STUDY METHODS

The methods employed in studying the problem of acid mine drainage within the Hillman State Park property are described under the following phases of work.

COMPILATION OF INFORMATION

An initial and continuing phase of work concerned the collection of basic data. A summary of the information gathered and the primary information source is as follows:

Topographic Maps of Hillman State Park were provided by the Department of Environmental Resources, Harrisburg, Pa.

Mining Operations data was obtained from Mr. Walter Robertson of the Harmon Creek Coal Corporation.

Mining Maps of the Hillman State Park area were obtained from Englehart and Powers, Engineers, Canonsburg, Pa.

Property Map of the Hillman State Park area was provided by the Department of Environmental Resources, Harrisburg, Pa.

Oil and Gas Well Data was provided by the Cassidy Oil Company of Florence, Pa. Additional information regarding the Florence-Five Points Oil Field was obtained from the United States Geological Survey Geologic Atlas of the Burgettstown-Carnegie area.

Adjacent Property Owners to Hillman State Park were identified from the records of Washington County, Washington, Pa.

Aerial Photographs of the Hillman area were obtained from the United States Geological Survey, Washington, D. C. Date of photography - March 23, 1969.

Basic Runoff Criteria for the Hillman area were provided by the Soil Conservation Service, U. S. Department of Agriculture, Pittsburgh, Pa.

Weather Statistics for the area were obtained from monthly publications of the National Climatic Center, U.S. Department of Commerce, Ashville, N.C.

LOCATION OF POLLUTION SOURCES

Stream-Walking - The location and identification of pollution sources was performed by the stream-walking method. This consisted of walking the lengths of identifiable streams and tracing recognizable water flows to their points of origin. The search was initiated at the mouths of the major streams and proceeded upstream into minor tributaries.

Period - The search for pollution sources began in July, 1970, and was approximately 75% complete by September, 1970. Additional sources were located during December, 1970, and January and February, 1971.

Winter Months - Sources identified in the winter months were not located earlier because low precipitation levels in July and August, 1970, resulted in limited flows in a number of source-related stream valleys. In addition, the discovery of certain pollution sources proved less difficult in the winter months due to the absence of heavy brush.

Stations - All identified pollution sources were numbered as located for purposes of future study. Many sources were red-flagged so that subsequent field identification would be facilitated. Sampling stations were also set up on major streams, principal tributaries, and large areas of ponded water. The locations of all stations are shown on the Inventory Maps of Appendix A.

Additions-Deletions - As the study progressed a number of stations were added as additional pollution sources were identified. With the accumulation of information, some stations were deleted.

Aerial Maps - The aerial maps contained in Appendix A were not available for use during the early stages of source identification but were used during the later stages of the study period to locate or identify features.

MONITORING

Water Quality Study Period - Stream quality readings were obtained at pollution sources and sampling stations during the 13-month period July, 1970, through July, 1971.

Frequency - The frequency of sampling varied somewhat throughout the survey period. Samples were generally obtained twice per month until October, 1970 and once per month thereafter. Sampling generally exceeded the once per month level at those sources identified later in the study period.

Map Identification - The locations of all sampling stations are shown on the Inventory Maps contained in Appendix A.

Weirs - Simplified weirs were constructed at five of the sampling stations to facilitate flow measurements. Some difficulties were experienced in maintaining the weirs operable over the study period. Repairs were often necessitated after intervals of heavy flow or after periods of ice formation.

Stream Flows - Stream flows at each of the monitoring stations were measured either by flow meter, weirs or velocity flow.

Flow Meter- The flow meter method of measurement was normally used where large flows were encountered. The measuring device was a Gurley Pygmy Type Current Meter (No. 625F). In this method, a measurement of the stream cross sectional area is obtained and velocity rates are recorded with the Gurley Meter at small intervals across the stream. The product of area and velocity provides a measurement of flow.

Weir Flow - Weir measurements were obtained where nominal flows were encountered and where the method could be easily adapted to existing conditions. The weirs were either natural or constructed. The quantities of water flowing through the weirs were collected for timed periods and direct calculations of flow were then made.

Velocity Flow - The velocity method was used to estimate flows on small streams or discharges where flow meters or weirs could not readily be utilized. An estimate of the cross-sectional flow area is obtained and an average velocity is estimated using measured time intervals for carried stream particles. The product of area and velocity provides an estimated flow quantity.

ANALYSIS

Testing Procedures - A description of the testing methods used to analyze water quality is provided in Table I of Appendix B.

Water Quality - Water samples obtained at all sampling stations were analyzed for pH, acidity, alkalinity, iron, sulfate and aluminum content. The results of these tests are tabulated in Appendix B, both in detailed and summary form.

Stream Loadings - Stream loadings, reported in pounds per day, were calculated from the measured ion concentrations and stream flows. The results are also tabulated in Appendix B.

Stream Quality - The quality of streams within Hillman State Park were evaluated at high flow and low flow periods. The principal criteria used for evaluation were pH and net acidities (acidity less alkalinity). Stream quality results are provided in the following section of this report.

Material Balance - Material balance investigations based on sulfate stream loadings were made at various intervals during the study period. This analysis was aimed at defining significant but undetected pollution sources. Material balance results are also presented in the following section.

Additional - Additional analysis performed during the course of study involved investigating the relationship of actual source areas to seepage emission locations, estimating the relative contributions of acid mine drainage by individual sub-watersheds, evaluating potential abatement methods, and estimating quantities of acid mine drainage which could be abated.

STUDY RESULTS

GENERAL DESCRIPTION OF POLLUTION SOURCES

Surface Mining Problem - Acid mine drainage in Hillman State Park is the result of disrupted surface drainage caused by extensive surface mining and partial reclamation practices in the area. Deep mining is essentially non-existent over the area and thus is not a factor.

Depressions - Numerous surface depressions, many measuring several hundred feet wide and several thousand feet in length, now persist in the area. In addition to the disturbed natural topography, the mining activities have also left large land areas barren or near barren.

Sub-Watersheds - The many depressions in the Hillman State Park area form numerous sub-watersheds which are-isolated and not surface drained by the local streams. These sub-watersheds are identified by number on the Composite Map contained in Appendix C.

Acid Mine Drainage Formation - The development of much of the acid mine drainage in Hillman State Park occurs as runoff water collects in the lower portions of the un-drained sub-watersheds and subsequently filters through the loose strip backfill to the original bottom coal elevation. During the runoff, retention and filtering process, the water becomes acidic as it contacts remnant coal and spoil particles which, common to the Pittsburgh Coal seam, are high in reactive sulfur content. After reaching the bottom coal elevation, the water moves along the coal structure and eventually exits at down-dip locations. This usually occurs as seepage along the stream banks below the elevations of the strip mining activity. A second source of acid drainage are the numerous spoil slopes immediately adjacent to the receiving streams.

Runoff water on these slopes continuously contacts reactive materials and thus adds to the acid formation problem.

Delineation of Sources - Prominent seepage and runoff locations are generally identified as sources in this report. The precise delineation of many of the Hillman State Park sources is difficult because much of the seepage and runoff occurs at a number of points along the stream banks. Also, the amount and location of seepage and runoff often varies with changes in the amount and intensity of precipitation. Because of this, it was necessary during the study to monitor several receiving streams at significant distances downstream. This procedure increased the likelihood that the bulk of the drainage would be recorded.

INDIVIDUAL STATIONS

Classification - Forty-four sampling stations were monitored during field study of the Hillman area. Classification and description of the types of sampling stations are as follows:

> AMD Sources - These stations consisted of points established at prominent acid mine seepage and/or runoff locations as described in the previous section. In cases where more than one seepage area drained directly into a major stream, the sampling point was selected along the major stream.
>
> Gauging Stations - These stations were set up at the mouths of major tributaries or at other suitable locations which would provide a cumulative check on stream quality and the required data for calculations of stream loadings and material balances.
>
> Ponds - These sampling stations were established at major water ponding locations or other slow-moving water areas to provide a check on water quality changes, if any, in stagnant water areas.

Distribution of Station Types - The numerical distribution of the various sampling station types is:

TYPE	Number
AMD Sources	24
Gauging Stations	14
Ponds	6
TOTAL	44

Water Quality By Station - Water quality results for each station are presented in the tabulations contained in Appendix B. A summary of station types and the average data compiled over the survey period for each station is provided in Table 2 of Appendix B.

Major Sources - Of the 24 identified acid mine drainage sources, eight are considered major pollution sources. In this study, a major source is designated as one which on the average contributes a net load of more than 350 pounds of acid per day to receiving streams. (Net acid load equals acid load minus alkaline load). The following descriptions of the eight major sources are best reviewed in conjunction with the Composite Map provided in Appendix C.

Station 4: This major source is located on Dilloe Run outside the Hillman Park property near the northern panhandle portion of the park lands. Average net acidity is 159 mg/l; average net acid loading is 361 lbs./day.

The acid mine drainage monitored at this source is predominantly attributable to undrained strip areas located north and west of the station and outside the main park property. A portion of the pollution is traced to poor surface drainage conditions within the Hillman panhandle area (sub-watersheds I-3 and 1-4).

Station 4A: This major source, also located outside the Hillman State Park boundary, is situated on a small north-flowing tributary to Dilloe Run. Average net acidity is 738 mg/l; average net acid loading Is 820 lbs./day.

The majority of acid flow from this source emerges as seepage from the hillside along the north-south roadway leading past the Tarr Farm. The principal causes of seepage are the undrained sub-watershed I-3, I-4 and 3-I located to the west and south of Station 4A.

Station 5: Station 5 is located along the northeastern boundary of Hillman State Park on an unnamed tributary to Brush Run. Average net acidity is 144 mg/l; average net acid loading is 347 lbs./day.

This major source combines drainage from several seepage areas located upstream. The drainage is attributable to undrained sub-watersheds, principally 3-8, 3-10, and 3-12, located in the park to the northwest, and several areas to the north located outside the park.

Station 12: Station 12 is located in the northcentral region of Hillman Park on a main southeast flowing tributary to Brush Run. Average net acidity is 814 mg/l; average net acid loading is 887 lbs./day.

The source consists of acid drainage at the origin of the stream and discharges from both sides of the stream valley a short distance downstream. The bulk of the acid flow is attributable to undrained sub-watersheds located to the west and northwest (I-7, I-8, 1-9, I-10, I-11). A smaller portion appears to be drainage from sub-watershed 3-I situated outside of the park area.

Station 12A: This major source is located about 800 ft. downstream from Station 12. Average net acidity is 746 mg/l; average net acid loading is 3166 lbs./day.

The acid mine drainage at this site is a cumulative measure of the discharge at Station 12 and additional seepage from the stream banks below Station 12. The prominent sub-watersheds which cause the acid drainage are those located to the north, northwest and west.

Station 17: This major source is located in the northwest region of Hillman State Park at the origin of the largest south-flowing tributary to Brush Run. Average net acidity is 315 mg/l; average net acid loading is 432 lbs./day.

The acid mine drainage at Station 17 occurs as seepage at the original coal elevation and emits from three directions - east, north and west. The principal areas which cause the seepage are sub-watersheds I-6, I-12 and I-15.

Station I7A: Station 17A is situated approximately 2,500 feet downstream from Station 17. Average net acidity is 247 mg/l; average net acid loading is 1660 lbs./day.

The pollution monitored at this location is a cumulative measure of pollution emitting upstream at Stations 17 and 19 and additional seepage which occurs along the stream banks between those sources and Station 17A. The un-drained sub-watersheds which contribute to the pollution at Station 17A include areas I-I, I-6, 1-12, I-13, 1-14, I-18, I-19, and I-20.

Station 43: This source is situated on Hogs Run in the eastern portion of Hillman State Park. Average net acidity is 173 mg/I; average net acid loading is 927 lbs./day.

The acid mine drainage at Station 43 accumulates from a number of small upstream discharges. Primary sub-watersheds which contribute to the total drainage include 4-5, 4-6 and 4-II, all located to the west of Station 43.

Within the above descriptions, only the sub-watersheds which are believed to predominantly contribute acid mine drainage to major sources are noted. A more complete listing of sources and contributing watersheds is provided in Table 7 of Appendix C.

ANALYSIS OF TEST RESULTS

High Acidities - Some of the Hillman State Park water quality test results are confusing with regard to normally expected relationships of pH and net acidity/alkalinity. Although it is often stressed that pH is only an indicator of acid content, the net acidities obtained in some streams appear somewhat high relative to recorded pH readings.

Examples - Stations I, 2, and 3 present typical examples of the results obtained. The average test values for these stations over the total study period were as follows:

Station	pH	Acidity, mg/l	Alk.,mq/l	Net Acidity mg/l
1	6.4	177	75	102
2	6.4	179	55	124
3	6.3	176	78	98

At the indicated pH levels, one might normally expect net alkalinity rather than net acidity. In addition, the above average results tend to be reasonably consistent yet individual readings at each station show greater variation.

Plot of pH - Net Acidity Relationship - A plot of results for all stations was prepared in an effort to better interpret the seemingly high pH, high acidity results. This plot, Chart I in Appendix B, shows a generally large variation in the pH - acidity relationship yet reasonably defines a trough within which all of the data fit. Also, it is interesting

to note that where two stations exist along a common stream (i.e., Stations 12 and 12A and Stations 17 and I7A) the slopes connecting the common stations parallel the main trough limits. This tends to suggest the common stream data is consistent, at least on an average basis.

WATER QUALITY CHARTS

Station Data - Plots of water quality at ten important stations are provided in Appendix B. Water quality parameters included in the charts are flow, pH, acidity, alkalinity and sulfate.

Rainfall - Monthly rainfall data is presented on each water quality chart to enable a more direct evaluation of stream quality changes relative to amounts of precipitation.

Results - Study of the water quality charts indicates that approximately one-half of those stations charted show a slight deterioration in water quality after periods of heavy precipitation. Thus, some "slugging" occurs.

Since only a surface drainage problem exists in Hillman State Park, the explanation seems to be that heavy rainfall results in water contact with pyritic surfaces not normally contacted in the infiltration and runoff process. The water is thus more heavily contaminated.

STREAM QUALITY

General - Plates VII and VIII provide general representations of the water quality of the principal streams in Hillman State Park. Stream qualities are presented for both high flow and low flow conditions.

Basis - The stream quality determinations are based on evaluations of pH and net acidities as recorded along stream lengths. More precisely, the stream color indications of Plates VII and VIII classify stream quality as follows:

Blue - Predominantly alkaline flows.

Yellow - Variable acid flows with pH of 5.5 or above and net acid concentrations less than 300 mg/l.

Red - Principally acid flows with pH less than 5.5 and net acid concentrations greater than 300 mg/l.

Results - Inspection of Plates VII and VIII indicates a not too significant difference between stream quality in Hillman State Park during high and low flow periods. Although some "slugging" action occurs, most streams in the area fall into the variable acid flow category under both conditions of flow. Other items of note include:

1. The water quality of Brush Run as it enters Hillman State Park is predominantly alkaline. After entering the water quality remains satisfactory for a distance of about 1500 ft. until Brush Run is joined by its first south-flowing major tributary. For the remainder of its course to Raccoon Creek, Brush Run remains in the variable acid flow classification.

2. The water quality of Dilloe Run is generally poor to a point almost midway along its course to Raccoon Creek. The overall water quality does not appear to change appreciably with changed flow conditions.

3. Hogs Run remains within the limits of the variable acid flow category, but does, upon inspection of individual station data, appear to degrade in quality somewhat in moving from low to high flow conditions.

4. The minor stream which borders the extreme southeast corner of Hillman State Park degrades slightly in water quality during low flow. The problem is caused by the deep and strip mined areas located outside and to the south of Hillman State Park.

5. Study of the water quality data at specific stations and along various stream lengths indicates that stream neutralization occurs. As discussed in a previous section, various limestone strata are present in the area and are undoubtedly a factor in the neutralizing action.

ACID LOADINGS

Summary - A summary tabulation of average acid load discharged into the principal streams of Hillman State Park is provided on Table 6 of Appendix C.

Average Amounts - The total acid load delivered to all stream amounts to 10,600 lbs/day while the net acid load, based on total acidity less alkalinity, is 7,900 lbs/day. As indicated on Table 6, Brush Run and Dilloe Run account for over 80% of the total acid loadings.

MATERIAL BALANCES

Frequency - Four material balances using total sulfate loadings were made during the study period for the Brush Run drainage area. The Brush Run drainage area represents approximately 85% of the Hillman State Park total.

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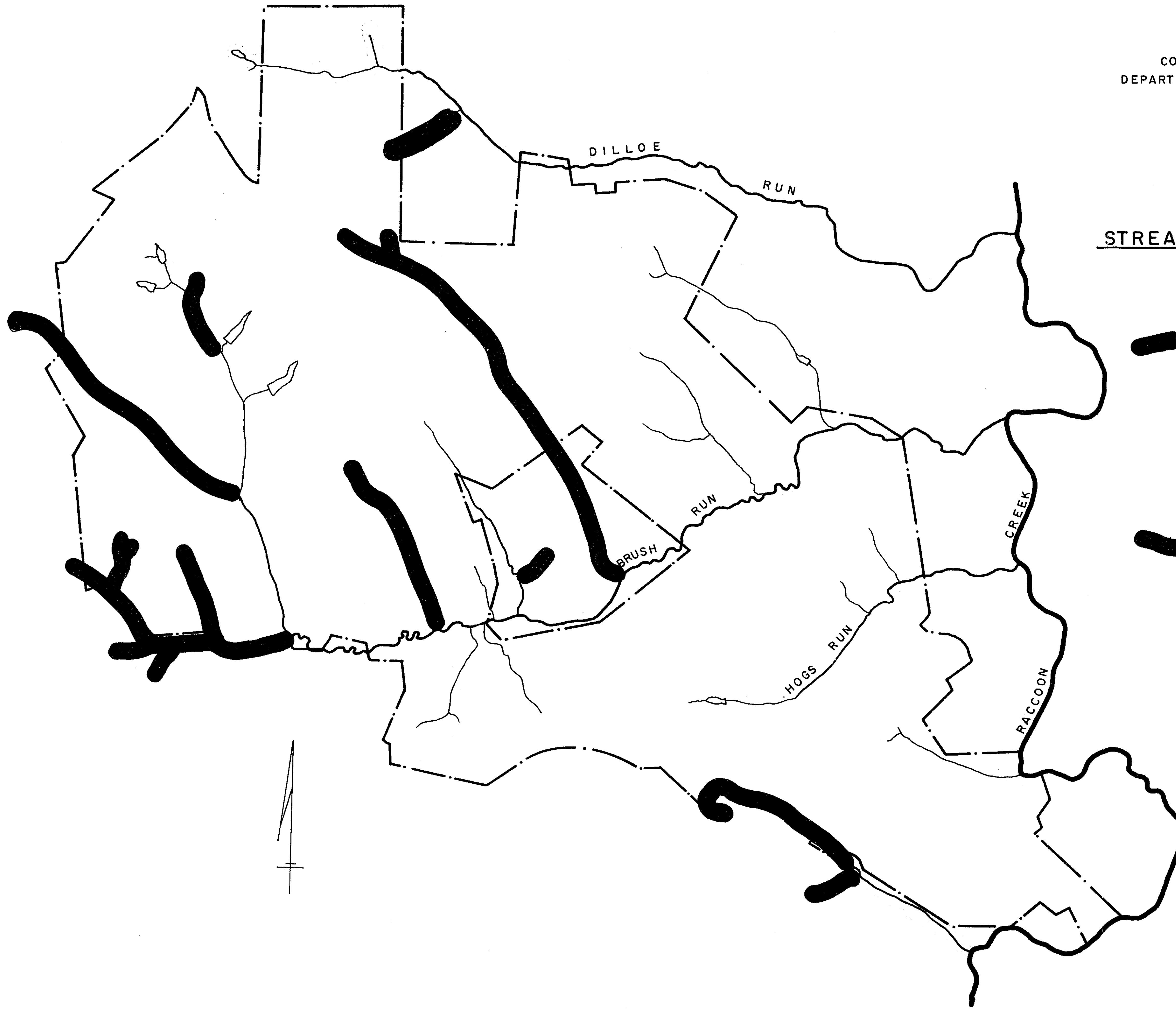
PLATE VII

STREAM QUALITY HIGH-FLOW



PREDOMINANTLY ALKALINE FLOWS

VARIABLE ACID FLOWS WITH pH OF 5.5 OR ABOVE AND NET ACID CONCENTRATIONS LESS THAN 300 MG/L.

PRINCIPALLY ACID FLOWS WITH pH LESS THAN 5.5 AND NET ACID CONCENTRATIONS GREATER THAN 300 MG/L.

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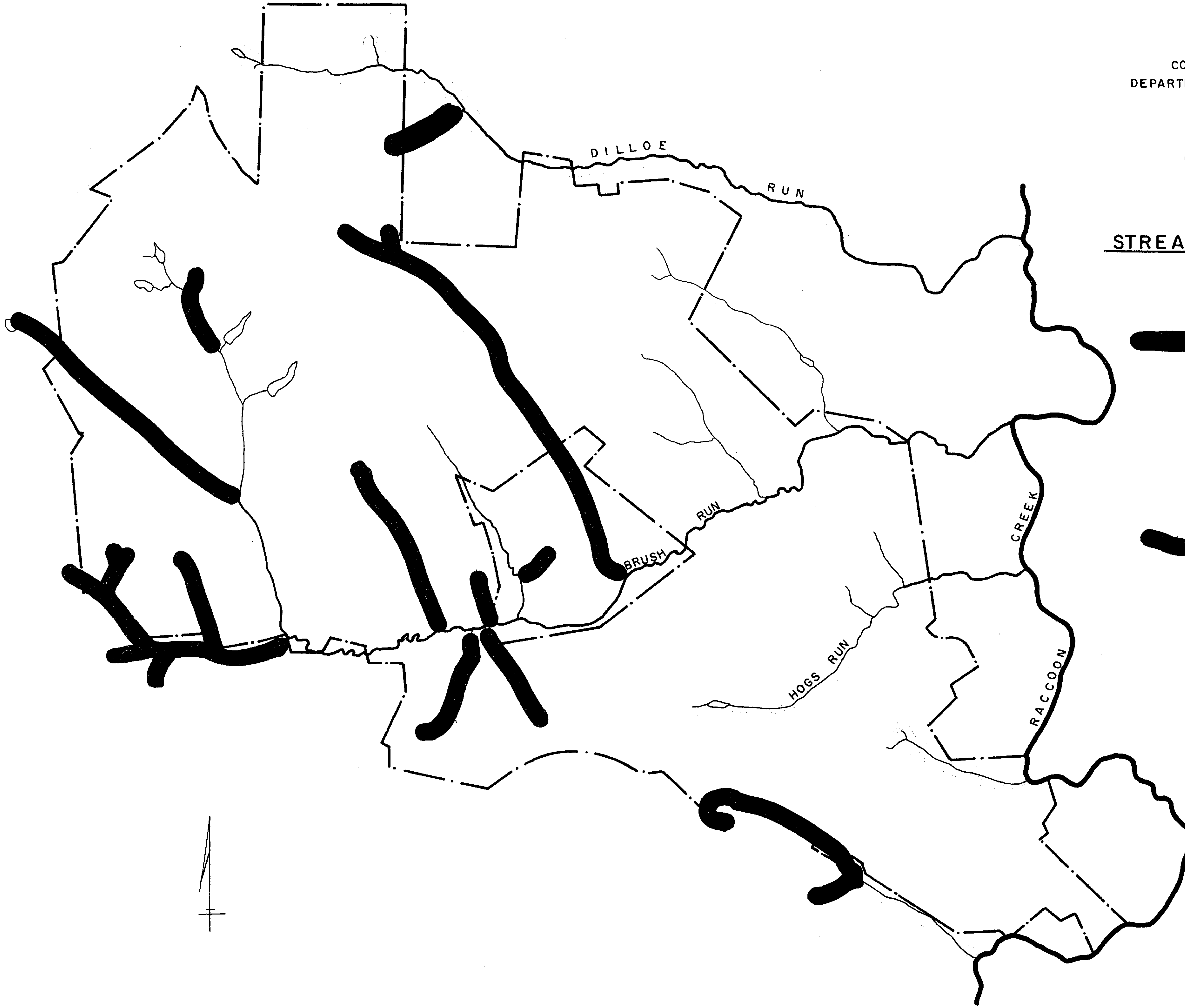
HILLMAN STATE PARK
(RACCOON CREEK WATERSHED)

PLATE VIII

STREAM QUALITY LOW-FLOW



PREDOMINANTLY ALKALINE FLOWS

VARIABLE ACID FLOWS WITH pH OF 5.5 OR ABOVE AND NET ACID CONCENTRATIONS LESS THAN 300 MG/L.

PRINCIPALLY ACID FLOWS WITH pH LESS THAN 5.5 AND NET ACID CONCENTRATIONS GREATER THAN 300 MG/L.

Method - The method involved the calculation and summation of total sulfate loads for all tributaries of Brush Run and comparing the result t o the calculated total sulfate load entering Raccoon Creek at the mouth of Brush Run.

Results - For the four material balance investigations, differences between tributary totals and the total sulfate load at the mouth of Brush Run varied from about 5% to 38%. A composite material balance was also made using the average sulfate loads for the total study period. The composite variation, approximately 19.5%, is generally representative of the range of results for the individual analyses. The composite data are shown on Plate IX. The results seem to indicate that no major acid drainage sources have gone undetected within the Brush Run drainage area, particularly since the tributary totals exceed the Brush Run total. There would be some cause for concern if the excess load occurred within the Brush Run total.

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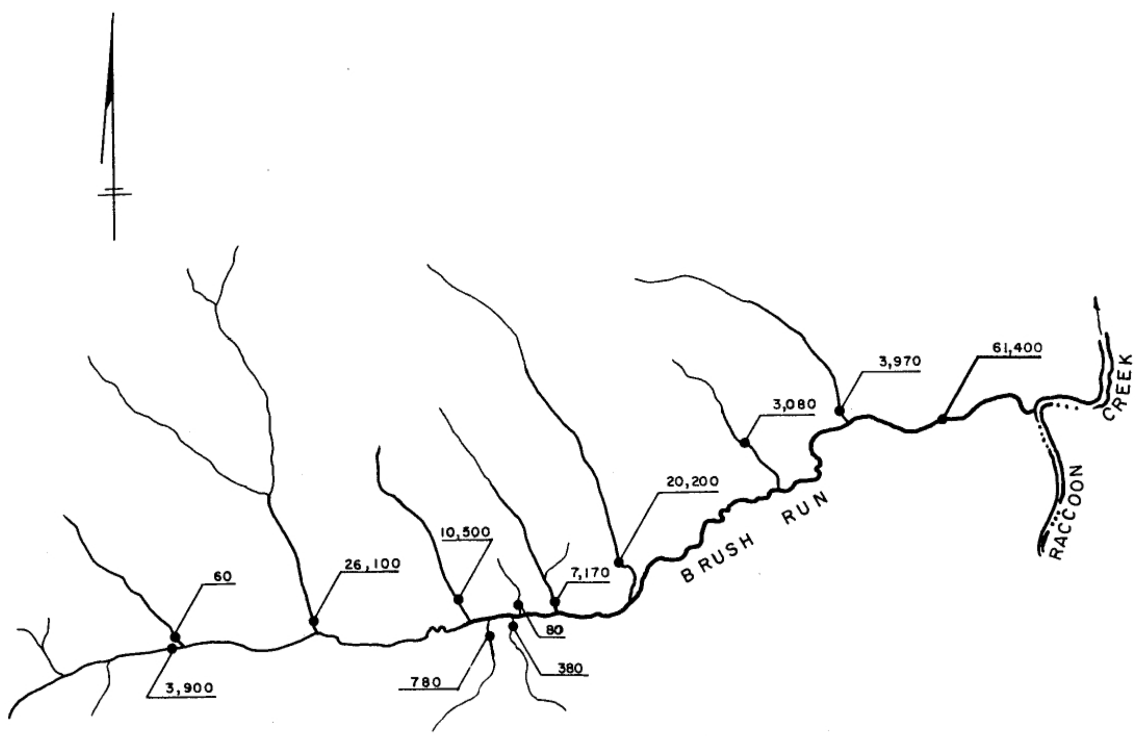
PLATE IX

COMPOSITE MATERIAL BALANCE DATA

SULFATE LOAD BRUSH RUN



TOTAL SULFATE LOAD, TRIBUTARIES = 76,220 LBS/DAY
TOTAL SULFATE LOAD, MOUTH = 61,400 LBS/DAY