SUMMARY OF FINDINGS

1. Water losses into the abandoned deep mines are the major sources of Acid Mine Drainage (AMD) attributable to the Mill Creek watershed. The lost water recharges two major mine pool complexes in the Wyoming Valley and is subsequently discharged as AMD from outlets that are located outside of the Mill Creek watershed limits.

2. The major sources of recharge of the mine pools in the study area consist of surface water losses, leakage from water mains and sewers, and the inflow of groundwater through the southeastern rim of the coal basin.

3. Acid water discharges from strip mine areas and waste banks into Mill Creek are a minor source of stream pollution, limited to isolated stream stretches.

4. The South Wilkes-Barre Boreholes and the Askam Borehole are the major known outlets for AMD discharges from the South-East Mine Pool Complex. Mine pool discharges from the South Wilkes-Barre Boreholes are attributable to mine pool recharge sources in the Mill Creek watershed, as well as the Solomon, Warrior and Nanticoke Creek watersheds.

5. Discharges from the Askam Borehole are limited to mine pool recharge sources in Warrior, Nanticoke and part of Solomon Creek watersheds.

6. For the 366 days of the study period (5/l/75-4/30/76), the following recorded AMD discharges emanated from the two major complexes:

MINE POOL COM-PLEX	OUTLET	MAGNITUDE OF AMD DISCHARGES							
		OUTFLOW		ACIDITY		IRON		SULFATES	
		MG	MGD	CONC. ppm	LOAD LBS/DAY	CONC. ppm	LOAD LBS/DAY	CONC. ppm	LOAD LBS/DAY
SOUTH-EAST	South W-B Boreholes	10,680	29.18	360	87,504	182	44,239	1,717	417,350
	Askam Borehole	1,670	4.56	256	9,724	192	7,293	1,818	69,056
	TOTAL	12,350	33.74		97,228		51,532		486,406
NORTH-WEST	Plainsville Borehole	1,390	3.80	94	2,975	78	2,469	1,112	35,199
	Buttonwood Tunnel	*5,900*	*16.12*	*182*	*24,439*	*109*	*14,636*	*1,212*	*162,747*
	TOTAL	*7,290*	*19.92*		*27,417*		*17,105*		*197,946*

7. The magnitude of water losses (MGD) that recharge the study area mine pools, the resulting production of acid (lbs/day) in the deep mines, and the allocation of mine pool recharge to water loss sources are as follows:

SOURCE OF WATER LOSSES OR MINE POOL RECHARGE	MAGNITUDE OF AMD PRODUCTION BY WATERSHEDS (5/1/75-4/30/76)							
	MILL CREEK (STUDY AREA)				SOLOMON CREEK		WARRIOR CR. & NANTICOKE CR.	
	NORTH-WEST COMPLEX		SOUTH-EAST COMPLEX					
	MGD	ACID LBS/DAY	MGD	ACID LBS/DAY	MGD	ACID LBS/DAY	MGD	ACID LBS/DAY
STREAMBEDS	1.65	1,292	4.39	13,164	1.07	3,209	3.22	6,867
"OFF-STREAM" INFILTRATION	5.89	4,612	8.69	26,060	6.74	20,212	10.63	22,668
LEAKY PIPELINES (Estimated)	1.00	783	4.00	11,995	3.80	11,395	2.50	5,331
GROUNDWATER (Estimated)	1.00	783	4.00	11,995	4.00	11,995	4.00	8,530
T O T A L (Min. All Sources)	9.54	7,470	21.08	63,214	15.61	46,811	20.35	43,396
TOTAL RECHARGE OF MINE POOLS	9.54	7,470	← ← ← 57.04 MGD; 153,421 LBS/DAY → → →					

8. Additional studies and field tests are required to verify the magnitude and location of leakage from water mains and sewers into the mine pools.

9. Verification of the extent of mine pool recharge by groundwater sources requires hydrogeologic studies and field pumping tests.

10. Inflow and outflow relationships for the Upper and Lower mine pools in the South-East Mine Pool Complex are summarized below:

11. The inflow/outflow relationships indicate the following:

a. Out of the total expected AMD discharges from the Upper mine pools, only 21.5% emanate from the Askam Borehole.

DESCRIPTION	INFLOW (OUTFLOW) MG		
	5/1/75 to 4/30/76	MEAN YEAR	% OF TOTAL
UPPER MINE POOLS	7,441	6,680	100.0
ASKAM BOREHOLE	(1,673)	(1,440)	21.5
UNACCOUNTED BALANCE	(5,768)	(5,240)	78.5
LOWER MINE POOLS	13,417	12,190	100.0
SOUTH W-B BOREHOLES	(10,680)	(9,400)	77.1
UNACCOUNTED BALANCE	(2,734)	(2,790)	22.9

b. The balance of the expected Upper mine pool discharge (78.5%) flows through the breached barrier pillars or overflows into adjacent mine pools, subsequently discharging into the Susquehanna River.

c. The magnitude of Upper mine pool recharge to the Lower mine pools of the South-East Complex is presently unknown. Additional monitoring and studies are required to determine the amount of recharge.

d. Approximately 77% of the total water losses into the Lower mine pools is discharged through the South Wilkes-Barre Boreholes.

e. Total AMD discharges from the Askam and South Wilkes-Barre Boreholes are approximately 60% of the estimated total water losses into the South-East Mine Pool Complex.

12. During the lowest consecutive thirty days of low flow in the study area streams (8/26/75-9/25/75), there were no AMD discharges from the Askam Borehole. During the same thirty day period, discharges from the three South Wilkes-Barre Boreholes were reduced from the average annual rate of 29.2 MGD to 21.8 MGD.

13. Losses from leaky water mains and sanitary sewers are not related to the hydrologic cycle in the study area. Therefore, during periods of little or no precipitation, when surface water losses are diminished, the rate of pipeline losses remains virtually unchanged.

14. During the thirty consecutive "low flow" days, the magnitude of mine pool recharge varied considerably from the average annual values, as illustrated in the following:

AMD DISCHARGES AND SOURCE OF MINE POOL RECHARGE	STUDY PERIOD			
	366 DAYS 5/1/75-4/30/76		30 CONSECUTIVE LOW FLOW DAYS 8/26-9/25/75	
	MGD	% OF TOTAL	MGD	% OF TOTAL
AMD DISCHARGES	29.18	100.0	21.80	100.0
STREAMBED LOSSES	4.23	14.5	1.50	6.9
OF -STREAM LOSSES	11.93	40.9	6.24	28.6
SUB-TOTAL SURFACE LOSSES	*16.16*	*55.4*	*7.74*	*35.5*
GROUNDWATER RECHARGE	6.19	21.2	7.13	32.7
PIPELINE LEAKAGE	6.83	23.4	6.93	31.8

15. Prolonged drought periods may diminish the groundwater inflow into the coal basin. However, shorter periods of low precipitation would not materially change the average annual rate of mine pool recharge from groundwater sources.

16. During periods of "low flow" in the area streams, pipeline leakage, groundwater recharge and streambed losses contribute more than 70% of the AMD discharges from the South Wilkes-Barre Boreholes.

17. If 50% of the estimated groundwater inflow into the mine pools is intercepted, and the pipeline and streambed losses are prevented, the mean annual AMD discharge from the boreholes would be reduced approximately 50%.

18. The acid and iron load discharged from the known outlets of each major mine pool complex is as follows:

COMPLEX	DISCHARGE POINT	LOAD IN LBS/DAY			
		MEAN YEAR DAILY AVERAGE		30 CONSECUTIVE LOW FLOW DAYS (8/26-9/25/76)	
		ACID	IRON	ACID	IRON
SOUTH-EAST	ASKAM BOREHOLE	8,400	6,300	0	0
	SO. W-B BOREHOLES	77,200	39,000	29,400	14,900
SUB-TOTAL SE COMPLEX		85,600	45,300	29,400	14,900
NORTH-WEST	PLAINSVILLE BH	2,600	2,200	0	0
	BUTTONWOOD TUNNEL	22,300	12,900	4,850	2,800
SUB-TOTAL NW COMPLEX		24,900	15,100	4,850	2,800
TOTAL SE AND NW COMPLEXES		110,500	60,400	34,250	17,700

NOTE: The discharges loads of acid and iron above degrade the quality of the Nanticoke and Solomon Creeks as well as the Susquehanna River.

19. During the 30-day low flow period of the study, the South WilkesBarre Boreholes discharged 85% of the total acid and iron load that emanated from all the known discharge points in both the South-East and North-West Complexes.

20. The increase of Acid and Iron concentration in the Susquehanna River resulting from the known AMD discharges in the Wyoming Valley is tabulated overleaf:

DESCRIPTION		MEAN YEAR	30-DAY LOW FLOW		
			8/26/75	RECURRENCE INTERVAL	
			9/25/75	2-YEAR	10-YEAR
RIVER FLOW	cfs	15,210	6,017	1,600	960
	MGD	8,534	3,887	1,034	620
AMD DISCHARGES					
ACID LOAD LBS/DAY		110,500	34,250	29,500	27,400
IRON LOAD LBS/DAY		60,400	17,700	15,250	14,160
INCREASED CONCENTRATION IN THE SUSQUEHANNA RIVER					
ACID	ppm*	1.55	1.06	3.42	5.30
IRON	ppm*	0.85	0.55	1.77	2.74

* parts per million

21. AMD discharges from the South Wilkes-Barre Boreholes can increase the iron concentration in the River beyond the present water quality standards (1.5 ppm). The increase in total iron concentration above the standards is expected to occur during 30 consecutive days of low flow at a 2-year recurrence interval.

22. Mill Creek watershed losses into the North-West Mine Pool Complex are equivalent to 60% of the discharges from the Plainsville Borehole.

23. Water losses from the Mill Creek watershed into the North-West Complex represents a very small portion of the total water losses from the watersheds that overlie the North-West Pool Complex.

24. The concentration of acid and iron in the AMD discharges during the study period was found to be considerably lower than the concentration recorded in 1974 and 1975.

25. Within the coal basin, "off-stream" surface water losses are due to a high rate of infiltration into the underlying mine pools. The rate of infiltration in stripped areas is approximately 68% of the precipitation over the area.

26. Reclamation of stripped areas by grading and seedi,ig would increase the runoff from the reclaimed areas and reduce the present annual infiltration by approximately 20 inches.

27. Benefits to the AMD abatement effort that can be derived from the reclamation of stripped areas is equivalent to 4.2 lbs/day of acid removal for every acre reclaimed.

28. The study area is being supplied with water by a Public Utility

whose franchise area extends throughout the Wyoming and Lackawanna coal basins. Between 34% and 50% of the available "at source" water supply does not reach the service areas, due to unaccounted losses during transmission and distribution. The leakage of clean, potable water from water mains recharges the mine pools in the coal basins and becomes acid.

29. Present regulations related to discharges into the Commonwealth waters do not prohibit or preclude discharges of clean water into the deep mines.

30. Approximately 140 MGD of additional water supply sources will have to be developed to meet the projected water need in the Wyoming Valley by the year 2020. The Susquehanna River is being considered as a major new water supply source for the projected water needs.

31. Comparison between projected population and the additional 140 MGD required to supply them in 2020 indicates the following:

a. The actual water needs of the population to be served in the year 2020 is 94 MGD.
b. The required supply of 140 MGD includes unaccounted losses in the water supply system.
c. The expected pipeline losses into the underlying deep mines in the Wyoming Valley alone could amount to 46 MGD.

32. The prevention of pipeline leakage and the beneficial use of intercepted groundwater can serve a dual purpose:

a. Provide additional water supply for the area.
b. Provide a significant contribution to the AMD abatement program in the Northern Anthracite Basin.

33. A considerable reduction in surface water losses into the deep mines can be achieved by the construction of six AMD abatement projects in the Mill Creek watershed.

a. Five of the proposed projects will reduce AMD discharges from the South Wilkes-Barre Boreholes.
b. The sixth project, located in the Gardner Creek tributary of Mill Creek, will reduce surface water losses into the North-West Mine Pool Complex. These water losses contribute to the AMD

discharges from the Plainsville Borehole and the Buttonwood Tunnel.

34. Additional reduction in the present AMD discharges from the South Wilkes-Barre Boreholes can be achieved by constructing five abatement projects in the adjacent Solomon Creek watershed. These projects were previously recommended in the SL 181-3 Report.

35. The estimated construction cost for ten of these projects and the anticipated benefits to be derived from their. implementation are summarized in the following:

WATERSHED	NO. OF PROJECTS	ESTIMATED COST $	ESTIMATED BENEFITS		
			LOSSES PREVENTED MG/YEAR	ACID * REMOVAL LBS/DAY	COST $/LB/DAY
MILL CREEK	5	6,417,100	3,008	24,700	259.8
SOLOMON CREEK	5	3,628,500	726	5,965	608.3
SUB-TOTAL **	10	10,045,600	3,734	30,665	327.6

* *Based on present acid concentration of 360 ppm in the AMD discharges from the South Wilkes-Barre Boreholes (1973/74 acid concentration 638 ppm)*

** *Total proposed "Definite Projects" to reduce surface water losses into the "Lower" mine pools in the South-East Mine Pool Complex.*

36. Implementation of the 10 projects above is expected to reduce 40% of the present AMD discharges from the South Wilkes-Barre Boreholes,

37. The abatement project proposed for Gardner Creek together with a streambed loss prevention program in the lower reaches of Mill Creek will reduce surface water losses into the North-West Complex. The total estimated cost for the Gardner Creek project is $794,000, or the equivalent of $434 per pound of acid removal per day.

38. Additional reduction in the borehole discharges is expected by eliminating pipeline leakage and by intercepting the inflow of groundwater into the mine pools. The prevention of pipeline leakage and groundwater interception are multi-purpose projects that will benefit other interests in the area.