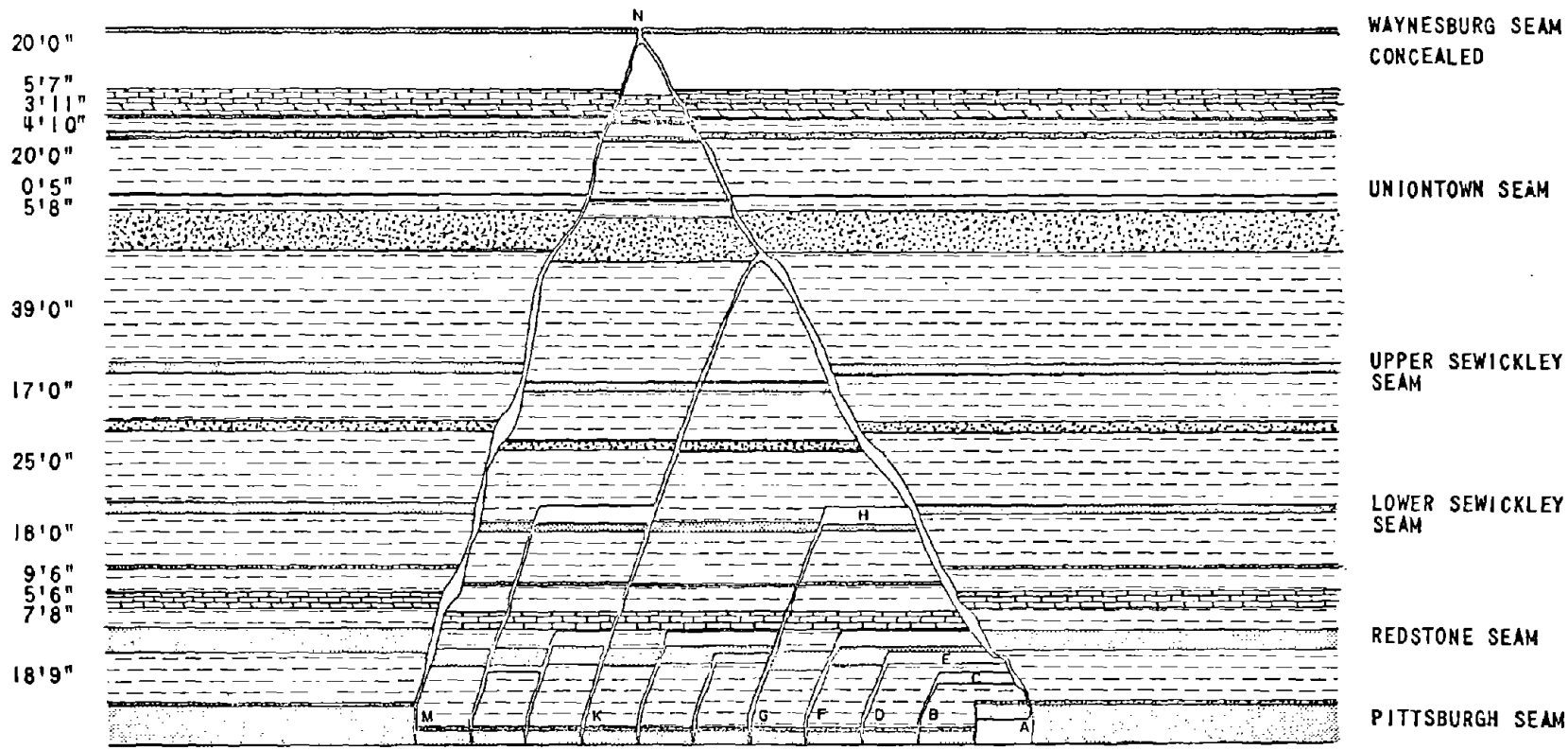
σ_c = Compressive strength of cube (psi)

σ_p = Compressive strength of square prism (psi)

K = 5718 lb-in.$^{-3/2}$ = Constant based on strengths of two-inch cubes

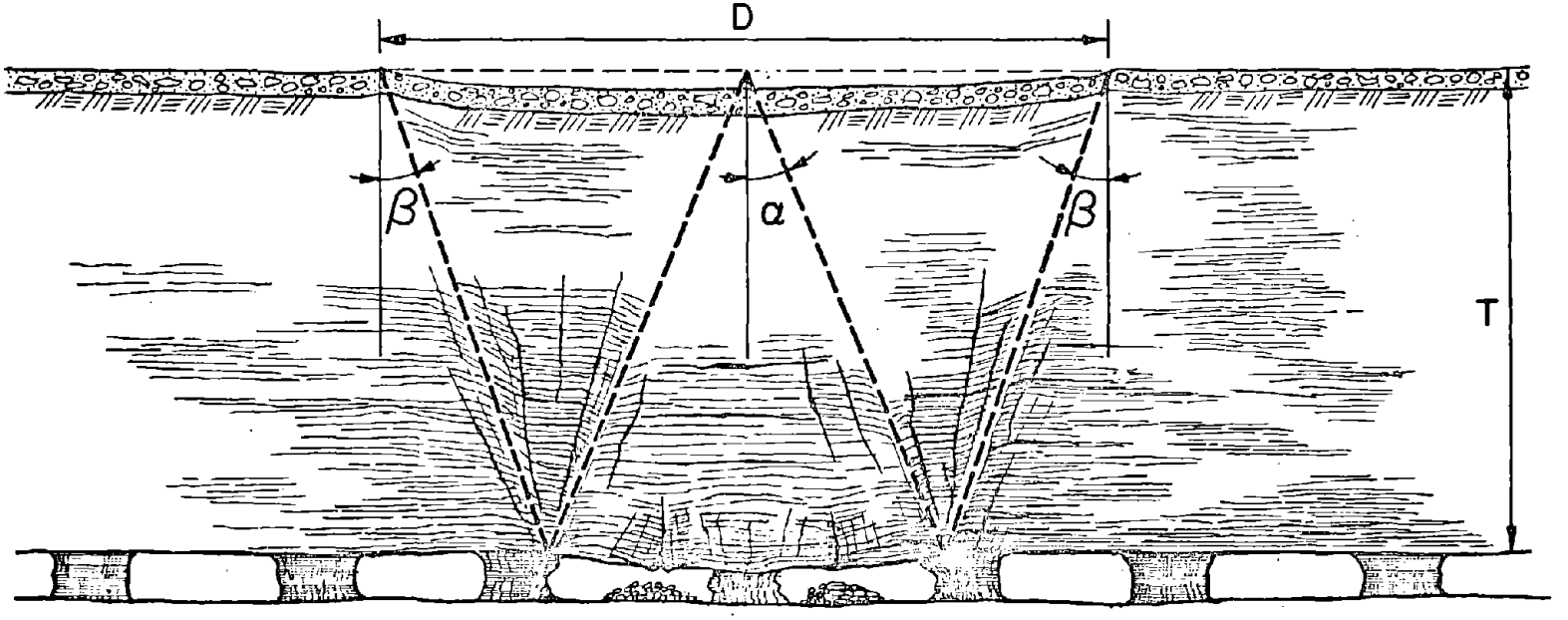
W = Width of prism (in.)

H = Height of prism (in.)



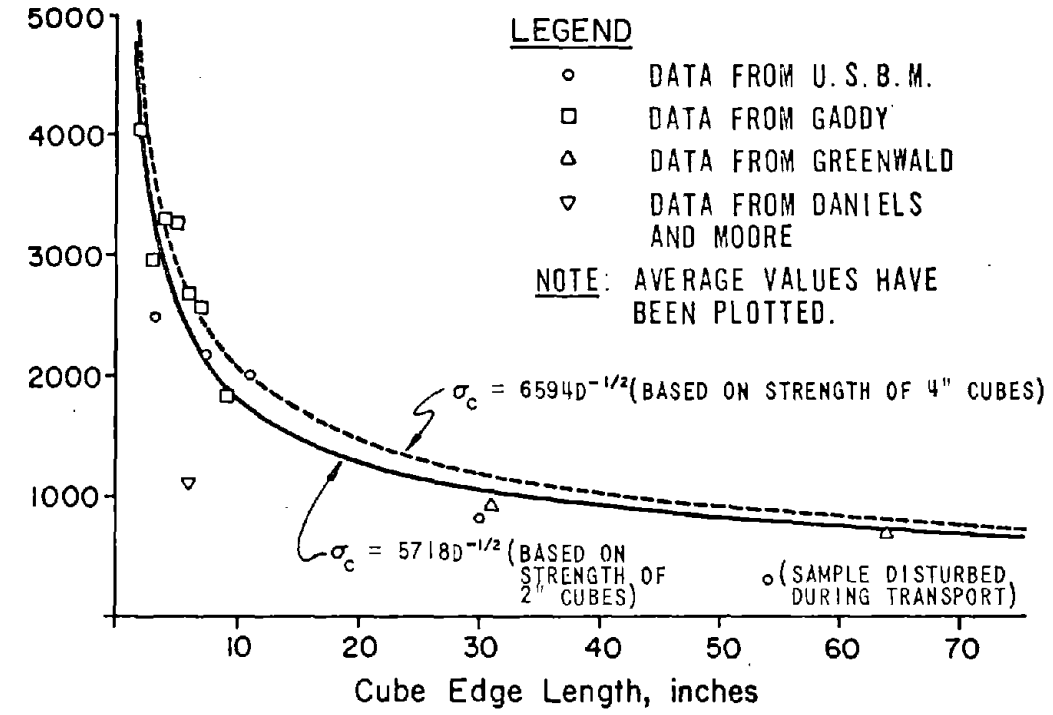
Sectional View Showing Probable Action of Overlying Strata
On Removal of Pillars in Pittsburgh or "Big Vein" Seam
Georges Creek Region, Maryland
SCALE: 1/8 inch = 1 foot

FIGURE 7.1 PROBABLE CHARACTER OF OVERBURDEN FAILURE ABOVE TOTAL EXTRACTION ROOM-AND-PILLAR MINE IN PITTSBURGH COAL AS DEDUCED FROM FIELD OBSERVATIONS (AFTER REPPERT, 1911)



$$D = 2T(\tan\alpha + \tan\beta)$$

FIGURE 7.2 RELATIONSHIP BETWEEN TROUGH DIAMETER, OVERBURDEN THICKNESS, AND ANGLES OF BREAK AND DRAW FOR TROUGH SUBSIDENCE ABOVE ABANDONED MINE IN PITTSBURGH COAL REGION DUE TO PILLAR FAILURE



COMPARATIVE STRENGTH OF CUBES OF PITTSBURGH COAL AS A FUNCTION OF CUBE EDGE LENGTH (AFTER HUSTRULID, 1976)

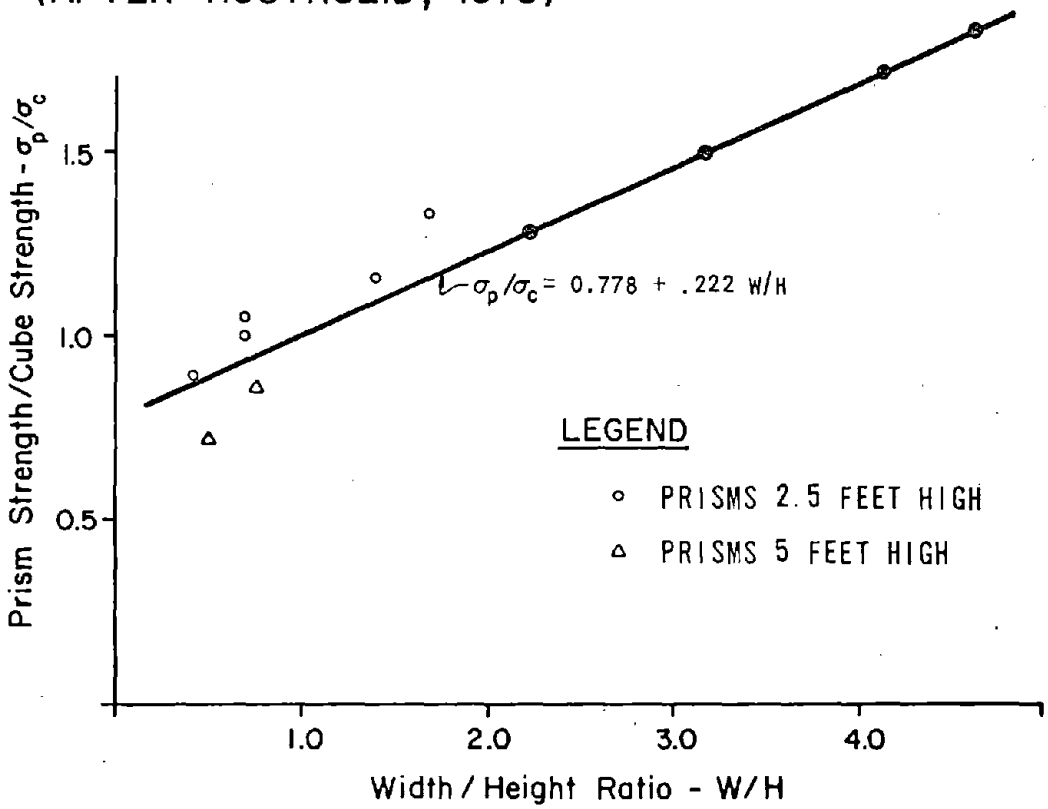


FIGURE 7.3 RATIO OF PRISM TO CUBE STRENGTH OF PITTSBURGH COAL AS A FUNCTION OF WIDTH-HEIGHT RATIO OF THE PRISM; CONSTANT HEIGHT, VARIABLE WIDTH. (AFTER HUSTRULID, 1976)

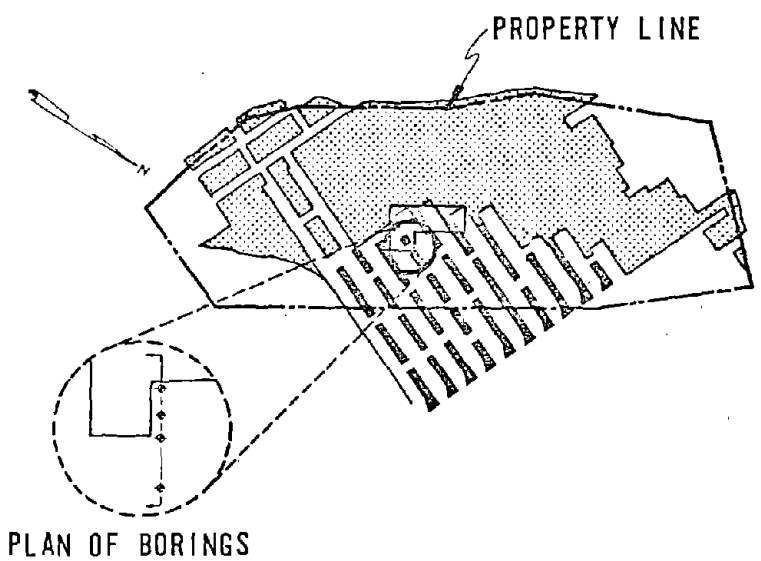


FIGURE 7.4 PLAN OF MINE AT SITE 155

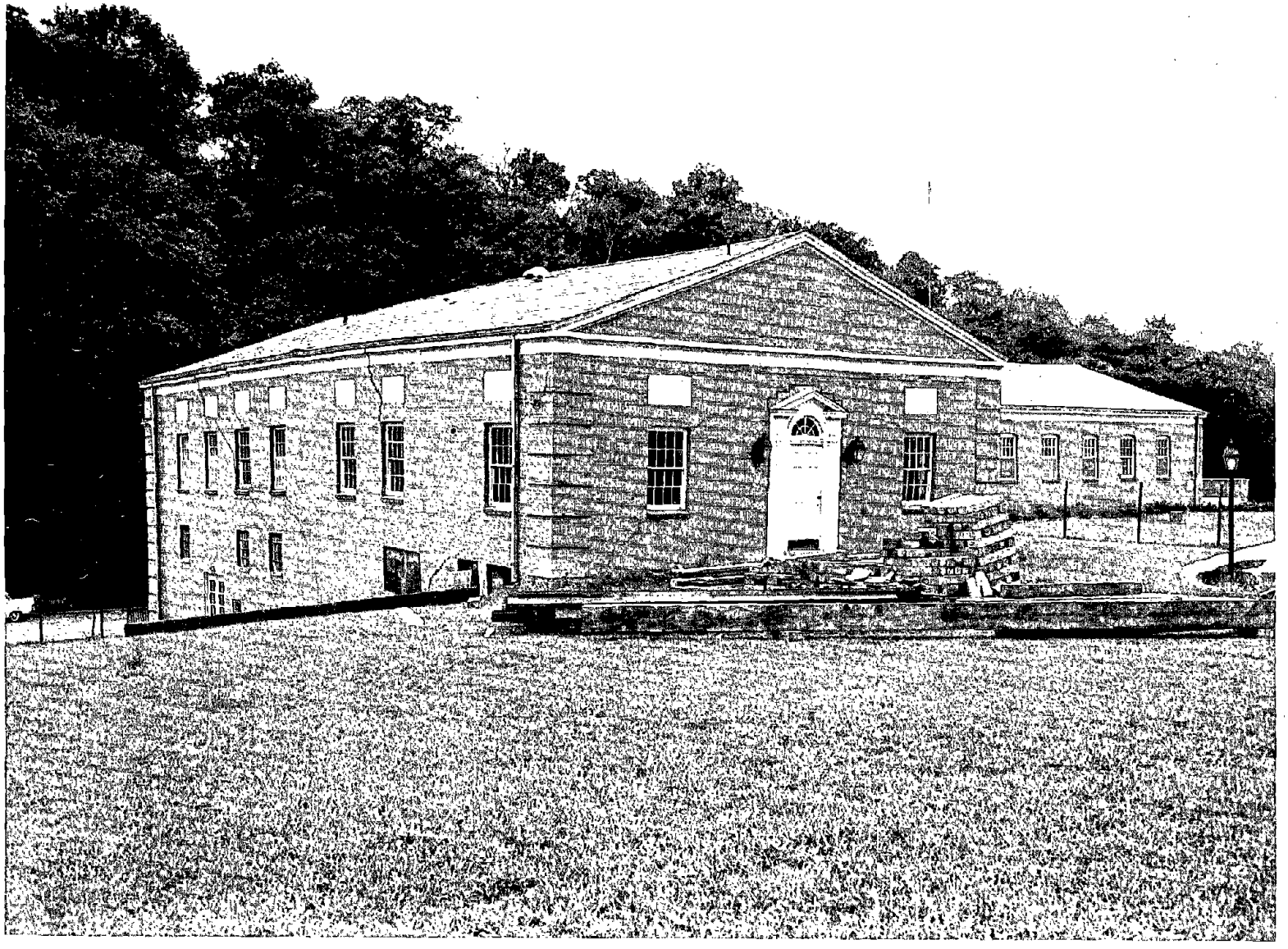


FIGURE 7.5 MUNICIPAL BUILDING IN ALLEGHENY COUNTY, PENNSYLVANIA DAMAGED BY SUBSIDENCE 120 FEET ABOVE ABANDONED MINE (SITE 155)

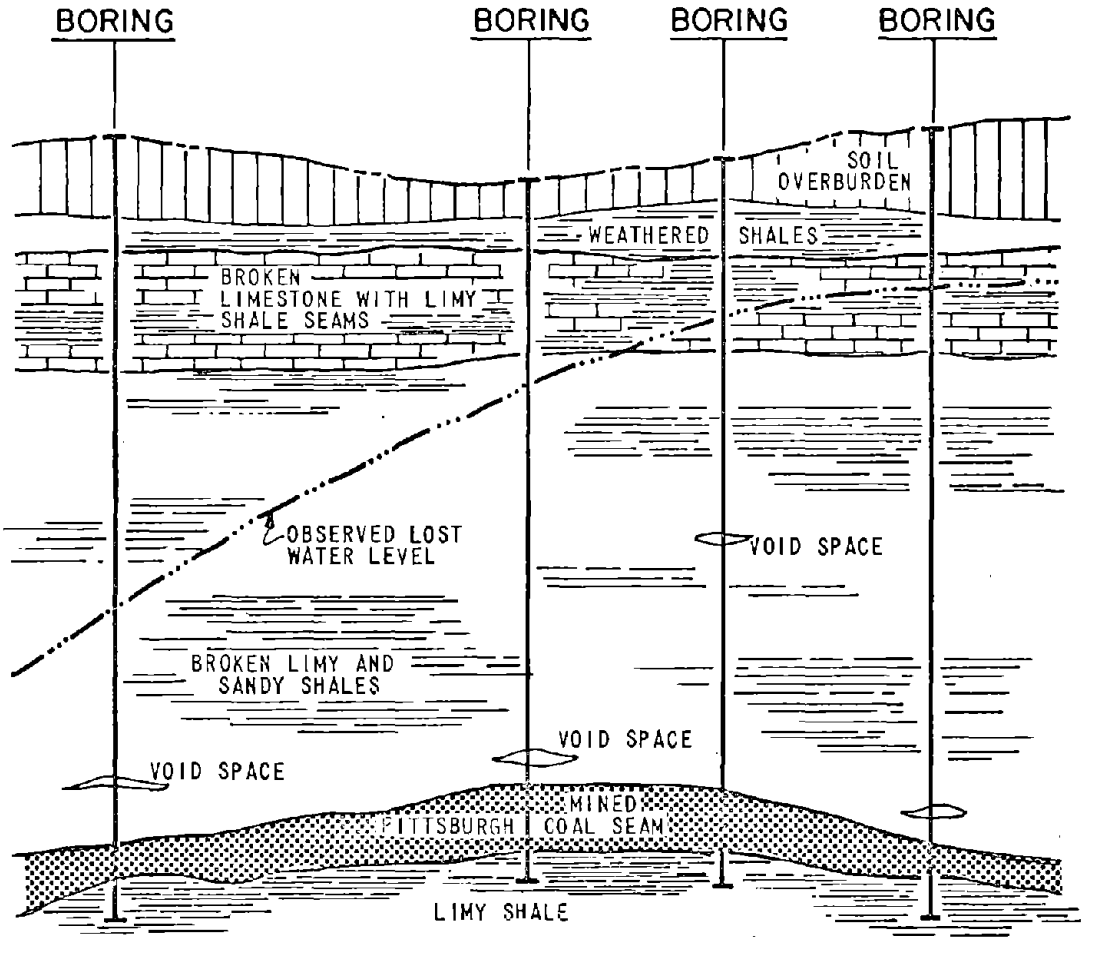


FIGURE 7.6 SECTION THROUGH BORINGS AT SITE 155

8. TROUGH SUBSIDENCE ASSOCIATED WITH PUNCHING OF PILLARS INTO THE MINE FLOOR

Character and Origin of the Mine Floor

The Pittsburgh Coal horizon represents a gigantic coastal swamp where, 275 million years ago, plant life abounded. The swamp was located along the coast between the open water of the sea and a flat lowland that supported substantial numbers of large and small lakes[27]. Sediments deposited in the relatively calm environment of the lakes were primarily fresh water carbonates, silt, and clay. As the lakes filled with sediment, swamp conditions developed and the lake sediments gradually transformed into the limestone, siltstone, shale, and claystone that were to become the mine floor beneath the Pittsburgh Coal, the coal itself forming from the organic material within the swamp.

Limestone, siltstone, and shale strata where found directly beneath the Pittsburgh Coal are blocky in nature, and in coal mines, are generally competent in distributing loads delivered by coal pillars and in resisting heave into mine openings. Claystone is another matter, however.

Claystone is a massive, relatively soft rock that lacks the laminations typically found in other sediments, but is commonly dissected by smooth curved slickensides resulting from differential movements that took place while the material was still in a soft state. These slickensides, spaced at a fraction of an inch to a foot or two, weaken the rock and promote its deterioration when exposed to air and moisture for prolonged periods of time. With weathering, the rock assumes the character of clay soil, accounting for its being called "underclay" by people in the coal mining industry.

Underclay in routine mining operations is actually soft only in the top inch or two and even then only where ponded with water. [In such a condition, it might be classified as a low plasticity clay (CL), according to the Unified Soil Classification.]

Mining Problems

Heaving of the underclay mine floor (or 'hooving' as it is more commonly called by miners) presents problems at various locations in the Pittsburgh Coal region and indeed in many coal mines in the Appalachian region and other parts of the United States, particularily in Illinois.

Heaving takes place in some Ohio mines where a thick limestone bed (part of the Pittsburgh Formation) lies about eight feet above the mine roof. The pattern of mine roof

collapse during mining causes redistribution of the roof load from the mined-out area onto the pillars behind the mine face, driving these pillars into the underclay. The underclay in the affected Ohio mines is one to two feet thick[66]. Several of the mine operators in this region are presently examining special methods of roof control to avoid heaving, including destroying the continuity of the limestone by blasting.

In a somewhat similar situation in a mine in southwestern Pennsylvania where the underclay is two feet thick and the overburden is 300 feet thick, movement of underclay into the mine opening during retreat mining has sometimes been so substantial as to break props temporarily supporting the roof, and cause portions of some rooms to collapse before support could again be reestablished[72].

In yet another mine in southwestern Pennsylvania under 400 feet of cover, movements of underclay into mine openings during and shortly after mining has necessitated that the operator reevaluate his pillar formulas in locations where permanent support beneath buildings is required. The underclay at this mine is seven to eight feet thick.

The inherent low strength of underclay and its tendency to lose strength on exposure dictates that mining conducted above substantial thicknesses of it be maintained in a dry condition. As a protective measure, therefore, some operators have left a three- to six-inch layer of "bottom coal" in-place on the mine floor.

Although difficulties in mining above underclay are becoming better recognized, only a few documented subsidence difficulties related to underclay are known. The following case history describes a situation where underclay seems to have played a very prominent role (Site 1200).

Case History

Introduction

In early 1974, the town of Farmington in Marion County, West Virginia, was visited by consulting geotechnical engineers to determine the cause of ground movements that had become prominent in October of the preceding year and that had by that time already caused damage to several homes, commercial establishments, churches, schools, and utility lines[39].

The first serious movements in October of 1973 ruptured a water line, leading to water damage in several homes. Subsequent movement in adjoining parts of the town during December and January damaged a number of churches, homes, and a high school, which was ultimately abandoned. A total of 43 buildings were affected in the seven month period of subsidence and it was speculated that four or five scattered incidents of home damage reported the preceding May and June had been a precursor to the major episode in fall and winter. Through this period of time, nearly 50 water line breaks were reported in the disturbed area, an area that extended over nearly 40 acres.

Nature of the Damage

Following the major subsidence episode, federal[17] and state officials inspected 25 of the most seriously damaged homes. These homes exhibited, variously, misaligned doors and steps, fallen chimneys, and cracks in interior and exterior masonry. Damage was largely confined to basements, but sometimes extended to upper floors where in a few cases cracks wide enough to permit the entry of rain were observed. In the high school, located in the north part of town, the brickwork around several windows and doors was severely distorted; more than 100 feet of an interior metal staircase was wrenched away from an adjoining wall; and wood floors in several of the classrooms and hallways were buckled.

Movements have continued and although they are on a more modest scale, they thwart the attempts of residents to make final repairs to homes and property.

Mining History

The mine underlying the general area opened in the early 1920's and operated continuously until July of 1971 when the mine was abandoned. Mining beneath the disturbed area was conducted in the period 1959 through 1961, almost 12 years before subsidence was recognized at ground surface.

The mine had been developed using a conventional room-and-pillar system, with 15-foot wide entries being driven on 90-foot centers to develop square pillars 75 feet on a side. During retreat mining beneath undeveloped areas, these pillars were systematically removed in a total extraction operation. Beneath the town, the area where subsidence damage took place, no more than 50

percent of the coal was removed, as is the accepted practice where permanent support is desired. To achieve 50 percent extraction, the pillars were split by driving 15-foot-wide cuts into two mutually perpendicular faces of each pillar, creating two 30-by 30-foot pillars and one 30-by 75-foot pillar notched 5- to 10-feet deep on one long side (Figure 8.1). While the total extraction operation resulted in some noticeable movements at ground surface--notably the northwest-southeast crevasses several tens of feet deep that developed in a farmer's field west of town and are still visible today--only one incident of subsidence damage is known to have accompanied the splitting of pillars beneath the town itself. In that instance, the east face of the high school building was damaged, necessitating the construction of a large steel buttress adjacent to the main entrance to prevent collapse of the wall. Although precise mining details accompanying this disturbance are unknown, available mine maps indicate that pillars 30 by 30 feet were left immediately below the damaged area. The damaged area was no closer than 200 feet to the nearest limit of total extraction mining and was located 300 feet above the mine.

Initial Interpretation

Most of the damage in 1973 was experienced by homes located near the base of Sherry Hill, which occupies a prominent position almost in the center of town (Figure 8.1). At a number of these homes, basement walls on the uphill side were cracked and deflected inward, suggesting the presence of rather substantial earth pressures behind the walls. On account of this, early interpretations of the cause of property damage favored the possibility of slope failures brought about by the excessive rains of 1973. A thorough field reconnaissance made shortly after this subsidence, however, disclosed none of the typical indicators of slope movements--cracks along hilltops and hillsides, irregulartities in slope profile, displaced trees, and so on--particularly on a scale that could have resulted in damage of the magnitude reported. Nonetheless, it was clear that increased earth pressure had played a part in damaging several of the homes. It was concluded by the geotechnical engineers based on the evidence which follows, that the cause of the movements had most probably been subsidence.

Character of Overburden and Mine Void

Overburden in the subsided area, ranging in thickness from 230 to 450 feet, including the mantle of colluvial soil 10 to 30 feet thick at ground surface, consists of rock typical of the Monongahela Formation--alternating shale, limestone, sandstone, and thin coal. The Pittsburgh Coal is 6.5 to 8 feet thick beneath the subsided area and is underlain by a few inches of shale, which in turn, is underlain by underclay, believed to average about six feet in thickness.

Twenty-nine air rotary holes drilled to mine level by the State of West Virginia for the purpose of injecting mine waste into the mine void to arrest further subsidence revealed a variable condition at mine level. In nine of the drill holes, the mine void was approximately seven feet high. Five of these holes were located in the east part of town where relatively little subsidence damage took place, and the remaining four were distributed among the more numerous holes placed to the north and west, where the damage was more severe. Of the remaining twenty holes, ten revealed voids four to six feet high (most four feet high, about three feet less than original void height); two exhibited one and two foot voids (five to six feet less than original void height); and the remaining eight holes, nearly one-third of the total, exhibited no voids at all, or voids only a few inches in height. (Three additional holes that had been drilled encountered intact mine pillars.)

Subsequent Interpretation

The collapsed nature of the voids supported the thesis that subsidence of some type had been responsible for the disturbance rather than slope movements. Of the three recognized modes of subsidence--(1) sinkhole development, (2) pillar failure, and (3) bearing capacity failure--only (3) seems plausible. No sinkholes were found in the field reconnaissance, and widespread sinkhole development through overburden thicknesses of 250 and more feet with entries at mine level only 15 feet wide seems out of the question. Pillar failure seems equally unlikely. The smaller 30 by 30 foot pillars are estimated to have a factor of safety of 1.5 to 3 using conventional pillar formulas and best estimates of coal strength (Section 4). The larger 30 by 75 foot pillars are estimated to have a factor of safety of two to three, the range factor of safety being due to the variation in overburden thickness. The aforementioned factors of safety are thought to be adequate for the coal pillars in question, and it is very doubtful that

the pillars had degraded to such an extent in the ten years following mining that their strength had been compromised. (It is acknowledged that the factor of safety of 1.5 for the 30 by 30 foot pillars is near the lower limit of acceptability where surface support is required.)

Evidence suggests that it is much more probable that the strength of the underclay had decreased appreciabley since mining. An investigation of the factors preceding the subsidence revealed that the pumps in operation to dewater the mine were shut off when the mine was closed in 1971. The mine began to flood soon after, and subsequent drill holes showed several feet of water within the mine. It was the conclusion of the geotechnical engineers and the Bureau of Mines, therefore, that flooding of the mine had caused sufficient softening of the underclay to permit punching of the pillars into the underclay, thereby causing subsidence. (The punching may or may not have also been accompanied by rotations of the pillars that initiated roof failures which assisted in the subsidence process.) It is of note that the Bureau of Mines felt that the quantity of coal extracted at the site by the coal operator (50 percent) would not, under ordinary circumstances, be considered excessive.

Bearing Capacity of Underclay

When the bearing capacity of underclay is exceeded, the loads imposed on it by the coal pillar induce lateral plastic flow, much as if the clay were squeezed between two rough parallel plates--one plate being the underside of the pillar and the other being the top surface of the rock beneath.

The bearing capacity of underclay in such a situation can be represented by the equation[103]:

$$q_o = S_u N_m + q \qquad (8.1)$$

where S_u is the undrained shear strength of the underclay; N_m is a bearing capacity factor whose value depends upon the ratio of the shear strength of the underclay to that of the rock beneath, upon the relative thickness of the underclay layer to the width of the pillar, and upon the two plan dimensions of the pillar; and q is the surcharge exerted on the underclay by the material between the pillars.

In a mine, the surcharge on the underclay is neglible or nonexistant. The pillars rest directly on the underclay and no appreciable load acts downward on the surface of the clay in the entries or splits between pillars. The bearing capacity, therefore, is principally a function of the shear strength of the underclay and the bearing capacity factor.

The strength of underclay varies appreciably with water content and with position of the water table. Raising the water table reduces the unit weight of the material (its weight per unit volume), thereby reducing the effective stresses that generate shear resistance. Since the buoyant weight of the material (its total weight per cubic foot minus the weight of an equal volume of water) is only about 60 percent of the total unit weight before immersion, the component of bearing capacity due to frictional resistance is only about 60 percent of that before immersion. Immersion of the material also has the effect, over a period of time, of increasing the water content of the material. The decrease in strength of cohesive soils accompanying increase in water content is well documented in the literature. One of the more important effects of immersion is to destroy the surface tension in pores and slickensided surfaces that provide the material with much of its cohesion. Thus, the undrained shear strength of underclay is diminished when the material is immersed in water for a prolonged period of time.

Few tests of underclay strength have been conducted up to this time[4, 6], but some indication of its strength can be learned from the in-place compression tests of mine pillars in the Pittsburgh Coal made by the Bureau of Mines several years ago[48], tests which are in general agreement with laboratory and field tests on similar Pennsylvanian age claystones not directly beneath coalbeds. The underclay at the site of these tests in Bruceton, Pennsylvania, was 10 to 15 inches thick and possessed a water content of four to five percent. The water table was located at the base of the coal bed. Two pillars of square cross section, one 2.5 feet on a side and the other 3.5 feet on a side, failed in compression by punching into the underclay. In the words of the investigators, "the floor of the....passageway....has been heaved and broken by the thrust of the clay forced out from under the pillar" and the pillars "were pulled to pieces from the bottom upward by lateral movement of the fireclay." (Fireclay is another term for underclay.) Taking into account the shape and dimensions of the pillar and the thickness of underclay, it appears that the undrained strength of the underclay at the time of failure was between four and five tons per square foot.

If the underclay at the West Virginia site were of the same strength and thickness (15 inches) as at Bruceton (or alternatively, if only the top 15 inches of the underclay had softened appreciably before failure took place), the factor of safety against punching of the pillars into the underclay (the factor of safety being defined as the ratio of bearing capacity to stress delivered by the pillar) would be only 0.7 to 1.2 at the time subsidence took place. If the underclay at the West Virginia site were six feet thick, as estimates indicate, then the factor of safety against bearing capacity failure could have been as low as 0.4. In fact, with an underclay thickness of six feet, it is likely that failure would have begun when the strength of the underclay had decreased to nine or ten tons per square foot, because the bearing capacity of the underclay is inversely proportional to its thickness when underlain by a material of substantially greater strength. It is possible that the buoyant effect of the water in the mine forestalled failure for a time by reducing the pressure of the overburden on the pillars. But this effect, if it did exist, was eventually more than compensated for by the loss of strength of the mine floor.

Although much of the foregoing is speculative owing to a lack of observational evidence at mine level, the bulk of the evidence points to a bearing capacity failure of the underclay.

Summary and Conclusions

The case history and preceding discussions suggest certain factors that favor bearing capacity failure as a subsidence mechanism:

1. An underclay mine floor;

2. High pillar stresses; and

3. Flooded mine conditions.

The relative influence of these factors is represented graphically in Figure 8.2, prepared using Equation 8.1 as a basis and varying the strength and thickness of the underclay and the cross-sectional area of the pillars. (All pillars are assumed to be square). Each curve represents the variation in bearing capacity of a particular thickness of underclay with variation in shear strength, the cross-sectional area of the mine pillars and percent extraction being held constant. Certain points illustrated by the figure are presented in Table 8.1.

The few examples given in the table serve to illustrate how certain of the parameters characterizing the geology and mining activity at a site can independently influence the likelihood of subsidence by failure of the mine floor. Actual situations involve a large number of interacting factors that often cannot be so conveniently characterized, although the principal factors at every site remain essentially the same.

Certain generalizations regarding failure of the mine floor and subsidence suggest themselves from the foregoing considerations:

1. It appears that mine floor failure will take place as soon as the bearing capacity has dropped to a critical level and it is likely that such failure will take place only a moderate period of time after the mine is flooded (perhaps 10 years or so). It is unlikely that any large scale subsidence will take place above a mine closed and flooded for several decades if signs of such movement have not been noticed earlier. It is probable, however, that movements, once begun, will continue for a period of several years after the onset of subsidence and will continue to aggravate already damaged structures.

2. It is also likely that subsidence due to punching of pillars into the mine floor will take place over as wide an area of the mine floor as is flooded and softened, in contrast to the relatively limited extent of subsidence due to pillar failure, which is governed by the thickness of overburden, and which seems to initiate by the failure of a single pillar.

3. It seems also that settlements taking place due to failure of the mine floor can sometimes increase earth pressures to levels sufficient to damage homes by locally steepening hillslopes or reactivating earth slides. (It would seem that this phenomenon need not be confined to subsidence associated with failure of the mine floor, even though it appears to have been prominent only in a case due to that cause.)

It is impossible to determine just how prevalent bearing capacity failure has been through the years in relation to the Pittsburgh Coal. Certainly there has been no documented subsidence incident on the same scale as the one at Farmington, West Virginia, and it is not clear that bearing capacity failure has been a prevalent mechanism in causing subsidence

above abandoned mines in the Pittsburgh Coal, particularly in the Greater Pittsburgh area. Long pillar lines, modest overburden thicknesses and relatively dry mine conditions (dry enough to make the Pittsburgh Coal in this area one of the most fire-prone beds in the district[70]) do not seem conducive to bearing capacity failure except perhaps in localized areas where water may be ponded due to roof falls or bulkheads. Every year, however, more coal is being mined in the southern part of the field under deeper cover and under less well drained conditions than in the past. These conditions favor bearing capacity failure provided that a weak mine floor is present. Substantial thicknesses of underclay do exist in certain areas currently being mined and it is probable that mine floor failure will present a very real problem in future mining where room-and-pillar methods are employed. It is also quite possible that unless some positive steps are taken, another subsidence incident like the one at Farmington could take place. This problem will require the reevaluation of pillar requirements for long-term surface support, and hopefully such a reevaluation will be undertaken in light of "state-of-the-art" soil mechanics.

Table 8.1

CONCEPTS REGARDING SUBSIDENCE DUE TO PUNCHING OF PILLARS INTO THE MINE FLOOR

Figure 8.2 illustrates the following points:

a. For two mines possessing the same geometry, percent extraction, overburden thickness, and underclay strength, the mine underlain by the greater thickness of underclay is more prone to bearing capacity failure of the mine floor and resultant subsidence. (Compare Case A with Case A'. In both cases, the pillars are 75 by 75 feet and the shear strength of the underclay is 4 tsf. The bearing capacity in Case A is 145 tsf, whereas it is only 40 tsf in Case A'. The thickness of the underclay in Case A is one-half foot and in Case A' four feet.)

b. For two mines located beneath the same thickness of cover, the mine possessing pillars of greater cross-sectional area is less prone to bearing capacity failure and subsidence than the one with pillars of smaller cross-sectional area. (Compare Case A' with Case A". Case A' represents a situation where pillars measure 75 by 75 feet in plan. Case A" represents a situation where pillars measure 30 by 30 feet. The underclay is the same thickness and strength in both cases, but the bearing capacity in the former case is 40 tsf while in the other latter it is 28 tsf.) If to achieve the desired percent extraction the 75 by 75 foot pillars on 90 foot centers are reduced to 60 by 60 foot blocks by taking cuts off the faces rather than split into 30 by 30 foot blocks, then the bearing capacity is reduced only to 36 tsf. This supports the concept that slabbing of pillars (taking cuts off the faces of the pillars) can create a situation less prone to bearing capacity failure and subsidence than one in which the pillars are split.

c. For two mines that are alike, the one with the mine floor of lower shear strength is more prone to bearing capacity failure and resultant subsidence. (Compare Case C' with Case A'. Case C' represents a situation where pillars 75 feet square rest on underclay four feet thick. The shear strength of the underclay is 2-1/4 tsf and the bearing capacity is 18 tsf. Case A' represents a situation where the pillars and underclay thickness are the same as in Case C', but the shear strength of the

Table 8.1
(Continued)

underclay is 4 tsf. Here the bearing capacity is 31 tsf. Flooding of a mine may effect a reduction in shear strength, such as from A' to C', and if the factor of safety is low enough, this may be sufficient to bring about a bearing capacity failure of the mine floor.

Reproduced from best available copy.

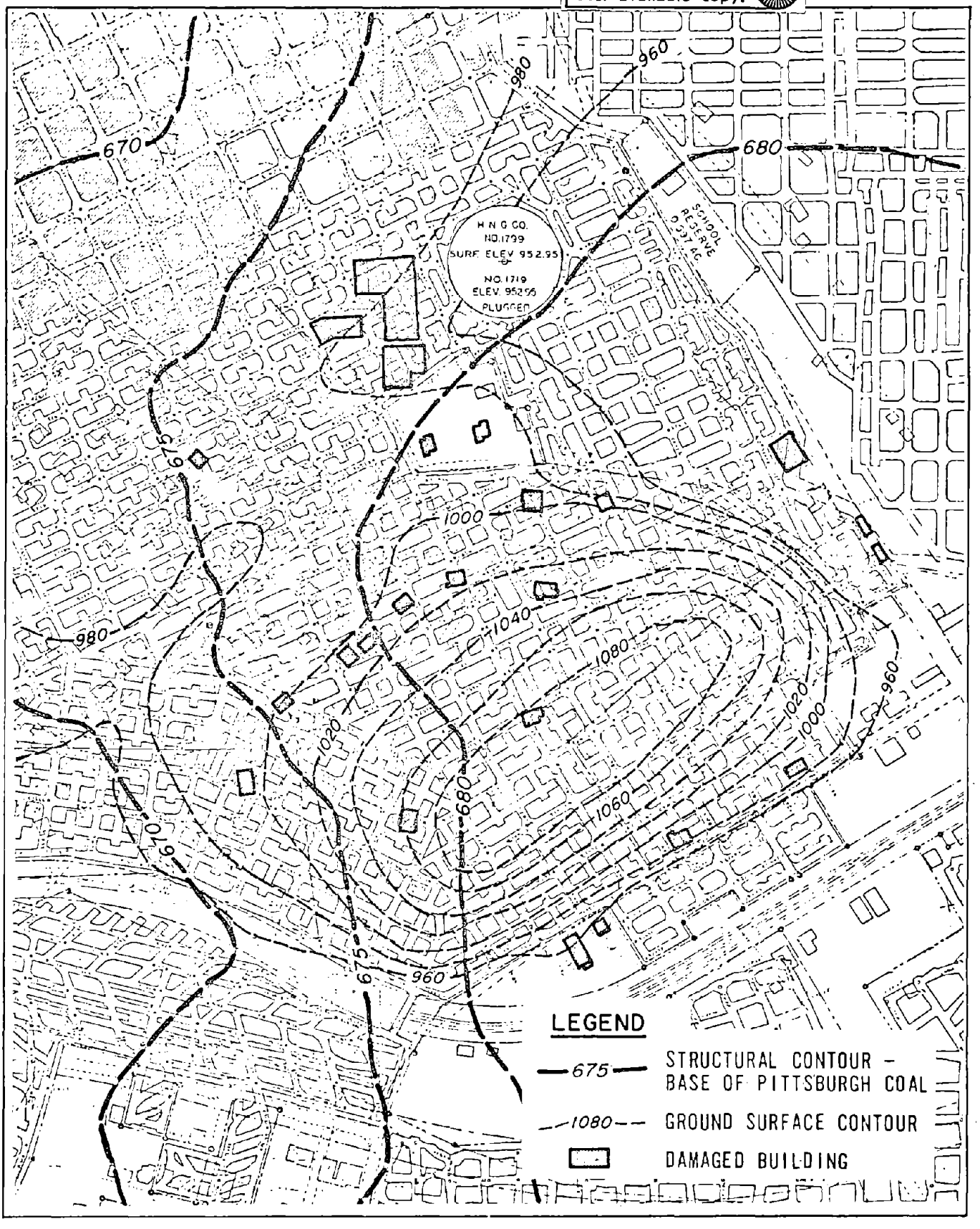


FIGURE 8.1 MAP OF MINE LOCATED BENEATH SITE 1200, FARMINGTON, MARION COUNTY, WEST VIRGINIA (AFTER WEST VIRGINIA DEPARTMENT OF NATURAL RESOURCES)

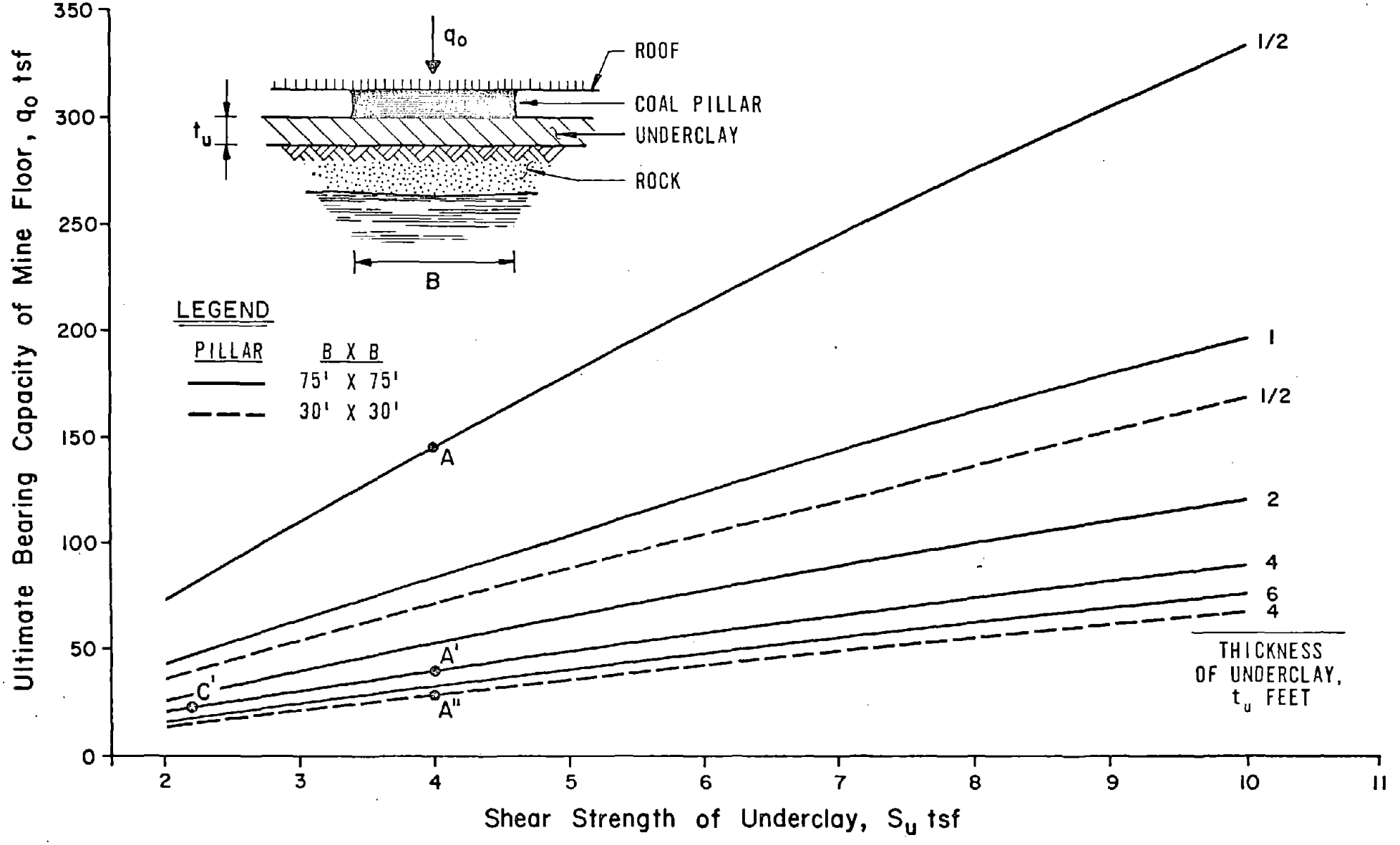


FIGURE 8.2 VARIATION IN BEARING CAPAPACITY OF MINE FLOOR RELATIVE TO SHEAR STRENGTH AND THICKNESS OF UNDERCLAY AND PLAN DIMENSIONS OF COAL PILLARS

9. COSTS OF SUBSIDENCE TO THE PUBLIC

Costs associated with subsidence can be separated into three categories--those due to repair of homes and property, those due to elimination of hazardous conditions, and those due to prevention of subsidence.

Damage to Homes and Property

Of the 354 incidents of subsidence documented in the present study, all taking place in the period 1956 through 1976, 111 or nearly 1 in 3 involved damage to property. Of these, 97 incidents resulted in damage to 249 structures, an average of 2.6 structures per incident in which a structure was damaged. The single incident in West Virginia (Site 1200) was abnormally large and damaged 43 structures. Excluding it from the total, the number of structures per structure damage incident averaged 2.2 (Figure 9.1). Eleven other incidents have involved damage to steets and roadways.

Thirty-nine percent of the damaged homes were located less than 100 feet above mine level. Forty-one percent of the damaged homes were affected by trough subsidence. Trough subsidence incidents were far fewer in number than sinkholes, but damaged proportionately more homes owing to their greater individual areal extent. Damage was caused primarily by differential movements of the foundations, and less frequently by increased earth pressures on foundation walls.

Cost data relative to home damage are available for 39 of the 249 structures. These 39 were insured by the Pennsylvania Mine Subsidence Insurance Fund and received cash settlements totalling $231,000. The distribution of dollar amounts by claim is shown in Figure 2.21. Assessed valuations of 21 of the 39 homes are known, and averaged $30,000 per home. Dollar damage to these 21 homes amounted to 29 percent of their collective assessed valuation. Assuming that all structures documented in this study were damaged to the same extent as the 39 insured homes, then a rough (and possibly high) estimate of the dollar damage to the 30 or so homes damaged each year by subsidence above the mined Pittsburgh Coalbed is $178,000.

Dollar damage to the more than 40 homes and structures in the West Virginia incident was estimated to be in excess of $800,000 [112].

Commonly required repairs to subsidence damaged homes in western Pennsylvania have been realignment of doors and windows, replacement of brickwork, patching of cracks, and repainting. More extensive repairs have included releveling of homes and reconstruction of foundations and basements. Detailed itemizations of repairs were available for only a few of the damaged homes, and unfortunately with the data available, it is not possible to devise a scale or rating system that correlates extent of damage to thickness of overburden or other parameters.

Nonetheless, it is significant that some of the most severe damage to homes has taken place 100 or more feet above mine level (150 feet at Site 248 and 230 to 450 feet at Site 1200), whereas not may years ago it had been commonly assumed (evidently for lack of documentation to the contrary) that homes 100 or more feet above mine level were relatively free of the threat of subsidence once mining had been completed.

Elimination of Hazardous Conditions and Prevention of Subsidence

Since the early 1960's as part of a state general funds program, the Pennsylvania Office of Mine Area Restoration has filled with soil those sinkholes that they considered hazardous. Approximately $40,000 is expended in this work per year in the bituminous coal region of western Pennsylvania, and the great majority is used to fill the 30 or more sinkholes reported above the Pittsburgh Coal annually[77].

Since 1967, the same office has also been engaged in flushing abandoned mines with fly ash or mine refuse to abate on-going subsidence. Fifty-five sites underlain by the Pittsburgh Coal have been flushed in the first nine years of the program. Most of the sites have been in Allegheny County[77].

Flushing projects are conducted under Operation Scarlift, which is financed under Pennsylvania's $500 million Land and Water Conservation and Reclamation Fund, authorized by Amendment to Article IX of the Constitution of Pennsylvania[84]. Thirty million dollars of the fund have been designated for abating subsidence above abandoned mines in the state's anthracite and bituminous regions and for the control and extinguishment of fires in abandoned mines. Approximately $2 million has been spent thus far in Pennsylvania for abating on-going subsidence in abandoned mines in the Pittsburgh Coal. Yearly costs vary, but have averaged about $220,000 [77]. Costs of flushing the 40-acre site in West Virginia will be about $1 million[90]. That project is funded jointly by the State of West Virginia and the Federal government under the Appalachian Program.

Discussion

Considering the size and population of the Pittsburgh Coal Region--6,000 square miles and 3-1/2 million persons--the annual frequency and costs of subsidence above abandoned mines appears to be rather small. Although untold numbers of sinkholes and troughs probably develop each year, subsidence that damages property or creates hazardous conditions above abandoned mines in Maryland, Ohio, and West Virginia, is apparently nonexistent, except for the single incidents in Maryland (Site 1000) and West Virginia (Site 1200). In relatively highly populated Pennsylvania, only about 45 such subsidence incidents are reported each year. In Pennsylvania, remedial measures and repairs associated with these 45 incidents cost an estimated $438,000 annually--$260,000 in state funds to fill sinkholes and flush mines, and $178,000 in insurance premiums and personal funds to repair damaged homes.)

Seventy percent of the subsidence incidents documented in this study have been located in Allegheny County, Pennsylvania, which is also the most densely populated section of the region. Documented subsidence incidents in the county in recent years (1971-1975) have numbered 1 per 35,000 individuals residing over the mined-out area and 1 per 10,500 housing units located above the mined-out area (Figure 9.2). Distributing these costs among county residents residing above the mined-out area amounts to 28 cents per capita per year.

The costs of subsidence are in fact somewhat higher than this figure indicates. Costs not included in the foregoing are those due to damage to commercial structures utilities or transportation rights-of-way, and those that might be considered preventive costs--those which derive from engineering and construction measures undertaken to prevent or minnimize subsidence damage to buildings.

Specific data on damage to commercial structures are almost completely lacking, although interviews with individuals associated with various commercial interests suggested that difficulties due to subsidence above abandoned mines are not common and for the most part are not differentiable from those due to ground movements of other origin. It would seem that costs in this category probably do not exceed those of damage to homes.

Engineering and construction costs associated with building over mined-out areas (modular construction, specially reinforced shallow foundations, deep foundations to the base of the mine, grout-gravel columns within the mine, and mine flushing)[2, 11, 37, 45, 47] may add ten percent to the cost of a structure. The total costs that have been associated

with this activity to date cannot be assessed with any reliability. However, most of such costs have been associated with the construction of major structures rather than residences, and most have been employed only during the past two decades.

Assessment of the costs of subsidence above abandoned mines in the period before the mid-1950's is virtually impossible. Records of subsidence prior to the mid-1950's are almost nonexistent, probably due in great part to the lack of a designated government authority in that period to deal with subsidence related problems. Even so, it is probable that subsidence of consequence was less than today owing to a lesser population, a greater proportion of frame buildings better able to accommodate the ground movements, and perhaps a lesser frequency of subsidence above mines that were, at that time, less deteriorated. Furthermore, subsidence may to some extent have been accepted as a "way of life". This attitude seems to be reflected in a study of subsidence made 60 years ago[114]. Although principally concerned with subsidence due to active mining, it is probably equally true for abandoned mines".....

> The outcrop of the Pittsburgh Coalbed extends for many miles in western Pennsylvania, and above these shallow workings many sinkholes have formed. These have attracted very little public attention, as they are considered to be of only a temporary character and most of the buildings above the mined areas are frame and the damage to them has also been only temporary, for if tilted out of line, these buildings have frequently resumed their normal condition after a few months."

Now more than ever before, communities are spreading out to areas mined in years past. Over 10,000 homes in southwestern Pennsylvania are supported by coal pillars purchased and left in place during mining to support the ground surface[23]. Many other homes are now being constructed over areas mined by modern full extraction methods where the probability of future subsidence is small. However, a considerable number of homes are being constructed in areas without pillar support, mined before modern methods had been developed. For many of these homes future subsidence is a definite possibility. On account of this it is expected that the costs associated with subsidence above abandoned mines will increase. It seems apparent now that the more efficient mining methods that are currently being practiced will benefit society not only from the standpoint of conservation of coal, but also by eliminating future burdens of repairing damaged property and undertaking costly measures to prevent subsidence.

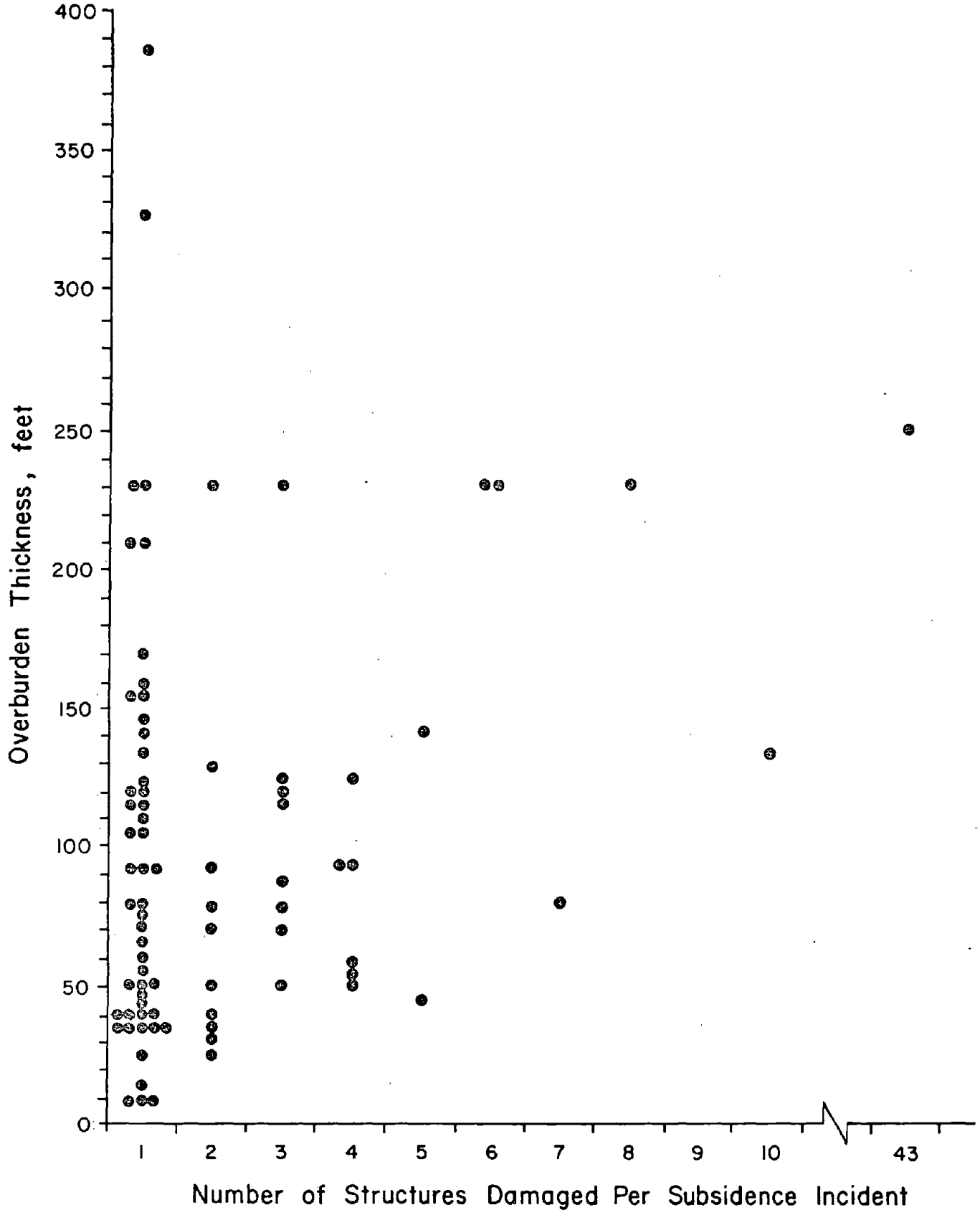
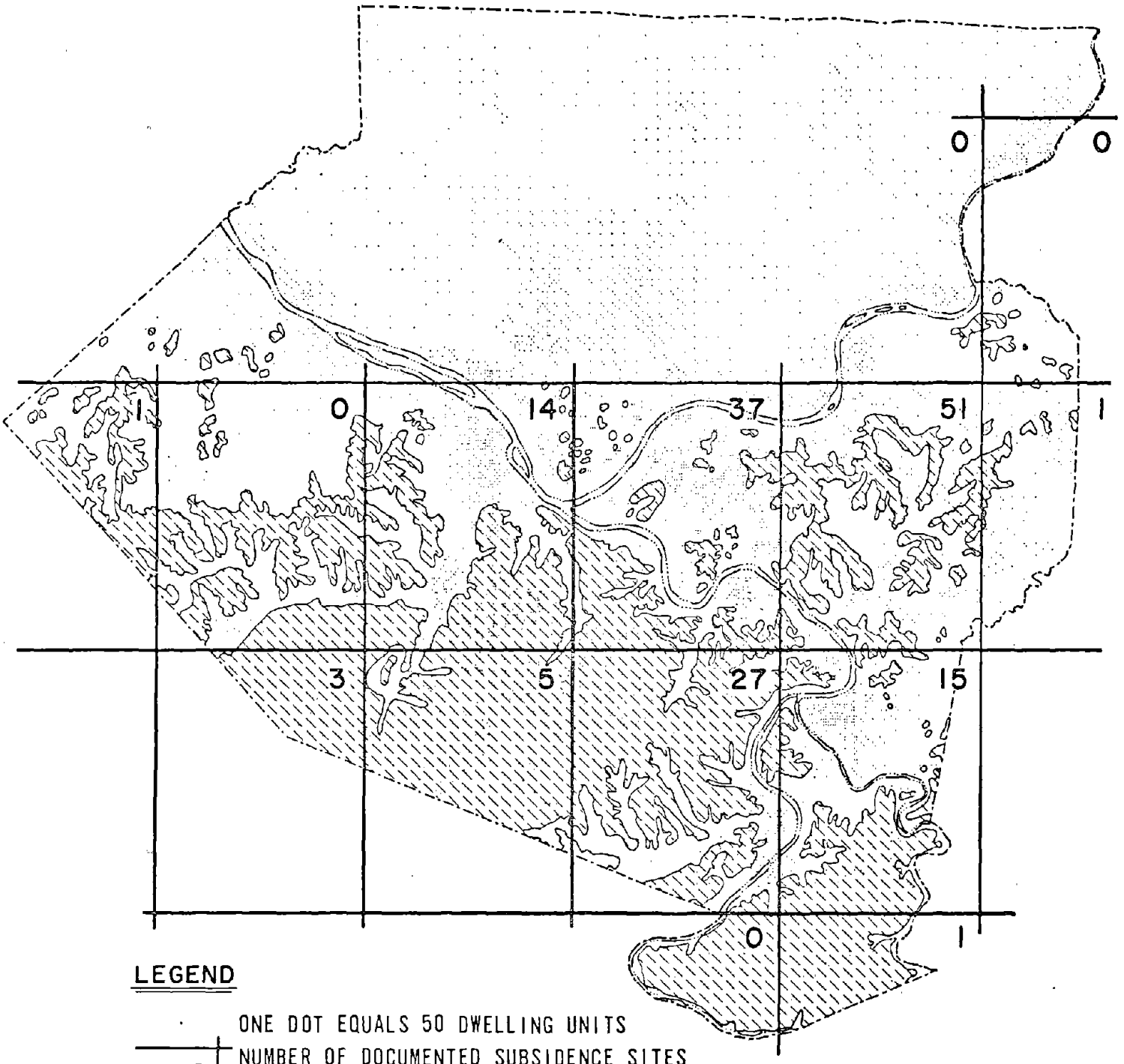


FIGURE 9.1 NUMBER OF STRUCTURES DAMAGED PER SUBSIDENCE INCIDENT RELATIVE TO OVERBURDEN THICKNESS



LEGEND

· ONE DOT EQUALS 50 DWELLING UNITS

15 | NUMBER OF DOCUMENTED SUBSIDENCE SITES WITHIN 7.5' QUADRANGLE

NOTE:

BASE MAP PREPARED BY SOUTHWESTERN PENNSYLVANIA REGIONAL PLANNING COMMISSION (OCTOBER, 1967).

FIGURE 9.2 DOCUMENTED SUBSIDENCE SITES IN ALLEGHENY COUNTY, PENNSYLVANIA (1957 - 1976) RELATIVE TO DISTRIBUTION OF TOTAL DWELLING UNITS

10. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This report summarizes the available information relative to documented incidents of subsidence that have taken place above abandoned mines in the Pittsburgh Coal Region. Three hundred fifty-four incidents have been identified at 302 individual sites, all in the period 1955-1976. Three hundred of the sites were located in Pennsylvania, one was located in Maryland, and one was located in West Virginia. None were located in Ohio.

Generalizations regarding the geometry of the subsidence features, their location, frequency of occurrence, relationship to mining and so on, were presented in Section 2 along with several case histories that illustrate the character of subsidence over abandoned mines. The geologic setting of the Pittsburgh Coal Region was reviewed in Section 3, and the type of mining practiced decades ago in areas now experiencing subsidence was reviewed in Section 4. The mechanisms governing sinkhole and trough subsidence were discussed in Sections 5 through 8 and the costs to the public of subsidence above abandoned mines were discussed in Section 9. Details regarding individual subsidence incidents were presented in Table A and locations were presented on U.S.G.S. topographic maps in the accompanying folio.

Conclusions and Recommendations

Much of the mining practiced decades ago was less efficient than today. Coal was relatively cheap and there was less motivation for full extraction. Entries and rooms remaining after abandonment of these mines are now collapsing due to deterioration of coal pillars, mine roof, or mine floor. This is leading to the development of sinkholes and troughs. Few detailed investigations have been conducted to ascertain the factors responsible for subsidence at particular sites, and an element of speculation is still involved in the interpretation of any subsidence incident. It is evident, nonetheless, that activities by man following mining sometimes hasten the subsidence process.

The data collected in this study are almost all empirical and consequently can be applied only tentatively to areas outside the Pittsburgh Coal Region. Published reports regarding subsidence in other parts of the United States and Europe indicate that subsidence features in those areas resemble subsidence features in the Pittsburgh Coal Region at least qualitatively. Insofar as this is true, it is

probable that the mechanisms responsible for subsidence are similar. Where the stratigraphy and mining methods are similar to those in the Pittsburgh Coal Region, a very close similarity in subsidence features is expected. There is no known body of data comparable to that in the present study to permit correlation with subsidence as it occurs elsewhere.

Subsidence above abandoned mines in the Pittsburgh Coal presently costs the taxpayers of Pennsylvania about $438,000 annually. This cost is associated with repair of damaged homes and property, rectification of hazardous conditions, and implementation of measures to abate on-going subsidence. While this amount is actually quite small on a per capita basis, individual subsidence incidents still present a substantial financial and psychological hardship to those whose homes or property have been damaged. As communities spread over areas mined long ago, the number of reported incidents of subsidence will undoubtedly increase.

The study suggests that there is really no distance above mine level that is safe from subsidence. Although sinkholes are not usually found more than 100 feet above a mine, troughs have developed hundreds of feet above mine level, and these have caused some of the most severe damage to homes.

Although the large number of subsidence incidents catalogued in this study has permitted the delineation of certain common characteristics of subsidence in the Pittsburgh Coal Region, data are not adequate to establish correlations between damage to structures and thickness of overburden or other parameters. It is clear that there is no means available as yet to predict from these data exactly when or where subsidence will take place in the future. The possibility of subsidence must be expected anywhere in the region unless it can be proved that the area has not been mined, that long-term pillar support has been provided or that the mine voids are fully collapsed.

While it is doubtful that one will ever be able to predict with precision the time of occurrence or the extent of subsidence at a particular site, it may ultimately be possible to determine the likelihood of subsidence taking place at a particular site based on certain geologic, mining, and other criteria. The ability to make such determinations would materially assist the engineering profession in more economic design of structures above mined-out areas and in establishing the most economical subsidence prevention measures for particular site situations. Agencies like the U. S. Department of Housing and Urban Development, which is currently engaged in a program to develop guidelines for the construction of housing in mine subsidence areas, would be particularly benefitted. But, the development of correlations and criteria depend on more refined data than have been collected to date.

For this reason, it is strongly recommended that a continuing program of collection and interpretation of subsidence data be implemented, refining the relationships for the Pittsburgh Coal Region that have been defined in the present work and broadening the data base to other coalbeds in Pennsylvania and other localities where subsidence is an important consideration.

It is apparent from the present work that data for this purpose must be current and must be collected immediately after subsidence has taken place. The most practical vehicle for collection of these data seems to be the state agencies that are directly involved in subsidence control and abatement. Pennsylvania is one of the few states that maintains such agencies; and so, it may be most reasonable for the present to restrict continuing program efforts to Pennsylvania. Of course, ultimately, it would be of benefit to collect and interpret data from a variety of geographic, geologic, and mining environments.

To ensure uniformity and thoroughness in data collection, data for each subsidence incident should be tabulated in a format such as Table A of the present report and should include a detailed description, including photographs of damage to structures, made in the context of a damage rating system such as shown in Table 10.1.

A body of engineers from the government and private sectors should be established to periodically review the data collected and develop on the basis of their review the criteria that will lead to more rational engineering practice in mined-out areas.

The activities outlined above should be coordinated and funded by the Bureau of Mines and other agencies that promise to benefit from the information derived, and the information so-derived should be disseminated to the public by these agencies on a regular basis.

TABLE 10.1

Classification

of

Subsidence Damage

(Pennsylvania Department of Environmental Resources)

	Damage Level	Description of Typical Damage
1.	Very Slight	Hairline cracks in plaster. Perhaps isolated slight fracture in the building, not visible on outside.
2.	Slight	Several slight fractures showing inside the building. Doors and windows may stick slightly.
3.	Medium	Slight fracture showing on outside of building (or one main fracture). Doors and windows sticking; service pipes may fracture.
4.	High	Service pipes disrupted. Open fractures requiring rebonding and allowing weather into the structure. Window and door frames distorted; floors sloping noticeably; walls leaning or bulging noticeably. Some loss of bearing in beams. If compressive damage, overlapping of roof joints and lifting of brickwork with open horizontal fractures.
5.	Very High	As above, but worse, and requiring partial or complete rebuilding. Roof and floor beams lose bearing and need shoring up. Windows broken with distortion. Severe slopes on floors. If compressive damage, severe buckling and bulging of roof and walls.

REFERENCES

1. A. W. Martin Associates, "Development of a Comprehensive Program of Insurance Protection Against Mining Subsidence and Associated Hazardous Location Risks", Report ARC-73-163-2558, prepared for Appalachian Regional Commission, Washington, D.C., June 1975.

2. A. W. Martin Associates, "Relationship Between Underground Mine Water Pools and Subsidence in the Northeastern Pennsylvania Anthracite Fields," Report ARC-73-111-2553, prepared by Appalachian Regional Commission, Washington, D.C., April 1975.

3. Ackenheil, A. C. and M. T. Dougherty, "Recent Development in Grouting for Deep Mines," presented at the September 1968, ASCE Annual Meeting and National Meeting on Structural Engineering, held at Pittsburgh, Pennsylvania, preprint 727, 1968.

4. Adler, L. and M. C. Sun, "Ground Control in Bedded Formations," Virginia Polytechnic Institute Research Division, Bulletin 28, December 1968.

5. Afrouz, A., "Yield and Bearing Capacity of Coal Mine Floor," International Journal of Rock Mechanics and Mining Sciences, Volume 12, 1975.

6. Ashley, George H., "The Maximum Rate of Deposition of Coal," Economic Geology, Volume 2, January and February 1907.

7. Ashley, George H., "Production and Reserves of the Pittsburgh Coalbed," Transactions of the American Institute of Mining and Metallurgical Engineers, Volume 130, pp. 56-64, 1938.

8. Barry, A. J. and O. B. Nair, "In Situ Tests of Bearing Capacity of Rock and Floor in Selected Bituminous Coal Mines," Bureau of Mines, RI 7406, June 1970.

9. Battista, W. (personal communication).

10. Bauschinger, J., Mitteilungen aus dem Mechanisch - Technischen Laboratorium der K. Technischen Hochschule in Munchen, Volume 6, 1876.

11. Bell, F. A., editor, Methods of Treatment of Unstable Ground, Newnes-Butterworths, London, 1975.

12. Berryhill, H. L., S. P. Schweinfurth, and B. H. Kent, "Coal-Bearing Upper Pennsylvania and Lower Permian Rocks, Washington Area, Pennsylvania," Professional Paper 621, U. S. Geological Survey, 1971.

13. Bieniawski, Z. T., "In Situ Strength and Deformation Characteristics of Coal," Engineering Geology, Volume 2, No. 5, August 1968.

14. Black, W. (personal communication).

15. Brauner, G., "Subsidence Due to Underground Mining," (in two parts) U. S. Bureau of Mines, I. C. 8571 and 8572, 1973.

16. Briggs, H., Mining Subsidence, Edward Arnold and Company, London, 1929.

17. Bureau of Mines Staff Engineers, "Investigation of Subsidence in Farmington, Marion County, West Virginia," U. S. Bureau of Mines, Mineral Resources and Environmental Development, February 1974.

18. Bushnell, K. O., "Map Showing Areas that Correlate with Subsidence Events due to Underground Mining of the Pittsburgh and Upper Freeport Coalbeds, Allegheny, Washington, and Westmoreland Counties, Pennsylvania," U. S. Geological Survey Map, MF-693C, 1975a.

19. Bushnell, K. O., "Map Showing Depths to the Pittsburgh Coalbed, Mining Activity and Related Surface Subsidence, Allegheny, Washington, and Westmoreland Counties, Pennsylvania," U. S. Geological Survey Map MF-693A, 1975b.

20. Caudle, R. D., "Mine Roof Stability," in Ground Control Aspects of Coal Mine Design, Proc. Bureau of Mines Technology Transfer Seminar, Lexington, Kentucky, March 1973.

21. Century Engineering, Inc., "Mine Subsidence Risk Evaluation, Frostburg State College, Frostburg, Maryland," prepared for Maryland Department of General Services, Baltimore by Century Engineering, Inc., Towson, Maryland, 1975.

22. Coates, D. F., Rock Mechanics Principals, Department of Energy, Mines and Resources, Mines Branch Monograph 874, Ottawa, Canada, 1967.

23. Cortis, S. E., (personal communication).

24. Cortis, S. E., "Coal Mining and Protection of Surface Structures are Compatible," American Mining Congress Coal Convention, Pittsburgh, 1969.

25. Cortis, S. E., T. B. Alexander, W. E. Edmunds and J. L. Craft, "Greater Pittsburgh Region Maps of Mined-Out Areas and Thickness of Rock over the Pittsburgh Coal," Pennsylvania Geological Survey Map 45, 1975.

26. Crane, W. R., "Essential Factors Influencing Subsidence and Ground Movement," U. S. Bureau of Mines I.C. 6501, 1931.

27. Cross, A. T., 1952, "The Geology of Coal," Report of Investigations No. 10, State of West Virginia, 1952.

28. Dahl, H. D. and R. C. Parsons," Ground Control Studies in the Humphrey No. 7 Mine, Christopher Coal Division, Consolidation Coal Company," AIME preprint 71-AM-101, 1971.

29. Daniels, J. and L. D. Moore, "The Ultimate Crushing Strength of Coal," Engineering and Mining Journal, August 1907.

30. DeLong, R. M., "The Pittsburgh No. 8 and Redstone No. 8A Coalbeds in Ohio," Ohio Division of Geological Survey, Report of Investigations No. 26, Columbus, 1955.

31. Denkhaus, H. G., "A Critical Review of the Present State of Knowledge Related to the Strength of Mine Pillars," Journal of the South African Institute of Mining and Metallurgy, 1962.

32. Dowd, J. J., L. A. Turnbull, A. L. Toenges, R. F. Abernethy, and D. A. Reynolds, "Estimate of Known Recoverable Reserves of Coking Coal in Westmoreland County, Pennsylvania," U. S. Bureau of Mines, R.I. 4803, 1951.

33. Eavenson, H. N., 1938, The Pittsburgh Coalbed: Its Early History and Development, The American Institute of Mining and Metallurgical Engineers.

34. Edgerton, C. D., "The Mine Map Repository - A Source of Mine Map Data," U. S. Bureau of Mines, I. C. 8657, 1974.

35. Fayol, H., "Sur les Mouvements de Terrain Proroque's par L'.Exploitation des Mines," Bul. de la Societe' de L'Industrie Minerale, II ser, V 14, 1885.

36. Gaddy, F. L., "A Study of the Ultimate Strength of Coal as Related to the Absolute Size of the Cubical Specimens Tested," Bulletin of the Virginia Polytechnic Institute, No. 112, 1956.

37. Gamble, J. C., and R. E. Gray, "Mine Subsidence and Mine Subsidence Control," The Encyclopedia of Applied Geology, Encyclopedia of Earth Science Series, R. W. Fairbridge and C. W. Finkl, Jr., eds., Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pennsylvania, 1976.

38. General Analytics, Inc., "Evaluation of Mine Subsidence, Neighborhood Development Program, Webster-Elba and Roberts-Devilliers Project Action Areas," prepared for Urban Redevelopment Authority of Pittsburgh, March 1973.

39. General Analytics, Inc., "Investigation of Earth Movements at Farmington, West Virginia," February 1974.

40. General Analytics, Inc., "Subsurface and Mining Investigation, Proposed High Rise Apartment, Mt. Washington, Pittsburgh, Pennsylvania," March 1966.

41. Germanis, E. and S. Valliappan, "Mining Subsidence at the Graving Dock Site, New Castle," Symposium on Recent Developments in the Analysis of Soil Behavior and their Application to Geotechnical Structures, University of New South Wales, Australia, 1975.

42. Getzler Z., M. Gellart, and R. Eitan, "Analysis of Arching Pressures in Ideal Elastic Soil", Journal of the Soil Mechanics and Foundations Division, Proc. ASCE, Vol. 96, No. SM4, July 1970.

43. Geyer, J. N., "Factors and Conditions that Aid in Alinement of Pillar Extraction Lines in Coal Mining," U. S. Bureau of Mines, IC 6727, June 1933.

44. Gray, R. E., J. C. Gamble, R. J. McLaren and D. J. Rogers, "State of the Art of Subsidence Control," Report ARC-73-111-2550, prepared by General Analytics, Inc., for the Appalachian Region Commission, Washington, D. C., 1974.

45. Gray, R. E., and J. F. Meyers, "Mine Subsidence and Support Methods in Pittsburgh Area," Journal of the Soil Mechanics and Foundations Division, Proc. ASCE, Vol. 96, No. SM4, April 1970.

46. Gray R. E. and H. A. Salver, Discussion of "State of Predictive Art in Subsidence Engineering," by B. Vought and W. Pariseau, ASCE Proc. Paper 7187, 1970.

47. Gray, R. E., H. A. Salver, and J. C. Gamble, "Subsidence Control for Structures Above Abandoned Coal Mines," presented at Symposium on Cavern and Mine Subsidence, Session 91, 55th Annual Meeting, Transportation Research Board, Washington, D. C., 1976.

48. Greenwald, H. P., H. C. Howarth, and I. Hartman, "Experiments on Strength of Small Pillars of Coal in the Pittsburgh Bed," U. S. Bureau of Mines, Technical Paper 605, 1939.

49. Greenwald, H. P. and E. R. Maize," Studies of Roof Movements in Coal Mines," U. S. Bureau of Mines, RI 3452, 1939.

50. Greenwald, H. P., E. R. Maize, L. Hartman, and G. S. Rice, "Studies of Roof Movement in Coal Mines, I. Montour 10 Mine of the Pittsburgh Coal Co.," U. S. Bureau of Mines, R.I. 3355, 1937.

51. Griffith, W., and E. T. Conner, "Mining Conditions Under the City of Scranton, Pennsylvania," U. S. Bureau of Mines, Bulletin 25, 1912.

52. Hall, R. C., "The Strength of Mine Roofs," Mines and Minerals, Volume 30, 1910.

53. Hausse, R., "Vonder Niedergehen des Gebirges beim Kohlenbergbau und den damit Zusammenhagenden Boden- und Gebaudessen kungen," Ziet für das Berg-Hütten und Salinenwesen, 1907.

54. Herbert, C. A., and J. J. Rutledge, "Subsidence Due to Coal Mining in Illinois," U. S. Bureau of Mines, Bulletin 238, 1927.

55. Heuze' F. E., and R. E. Goodman, "Room and Pillar Structures in Competent Rock," Underground Rock Chambers, ASCE, 1971.

56. Hickock, W. O. IV, and F. T. Moyer, "Geology and Mineral Resources of Fayette County, Pennsylvania," Bulletin C26, Pennsylvania Geological Survey, Fourth Series, 1940.

57. Holland, C. T., "Pillar Design for Permanent and Semi-Permanent Support of the Overburden in Coal Mines," Proc., 9th Canadian Rock Mechanics Symposium, Montreal, 1973.

58. Holland, C. T., "The Strength of Coal Mine Pillars," Proceedings of the 6th Symposium on Rock Mechanics, University of Missouri, Rolla, 1964.

59. Holland, C. T. and F. L. Gaddy, "Same Aspects of Permanent Support of Overburden on Coalbeds," Proc., West Virginia Coal Mining Institute, 1957.

60. Hustrulid, W. A., "A Review of Coal Pillar Strength Formulas," Rock Mechanics, Vol. 8, No. 2, July 1976.

61. Jeffrey - A Century of Pioneering in Mining Machinery Worldwide, Jeffrey Planning Machinery Division, Dresser Industries, 1976.

62. Jennings, J. E., "Building on the Dolomites in the Transvaal," The Civil Engineer in South Africa, 1966.

63. Johnson, M. E., "Atlas of Pennsylvania, No. 27 Pittsburgh Quadrangle," Pennsylvania Geological Survey, Fourth Series, 1929.

64. Johnson, M. E., "Mineral Resources of the Greensburg Quadrangle, Westmoreland County, Pennsylvania," Bulletin A37, Pennsylvania Geological Survey, Fourth Series, 1925.

65. Keystone Coal Industry Manual, McGraw Hill, Inc., 1975.

66. Kidder, N. (personal communication).

67. Kohl, W. R., and Briggs, R. P., "Map of Rock Types in Bedrock of Allegheny County, Pennsylvania," U. S. Geological Survey, Map MI-685A, 1975.

68. Lewis, R., and Clark, A., Elements of Coal Mining, 3rd Edition, McGraw-Hill, New York, 1966.

69. Littlejohn, S., "Old Coal Workings - A Cover-Up Job," Ground Engineering, Volume 8, No. 1, January 1975.

70. Magnuson, M. O., (personal communication).

71. Magnuson, M. O., and Cox, R., "Environmental Protection of Surface Areas near Underground Mining Sites," Coal Age, July 1975.

72. Maize, E. R., and Greenwald, H. P., "Studies of Roof Movement in Coal Mines, Crucible Mine of the Crucible Fuel Company," U. S. Bureau of Mines, RI 3452, June 1939.

73. Maize, E. R., Thomas, E., and Greenwald, H. P., "Studies of Roof Movement in Coal Mines, Study of Subsidence of A Highway Caused by Mining Coal Beneath," U. S. Bureau of Mines, RI 3562, March 1941.

74. McCulloch, C. M., Diamond, W. P., Bench, B. M., and Deul, M., "Selected Geologic Factors Affecting Mining of the Pittsburgh Coalbed," U. S. Bureau of Mines, RI 8093, 1975.

75. Moebs, N. N., "Geologic Guidelines in Coal Mine Design," in Ground Control Aspects of Coal Mine Design, Proc. Bureau of Mines Technology Transfer Seminar, Lexington, Kentucky, March 1973.

76. Molinski, A. E., (personal communication).

77. Morgan, T. A., "Coal Mine Roof Problems," in Ground Control Aspects of Coal Mine Design, Proc., Bureau of Mines Technology Transfer Seminar, Lexington, Kentucky, March 1973.

78. National Coal Board, Subsidence Engineers' Handbook, National Coal Board, London Second Edition, 1975.

79. National Oceanic and Atmospheric Administration Climatography of the United States, Climates of the States, Annual Summary of Chimatological Data for the Commonwealth of Pennsylvania, U. S. Department of Commerce, Washington, D. C., 1971-1975.

80. Newhall, F. W., and L. N. Plein, "Susidence at Merrittstown Air Shaft Near Brownsville, Pennsylvania," Proc., AIME, 1933.

81. Obert, L., and W. I. Duvall, Rock Mechanics and the Design of Structures in Rock, John Wiley and Sons, Inc., 1967.

82. Officials of the National Oceanic and Atmospheric Administration, Climates of the States Volume I - Eastern States Plus Puerto Rico and the U. S. Virgin Islands, Water Information Center, Inc., 1974.

83. Paul, J. W., and Plein, L. N., "Methods of Development and Pillar Extraction in Mining the Pittsburgh Coalbed in Pennsylvania, West Virginia, and Ohio," U. S. Bureau of Mines, I. C. 6872, December 1935.

84. Pennsylvania Department of Environmental Resources, "Bond Issue Report for Period Ending June 1975," Department of Environmental Resources, Harrisburg, Pennsylvania, 1975.

85. Philbrick, S. S., "Cyclic Sediments and Engineering Geology," Proc., Twenty-First International Geological Congress, International Geological Congress, 1960.

86. Rankilor, P. T., "The Construction of a Photoelastic Model Simulating Mining Subsidence Phenomena," International Journal of Rock Mechanics and Mining Sciences, Vol. 8, No. 5, September 1971.

87. Rankilor, P. R., "Engineering Geology and Mining," Ground Engineering, Vol. 9, No. 7, October 1976.

88. Reppert, A. E., "Pillar Falls and the Economic Recovery of Coal from Pillars," Proc., West Virginia Coal Mining Institute, 1911.

89. Rice, G. S., "Tests of Strength of Roof Supports used in Anthracite Mines of Pennsylvania," U. S. Bureau of Mines, Bulletin 303, 1929.

90. Ryan, R., (personal communication).

91. Schweinfurth, S. P., "Geologic Map of the California Quadrangle," U. S. Geological Survey, GO 648, 1967.

92. Sheorey, P. R., and Singh, B., "Strength of Rectangular Pillars in Partial Extraction," International Journal of Rock Mechanics and Mining Sciences, Vol. 11, No. 1, January 1974.

93. Sneddon, D. R., (personal communication).

94. Southwestern Pennsylvania Regional Planning Commission, "Preliminary Data Report No. 1, Selected Household Characteristics for Allegheny County," Southwestern Regional Planning Commission, Pittsburgh, Pennsylvania, 1969.

95. Stahl, R. W., "Extracting Final Stump in Pillars and Pillar Lifts with Continuous Miners," U. S. Bureau of Mines, RI 5631, 1960.

96. Stone, R. W., "Geology and Mineral Resources of Greene County, Pennsylvania," Bulletin C2, Pennsylvania Geological Survey, Fourth Series, 1932.

97. Swanson, V. E. and H. L. Berryhill, Jr., "Geology of the Washington East Quadrangle, Pennsylvania," U. S. Geological Survey, GQ 334, 1974.

98. Terzaghi, K., "Rock Defects and Loads on Tunnel Supports," in Rock Tunneling with Steel Supports, by R. V. Proctor and T. L. White, Commercial Shearing and Stamping Company, 1946.

99. Terzaghi, K. and R. B. Peck, Soil Mechanics in Engineering Practice, John Wiley and Sons, New York, 1967.

100. Thomas, L. J., An Introduction to Mining, Hicks Smith and Sons, Sydney, 1973.

101. Thornbury, W. D., Regional Geomorphology of the United States, John Wiley and Sons, New York, 1965.

102. Tilton, J., (personal communication).

103. Vesic, A., "Bearing Capacity of Shallow Foundations," in Foundation Engineering Handbook, Winterkorn and Fang, Eds., Van Nostrand Reinhold Company, New York, 1975.

104. Voight, B., and W. Pariseau, "State of Predictive Art in Subsidence Engineering," Journal of the Soil Mechanics and Foundation Division, Proceedings of the American Society of Civil Engineers, Vol. 96, No. SM 2, 1970.

105. Wagner, W. R., Craft, J. L., Heyman, L., and Harper, J. A., "Greater Pittsburgh Region Geologic Map and Cross-Sections," Pennsylvania Geological Survey, Map 42, 1975a.

106. Wagner, W. R., Heyman, L., Craft, J. L., Edmunds, W. E., and Harper, J. A., 1975b, "Greater Pittsburgh Region Structure Contour Map," Pennsylvania Geological Survey, Map 43.

107. Wagner, W. R., Heyman L., Gray, R. E., Belz, D. J., Lund, R., Cate, A. S., and Edgerton, C. D., "Geology of the Pittsburgh Area," Pennsylvania Geological Survey General Geology Report G59, 1970.

108. Wallace, J. J., J. J. Dowd, J. M. Provost, R. F. Abernethy, and D. A. Reynolds, "Estimate of Known Recoverable Reserves of Coking Coal in Allegheny County, Pennsylvania, U. S. Bureau of Mines, RI 5003, 1953.

109. Wallace, J. J., W. Dowd, J. M. Provost, R. F. Abernethy, and D. A. Reynolds, "Estimate of Known Recoverable Reserves of Coking Coal in Washington County, Pennsylvania," U. S. Bureau of Mines, RI 5109, 1955.

110. Wanless, H. R., Baroffio, J. R., and Trescott, P. C., "Conditions of Deposition of Pennsylvania Coalbeds," Proc., Symposium on Environments of Coal Deposition, Annual Meeting, Miami Beach, Florida, Special Paper No. 114, Geological Society of America, Boulder, Colorado.

111. White, L. C., G. H. Ashley, and J. A. Bownocker, "The Pittsburgh Coalbed," Transactions of the AIME, Volume 74, pp. 481-506, 1926.

112. West Virginia Department of Natural Resources, "Town of Farmington, Marion County, West Virginia," undated.

113. Young, L. E., "Surface Subsidence in Illinois Resulting from Mining," Cooperative Coal Mining Series, Bulletin 17, Illinois Geological Survey, Urbana, Illinois, 1916.

114. Young, L. E., and Stoek, H. H., "Subsidence Resulting from Mining," University of Illinois Engineering Experiment Station, Bulletin 91, Urbana, Illinois, 1916.

SOURCES OF SUBSIDENCE INFORMATION

Data Collection

The first quarter of the study was devoted to identifying documented cases of mine subsidence above the Pittsburgh Coal in the States of Maryland, Ohio, Pennsylvania, and West Virginia. Three hundred fifty four incidents of subsidence were identified during this period, all but two of them located in southwestern Pennsylvania. This distribution of sites led to the choice of southwestern Pennsylvania, and more specifically the Greater Pittsburgh Area, as the locale for concentrated study in the second phase of the project.

The second phase entailed the location of the subsidence sites in the field, the collection of relevant site data, and the analysis of these data to deduce the mechanisms of subsidence and the factors responsible.

Data collected in the second phase fell into six broad categories--subsidence; mining; geological; climatic; surface development; and economic.

Identification of Sites of Subsidence

The search for sites of subsidence was begun by reviewing previous studies that had been conducted in southwestern Pennsylvania. A map prepared by K. O. Bushnell in 1975 for the U. S. Geological Survey and entitled, "Map Showing Depths to the Pittsburgh Coalbed, Mining Activity, and Related Surface Subsidence, Allegheny, Washington, and Westmoreland Counties," Map MF693-A[16] provided the locations of 88 sites of subsidence in a three county area centering around Pittsburgh. His data were acquired largely from another study conducted at about the same time for the Appalachian Regional Commission by A. W. Martin Associates. The A. W. Martin study entitled, "Development of a Comprehensive Program of Insurance Protection against Mining Subsidence and Associated Hazardous Location Risks" (Report ARC-73-163-2558, June 1975)[1] presented 142 locations of subsidence gathered from insurance claims, newspaper articles, the Allegheny County government, and the Pennsylvania Office of Mine Subsidence Regulation.

Beginning with this core of information, a search was initiated in the present study for additional sites of subsidence. Contact was first made with officials of the Geological Surveys and Departments of Mines of Maryland, Ohio, Pennsylvania, and West Virginia. This effort yielded considerable subsidence information from Pennsylvania, but

only limited information from the other three states which have no personnel concerned directly with subsidence. Only one subsidence incident was identified in Maryland and only one was identified in West Virginia. None were identified in Ohio.

To learn more about subsidence in Maryland, Ohio, and West Virginia, local governmental units and other potentially knowledgeable groups were contacted. These included city engineers in seven major centers of population located above or immediately adjoining the Pittsburgh coal; county engineers at the state and district levels; bridge-and-building and maintenance-of-way departments of five major railroads operating in the area; utility and pipeline companies; two universities; and three other engineering consulting firms. This effort yielded no additional sites of subsidence although individuals contacted often allowed that subsidence may have taken place in their localities. Seeming to contribute to the lack of success in locating subsidence sites were the following factors: the agency or group did not maintain formal records of subsidence incidents; the agency or group discarded files after a designated period of time had elapsed; reports of damage to structures or utilities that might have been due to subsidence were not differentiated from damage cases due to other causes; personnel were not well acquainted with files dating before their own, often short, terms of employment; or individuals contacted had only a slight awareness of the nature of mine subsidence.

Much the same lack of awareness was encountered on the local level in southwestern Pennsylvania despite the several hundred sites that had been identified in that region. On account of this, it was concluded that local governmental units and individuals (excepting perhaps those individuals whose homes and property had been damaged) were most often not particularly valuable sources of information regarding subsidence. In Pennsylvania, the lack of awareness on the part of local officials may have been due to the fact that individuals who have experienced subsidence losses deal directly with the state, with minimal, if any, contact with local officials. In other states, the lack of awareness may be due either to the rarety of subsidence incidents or to these incidents going unnoticed on account of the low population densities. Because of the lack of subsidence information from the states of Maryland, Ohio, and West Virginia, it was concluded at the end of the first phase of the work that in the second phase the principal effort would be devoted to the southwestern Pennsylvania area.

Identification of Specific Subsidence Sites

Subsidence incidents in southwestern Pennsylvania were identified principally from the following sources:

1. The Pennsylvania Department of Environmental Resources, including the Ebensburg Office of Resources Management, the McMurray Office of Mine Subsidence Regulation, and the Pittsburgh and Ebensburg Offices of the Mine Subsidence Insurance fund;

2. The Bruceton Energy Research Center of the U. S. Bureau of Mines in Bruceton, Pennsylvania;

3. Newspaper accounts of the Pittsburgh Press, the Pittsburgh Post-Gazette, the (Penn Hills) Progress, and various other local papers;

4. Our own files and records; and

5. The published reports and maps by A. W. Martin and K. O. Bushnell, referenced earlier.

Approximately 80 percent of the sites were identified through the state agencies above. Information acquired from other sources often did no more than duplicate state information. Several reports obtained from Mr. M. A. Magnuson of the Bureau of Mines Pittsburgh Fire Control Office, however, were unusually well documented and provided on-site information not obtainable elsewhere.

Site Locations

Upon identifying and compiling a list of all known subsidence sites, their locations were posted on the U.S.G.S. 7-1/2-minute topographic maps, which appear in the accompanying folio. Maps on which sites fall are listed in Table 1.1. Locations of the quadrangles are shown by state in Figures A-1 through A-4.

Sketch maps in state files provided the locations of 27 of the sites. Another 173 sites, about 57 percent of the total, were located using street address information and street maps acquired from boroughs, townships, cities, and counties. Since none of these maps provided street addresses, each site had to be located individually in the field. There were 102 sites for which specific locations could not be determined. After field location, additional site information was sought on the topics to be discussed below. Naturally, precise site locations had to be determined first to permit relating the subsidence incident to the correct mine, correct overburden thickness, and so on.

Geometry of Subsidence Features

Records of the Office of Resources Management (ORM) of the Pennsylvania Department of Environmental Resources provided subsidence geometry data from the nearly 200 subsidence features that have been filled in under their direction and 55 sites that had been stabilized under their mine flushing program. These programs have been in operation only since 1960's, which accounts for the fact that most data in this study are confined to that period.

The Pittsburgh Office of Mine Fire Control of the U. S. Bureau of Mines provided information and sketch maps of the geometry of seven additional subsidence cases that had resulted in damage to homes. Information regarding movement of the ground surface above active mines in the Pittsburgh coal region was obtained from the Pennsylvania Office of Mine Subsidence Regulation in McMurray, Pennsylvania, which in the past ten years has conducted five separate ground surveys above active mines in the Pittsburgh coal in cooperation with the respective coal mine operators. Data from four other ground surveys were obtained from Bureau of Mines publications of the 1930's and 1940's, which are referenced in Table 6.2.

Topographic Information

Ground surface elevations were taken largely from U. S. Geological Survey 7-1/2-minute topographic maps, as interpreted during on-site visits. This information, coupled with elevations of the base of the coal given by mine maps, provided estimates of overburden thickness at each site of subsidence located in the field. In about ten percent of the cases, this information could be obtained directly from reports of state or federal representatives who visited the site shortly after subsidence had taken place. Being first hand, these data were used in preference to estimates made in the present study, although both the reported values and estimates were generally in good agreement.

Geological Information

General geological information on southwestern Pennsylvania was obtained largely from published reports of the U. S. Geological Survey, the U. S. Bureau of Mines, and the geological surveys of Pennsylvania, West Virginia, Ohio, and Maryland. Specific references are cited at appropriate points in the text.

Reports of over 100 subsurface investigations performed by GAI in the Greater Pittsburgh area provided specific information regarding the stratigraphy at various locations in the Pittsburgh Coal Region and served to demonstrate local variability of rock strata from the often generalized stratigraphic columns appearing in published documents.

Mining Information

Mining information, principally period of mining and mine configuration, were gleaned from site-by-site examination of coal company mine maps on file with the Pennsylvania Office of Mine Subsidence Regulation in McMurray, Pennsylvania, and with the U. S. Bureau of Mines Mine Map Repository[30] in Pittsburgh. More general mining information, including the names of mines and mine operators and the elevation of the base of the Pittsburgh Coal, was determined from maps prepared by the Works Projects Administration (WPA Project 4483) in the early 1930's and in several more recent publications by the U. S. Geological Survey which have been referenced earlier.

Mine names and operators indicated on individual mine maps were used in preference to those on WPA maps if a discrepancy between the two existed. Further information regarding changes of mine ownership and periods of second mining in particular regions was determined through discussions with representatives of several of the principal mining companies.

Invaluable discussions regarding mining methods were held with representatives of most of the 15 coal companies still actively mining the Pittsburgh coal in Pennsylvania, Ohio, and West Virginia (no active deep mining is being conducted in Maryland) as well as with state mining engineers, representatives of the U. S. Bureau of Mines and representatives of Equitable Gas of Pittsburgh.

Climatic Information

Data regarding the climate of southwestern Pennsylvania, particularly precipitation, were obtained from the Annual Summary of Climatological Data for the Commonwealth of Pennsylvania[70], issued each year by the National Oceanographic and Atmospheric Administration of the U. S. Department of Commerce. Individual monthly records for the two Pittsburgh weather stations were obtained from Local Climatological Data, Pittsburgh, Pennsylvania, issued by the same organization.

Surface Development

Data regarding the distribution and density of housing in southwestern Pennsylvania were obtained from the U. S. Bureau of the Census and from the housing unit density map prepared in 1967 by the Southwestern Pennsylvania Regional Planning Commission[94].

The ages of homes affected by subsidence were determined from records of the Mine Subsidence Insurance Fund and from discussions with homeowners themselves.

Damage at Specific Sites

Discussions with claims adjustors of the Pennsylvania Mine Subsidence Insurance Fund were beneficial in establishing the sequence of events associated with several particular occurrences of subsidence and with the probable causes of subsidence, a number of which could be attributed to activities at ground surface. These discussions were supplemented by conversations with a number of mine subsidence insurance policy holders whose homes had been damaged by subsidence.

Beneficial discussions were also held with representatives of the West Virginia Department of Mines, who are presently engaged in a large scale mine flushing operation to arrest further subsidence at a large site in Marion County, West Virginia, and who graciously introduced the writer to several of the residents of the area. Similar enlightening discussions were held with representatives of the Maryland General Services Administration, who are associated with the subsurface stabilization work presently being carried out in Frostburg, Maryland.

Economic Impact

The Office of the Pennsylvania Mine Subsidence Insurance Fund in Pittsburgh provided cost figures associated with the repair of 40 insured homes that had suffered subsidence damage. An enumeration of specific damages to the homes were also obtained in a number of cases.

Estimates of costs associated with the filling sinkholes and depressions came from the Pennsylvania Office of Resources Management in Ebensburg, Pennsylvania, as did estimates of costs associated with mine flushing.

Comparative costs of damage to homes due to active mining were obtained from the Pennsylvania Office of Mine subsidence Regulation in McMurray, Pennsylvania.

Qualitative information regarding damage to pipelines and highways was provided by various utilities and the Pennsylvania Department of Transportation.

Case Histories

Information on case histories at particular sites was gathered from first-hand accounts, reports of investigations by government agencies, and consultants, personal observation, newspapers, and other sources. Although the case histories are actual, identifying details have sometimes been deleted as a liability prevention measure.

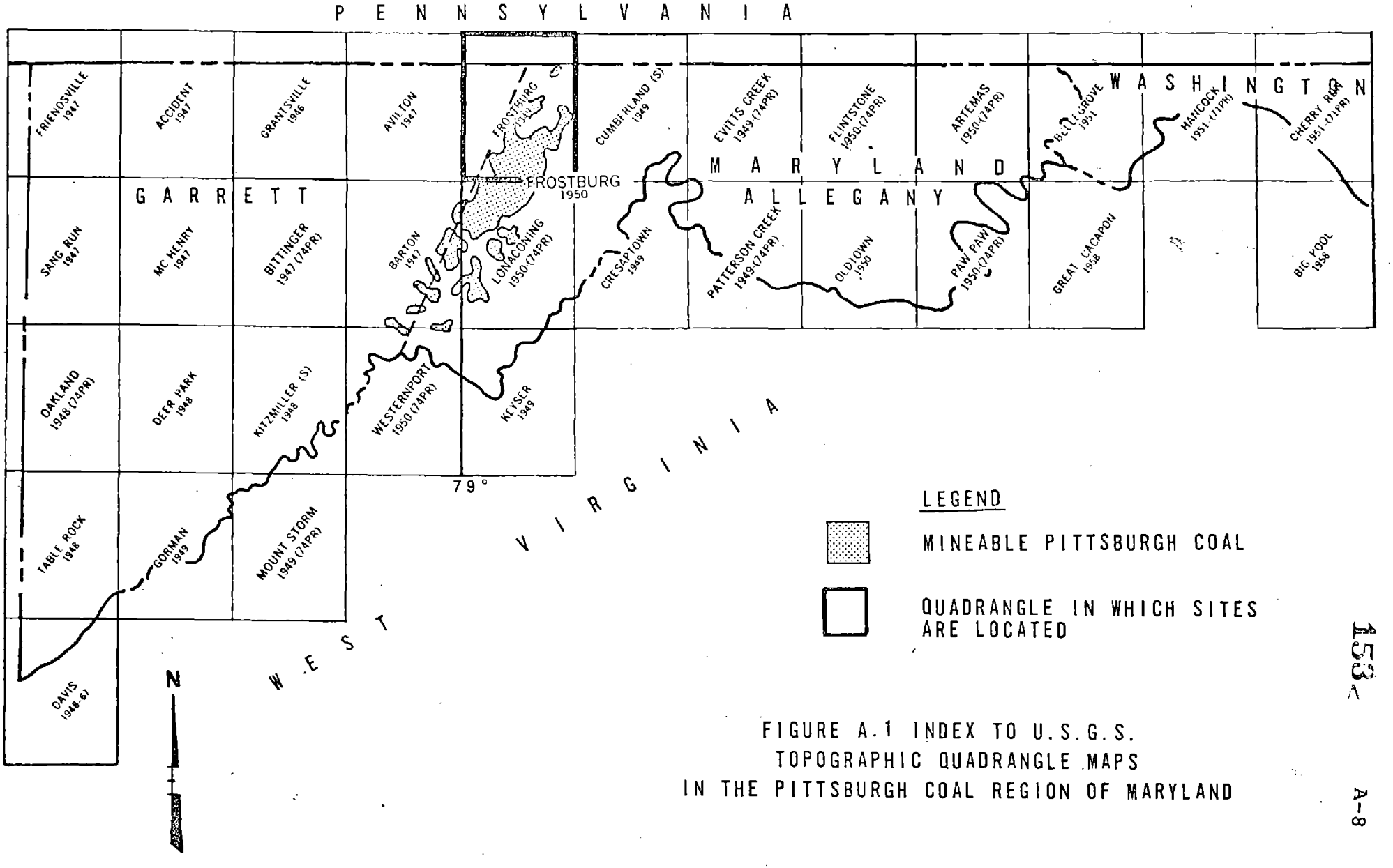


FIGURE A.1 INDEX TO U.S.G.S.
TOPOGRAPHIC QUADRANGLE MAPS
IN THE PITTSBURGH COAL REGION OF MARYLAND

153

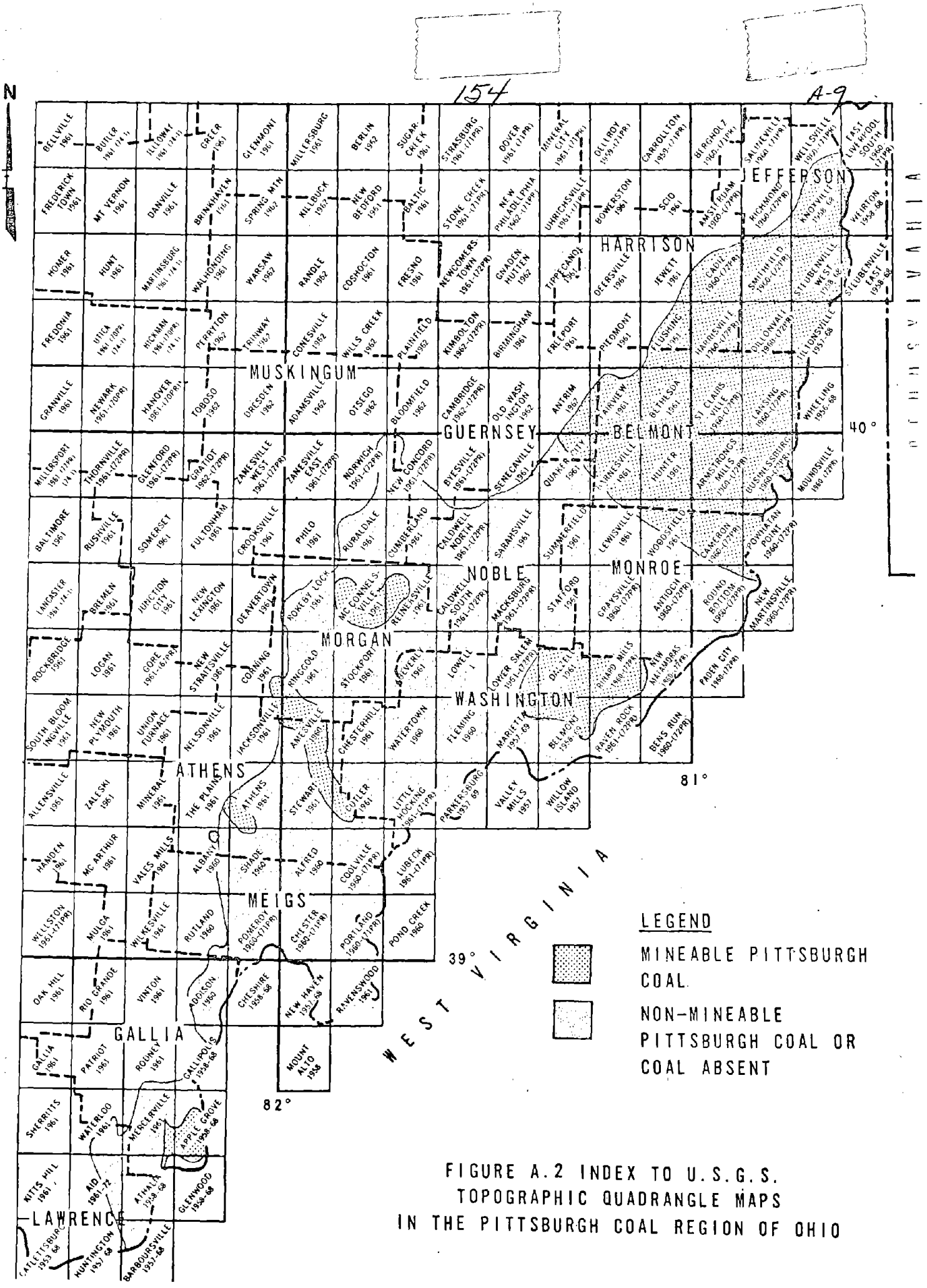


FIGURE A.2 INDEX TO U.S.G.S. TOPOGRAPHIC QUADRANGLE MAPS IN THE PITTSBURGH COAL REGION OF OHIO

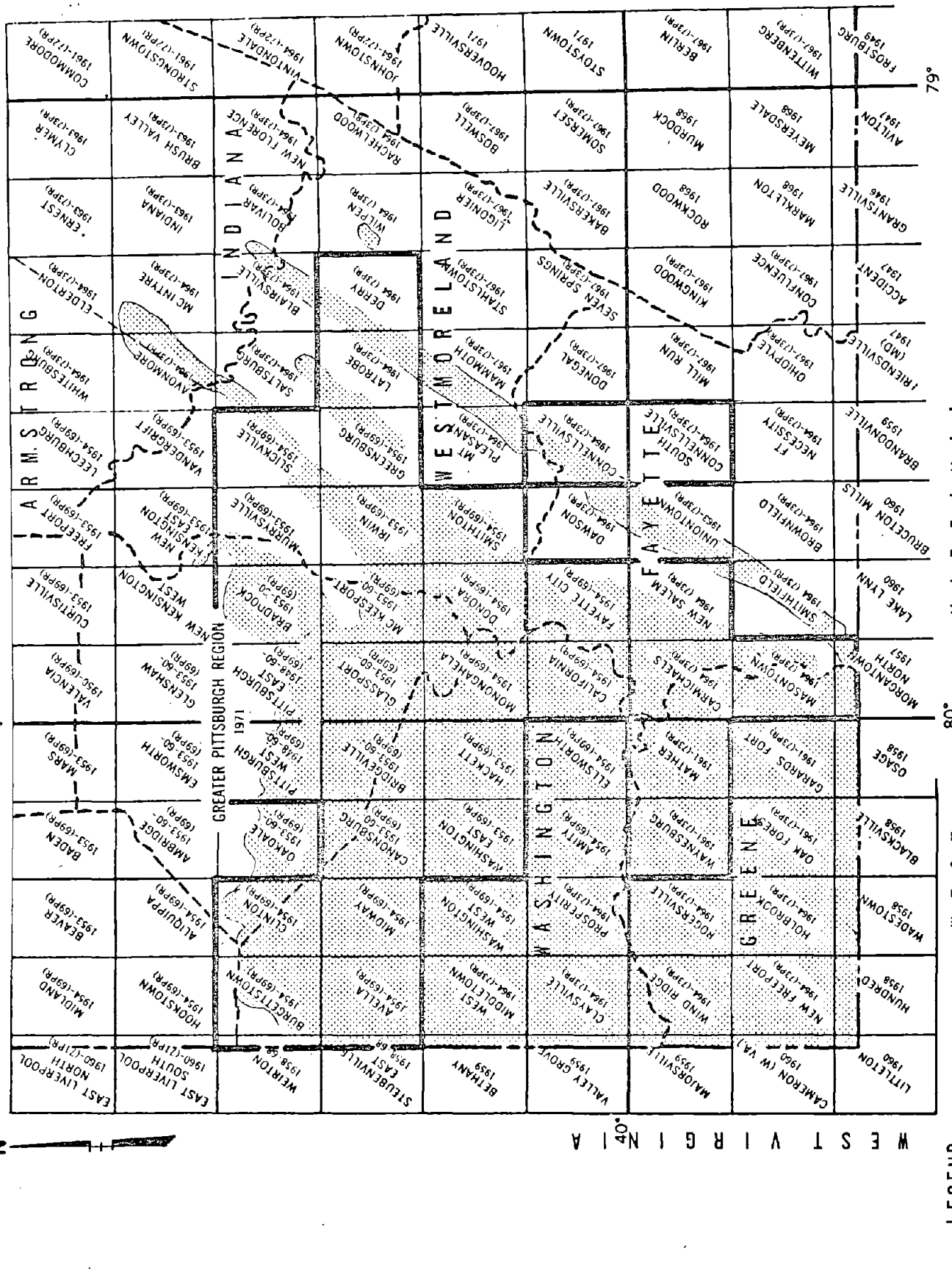
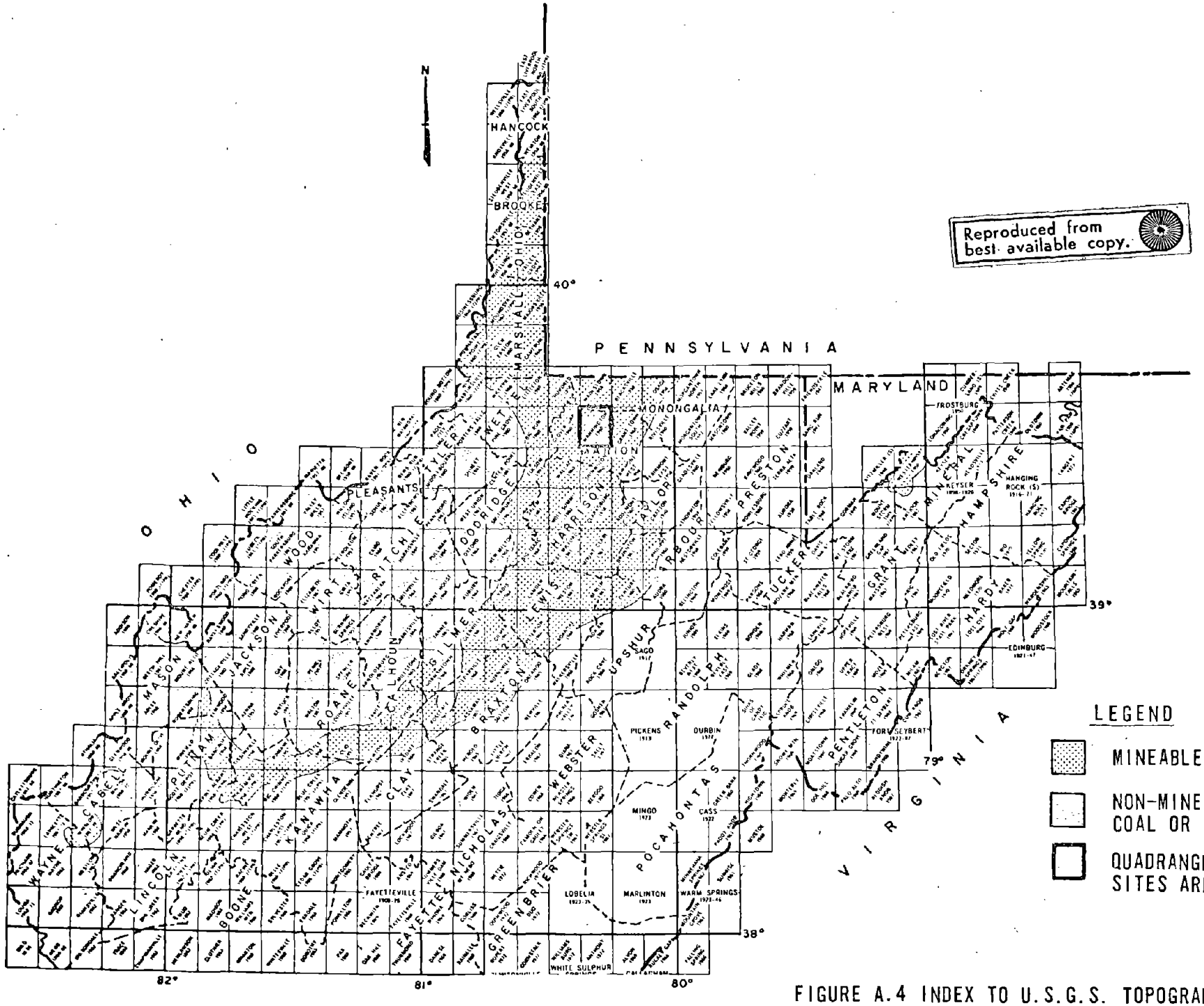


FIGURE A.3 INDEX TO U.S.G.S. TOPOGRAPHIC QUADRANGLE MAPS IN THE PITTSBURGH COAL REGION OF PENNSYLVANIA



Reproduced from best available copy.

FIGURE A.4 INDEX TO U.S.G.S. TOPOGRAPHIC QUADRANGLE MAPS IN THE PITTSBURGH COAL REGION OF WEST VIRGINIA

Table A

Frostburg — Allegany County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*1000	-/65	Frostburg State College	Frostburg	College Buildings		X	X		Century Engineering

Table A

Frostburg — Allegany County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
1000				Consol. Coal	Consol No. 13 & 4 Ocean No. 2 Union	1922	80		20-40	50-230	70-270	33		SH	SH	

Table A

Baldwin Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
1	8/57	Evelyn Road	Pgh. East	1 Home					BuMines
*2	7/73	260 Revo Road	Pgh. East		Filled BD 799				DER-ORM
*3	4/75	40 Gensler Road	Pgh. East		Filled BD 943	X			DER-ORM
*4	4/75	622 Penn Street	Pgh. East		Filled BD 957	X			DER-ORM

Table A

Baldwin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
1	9d	0.1	S	Pittsburgh Coal	Wick						140					
2	10d	15	S	Pittsburgh Coal	Becks Run			1035			10					
3	8d	6	S	Pittsburgh Coal	Becks Run/Walton	<1920		1025			6					
4	8d	20	S	Pittsburgh Coal	Becks Run	<1920		1020			40					

Table A

Baldwin Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*5	9/55	Klein Manor #1	Pgh. West	1 Home		X			BuMines
*6	-/67	407 Pearce Road	Pgh. West	1 Home		X			DER-ORM
	6/67	403 & 404 Pearce Road	Pgh. West	2 Homes		X			DER-ORM
	3/71	403 Pearce Road	Pgh. West	1 Home		X			DER-MSIF (180), AWM
*7	11/71 -/73	1429 Perri Drive	Pgh. West	1/2 Duplex	Other Half (1427) Damaged 12/71	X			DER-MSIF (322) AWM
	-/73	1423, 1425, & 1429 Perri Drive	Pgh. West	3 Homes (severe)	Flushed SL 422-1	X	X		DER-MSIF (282,283,322) DER-ORM, AWM
	-/-	1435 & 1437 Perri Drive	Pgh. West	2 Homes		X			DER-MSIF (259,260)
*8	6/72	709 & 711 Rose Lane	Pgh. West		Filled BD 644	X			DER-ORM
9	2/73	Grandview Avenue	Pgh. West		Filled BD 408 & 709				DER-ORM

Table A

Baldwin Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
5				Pittsburgh Coal	South Hill	1941		975			48					
6				Pittsburgh Term.	Mansfield 1 & 2	1900-1930		975			90					
7				Pittsburgh Coal	South Hill	1940		987	10	69	79		33		Clay	
8	30x60	15	S	Pittsburgh Coal	Oak Hill	1940		975			140					
9																

Table A

Bethel Park Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
10	2/61	Wallace Avenue	Bridgeville			X			AWM
11	-/-	Clifton Road	Bridgeville	5 Homes					AWM

Table A

Bethel Park Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
10	5d	40	S	Pgh. Term. Coal	No. 8	1929					40					
11																

154

Table A

Brentwood Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
12	5/71	Public Park	Pgh. East		Filled BD 463	X			DER-ORM
*13	-/76	404 & 406 East Garden Drive	Pgh. East	3 Homes		X			DER-ORM

Table A

Brentwood Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
12	8d	3		Pittsburgh Coal	Lower Walton	<1920										
13				Pittsburgh Coal	Lower Walton	<1920		1005			120					

Table A

Bridgeville Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*14	1/56	Station and Coulter	Bridgeville			X			BuMines
*15	3/73	904 Laurel Street	Bridgeville		Filled BD 741	X			DER-ORM

Table A

Bridgeville Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
14				McLane Coal	Katie/Essen	1905-1930		820			30					
15	5d	20	S	Pittsburgh Coal	Bridgeville	1900-1920		820			30					

Project 76-541

Table A

Carnegie Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*16	11/55	429 Dawson Avenue	Pgh. West	1 Home		X			BuMines
*17	6/73	333 Thomas Street	Pgh. West		Filled BD 785	X			DER-ORM
18	1/75	Dawson Avenue	Pgh. West		Flushed SL 445	X	X		DER-ORM
19	-/-	Lincoln Avenue	Pgh. West	3 Homes		X			AWM

Table A

Carnegie Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
16	30d	1.2	T	Pittsburgh Coal	Mansfield/ Enterprise	1900-1930		870			35			(SH)	(SH)	
17	2d			Pittsburgh Coal	Moon Run No. 2	1900-1940		930			20					
18				(Local Mining)		1951			12	24	36					
19				Pittsburgh Coal	Mansfield	1900-1935										

Table A

Churchill Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*20	6/71	2511 Collins Road	Braddock		Filled BD 476 & 638	X			DER-ORM
*21	6/72	2322 Marbury Road	Braddock	1 Home		X			DER-MSIF (234), AWM
	7/74	2325 Marbury Road	Braddock	1 Home	Subsidence at 2312 Marbury on 4/66	X			DER-MSIF (380)
*22	10/72	760 Margaretta Street	Braddock		Filled BD 659	X			DER-ORM
*23	12/72	822 Margaretta Street	Braddock		Filled BD 666	X			DER-ORM
	1/75	822 Margaretta Street	Braddock		Filled BD 914	X			DER-ORM
*24	3/75	1632 Georgetown Place	Braddock		Filled BD 936	X			DER-ORM

Table A

Churchill Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
20	12d	15	S	Pittsburgh Coal	Hampton	1890-1900		1125			15					
21				Pittsburgh Coal	Hampton	1890-1900		1120			40					
22				Pittsburgh Coal	Oak Hill No. 3	1900-1910		1075			15					
23	-/2d	12/2	-/S	Pittsburgh Coal	Oak Hill No. 3	1900-1910		1080			50					
24	5d	6	S	Pittsburgh Coal	Hampton	1890-1900		1125			25					

Project 76-541

Table A

Collier Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*25	-/-	Washington Road	Bridgeville	School					AWM

Table A

Collier Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
25								835			75					

Table A

Crafton Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
26	4/73	Mueller Street	Pgh. West		Filled BD 743				DER-ORM

Table A

Crafton Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
26	3d	40														

Table A

Duquesne — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*27	2/66	1223 Goldstrohm Lane	McKeesport		Filled BD 187	X			DER-ORM
*28	7/66	726 Catherine Street	McKeesport		Filled BD 194	X			DER-ORM
*29	4/67	236 Peter Street	McKeesport		Filled BD 235	X			DER-ORM
*30	1/71	1103 Goldstrohm Lane	McKeesport		Filled BD 419	X			DER-ORM
*31	6/71	1131 W. Grant Avenue	McKeesport		Filled BD 479	X			DER-ORM

Table A

Duquesne — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
27	6d	25	S	Pittsburgh Coal	Risher	<1916		970			25					
28	4d	15	S	Pittsburgh Coal	Risher	<1916		975			15					
29	6d	15	S	Pittsburgh Coal	Risher	<1916		970			15					
30				Pittsburgh Coal	Risher	<1916		970			0					
31	6-8d	4-12	S	Pittsburgh Coal	Risher	<1916		965			12					

Project 76-541

Table A

East McKeesport Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*32	9/74	310 Santo Street	Braddock	Garage	Filled BD 902	X			DER-ORM

Table A

East McKeesport Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
32	4x7	1.5	S	Pittsburgh Coal		1917		1055			45					

Table A

Elizabeth Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*33	2/56	820 Everglade Drive	McKeesport	Driveway		X			
*34	12/58	158 Mt. Vernon Drive	McKeesport	1 Home	Septic Tank Overflow Emptied into Mine	X			GAI (Report 59-101)
35	4/69	Route 48	McKeesport	1 Home					DER-MSIF (136), AWM

Project 76-541

Table A

Elizabeth Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
33	4d	14	S	Pittsburgh Coal	Painter	1905-1915		930			150					
34				Consolidation Coal	Yough. Mine	<1900		980			110					
				Boston Gas Coal		1952										
35																

182

Table A

Findlay Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*36	-/-	Route 30	Clinton	School					AWM

Table A

Findlay Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
36		1.0						1180			70					

Project 76-541

Table A

Forest Hills Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
37	8/72	652 Filmore Road	Braddock		Filled BD 597				DER-ORM
38	6/75	Fairfax Road	Braddock		Filled BD 965				DER-ORM
*39	8/75	1015 Sherwood Drive	Braddock		Filled BD 977 & 991				DER-ORM

Table A

Forest Hills Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft) Soil	Rock	Total	Overburden (ft) (Massive Beds) LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
37	4d	15														
38	5d	8														
39	2d	8	S	Pittsburgh Coal	Hampton			1110			10					

Project 76-541

Table A

Forward Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*40	12/73	Route 136	Donora		Filled BD 834				DER-ORM

202

Project 76-541

Table A

Forward Township

Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
40				Hillman Coal & Coke	Ella			800			200					

Table A

Greentree Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*41	5/71	109 Noblestown Road	Pgh. West		Filled BD 472 & 568	X			DER-ORM
42	6/74		Pgh. West		Filled BD 881				DER-ORM

Project 76-541

Table A

Greentree Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
41				Pittsburgh Coal	Idlewood	1905-1920		960			90					
42	15d	25														

190

Project 76-541

Table A

Jefferson Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
43A	11/55	Route 885, Jefferson Manor Development	Glassport	1 Home	Pillar Extraction (Active)				BuMines

Table A

Jefferson Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
43A				Glass Run	Alice						120					

Project 76-541

Table A

Kennedy Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
44	3/67	Kenridge Drive	Pgh. West	3 Homes	Mine Fire				BuMines
45	-/-	McKees Road	Pgh. West	3 Homes					AWM

PSD 63

Table A

Kennedy Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
44				Fairhaven Coal Co.	McKees Rocks						25-55					
45																

Table A

Lincoln Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
46	1/71	682-B Pierce Road	McKeesport		Filled BD 416				DER-ORM
	8/75	682-B Pierce Road	McKeesport		Filled BD 979				DER-ORM

Table A

Lincoln Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
46	4d/10d	25/12	S/S	Pittsburgh Coal	Lovedale			1015								

Table A

McDonald Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*47	7/73	Hill Street & Center Avenue	Canonsburg		Filled BD 779				DER-ORM

Table A

McDonald Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft) Soil	Rock	Total	Overburden (ft) (Massive Beds) LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Mining Activity				Available Site Data								
47	2x6	18	S	Pittsburgh Coal	Nickel Plate			1035			25					

Table A

Monroeville Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*48	10/63	3700 Wm. Penn Highway	Braddock		Filled BD 120	X			DER-ORM
*49	4/64	Route 22	Braddock		Filled BD 127	X			DER-ORM
*50	12/74	818 Sweetleaf Drive	Braddock	1 Home	Ultimate Cause of Subsidence was Active Mining in Upper Freeport Coal 640 ft Below the Pittsburgh Coal				DER-MSIF (354)

Table A

Monroeville Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
48				Pittsburgh Coal	Oak Hill No. 4	1890-1900		1140			30					
49	12d	12	S	Pittsburgh Coal	Oak Hill No. 4	1890-1900		1150			12					
50				Pittsburgh Coal	Oak Hill No. 5	<1935		1125			65					

Project 76-541

Table A

Mount Oliver Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
51	-/63	Walter Avenue	Pgh. East		Vacant Lot	X			BuMines

202

Table A

Mount Oliver Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
51	2	25	S	Pittsburgh Coal	Becks Run	1920		1020			35					

Project 76-541

Table A

Munhall Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
53	7/72	4500 Morgan Lane	Pgh. East		Filled BD 615				DER-ORM
54	11/72	Morgan Lane	Pgh. East		Filled BD 657				DER-ORM
*55	8/73	4317 Main Street	Pgh. East		Filled BD 809	X			DER-ORM
*56	5/74	226 Morgan Lane	Pgh. East		Filled BD 872				DER-ORM
*57	5/75	3644 Valewood Drive	Pgh. East		Filled BD 961	X			DER-ORM

323

Table A

Munhall Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
53	25d	8														
54	20d	15														
55				Pittsburgh Coal	Risher	<1917		1050			49					
56	24d	30	S		Schotting No. 3			1060			30					
57	8d	22	S	Pittsburgh Coal	Risher	<1917		1050			22					

Table A

North Fayette Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
58	7/68	Glen Gormley Plan	Oakdale	2 Homes	Fly Ash "Experiment"	X			BuMines, AWM
59	4/72	113 Leghorn Road	Oakdale	Foundation	Filled BD 188				AWM
	7/75	111 Leghorn Road	Oakdale		Filled BD 978				DER-ORM

Table A

North Fayette Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
58				Pittsburgh Coal	Dixon	1917-1937					50					
59		1/1									35					

Table A

North Versailles Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*60	2/56	308 Cedarhurst Avenue	McKeesport	1 Home		X			BuMines
*61	1/72	Green Valley School Crestview Drive	McKeesport		Filled BD 547				DER-ORM
*62	12/73	1701 Girard Avenue	Braddock		Filled BD 839	X			DER-ORM

Table A

North Versailles Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
60	5x10	10	S		Kucnel	<1930		1065			10-15					
61	5d	30	S		Kucnel			1030			90					
62						<1937		980			20					

208

Table A

Penn Hills Township (1 of 4) Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*63	-/57	8920 Upland Terrace	Braddock	Front Yard					BuMines
64	2/57	McCutcheon & Grand View Lanes	Braddock						BuMines
*65	4/65	7967 Thon Drive	Braddock	1 Home					DER-MSIF (131), AWM
*66	3/66	100 Woodgate Road	Braddock	1 Home	House on Caissons				GAI (Rpt. 66-145)
*67	7/68	229 Union Green Drive	Braddock	1 Home		X			DER-ORM, DER-MSIF (156), AWM
	2/74	Union Green Drive(†)	Braddock		Filled BD 847	X			DER-ORM
*68	1/69	135 Prescott Drive	Braddock		Filled BD 306	X			DER-ORM
*69	4/69	407 Collins Drive	Braddock		Filled BD 314				DER-ORM, AWM
*70	4/71	1131 Lawndale Street	Pgh. East		Filled BD 450				DER-ORM
	4/71	1121 Lawndale Street	Pgh. East			X			DER-ORM
*71	9/71	213 Cypress Hill Drive(†)	Braddock		Filled BD 420 & 546				DER-ORM
	1/73	213 Cypress Hill Drive	Braddock		Filled BD 693				DER-ORM
	4/75	213 Cypress Hill Drive(†)	Braddock		Filled BD 956				DER-ORM
	-/-	217 Cypress Hill Drive	Braddock		Filled BD 420				DER-ORM

Table A

Penn Hills Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
63	5	6	S	Pittsburgh Coal				1155			27					
64	8d		S	Pittsburgh Coal		<1930					10					
65				Pittsburgh Coal	Sandy Creek			1165			35					
66				Pittsburgh Coal	Sandy Creek			1140			60					
67	10d	20	S	Snyder Coal	No. 3	<1930		1205			<50					
68	5d	15	S	Pittsburgh Coal	Sandy Creek	1900		1100			15					
69	5d	20	S	Pittsburgh Coal				1110			30					
70	8d/8d	12/12	S/S	Pittsburgh Coal	Sandy Creek	<1930		1160			12					
71	10d/10d	0.8/3	S/S	Pittsburgh Coal	Plum Creek			1160			10					

Table A

Penn Hills Township (2 of 4) Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*72	3/72	Banyon Drive & Frankstown Road	Braddock	Roadway	Flushed SL 431	X	X		Pgh. Press, DER-ORM, AWM
*73	3/72	108 & 109 Marose Drive	Braddock	2 Homes		X			Progress
*74	4/72	1120 Frey Road	Braddock		Filled BD 579	X			AWM, DER-ORM
*75	4/72	316 Crescent Garden Drive	Braddock		Filled BD 565 & 595				AWM, DER-ORM
*76	5/72	318 Dorothy Drive	Braddock		Filled BD 580				AWM, DER-ORM
	3/75	238 Dorothy Drive	Braddock		Filled BD 935				DER-ORM
*77	7/72	949 Jefferson Heights Drive	Braddock		Filled BD 670	X			DER-ORM
*78	8/72	6251 Leechburg Road	Braddock		Filled BD 660	X			DER-ORM
*79	11/72	2904 Laketon Road	Braddock	Road Intersection	Filled BD 689				AWM, DER-ORM
*80	11/72	7761 Pershing Street(†)	Pgh. East		Filled BD 653				DER-ORM
	7/73	7761 Pershing Street	Pgh. East		Filled BD 653				DER-ORM
*81	12/72	325 Woodstone Drive	Braddock		Filled BD 705				DER-ORM
*82	2/73	342 Jefferson Road	Braddock		Filled BD 721 & 938	X			DER-ORM

Table A

Penn Hills Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
72	100x50	3	T	Pittsburgh Coal	Sandy Creek	<1875		1150	8	58	66		18	(SH)		
73				Pittsburgh Coal	Sandy Creek	1905-1910		1130			25					
74	8x30	18	S	Pittsburgh Coal	Sandy Creek	1890-1900		1105			85					
75	12x20	12	S	Pittsburgh Coal				1140			12					
76	3d/45x50	15/15	S/S	Pittsburgh Coal				1160			15					
77	6x8	20	S	Pittsburgh Coal	Sandy Creek	1890-1900		1095			20					
78	4d	4	S	N.Y. & C.G.C.	Snyder No. 3	1902		1200			10					
79	2d	2	S	Pittsburgh Coal	Sandy Creek			1140			50					
80	3d	15	S	Pittsburgh Coal	Sandy Creek	<1930		1160			60					
81	10d	4	S	Pittsburgh Coal	Plum Creek			1150			25					
82	3-5d	20	S	Cleveland-Pittsburgh Coal	Sandy Creek	1890-1900		1130			20					

Project 76-541

Table A

Penn Hills Township (3 of 4) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*83	3/73	355 Rodi Road	Braddock		Filled BD 734	X			DER-ORM
*84	4/73	131 Lynnwood Drive	Braddock		Filled BD 757	X			DER-ORM
*85	7/73	140 Harvard Drive	Braddock		Filled BD 805	X			DER-ORM
*86	9/73	11379 & 11383 Althea Road	Braddock		Filled BD 814				DER-ORM
*87	3/74	221 Clay Drive	Braddock		Filled BD 856 & 939	X			DER-ORM
88	5/74	Hershey Road	Braddock		Filled BD 871				DER-ORM
*89	5/74	440 Janice Drive	Braddock		Filled BD 874				DER-ORM
*90	6/74	141 Mohawk Trail Drive	Braddock		Filled BD 882				DER-ORM
*91	7/74	102 Ridgecrest Drive	Braddock		Filled BD 886	X			DER-ORM
92	7/74	8523 Pershing Street	Pgh. East		Filled 889				DER-ORM
*93	2/75	609 National Drive	Braddock		Filled BD 920				DER-ORM
*94	11/75	405 Jefferson Road	Braddock		Filled BD 997	X			DER-ORM
*95	11/75	112 Lanford Drive	Braddock		Filled BD 998	X			DER-ORM

Table A

Penn Hills Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
83	5d	10	S	Pittsburgh Coal	Sandy Creek	1890-1900		1120			10					
84	5d	5	S	Pittsburgh Coal	Sandy Creek	1905-1910		1130			5					
85				Pittsburgh Coal	Sandy Creek	<1875		1140			40					
86	12d	25	S	Pittsburgh Coal	Sandy Creek	<1930		1155			45					
87	6x15	30	S	Pittsburgh Coal	Sandy Creek	1890-1900		1120			30					
88	10d	20														
89	6d	3	S	Pittsburgh Coal	Sandy Creek	<1930		1140			3					
90	4-6d	6-10	S	Pittsburgh Coal				1130			30					
91	10d	20	S	Pittsburgh Coal	Sandy Creek	1910-1915		1100			20					
92	20d	30														
93	3d	4	S	Pittsburgh Coal		<1930		1160			30					
94	4d	12	S	Pittsburgh Coal	Sandy Creek	1890-1900		1130			90					
95	4d	15	S	Pittsburgh Coal	Sandy Creek	<1875		1150			15					

Table A

Penn Hills Township (4 of 4) Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
96	-/-	Grove Road	Braddock	3 Homes					AWM
97	-/-	Frankstown Road	Braddock	3 Homes					AWM
98	-/-	Veronica Drive	Braddock	2 Homes					AWM
99	-/-	Rodi Road	Braddock	Commercial Bldg.					AWM

Table A

Penn Hills Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
96																
97																
98																
99																

Table A

Pittsburgh (1 of 4) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*100	11/55	23 Briggs	Pgh. East	Ground Cracks 20 to 40 Feet Long		X			BuMines
*101	5/57	2360, 2362, & 2366 Almont Street	Pgh. East	3 Homes		X			BuMines
*102	1/60	1004 Welfer Street(†)	Pgh. East						AWM
	11/73	1025 Welfer Street	Pgh. East		Filled BD 836				DER-ORM
*103	3/64	4540 Homeridge Drive	Pgh. East						BuMines
	2/70	Homeridge Drive	Pgh. East		Filled BD 548				DER-ORM
*104	4/64	Mooney Road & Mifflin Road	Pgh. East						BuMines
*105	6/64	2250 Noblestown Road	Pgh. West		Filled BD 134	X			DER-ORM
106	6/66	1706 Westinghouse	Pgh. West						AWM
*107	6/66	250 Bonifay Street	Pgh. East		Filled BD 200	X			DER-ORM
*108	9/67	5710 & 5716 Mifflin Road	Glassport	2 Homes		X			Pittsburgh Press, AWM

Table A

Pittsburgh — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
100	15d			U.S. Coal & Supply	South Hill	1917	Boot-leg	990			74					
101	120d	1.0	T	Pittsburgh Coal	Becks Run	1907		990			70			(SH)	(LS)	
102	2d	18	S					1105			39					
103	2d/6d	10/6	S/S	Pittsburgh Coal	Schotting - 1	<1930		1065			30					
104	2d	10	S	Pittsburgh Coal	Schotting - 1	<1930		1050			44					
105				Pittsburgh Coal	Boyle	1905-1920		970			25					
106				Pittsburgh Term. Coal	1 & 2	<1930					84					
107	3d	15	S	Pittsburgh Coal	Becks Run/ Walton	<1920		1035			45					
108				Pittsburgh Coal	Risher	1917		1015			60-80					

Table A

Pittsburgh (2 of 4) Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*109	7/70	77 Matera Place	Pgh. West	1 Home					DER-MSIF (181), AWM
	-/73	37, 41, 45, & 77 Matera Place	Pgh. West	4 Homes	Flushed SL 436		X		DER-ORM, AWM
	7/76	41 Matera Place	Pgh. West	1 Home					DER-MSIF (438)
110	2/71	636 Duff Street	Pgh. East		Filled BD 429				DER-ORM
111	4/71	Final Street	Pgh. West		Filled BD 428				DER-ORM
*112	10/71	1510 Barbadoes Avenue	Pgh. West	1 Home	Flushed SL 422	X	X		DER-ORM, DER-MSIF (183), AWM
113	12/71	Glenarm Avenue	Pgh. West	Street Cracks	Flushed SL 426		X		DER-ORM, AWM
114	1/72	Morange Road	Pgh. West		Flushed SL 433	X	X		DER-ORM, AWM
*115	4/72	1497 Celtic Avenue	Pgh. East	Driveway	Filled BD 591	X			DER-ORM, AWM
*116	7/72	317 Amabelle Street	Pgh. West		Filled BD 620				DER-ORM
117	11/72	701 Kohler Avenue	Pgh. West		Filled BD 667				DER-ORM

Table A

Pittsburgh — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
109				Pittsburgh Coal	Idlewood	<1930		1090	20-35	15-30	50					
110																
111																
112				Pittsburgh Coal		1941-1942		995	10	160	170	13			Clay	
113				Pittsburgh Coal	South Hill				5	115	120		10-15			
114				Boyle Coal		1941			20	9	29					23
115	30d	0.5-2	T	Pittsburgh Coal	Becks Run	<1920		1010			70			(SH)	(LS)	
116	12x12	5	S	Pittsburgh Coal				1035			25					
117	8d	8														

820

Project 76-541

Table A

Pittsburgh (3 of 4) Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
118	4/73	1536 Roseberry Street	Pgh. West		Filled BD 755	X			DER-ORM
119	5/73	3385 & 3387 Monroe Street	Pgh. East		Filled BD 768				DER-ORM
*120	5/73	783 Oakville Street	Pgh. East		Filled BD 770				DER-ORM
121	7/73	Arcata Street	Pgh. East		Filled BD 719	X			DER-ORM
*122	8/73	1740 & 1744 Creedmore Avenue	Pgh. West		Filled BD 808	X			DER-ORM
*123	9/73	Potomac Avenue & Banksville Road	Pgh. West	4 Buildings & Roadway	Flushed SL 441	X	X		DER-ORM, AWM
*124	12/73	507 Laughlin Avenue	Pgh. East		Filled BD 824	X			DER-ORM
125	12/73	Glenhurst Avenue	Pgh. East		Filled BD 825				DER-ORM
*126	4/74	178 Mifflin Road	Glassport	1 Church (Hays United Methodist)	Filled BD 865				DER-ORM
127	-/-	Warrington Avenue	Pgh. East	Floors of Garages		X			AWM

Table A

Pittsburgh — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
118		15		Pittsburgh Coal	Venture	1920-1925		990			115					
119	4d	12														
120	10d	18	S		Schotting No. 1			1055			45					
121				Pittsburgh Coal	Lower Walton	<1920										
122				Pittsburgh Term.	Oak Hill/South Hill	1900-1940		980			90					
123		0.5		Pittsburgh Coal	Enterprise/ Mansfield	1900-1934		925	20	74	94		5		Clay	
124				Pittsburgh Coal	Becks Run	<1920		1020			40					
125																
126	4d	8	S	Pittsburgh Coal	Schotting No. 1			1010			40					
127						<1920										

2222

Table A

Pittsburgh (4 of 4)

Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
128	-/-	Rosecrest Street	Pgh. East	Driveway					AWM
129	-/-	Woodbourne Avenue	Pgh. West	10 Homes	Flushed SL 422	X			AWM, DER-ORM

Table A

Pittsburgh — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Company	Mine Name	Last Mined	Available Site Data: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
128																
129				Pittsburgh Coal	South Hill	1900-1940										

5232

Project 76-541

Table A

Pleasant Hills Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*130	-/60	234 Constitution Drive	Glassport	1 Garage					Building Inspector (Per. Com.)
*131	3/63	National Drive & Old Clairton Road	Glassport			X	X		GAI (Rpt. 62-122)
*132	-/72	367,369, & 373 Cavan Dr.	Glassport	3 Homes	Flushed SL 423	X	X		DER-ORM, AWM
*133	8/73	Old Clairton Rd. & Gill Hall Road	Glassport	Apartments		X	X		Pittsburgh Press, AWM
*134	2/73	385 Tara Drive	Glassport	1 Home	Damaged 1971-1973	X			DER-MSIF (313), AWM
	8/73	381 Tara Drive	Glassport	1 Home		X			DER-MSIF (291), AWM
	-/74	Tara Drive	Glassport	3 Homes	Flushed SL 423-1A	X	X		DER-ORM, AWM
135	-/74	385 Terrace Street	Glassport	1 Home		X			

Table A

Pleasant Hills Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
130				Pittsburgh Coal	Montour No. 8			980			160					
131				Pittsburgh Term.	No. 6	1905-1910	Total	980	15	175	190	40	37		LS	130
132				Pittsburgh Coal	Montour No. 8	1915-1925		1020	10	80	90	0-2	0-10		Clay	
133	120d	0.8	T	Pittsburgh Term.	Montour No. 8	1915-1925		1010	11	129	140	18			Clay	
134				Pittsburgh Coal	Montour No. 8	1915-1925		1008	14	100	114	4-12			Clay	
135				Pittsburgh Term.	No. 6	1905-1910		940			90					

Table A

Plum Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
136	4/70	Boyce Park	Braddock		Filled BD 487				DER-ORM
137	1/71	Leechburg Road & New Texas Road	New Kensington West		Filled BD 528				DER-ORM
*138	5/71	Boyce Park	Murrysville		Filled BD 421				DER-ORM
*139	12/72	418 Vale Avenue	Braddock		Filled BD 686				DER-ORM
140	1/74	400 New Texas Road	Murrysville		Filled BD 838				DER-ORM

Table A

Plum Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
136	3d	35														
137	3d	12														
138	3d	15	S	Pittsburgh Coal	Plum Creek			1175			25					
139				Pittsburgh Coal	Plum Creek			1140			25					
140	5d	5														

Project 76-541

Table A

Port Vue Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
141	-/-	Portsmouth Drive	Glassport	3 Homes					AWM
322	1/74	1006, 1008, & 1010 Bellaire Road	Glassport	3 Homes					DER-ORM, BuMines, McKeesport Daily News

Table A

Port Vue Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
141																
322						1935		965			65					

Table A

Robinson Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
142	3/71	500 Faulk Road	Pgh. West		Filled BD 448	X			DER-ORM
143	-/-	Baldwin Road Rosslyn Farms	Pgh. West	Apartment		X			AWM

Table A

Robinson Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
142	4d	6		Pittsburgh Coal	Moon Run No. 3	1900-1930										
143				Pittsburgh Coal	Moon Run No. 3	1900-1930										

Project 76-541

Table A

Scott Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*144	8/56	2184 Greentree Road	Pgh. West	1 House					BuMines

Table A

Scott Township

Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
144		25		Pittsburgh Coal	Nixon	1935		845			25					

Table A

South Park Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*145	1/58	1154 & 1158 Broughton Road	Glassport	2 Homes		X			AWM
146	5/70	5852 Curry Road	Glassport			X	X		Newspaper, AWM
*147	5/70	862 & 866 Connolly Avenue	Glassport		Previous Damage 1920's	X	X		AWM
*148	12/71	1100 Block-Forest Avenue	Glassport		Previous Subsidence 1953	X			AWM
	12/71	1174 Forest Avenue	Glassport	1 Home		X			DER-MSIF (332)
	2/72	Forest Avenue	Glassport		Flushed SL-413-2	X			AWM
*149	12/71	Locust Street	Glassport	5 Homes		X			AWM
150	7/73	1601 Wallace Drive	Glassport		Filled BD 810				DER-ORM
*151	-/-	Brownsville Road	Glassport	Nativity Church	Flushed SL 413	X	X		DER-ORM, AWM
	-/-	Brownsville Road	Glassport	7 Homes		X			AWM
*152	-/-	U.S. Bureau Mines Exp. Sta.	Glassport			X	X		GAI (Rpt. 75-648)
153A	-/36	Library	Bridgeville		Active Mining	X	X	X	BuMines

Table A

South Park Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
145	60d	0.2-1	T	Bruceton Fuel	Porter	1905-1910		915			40			(SH)	(SH)	
146				Bruceton Fuel	Porter	1905-1910	80	920	3-10		69	3			Clay	
147				Bruceton Fuel	Porter	1905-1910		920			180					
148				Bruceton Fuel	Porter	1905-1910		915			105					
149				Bruceton Fuel	Porter	1905-1910		910			140					
150	12d	10				<1930		1020								
151				Bruceton Fuel	Porter	1905 1910		920			80					
152	2-10	5	S	Bruceton Fuel	Porter	1925	100	1005	9		52				Ls.	
153A		2.2		Pittsburgh Coal	Moutour No. 10				8		>235	60	50	(SH)	Clay	

Project 76-541

Table A

Swissvale Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
154	-/-	Patterson Avenue	Pgh. East	Roadway & Waterline					AWM

Table A

Swissvale Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
154																

Table A

Upper St. Clair Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*155	11/59	1820 McLaughlin Run Road	Bridgeville	Municipal Building		X	X		GAI (Rpt. 59-153), AWM
*156	3/75	1514 McLaughlin Run Road	Bridgeville		Filled BD 945	X			DER-ORM

Table A

Upper St. Clair Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
155				Pittsburgh Term. Coal	Harrison Mine/ No. 8	1920-1935	75	855	11	110	121	20		SH	SH	
156	10d	3	S	Pittsburgh Coal	Bridgeville	1900-1920		865			75					

0242

Project 76-541

Table A

West Homestead Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*157	3/71	3668 Pinewood Drive	Pgh. East		Filled BD 453				DER-ORM
	6/73	3668 Pinewood Drive	Pgh. East		Filled BD 778				DER-ORM

Table A

West Homestead Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
157	3d/-	5/9	S/-		Calhoun	<1930		1080			9					

242

Table A

West Mifflin Borough (1 of 6) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
158	-/62	Eliza Street	Pgh. East	1 Home	Severe Foundation Damage				AWM
159	-/65	Orchard Drive	Glassport	1 Home		X			DER-ORM
*160	7/65	207, 211, 215, & 219 Bost Drive	Glassport	4 Homes	Flushed SL 404-3	X			BuMines, DER-ORM
*161	-/67	School Street & Eliza Street	Pgh. East	1 Home					DER-ORM
162	3/68	Bettis Road	Glassport		Filled BD 552				DER-ORM
	6/74	Bettis Road	Glassport		Filled BD 879				DER-ORM
*163	6/68	716 & 720 Shadyside Drive	Glassport	2 Homes	Flushed SL 404-1	X			Pittsburgh Press, AWM, DER-ORM, BuMines
*164	1/69	712 St. Germaine Drive	Glassport	1 Home		X			DER-MSIF (123) AWM
*165	5/69	609 Shadyside Drive	Glassport	1 Home	Filled BD 317	X			AWM, DER-ORM

Table A

West Mifflin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
158																
159				Pittsburgh Coal	First Pool No. 1	1902					135					
160		0.2		Pittsburgh Coal	Aliquippa	1910-1915		1030			124					
161				Pittsburgh Coal	Risher			1060			10-20					
162	10d	14														
163				Pittsburgh Coal	Aliquippa	1910-1915		1014			30					
164				Pittsburgh Coal	Aliquippa	1910-1915		1010			10					
165	2x3	14	S	Pittsburgh Coal	Aliquippa	1910-1915		1010			14					

Table A

West Mifflin Borough (2 of 6) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*166	7/69	395, 399, 403, & 407 Livingston Road	Glassport	4 Homes	Flushed SL 404-2	X			DER-ORM, AWM
*167	5/69	1416 Willard Avenue	McKeesport		Filled BD 349				DER-ORM, AWM
*168	2/70	Curry Hollow Road	Glassport		Filled BD 482 & 359	X			DER-ORM
*169	3/70	4619 Greensprings(†) Avenue	Pgh. East		Filled BD 365				DER-ORM
	4/71	4605 Greensprings Avenue	Pgh. East		Filled BD 443				DER-ORM
	11/72	4601 Greensprings Avenue	Pgh. East		Filled BD 671				DER-ORM
*170	7/70	618 Hazel Street	Pgh. East		Filled BD 418				DER-ORM
171	7/70	Shady Lane	Braddock	2 Homes					BuMines

5-23

Table A

West Mifflin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
166				Pittsburgh Coal	Aliquippa	1910-1915		1040			50-60					
167	3d	10	S	Pittsburgh Coal	Risher			960			40					
168	5x6	20	S	Pittsburgh Coal	Aliquippa	1910-1920		1010			20					
169		20		Pittsburgh Coal	Risher	<1930		1075			20					
170				Pittsburgh Coal	Risher	<1930		1080			0					
171	80d		T	Pittsburgh Coal	Risher	<1930		990			35			(SH)		

Table A

West Mifflin Borough (3 of 6) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*172	9/70	2835 New England Hollow Road	Glassport		Filled BD 409	X			DER-ORM
*173	1/71	Thompson Run Road & Road	Glassport	Roadway	Filled BD 414				DER-ORM
*174	5/71	3709 Outlook Drive	Braddock		Filled BD 442				DER-ORM
*175	12/71	836 Elm Street	Pgh. East		Filled BD 532				DER-ORM
*176	3/72	Lincoln Avenue	Pgh. East	Roadway	Filled BD 561		X		DER-ORM
*177	7/72	4034 Donna Avenue	Pgh. East		Filled BD 601				DER-ORM
178	7/72	Bowes Avenue	Pgh. East		Filled BD 602				DER-ORM
*179	8/72	250 Castle Drive	Pgh. East		Filled BD 630				DER-ORM
	1/74	262 Castle Drive	Pgh. East		Filled BD 842				DER-ORM
*180	8/72	2612 Campbell Circle	Glassport		Filled BD 637	X			DER-ORM

Table A

West Mifflin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
172				Pittsburgh Coal	Aliquippa	1910-1915		1015			0					
173				Pittsburgh Coal	Risher	<1930		1000			10					
174				Pittsburgh Coal	Risher	<1930		1035			65					
175	2d	14	S	Pittsburgh Coal	Risher	<1930		1070			14					
176	1.5x1			Pittsburgh Coal	Risher	<1930		1045	3	17	20				Clay	
177	4d	20	S	Pittsburgh Coal	Risher	<1930		1045			40					
178	6d	20	S	Pittsburgh Coal	Risher	<1930					40					
179	2d/2d	24	S/S	Pittsburgh Coal	Risher	<1930		1010			60					
180	4d	15	S	Pittsburgh Coal	Risher	1900-1910		940			100					

248

Table A

West Mifflin Borough (4 of 6) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*181	11/72	512 Oak Street	Pgh. East		Filled BD 672				DER-ORM
*182	11/72	3000 New England Hollow Road	Glassport			X			DER-ORM
	6/73	3012 New England Hollow Road	Glassport		Filled BD 789	X			DER-ORM
	5/75	3015 New England Hollow Road	Glassport		Filled BD 960 & 990	X			DER-ORM
*183	1/73	4746 Bowes Avenue	Pgh. East		Filled BD 694				DER-ORM
184	3/73	Centerview Avenue	McKeesport		Filled BD 730				DER-ORM
*185	3/73	432 Grandview Avenue	McKeesport		Filled BD 736				DER-ORM
*186	5/73	Centerview Avenue and Elmora Avenue	McKeesport		Filled BD 759				DER-ORM

Table A

West Mifflin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
181				Pittsburgh Coal	Risher	<1930		1065			20					
182	-/6d/8d	15/15/20	S/S/S	Pittsburgh Coal	Aliquippa/ First Pool	1910-1915		1030			20					
183				Pittsburgh Coal	Risher	<1930		1035			25					
184																
185	4d	20	S	Pittsburgh Coal	Risher	<1930		960			120					
186	6d	8	S	Pittsburgh Coal	Risher	<1930		960			8					

Project 76-541

Table A

West Mifflin Borough (5 of 6) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*187	5/73	4006 Home Street	Pgh. East		Filled BD 760				DER-ORM
*188	5/73	625 Corbin Street	Pgh. East		Filled BD 765				DER-ORM
*189	12/73	814 Maple Street	Pgh. East		Filled BD 827				DER-ORM
	1/74	711 Maple Street	Pgh. East		Filled BD 841				DER-ORM
*190	5/74	3320 & 3326 Homestead Duquesne Road	Glassport		Filled BD 870	X			DER-ORM
*191	9/74	3301 Whitaker Street	Pgh. East		Filled BD 899				DER-ORM
*192	11/74	Blackberry Road	Glassport		Filled BD 906	X			DER-ORM
193	11/74	West Mifflin Recreation Field			Filled BD 908				DER-ORM
*194	2/75	4426 Elizabeth Street	Pgh. East		Filled BD 924				DER-ORM

Table A

West Mifflin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Available Site Data: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
187	2d	4	S	Pittsburgh Coal	Risher	<1930		1050			10					
188	4d	8	S	Pittsburgh Coal	Risher	<1930		1035			85					
189	8d/12d	5/15	S/S	Pittsburgh Coal	Risher	<1930		1060			50/40					
190	12d	18	S	Pittsburgh Coal	Risher	1900-1910		955			35					
191	5d	6	S	Pittsburgh Coal	Risher	<1930		1070			20					
192	8d	15	S	Pittsburgh Coal	First Pool Walton Ext.	1900-1910		960			100					
193	4d	6														
194	4d	10	S	Pittsburgh Coal	Risher	<1930		1040			30					

Table A

West Mifflin Borough (6 of 6) — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*195	2/75	4743 Coal Road Ext.	Pgh. East		Filled BD 925				DER-ORM
*196	3/75	409 Victoria Street	Pgh. East		Filled BD 926				DER-ORM
197	4/75	State Route 885 Lebanon Road	Glassport		Filled BD 942				DER-ORM
*198	10/75	4616 Huber Lane	Pgh. East		Filled BD 993				DER-ORM
*199	-/-	Glencoe Drive	Glassport			X			AWM
*200	-/-	121 Main Entrance Drive	Glassport	1 Home					DER-MSIF (251), AWM

Table A

West Mifflin Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
195	2-10d	2-15	S	Pittsburgh Coal	Risher	<1930		1045			15					
196	6d	12	S	Pittsburgh Coal	Risher	<1930		1050			12					
197	15d	25														
198	4d	20	S	Pittsburgh Coal	Risher	<1930		1050			30					
199				Pittsburgh Coal	Risher	1900-1910		1010			80					
200				Irwin Run Coal	Irwin Run	<1930		1020			40					

Table A

White Oak Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*201	1/57	2608 Mohawk Drive	McKeesport						BuMines
202	3/63	3401 Foster Road	McKeesport		Filled BD 97				DER-ORM
*203	5/69	Regional Pk. No. 2	McKeesport		Filled BD 319				DER-ORM, AWM
*204	8/73	3413 Foster Road	McKeesport		Filled BD 807				DER-ORM

Table A

White Oak Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
201	"Large Cavity in Yard"			Pittsburgh Coal	Osceola			1040			40					
202	4d	25														
203								1170			5					
204	15d	15	S		Mehaffey			1145			15					

257

Project 76-541

Table A

Wilkins Township — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*205	5/71	226 Kingston Drive	Braddock		Filled BD 449	X			DER-ORM
	1/73	224 Kingston Drive	Braddock		Filled BD 697	X			DER-ORM
*206	5/71	356 Frazier Drive	Braddock		Filled BD 471	X			DER-ORM
*207	5/72	943 Elizabeth Street	Braddock		Flushed BD 581				DER-ORM, AWM
208	5/72	Farnsworth Road	Braddock		Flushed BD 564	X			DER-ORM, AWM
209	6/72	Briaridge Drive	Braddock		Filled BD 692				DER-ORM
*210	6/72	1460 Jefferson Hghts.Dr.	Braddock		Filled BD 584	X			DER-ORM
*211	4/72	179 Sunset Drive	Braddock		Filled BD 582	X			DER-ORM, AWM
*212	7/72	145 Sunset Drive	Braddock		Filled BD 614	X			DER-ORM
*213	5/75	Negley Avenue & Churchill Lane	Braddock		Filled BD 959				DER-ORM

Table A

Wilkins Township — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
205	-/2x3	30/15	-/S	Pittsburgh Coal	Sandy Creek	1900-1905		1080			30					
206	5x10	12	S	Pittsburgh Coal	Sandy Creek	1900-1905		1075			15					
207	2d	12	S	Pittsburgh Coal	Hampton	<1930		1065			12					
208	12d	6				1940										
209	5d&12d	6-10														
210	6x10	15	S	Pittsburgh Coal	Sandy Creek	1900-1905		1090			15					
211	10d	25	S	Pittsburgh Coal	Sandy Creek	1900-1905		1090			25					
212	3d	12	S	Pittsburgh Coal	Sandy Creek	1900-1905		1095			12					
213	8d	6	S	Pittsburgh Coal	Oak Hill No. 3	<1930		1055			25					

Table A

Wilkinsburg Borough — Allegheny County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*214	4/70	1433 Sylvan Terrace	Braddock		Filled BD 367, 459, & 461	X			DER-ORM
	3/73	Kramer and Sylvan	Braddock		Filled BD 772	X			DER-ORM
	1/74	1433 Sylvan Terrace	Braddock		Filled BD 840	X			DER-ORM
*215	11/73	1014 Old Gate Road	Braddock	1 Home		X			DER-MSIF (312)
	-/74	1014 Old Gate Road	Braddock	1 Home		X			DER-ORM
*216	7/74	2639 Graham Boulevard	Braddock		Filled BD 884				DER-ORM

Table A

Wilkinsburg Borough — Allegheny County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
214				Pittsburgh Coal	Hampton	1890-1900		1135			45					
215				Pittsburgh Coal	Hampton	1890-1900		1125			155					
216	5d	6	S	Pittsburgh Coal				1150			140					

Project 76-541

Table A

Bullskin Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	Subsidence Feature: U.S.G.S. Quadrangle	Subsidence Feature: Damage	Subsidence Feature: Remarks	Information Available: Mine Map	Information Available: Boring Log	Information Available: Level Survey	Information Available: Sources of Information
217	1/72	Prittstown	Connellsville		Filled BD 539				DER-ORM

246

Table A

Bullskin Township — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
217	14d	2														

Project 76-541

Table A

Connellsville Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
218	5/73	Cummins & Speelman Avenues	Connellsville		Filled BD 766				DER-ORM

Table A

Connellsville Township — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Available Site Data: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Available Site Data: Overburden Thickness (ft): Soil	Rock	Total	Available Site Data: Overburden (ft) (Massive Beds): LS	SS	Available Site Data: Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
218	12d	5														

492
264

Table A

Dunbar Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*219	6/72	Bel-Aire Lounge Route 119 South	S. Connellsville		Filled BD 592				DER-ORM

Table A

Dunbar Township — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
219	3x5	5	S	Cambria Steel	Morrell	1952		940			55					

Table A

Georges Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
220	6/66	RD 3 (Smithfield)	Smithfield		Filled BD 191				DER-ORM
221	6/73	Route 266 (Smithfield)	Smithfield		Filled BD 786				DER-ORM

CS

Table A

Georges Township

Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
220																
221	80	2.5-5														

Project 76-541

Table A

German Township

Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
222	7/73	Smithfield Road	Masontown		Filled BD 796				DER-ORM

Table A

German Township

Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
222	12	12														

Project 76-541

Table A

Masontown Borough — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	Subsidence Feature: U.S.G.S. Quadrangle	Subsidence Feature: Damage	Subsidence Feature: Remarks	Information Available: Mine Map	Information Available: Boring Log	Information Available: Level Survey	Information Available: Sources of Information
*223	12/72	234 Smithfield Road	Masontown		Filled BD 664				DER-ORM

Table A

Masontown Borough — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft) Soil	Rock	Total	Overburden (ft) (Massive Beds) LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
				Mining Activity												
223				Hecla Coal	Griffin #2			860			55					

278

Project 76-541

Table A

Menallen Township

Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	Subsidence Feature: U.S.G.S. Quadrangle	Subsidence Feature: Damage	Subsidence Feature: Remarks	Information Available: Mine Map	Information Available: Boring Log	Information Available: Level Survey	Information Available: Sources of Information
224	4/67	Park Drive & Stotler Road	New Salem		Filled BD 563				DER-ORM
225	6/73				Filled BD 696 & 783				DER-ORM

R 13

Project 76-541

Table A

Menallen Township

Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
224	4d	15	S	Pittsburgh Coal		1942					44					
225																

474

Project 76-541

Table A

North Union Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
226	1/71	Coolspring Road	Uniontown		Filled BD 432				DER-ORM

Table A

North Union Township — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
226																

276

Project 76-541

Table A

Redstone Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*227A	-/32	Merrittstown	Carmichaels		Study of Air Shaft (Active)	X	X	X	Trans AIME, Vol. 119, 1936

227

Project 76-541

Table A

Redstone Township

Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
227A		3.9		Republic Steel	Republic			678			317	85	40			

278

Project 76-541

Table A

South Union Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
228A	9/62	Route 40	New Salem	Telephone Cables	Pulling Pillars (Active)				BuMines
229	5/72	Route 21			Filled BD 585				DER-ORM
230	6/73	New Salem Road			Filled BD 793				DER-ORM
*231	9/67	Route 40	New Salem		Filled BD 242				DER-ORM

Table A

South Union Township — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
228A			S	Farm Coal	Snyder Mine #1			920			34					
229	8	18														
230	2	7														
231						1960		1070			40					

280

Table A

Springhill Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
232	10/73	Route 119	Smithfield		Filled BD 815				DER-ORM

Table A

Springhill Township — Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
232																

288

Table A

Washington Township — Fayette County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*233	-/63	Fayette Avenue & Delmont Street	Donora	3 Homes	Flushed SL 421				DER-ORM
*234	-/68	920 & 928 Fayette Avenue	Fayette City	2 Homes	Flushed SL 421		X		DER-ORM
235	3/73	Route 201	Fayette City		Filled BD 769				DER-ORM
*236	2/76	500 Perry Avenue	Fayette City	School		X	X		GAI (Rpt. 76-522)
237	-/-	Mutich Street	Donora	3 Homes					DER-ORM

283

Table A

Washington Township

Fayette County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
233				Pittsburgh Coal	Somers No. 1	<1933		835			125					
234				Pittsburgh Coal	Somers No. 1	<1933		835	30	64	120-140					
235																
236	160 x 190	1.5	T	Pittsburgh Coal	Tremont	<1907			20	105	125			SH	Siltst.	
237				Pittsburgh Coal	Tremont	1960										

Table A

Cumberland Township — Greene County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
238A	-/38		Carmichaels		Active Mining	X	X	X	BuMines RI 3452
*239A	-/39	Pennsylvania Route 88	Mather		Road Survey (Active)	X	X	X	BuMines RI 3562
*240A	-/69	Ceylon & Maple Roads	Carmichaels		Road Survey (Active)	X		X	DER-MSR

285

Table A

Cumberland Township

Greene County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
238A		3.5		Crucible Fuel	Crucible						350-500			SH	Clay	
239A		3.2		Crucible Fuel	Crucible			581			530					
240A		2.0	T	Buckeye Coal	Nemacolin			590			390			(SH)	Clay	

Project 76-541

Table A

Dunkard Township

Greene County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
241A	-/69	Bobtown	Masontown	1 Home	Active Mining			X	DER-MSR

Table A

Dunkard Township — Greene County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
241A		1.5	T	Jones & Laughlin	Shannopin No. 2		Total	820	45	389	434		(30)	(SH)	(Clay)	

888

Table A

Monongahela Township — Greene County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*242A	-/39	Pennsylvania Route 88	Masontown		Road Survey (Active)	X		X	BuMines RI 3562
243	-/-	Route 21	Masontown			X	X		GAI (Rpt. 66-200)

Table A

Monongahela Township

Greene County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
242A		3		Buckeye Coal	Nemacolin			670			297					
243		2		U. S. Steel	Ronco	1953	Total	645	35	115	150				Clay	46

Table A

Morgan Township — Greene County

Site No.	Date of Subs.	Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*244A	2/72		Waynesburg	1 Home	Longwall Extraction (Active)	X		X	DER-MSR

Table A

Morgan Township — Greene County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
244A			T	Jones & Laughlin	Gateway			455			579					

292

Project 76-541

Table A

Washington Township

Greene County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*245A	-/68 -/69	Red Dog Road	Waynesburg		Road Survey (Active)	X	X	X	DER-MSR

Table A

Washington Township

Greene County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
245A		4.4	T	Republic Steel	Clyde		Total	388	13	669	682	132	75		SH	

Table A

Burgettstown Borough — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*246	6/72	Union High School	Burgettstown		Filled BD 623				DER-ORM
*247	3/75	Burgettstown	Avella		Filled BD 941				DER-ORM

Project 76-541

Table A

Burgettstown Borough — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
246	6-8d	35	S					1015			35					
247	20&30d	5&45	S					1005			45					

296

Table A

California Borough (1 of 2) — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*248	-/21	204, 206, 213, 214, 215 Ellsworth Avenue	California		Subsidence Prior to Construction of Homes - Active Mining				DER-MSIF
		201, 212 Skyline Drive	California						DER-MSIF
	-/64	218, 222 Ellsworth Avenue	California						DER-MSIF
		212 Skyline Drive	California						DER-MSIF
		California Heights	California	3 Homes	May Refer to Preceding 3 Homes				DER-ORM
	8/64	226 Ellsworth Avenue & 201 Skyline Drive	California						DER-MSIF
	10/71	834 Wood Street	California						DER-MSIF
	-/72	208 Ellsworth Avenue & 947 Wood Street	California						DER-MSIF
	5/72	970 Wood Street	California	1 Home					DER-MSIF (224)
	7/72	834, 948, 970 Wood Street	California	2 Homes	Flushed SL 437-1A				DER-MSIF (304, 219), DER-ORM, AWM
	12/72	213, 214, 215, 217, 218, Ellsworth Avenue & 201 Skyline Drive	California	6 Homes	Flushed SL 437	X			DER-MSIF (271, 248, 241, 246, 240 & 247), DER-ORM, AWM
	4/73	204, 206, 208, 214, 218, 219, 221, 222, 226 Ellsworth Avenue	California	8 Homes					DER-MSIF (262, 261, 267, 285, 240, 272, 269, 276), AWM

Table A

California Borough — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
248	600 x 1900		T	Pittsburgh Coal	Vigilant	<1935		750			220-244			(SH)	(Clay)	

Table A

California Borough (2 of 2) Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*248 (cont'd)	4/73	201, 203, 208, 210, 212, 218, 220 Skyline Drive	California	6 Homes					DER-MSIF (284, 268, 270, 273, 266, 274), AWM
		947 Wood Street	California	1 Home					DER-MSIF (265), DER-ORM, AWM
*249	-/69	1004, 1018 Upper Green Street	California						DER-MSIF
	3/73	1004 Upper Green Street	California	1 Home					DER-MSIF (289), DER-ORM
	7/73	1018 Upper Green Street	California	1 Home					DER-MSIF (288), AWM
*250	-/72	630, 635 Hickory Street	California		Flushed SL 429				DER-ORM, DER-MSIF
		636, 642 Park Street	California		Flushed SL 429				DER-ORM
	8/74	635 Hickory Street	California	1 Home					DER-MSIF (339)
251	10/71	270 Pennsylvania Avenue	California						DER-MSIF
	5/72	270 Pennsylvania Avenue	California						DER-MSIF, AWM

CSG

Table A

California Borough

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
248	600 x 1900		T	Pittsburgh Coal	Vigilant	<1935		750			220-244			(SH)	(Clay)	
249	50 x 100		T	Pittsburgh Coal	Vigilant	<1935		750			210			(SH)	(Clay)	
250	200 x 400		T	Pittsburgh Coal	Vigilant	<1935		750	10	134	144	30		(SH)	(Clay)	
251																

300

Project 76-541

Table A

Canonsburg Borough — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*252	3/75	76 West Pike Street	Canonsburg	Rexall Drug Store	Filled BD 934				DER-ORM

Table A

Canonsburg Borough — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
252	20d	28	S					900			55					

Project 76-541

Table A

Cecil Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*253	3/75	108 Roosevelt Avenue	Canonsburg		Filled BD 944				DER-ORM

303

Table A

Cecil Township

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
253	8d	4	S	Pittsburgh Coal	Brier Hill	<1930		1035			15					

Project 76-541

Table A

Centerville Borough

Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
254A	-/66	Centerville	California	1 Home	Active Mining	X	X		DER-MSR

305

Table A

Centerville Borough — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
254A				U. S. Steel	Karen			814	25	355	380					

Project 76-541

Table A

Chartiers Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*255	3/71	839 Regent Street	Washington East		Filled BD 434				DER-ORM
	3/74	839 Regent Street	Washington East		Filled BD 853				DER-ORM

203

Table A

Chartiers Township

Washington County

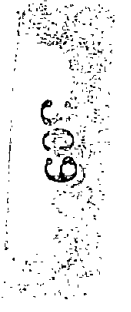
Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
255	10d/4d	20/6	S/S	Pittsburgh Coal	Allison	<1930		1030			20					

Project 76-541

Table A

Fallowfield Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	Subsidence Feature: U.S.G.S. Quadrangle	Subsidence Feature: Damage	Subsidence Feature: Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
256	4/69	Wilson Street	Monongahela		Filled BD 540				DER-ORM
257	6/75				Filled BD 964				DER-ORM



Project 76-541

Table A

Fallowfield Township

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
256	2 X 5	15			Wilson	1905										
257																

310

Project 76-541

Table A

Midway Borough — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*258	3/75	202 East Dickson Street	Midway		Filled BD 933				DER-ORM

Project 76-541

Table A

Midway Borough

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
258	35d	22	S	Carnegie Coal	Primrose			1060			22					

312

Project 76-541

Table A

Mount Pleasant Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*259	-/-		Midway		Filled BD 900				DER-ORM

Table A

Mount Pleasant Township

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft) Soil	Rock	Total	Overburden (ft) (Massive Beds) LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
259				Pittsburgh Coal	Midway	<1930		1035			40					

Project 76-541

Table A

New Eagle Borough — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*260	5/72	First Avenue & Madison Street	Monongahela	4 Homes	Flushed SL 423				DER-ORM, AWM
	6/72	First Avenue & Madison Street	Monongahela		Filled BD 593				DER-ORM

Project 76-541

Table A

New Eagle Borough — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
260	-/5x24	2/-		U. S. Steel	New Eagle	<1900		770	15	45	60		12			

316

Table A

North Strabane Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*261	11/65	511 Thomas Road	Hackett	1 Home					DER-MSIF (52), AWM
*262A	-/69	Linnwood Road	Washington East		Road Survey (Active)	X		X	DER-MSR

Table A

North Strabane Township — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
261				Mathies Coal	Mathies			810			385					
262A		3.1	T	Mathies Coal	Mathies		Total				260			(SH)		

Project 76-541

Table A

Peters Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*263	9/68	Hill Place Road	Bridgeville	1 Home	May be Active Mining				DER-MSIF (115), AWM
*264	5/75	Fawn Valley Drive	Bridgeville						

Project 76-541

Table A

Peters Township

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
263				Mathies Coal	Mathies			815			325					
264				Mathies Coal	Mathies			750			350	66		SH	SH	

320

Project 76-541

Table A

Robinson Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
265	1/69	Route 980	Canonsburg		Filled BD 313				DER-ORM

Table A

Robinson Township

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
265	10d	20		Pittsburgh Coal	Montour No. 9	1954										

Project 76-541

Table A

Smith Township

Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*266	3/73	T. R. 819	Burgettstown		Filled BD 726				DER-ORM
267	7/73	731 Perry Highway			Filled BD 790				DER-ORM
268	11/73	Bulger Road			Filled BD 831				DER-ORM
269	7/75	P. O. Box 253			Filled BD 973				DER-ORM

Table A

Smith Township

Washington County

Site No.	Areal Extent (ft)	Max. Settle-ment (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
266				Carnegie Coal	Patterson			1010			50					
267		20														
268																
269	10d	8	S	Greensburg & Connellsville C&C	Francis	1935					30					

Project 76-541

Table A

Somerset Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*270A	-/70		Hackett		Active Mining			X	DER-MSR
*271A	-/71	Eighty-Four, R.D. #2	Washington East 1 Home		Not Being Mined; To Start 1-72				DER-MSIF (204), AWM

Table A

Somerset Township — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
270A		3.8	T	U. S. Steel	Maple Creek		Total	750			250			(SH)	(LS)	
271A				Bethlehem Mines	No. 60			725			475					

Project 76-541

Table A

Union Township

Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
272	4/71	Hackett	Hackett		Filled BD 444				DER-ORM
*273	11/73	3448 Fawn Valley Lane	Bridgeville		Filled BD 828				DER-ORM
*274	11/73	Braden & Keystone Streets	Bridgeville		Filled BD 832				DER-ORM
*275	2/75	6720 Highland Ave.	Bridgeville		Filled BD 928				DER-ORM

Table A

Union Township

Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
272																
273	7	15	S	Pittsburgh Coal	Germania	<1930		1025			35					
274				South Fayette Coal	Presto	<1930		1050+			<20					
275				South Fayette Coal	Presto	<1930		1050+			<20					

Project 76-541

Table A

West Finley Township — Washington County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
276A	4/75		Valley Grove		Road Survey (Active - Shortwall)	X		X	DER-MSR

Table A

West Finley Township — Washington County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
276A		1	T	Valley Camp	No. 3						539					

Table A

Delmont Borough — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*277	2/74	290 Freemont Street	Slickville		Filled BD 857				DER-ORM
*278	6/74	Berry Lane	Slickville		Filled BD 883 & 950				DER-ORM
*279	-/-		Slickville		Filled BD 563				

Table A

Delmont Borough — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
277	15d	5	S	Pittsburgh Coal	Delmont			1230			30					
278	28d	35	S					1260			70					
279								1280			15					

2222

Project 76-541

Table A

Derry Township

Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
280	2/66	Keystone Club Road			Filled BD 177				DER-ORM
*281	6/72	1074 Hillview Avenue	Derry		Filled BD 599				DER-ORM

Table A

Derry Township

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
280	5 X 8	15														
281	8d	6	S	Bradenville Coal		1927		970			200					

Project 76-541

Table A

East Huntingdon Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*283	5/72	1000 Modulus Road	Connellsville		Filled BD 649 & 887				DER-ORM

65

Project 76-541

Table A

East Huntingdon Township

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
				Available Site Data												
283	3d	22	S	A. C. Overholt	Emma	<1930		1095			22					

633

Project 76-541

Table A

Fairfield Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	Subsidence Feature: U.S.G.S. Quadrangle	Subsidence Feature: Damage	Subsidence Feature: Remarks	Information Available: Mine Map	Information Available: Boring Log	Information Available: Level Survey	Information Available: Sources of Information
284	5/64	Route 711	Wilpen		Filled BD 129				DER-ORM

Table A

Fairfield Township

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
284	5d	30														

Table A

Franklin Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*285	9/69	Old Route 22	Slickville	Roadway	Filled BD 326				DER-ORM
*286	2/73	Route 22	Slickville		Filled BD 713				DER-ORM

Table A

Franklin Township — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
285				Westmoreland Coal	Export			965			45					
286	3d	25	S	Pittsburgh Coal	Delmont	<1930		1045			35					

Project 76-541

Table A

Hempfield Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*287	-/-	2333 Hunter Road	Greensburg		Filled BD 424				DER-ORM

Table A

Hempfield Township — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
287	4 X 8	20	S	Keystone Coal Co.	No. 2	1936		940			80					

342

Project 76-541

Table A

Madison Borough

Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*288	1/65	Along L.R. 64117	Smithton		Filled BD 229				DER-ORM

343

Project 76-541

Table A

Madison Borough

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
288	10d	15	S	Westmoreland	Whyle	1915		1070			70					

344

Project 76-541

Table A

Monessen — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*289	5/56	Boyd Street & Arbor Avenue	Monongahela	4 Homes & water main					BuMines
*290	1/63	Sycamore & Dennis	Monongahela	10 Homes					BuMines
*292	12/72	Ross Street	Monongahela		Filled BD 683				DER-ORM
293	5/75	700 Black - Graham Avenue	Donora		Filled BD 954				DER-ORM

Table A

Monessen — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
289	200d	1	T			<1930		970			94					
290	200d		T			Early 1930's		955			135					
292			S	Henderson Coal	Iron Mine No. 1	<1930		975			25					
293	10d	7	S													

346

Table A

North Belle Vernon Borough — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*294	-/64	Hill Street & Pine Alley	Donora	State Police Barracks	Flushed SL 421-1				DER-ORM
*295	-/65	Fells Street & Vernon	Donora	1 Home	Flushed SL 421				DER-ORM
296	5/73	Monessen Avenue & Cook Road		1 Building	Flushed SL 439				DER-ORM

347

Table A

North Belle Vernon Borough — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
294								875			35					
295				Pittsburgh Coal	Somers No. 1	<1933		865			105					
296																

248

Project 76-541

Table A

North Huntingdon Township (1 of 2) — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*297	1/66	125 & 127 Ormsby Drive	McKeesport		Filled BD 190, Flushed SL 407		X		DER-ORM, AWM
	10/67	126 Ormsby Drive	McKeesport		Filled BD 247				DER-ORM
298	2/66	Painterstown Road	Irwin		Filled BD 180				DER-ORM
299	11/66	235 Lincoln Way	McKeesport		Filled BD 217				DER-ORM
300	10/67	Sherrick Drive	McKeesport		Filled BD 248				DER-ORM
301	4/68	Skellytown Road	Irwin		Filled BD 571				DER-ORM
*302	4/69	227 Semple Drive	McKeesport		Filled BD 322				DER-ORM
	7/71	229 Semple Drive	McKeesport		Filled BD 322 & 484				DER-ORM
*303	6/71	Jane Claire Drive	McKeesport		Filled BD 465				DER-ORM
304	11/71	Lincoln Way	McKeesport	1 Home	Flushed SL 422		X		DER-ORM
305	4/72	Tomco Lane	McKeesport		Filled BD 574				DER-ORM
*306	4/72	413 Jane Claire Drive	McKeesport		Filled BD 577				DER-ORM
	6/73	413 Jane Claire Drive	McKeesport		Filled BD 777				DER-ORM
*307	5/72	206 Sherrick Drive	McKeesport		Filled BD 576 & 598				DER-ORM, DER-MSIF
*308	10/72	321 Sherrick Drive	McKeesport		Filled BD 654				DER-ORM
309	12/72	Skellytown Road	Irwin		Filled BD 684				DER-ORM

Table A

North Huntingdon Township — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
297	30d/5d	15/5	S/S	Westmoreland Coal				1090			20					
298	8d	15	S								35					
299	50 X 20	18	S	Adamsburg Coal							19					
300	10d	25	S								25					
301	20d	20														
302	3d/4d	10/12	S/S	Westmoreland Coal				1130			12					
303	15d	7	S	Westmoreland Coal				1060			50					
304	20d	1.7	S	Youghiogheny River Coal	Osceola		Total		5-10	24	34					
305																
306	4d/-	12/12	S/-	Westmoreland Coal				1060			130					
307	2d	20	S	Westmoreland Coal				1175			30					
308	15d	25	S	Westmoreland Coal				1180			25					
309	2d	16	S		Larimer						30					

Project 76-541

Table A

North Huntingdon Township (2 of 2) — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
*310	1/73	200 Michael Drive	McKeesport		Filled BD 691				DER-ORM
312	3/74	203 St. Clair Drive		Driveway	Filled BD 852				DER-ORM
313	4/74	Five Pines Road			Filled BD 864				DER-ORM
314	7/75	St. Clair Drive			Filled BD 970				DER-ORM

Table A

North Huntingdon Township — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	Mining Activity: % Ext.	Available Site Data: Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
310	10d	20	S	Westmoreland Coal				1155			20					
312	3d	2														
313	12d	20														
314	10d	18														

Project 76-541

Table A

Penn Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
315	9/71	Route 993			Filled BD 514 & 558				DER-ORM

353

Project 76-541

Table A

Penn Township

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Available Site Data: Mining Activity: Type	Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
315	3d	15		Keystone Coal		1920										

Project 76-541

Table A

South Huntingdon Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
316A	-/64	I-70	Smithton		Road Survey (Active)			X	DER-MSR
317	5/68	Route 970	Smithton		Filled BD 280				DER-ORM

Table A

South Huntingdon Township — Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
316A		4.3	T				Total				340					
317	15d	15		Davis Coal Co.												

Project 76-541

Table A

Unity Township — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
318	5/65	Lloydsville	Latrobe	5 Homes	Mine Fire				BuMines
319	2/66	Jones Street	Latrobe		Filled BD 178 (Mine fire)				DER-ORM
*320	12/72	Whyle Road (Whitney)	Latrobe		Filled BD 662				DER-ORM

Table A

Unity Township

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settlement (ft)	Type	Mining Activity: Mining Company	Mining Activity: Mine Name	Mining Activity: Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Overburden Thickness (ft): Rock	Overburden Thickness (ft): Total	Overburden (ft) (Massive Beds): LS	Overburden (ft) (Massive Beds): SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
								Available Site Data								
318	100X200		T								44			(SH)	(SH)	
319											25					
320	15d	7	S	H. C. Frick Coke	Hostetter Works	<1900		1060			75					

Project 76-541

Table A

West Newton Borough — Westmoreland County

Site No.	Date of Subs.	Subsidence Feature: Street Address	U.S.G.S. Quadrangle	Damage	Remarks	Information Available: Mine Map	Boring Log	Level Survey	Sources of Information
321	3/62	Chestnut Street	Donora		Filled BD 65				DER-ORM

359

Project 76-541

Table A

West Newton Borough

Westmoreland County

Site No.	Areal Extent (ft)	Max. Settle-ment (ft)	Type	Available Site Data: Mining Activity: Mining Company	Mine Name	Last Mined	% Ext.	Elev. Base of Coal (ft)	Overburden Thickness (ft): Soil	Rock	Total	Overburden (ft) (Massive Beds): LS	SS	Immed. Mine Roof	Mine Floor	Depth to Ground Water (ft)
321	8d	25	S	Pittsburgh Coal	Ocean No. 5						75					

360