DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF–1010
POMEROY–LANDSLIDE DEPOSITS,
WASHINGTON COUNTY, PA.
SHEET 1 OF 2

INTRODUCTION

This map is one of a series of 1:50,000-scale county maps in the Greater Pittsburgh region; it identifies areas with potential slope-stability problems significant to regional development. Intensive interpretation of landslides on 1975 GS-VDWD black and white, vertical aerial photographs (1:24,000) was supplemented by field reconnaissance in the fall of 1975 and the spring of 1976. The map does not show all recent landslides as many are too small to be discerned on the aerial photographs. Furthermore, many slopes not designated as containing older landslides undoubtedly include some, but the geomorphic evidence for them has been obliterated by erosion or modified by man.

The map is a guide to areas where detailed studies of slope stability would be most vital to the general public. In these areas, site examinations are necessary to determine the degree to which slope instability affects a contemplated land use. The map is not intended to replace detailed geological and engineering studies of specific sites by competent technical personnel.

SOURCES OF DATA

Landslides have been shown on geologic quadrangle maps by Berryhill (1964), Berryhill and Schweinfurth (1964), Berryhill and Swanson (1964), Kent (1967), Roen (1973), Roen and others, (1968), Schweinfurth (1967, 1976a, b), and Swanson and Berryhill (1964). Additional information concerning sliding in portions of Washington County is available in reports by Kent and others (1969), Berryhill and others (1971), Kent (1972), and Uhrin (1974).

Earlier products derived from the present investigation include reports by Pomeroy (1976a, b; 1977a, b). For more information regarding landslide map features and diagrams, the reader is urged to refer to the neighboring Allegheny County reports by Briggs and others (1975) and Pomeroy and Davies (1975).

The soil survey of Washington County (U.S. Soil Conservation Service, 1974a, b) was also used as a source of data.

The author acknowledges the assistance of members of the Washington County Planning Commission.

GEOLOGY AND SOILS AND THEIR RELATION TO LANDSLIDING

Bedrock in Washington County consists of flat-lying to subhorizontal cyclic sequences of sedimentary rocks of Pennsylvanian and Permian age; these rocks include, from oldest to youngest, the Conemaugh, Monongahela, and Dunkard Groups (figs. 1 and 2). Washington County is an integral part of a recent 1:125,000-scale geologic map of the Greater Pittsburgh region (Wagner and others, 1975).

The term "soil" is used in this report in the engineering sense; it includes material that has resulted from rock weathered in place (residuum) as well as weathered material that has moved downslope and accumulated at the base of slopes (colluvium). Most landslides observed in Washington County occur in colluvial or residual non-red clayey to clayey silt soil and in weathered rock derived from mudstone, claystone, and shale of the Dunkard Group. Guernsey soil (fig. 3) derived principally from claystone associated with thin beds of limestone and from thicker units of mudstone is particularly prone to sliding and is the major troublesome soil in the county. The Upshur soil derived from Conemaugh red mudstone (fig. 3) which is so prevalent in adjacent Allegheny and Beaver Counties occurs only in the extreme eastern and northwestern parts of the county.

Non-red clayey to clayey silt soil samples from 28 recent slides in the county indicate a moderate to high plasticity index based on physical-properties tests performed by K. S. Donovan, M. Moore, and B. Kauffman and supervised by S. Obermeier (USGS). X-ray diffraction techniques conducted by S. McNabb (USGS) and interpreted by M. Hess (USGS) for one red and three non-red samples reveal that the clays consist of illite, kaolinite, vermiculite, and interlayered minerals. Although the clay mineralogy of the soils derived from the Conemaugh and Dunkard Groups is similar, the limited data suggest that the Dunkard soils have a slightly greater proportion of expandable minerals. Similar clay mineralogical data were obtained from two Library soil localities in Washington County by Ciolkosz and others (1976). Data on Atterberg limits and potential volume change for a few mudstone, claystone, and landslide-material samples are given in Kent and others (1969) and in Berryhill and others (1971).

An extrapolation of U.S. Soil Conservation Service figures (1974a, b) for soil types and acreage in Washington County reveals that the areal distribution of landslide-prone soils (based on a slope of at least 8 percent and a moderate to high shrink-swell ratio) amounts to approximately 75 percent of the total acreage. This percentage contrasts sharply with the 18 and 20 percent figures for Allegheny and Beaver Counties, respectively.

FEATURES SHOWN ON THE MAP

Recent Landslides

More than 95 percent of the recent landslides in Washington County are small, generally less than 30 m in maximum dimension. Landslides whose maximum dimension is less than 9 m have not been plotted because of the map scale. The earthflow (fig. 4*B*) is the most dominant landslide type in the county. Slumps, earthflows and debris slides (figs. 4*A-C*) and combinations of the three are usually less than 2.5 m thick. However, a few slides occurring in relatively thick colluvium along lower slopes involve heterogeneous unconsolidated material more than 15 m in thickness. Also, some slides occur in relatively thick manmade fill deposits which may or may not be related to mining. Over 2,300 recent slides have been identified in Washington County.

In addition to obvious recently active slides, the unit "recent landslides" includes those slides which, judging from their appearance on the aerial photographs and from ground observations, are believed to have formed within the past 100 years. Since documentation commonly is lacking, the differentiation of "recent" from "older" slides is based on the reconnaissance investigator's judgments. Therefore, some slides mapped as "older" might actually have moved within the past 100 years.

Recent slides in the county have been caused by natural forces (unusually heavy rainfall falling within a period of a few days to several years), by man-generated factors, or by a combination of these causes. The ubiquitous earthflow seen in pastures seemingly has no important man-generated cause unless it can be attributed to a land-use change from forest to pasture ; most often, however, an earthflow appears to have been triggered by heavy rainfall.

Man's modifications of sensitive slopes include: excavation at the base of a slope resulting in its oversteepening; overloading a slope with fill causing instability; altering drainage conditions which affect both the surface and ground water; and vibrations caused by increased heavy construction (blasting and pile driving). Any one of these actions can overstress the soil and cause slippage. Many of the slides in table 1 were initiated by man's activity.

Soil creep is the imperceptible downslope movement of soil and rock material (fig. 4*D*) and is not considered a landslide process; however, accelerated creep often precedes sliding. Creep is common on many slopes throughout the county where ground breakage is lacking.

Most slides closely resemble the example shown in figure 4*E*. A poorly drained hummocky surface commonly containing seeps and cattail marshes characterizes the toe of a recent slide. Fresh scars and obvious frontal movement typify the entire mass of an active slide. Fewer than half of the slides shown as recent were active at the time of the reconnaissance. Many slides stabilized, at least temporarily, after movement occurred.

Slope failures related to strip mining constitute less than 4 percent of the recent slides and generally are due to slumping of spoil banks. Reconnaissance indicated that movement had been restricted generally to the waste material, and failure is largely independent of the underlying natural slope. The cause of failure might be poorly controlled surface and subsurface runoff, improperly compacted spoil material, or a combination of these causes. A few slides occur where the highwall has been cut into relatively thick colluvium, and the unstable material has begun to move. Relatively few slides have occurred in reclaimed land. Two sizable earthflows, located about 3 km southwest of Monongahela in eastern Washington County, occur along a regraded slope where the Waynesburg coal had been previously stripped (Roen and others, 1968).

Fill failures unrelated to coal mining are relatively few, unlike the situation in adjacent more populous Allegheny County (Pomeroy and Davies, 1975). A few examples are cited in table 1.

Landslides are not shown on the Prosperity quadrangle (Kent, 1972) because their representation would obscure the mapped bedrock units; Kent's keen observations, however, are appropriate to reproduce herein.

> "Limestone units with interbedded layers of claystone and black shale create zones of impervious bedrock that act as barriers to downward percolation of ground water through overlying siltstone and sandstone, causing ground water to move laterally to hillsides. In landsliding of the earthflow type water-saturated matrices of soil and rock fragments begin creeping or flowing downhill, and usually some rotational movement creates conspicuous scars or scallops near the uphill boundary of the hummocky, grass-covered mounds of slide material. Undoubtedly there are many localities along hillsides in the area where such matrices of soil and rock fragments are ready to slide, and will do so as soon as some natural or artificial event triggers them. A prolonged period of heavy rainfall may activate new landslides, or any excavation of the toe of a dormant slide may reactivate the slide. Limestone units mark the originating points of present slides, and they also mark the most likely points from which new slides will develop in the future."

Recent landslide investigations in Washington and adjacent counties to the north and east indicate that limestone does not have to be a necessary ingredient in the landslide process. In Washington County large slides have developed on slopes underlain by mudstone and other lithologies; there is no indication that limestone has played a significant role. Berryhill and others (1971, p. 29) mention some large slides which have developed on thick units of mudstone that contain a large amount of clay.

Older Landslides

More than 8,000 older landslides have been identified by reconnaissance methods in the present inventory in Washington County. Approximately 45 percent of these slides have well-defined geomorphic features, such as hummocky ground, that indicate former movement. The remaining 55 percent have similar but subdued characteristics and are fairly to poorly defined (indefinite). The head scarp and hummocky lower slope of indefinite slides are not always apparent due to erosion.

Figure 5 shows the characteristic topographic expression of older landslides. Generally, older landslides occur in hillside recesses which are concave both across slope and downslope. Instability is enhanced in these concave-shaped areas which collect more ground water than adjacent slopes. About 81 percent of the older slides occur on concave slopes; the remainder occur on planar, convex, or a combination of slope forms. Colluvial material at the foot end of many older landslides exceeds 10 m in thickness.

Older landslides shown on the map are either individual slides or a series of coalesced slides that are mapped together as one unit. Some of the latter are as wide as 7.0 km and do not represent a single event in the history of the area but are part of a continuing process that has been occurring since Wisconsin Glaciation. The rate of sliding was no doubt greater immediately after Wisconsin time because of increased rainfall.

These older landslides, although presently stable, can be reactivated by a prolonged period of heavy rainfall and by man-generated slope modification.

Areas Most Susceptible to Sliding

It is important to note that landslides can occur anywhere in the geologic section when optimum conditions for movement are present. However, the weathered material from some rock units has a greater potential for sliding than others. Figure 2 shows the relative susceptibility to landsliding of the weathered material derived from the various rock units.

Areas underlain by mudstones and claystones of the Dunkard Group, particularly that part of the section lying above the Washington coal, are more susceptible to sliding than are other areas as evidenced by the many recent and older landslides in this terrain. Second in importance are the areas underlain by the indurated red clays of the Conemaugh Group and of the Waynesburg Formation of the Dunkard Group.

Of the more than 2,300 recent slides documented on the map, approximately 89 percent occur within the Dunkard Group whose areal extent amounts to about two-thirds of the county area. A composite inventory of all slides (recent and older) shows that three times as many slides per square kilometer have occurred on Dunkard slopes as on Conemaugh slopes.

Throughout the Allegheny Plateau, stress release following the removal of support by stream erosion along major valley walls has produced extensive parallel joints that can result in the rotational slumping of bedrock and adjacent colluvium. Some landslides along the Monongahela River and some tributary valleys in the eastern part of the county owe their origin to this process.

Isopleths of area covered by landslide deposits

Methods--The isopleth map was constructed to quantify the distribution of landslide deposits in the county. R. H. Campbell first applied the isopleth technique to landslide distribution in a southern California quadrangle (Campbell, 1973). The technique was later applied to a smaller scale compilation in the San Francisco region (Wright and Nilsen, 1974; Wright, Campbell, and Nilsen, 1974).

Briefly, the following procedures were used:

1. A grid of 0.10 in. x 0.10 in. squares (100 $in.^2$) was placed over the landslide map. Each intersection which fell within or on the boundary of a landslide was marked with a dot.
2. A circle 1 $in.^2$ in area was then moved across the grid overlay, and at each 0.5-in. interval, the total number of dots was counted and recorded on the grid beneath the center of the circle.
3. Numbers of dots were translated into percent of area covered by landslide deposits. For example, if there were 10 dots within a 100-square area, a value of 10 percent would be assigned to that area. Contours were then drawn at 1 percent and at multiples of 10 percent.

The resultant isopleth map thus shows the percentage of the area covered by landslide deposits. Its utility is evident in that one can quantitatively compare slope conditions among various parts of the county. Furthermore, an isopleth map used in combination with maps showing geology, soils, slope, relief (all of which affect landsliding) enables one to make a framework for a slope stability map.

The relative groups suggested below show degrees of landslide susceptibility which may be useful in regional planning:

Landslide susceptibility	Percent of area covered by landslide deposits
Very high to severe	70-80+ percent
High to very high	50-70 percent
Moderate to high	30-50 percent
Low to moderate	10-30 percent
Nil to low	0-10 percent

It is recommended that the intervals be colored to make the map easier to interpret.

Discussion.--Slopes most susceptible to landsliding in several counties in the Greater Pittsburgh region are concentrated within two major red-bed sequences in the Conemaugh Group of Pennsylvanian age (Pomeroy and Davies, 1975, Pomeroy, 1977e). However, since in Washington County landsliding is more widespread and is especially pronounced throughout a 180-m section in part of the Dunkard Group of Permian age, an inventory map of landslide deposits in Washington County alone makes a slope-stability study difficult.

The user should bear in mind that the isopleth map is based largely on the distribution of older landslide deposits because the area covered by older deposits is significantly greater than the area covered by recent landslide deposits. This map is not an incidence map of recent landslides. Areas of frequent landslides, such as the strip-mine area surrounding Hanlin Station in the northwestern part, may show on the isopleth map as having a moderate susceptibility to landsliding. Other areas with a moderate number of man-induced small recent slides such as the I-79 corridor area between Washington and the Allegheny County line occur in a generally low-susceptibility area. In both areas despite man's influence, the slope material is simply not as prone to sliding as that of areas in the southern part of the county.

In the present study some factors which relate to slope stability (geology, soils, slope, relief) have been combined with the isopleths to present a clearer understanding of landslide susceptibility. The contouring reveals several areas of varying size having 50 to 80 percent of the land covered by landslide deposits. These high-susceptibility areas have the following characteristics: 1) they are underlain by Washington and Greene Formations of the Dunkard Group; 2) they involve Guernsey-Culleoka soils; 3) they have 25 to 60 percent slopes; and 4) they have average maximum relief of 90-150 m. By contrast, most areas showing less than one percent of the area covered by landslide deposits are located in the northwestern part of the county and have the following characteristics: 1) they are underlain by upper part of the Conemaugh and lower part of the Monongahela Groups; 2) they involve Weikert-Culleoka soils; 3) they have 8 to 25 percent slopes; and 4) they have average maximum relief of 45-60 m.

ROCKFALLS (not shown on map)

Widely differing physical characteristics of individual lithologies cause geologic engineering problems in an area underlain by cyclic sedimentary rocks. The rockfall problem is a prime example.

Rockfalls (fig. 4*F*) are produced by weathering and erosion which affect mudstone and shale more readily than sandstone, siltstone, and limestone. As a result, unsupported ledges of the more resistant rocks break away by falling. Jointing is a significant factor. In Washington County, joints are common in cut slopes along the Monongahela River, along tributary drainages in the extreme eastern part of the county, and along stretches of major highways (such as I-79 north of Washington). However, rockfall volumes in these localities are small and not mappable at the scale of this map. Rockfalls can occur anywhere in the geologic section, and their potential for catastrophic damage cannot be underrated. One rockfall in 1942 in adjacent Beaver County killed 22 people (Ackenheil, 1954).

SUMMARY

More than 10,000 landslides have been identified in Washington County. Landslide-prone soils are more extensive in Washington County than in any of the other counties which are part of the Greater Pittsburgh region. The widespread earth movements are not confined to distinct geologic horizons; this fact makes the job of showing susceptible horizons difficult. The isopleth map pinpoints those areas where susceptibility to sliding is high. Most landslides are earthflows which occur in colluvial or residual non-red clayey to clayey silt soil and weathered rock derived from mudstone, claystone, and shale of the Dunkard Group. Downslope movement of soil and weathered rock is a continuing and natural process which can be accelerated by man. Proper engineering and judicious use of land in sensitive areas can be used to check the threat of landslides.

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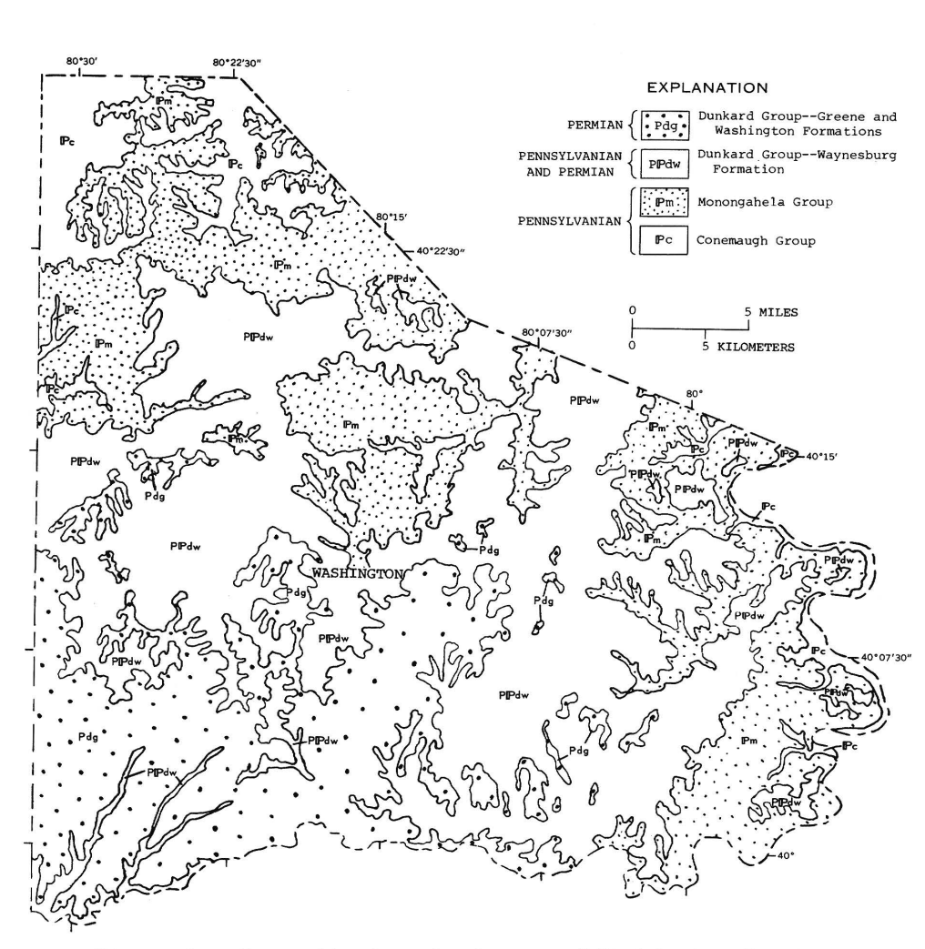


Figure 1.--Generalized geologic map of Washington County. Adapted from geologic map of Pennsylvania by the Pennsylvania Geological Survey (1960).

SYSTEM	GROUP	FORMATION	APPROXIMATE THICKNESS, IN METERS	LITHOLOGY	KEY HORIZONS	RELATIVE SUSCEPTIBILITY OF DERIVATIVE SOILS AND WEATHERED ROCK TO LANDSLIDING (assuming that rocks underlie slopes steeper than 15 percent and that other conditions are generally equal)
Quaternary	Alluvium		15	Unconsolidated clay to cobbles		Negligible
Permian	Dunkard	Greene	145	Mudstone, siltstone, sandstone, limestone, shale, claystone, coal (cyclic)		High to severe
		Washington	60	Limestone, mudstone, siltstone, sandstone, shale, claystone, coal (cyclic)		
					Washington coal	
Permian and Pennsylvanian		Waynesburg	42	Mudstone, sandstone, siltstone, limestone, shale, claystone, coal (cyclic)		Moderate to high
					Waynesburg coal	
Pennsylvanian	Monongahela	Uniontown	30	Mudstone, shale, sandstone, siltstone limestone, claystone, coal (cyclic)		Low to moderately high
		Pittsburgh	91			
					Pittsburgh coal	
	Conemaugh	Casselman	67	Mudstone, shale, sandstone, siltstone, limestone, claystone, coal (cyclic)		Moderate to high
					Ames Limestone	
		Glenshaw	30			Low to moderate

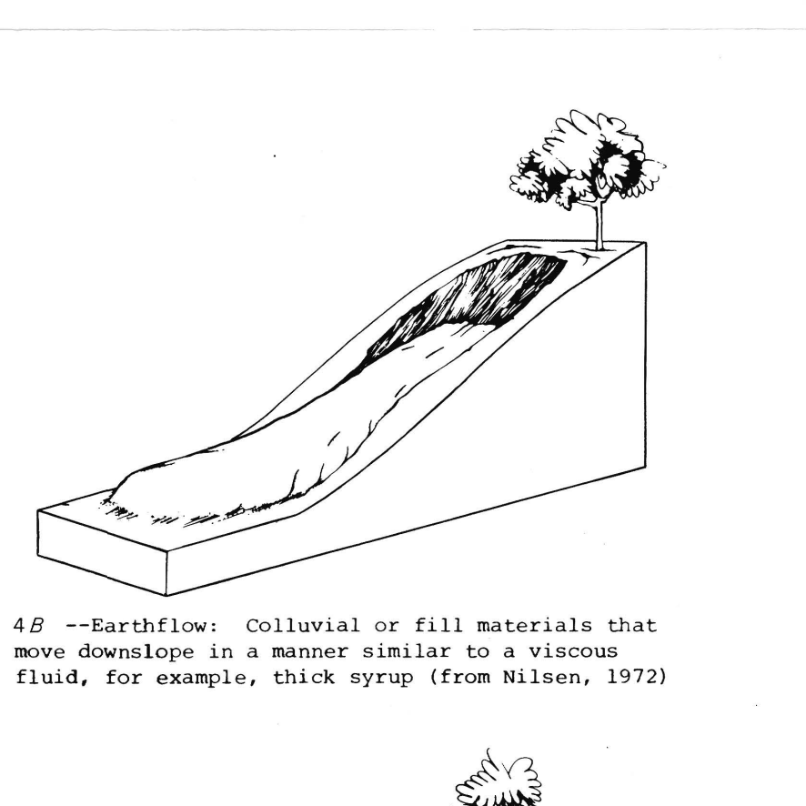
Figure 2.--Generalized stratigraphic section, Washington County, Pa., and relative susceptibility of derivative earth material to landsliding.

SOIL NAME	STRATIGRAPHIC INTERVAL	LITHOLOGY OF PARENT MATERIAL
Guernsey - Culleoka	Conemaugh - Monongahela - Dunkard	Non-red shale, mudstone, claystone, siltstone, limestone
Weikert - Culleoka[1/]	Conemaugh - Monongahela - Dunkard	Mostly non-red shale, siltstone, mudstone
Guernsey	Monongahela - Dunkard	Non-red shale, mudstone, limestone, claystone
Culleoka[1/]	Conemaugh - Monongahela - Dunkard	Mostly non-red shale, siltstone, mudstone
Clarksburg - Guernsey	Monongahela - Dunkard	Variable, colluvial material
Brooke	Monongahela - Dunkard	Limestone, calcareous shale, non-red mudstone
Upshur	Conemaugh	Red mudstone, claystone, shale
Library	Monongahela - Dunkard	Limestone, non-red mudstone and shale, claystone

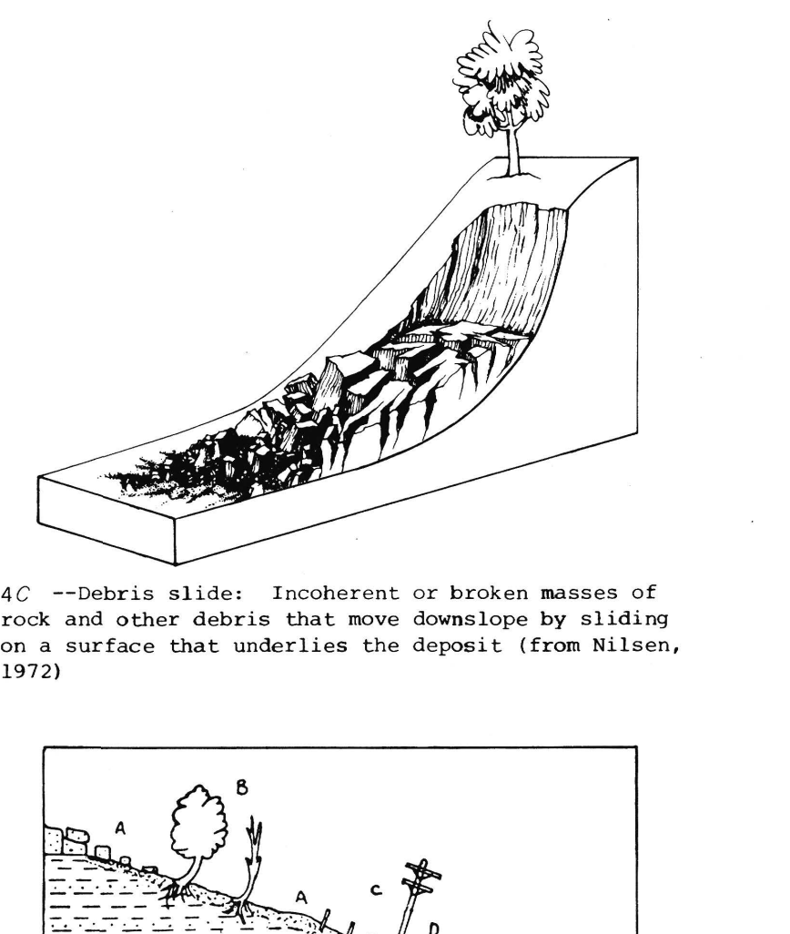
Note: Soils shown above are highly plastic and generally have a moderate or high shrink-swell potential

[1/] Shrink-swell potential is regarded as low for both soils but an American Association of State Highway Officials rating of A-7 (USSCS, 1974, table 2) for Culleoka soils indicates instability. Many landslides occur in both Culleoka and Weikert - Culleoka soils.

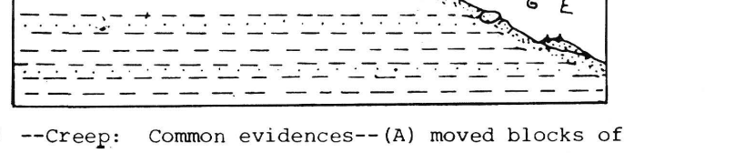
Figure 3.--Major landslide-prone soils, Washington County, listed in decreasing order of abundance.



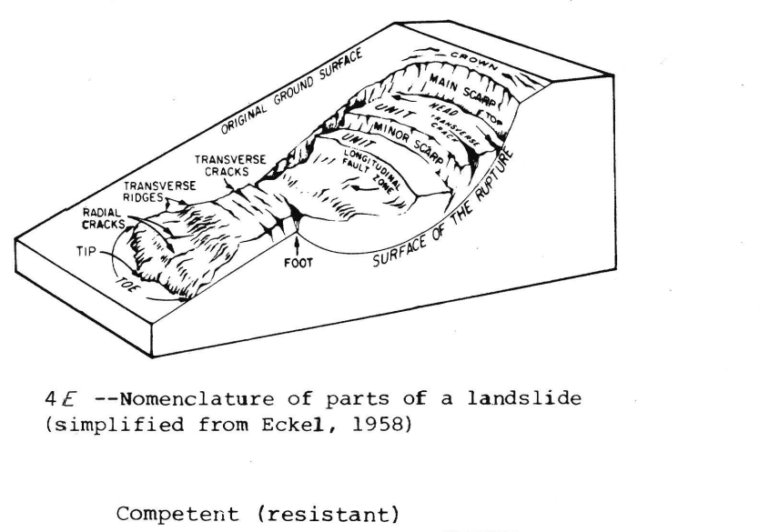
4*B* --Earthflow: Colluvial or fill materials that move downslope in a manner similar to a viscous fluid, for example, thick syrup (from Nilsen, 1972)



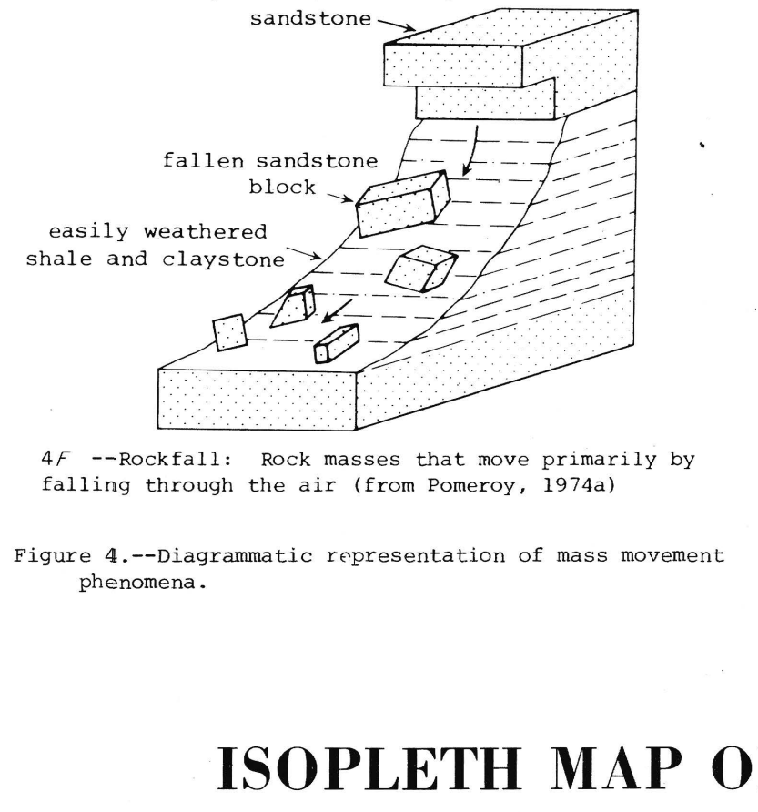
4*C* --Debris slide: Incoherent or broken masses of rock and other debris that move downslope by sliding on a surface that underlies the deposit (from Nilsen, 1972)



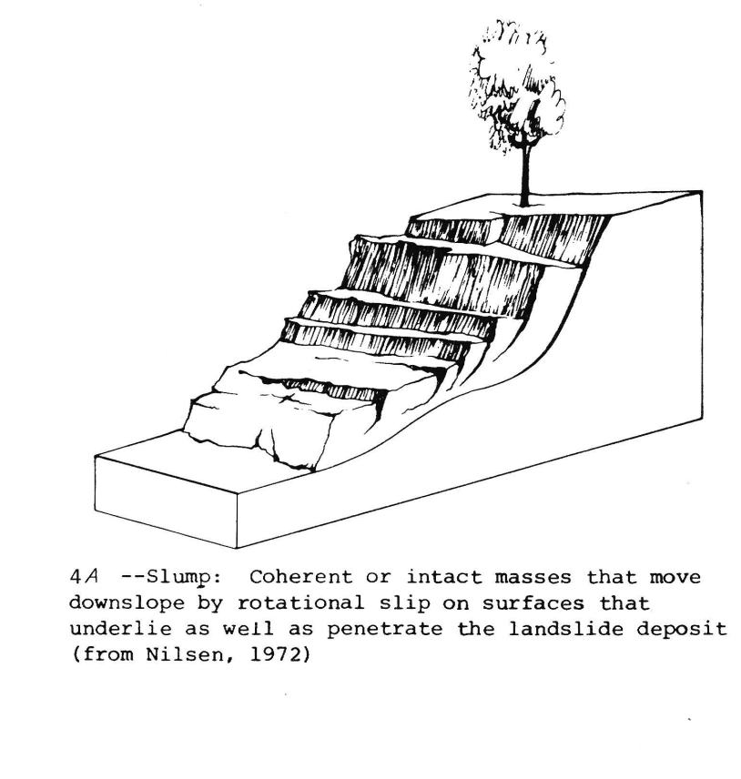
4*D* --Creep: Common evidences--(A) moved blocks of rock; (B) trees tilted at appreciable angles downslope with curved trunks concave upslope; (C) displaced posts, poles, and monuments; (D) broken or displaced retaining walls and foundations; (E) roads and railroads moved out of alinement; (F) turf rolls downslope from creeping boulders; (G) stone line at approximate base of creeping soil (modified from Sharpe, 1938)



4*E* --Nomenclature of parts of a landslide (simplified from Eckel, 1958)

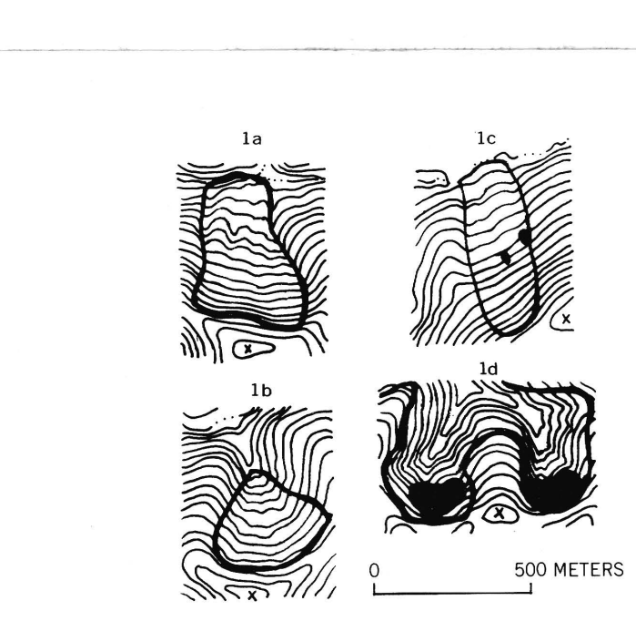


4*F* --Rockfall: Rock masses that move primarily by falling through the air (from Pomeroy, 1974a)



4*A* --Slump: Coherent or intact masses that move downslope by rotational slip on surfaces that underlie as well as penetrate the landslide deposit (from Nilsen, 1972)

Figure 4.--Diagrammatic representation of mass movement phenomena.

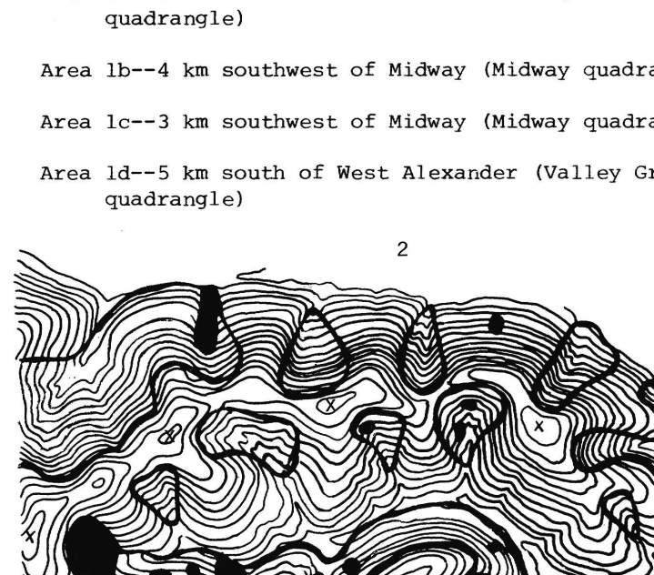


Area 1a--0.5 km east of Dutch Fork Lake (West Middletown quadrangle)

Area 1b--4 km southwest of Midway (Midway quadrangle)

Area 1c--3 km southwest of Midway (Midway quadrangle)

Area 1d--5 km south of West Alexander (Valley Grove quadrangle)

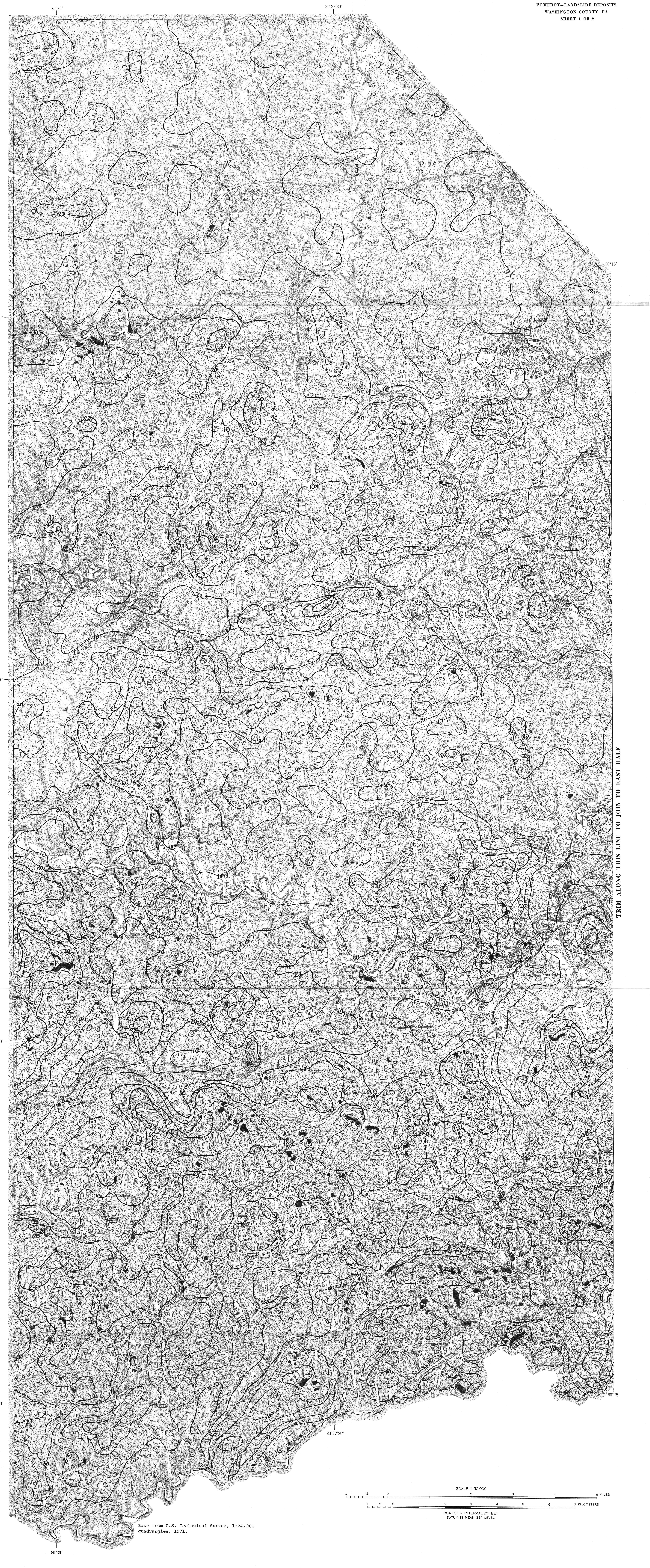


Area 2--2 km west of Prosperity (Prosperity quadrangle)

Figure 5.--Selected areas at 1:24,000 scale showing relation of landslides to topography. Older landslides are outlined; solid black areas are recent landslides. Tops of hills are indicated by x's. Contour interval, 20 feet.

Table 1. Guide to selected landslide localities in Washington County, Pa.

LOCALITY NUMBER	LOCATION	GEOLOGIC HORIZON	COMMENTS
1	Slope behind large apartment complex above Library Rd. (Pa. 88)	Head scarp at approximate level of Waynesburg coal. Waynesburg Formation of Dunkard to upper part of Pittsburgh Formation of Monongahela.	Recently active earthflow emanated from west side of older flow. Scarp is 1.5 m high; slide is 30 to 45 mm wide. Probably started as a result of cutting lower slope for parking area behind apartments.
2	Peters Township High School athletic field (1.2 km east of Donaldsons Crossroads)	Washington Formation base to Waynesburg Formation, both of Dunkard.	Recent earthflow within older landslide. Possibly triggered by slope renovation above field track.
3	Secondary road, 2 km south of Midway	Pittsburgh Formation (upper part) of Monongahela.	Two small slumps above road along modified slope. Buried telephone cable was exposed in slide area at time of reconnaissance. Cable was subsequently relocated away from slide area.
4	US 22 south of Bavington	Casselman Formation of Conemaugh (30-45 m below Pittsburgh coal).	Slumping along south side of highway cut (30-40 percent grade); bluish-gray clay identified at line of seeps.
5	Hanlin Station vicinity	Casselman Formation of Conemaugh.	Recent slides along hill northeast of settlement and 1 km to west. Largest slide is nearly 500 m in width. Sensitive slopes are underlain by red mudstone and claystone. Failures have largely resulted from road construction necessary to gain access to Pittsburgh coal at hilltops.
6	Secondary road 1.7 km east of Buffalo Creek-Dutch Fork intersection	Washington and Waynesburg Formations of Dunkard.	Active slide (150 m wide) within 1-km-wide older landslide. Movements in 1976 shifted alinement of a few telephone poles; more extensive renewed movement in 1977 sheared off some poles. Recent sliding may have been caused by heavy rainfall along the previously unstable slope.
7	Castleman Run Road at state border, 4 km west of Dutch Fork Lake	Washington Formation (basal part) of Dunkard.	Wide (1.2 km) zone of discontinuous small active slumps in soil lying above Washington coal outcrop. Fresh scarps exposed as much as 60 m above road. Road widening might have renewed slope movement.
8	Texaco gas station along US 40 on west side of Claysville	Greene Formation (lower part) to Washington Formation, both of Dunkard.	Active slide greater than 100 m in length. Gray-clay sliding surface exposed at head along with ubiquitous springs. Excavation at base of slope may have caused slide.
9	Industrial development along US 40 2.5 km east of Claysville	Greene Formation (lower part) to Washington Formation, both of Dunkard.	Slump at the top with earthflow at base. Poorly compacted fill at top and inadequate drainage provisions might have triggered slide. Younger slide within older landslide.
10	Southeast side of road northeast of Good Intent	Greene Formation (lower part) of Dunkard.	Road widening has disturbed sensitive slope and has caused discontinuous thin-skinned sliding above a 0.6-km section of the road.
11	Road 0.6 km west of Pa. 19 south of Amity	Washington Formation (lower part) of Dunkard.	Wide (300 m) zone of active sliding within older landslide. Discontinuous scarps and slanted trees along slope.
12	Subdivision just north of US 40	Greene Formation (lower part) of Dunkard.	Fill slump behind vacant lot and rear yard of house. Over-extension of fill has overloaded slope. Scarp is as high as 2.5 m.
13	Slope behind new house 1.5 km east-northeast of I-79 interchange near Harts Mill	Washington Formation (upper part) of Dunkard.	Earthflow (1976) pushed in rear basement wall of new house. Head scarp extends discontinuously behind adjacent houses. More recent (1977) movement has threatened house at south end of row. Older slump benches visible on slope above recent scarps.
14	Residence at Speers	Casselman Formation of Conemaugh.	Backyard fill failure; head scarp within 3 m of foundation. Inadequate drainage provision behind house, poorly compacted fill, and modification of slope at its base may have contributed to the failure.



CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

Base from U.S. Geological Survey, 1:24,000 quadrangles, 1971.

TRIM ALONG THIS LINE TO JOIN TO EAST HALF

ISOPLETH MAP OF LANDSLIDE DEPOSITS, WASHINGTON COUNTY, PENNSYLVANIA - A GUIDE TO COMPARATIVE SLOPE STABILITY

By

John S. Pomeroy

1978

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