CHAPTER VI

STREAM QUALITY EVALUATION

COAL MINE DRAINAGE EFFECTS ON WATER QUALITY IN THE WEST BRANCH SUSQUEHANNA RIVER AND ITS TRIBUTARIES

INTRODUCTION

The West Branch Susquehanna River Basin encompasses 6900 square miles in north central Pennsylvania. The headwaters, located in the southwestern portion of the basin, originate in the coal-rich region of Cambria County in the Appalachian Plateau Province. A dendritic drainage system is tributary to the main stream which follows a zig-zag course, generally in an easterly direction, for approximately 240 miles from the drainage head in the Barnesboro-Spangler Area to the confluence of the West Branch with the Susquehanna River at Northumberland. (See Figure VI-3). The geographical relationship of the watershed of the West Branch to the various Pennsylvania coal fields is shown in Figure VI-8. Tributary and direct contributions of coal mine drainage are added to the main watercourse at irregular intervals along the first 142 miles of the West Branch from the headwaters to Renova. These discharges have a measurable effect on the West Branch throughout its entire length. Plate 1 (attached envelope) is a map showing the influence coal mine drainage has on water quality in the River Basin.

The 1971 Mine Drainage Engineering Study of the West Branch Headwaters was supplemented with stream survey work to determine water quality in the river and its tributaries as a result of mineral laden discharges. As with the source study, stream analysis efforts were concentrated in the headwaters area. However, in order to determine the point of alkaline recovery in the West Branch, detailed sampling was conducted within the forty (40) mile reach from Bakerton to Bower Station. The U.S.G.S. gaging station located at Bower provided the discharge data essential to a profile evaluation of water quality in terms of chemically different stream reaches. Sampling during "steady-state" flow affords a reasonable basis for comparing inputs to the stream with downstream quality. This study establishes a water quality profile with respect to coal mine drainage parameters in the West Branch Susquehanna River for a discharge of 129 cfs at Bower Station.

Only a cursory survey was undertaken below Bower and downstream from the Curwensville Reservoir. Tributary contributions of acidity were identified and compared with previous loadings given in the FWQA Report - Mine Drainage in the Susquehanna River Basin (1970). While acid load values were determined for thirty-one (31) tributaries between Curwensville and Renova, it was not possible to relate these loadings to chemical quality in the West Branch due to the size of the river and time-lag factors, hydrologic variations experienced during the survey and limited sampling.

Evaluation of water quality in the West Branch below Curwensville is based largely on historical data made available by the Pennsylvania Department of Environmental Resources water quality network sampling and the Water Quality Records reported by the U.S. Geological Survey.

SUMMARY

A thorough evaluation of the stream quality data compiled for the 40 mile reach of the West Branch from the headwater to Bower Station lead to the establishment of several stream characteristics that are of great importance in the development of any future comprehensive abatement planning:

1. The outstanding characteristic of the stream is that under present conditions (with deep mine waters from Lancashire No. 20 operating mine and Lancashire No. 15 abandoned pool under full control) it is a self neutralizing system, maintaining a remarkably consistent quality at Bower Station (pH 6 to 7) which is satisfactory for recreational uses in the Curwensville Reservoir. Material balances indicate a stream system alkalinity generation capacity ranging from 30,000 to 210,000 pounds per day, which is sufficient to neutralize all presently known acid loadings to the West Branch headwaters.

2. Magnitudes in pollutant loadings from basic flow to high flow conditions can vary by a factor of ten (10) as far downstream as Stifflertown, beyond which point acidity decreases. Maximum stream acid loadings vary with rainfall from 20,000 to 130,000 pounds per day.

3. The unique and unexpected feature of the West Branch is its ability to generate an acid slug (slugging index about 10) within itself in the reach between Spangler and Stifflertown, attaining magnitudes of 50,000 ppd acidity which is equal to the total acid loading generated by all the major sources above Spangler. This is a diffuse source (probably supplied by refuse sediments bordering or within the stream) which is impossible to control.

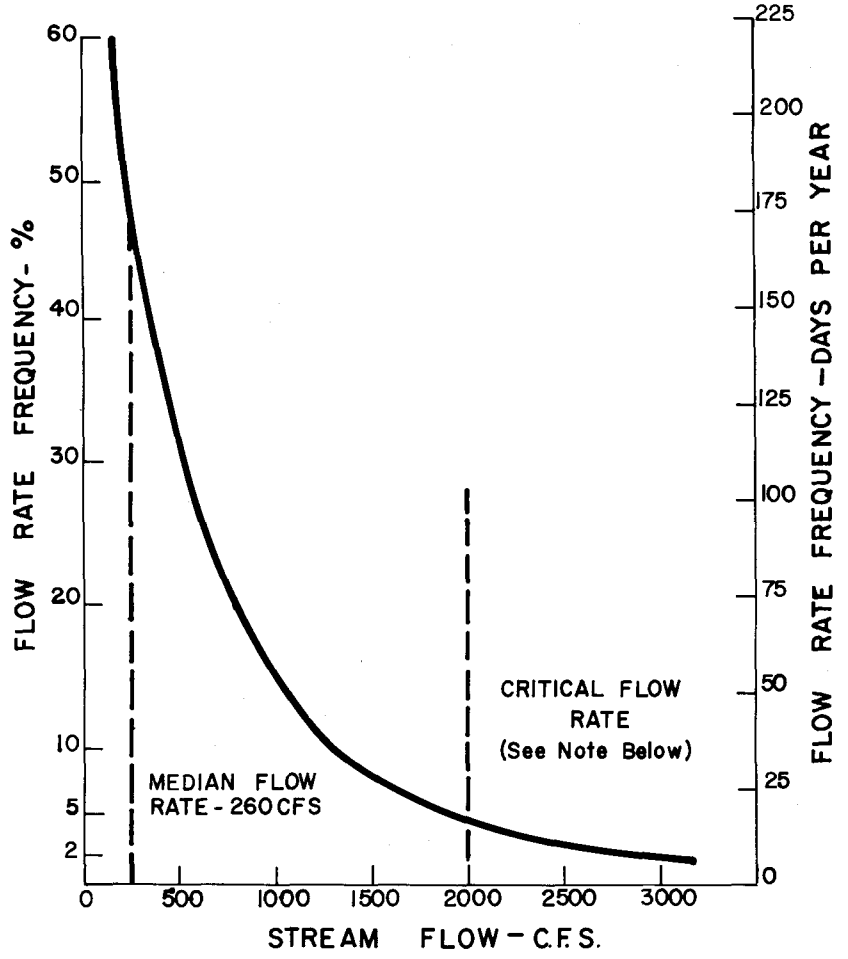
4. The overall acid loading conditions to the West Branch are such that no significant length of stream above Bower Station can be permanently recovered for recreational use even with abatement expenditures of the order of $20 to $30 million.

CHARACTERISTICS OF STREAMFLOW - HEADWATERS AREA

The direct influence of rainfall substantially changes the flow and character of mine drainage from exposed strip areas and spoil piles. Instream loadings may increase proportionately to rainfall dependent on intensity, duration and relationship of the volumes from mine drainage sources to dilution runoff from unaffected watersheds. A valid condition for developing a water quality profile occurs when the stream is in a relative state of hydrologic continuity. Such a "steady-state" condition relates an average type of water quality. Data generated during non-steady streamflow should be qualified as such for proper interpretation. During our sampling of the West Branch upstream from Bower, both streamflow conditions were encountered. The "steady-state" condition or "base" flow as discussed in this report refers to a stream discharge which has not been influenced by an appreciable rainfall and direct surface runoff. These flows will include nevertheless, volumes other than natural streamflow such as ground water diverted to the surface through mine openings and pumping. Survey data collected during "base" flow conditions were averaged to develop an in-stream loading profile. The resultant discharge for the headwaters area was determined to be 129 cfs, between the minimum (55 cfs) and mean flow (538 cfs) as recorded at Bower Station during the year 1971.

Higher streamflows were experienced during four (4) of our surveys. Sampling conditions, however, were far from identical with respect to the elapsed period of rainfall and the stage of runoff. In addition, the November 10, 1970 survey with nearly 500 cfs at Bower, was during the acid breakout period with in-stream neutralization taking place. The other three high flow surveys were conducted at: 1) peak flow 2400 cfs (Sept. 15, 1971), 2) initial rising stage, 362 cfs (June 21, 1972) and, 3) rising stage prior to flood conditions, 5200 cfs (June 22, 1972).

Figure VI-l is a graphical representation of discharge data statistics for the West Branch Susquehanna River at Bower Station (1914 to 1963). The drainage area to this point consisting of 315 square miles produces a median flow rate of 260 cfs. However, flow rates in excess of 2000 cfs occur at 5% frequency, and flows ranging from 3,000 to 10,000 cfs occur at a 1% frequency level. Subsequent discussion will develop a basis for evaluating the effectiveness of treating the West Branch flow at a point above Spangler and the limitations of such a course of action with respect to high flow expectancy at Bower Station.



NOTE:

Critical Flow (About 2000 CFS) Is That Above Which Control Of Stream Acidity Between Spangler And Bower Becomes Economically Infeasible.

Critical Flow Rate Can Be Expected To Be Exceeded About 20 Days Per Year.

DURATION OF DAILY FLOW OF WEST BRANCH SUSQUEHANNA AT BOWER, PA.

DISCHARGE IN CFS WHICH WAS EQUALED OR EXCEEDED FOR THE INDICATED PERCENT OF TIME FOR PERIOD 1914 TO 1963

DATA FROM U.S. GEOLOGICAL SURVEY REPORTS

FIGURE VI-1

PRE-BREAKOUT HEADWATER STREAM QUALITY

A mine drainage study of the entire Susquehanna River Basin was conducted by FWQA from 1964 to 1967, during the months of June through October. Water quality in the West Branch Headwaters was determined for a low flow of about 80 cfs at Bower. The following statements are taken from the FWQA Report to summarize their findings and characterize stream quality in the headwaters area prior to the "breakout".

1. The West Branch above Lesle Run contained 450 mg/l of acidity, or about 4800 lbs./day acid loading. 4100 lbs./day was attributed to the Barnes and Tucker pumped discharge.

2. Lesle Run and Fox Run were found to contribute 1200 and 2200 lbs./day of acidity respectively.

3. Average acidity in the West Branch in the vicinity of North Barnesboro was 200 mg/l for a flow of about 18 cfs.

4. The main stream at a point just above Beaver Run contained 50 mg/l of acidity. "In general, concentrations of mine drainage indicators were found to decline throughout the length of the reach from the headwaters to Chest Creek."

5. Two (2) significant alkaline contributions identified between Stifflertown and McGees Mills were Beaver Run, 7600 lbs./day and Chest Creek, 2500 lbs./day.

6. The West Branch was found to be essentially neutral in the reach below Chest Creek to Anderson Creek. The Curwensville Reservoir was sampled during the summers of 1966 and 1967 and found to exhibit no water quality stratification.

7. The pH range of the West Branch Reach between Chest Creek and Anderson Creek was reported to be 3.l to 7.6. Fish and other aquatic life were observed in this reach, most frequently downstream from the Curwensville Dam. The aquatic population was found to be somewhat depressed due to residual amounts of mine drainage.

8. "Relatively frequent fluctuations between net acidity and net alkalinity were found to occur in the reservoir as a whole in response to variations in upstream quality of the West Branch."

Quarterly sampling conducted by the Pennsylvania Department of Health (currently the Department of Environmental Resources) noted a trend in water quality improvement in the West Branch at Bower during 1969. Presumably, this was a result of mine drainage treatment initiated by Barnes and Tucker (January 1968) at Lancashire #20 in the Bakerton Area, which eliminated the 4100 lbs./day of acidity reported by the FWQA survey. Recognition of this improvement in water quality was reflected by an optimistic stocking program undertaken in the reservoir which was largely successful and served to enhance sport fishing and recreational values associated with the Curwensville Dam.

EFFECT OF THE BREAKOUT ON STREAM QUALITY

The 1970 breakout of new sources of mine drainage in the headwaters (Watkins vicinity) resulted in severe water quality degradation in the West Branch. The discovery of failing water quality in June prompted an immediate and an intensive investigation by the Pennsylvania Department of Health (D.E.R.) to locate and control the pollution threat. On June 16, 1970, the river at Bower Station was found to be acid (68 mg/l) with a pH of 3.8. Emergency neutralization procedures undertaken by the State and Barnes and Tucker controlled the acid problem to a limited extent during the month of July. The impact of the breakout condition and high level acid pollution was fully realized from August 2 to 22 during which time there was no addition of alkaline materials to the West Branch upstream from the Curwensville Dam. Peak acid levels determined by Pennsylvania Department of Health (D.E.R.) coincident with this period were 980 mg/l at Cherry Tree, 480 mg/l at McGees Mills, and 270 mg/l at Bower Station. Fish kills which occurred as a direct result of these adverse conditions were reported on July 27 in the reach below the reservoir from Curwensville to Clearfield, and August 27 in the Curwensville Reservoir.

The acid effects on water quality in the West Branch at Bower and below the Curwensville Dam for the period from the middle of June through September are shown graphically in Figure VI-2. The data indicates that alkaline conditions were finally established at Bower and below the Dam on September 10 and 20 respectively, through control measures undertaken in the breakout (Watkins) area. Control measures consisted of treating the acid water generated by the abandoned workings of Lancashire 15 Mine by lime neutralization at the Maberry Borehole and in-stream treatment with caustic and soda ash below the breakout point (near Watkins).

STREAM FLOW & NET ALKALINITY CONCENTRATION
FOR SAMPLING STATIONS ABOVE & BELOW THE CURWENSVILLE RESERVOIR
JUNE 16 - SEPT. 30, 1970

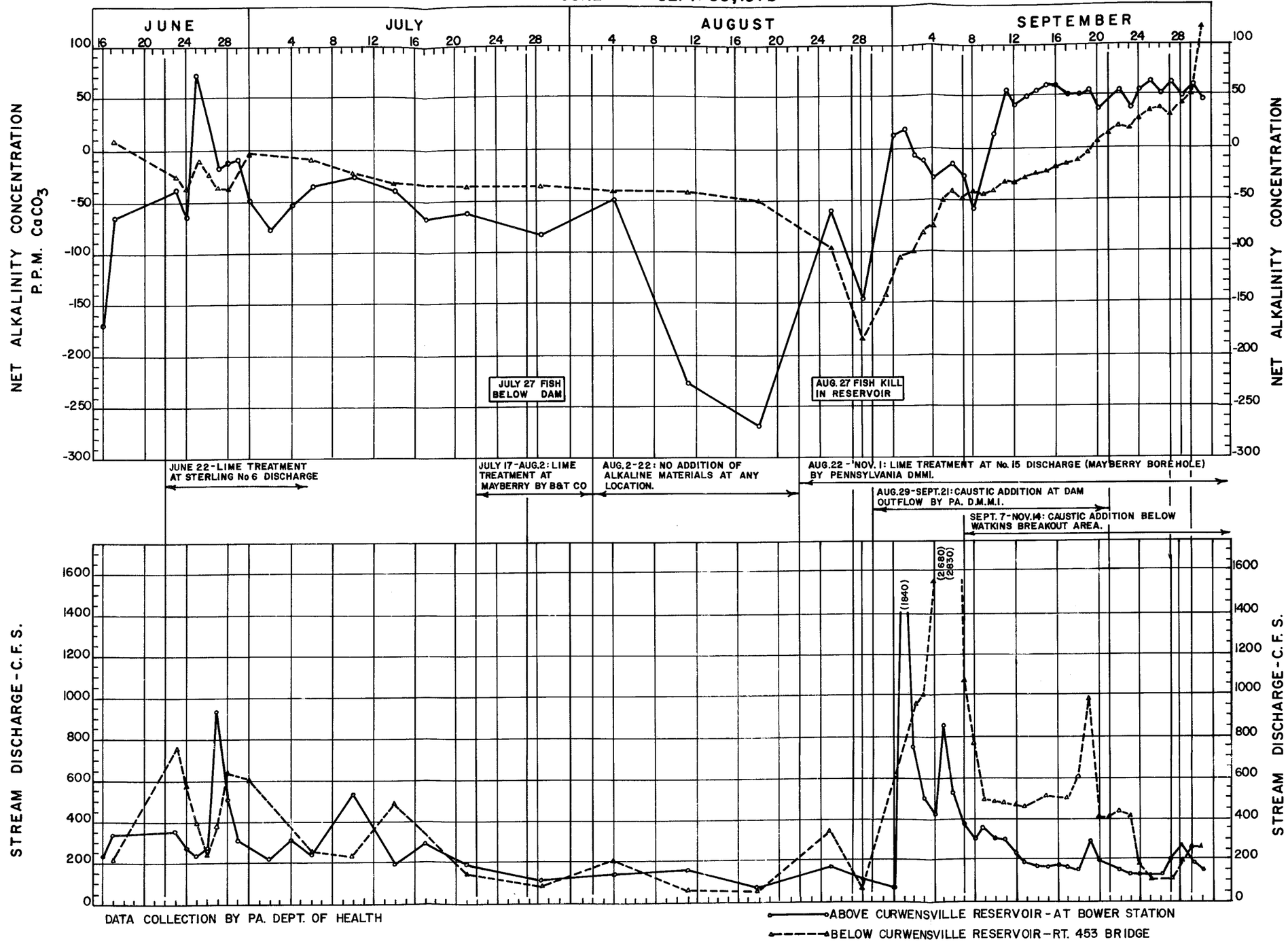


FIGURE VI - 2

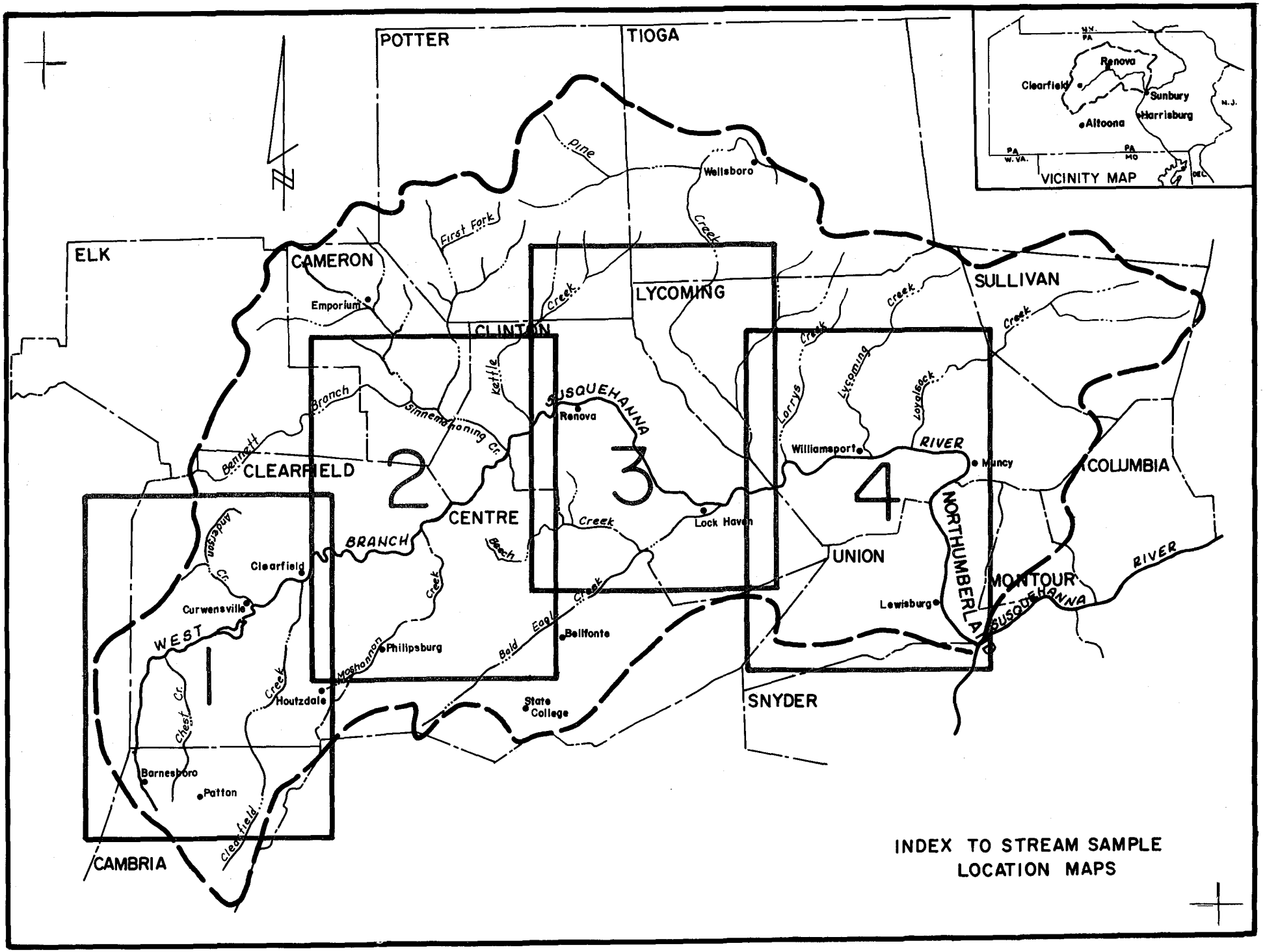

POTTER
TIOGA
ELK
CAMERON
CLINTON
LYCOMING
SULLIVAN
CLEARFIELD
CENTRE
UNION
SNYDER
MONTOUR
COLUMBIA
CAMBRIA
WEST BRANCH
SUSQUEHANNA RIVER
NORTHUMBERLAND
Emporium
Wellsboro
Renova
Williamsport
Muncy
Lock Haven
Clearfield
Curwensville
Philipsburg
Bellfonte
Houtzdale
State College
Lewisburg
Barnesboro
Patton
Pine Creek
First Fork
Kettle Creek
Sinnemahoning Cr.
Bennett Branch
Anderson Cr.
Chest Cr.
Clearfield Creek
Moshannon Creek
Bald Eagle Creek
Beech Creek
Larrys Creek
Lycoming Creek
Loyalsock Creek
1
2
3
4
VICINITY MAP
Renova
Clearfield
Sunbury
Harrisburg
Altoona
INDEX TO STREAM SAMPLE
LOCATION MAPS

FIGURE VI-3

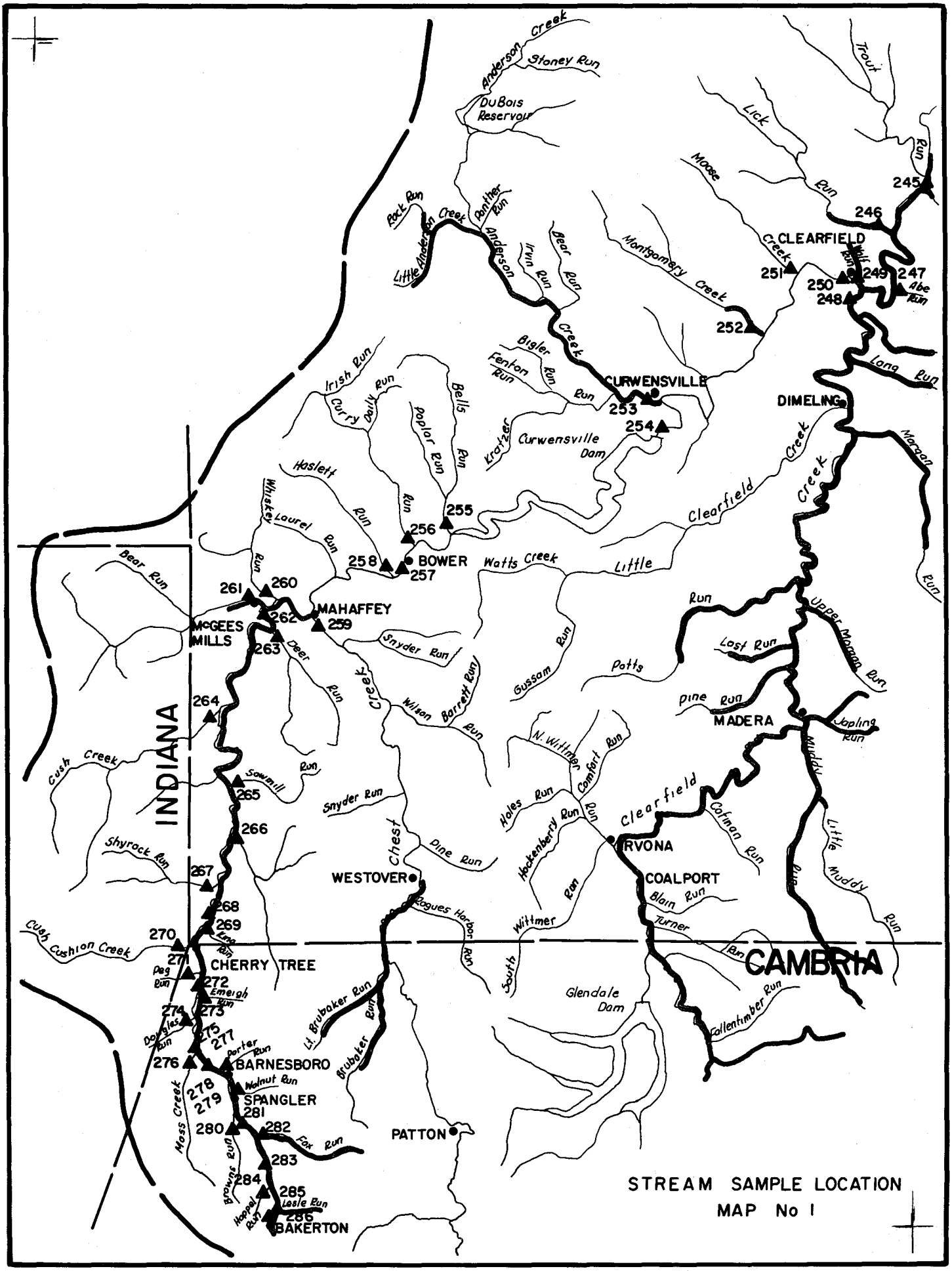

Anderson Creek
Stoney Run
DuBois Reservoir
Trout Run
Lick Run
Moose Run
245
246
CLEARFIELD
Montgomery Creek
251
250
248
249
247
Abe Run
252
Rock Run
Panther Run
Little Anderson Creek
Anderson Creek
Irvin Run
Bear Run
Bigler Run
Fenton Run
Run
CURWENSVILLE
253
254
Lang Run
DIMELING
Irish Run
Curry Daily Run
Bells Run
Poplar Run
Kratzer Run
Curwensville Dam
Morgan Run
Clearfield Creek
Hasletf Run
Whiskey Run
Laurel Run
255
256
258
BOWER
257
Watts Creek
Little Clearfield Creek
Bear Run
261
260
MAHAFFEY
259
262
McGEES MILLS
263
Deer Run
Snyder Run
Gussam Run
Patts Run
Upper Morgan Run
Lost Run
264
Wilson Barrett Run
pine Run
MADERA
Joplin Run
INDIANA
Cush Creek
Sawmill Run
265
Snyder Run
N. Wittmer Run
Comfort Run
Holes Run
Muddy Run
266
Shyrock Run
Chest Creek
Dine Run
Hackenberry Run
Clearfield Run
Cofinan Run
267
WESTOVER
IRVONA
COALPORT
Little Muddy Run
268
269
Rogues Harbor Run
Blain Run
Turner Run
270
Cush Cushion Creek
Ezra Run
271
Peg Run
CHERRY TREE
Wittmer Run
CAMBRIA
272
Emeigh Run
273
274
Douglas Run
Lt. Brubaker Run
Brubaker Run
South Glendale Dam
275
277
Porter Run
276
BARNESBORO
Fallenhmber Run
Walnut Run
278
279
SPANGLER
281
Moss Creek
280
282
Fox Run
PATTON
283
Brewer Run
284
285
Lesle Run
Hoppel Run
286
BAKERTON
STREAM SAMPLE LOCATION
MAP No I

FIGURE VI-4

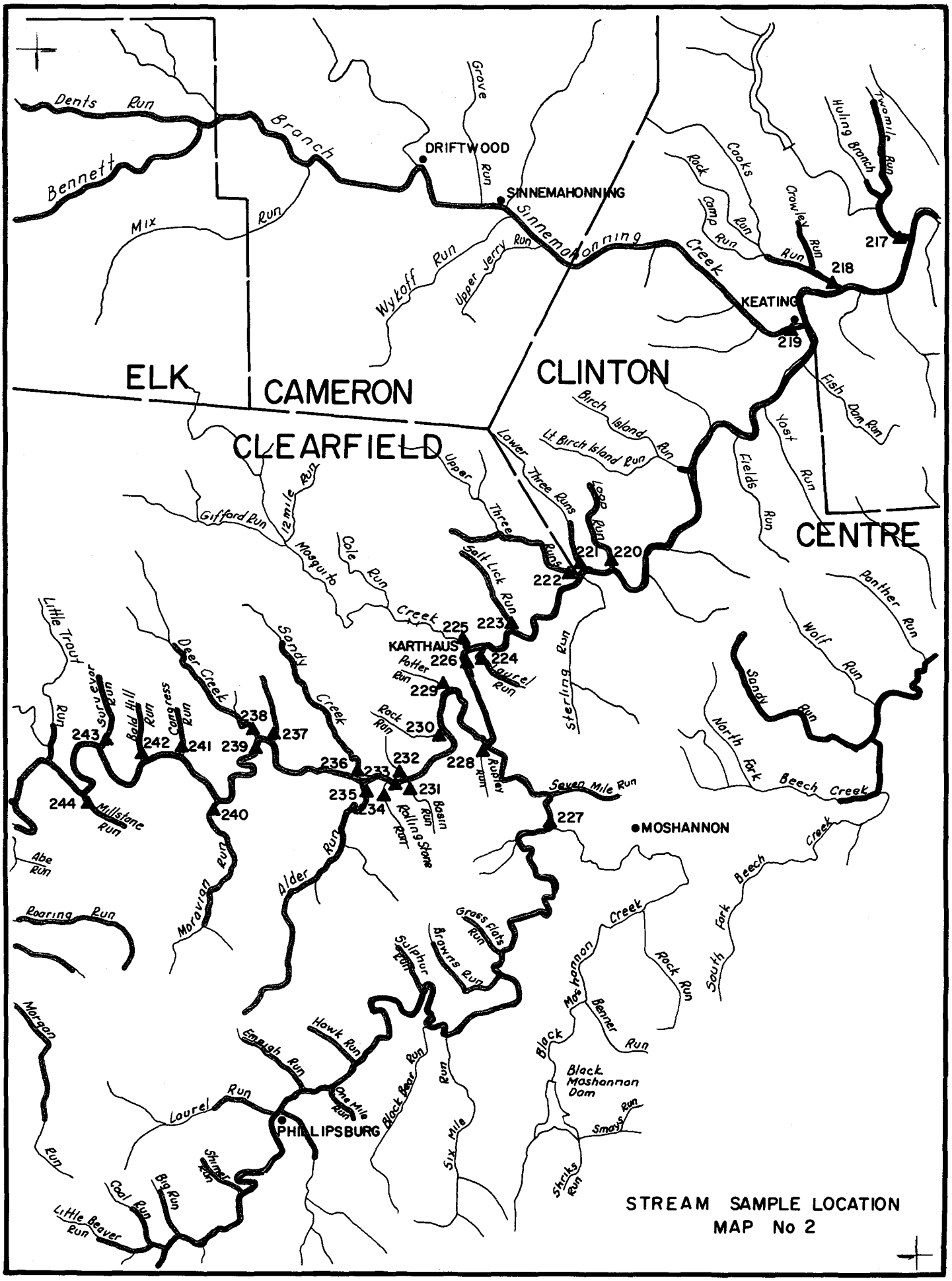

ELK
CAMERON
CLEARFIELD
CLINTON
CENTRE
Dents Run
Bennett Branch
Mix Run
Grove Run
DRIFTWOOD
SINNEMAHONNING
Sinnemahonning Creek
Wykoff Run
Upper Jerry Run
Cooks Run
Rock Camp Run
Crowley Run
Huling Branch
Twomile Run
217
218
KEATING
219
Fish Dam Run
Yost Run
Fields Run
Birch Island Run
Lt Birch Island Run
Lower Three Runs
Upper Three Runs
Loop Run
221
220
222
Salt Lick Run
Gifford Run
12 mile Run
Mosquito Creek
Cole Run
Little Trout Run
Surveyor Run
Bald Hill Run
Congress Run
Deer Creek
Sandy Creek
225
223
KARTHAUS
226
224
Potter Run
Laurel Run
Sterling Run
Panther Run
Wolf Run
Sandy Run
North Fork Beech Creek
229
Rock Run
230
238
237
243
242
241
239
236
233
232
228
Rupley Run
Seven Mile Run
244
Millstone Run
235
234
231
Basin Run
Rolling Stone Run
240
227
MOSHANNON
Abe Run
Roaring Run
Moravian Run
Alder Run
Grass Flats Run
Sulphur Run
Browns Run
South Fork Beech Creek
Moshannon Creek
Rock Run
Black Moshannon
Benner Run
Black Moshannon Dam
Morgan Run
Howk Run
Emeigh Run
Laurel Run
One Mile Run
PHILLIPSBURG
Black Bear Run
Six Mile Run
Smays Run
Shimer Run
Cool Run
Big Run
Little Beaver Run
Shicks Run
STREAM SAMPLE LOCATION
MAP No 2

FIGURE VI-5

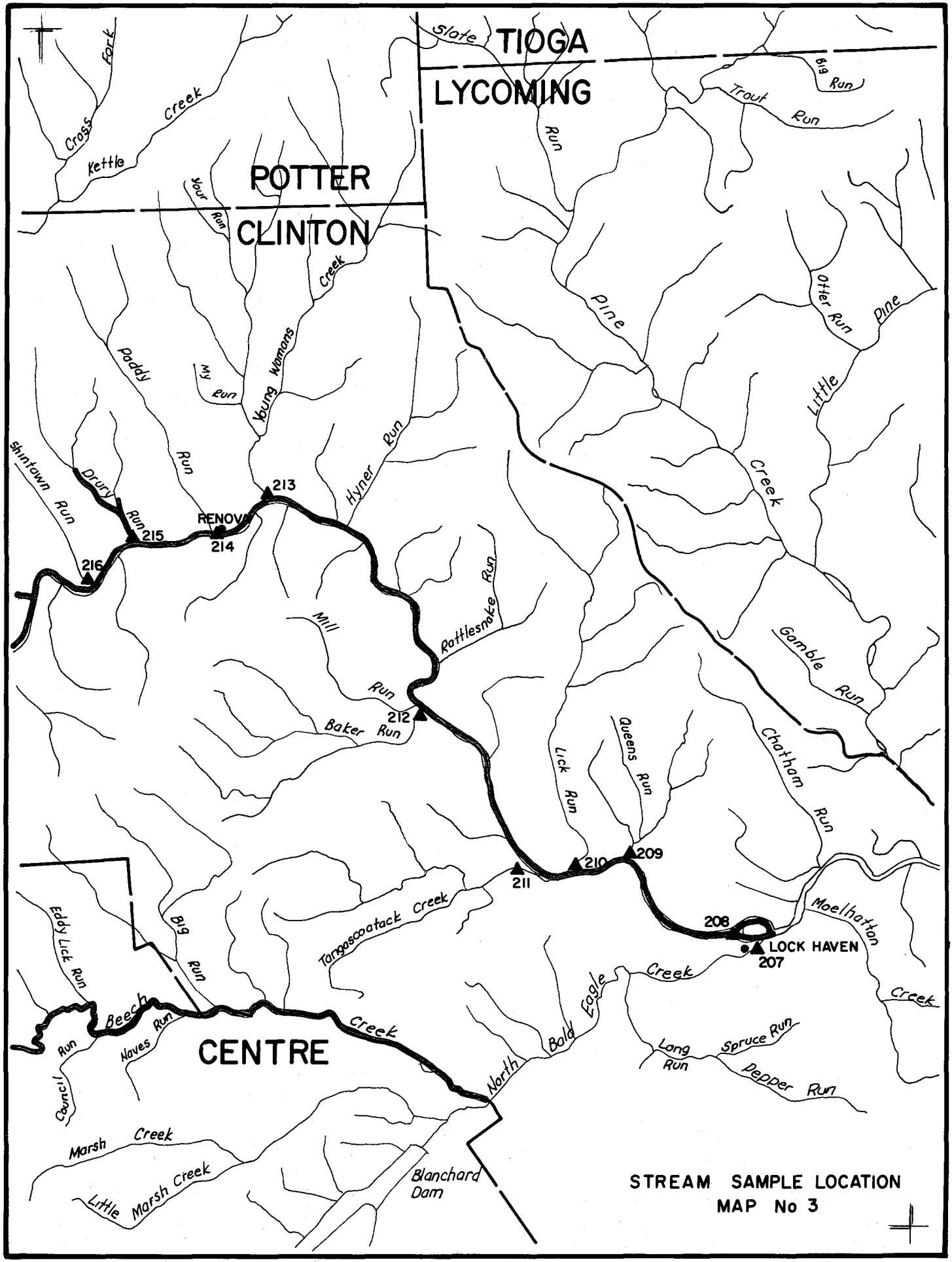

TIOGA
LYCOMING
POTTER
CLINTON
CENTRE
Slate Run
Trout Run
Big Run
Cross Fork
Kettle Creek
Young Womans Creek
Paddy Run
My Run
Drury Run
Shintown Run
Hyner Run
Pine Creek
Little Pine Creek
Otter Run
Rattlesnake Run
Mill Run
Baker Run
Lick Run
Queens Run
Chatham Run
Gamble Run
Tangascoatack Creek
Eddy Lick Run
Big Run
Beech Creek
Council Run
Naves Run
Marsh Creek
Little Marsh Creek
Blanchard Dam
North Bald Eagle Creek
Long Run
Spruce Run
Pepper Run
Moelhatton Creek
RENOVO
LOCK HAVEN
213
214
215
216
212
211
210
209
208
207
STREAM SAMPLE LOCATION
MAP No 3

FIGURE VI-6

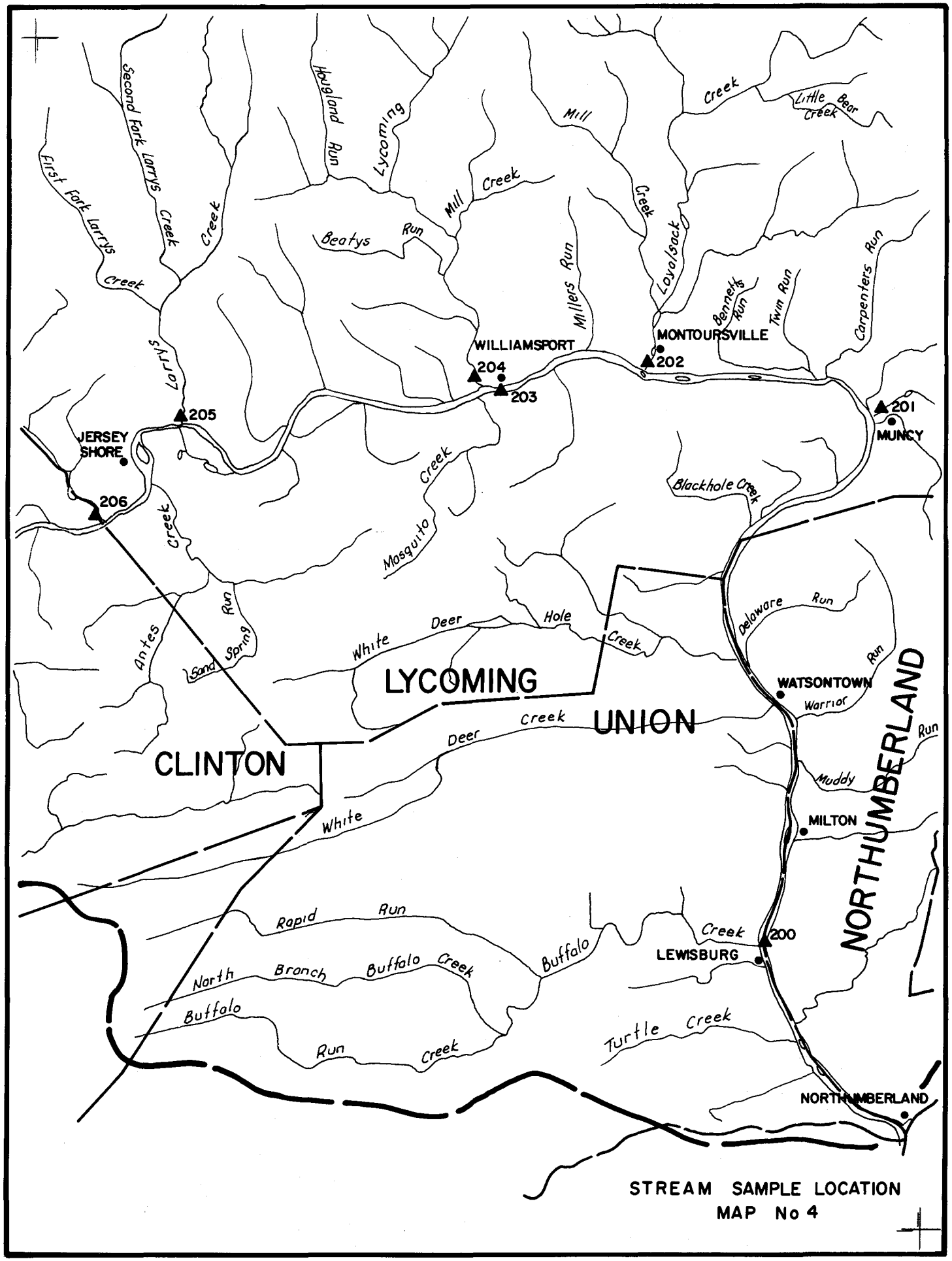
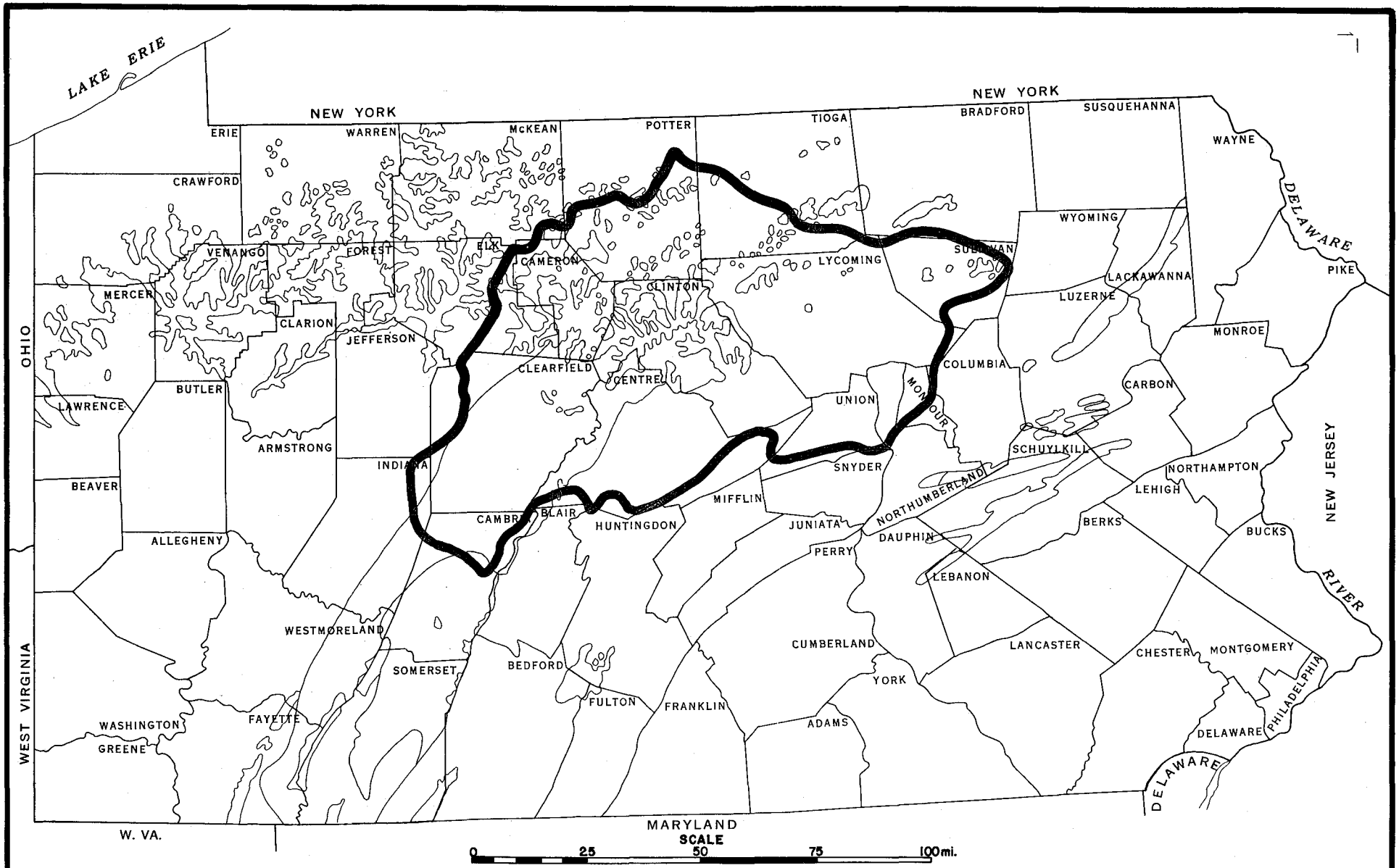

Second Fork Larrys Creek
First Fork Larrys Creek
Larrys Creek
Hoagland Run
Lycoming Creek
Mill Creek
Beatys Run
Millers Run
Mill Creek
Loyalsock Creek
Little Bear Creek
Bennets Run
Twin Run
Carpenters Run
WILLIAMSPORT
204
MONTOURSVILLE
202
203
201
MUNCY
205
JERSEY SHORE
206
Mosquito Creek
Blackhole Creek
Antes Creek
Sand Spring Run
White Deer Hole Creek
Delaware Run
LYCOMING
WATSONTOWN
Warrior Run
UNION
Deer Creek
CLINTON
Muddy Run
MILTON
White
NORTHUMBERLAND
Rapid Run
Creek
200
LEWISBURG
North Branch Buffalo Creek
Buffalo
Buffalo Run Creek
Turtle Creek
NORTHUMBERLAND
STREAM SAMPLE LOCATION
MAP No 4

FIGURE VI-7



PENNSYLVANIA COAL FIELDS

WEST BRANCH SUSQUEHANNA RIVER WATERSHED AREA

WATERSHED OF WEST BRANCH OF SUSQUEHANNA RIVER WITH RELATIONSHIP TO THE PENNSYLVANIA COAL FIELDS

FIGURE VI-8

STREAM ANALYSES DURING STUDY PERIOD (1971)

The start-up of pumping and treatment of Lancashire #15 water at the Duman's Dam site in November, 1970 resulted in cessation of from this source to the West Branch in February 1971 and a return to "pre-breakout" water quality as determined by our recent stream analysis. Figure VI-3 is an index to the location maps (Figures VI-4 thru VI-7) designating our survey sampling points. Streams shown on the location maps are color coded to indicate whether they are: (l) continually acid affected (red), (2) intermittently acid affected (yellow), or (3) alkaline (blue). Chemical data for each of the numbered sampling points are included in the Appendix.

PRESENT IN-STREAM LOADINGS – BAKERTON TO BOWER

Water quality and in-stream loadings characteristic of the West Branch drainage head from Bakerton to Bower are given in Figure VI-9.

FIGURE VI-9

WEST BRANCH IN-STREAM LOADINGS - BAKERTON TO BOWER

(1971)

No.	Location	Flow cfs	pH	Alkalinity lbs./day	Iron lbs./day	Sulfate lbs./da
286	Bakerton	3.56	3.6	- 4,926	263	21,669
283	Watkins	5.44	3.0	- 9,980	983	30,828
281	Spangler	10.0	3.0	-12,204	1,323	44,604
278	N. Barnesboro	20.0	3.6	-15,984	1,825	65,340
275	Garmantown	25.0	4.1	-17,820	1,080	79,110
272	Rt. 240 Bridge	28.0	4.3	-16,632	620	87,091
268	Stifflertown	40.0	4.4	-14,041	1,239	122,422
262	McGees Mills	68.6	6.8	7,125	766	112,458
257	Bower	129.0	7.3	13,748	400	159,447

These values are for a steady state condition and should approximate the average present pollutant loading in this main stream reach. There are three continuous acid tributaries entering the West Branch in this reach. Lesle Run near Bakerton contributes an average acidity of 250 lbs./day, Fox Run near Spangler with l,919 lbs. of acid per day and Bear Run at McGees Mills contributes l,406 lbs. of acidity per day. Hoppel Run, near the Watkins area exhibited marginal to alkaline characteristics early in our survey, but changed to an acid stream (49 mg/l acidity) as determined by the September 1971 sample. Later checks in June of this year (1972) confirmed an acid condition in this stream. All other

tributaries upstream from Bower were found to be alkaline at their point of confluence with the main branch. The range of total alkaline contribution for steady state conditions is 25,000 to 30,000 lbs./day. Eighty-five percent of this alkalinity is produced by five streams, listed in descending magnitude of contribution as follows:

Name of Tributary	Alkalinity lbs./day
Beaver Run	7,717
Chest Creek	6,794
Browns Run	5,679
Walnut Run	2,468
Cush Creek	1,153
Total	23,811

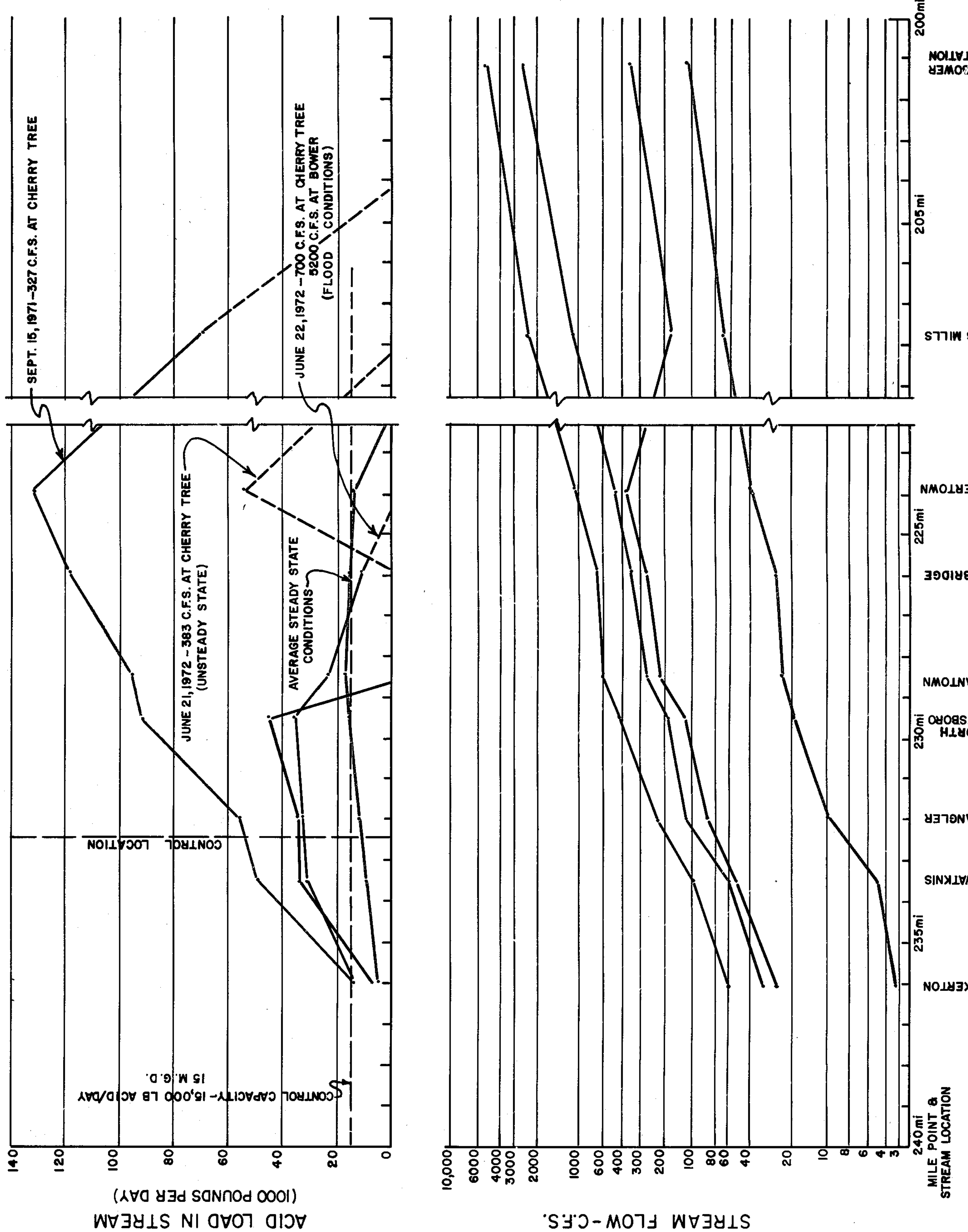
The neutralization capacity of these streams causes alkaline recovery in the West Branch at McGees Mills. Further downstream at Bower an average pH of 7.3 and a net alkalinity of 20 ppm was determined for steady flow conditions.

A wide range of in-stream loadings are indicated by sampling during rainfall and varying stages of high flow. The graph in Figure VI-10 shows the extreme variation in acidity loadings for three (3) surveys, each conducted at different times during a storm period. Plotted values are also shown for average steady state conditions. It is significant to note that over the range of flows sampled, all of the surveys indicated alkaline recovery of the West Branch at the Bower Station, although one (1) sample (September, 1971) showed a marginal quality with a pH of 5.8 and alkalinity of only 6 mg/l.

ACID TRIBUTARIES BELOW THE CURWENSVILLE DAM

Most of the tributaries, as well as stations on the West Branch, below Curwensville were sampled on a "once through" basis in October and November 1970. In-stream loadings determined for the reach from Curwensville to Clearfield are presented in Figure VI-11.

The West Branch water quality near Frenchville was measured on three (3) occasions. Two (2) samples were slightly alkaline (4 mg/l), with pH's of 6.1 and 5.8. The third sample was acid (32 mg/l) with a pH of 3.9. It is evident that water quality in the main branch at this point is highly dependent upon the acid load contribution from Clearfield Creek.



ACID LOAD IN STREAM
(1000 POUNDS PER DAY)
STREAM FLOW-C.F.S.
SEPT. 15, 1971 - 327 C.F.S. AT CHERRY TREE
JUNE 22, 1972 - 700 C.F.S. AT CHERRY TREE
5200 C.F.S. AT BOWER
(FLOOD CONDITIONS)
JUNE 21, 1972 - 383 C.F.S. AT CHERRY TREE
(UNSTEADY STATE)
AVERAGE STEADY STATE
CONDITIONS
CONTROL LOCATION
CONTROL CAPACITY - 15,000 LB ACID/DAY
15 M.G.D.
MILE POINT &
STREAM LOCATION
240mi
235mi
230mi
225mi
205mi
200mi
BAKERTON
WATKINS
SPANGLER
NORTH BARNSBORO
GARMANTOWN
RT240 BRIDGE
STIFFLERTOWN
McGEES MILLS
BOWER STATION

FIGURE VI-10

Eleven (11) acid tributaries were sampled below Frenchville to Karthaus. Some of these streams were sampled during a wet period in November 1970, accounting for the high flows reported. Pollutant loadings for this reach are tabulated in Figure VI-12.

The data shows that substantial acid contribution occurs in this reach. The total acid load based on these values is 276,000 lbs./day. Over 70% of this load is generated by the drainage from Moshannon Creek, Potter and Alder Runs. The acid load in the West Branch for a discharge of l,076 cfs at Karthaus was measured at 174,000 lbs./day. Average water quality for several samples at this point in the main stream indicated a pH of 4.l, acidity 40 mg/l, iron 4 mg/l, and sulfates 176 mg/l.

Eight (8) acid tributaries were sampled between Karthaus and Renova. Pollution loadings for these streams are tabulated in Figure VI-12.

Approximately half of the total 25,862 lbs./day of acid received by this reach of the main branch is accounted for by the discharge from a single tributary, Saltlick Run. During our survey, Sinnemahonning Creek contained a marginal net alkalinity of 5 mg/l and a pH of 6.5 for a 995 cfs flow. Kettle Creek (231 cfs) indicated a neutral water quality with 6 mg/l each of alkalinity and acidity. The West Branch at Renova, below these discharges was sampled at a discharge of 8,384 cfs. A pH of 4.6 and an in-stream loading of 634,000 lbs./day of acidity were determined for this flow rate.

No acid tributaries were found in the West Branch downstream from Renova. The river itself at Lock Haven was slightly acid (6 mg/l) with a pH of 4.9 at the time of our sampling. Hydrologic conditions and generous alkaline contributions from Bald Eagle Creek (272,000 lbs./day) and Pine Creek (126,000 lbs./day) combined to produce an alkaline reserve (13 mg/l) at the Williamsport sampling point. In the same relative time period, chemical analysis for the Lewisburg station determined a pH of 6.8 and alkalinity of 15 mg/l.

FIGURE VI-11

POLLUTANT LOADINGS FOR WEST BRANCH TRIBUTARIES
BETWEEN
CURWENSVILLE AND FRENCHVILLE, PENNSYLVANIA
(OCTOBER-NOVEMBER, 1971)

NO.	NAME AND LOCATION	FLOW cfs	pH	ALKALINITY LBS./DAY	IRON LBS./DAY	SULFATES LBS./DAY
254	WBS at Curwensville	112	6.2	10,638	174	99,981
253	Anderson Creek	68.7	4.3	-8,904	111	24,856
252	Montgomery Creek	28.2	5.0	- 609	15	8,832
251	Moose Creek	20.0	6.2	432	11	3,132
250	WBS at Clearfield	265.0	7.1	37,206	143	178,875
249	Wolf Run	1.31	3.9	-295	7	2,225
248	Clearfield Creek	270.0	4.4	-27,702	292	237,654
247	Abes Run	10.0	3.8	-7,884	448	15,012
246	Lick Run	46.7	5.1	-1,009	25	19,418
245	Trout Run	71.1	5.6	-767	---	7,285
244	Millstone Run	4.76	3.5	-2,177	91	6,713
243	Surveyor Run	6.33	3.3	-7,008	442	18,949
242	Bald Hill Run	2.38	4.8	-363	75	8,087
241	Unnamed Tributary	0.28	2.9	-1,413	38	2,441
240	Moravian Run	7.31	4.3	-631	4	3,035

FIGURE VI-3
POLLUTANT LOADINGS FOR WEST BRANCH TRIBUTARIES

BETWEEN FRENCHVILLE AND KARTHAUS

NO.	NAME AND LOCATION	FLOW cfs	pH	ALKALINITY LBS./DAY	IRON LBS./DAY	SULFATES LBS./DAY
238	Deer Creek	30.0	3.9	-11,016	243	48,276
237	Unnamed Tributary	5.0	4.6	-810	27	2,592
236	Sandy Creek	30.0	4.6	-3,240	292	13,932
235	Alder Run	50.0	3.5	-49,680	6,210	80,460
234	Rolling Stone Run	1.9	3.1	-5,746	413	13,892
232	Mowry Run	0.5	3.2	-815	42	1,166
231	Basin Run	25.0	3.8	-22,950	634	63,450
230	Rock Run	15.0	3.6	-29,646	1,110	83,187
229	Potter Run	20.0	3.1	-57,456	3,683	135,864
228	Rupley Run	8.0	4.7	-1,555	9	4,147
227	Moshannon Creek	211	3.5	-93,431	5,241	240,413

BETWEEN KARTHAUS AND RENOVA

NO.	NAME AND LOCATION	FLOW cfs	pH	ALKALINITY LBS./DAY	IRON LBS./DAY	SULFATES LBS./DAY
225	Mosquito Creek	95.0	5.4	-513	154	29,754
224	Laurel Run	15.0	5.1	-648	24	1,944
223	Saltlick Run	20.0	4.0	-13,680	443	60,156
222	Upper Three Runs	50.0	5.6	-540	54	20,790
221	Lower Three Runs	25.0	5.5	-135	27	5,130
220	Loop Run	14.0	4.2	-4,838	76	24,645
218	Cooks Run	16.0	3.4	-5,011	899	9,936
215	Drury Run	23.4	5.0	-497	286	4,720

ACID SLUGGING CHARACTERISTIC OF THE REACH BELOW SPANGLER

Previous mention has been made of the wide range of in-stream pollutant loadings during rainfall and various stages of high flow, and effects observed during these high flow periods are graphically presented in Figure VI-10. The original data from which these curves were plotted are compiled in Figures VI-13 and VI-14.

The most drastic slug effect is shown in the stream sampling data for September, 1971 (Figure VI-13). During base flow conditions (129 cfs at Bower), the total acid loading in the stream at Spangler is about 12,000 ppd, which increases to 16,000 ppd at North Barnesboro. This increase is attributable to a normal acid loading from Springfield No. 4 refuse pile (just below Spangler) of about 6,000 ppd. A further increase in acid loading occurs within the next two miles below North Barnesboro to a maximum of 17,800 ppd at Garmantown, beyond which point the acidity gradually decreases until the stream becomes alkaline at McGees Mills, 25 miles downstream from Spangler.

In contrast, during the high flow period in September (2,400 cfs) the in-stream loading at Spangler rose to 57,000 ppd (a slugging index of 4.7) and increased gradually to a maximum of 131,000 ppd at Stifflertown (10 miles downstream from Spangler). The total increase in in-stream acid loading between Spangler and the point of maximum acid loading is now equivalent to 74,000 ppd, resulting in an overall slugging index of 11.0. The slug effect decreases the pH at McGees Mills to 4.4, and the acid slug is not completely neutralized until it mixes with the flow from Chest Creek to produce a pH of 6 at Bower Station (40 miles from the headwaters).

This acid slug has three unique features:

1. it attains magnitudes of 50,000 to 75,000 ppd which is greater than that produced by all known mine sources in the area above Spangler.

2. it is generated below Spangler where no sources for this quantity of acid are known.

3. the stream loading increases gradually over a 10-mile reach and hence is not being generated at a single point source such as Springfield No. 4 refuse pile.

FIGURE VI-13

ACID SLUGGING CHARACTERISTIC OF THE WEST BRANCH
REACH BELOW SPANGLER - 1971

SAMPLE LOCATION	DRAINAGE AREA		BASE FLOW 1971			HIGH FLOW PERIOD SEPTEMBER 1971		
	Sq. Mi.	% OF AREA AT BOWER	FLOW cfs	pH	ACIDITY lbs./day	FLOW cfs	pH	ACIDITY lbs./day
WBS at Bakerton	4.0	1.27	3.6	3.6	4,926	30.0	4.2	13,122
Lesle Run	.99	.31	.32	3.2	250	5.0	3.7	1,539
Hoppel Run	.73	.23	.80	6.6	-395	4.0	4.1	1,058
WBS at Watkins	7.62	2.42	5.4	3.0	9,980	59.0	3.0	48,745
Fox Run	7.74	2.46	2.7	3.3	1,919	30.0	4.3	7,614
WBS at Spangler	19.3	6.12	10.0	3.0	12,204	115.0	3.3	56,511
Browns Run	2.61	.83	5.2	7.6	-5,679			
Walnut Run	4.41	1.40	3.6	7.6	-2,468			
Porter Run	1.09	.35	0.6	7.6	-696			
WBS at N. Barnesboro	25.79	8.85	20.0	3.6	15,984	180.0	3.2	92,340
Moss Creek	7.46	2.37	2.7	7.2	-589			
WBS at Garmantown	34.00	10.78	25.0	4.1	17,820	245.0	3.6	96,579
Douglas Run	2.15	.68	1.0	8.0	-534			
Emeigh Run	3.84	1.22	0.9	7.3	-130			
WBS at Cherry Tree	42.26	13.40	28.0	4.3	16,632	327.0	3.9	118,309
Peg Run	2.24	.71	0.6	7.3	-95			
Cush Cushion Creek	12.47	3.96	5.0	7.4	-718			
Kings Run	2.42	.77	0.5	7.0	-42			
WBS at Stifflertown	61.60	19.50	40.0	4.4	14,041	475.0	4.0	130,815
WBS at McGees Mills	139.70	44.20	69.0	6.8	-7,125	1070.0	4.4	69,336
Bear Run	19.35	6.14	9.5	3.9	1,406	50.0	3.4	17,550
Chest Creek	129.21	41.00	42.1	7.3	-6,794	500.0	6.1	-54,000
WBS at Bower	315.00	100.00	129.0	7.3	-13,748	2400.0	5.8	-79,056

FIGURE VI-14

ACID SLUGGING CHARACTERISTIC OF THE WEST BRANCH
REACH BELOW SPANGLER - JUNE, 1972

SAMPLE LOCATION	DRAINAGE AREA		BASE FLOW 1971			HIGH FLOW PERIODS					
						JUNE 21, 1972			JUNE 22, 1972		
	Sq. Mi.	% OF AREA AT BOWER	FLOW cfs	pH	ACIDITY lbs./day	FLOW cfs	pH	ACIDITY lbs./day	FLOW cfs	pH	ACIDITY lbs./day
WBS at Bakerton	4.0	1.27	3.6	3.6	4,926	25.0	4.4	7,425	60.0	4.2	13,608
Lesle Run	.99	.31	.32	3.2	250	1.5	3.8	275	8.0	4.4	432
Hoppel Run	.73	.23	.80	6.6	-395	2.0	2.9	1,598	5.0	6.7	567
WBS at Watkins	7.62	2.42	5.4	3.0	9,980	50.0	3.6	33,480	100.0	3.6	30,780
Fox Run	7.74	2.46	2.7	3.3	1,919	20.0	4.6	108	50.0	5.7	0
WBS at Spangler	19.3	6.12	10.0	3.0	12,204	85.0	3.8	34,425	220.0	4.1	33,264
Browns Run	2.61	.83	5.2	7.6	-5,679						
Walnut Run	4.41	1.40	3.6	7.6	-2,468						
Porter Run	1.09	.35	0.6	7.6	-696						
WBS at N. Barnesboro	25.79	8.85	20.0	3.6	15,984	120.0	4.0	46,008	450.0	4.4	36,450
Moss Creek	7.46	2.37	2.7	7.2	-589						
WBS at Garmantown	34.00	10.78	25.0	4.1	17,820	215.0	5.9	-9,288	600.0	4.7	22,680
Douglas Run	2.15	.68	1.0	8.0	-534						
Emeigh Run	3.84	1.22	0.9	7.3	-130						
WBS at Cherry Tree	42.26	13.40	28.0	4.3	16,632	280.0	7.2	-68,040	700.0	5.1	11,340
Peg Run	2.24	.71	0.6	7.3	-95						
Cush Cushion Creek	12.47	3.96	5.0	7.4	-718						
Kings Run	2.42	.77	0.5	7.0	-42						
WBS at Stifflertown	61.60	19.50	40.0	4.4	14,041	400.0	4.6	54,000	1165.0	5.7	-12,582
WBS at McGees Mills	139.70	44.20	69.0	6.8	-7,125	180.0	6.9	-18,468	2300.0	6.6	-86,940
Bear Run	19.35	6.14	9.5	3.9	1,406	25.0	3.9	2,565	200.0	4.2	9,720
Chest Creek	129.21	41.00	42.1	7.3	-6,794	150.0	7.0	-21,870	1500.0	6.5	-56,700
WBS at Bower	315.00	100.00	129.0	7.3	-13,748	362.0	7.1	-35,186	5200.0	6.6	-168,480

This type of slugging can apparently be expected whenever stream flows exceed 2000 cfs at Bower. This flow is at the 5% frequency of occurrence level (see Figure VI-l); thus, stream slugging which would result in fish kills over a 40 mile reach of stream could be expected as often as 15 to 20 days per year.

An attempt was made to confirm the slugging effect data by conducting additional stream samplings in a two day period prior to the flood crest of storm Agnes (June 23, 1972). Samples were taken on June 21, a day on which it was raining heavily in the headwater area, but not below Garmantown. On June 23, samples were taken after essentially 24 hours of steady rain throughout the watershed during which there was 2" of precipitation (see rainfall data in Appendix D).

The data obtained is compared with base flow conditions in Figure VI-14. The slugging effect was confirmed with some interesting variations. On June 21, as the rain continued in the Spangler area, the slug began to build up below Spangler to about the same degree as was observed in September. It is also clear that this is a slug which will quickly hit Garmantown, where the West Branch at the time of sampling was essentially neutral (pH = 5.9) with an excess alkalinity of 9,000 ppd.

On June 22, after much steady rain, the slug effect is still discernible, but greatly diminished in intensity. This must mean that the slug is being generated by sources of accumulated soluble acid salts which dissolve rapidly when first wetted by high flows and are gradually leached out over a 24 hour period.

IMPORTANCE OF THE SLUG EFFECT

The identification and quantification of the slugging effect which is generated within the West Branch below Spangler is one of the most important points of information obtained in this study. This acid slug, which cannot be controlled, completely wipes out a 40 mile reach of the West Branch (as a fishing stream) at a 5% frequency level. Its order of magnitude is so great that it would also completely nullify any abatement measures instituted above Spangler where most of the known acid sources exist. Consequently, this slugging effect becomes the major factor in determining the real effectiveness of any abatement measures which might be instituted in the study area.

However, despite the intensity of this slug, the alkaline sources in the lower section of the West Branch headwaters area are sufficient to neutralize this slug at Bower Station so that the waters in Curwensville Reservoir are never affected. In other words, the initial 40 mile reach of the West Branch is a self-regulating natural neutralization plant with a maximum neutralizing capacity in excess of 200,000 ppd calcium carbonate (limestone) equivalent.