

BASELINE STUDY OF THE HYDROLOGY AND MORPHOLOGY
OF LITTLE SEWICKLEY CREEK, SEWICKLEY, PA

by

William S. Neubeck

Prepared under the direction of Dr. Marie Morisawa
for the Little Sewickley Creek Watershed Association



STATE UNIVERSITY OF NEW YORK AT BINGHAMTON

Binghamton, New York 13901

Department of Geological Sciences and
Environmental Studies
Telephone (607) 798-2264

This report presents the results of a study on the hydrology and morphology of Little Sewickley Creek, authorized by the LSCWA.

The research was carried out by a graduate student, William Neubeck, under my direct supervision. His results and recommendations carry my endorsement.

Marie Morisawa

Marie Morisawa, Ph.D.
Professor of Geology

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INTRODUCTION

It is now well established that urbanization in a watershed may have a profound effect on the stream and drainage (Carter, 1961; Wilson, 1967; Anderson, 1970; Hammer, 1972; LaFlure, 1978; Nelson, 1979). However, in the case of small watersheds (2-78 km²) generalizations concerning a watershed based on one or two other watersheds can be misleading. The small size of the watersheds can preclude their comparison due to amplification of variations in, for example vegetation, degree of urbanization, climate, and orientation. Add to this the complication of the lack of basic data for small watersheds and it becomes easy to see why increases in flooding, erosion, and siltation are becoming major problems in many small watersheds.

The members of the Little Sewickley Creek Watershed Association have undertaken the task of studying their watershed while it yet remains in a rural state in order to understand the stream and earth processes, thereby allowing them to make rational decisions concerning future land use. This, then, should result in minimized damage to the natural environment and its inhabitants.

This study is the first of a number of studies that will help achieve this necessary understanding through synthesis of basic baseline data on the 1) geology, 2) present land use, 3) hydrology, and 4) geomorphology of the Little Sewickley Creek watershed, which will be presented in this report. In addition, comparison of this information with that of other watersheds in the region, both rural and urbanized, will help to better define

the changes that are likely to occur in the future with increased urbanization in the watershed.

Data provided in this paper will be reported using the metric system of measurement. English units will be used only if the information is in reference to existing topographic and geologic maps using the English system. A table of English-metric conversions is provided in the appendix.

A glossary is also provided in the appendix for the definition of selected scientific terms. These terms are marked with an asterisk in the text.

PHYSICAL ASPECTS OF THE STUDY AREA

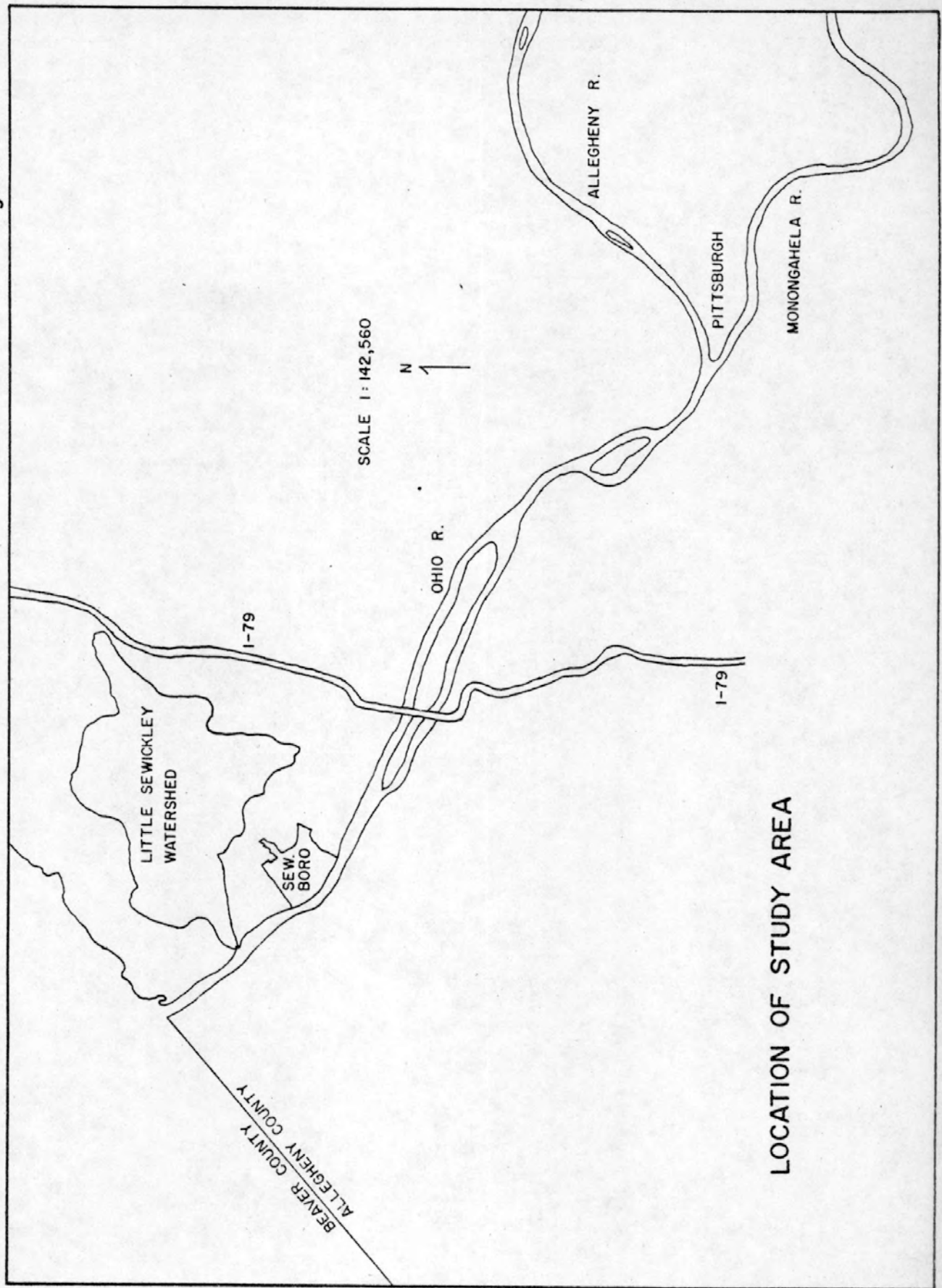
Geographic Setting

Little Sewickley Creek is a small southwest flowing stream in the central portion of the dissected Appalachian Plateau and is located in Allegheny County, PA, approximately 21.7 km northwest of Pittsburgh (Fig. 1). The stream drains an area of 25.2 km² and empties into the Ohio River which flows northwest in this area. The watershed is covered by the Ambridge and Emsworth 7½ minute U.S. Geological Survey topographic quadrangles, and portions of it lie in the boroughs of Franklin Park, Sewickley Hills, Bell Acres, Sewickley Heights, Edgeworth, Leetsdale, and Leet Township. The majority of the watershed is presently in a rural state while the surrounding areas are basically suburban residential, urban, and industrial, making the area an "island in the midst of the sea". Pressure for future development is strong due to the watershed's aesthetic qualities and location with respect to the city of Pittsburgh.

Geology

The rocks at the surface in the watershed are Middle Pennsylvanian in age (approximately 300 million years old) and are part of the Conemaugh Group*. This group is further broken down into two formations*; the older Glenshaw and the Casselman. These two formations are separated by the thin Ames Limestone bed (Fig. 2). In general, the beds are flat-lying sandstones (stippled), shales and siltstones (blank), limestones (vertical lines), and coal (solid black). The diagonal line pattern repre-

Figure 1



GENERALIZED GEOLOGIC SECTION — CONEMAUGH

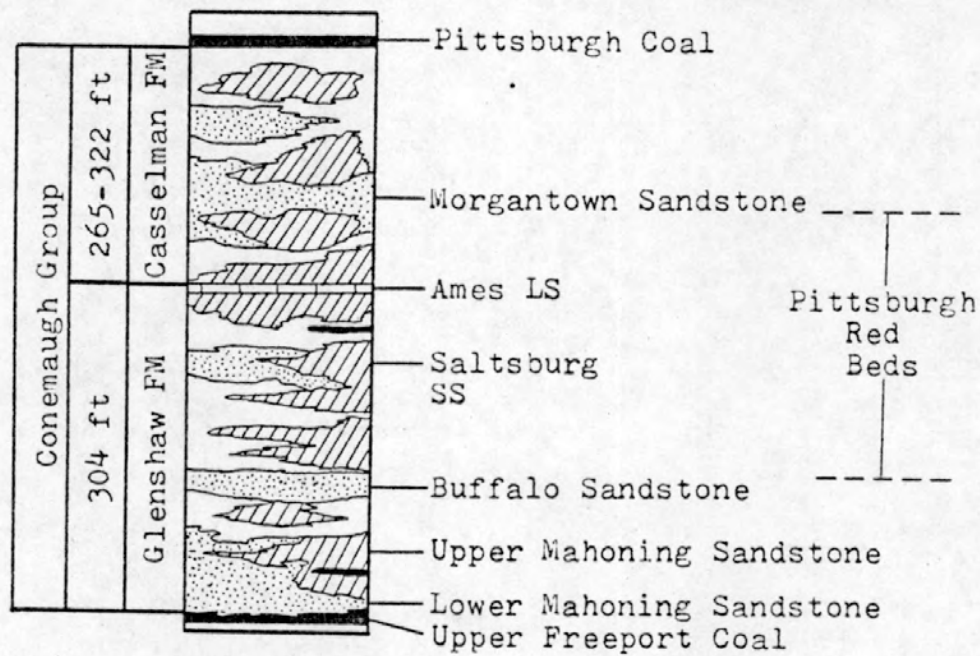


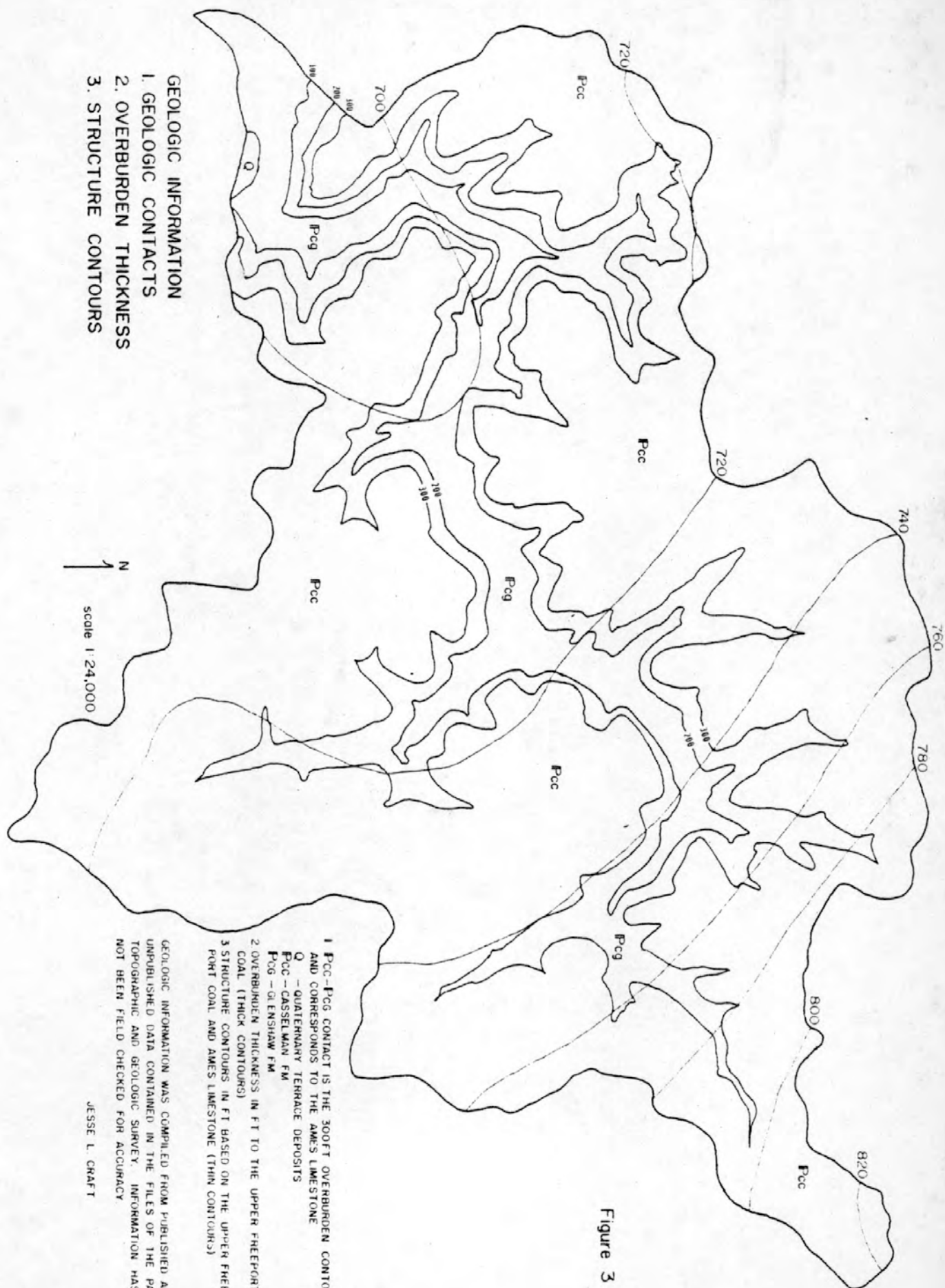
Figure 2. After O'Neill (1974).

sents red beds consisting of red siltstones, shales, and claystones which, though recurring throughout the Conemaugh, tend to be concentrated in the upper part of the Glenshaw and lower half of the Casselman Formations (Wagner, 1970a). In reference to these red beds Wagner, and others (1975) state:

The rocks of the Conemaugh Group are the most landslide prone of the Greater Pittsburgh Region. Unstable slope conditions are especially common in the middle part of the group from approximately 100 feet above the Ames limestone to the top of the Buffalo sandstone. Landslides are associated with red-clay shale units, known locally as the "Pittsburgh Red Beds". These red beds are found mainly below the Ames limestone member of the Glenshaw Formation. There is, however, a 10' to 20' thick red-bed unit in the Casselman Formation about 100' above the base. This upper red-bed unit has the greatest potential for urban associated landslides, as it is associated with slopes suitable for modern development, i.e., not oversteep and they have natural appeal because of aesthetic (sic) factors. Ancient landslides are especially common in this stratigraphic sequence. These old slides are extremely unstable when disturbed by construction activity.

Figure 3 is a geologic map which indicates where the formations are at the surface. The map also shows the thickness of the Conemaugh Group or the depth to the base of the Group. Finally, the map indicates the structure, or shape of the beds, to be a broad downfold similar to a shallow trough that dips to the southwest.

Joints, which are fractures in the rocks along which little or no movement has occurred, divide the rocks in Allegheny County vertically and at right angles to the horizontal layering. Joints are widely spaced in the sandstone units of the Conemaugh but very closely spaced in the shale units causing them to weather* quickly into tiny fragments. Joints can have a large influence on landslides since percolating groundwater moves along them causing an increase in local water pressure,



GEOLOGIC INFORMATION 1. GEOLOGIC CONTACTS 2. OVERBURDEN THICKNESS 3. STRUCTURE CONTOURS

- 1 Pcc-Pcg CONTACT IS THE 300FT OVERBURDEN CONTOUR AND CORRESPONDS TO THE AMES LIMESTONE
- Q - QUATERNARY TERRACE DEPOSITS
- Pcc - CASSELMAN FM
- Pcg - GLENSHAW FM
- 2 OVERBURDEN THICKNESS IN FT TO THE UPPER FREEPORT COAL (THICK CONTOURS)
- 3 STRUCTURE CONTOURS IN FT BASED ON THE UPPER FREEPORT COAL AND AMES LIMESTONE (THIN CONTOURS)

GEOLOGIC INFORMATION WAS COMPILED FROM PUBLISHED AND UNPUBLISHED DATA CONTAINED IN THE FILES OF THE PA TOPOGRAPHIC AND GEOLOGIC SURVEY. INFORMATION HAS NOT BEEN FIELD CHECKED FOR ACCURACY

JESSE L. CRAFT

thereby inducing a slide. In addition, joint patterns influence surface drainage patterns. Since the major joint directions in Allegheny County are northeast-southwest and northwest-southeast, many of the streams in the area parallel these directions (Wagner, 1970b). This alignment of the stream to the joint patterns can be clearly seen in the lower portion of the watershed, for example, at the upper end of Walker Park where the stream course changes abruptly from northwest to southwest. In general, most sections of the main trunk follow one of the two joint directions.

Continental glaciation in the Pleistocene Epoch is also partially responsible for the present form of the watershed. Of the four major advances of ice only the last two ice sheets (the Illinoian and Wisconsinan, .3 and .07 million years ago, respectively) reached western Pennsylvania, though neither advanced as far as Allegheny County. However, at the time, these ice sheets blocked the north flowing rivers forming lakes which eventually caused the waters to flow south along the present Ohio River and ultimately into the Gulf of Mexico. As the glaciers melted the water produced carried large amounts of silt, sand, and gravel which were deposited in the region and now occur as terraces between 900 and 1000 ft (Heyman, 1970). This glacio-fluvial* material, along with the easily eroded red beds has resulted in an abnormally wide floodplain below 1000 ft in the Little Sewickley Creek Watershed.

Soils

The dominant soils in the watershed are the Gilpin-Upshur and Gilpin-Weikert series (Fig. 4) which are moderately

deep, well drained soils formed from relatively acid shale and sandstone. Both series occur on upland slopes (Allegheny Soil Survey, 1973). A full description of the soil series in Figure 4 appears in the appendix.

Climate

The climate of the Pittsburgh region is classified as temperate continental with warm summers and the average annual precipitation is 100 cm (Trewartha, 1968). The highest stream flows in Little Sewickley Creek occur in the spring, though isolated higher peaks may occur during summer and fall thunderstorms. Approximately 40 thunderstorm days occur annually in the region (Geraghty, and others, 1973), and annual runoff is 35 to 40 cm (United States Geological Survey, 1976).

Watershed Characteristics

The watershed topography consists of steep hillslopes with flat uplands at 1100 ft corresponding to the surface of the Appalachian Plateau. Slope maps are often used to depict the degree of dissection of the land in an area. Since similar maps are already available for the watershed, two other methods of evaluating dissection, namely, the relief ratio and a graph of cumulative frequency distribution of elevations will be presented.

Pike and Wilson (1971) devised a quantitative measure of dissection known as the relief ratio, E, where

$$E = \frac{\text{Mean elevation} - \text{Minimum elevation}}{\text{Maximum elevation} - \text{Minimum elevation}}$$

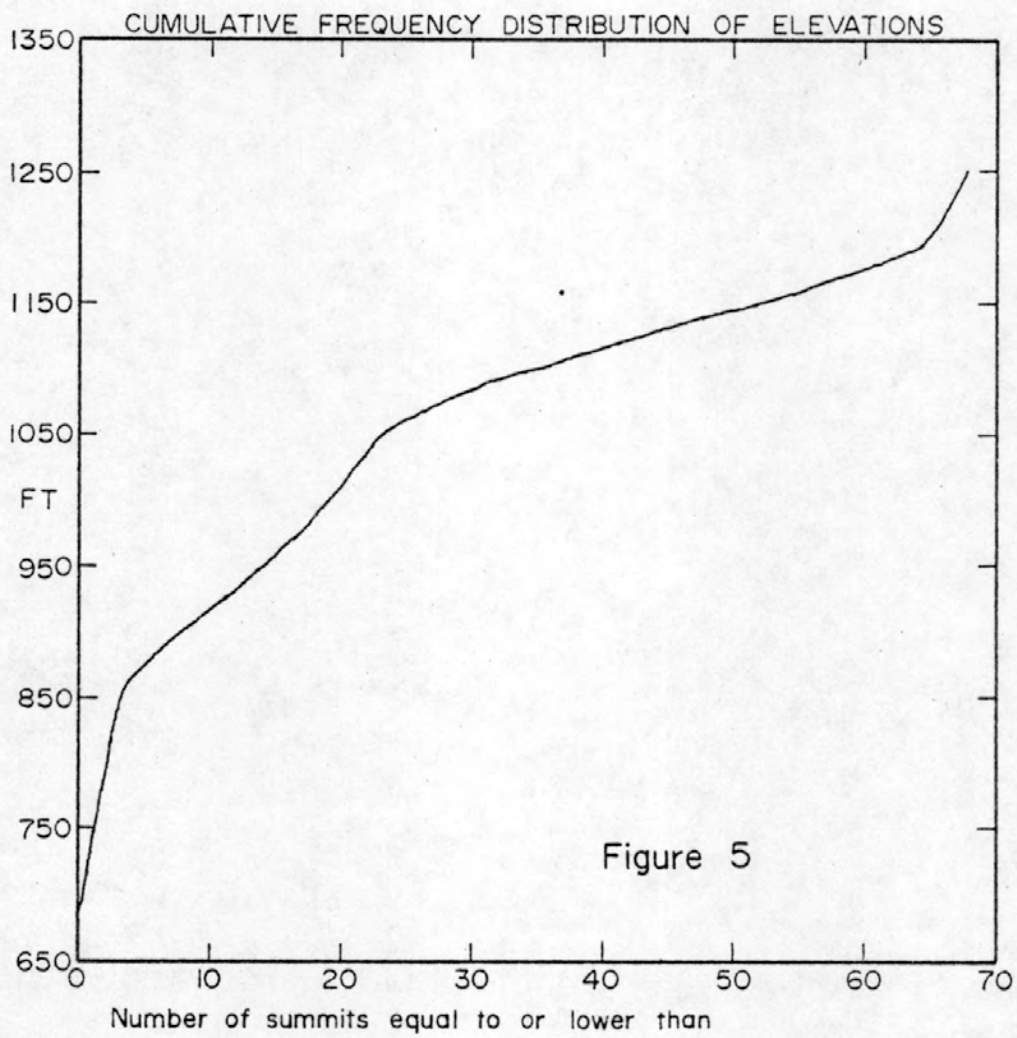
which characterizes the ratio of upland to lowland. The authors

state that E ranges from .15 to .85 with most values falling in the range .4 to .6. Low values indicate small areas of relief above a flat surface and high values indicate level surfaces with scattered depressions.

E was determined for Little Sewickley Creek watershed by using a grid overlay for sampling 68 random elevations. In this way it was determined that the mean elevation was 1067 ft. The maximum and minimum elevations as determined from the topographic quadrangles were 1310 ft and 685 ft, respectively. The relief ratio, then, is $E = .61$ indicating a high degree of dissection with flat upland areas.

Using the same sample points, a cumulative frequency distribution curve was constructed (Fig. 5) following the method outlined by Morisawa (1976). The curve indicates that approximately 62% of the area is at elevations between 1050 and 1200 ft, and approximately 30% of the area is at elevations between 850 ft and 1050 ft.

The longitudinal profile of the main trunk of Little Sewickley Creek is shown in Figure 6. Changes in slope as noted in the upper portion of the profile are often related to the bedrock variations in resistance to erosion (Hack, 1957; Brush, 1961; Morisawa, 1962). In this case the resistant units are indicated on the profile. Below the Saltsburg sandstone the stream can be considered pretty much at grade, or in equilibrium with the underlying lithologies* as indicated by the smooth profile. This linearity also indicates that there has been few major man effected changes which will also show up as nickpoints on the profile. The effects of man and the tributary profiles will be discussed later.



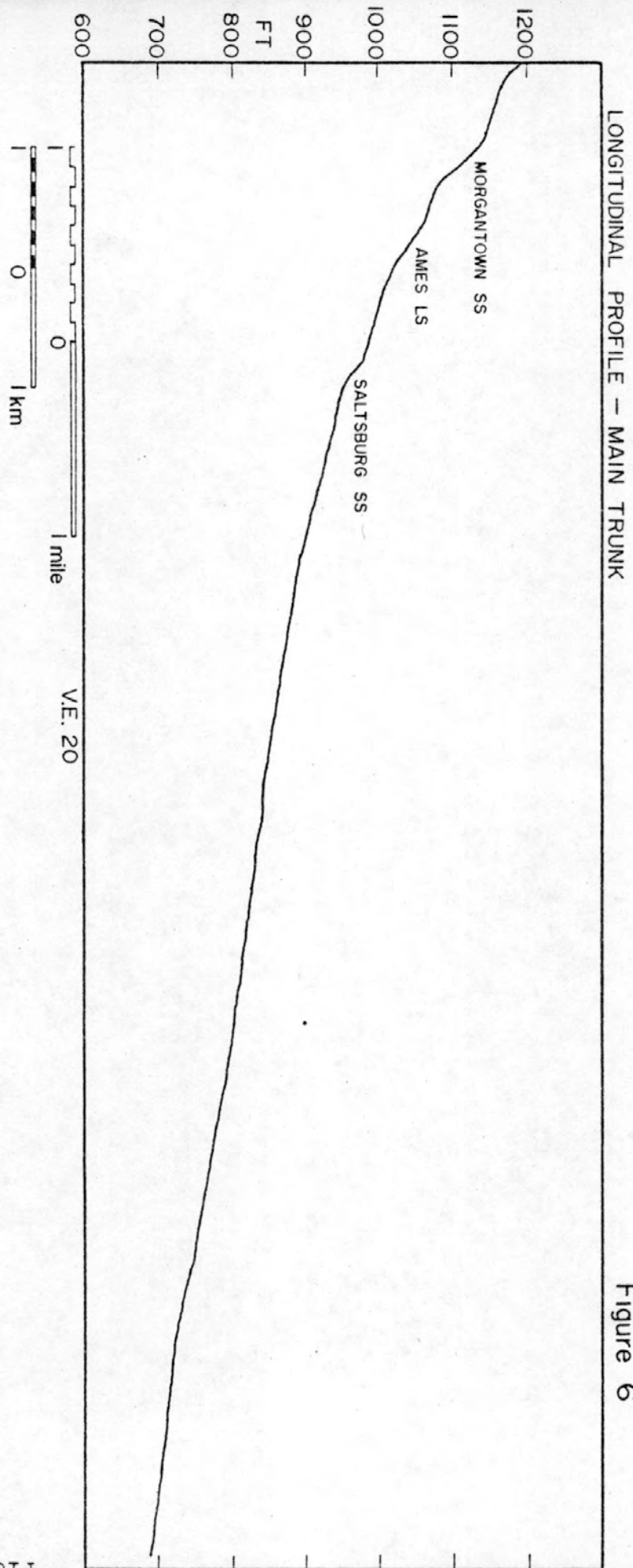


Figure 6

LAND USE

Knowledge of the land use within a particular area is essential for a full understanding of the drainage properties for that area. The way in which water moves from the place it lands to the mouth of a stream is highly dependent on the state of the land surface. Thus, the amount and spacial distribution of various types of land use are important factors controlling overall drainage characteristics. This section deals with land use in a quantitative sense and the aim is to provide land use data for the watershed in its present state and describe past trends by comparing this data with land use in 1938.

Methods

Land use data was obtained from two sets of air photos provided by the Pennsylvania State Geologic Survey; a 1938 set at a scale of 1:20,000 and a 1973 set at a scale of 1:12,600. To determine the relative percentages of different types of land use the categories were outlined on a sheet of mylar placed over the air photos and a grid overlay was then used to take a number of sample points. Where possible, data from the 1973 air photos was updated by field checks in order to provide information for the watershed in its present form. The categories used are defined as follows:

- forest - those areas where trees are the dominant vegetative cover
- grasslands - those areas where the dominant vegetative cover consists of grass or low scattered shrubs

including fields, pastures, and golf courses
residential - those areas used primarily for residential
housing, churches, schools, etc.

commercial - includes areas such as retail stores, shopping
centers and associated parking lots

industrial - areas used for industrial concerns

Due to the scales of the maps, areas covered by roads or by
water such as streams and ponds were not considered as separate
categories.

The categories were defined in such a manner as to
separate areas having different runoff* characteristics. Run-
off is highest for the residential, commercial, and industrial
categories since these areas all have a high percentage of im-
permeable area. Grasslands have moderate to low runoff and for-
ested areas have very low rates.

Results

Table 1 is a summary of the results obtained along with
standard deviations and standard error percent. Upon review of
these figures one reason for the infrequent occurrence of flooding
in the watershed becomes apparent. Presently, 93.7% of the
watershed is covered by either forest or grasslands. Therefore
percent runoff is low and the retention capacity of the land is
very high. Not only does this lower the amount of runoff from
a given storm but also the time required for the water to get to
the stream is increased resulting in lower peak discharges. In
addition, the majority of high runoff area is located near the
mouth. The only exceptions to this at the present time are the

Maronda Homes development and developments located in the headwaters along Camp Meeting Road. The only section adversely affected by urbanization and associated storm water drainage at this time is the section below Woodland Road. This will be discussed more fully later.

Stability of the stream is further aided by the fact that land use in the watershed has changed little in 41 years. Forested area has actually increased by 11.2%, grasslands have decreased by 27.2% and residential areas have increased by 129.2%. The latter still represents only 5.5% of the total watershed area. Thus, the stream has been able to maintain its equilibrium established long ago with the land on which it flows. This is in marked contrast to other more urbanized watersheds in the region whose problems are related to their stream's attempt to cope with upsets in equilibrium resulting from rapidly changing conditions.

TABLE 1. Land Use in Little Sewickley Creek Watershed

Land Use in 1938

(N = 1366)

Use	Percent of Total Area	Standard Deviation	Standard Error Percent
forest	59.0	.492	1.33
grassland	38.6	.487	1.32
residential	2.4	.153	0.41
commercial	0.0	-	-
industrial	0.0	-	-

Present Land Use

(N = 1061)

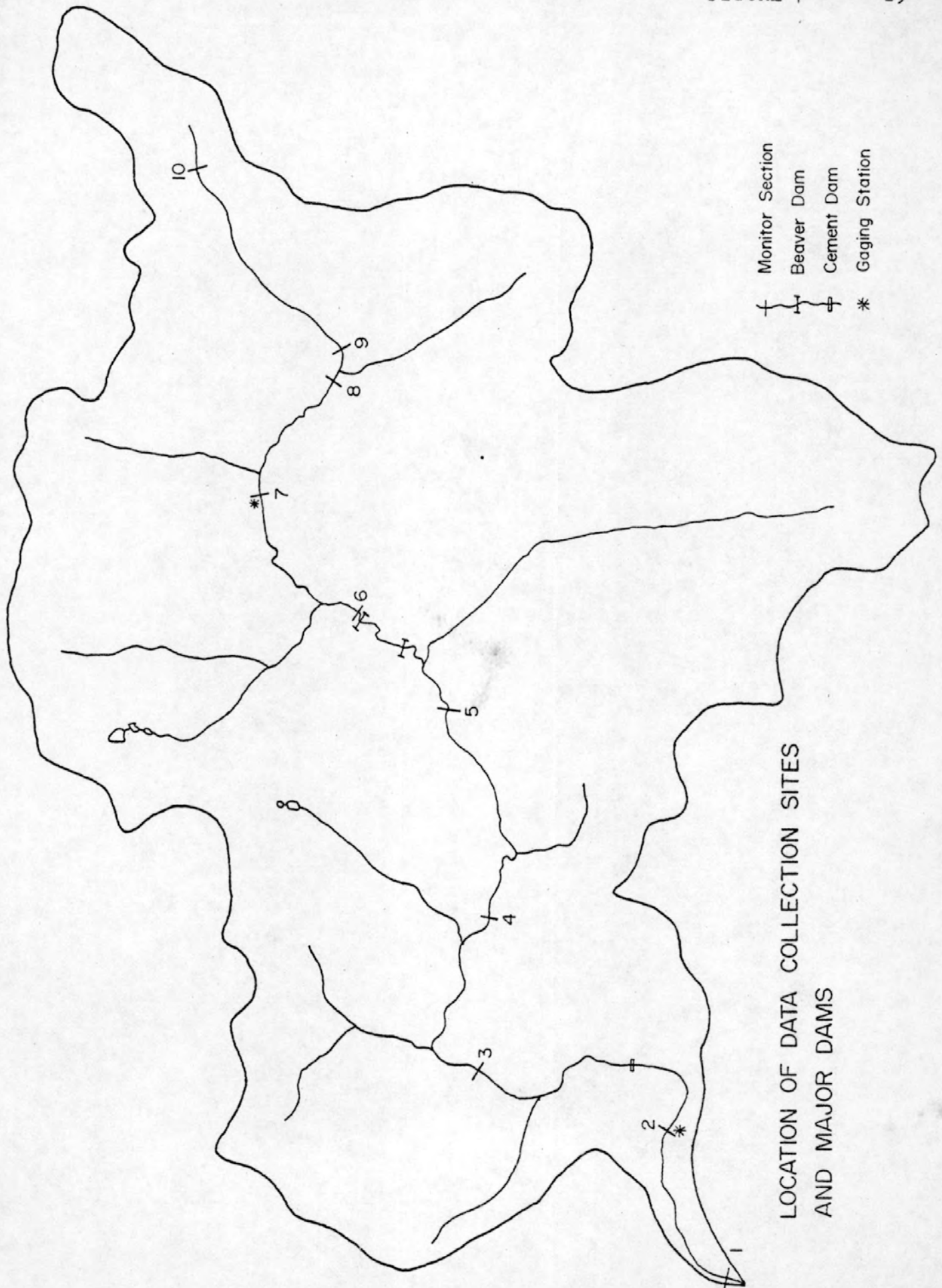
Use	Percent of Total Area	Standard Deviation	Standard Error Percent
forest	65.6	.475	1.46
grassland	28.1	.450	1.38
residential	5.5	.228	0.69
commercial	0.5	.071	0.22
industrial	0.3	.055	0.17

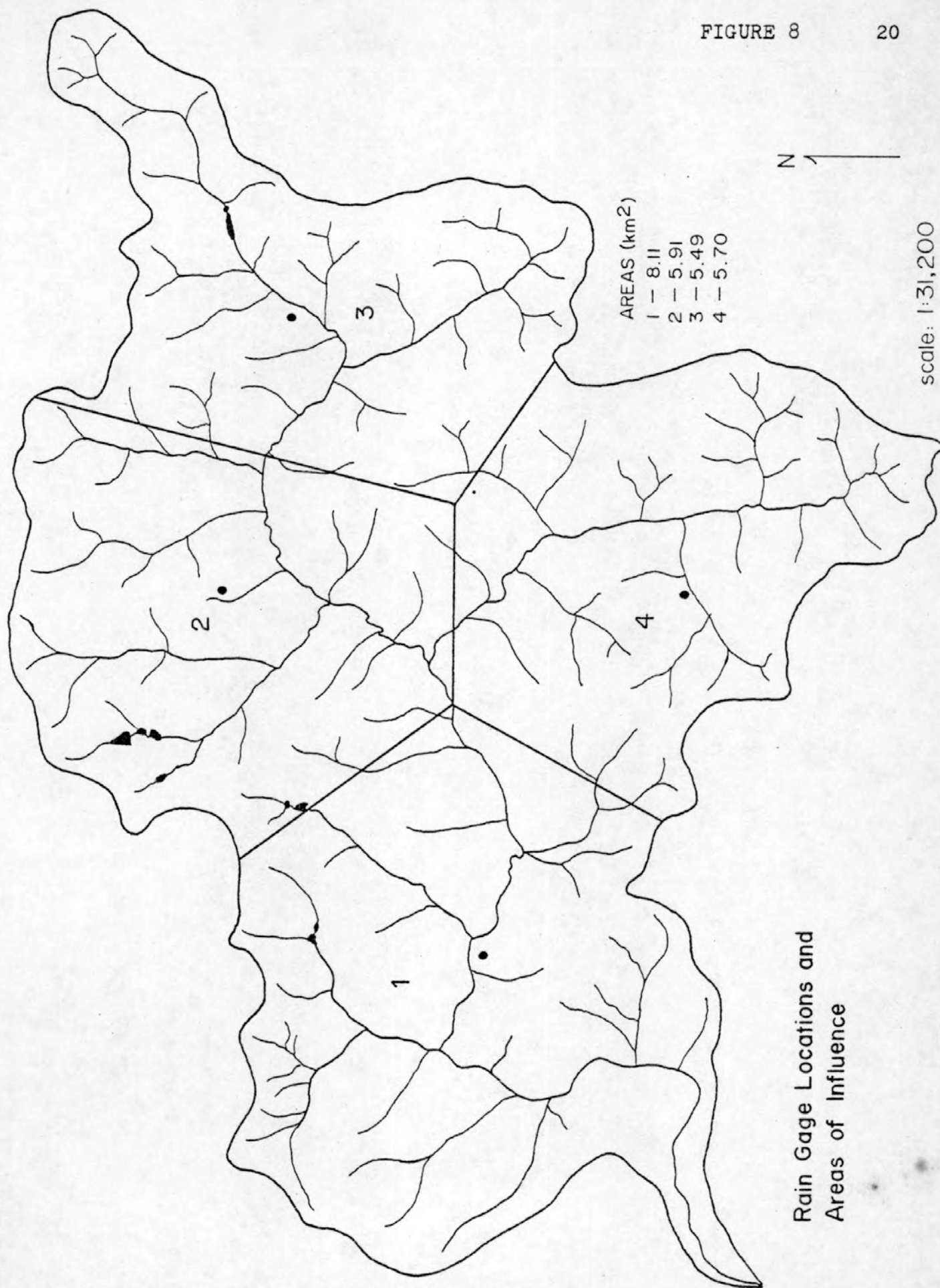
SURFACE HYDROLOGY

The term hydrology is defined as the science that relates to the water of the earth. Surface hydrology, in the context of this report, refers to the manner in which water entering in the form of precipitation is removed from the watershed by means of the drainage system. This section will provide baseline data on the drainage system in the form of precipitation data, base flow of the stream, storm hydrographs*, runoff data, hydraulic geometry*, and general analysis of the stream and its tributaries.

Method of Study

Data collection was obtained by installing two water level recorders on the main trunk of Little Sewickley Creek. One was placed near the mouth (picture P1 and P2) and the other approximately half way up the main trunk. This would allow analysis of both the upper and lower sections. Unfortunately, the upstream gage had to be relocated soon after its placement due to the construction of a beaver dam in early June approximately 70 meters below the gage causing ponding at the gage site. The gage was then moved farther upstream to its present location (Fig. 7, P3). Both gages were installed under the guidelines and procedures described by Corbett (1943). A number of monitoring stations were also established (Fig. 7) for the collection of instantaneous discharge* measurements to be used for the hydraulic geometry analysis. Precipitation data was collected by means of four rain gages set up within the watershed (Figure 8).





Data was collected after each rainfall event and the total volume of water for each event was determined by multiplying the amount of rainfall at each rain gage by its respective area of influence. Areas of influence were established using the Thiessen Method (Morisawa, 1978). The data is contained in Table 2.

Water level recorders provide continuous flow information in the form of the stage (or height) changes in the water level through time. However, more useful information can be obtained by constructing a stage/discharge rating curve for each of the gages. This curve, which will be unique for each gage site enables one to determine the discharge that corresponds to a particular stage since the relationship between the two is not linear and depends on the channel shape and other factors at the gage. The curves are constructed by plotting discharges measured at the gage site against the corresponding stage at the time of measurement. These instantaneous discharges were determined by using the equation

$$\text{discharge} = \text{av. velocity} \times \text{av. depth} \times \text{width}$$

$$\text{m}^3/\text{sec} = \text{m}/\text{sec} \times \text{m} \times \text{m}$$

Width of the water was determined by using a cloth tape. Average depth was determined by taking the average of at least ten depth measurements at equal intervals across the stream. Average velocity was determined by timing a float over a given distance. The average of eight to ten measurements across the channel was used for each determination. At high flows (greater than 0.15 m depth) velocities were determined for a number of small sections across the channel using a Gurley "pygmy" current meter (P4) according to the 0.6 method (Corbett, 1943). The velocity for each

Date	Time of Rain	1	2	3	4	Total Volume of Rainfall ($\times 10^4 \text{ m}^3$)
6/21	0000-1000	.25	.25	.25	.25	6.30
6/28	0800-0915	.851	.762	.775	.800	20.20
6/29	0400-0500	.051	.025	0	.075	2.32
6/30	2200-0000	.508	.610	.508	.450	13.10
7/1	1230-1500	.381	.330	.356	.400	9.27
7/2	0200-1100	.508	.686	.787	.650	16.20
7/4	0600-1000	2.032	1.829	1.778	2.100	49.00
7/9-10	1730-0730	2.413	1.956	2.032	2.100	54.30
7/13	2000-2030	0	.635	1.346	0	11.10
7/15	1200-1230	0	1.422	.889	.300	15.00
7/22	1242-2100	1.778	1.105	.622	2.100	36.30
7/23	1900-2000	.051	.038	.025	.050	1.06
7/24-25	1600-0700	.483	.686	.203	.300	10.80
7/25	1505-1515	.432	.356	.254	.300	8.71
7/25-26	1622-1638 0700-0830	.762	.965	.699	.700	19.70

Little Sewickley Creek Rainfall Data, June and July 1979

section was then multiplied by the corresponding cross sectional area of the water. The sum of these products is the discharge. Instantaneous discharges were measured at both gages over a range of flows and stage/discharge rating curves were constructed for each (Figs. 9 and 10). It should be noted, however, that many more readings need to be taken, especially at higher flows, to better define the curve and improve its accuracy.

Storm Flow Characteristics

One of the best ways to gain understanding about a stream is to study its reaction to rainfall events. While the number of heavy rains that occurred in the watershed during the time of data collection was few, data for a sufficient number of storm events was collected for the purpose of setting up baseline information. Summer rainfall events in the Pittsburgh region are most often associated with cold fronts which produce very localized thunderstorms. This localized nature can be seen in the rainfall data of Table 2. In the case of one storm, the watershed received between 1 and 2 cm of rain while areas just a few kilometers to the south received as much as 10 cm in a short time causing flooding on Ohio River Boulevard. It is the author's feeling that due to the setting, topography, and micro-climate the little Sewickley Creek watershed is likely to receive less precipitation in summer than the city of Pittsburgh. This is due mostly to increased convection over the relatively warmer city which produces thunderstorms (Lowry, 1969). This example points out the need in small watersheds for gathering on-site data rather than relying on regional information.

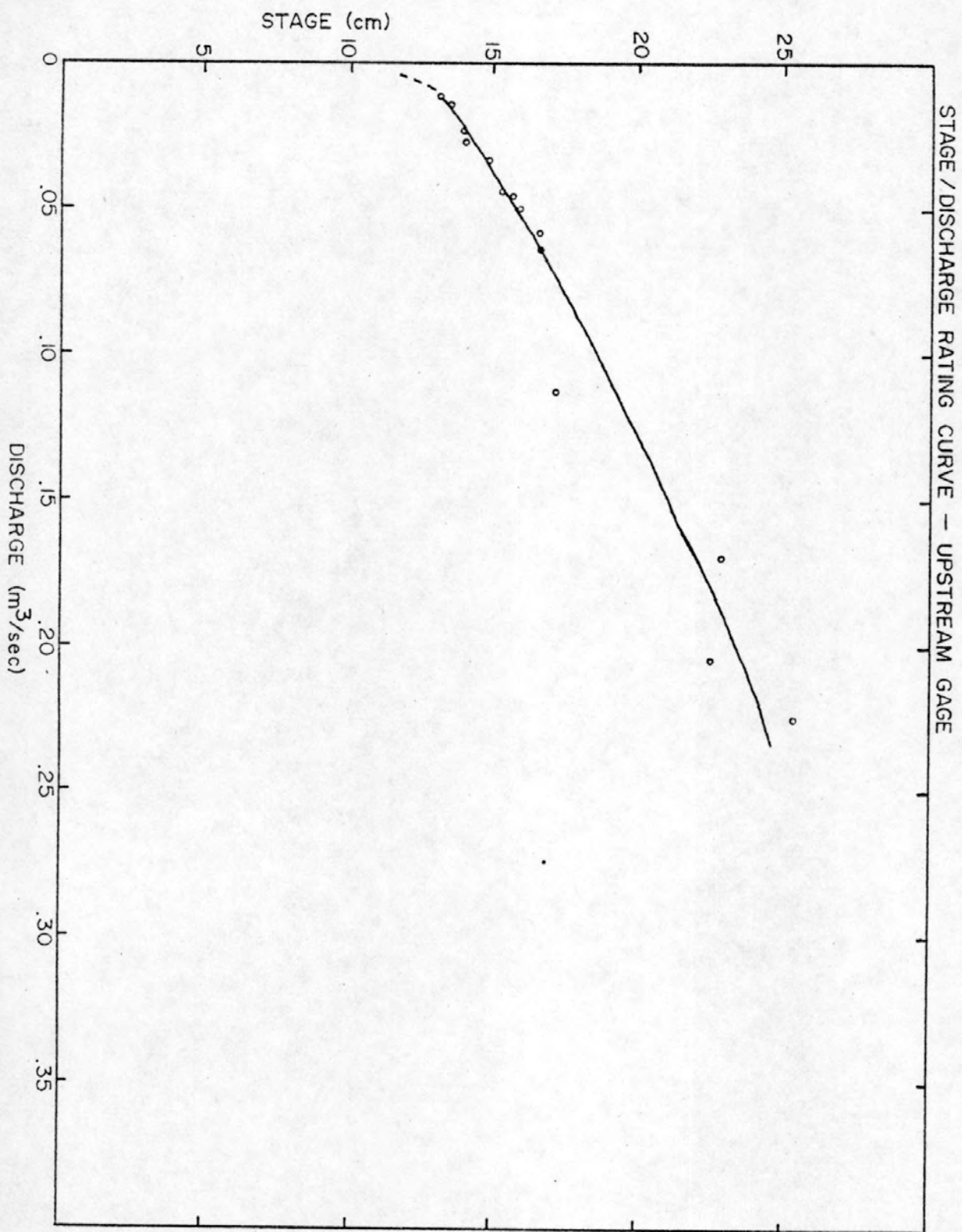


FIGURE 9

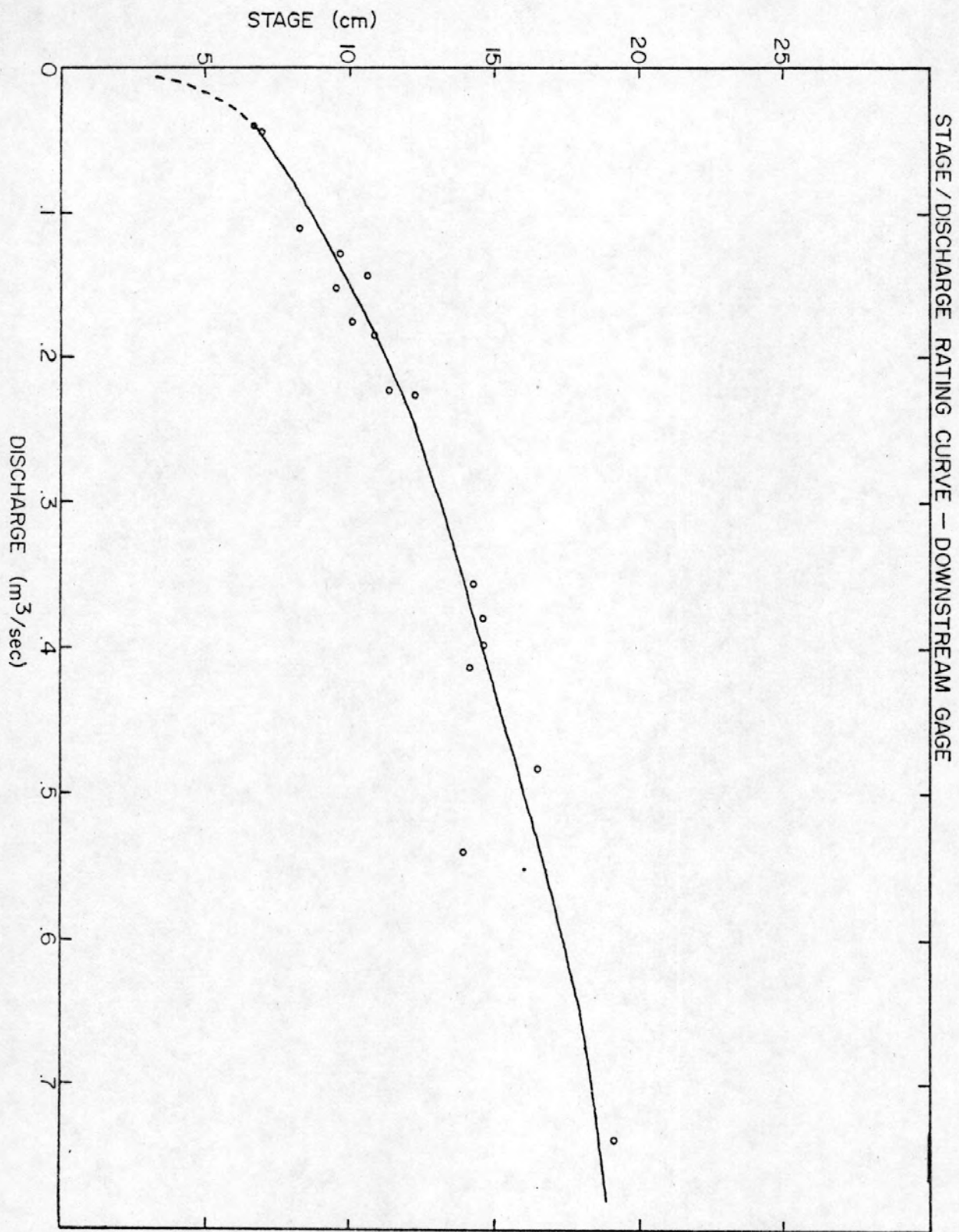
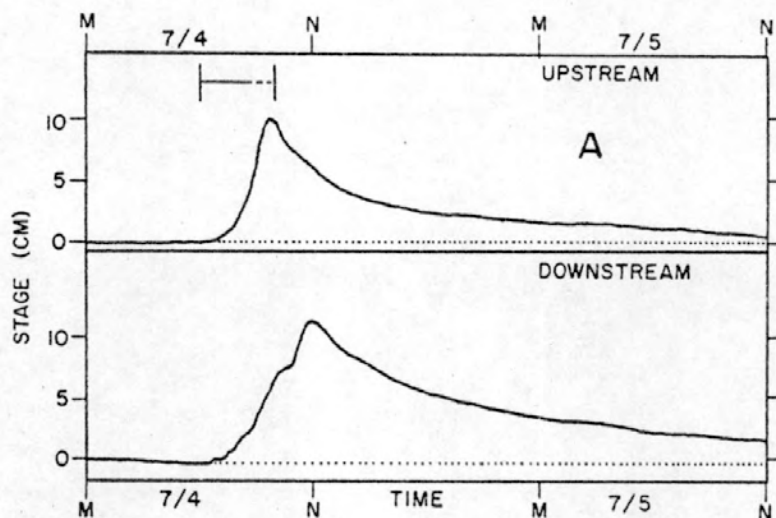
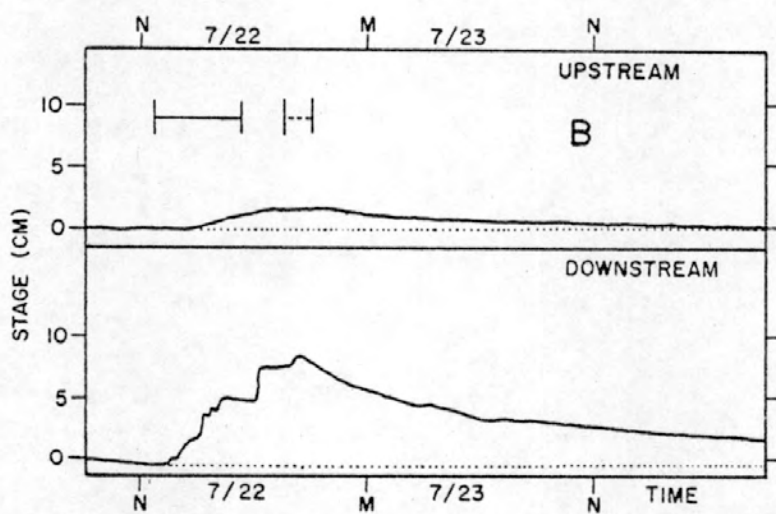


FIGURE 10

Hydrographs taken directly from the stage recorders for two storms are shown in Figure 11. The curves indicate the rise in stream level due to surface runoff (high peak) and inter-flow* through the soil (trail portion of curve) for the indicated storm. We are concerned with the area below the curve and above the dotted line which represents base flow. Base flow is defined as the discharge at a point in a stream that is equalled or exceeded 95% of the time during the year, and represents water derived from groundwater flow. Base flow for the upper gage is $0.019 \text{ m}^3/\text{sec}$ and that for the downstream gage is $0.073 \text{ m}^3/\text{sec}$. Figure 11-A is a set of hydrographs for the storm on July 4. The upstream curve is a typical one showing a rapid rise followed by a slow tapering off toward base level and represents a more or less natural watershed although the initial rise is probably slightly more rapid due to housing developments in the headwaters which decreases the time of rise (Carter, 1961; Wilson, 1967; Martins, 1968; Leopold, 1968; Anderson, 1970). Lag time, which is the difference in time between the middle of the rainfall and the peak on the hydrograph, is 1.75 hours. Lag time is affected by such things as moisture content of the soil, intensity of rain, slope, vegetative cover, and degree of urbanization. The above lag time is in general indicative of the natural state of the watershed. LaFlure (1978) found lag times from 15 to 45 minutes for similar storms in Powers Run (just north of Pittsburgh) which is heavily urbanized, though it drains a much smaller area. Lag times of 15 minutes also occur on Fuller Hollow Creek near Binghamton, New York. Fuller Hollow is similar in size to Little Sewickley but is heavily urbanized.



TIME OF RAIN SHOWN AT UPPER LEFT
LIGHT RAIN - ----
HEAVY RAIN - —



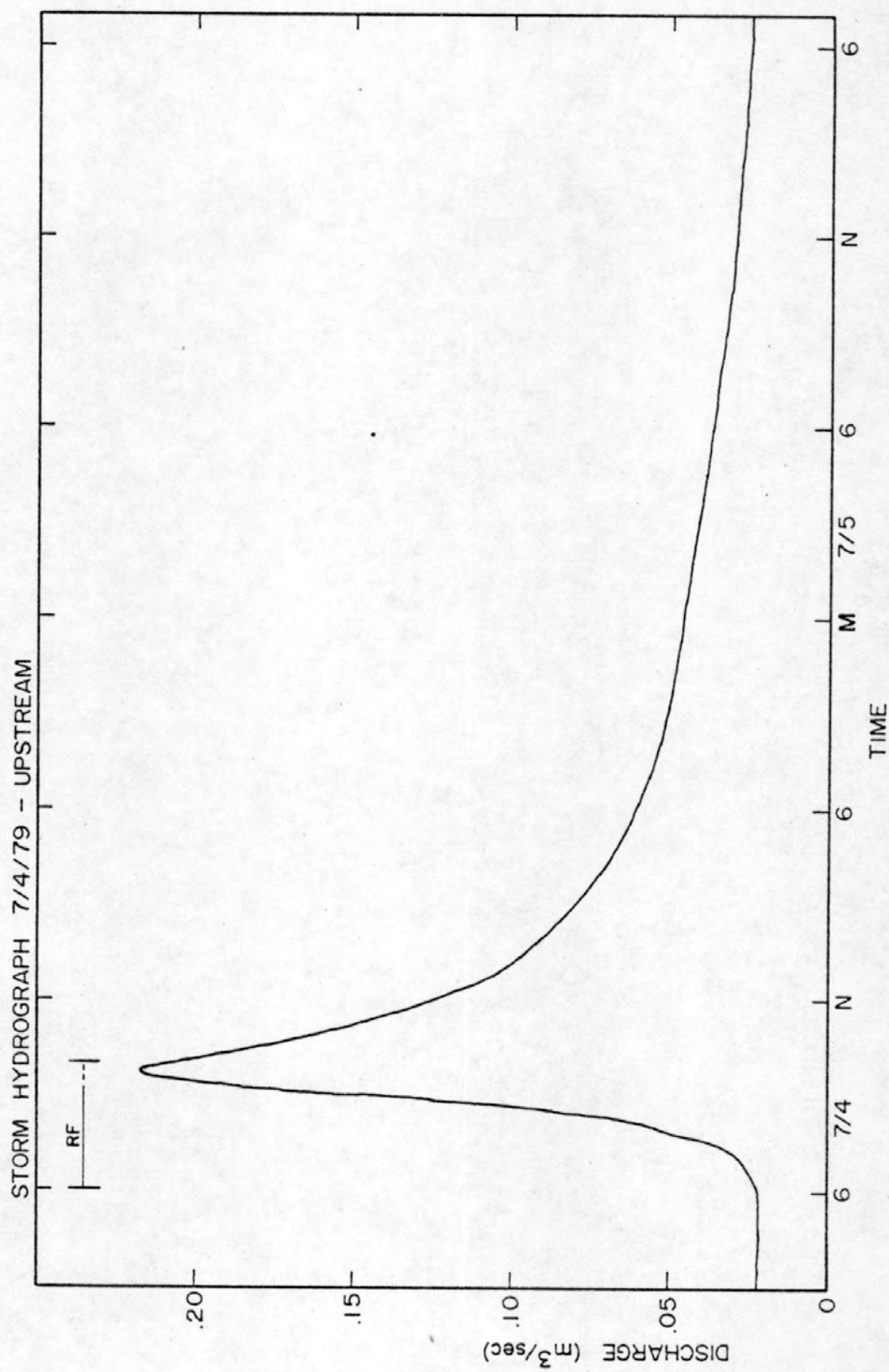
STORM HYDROGRAPHS - 7/4 & 7/22

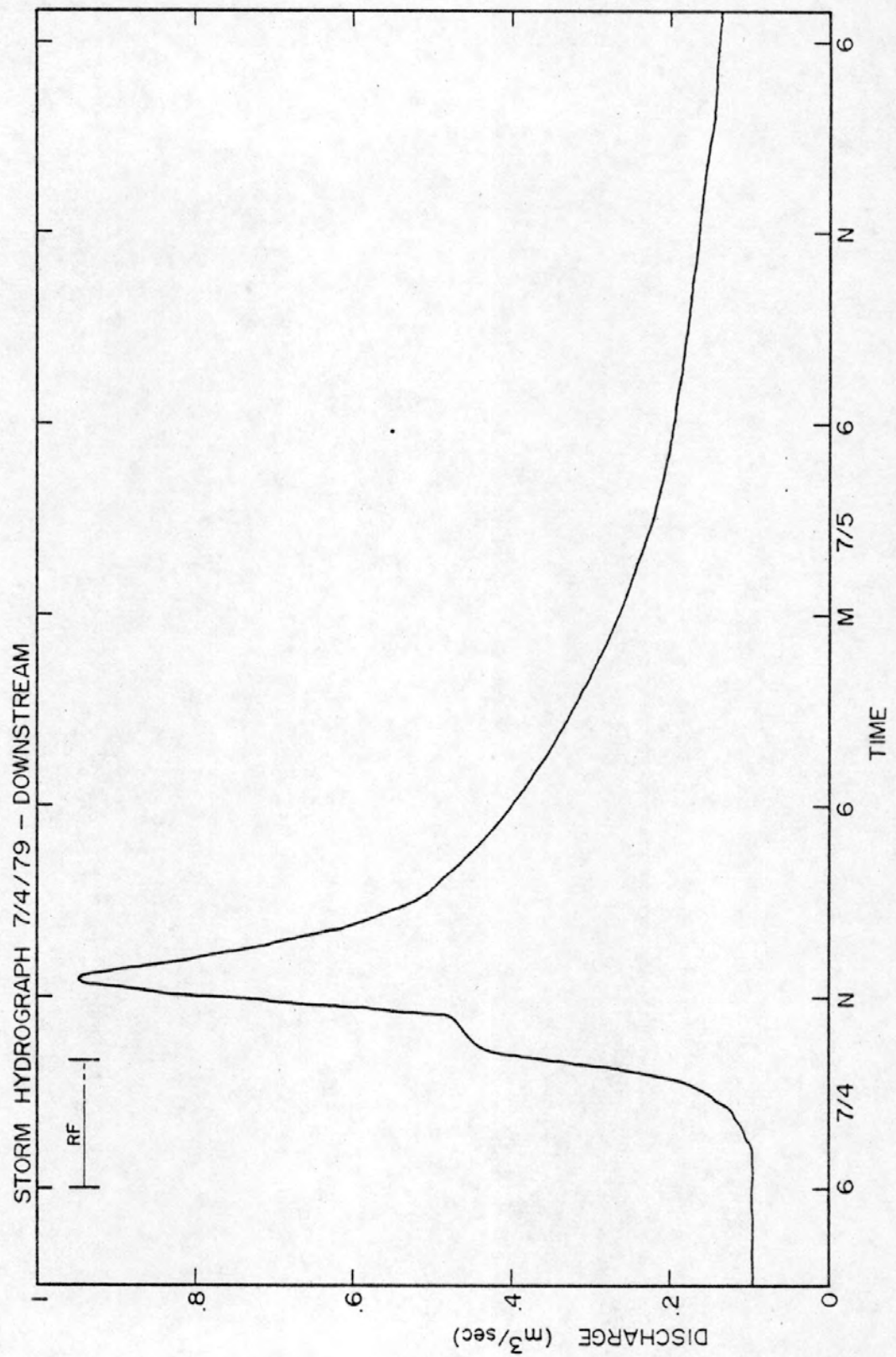
The downstream hydrograph is a similar curve. The small "step" on the rising portion of the curve is probably caused by the beaver dam just above the junction of the Fern Hollow tributary (Fig. 7). The initial rise is from downstream tributaries whereas above the step is from above the dam which temporarily retards the increased flow. This will be discussed more fully later. Note that the dam also increases the lag time which is 4.5 hours. The result is a lower peak discharge which decreases the chance of flooding.

Figure 11-B shows a very different set of hydrographs for the July 22 storm. This storm was more localized in that the upper part of the watershed received less rain than the other parts. This can be seen in Table 2 and the upstream hydrograph. The downstream curve is much more irregular due to the variation in rainfall intensity causing variations in the peaks from different tributaries. The large step is again caused by the beaver dams. The lower dam at this time had been abandoned by the beavers. Consequently the water level in the pond behind the dam had dropped allowing a greater retention capability which increased the lag time to 5.25 hours. Upstream lag time was 3.25 hours.

Runoff

Figure 11 contains hydrographs of stage against time. Figures 12 and 13 are hydrographs of discharge against time for the July 4 event. These were constructed by using the discharge rating curves to relate stage to discharge. Because the relation is not linear as mentioned previously the curves are expanded vertically. It is these curves that must be used to determine





the percentage of water that enters the stream as direct runoff and interflow. The procedure was to determine the area beneath the curve but above base flow. This area, when multiplied by the graph scales will give the total volume of water derived from direct runoff and interflow that passed by the gage from the storm. This value is then divided by the total volume of water that fell on the watershed above the gage. The result is the percent runoff for that storm. Table 3 shows the percent runoff for four storms as determined from the downstream gage records. These figures are very low compared to the regional

TABLE 3. Percent Runoff for Four Storms - Summer 1979

Storm Date	Total Runoff ($\times 10^4 \text{ m}^3$)	Total Rainfall from Storm Above Lower Gage ($\times 10^5 \text{ m}^3$)	% Runoff
6/28	0.605	1.97	3.07
7/04	2.67	4.78	5.59
7/10	1.96	5.29	3.71
7/15	1.14	1.50	7.58

figures given earlier. Runoff ranges from 35 to 40 cm per year for 100 cm of rain which is a runoff percentage of 35 to 40%. Reasons for the disparity are 1) that the rainfall events were low in intensity and widely spaced in time, 2) that absorption by the soil is high due to the soil types, and 3) the rural nature of the watershed. It should also be kept in mind that these events represent a statistically small sample. Lastly, Diemer (1978) has established a mean annual peak versus basin area relationship for 17 watersheds with areas less than 52 km^2

in the Pittsburgh area. From this relationship it was determined that the mean annual peak for Little Sewickley Creek is $21.2 \text{ m}^3/\text{sec}$. The highest peak for the four storms above was $.95 \text{ m}^3/\text{sec}$. Thus, the values for percent runoff shown in Table 3 are lower than would be expected for storms of greater magnitude since percent runoff increases with the magnitude of the storm. Nonetheless, the values still indicate that the probability of flooding is most likely lower in the Little Sewickley Creek watershed than others in the region.

Two points should be stressed here. First, use of regional data for small watersheds introduces large errors due to differences in size between large and small watersheds. Secondly, collection of data on Little Sewickley Creek should be continued in order to provide more complete and detailed information. Only then can the conclusions herein stated be refined allowing greater confidence in future decision making.

Flooding

Streams will always flood. It is a natural adjustment to a rapid change in discharge. When the volume and intensity of a rainfall event exceeds the drainage system's ability to remove the water the banks overflow. Thus, a stream's ability to efficiently carry large volumes of water is the key to the frequency of floods for that stream. Drainage efficiency depends on a large number of factors such as slope, drainage pattern, soil moisture conditions, infiltration capacity, vegetation, and percentage of impervious area. On the average, bankfull conditions are reached in a stream every 1.58 years (Leopold, and

others, 1964). However, local residents have stated that the number of floods along Little Sewickley Creek is far below this average. In fact, even during Hurricane Agnes in 1972 the only flooding that occurred was in the Quaker Village Shopping Center and in Nichol's Field just above Beaver Road, but this was due to a backwater effect from the Ohio River, not excessive flow in the creek. LaFlure (1978) found that the number of floods in the watersheds he studied was greater and flash floods were more severe. Why are there so few along Little Sewickley Creek? The author feels that the lack of urbanization is the major reason. The type of land use was shown to provide a high retention capability as witnessed by the low runoff values. In addition, the beaver dams discussed earlier act as detention ponds by temporarily retarding the water from the upper portion of the watershed and releasing it more slowly after the peak in the lower section. The overall peak, then, is much reduced. In the beginning of June there was one beaver dam the main portion of which was 18 meters long and 1.2 meters high just above the junction of Fern Hollow tributary (P5, Plate 1). At this time the beavers were active there. By mid July they had abandoned this dam for another about 400 m upstream (P6) the construction of which began in early June. As of July 19, the upper dam was about 12 meters long and 0.8 meters high. Evidence indicated that construction was continuing. Both of these dams now act to trap sediment and retard flow which is beneficial to the stream. However, if they continue to expand and migrate they will inundate more land which will later become swamps. This could be detrimental since beavers show no regard for the properties or structures of man.

Hydraulic Geometry

The concept of hydraulic geometry was introduced by Leopold and Maddock (1953) for studying stream characteristics. The idea, simply stated, is that mean depth, width, and mean velocity vary with discharge as simple power functions at a given stream cross section. Similar relations will also be found between different cross sections along the stream provided the discharge has the same frequency of occurrence at all points. Expressed in equation form:

$$W = aQ^b$$

$$\bar{D} = cQ^f$$

$$\bar{V} = kQ^m$$

where W is the width, $\bar{D}$ is the mean depth, $\bar{V}$ is the mean velocity, Q is the discharge, and a , b , c , f , k , and m are constants. Note that the above relationships are in the form of linear equations. Thus, a , c , and k are the "y" axis intercepts and b , f , and m are the slopes of the lines.

Leopold and Maddock (1953) state the average values for b , f , and m in the downstream direction for the river basins they studied were .5, .4, and .1 respectively. In other words, as one moves downstream width increases the most, average depth increases substantially, and velocity increases only slightly. At a particular cross section Leopold and Maddock found the average values $b = .26$, $f = .40$, and $m = .34$. Keep in mind that these two sets of values are averages taken from a number of large river basins, primarily in the Great Plains region of the southwest and therefore are not necessarily comparable with small streams in the Pittsburgh region. Downstream values for Little Sewickley Creek might better be compared with those of Central Pennsylvania, found by Brush (1961) to be $b = .56$, $f = .37$, and

$m = .08$. As yet, no values for at-a-station have been established for the region except for those of LaFlure (1978) discussed later. Note also that discharge, width, depth, and velocity are all related by the equation $Q = DWV$. Thus the sum of b , f , and m , and the product of a , c , and k should equal unity.

At-a-Station Hydraulic Geometry

Variations in stream characteristics at a cross section is determined by obtaining width, depth, and velocity data at a cross section at various discharges. To do this, ten monitoring stations were established along the main trunk of the stream (Fig. 7). The data collected is contained in the appendix.

To determine the equations linear regressions were run on discharge versus each of the three parameters using a Texas Instruments Programmable 57 calculator. The results are shown in Table 4 along with the correlation coefficients which were generally quite high. The average of these values is $b = .12$, $f = .32$, and $m = .56$. Comparison with Leopold and Maddock's results reveals that mean depth (f) is similar, but width (b) is low and mean velocity (m) is high. Explanation of this "disparity" requires a look at the physical aspect of the watershed. The high increase in velocity is probably due to the high relief in the watershed and the steepness of the tributary gradients (Figure 14 and 15). This increase in velocity at higher flows allows more rapid removal of the water resulting in lower peak discharge; another reason for the infrequent flooding. The reason for the low width value (b) is that little data for bankfull or very high flows was recorded. During lower flows the water is confined to

At-a-Station Hydraulic Geometry Equations

Discharge VS Velocity

Cross Section	Intercept	m	Correlation Coefficient
1	.77	.40	.99
2	.69	.51	.98
3	.71	.65	.99
4	.59	.62	.99
5	.66	.40	.99
7	1.71	.74	.99
8	1.82	.75	.99
9	1.30	.43	.95
10	1.55	.50	.95

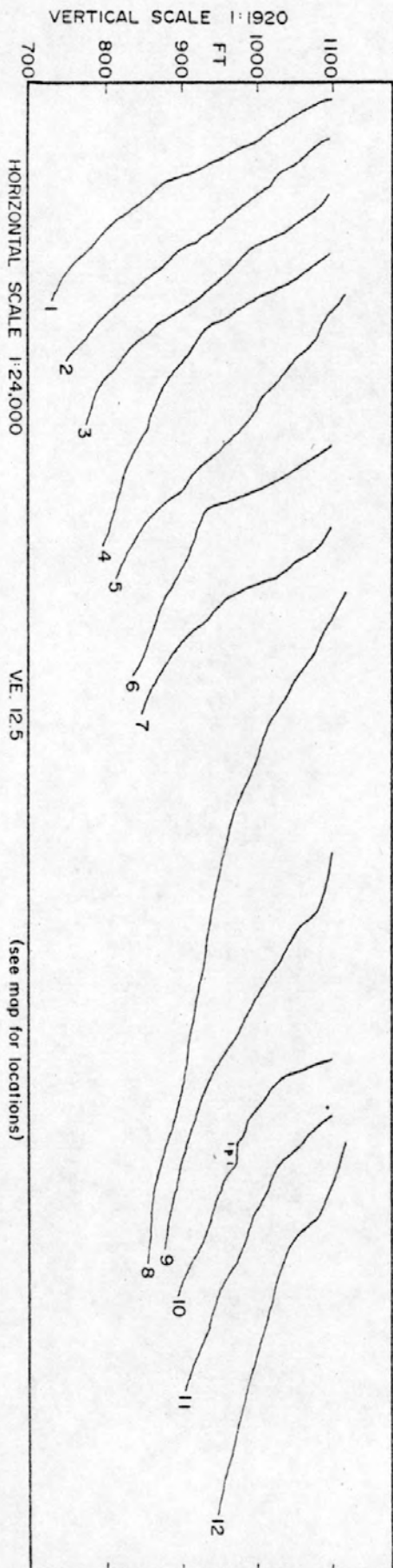
Discharge VS Depth

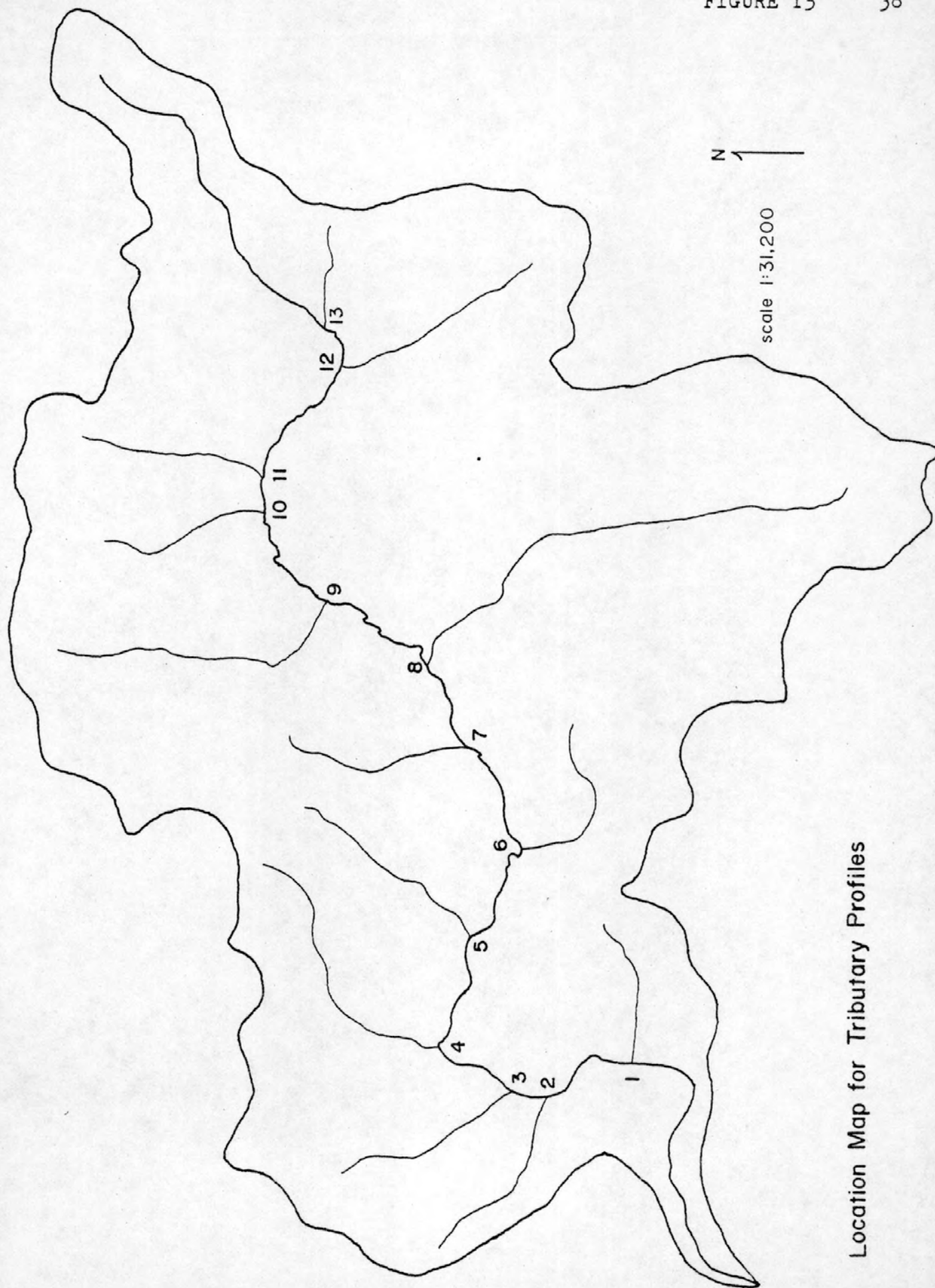
Cross Section	Intercept	f	Correlation Coefficient
1	.15	.45	.99
2	.13	.24	.88
3	.17	.26	.96
4	.17	.35	.98
5	.17	.38	.98
7	.17	.26	.98
8	.12	.09	.42
9	.30	.43	.88
10	.41	.44	.98

Discharge VS Width

Cross Section	Intercept	b	Correlation Coefficient
1	8.66	.15	.78
2	11.51	.24	.87
3	8.29	.09	.66
4	10.14	.03	.93
5	9.22	.22	.98
7	3.43	.00	.08
8	4.41	.16	.76
9	2.68	.14	.82
10	1.71	.07	.63

LITTLE SEWICKLEY CREEK TRIBUTARY PROFILES



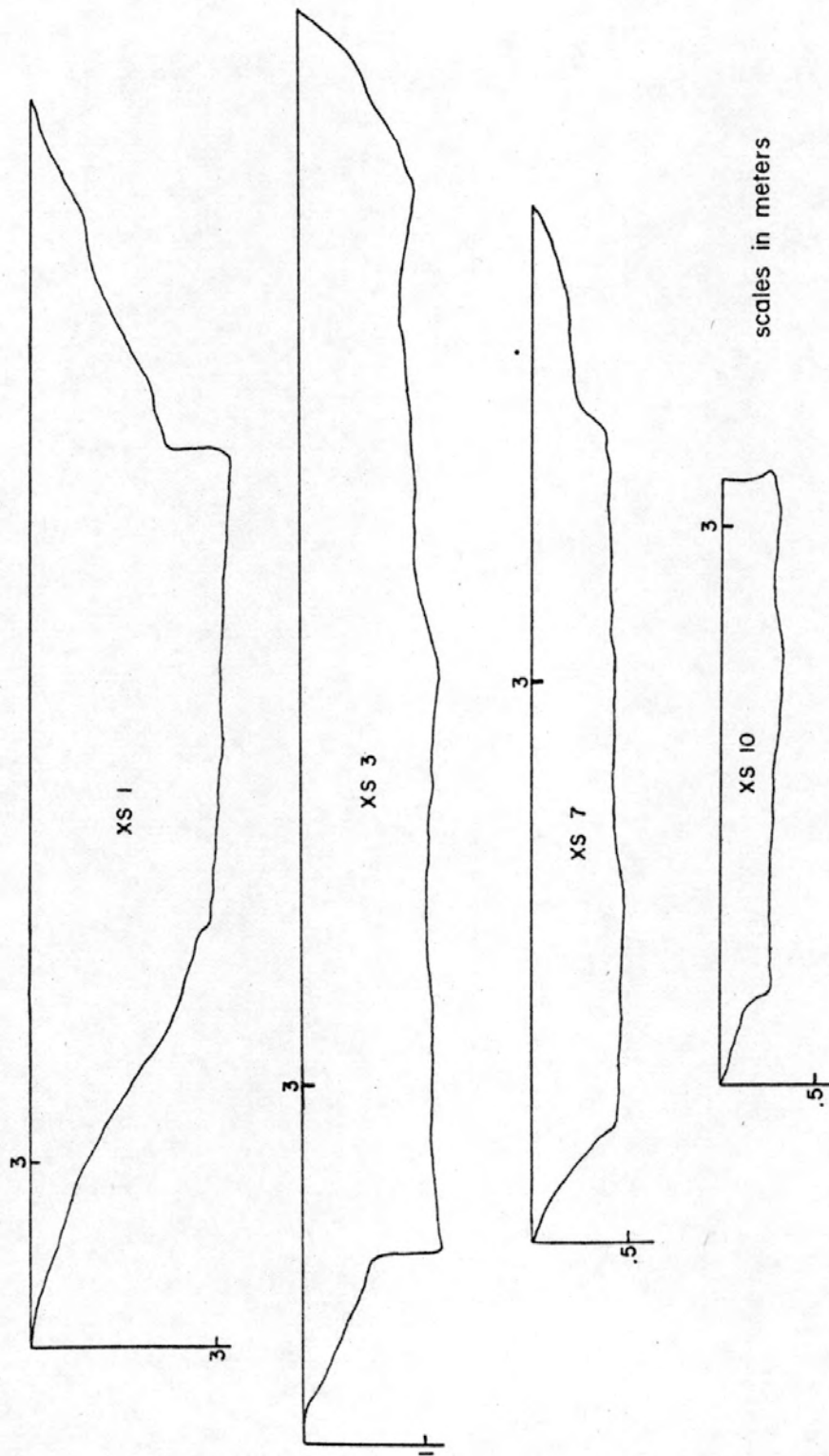


the lower portion of the channel which is, in general, steeper sided than the upper channel banks. Examples of this are shown in Figure 16. Note that the width increases very slowly on at least one side of the lower channel in all four examples. The values of b , f , and m will be different at higher flows. Again, more data needs to be gathered, particularly at higher flows.

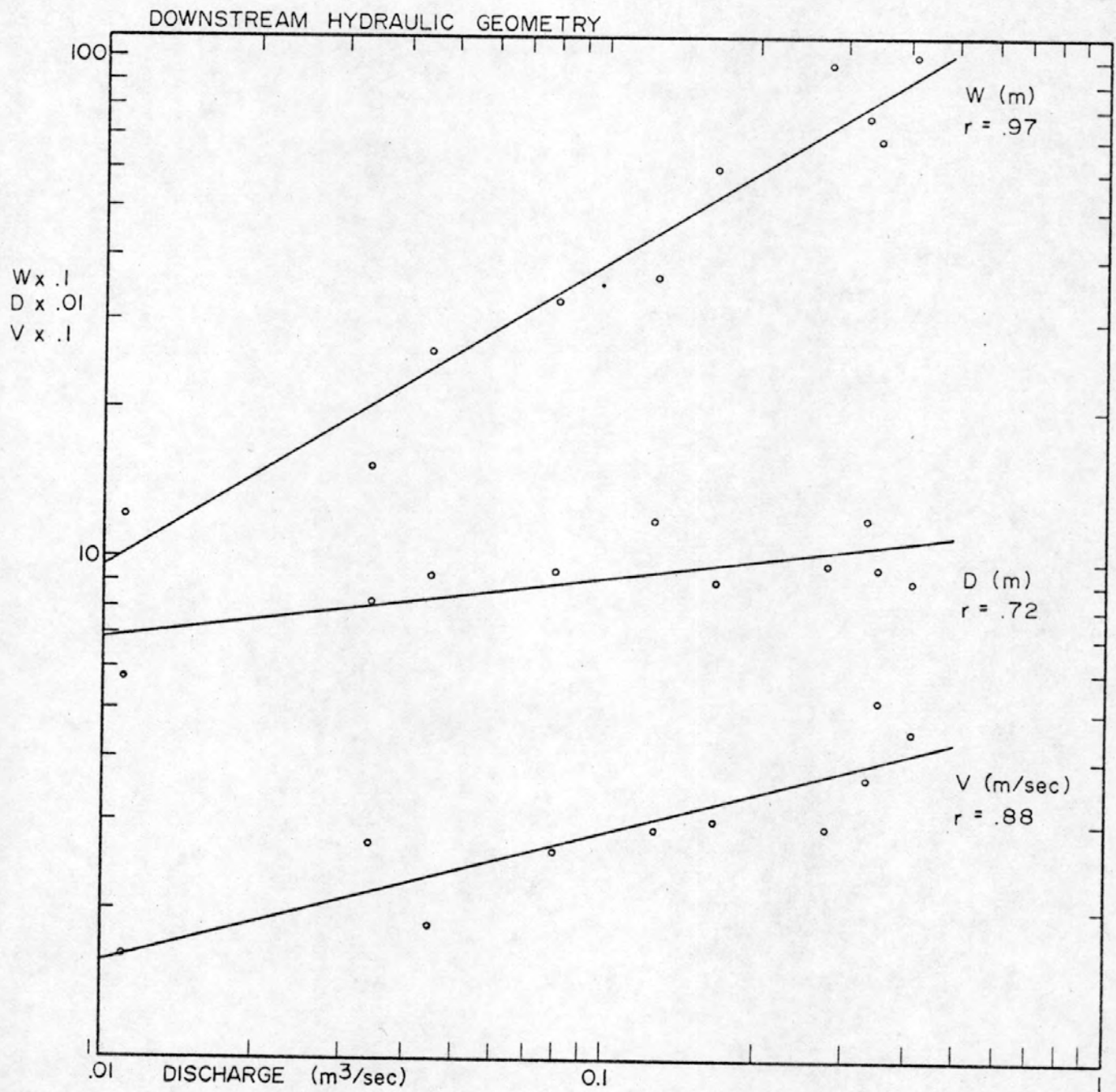
Downstream Hydraulic Geometry

Changes in the three parameters in the downstream direction were determined by running a linear regression using the data collected on June 13. The values obtained are $b = .61$, $f = .12$, and $m = .26$. The relationships are shown graphically in Figure 17. The June 13 data was collected after several days of rain which had ended a few days before. Inspection of the hydrographs, however, reveals that sufficient time had elapsed since the last rain so that flow frequency was essentially constant over the data collection period. The values, then, represent a moderate flow state.

These values indicate that width changes the most in the downstream direction and that lateral erosion dominates over downcutting; the depth value f being only .12. This is a reflection of the ease with which the stream erodes the red beds. Downcutting is hindered because resistant siltstone and sandstone which falls into the channel due to undercutting of the red beds acts to armor the channel bed. This is borne out by inspection of the channel bed which reveals a predominance of siltstone and sandstone in the size range of pebbles* to cobbles* according to the Wentworth scale of classification. Average velocity is shown



CROSS SECTIONS SHOWING STEEP BANKS OF INNER CHANNEL



to increase somewhat in the downstream direction at a given frequency. These values are also in contrast to those found by LaFlure (Table 5). At-a-station values were also dissimilar except for those for upper Squaw Run which is the most rural of the streams studied by LaFlure. The differences are seen as mainly due to the degree of urbanization between the streams cited.

In general, flow patterns and channel shape in Little Sewickley Creek reflect its rural nature since they indicate the stream to be in equilibrium with the rural characteristics and geology.

TABLE 5. Hydraulic Geometry Relationships Compared

At-a-Station

Parameter	Little Sewickley	upper	Squaw Run* lower	total
width (b)	.12	.12	.41	.25
depth (f)	.32	.35	.38	.40
velocity (m)	.56	.49	.21	.35

Downstream (at moderate flow)

Parameter	Little Swkly	Squaw*	Sietz*	Powers*	Guyasuta*
width (b)	.61	.52	.33	.37	.10
depth (f)	.12	.26	.21	.55	.21
velocity (m)	.26	.21	.47	.18	.69

*Data from LaFlure (1978)

Section Summary and Conclusions

In terms of surface hydrology Little Sewickley Creek is healthy. In relation to storm flow the stream has long lag times and low peaks relative to other streams in the region due to the type of land use and beaver dams. Runoff was shown to be low due primarily to land use and the soil types. Hydraulic geometry provided evidence for an efficient drainage character, especially at high flows. Combine these facts with the relatively lower number of high intensity storms and it becomes easy to understand why flooding is infrequent. .

Overall, the data suggests that the stream is in equilibrium with its natural environment and that so far the effects of man are few. Let us now turn from water flow to the channel itself.

GEOMORPHOLOGY

Geomorphology is that branch of geology which deals with the form of the earth's surface and the changes that take place in the evolution of landforms. In terms of this study geomorphology deals with the physical shape of the stream and tributaries with respect to the watershed as a whole and the processes acting within it.

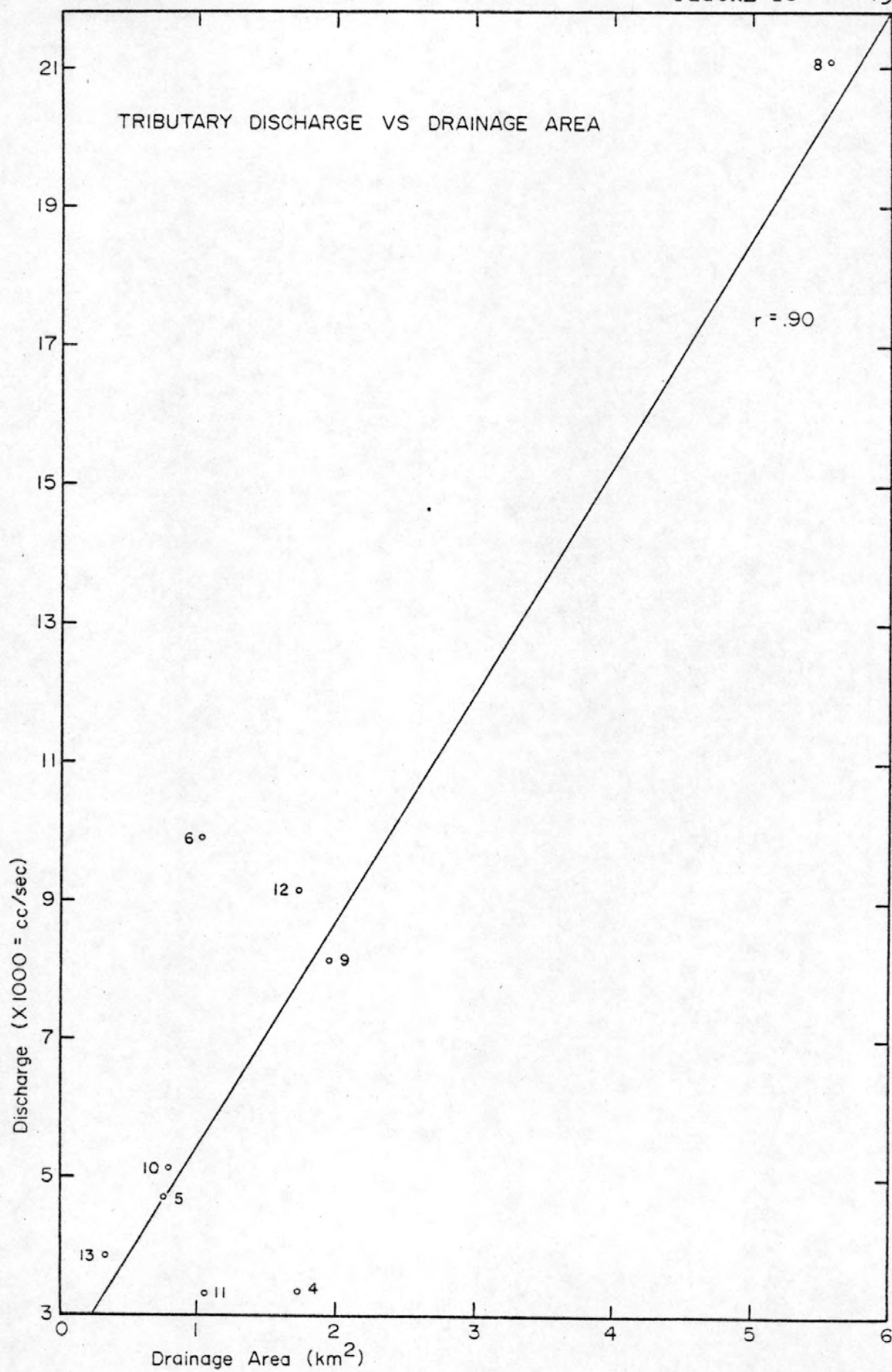
This section will 1) analyze the tributaries and how they relate to the main trunk and overall drainage, 2) relate cross sectional area to drainage area and compare the results with those of Nelson (1979) and LaFlure (1978), 3) present a

pool-riffle sequence analysis, 4) analyze the general erosion-sedimentation characteristics, and 5) present a case study on the effects of urbanization on a small tributary within the watershed.

Tributaries

As previously noted, gradients of the tributaries are quite high. Only the larger ones have floodplain development in the lower reaches, for example Fern Hollow (T8).

In order to get some idea of their drainage character, a set of discharge measurements were taken approximately 24 hours after the rain of July 2. This provided a moderate discharge while eliminating peaks, thus insuring a constant discharge frequency. These discharge measurements were then plotted against drainage area (Fig. 18). The line shown was determined by a linear regression run on the points. The correlation coefficient is quite high, though three aberrant points are apparent: T6, T11, and T4. Field checking revealed that T6 is fed by numerous springs which could explain the abnormally high discharge. Both T4 and T11 show unusually low discharges and both have heavily urbanized headwaters relative to the other tributaries. As noted before, residential developments increase the amount of impermeable area, thereby increasing runoff rates. After a rainfall these tributaries peak faster and higher, then drop off more quickly. Most of the water from the July 2 rain had already passed out of these tributaries which explains the lower readings. One would expect a low reading for T13 also (which drains Maronda Homes development). However, the lower



portion of this tributary is fed by a number of springs which maintains the higher discharge. To get a better idea of the nature of the tributaries, four of them will be described in some detail.

Tributary 2 is a deep, fairly straight, steep-sided valley that is almost completely forested. There is no floodplain development and in cross section the valley has virtually a perfect V shape indicating that downcutting is dominant. Channel width is about 1 meter. Small amounts of excess sediment occur near the mouth derived from landslides and/or construction activity from three homes in Quaker Heights located in the upper headwaters. A large duck pond originally located near the top of the valley is now completely filled with sediment. Landslides are numerous in the lower parts of the channel and occur mostly in the red beds. Most of the debris is quickly removed by the swift flowing water after storms.

Tributary 3 is also V shaped although the bottom and channel are a bit wider (2-3 m). The greater width is most likely due to greater discharge since T3 drains a larger area and the headwaters are located on a golf course. Like T2, the lower section of T3 is forested. T3 forks into two branches near the top and has a greater amount of excess sediment due to the lack of a sediment basin and debris from landslides which are greater in number than in T2.

T4 is a rather large tributary (1.72 km^2) with two major branches both of whose headwaters lie along Camp Meeting Road. The west branch and lower section run roughly parallel to Sevin Road. The east branch and lower section show floodplain develop-

ment. Valley walls are steep in the headwaters and become more rounded toward the mouth. Both branches have residential developments in the headwaters along Camp Meeting Road and Witherow Road. The tributary is in essentially a natural state (dominantly forested) with two major exceptions:

- 1) Developments in the headwaters have caused an increase in runoff resulting in greater lateral erosion causing numerous small landslides in the red beds. Though the gradient for T4 is similar to T2 and T3, valley walls are less steep in T4.

- 2) The west branch and lower section parallel the road and run directly adjacent to it in many places. Flow velocity is increased from channelization and impaired by culverts that carry the stream beneath the road. This has caused deposition upstream from the culverts and undermining of the road in many places requiring constant maintenance.

Tributary 9, draining an area of 1.94 km^2 , is a combination of forest and crop land in the lower and middle sections while the headwaters lie on a golf course near Camp Meeting Rd. The tributary has a developing floodplain in the lower section which narrows upstream, after a split into two main branches, to a steep V shape between 940 and 1100 ft. Forest cover is at climax in the upper middle section such that ground cover is reduced. Landslides are typical, though in this tributary many occur farther up on the valley slopes. The most notable man-induced change is seen in the western branch whose headwaters lie on the Sewickley Heights Golf Course. The course is drained through 5 ponds and a number of drainage pipes which empty into the tributary valley at the top of the slopes. There is nothing

to inhibit the flow. Therefore numerous deep rills have formed on the valley sides due to these pipes. The western branch itself has two stems the westernmost of which has a landfill site at the head of the valley. At the time of inspection the landfill was bare and the edge facing downstream was a vertical drop of 9 to 12 meters; an unstable situation.

In general, most tributaries of Little Sewickley Creek are in equilibrium with the local geology. They can, however, provide an early warning to problems in the headwater regions which, if detected early, can be remedied before serious damage to the main trunk occurs.

Cross Sectional Area VS Drainage Area

The size and shape that a stream channel takes depends on such factors as the resistance of the material through which the stream flows, the gradient, the amount of water that passes through the area, and the manner in which it passes, i.e., does the stream rise slowly or quickly. Short term channel shape is determined by floods of intermediate frequency and magnitude whereas the gross overall shape including the floodplain is determined by infrequent large floods (Morisawa, 1978).

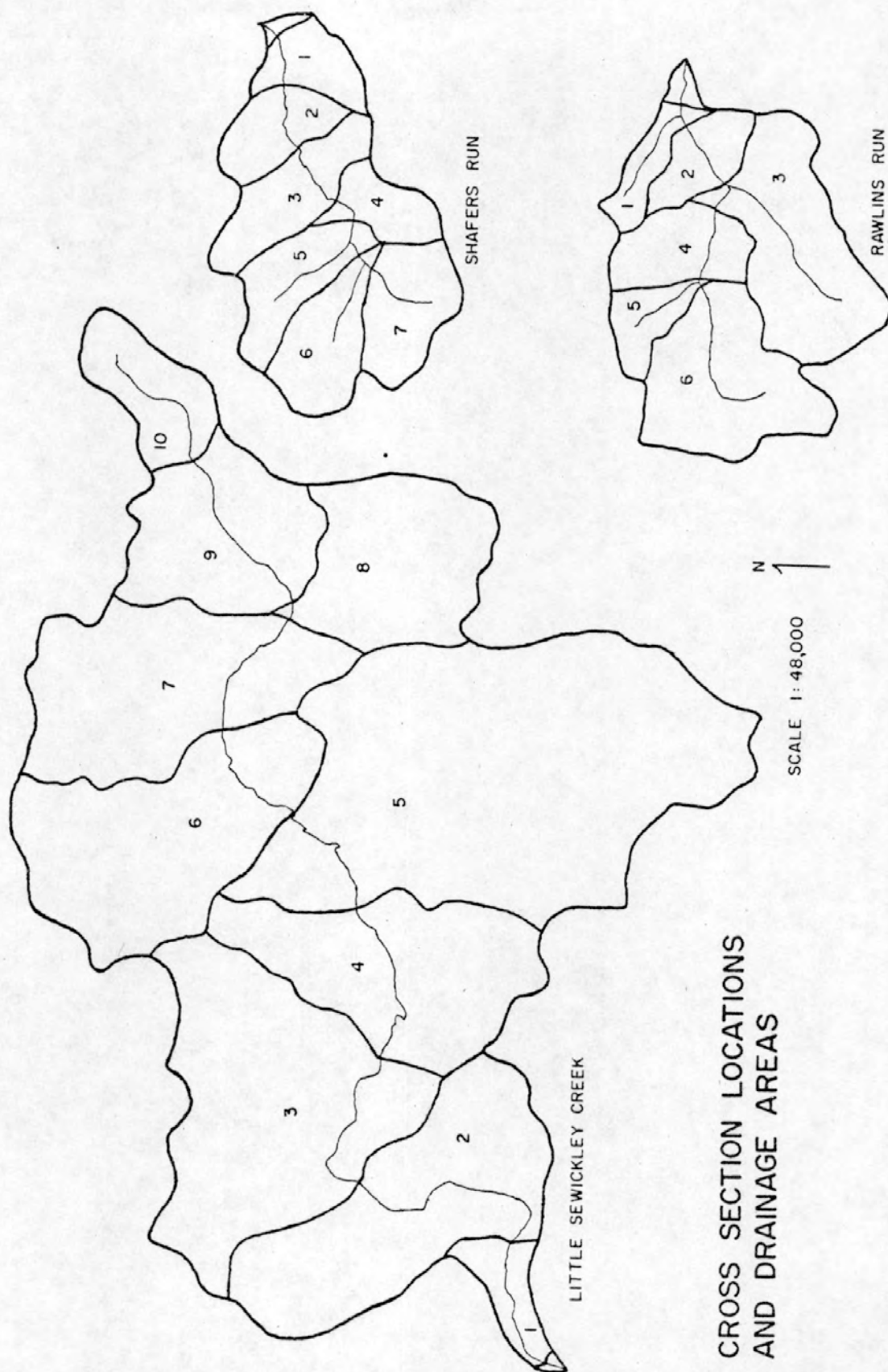
Numerous authors have used the technique of relating bankfull channel capacity of a cross section to the drainage area above that section (Harvey, 1969; Brown, 1971; Hammer, 1972; Dury, 1973; Gregory and Park, 1974, 1976; Robinson, 1976; LaFlure, 1978; Nelson, 1979). Bankfull channel capacity is the cross sectional area of the channel at maximum carrying capacity beyond which water flows over the banks. Many of the above cited

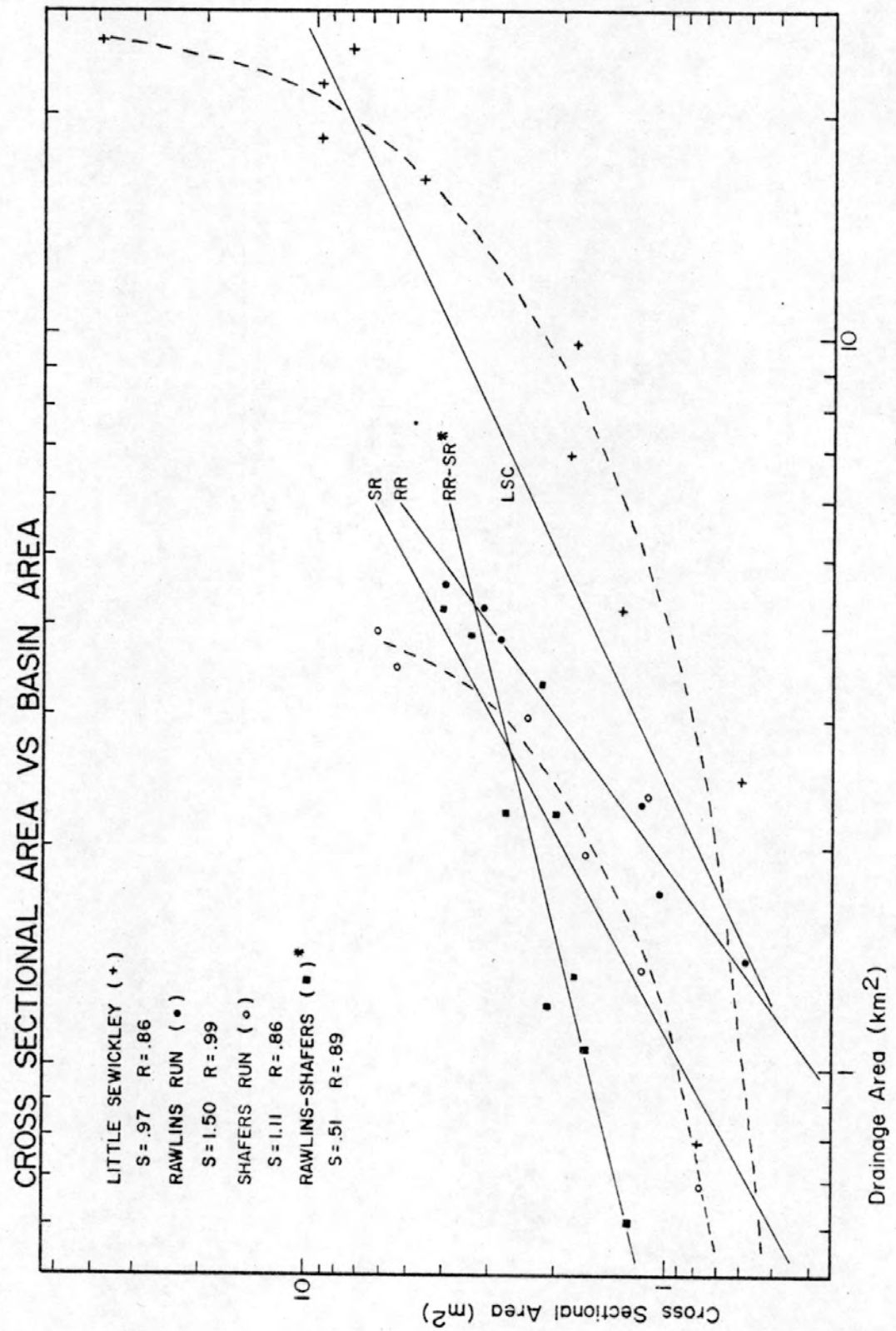
authors have found a disproportionate increase in channel capacity with increasing urbanization within a watershed.

A similar study was done on Little Sewickley Creek as well as on two other small watersheds, Rawlins and Shafers Runs, 25 km to the east. The results are compared with those of Nelson (1979) who also studied Rawlins and Shafers Runs and LaFlure (1978) who studied four watersheds in the Fox Chapel area.

Cross sections and drainage area locations for this study are shown in Figure 19 and Plates 2-7. The results are shown graphically in Figure 20 along with those of Nelson who combined his data for Rawlins and Shafers Runs. Linear regressions were run on the data as shown. However, in the case of Little Sewickley Creek and Shafers Run inferred trends are indicated with dashed curves. For both of these streams the rapid rise near the mouths is a reflection of urbanization. Little Sewickley Creek is channelized in many sections below the large cement dam (P7) and is heavily fed by storm sewers below beaver Road. Shafers Run has been channelized near the mouth and a number of new homes have been recently built in that area. Rawlins Run is natural throughout except for the lowest section right at the mouth. In general, the upper portion of these three watersheds can be considered as representing watersheds in a natural state with line slopes less than 1.5. Table 6 shows the line slopes for these watersheds along with those of LaFlure. For purposes of comparison, LaFlure's data was converted to the metric scale before determining the slopes of the lines.

Little Sewickley Creek, then, shows characteristics of a rural watershed consistent with others in the area in terms





of the rate of channel enlargement.

TABLE 6. Line Slopes for Pittsburgh Area Watersheds
Cross Sectional Area VS Drainage Area

<u>Watershed</u>	<u>Source</u>	<u>Slope</u>	<u>"Dominant" State</u>
Little Sewickley	this study	0.97	rural
Rawlins Run	this study	1.50	rural
Shafers Run	this study	1.11	rural
Rawlins-Shafers	Nelson	0.51	rural
Seitz Run	LaFlure	2.44	urban
Guyasuta Run	LaFlure	1.57	urban
Powers Run	LaFlure	3.45	urban
Upper Squaw Run	LaFlure	0.42	rural

Pool-Riffle Sequence Analysis

In 1964 Leopold and others suggested that ideally each meander wavelength in a stream channel should contain two pool-riffle sequences, each spaced at 5 to 7 times the channel width. The pools occur at the bends and riffles at the inflection points. Keller (1972) took this further and stated that riffles, pools, and point bars are common bed forms in both straight and meandering channels and that a predictable spacing would occur regardless of the channel pattern, though the exact spacing will vary. Finally, Keller and Melhorn (1978) added that the development of pools and riffles and predictable spacings was independent of channel bank and bed material. In light of these findings a study of the pool-riffle spacings of Little Sewickley Creek was

made to see if the spacings were in line with the above studies.

Six sections were sampled along the length of the main trunk and at least nine spacings were measured in each section. A 100 ft tape was used to measure the distance along the channel line between the centers of successive pools. Channel width was taken as the average of several measurements taken between each set of pools. The spacings shown in Table 7 are in good agreement with the studies cited and it is interesting to note that in the more rural upstream sections the standard deviation was lower than in the sections near the mouth which reflects the disruption caused by channelization.

TABLE 7. Pool-Riffle Spacings in Little Sewickley Creek

<u>Section</u>	<u>Av. L/W</u>	<u>Stnd Dev.</u>	<u>No. Samples</u>
mouth to Beaver Rd	6.1	3.2	9
Beaver Rd to cement dam	4.9	2.0	17
Walker Park	6.1	1.4	9
above Backbone Rd bridge	6.6	1.7	10
above Hunt Rd	6.5	1.8	9
headwaters above ponds	7.1	1.8	10

Another interesting point concerns the numerous small log dams that were constructed many years ago to form pools for the stocked fish. In places where the pools coincided with the natural pool spacing the dams were for the most part intact and

functioning well. In those places where the dams were out of sync with the pool spacings they were either destroyed or the adjacent banks were badly eroded (P8 and 9). If the placing of these dams is repeated in the future, better results will be obtained if they are placed at 5 to 7 times the channel width in that area.

Erosion-Sedimentation

Through time, streams and their tributaries erode the land on which they flow eventually reducing it to a flat surface. Erosion and sedimentation in a stream channel is a natural process by which the stream alters its channel such that equilibrium is achieved under a set of given conditions. This section will consider the areas in Little Sewickley Creek where natural and man-made alterations have affected changes in this equilibrium.

Natural Alterations

The biggest natural alteration causing large stream channel changes is undercutting of the banks on meander bends which in a great number of places causes trees to fall into the channel (P10 and 11). These then obstruct the channel forcing the water to go under, over, or around them. In most cases the water erodes beneath the log forming a large pool while upstream from the log a bar builds up due to the backwater effect caused by the obstruction. Often these changes are minor and temporary. In a few places, however, the water has chosen to go around the tree rather than under it, and lateral erosion can be acute as shown in P12 and 13. The locations of these areas is found on

Figure 21. A similar problem is the buildup of branches and sticks caused by a fallen tree or other obstruction which gives the same result (P14 and 15).

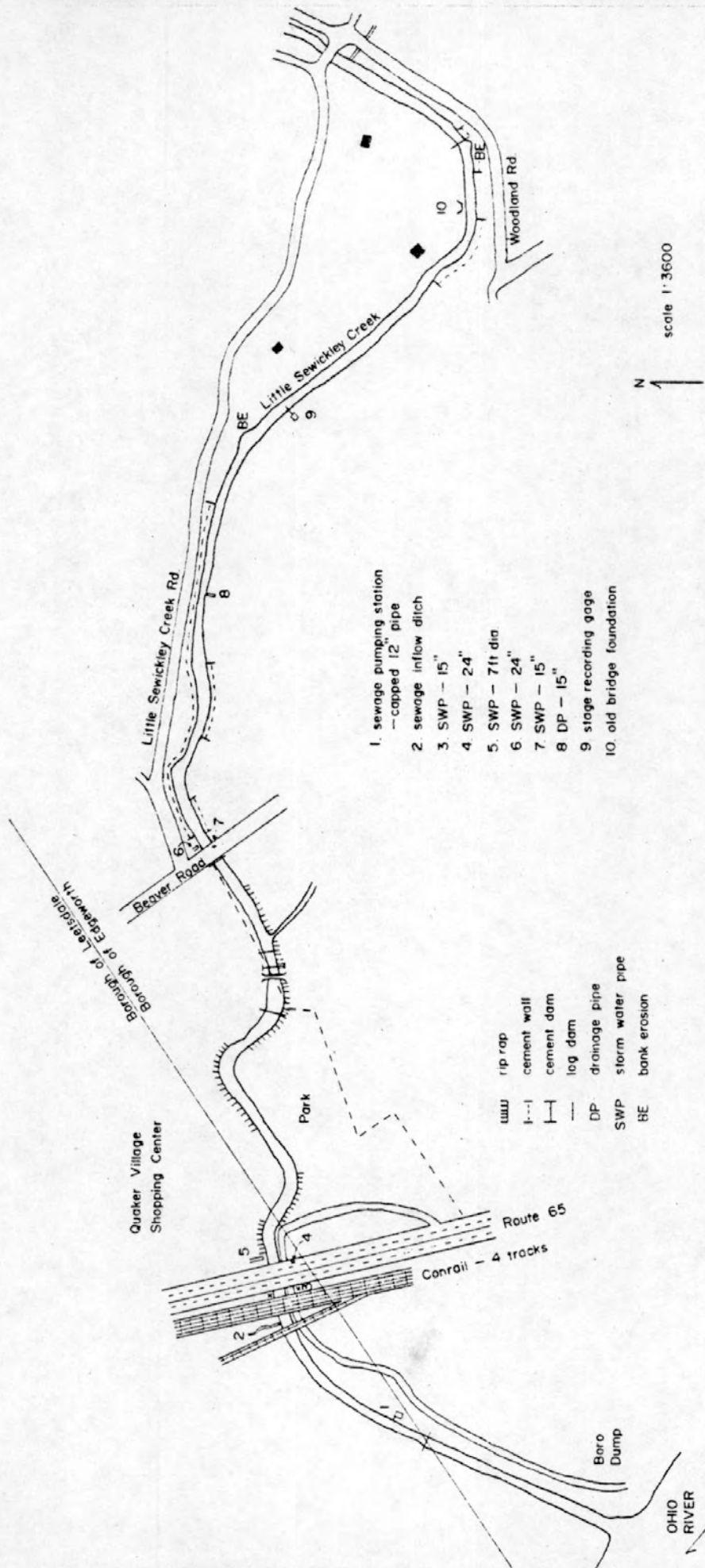
Another natural occurrence which is less frequent but causes more harm to man is landslides and slumps initiated by stream undercutting. This problem is most acute in areas where the stream flows at the base of steep, unstable slopes, usually on red beds. Lateral erosion by the stream removes the material supporting the slope causing a mass movement. One such area is located on Little Sewickley Creek Road just above its intersection with Woodland Road. A recent slide is shown in P16 and 17 and another is imminent. P18-21 are pictures of the road taken in early June. P22-25 were taken in late July. It is difficult to tell when rapid movement will take place. However, the slide will probably be initiated after a long period of rain which will reduce the internal resistance of the material that presently holds the slope intact. Another area exhibiting mass movement above the stream is along Audubon Rd in Sewickley Hills where slow creep is undermining the road (P26-28). Note the displacement of the center lines on the road surface.

There are a number of other areas where slope movements of various magnitudes are occurring. Some are stream related as the two cited above, others are not. There is little that can be done to stop them without large monetary expenditures, though placement of porous drain pipes or trenches from the base up into the unstable portions may relieve the excess water pressure, thereby stabilizing the slope (Terzaghi and Peck, 1948).

Man Induced Alterations

As noted earlier, the lower section of Little Sewickley Creek suffers high rates of erosion (Fig. 20) due to a number of alterations to the stream. Figure 21 is a map of alterations below the Woodland Road bridge. Channelization in the form of rip-rapping and walls increases the flow efficiency of the stream which in turn increases its erosive capabilities. P29 and 30 show a portion of a cement wall near the old bridge foundation. At one time the cement slabs were vertical. Undercutting by the stream eventually wore through these thick slabs which then fell into the channel. The section of rapid bank erosion below the stream gage is intensified by the straight, high velocity section upstream causing accelerated erosion. The problem is compounded by the numerous storm water pipes which efficiently transfer runoff into the stream causing higher peak discharges. In summary then, increased erosion in this section is caused by 1) increased runoff due to the high percentage of impermeable area, 2) higher peak discharges due to the efficiency of storm sewers, and 3) higher flow velocities due to channelization.

Channel constriction is another means by which man has altered the channel shape. Most often this occurs in the vicinity of bridges. Many times the space beneath the bridge for the stream is too small to efficiently accommodate higher discharges. A backwater effect upstream results in sedimentation and a reduction in bankfull channel capacity. As the water passes through the constriction its velocity is increased and this, along with its decreased sediment load causes erosion of the bridge structure and the channel downstream. An excellent example of this is found



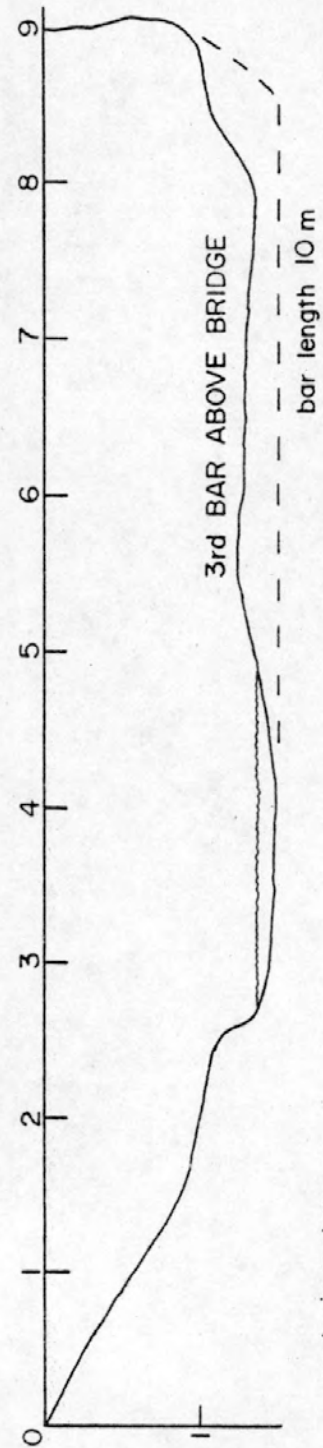
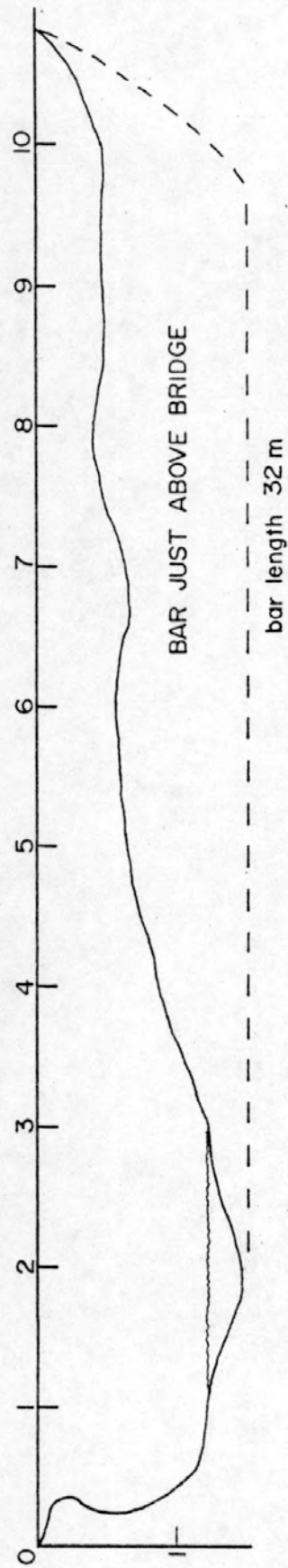
MAP OF MANMADE ALTERATIONS - LOWER SECTION

on Fern Hollow tributary (P8) at the bridge for Pony Hollow Road. Figure 22 shows two cross sections one of which was taken across the channel bar just upstream from the bridge, the other across a channel bar about 100 meters above the bridge. Note that the large bar is not only thicker, but three times longer. The large bar is composed almost entirely of coarse gravel indicating deposition occurred under high flow conditions. P31 shows the bridge (looking upstream). The degree of constriction is apparent as are the concrete chunks eroded from the walls below the bridge.

It should be noted here that one of the biggest problems in the watershed at this point is the decrepit shape of the stream associated structures. P32 is a picture of another bridge in Fern Hollow that is in bad need of repair. P33 and 34 show erosion of the road near this bridge and P35 shows undercutting of a retaining wall at the upper end of Walker Park. P36-39 show the decay and undermining of walls along Fern Hollow. Practically all structures need repair or replacement to insure unobstructed flow of the main stream and tributaries.

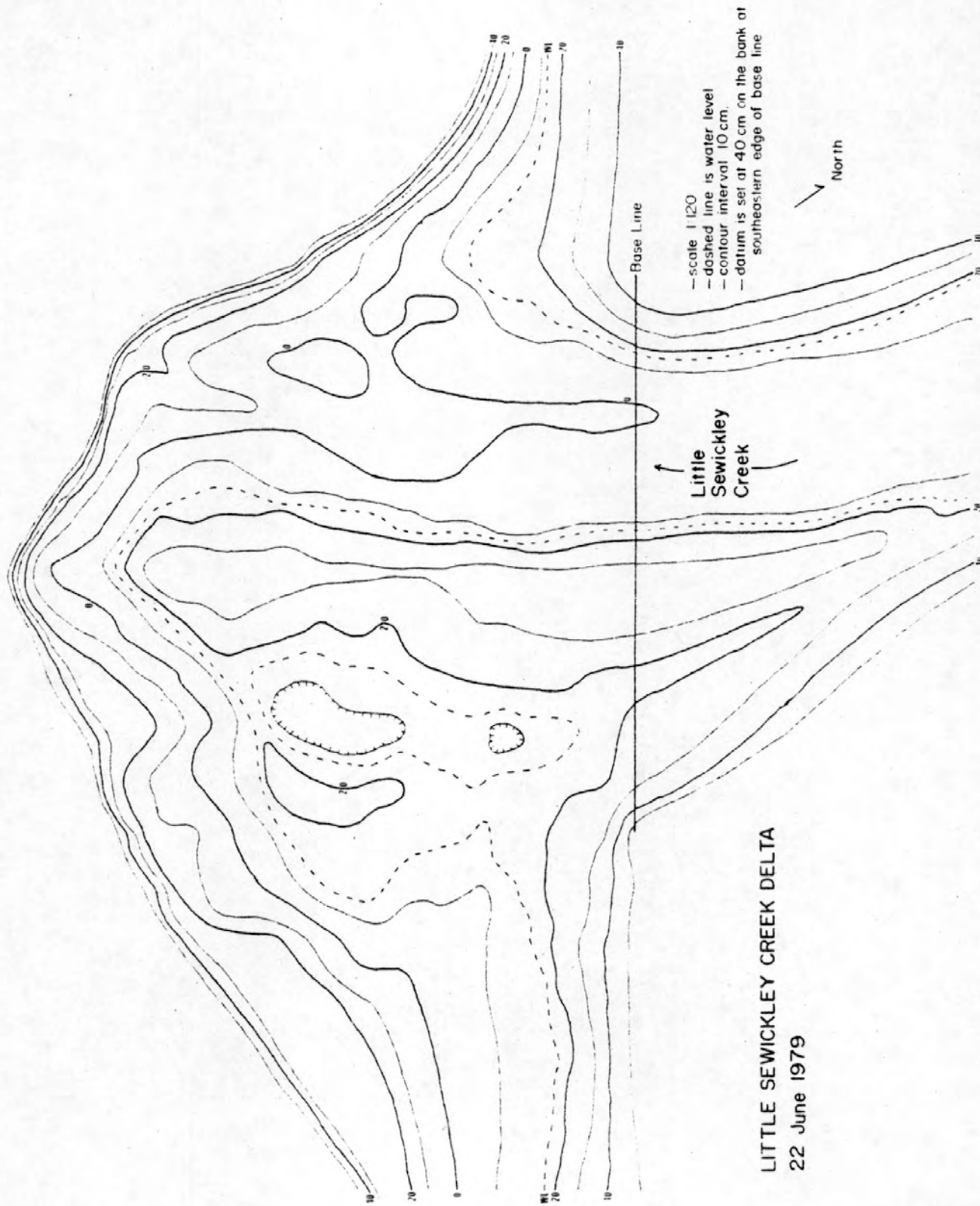
In general, sediment discharge from the stream has been small due to dams and retention ponds along the main trunk. However, the large cement dam is now completely filled in as is the retention pond in Sewickley Hills near the border of Franklin Park (P40). Now only the two beaver dams serve to catch sediment. In an attempt to provide some kind of estimate of the amount of sediment moving out of the watershed the delta into the Ohio River was mapped (Fig. 23). This will provide a base to which future studies can be compared.

BAR DEVELOPMENT DUE TO BRIDGE CONSTRICTION - FERN HOLLOW



scale in meters
scale for both sections 1:48
no vertical exag.
data taken 25 July 1979

—OHIO RIVER—



LITTLE SEWICKLEY CREEK DELTA

22 June 1979

Maronda Homes - A Case Study in Erosion-Sedimentation

The Maronda Homes development site is located just off Magee Road in the headwaters of tributary 13. Construction began in 1976 and presently there are over 25 homes with more under construction. While an erosion-siltation plan was filed for the project it was not implemented and the result was serious erosion of the land and fill areas in the headwaters of T13. P41-44 show gully development on unvegetated fill material at the top of the tributary. Plates 8-12 show a series of cross sections taken in the tributary from the headwaters to the mouth. Notice that the last two sections are substantially smaller in area than the upper three. This is due to 1) an ancient landslide through which the stream has cut and 2) a lower gradient since this section is part of the Little Sewickley floodplain. The gradient also fluctuates substantially in the upper section. Most sediment from the development has accumulated in low gradient sections some of which are caused by natural log dams. Fresh bar deposits are over 30 cm thick in two or three spots. One deposit is at least 60 cm thick just above one large log dam which has a vertical drop of one meter. Most of the sediment has been caught above this dam. Below the dam erosion has caused channel entrenchment of over one meter for a distance of 15 to 18 meters. In the lower section material eroded from the entrenched section has been deposited, decreasing the channel conveyance capacity. In general, then, the tributary has been seriously altered by the development. What further reactions can be expected? Hammer (1972) states that channel enlargement due to urbanization becomes apparent about four years after construction

and continues for about 26 years. This is due to increased runoff from the urbanized area and is already beginning below Maronda Homes. Figure 24 shows cross sections M1 and M3 on June 6 and July 21. It can be seen that the stream is already beginning to remove some of the deposited material since the development site has now been properly seeded (P45) and the runoff is able to pick up the material in the channel.

The damage to this tributary, though acute, is not uncommon. Much of it could have been prevented had the cleared area been properly seeded and a sediment basin constructed. Unfortunately it is now too late. Further enlargement, however, can be stopped now by installing a detention pond to retard high flows and reduce flow velocity.

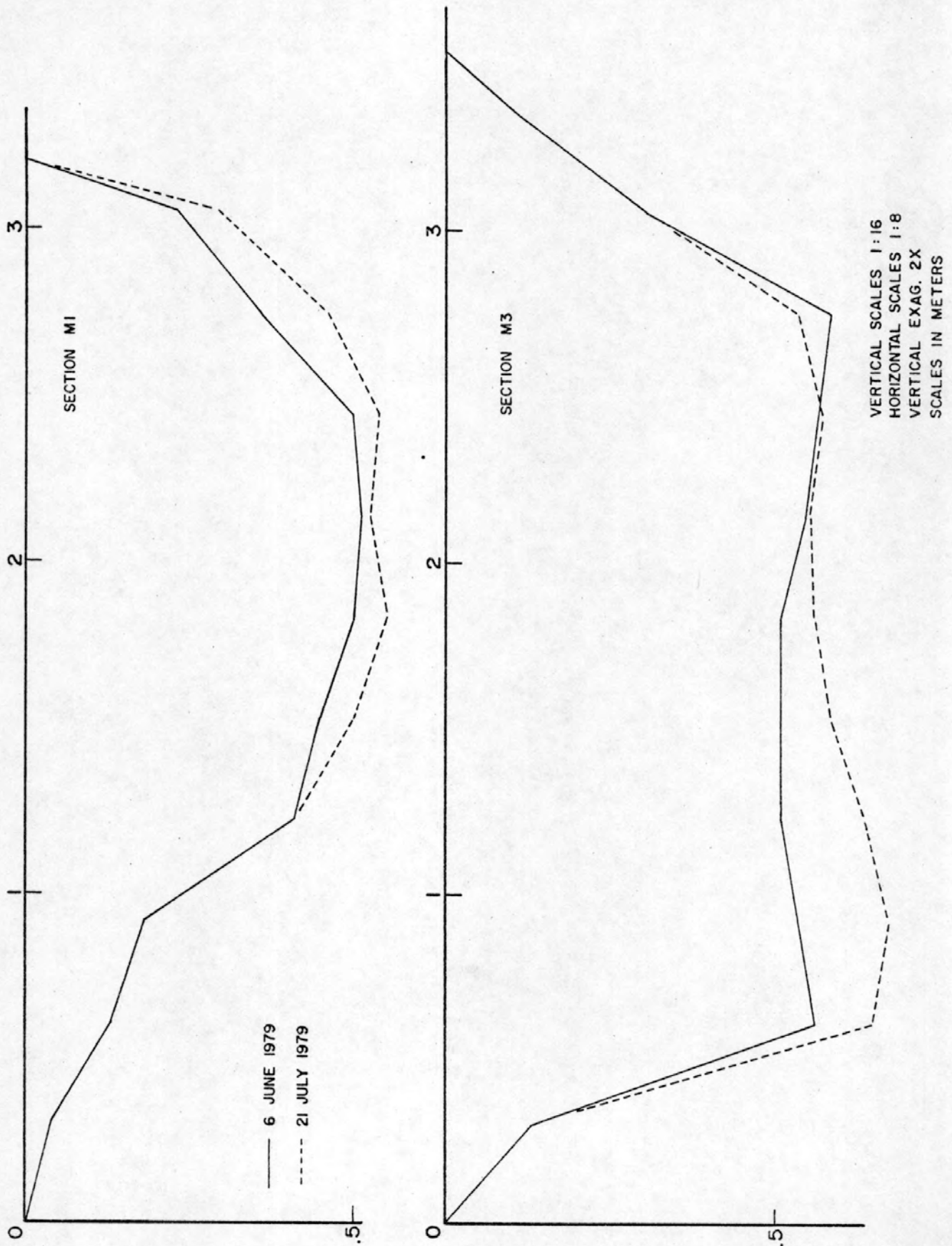
The above case study dramatizes the need for careful planning and implementation of erosion control plans - the fate of the Maronda Homes tributary need not recur elsewhere.

Section Summary and Conclusions

Once again the rural nature of the area is shown by the data. The quantitative data in the form of pool-riffle spacing, tributary data, and cross sectional area versus drainage area reflect a stream in equilibrium with the natural environment. Evidence to the contrary was also provided, however. The case of Maronda Homes sharply points out what can happen when man ignores natural processes as a part of his environment. Likewise the deteriorated walls and bridges point out the power of a stream and the need to maintain such structures for the well being of both man and nature.

One does not live near a stream, one lives with it.

CHANNEL CHANGES IN TRIBUTARY BELOW MARONDA HOMES



SUMMARY AND CONCLUSIONS

The foregoing study has provided information on the Little Sewickley Creek watershed for the purpose of establishing the baseline characteristics of the stream for comparison with future studies. This information takes the form of

- 1) basic data concerning the stream's environment, i.e., the geology, topography, soils and climate
- 2) the establishment of two permanent water level recorders and four rain gages for long term collection of hydrologic data along with an analysis of the data collected during June and July 1979
- 3) an overall description of the stream and its tributaries in terms of its drainage properties, channel morphology, and erosion-sedimentation characteristics
- 4) land use data for correlation with the above information and comparison with other rural and urbanized watersheds in the region

Analysis of the above information has given rise to the following conclusions:

- 1) The Little Sewickley Creek watershed is in a rural state and possesses characteristics which are consistent with other rural watersheds in the region. Thus, a standard is established by which the effects of urbanization of other watersheds in the area can be determined.
- 2) Urbanization has a pronounced effect on hydrologic and morphologic characteristics of streams as evidenced by

the recent construction in Maronda Homes and its effects on the tributary which drains the area. Continued health of the stream will require careful planning and maintenance of future developments in the area to prevent the increased runoff from increasing peak discharges and channel erosion and siltation.

- 3) The infrequent nature of flooding in the watershed is due to the type of vegetative cover, soil types, topography, efficiency of the drainage system, the beaver dams, and the length of time that the watershed has remained in its present state.
- 4) Man-made structures related to the stream and its tributaries have deteriorated to the point where drainage efficiency is being threatened, not to mention the threat to human property and safety.

RECOMMENDATIONS

Taken together, the information supplied by this report and those that follow are the keys to successful planning of the watershed's future. The following recommendations by the author should serve as a guide for some of these future decisions.

- 1) Strong laws and strict enforcement are needed in terms of construction in environmentally sensitive areas such as steep slopes, floodplains, and landslide prone areas in order to insure the safety of man, property, and the stream.

- 2) Specific to development sites, erosion on the cleared land can be minimized by proper landscaping and rapid revegetation of the disturbed area. Holding ponds and catchment basins should be constructed on site to prevent excess material from getting into nearby streams.
- 3) Streams adjacent to development sites should be equipped with check dams or detention ponds to prevent channel enlargement from excess runoff.
- 4) In reference to 2 and 3 above, do not assume that because an erosion-siltation plan has been filed for construction activity that it will be faithfully adhered to. Citizens must become watchdogs from the beginning to assure that the plans are followed. Do not be afraid to use litigation as a means of enforcement since there are a number of strong laws that can be applied.
- 5) Stream related structures should be carefully inspected and repaired as soon as possible.
- 6) More data is needed on stream flow to better define the conclusions stated. This study was not inclusive but rather serves as a base for comparison with future studies.
- 7) The watershed should be preserved in its natural state to insure the continued health of the stream. Also, the importance of aesthetic qualities to the well being of man has gained increasing recognition in the past few years. The Little Sewickley Creek watershed contains some of the most unique and scenic areas in the Pittsburgh region. Preservation is not a hindrance to progress, but rather an assurance of its continuation.

ACKNOWLEDGEMENTS

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APPENDIX

AT-A-STATION HYDRAULIC GEOMETRY DATA

Symbols

W - width of the water perpendicular to flow, in meters
 D - average depth of the water across channel, in meters
 V - average velocity of the water, in meters/second
 Q - discharge, in cubic meters/second

Cross Section 1

Date	W	D	V	Q
6/13	6.930	.0960	.527	.3510
6/19	7.188	.0696	.355	.1776
6/27	5.156	.0545	.301	.0846
7/2	7.214	.0698	.375	.1888
7/5	7.112	.0615	.365	.1596
7/10	7.315	.1016	.543	.4036
7/19	5.791	.0401	.240	.0557

Cross Section 2

Date	W	D	V	Q
6/13	10.058	.0900	.457	.4140
6/19	7.315	.0805	.315	.1855
6/27	6.096	.0718	.254	.1112
7/2	6.985	.1055	.302	.2225
7/5	6.807	.0873	.245	.1456
7/10	10.058	.0963	.369	.3574
7/19	6.096	.0558	.130	.0442

Cross Section 3

Date	W	D	V	Q
6/13	7.620	.1210	.366	.3370
6/19	6.960	.1049	.219	.1599
6/27	6.858	.0836	.145	.0831
7/2	7.315	.1124	.259	.2130
7/5	5.969	.1109	.223	.1476
7/10	7.798	.1306	.305	.3106
7/19	6.579	.0821	.106	.0573

Cross Section 4

Date	W	D	V	Q
6/13	9.754	.0980	.293	.2800
6/19	9.677	.0877	.171	.1451
6/27	9.398	.0612	.097	.0558
7/02	9.677	.0898	.169	.1469
7/05	9.500	.0817	.168	.1304
7/10	9.677	.1085	.257	.2698
7/19	9.144	.0526	.084	.0404

Cross Section 5

Date	W	D	V	Q
6/13	6.096	.0900	.302	.1660
6/19	5.639	.0639	.268	.0966
6/27	4.470	.0527	.191	.0450
7/02	5.664	.0694	.274	.1077
7/05	5.461	.0635	.245	.0850
7/10	6.299	.0901	.360	.2043
7/19	4.420	.0488	.178	.0384

Cross Section 6 was abandoned in early June due to ponding caused by the construction of a beaver dam.

Cross Section 7

Date	W	D	V	Q
6/13	3.252	.0950	.259	.0800
6/19	3.429	.0747	.176	.0451
6/27	3.353	.0646	.108	.0234
7/02	3.454	.0746	.167	.0430
7/05	3.454	.0710	.133	.0326
7/10	3.480	.0783	.212	.0578
7/19	3.327	.0568	.071	.0136

Cross Section 8

Date	W	D	V	Q
6/13	2.591	.0930	.186	.0450
6/19	2.540	.0893	.127	.0288
6/27	2.489	.0723	.089	.0160
7/02	2.565	.0847	.113	.0245
7/05	2.413	.0941	.113	.0257
7/10	2.464	.0975	.143	.0344
7/19	1.956	.0930	.063	.0115

Cross Section 9

Date	W	D	V	Q
6/13	1.524	.0820	.274	.0340
6/19	1.524	.0533	.233	.0189
6/27	1.295	.0413	.180	.0096
7/02	1.549	.0458	.235	.0167
7/05	1.524	.0410	.218	.0136
7/10	1.575	.0508	.279	.0223
7/19	1.270	.0406	.147	.0076

Cross Section 10

Date	W	D	V	Q
6/13	1.219	.0580	.162	.0110
6/19	1.219	.0409	.122	.0061
6/27	1.168	.0278	.059	.0019
7/02	1.194	.0407	.097	.0047
7/05	1.168	.0355	.084	.0035
7/10	1.219	.0432	.106	.0056
7/19	1.016	.0271	.091	.0025

SOIL SERIES DESCRIPTIONS (Allegheny Soil Survey, 1973)

- Gilpin-Upshur Soils

Moderately deep and deep, well drained soils formed from relatively acid shale and some sandstone interbedded with non-acid red clay shale. The Gilpin and Upshur occur on upland slopes in a complex with each other.

- Gilpin-Weikert Soils

Shallow and moderately deep, well drained soils formed from relatively acid shale and fine grained sandstone bedrock. The Gilpin and Weikert occur on steep to very steep upland slopes in a complex pattern with each other.

- Gilpin Soils

Moderately deep, well drained soils formed from relatively acid shale and some sandstone bedrock. They generally occur on convex upland slopes. They have moderate permeability and normally have a water table 4 feet below the surface throughout the year.

- Guernsey-Vandergrift Soils

Deep, moderately well drained soils formed from interbedded shale, limestone, and red clay shale bedrock. They occur on upland slopes. The Guernsey and Vandergrift occur as a complex with each other on upland slopes.

- Guernsey, Fine Loamy Variant, Soils

Deep, moderately well drained soils formed from interbedded shale and limestone bedrock. They occur on upland slopes. They have slow permeability and have a water table within 2 to 3 feet of the surface in the winter.

- Ernest Soils

Deep, moderately well drained soils formed from relatively acid colluvial material. They generally occur on concave landscapes at the base of steeper upland slopes. They have slow permeability and have a water table within $1\frac{1}{2}$ to 2 feet of the surface in the winter.

- Ernest-Vandergrift Soils

Deep, moderately well drained soils formed from relatively acid colluvial material. The Ernest and Vandergrift occur as a complex with each other on concave landscapes at the base of steeper upland slopes.

- Wharton Soils

Deep, moderately well drained soils formed from relatively acid gray clay shale. They generally occur on concave upland slopes. They have slow permeability and have a water table within $1\frac{1}{2}$ to 2 feet of the surface in winter.

- Cavode Soils

Deep, somewhat poorly drained soils formed from relatively acid gray clay shale. They generally occur on concave upland slopes. They have slow permeability and have a water table at 1 to $1\frac{1}{2}$ feet of the surface in the winter.

- Upshur Soils

Deep, well drained soils formed from nonacid red clay shale. They occur on upland slopes. These soils have slow permeability and have a water table below 3 feet of the surface in the winter.

- Philo Soils

Deep, moderately well drained soils formed from stratified, relatively acid alluvium. They occur on low lying, nearly level flood plains and are subject to occasional flooding. They have moderate permeability and have a water table within $1\frac{1}{2}$ to 2 feet of the surface in the winter.

- Hazleton Soils

Deep, well drained soils formed from acid sandstone. They generally occur on convex upland slopes. They have moderately rapid permeability and normally have a water table below 4 feet throughout the year.

- Culleoka Soils

Moderately deep, well drained soils formed from shale and fine grained sandstone bedrock. They generally occur on upland slopes. They have moderate permeability, and normally have a water table below 4 feet throughout the year.

- Rayne Soils

Deep, well drained soils formed from relatively acid shale and some sandstone bedrock. They generally occur on convex upland slopes. These soils have moderate permeability and normally have a water table below 4 feet throughout the year.

- Brinkerton Soils

Deep, poorly drained soils formed from relatively acid colluvial material. They generally occur on concave landscapes at the base of steeper upland slopes. They have slow permeability and have a water table at or near the surface in winter.

- Rainsboro Soils

Deep, moderately well drained soils formed from stratified terrace deposited material. They occur on stream terrace landscapes well above the floodplains. They have slow permeability and have a water table within $1\frac{1}{2}$ to 2 feet of the surface in the winter.

- Urban Land

This land consists of fill material which was hauled in and placed on the flood plains. Subsequently the areas were covered by urban works and structures. The fill includes shale, sandstone, limestone, brick, concrete, cinders, industrial waste, junk, and upland soil materials.

- Urban Land-Wharton Soils

Variable land consisting of highly disturbed land resulting from cut and fill operations and subsequent coverage with urban works. This occurs in a complex pattern with Wharton soils.

- Urban Land-Culleoka Soils

Variable land consisting of highly disturbed land resulting from cut and fill operations and subsequent coverage with urban works. This occurs in a complex pattern with Culleoka soils.



Plate 1. Beaver dam at Fern Hollow Trib.



Plate 2. Monitor Station 1, mouth of stream.

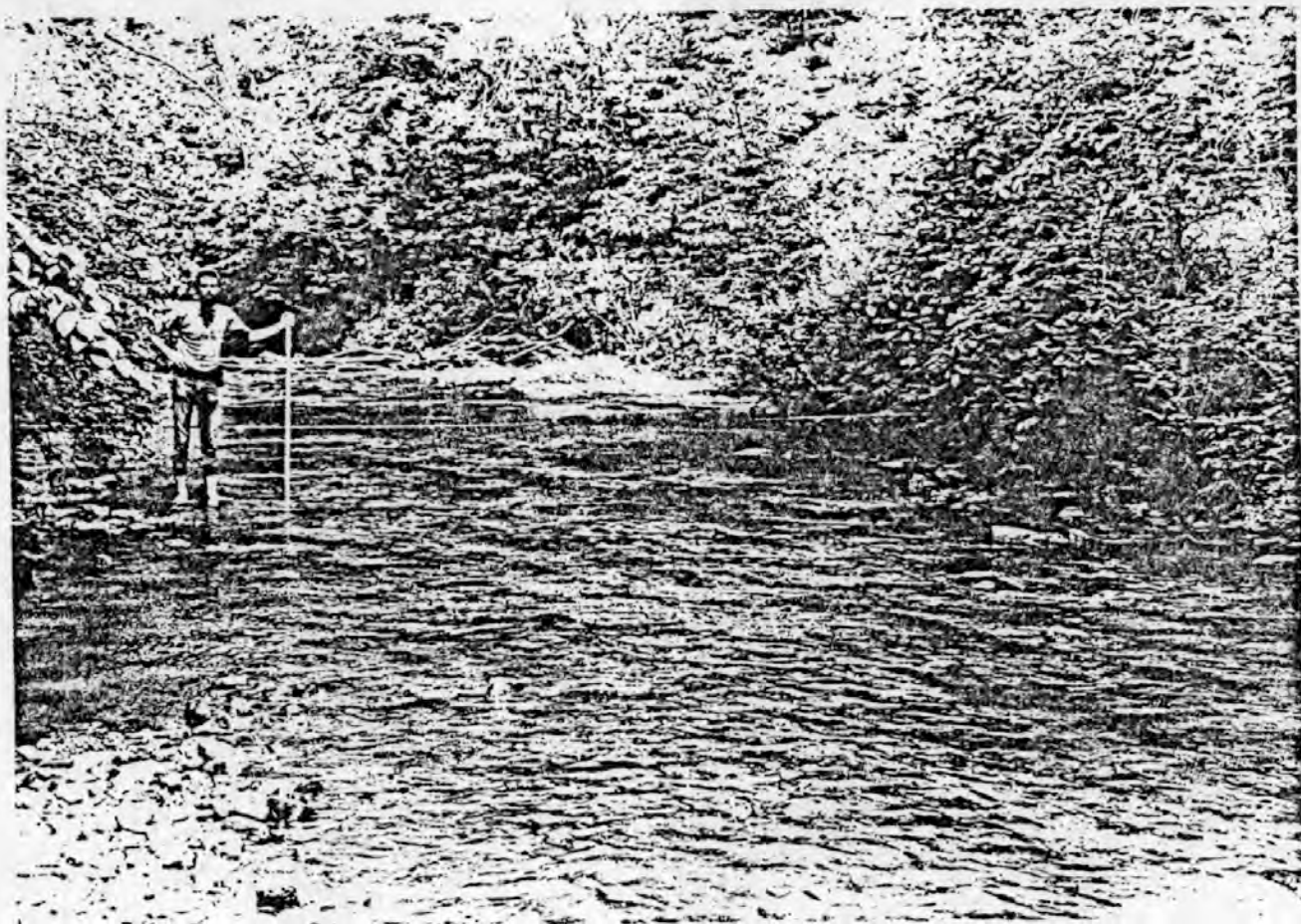


Plate 3. Monitor Station 2, downstream gage.



Plate 4. Monitor Station 3, Walker Park.

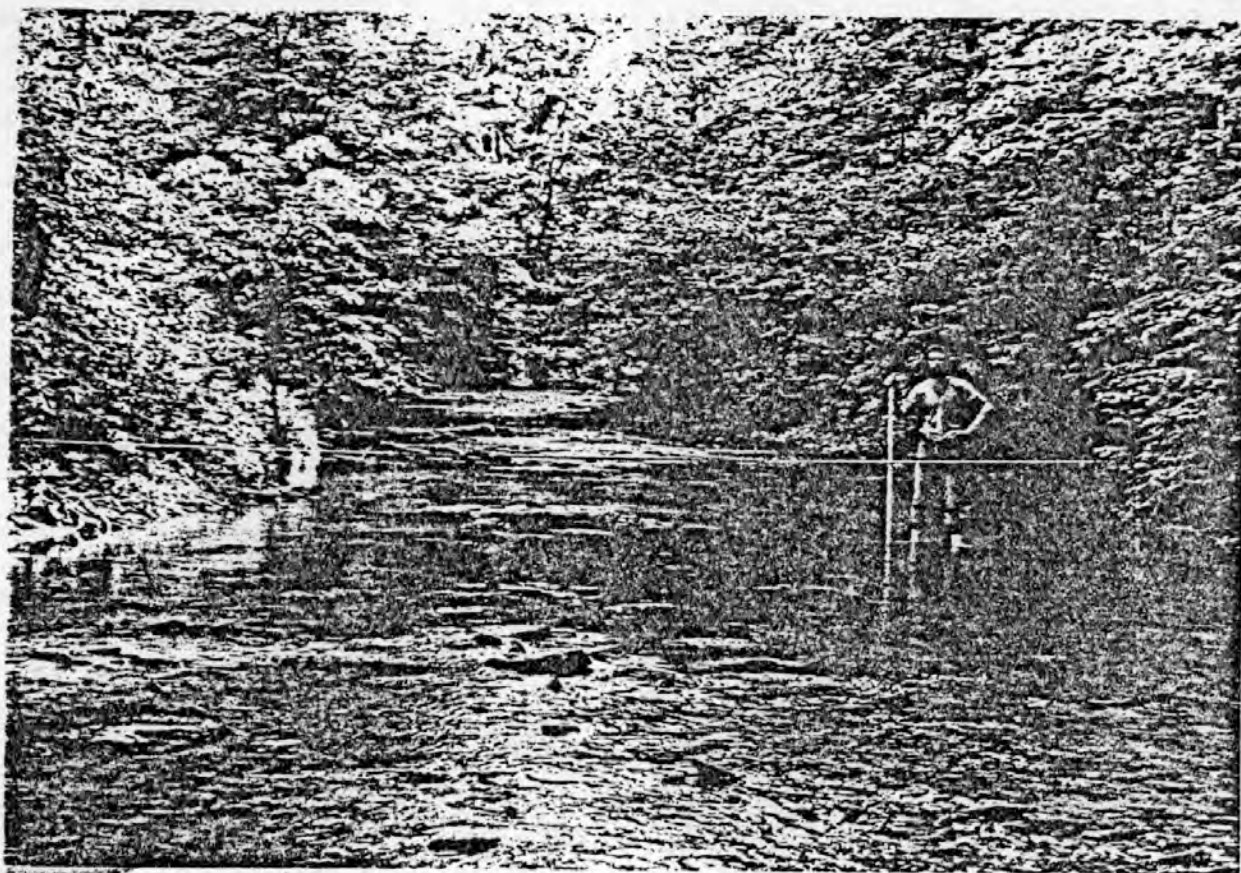


Plate 5. Monitor Station 4.

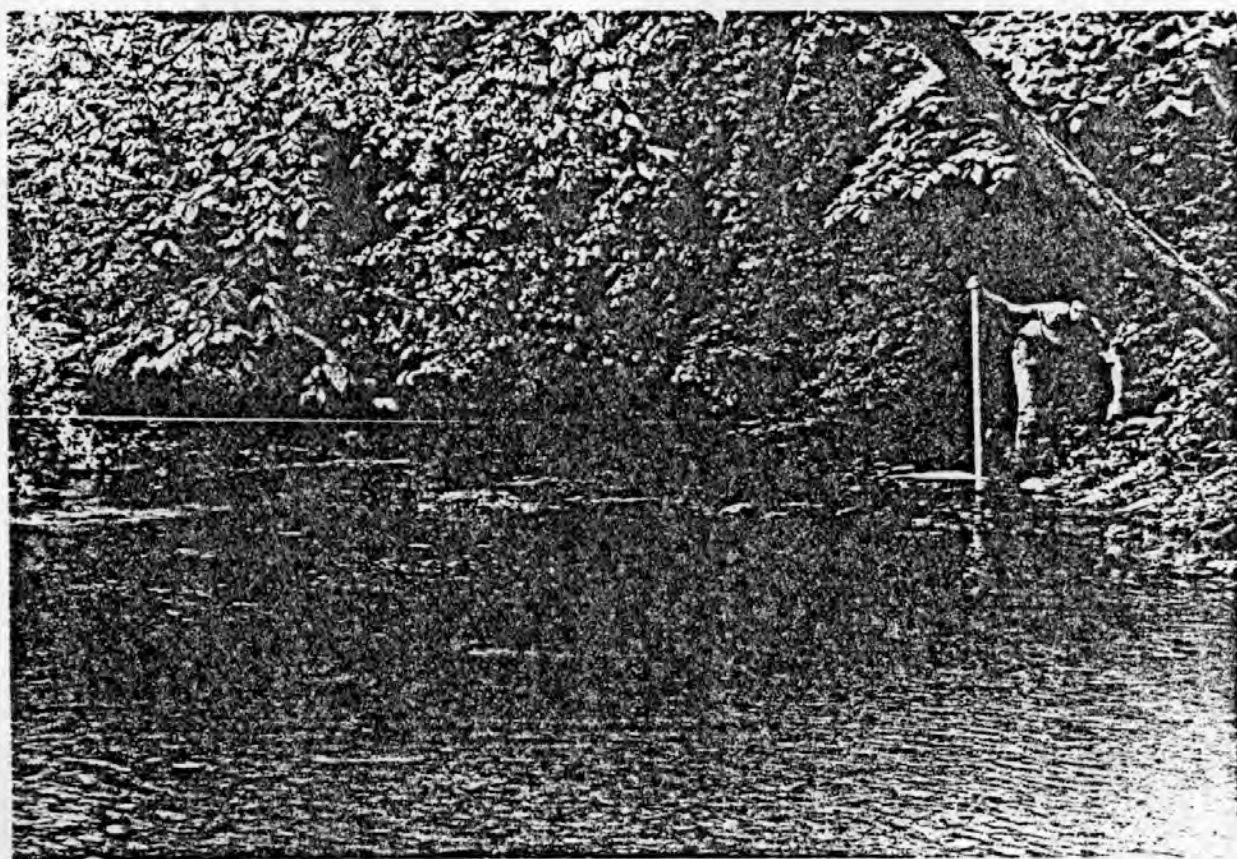


Plate 6. Monitor Station 5.



Plate 7. Monitor Station 7, upstream gage.

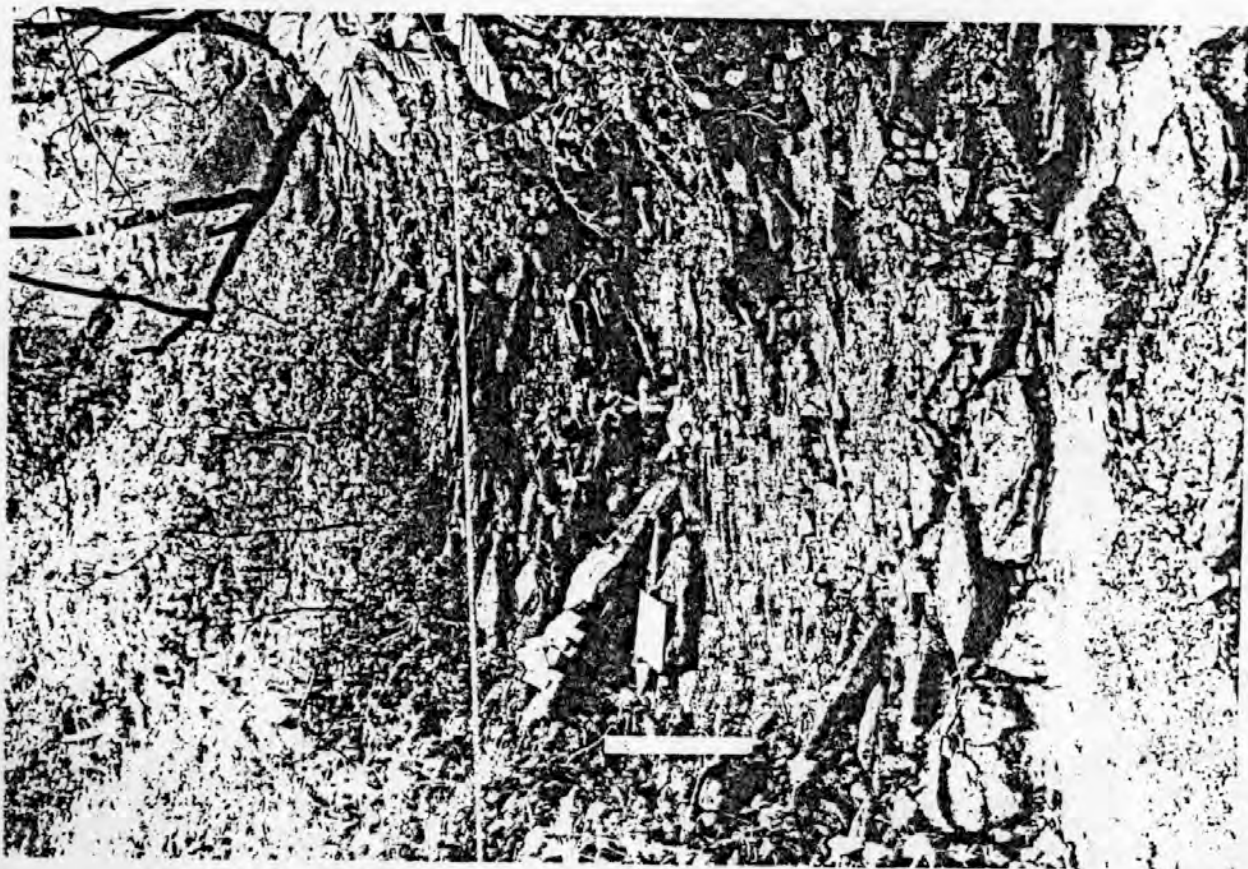


Plate 8. Maronda Homes Trib., cross section
M1, headwaters.

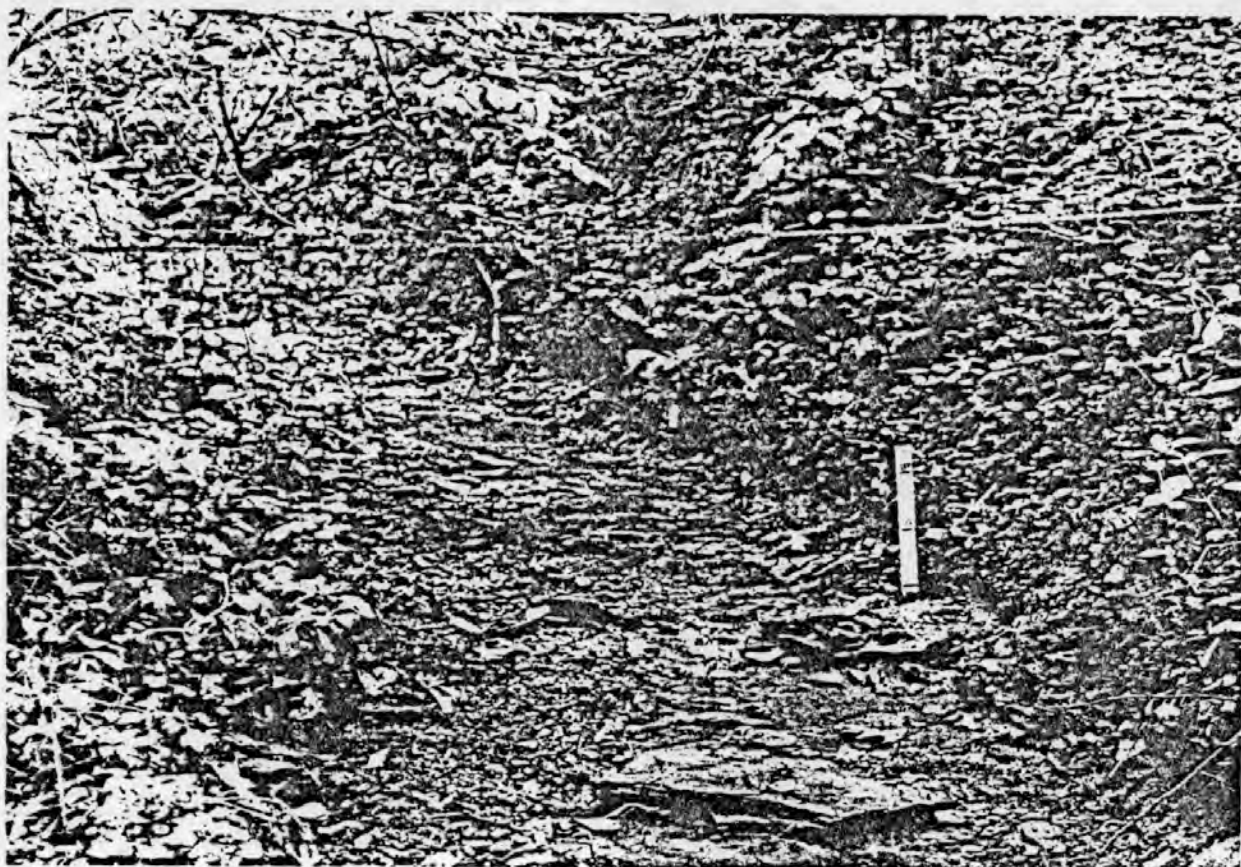


Plate 9. Maronda Homes cross section M2.



Plate 10. Maronda Homes cross section M3.

UNIT CONVERSION TABLE

<u>English-Metric</u>	<u>Conversions</u>	<u>Metric-English</u>
1 in = 2.54 cm	Length	1 cm = 0.394 in
1 ft = 0.3048 m		1 m = 3.289 ft
1 mi = 1.609 km		1 km = 0.621 mi
1 in ² = 6.45 cm ²	Area	1 cm ² = 0.155 in ²
1 ft ² = 0.093 m ²		1 m ² = 10.76 ft ²
1 mi ² = 2.59 km ²		1 km ² = 0.386 mi ²
1 in ³ = 16.387 cc	Volume	1 cc = 0.061 in ³
1 ft ³ = 0.0283 m ³		1 m ³ = 35.315 ft ³
1 ft ³ = 28.361 l		1 l = 0.0353 ft ³

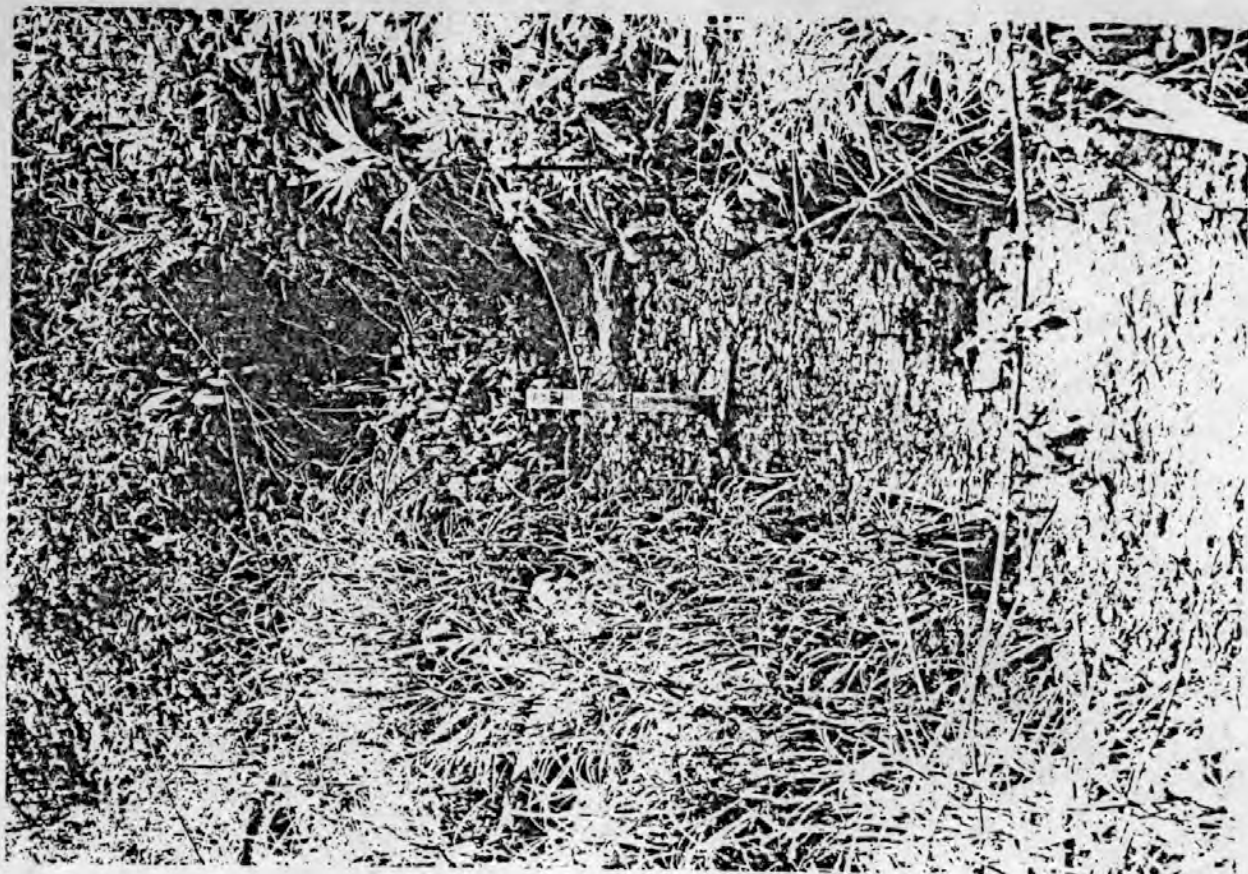


Plate 11. Maronda Homes cross section M4.

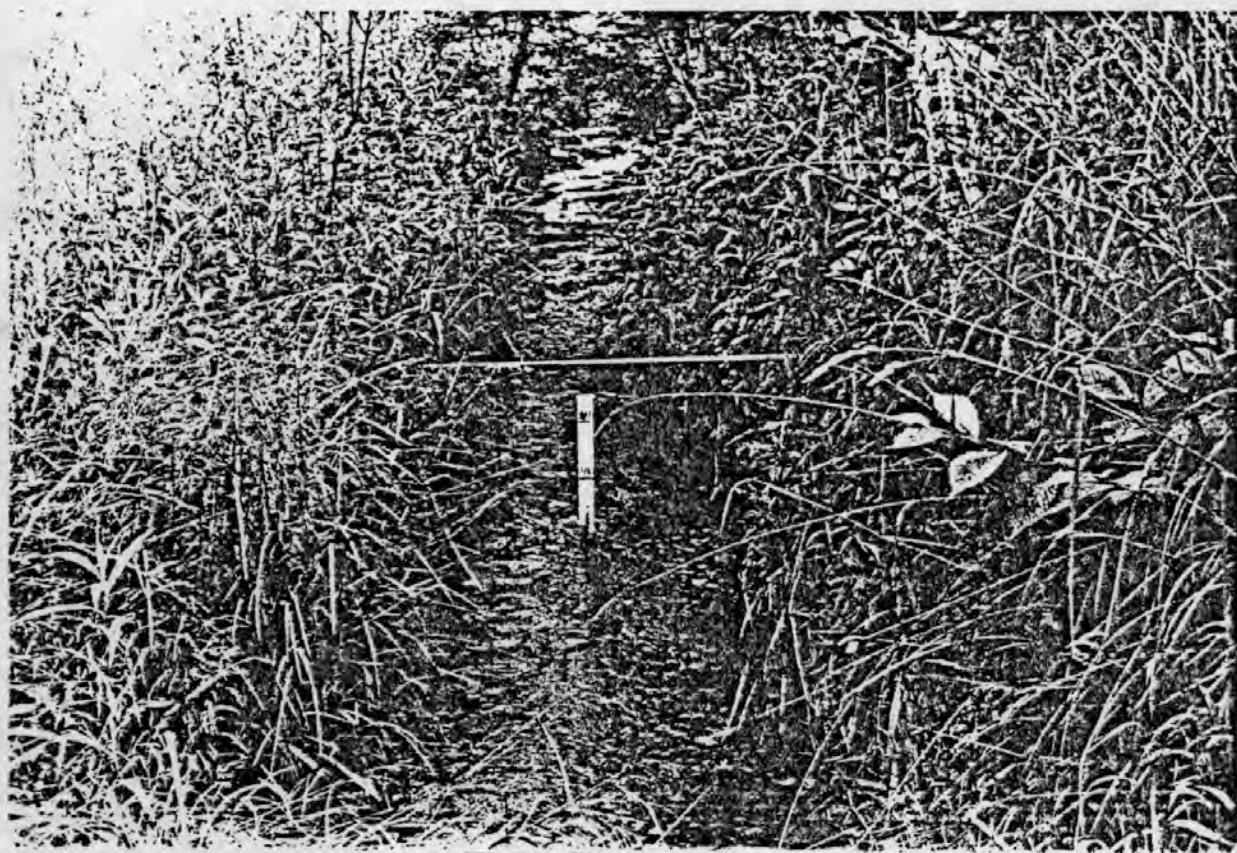


Plate 12. Maronda Homes cross section M5.

GLOSSARY

- cobble - a rounded rock fragment between 64 and 256 mm in diameter
- discharge - rate of flow at a given instant in terms of volume per unit time
- formation - the primary unit of formal mapping or description. Most formations possess certain distinctive combinations of distinctive lithic features
- glaciofluvial - pertaining to streams flowing from glaciers or to the deposits made by such streams
- group - rock stratigraphic unit consisting of two or more formations
- hydraulic geometry - a means by which stream flow and channel shape can be expressed in quantitative terms
- hydrograph - a graph showing stage, discharge, velocity, or other property of water with respect to time
- interflow - the process whereby rain water flows to the stream through the soil (below the surface but above the bedrock)
- lithology - the physical character of a rock, generally as determined megascopically or with the aid of a low power magnifier
- pebbles - smooth rounded stones ranging in diameter from 2 to 64 mm
- runoff - the quantity of water discharged through surface streams. Normally includes water running over the surface to the stream and interflow
- weathering - the group of processes, such as the chemical action of air and rain water or plants and bacteria, and the mechanical action of changes in temperature whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil