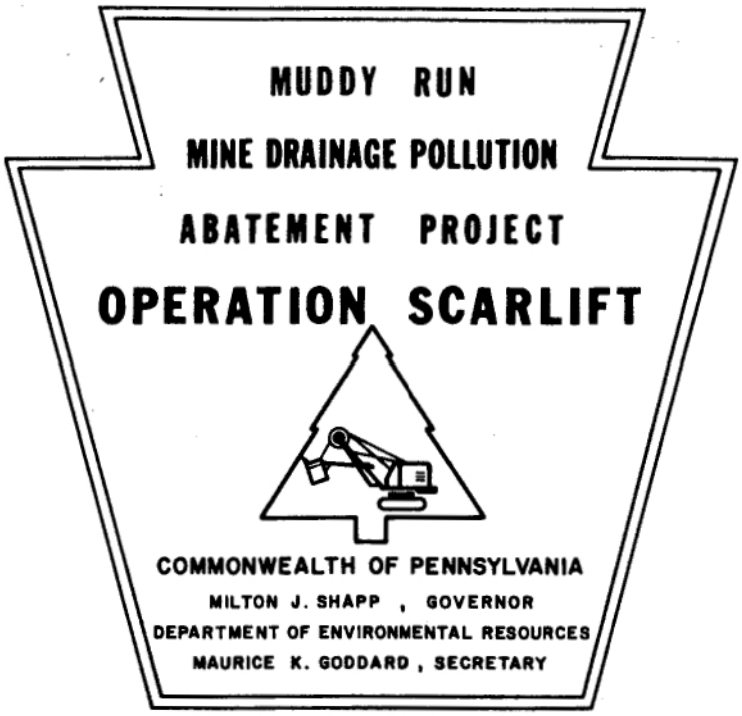


METHODS OF STUDY

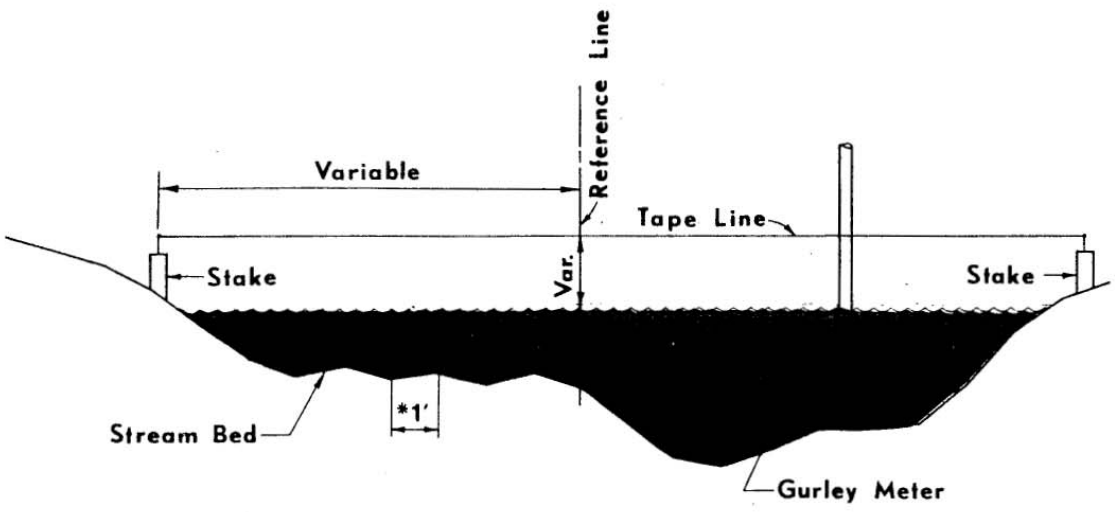
METHODS OF STUDY

The study was planned and executed in phases.

COLLECT AND REVIEW ALL DATA

All available existing information was gathered and examined in detail. Data collection included existing mine maps, surface maps, mining records, stream and rainfall data, soil information, coal structure contours, geology, ground water and well data, available planning information, existing aerial photos and photogrammetrics, tax maps and property worth data, coal reserves, historical information, and the pertinent portions of previous studies conducted within the Susquehanna River watershed by Federal and State agencies.

Liaison and data gathering included these agencies: Pennsylvania Department of Health, Pennsylvania Department of Environmental Resources, United States Bureau of Mines, the Coal Industry, U. S. Department of Agriculture, Pennsylvania Geological Survey, U. S. Environmental Protection Agency, Pennsylvania Department of Transportation, U. S. Geological Survey, local Sportsman's Groups, local citizens, and any other agency that may have had pertinent information.



*Cross Section Taken at 1 foot Intervals

TYPICAL STREAM CROSS SECTION

RECONNAISSANCE

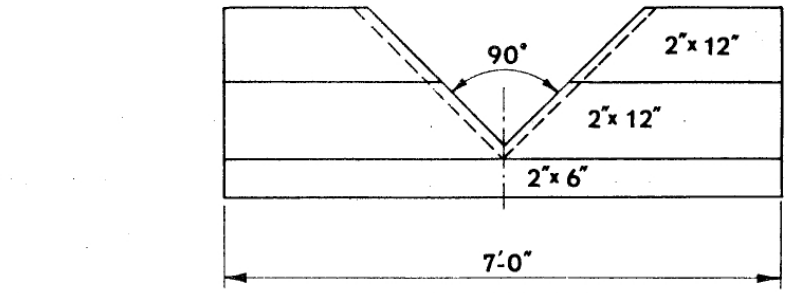
An initial field reconnaissance of the watershed was made after the locations of the water sampling and flow measuring stations were tentatively established from analysis of existing information (U. S. G. S. topographic sheets, previously located discharging surface and deep mines, hydrology of the area, stream flow information, E.P.A.'s Susquehanna River Study, and Department of Health's Water Quality Network Sampling Program).

The field reconnaissance established exact locations of flow measuring and water sampling stations. Stations were flagged, permission to enter the property for sampling and/or to construct weirs or other measuring devices was obtained where feasible.

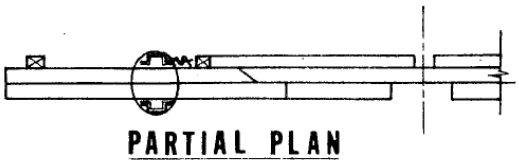
The specific locations for weirs and/or stream cross sections were selected to assure the most uniform channel (stream) configuration. Weir widths and types were selected, and the most expeditious sampling and measuring route developed.

The specific scope of the one year sampling and measuring program was established, with the control stations and access routes plotted on topo sheets.

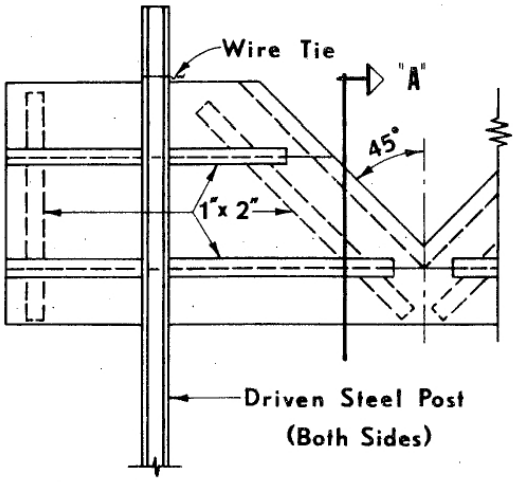
This initial reconnaissance revealed many unusual aspects of



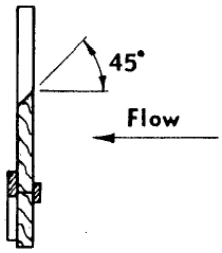
ELEVATION



PARTIAL PLAN



PARTIAL ELEVATION



SECTION "A"

TYPICAL V-NOTCH WEIR

the watershed which had to be considered for proper direction of the one year sampling program. Samples were taken and flow estimated at the time of the initial reconnaissance to help guide the study efforts in delineating the major problem areas.

Signs identifying the project were erected at advantageous locations in the watershed area.

CONTROL SAMPLING FOR ONE YEAR

A one year watershed sampling and measuring study was performed, which included the construction of weirs (28) where stream flows were small enough to accommodate economical weir construction. Stream cross sections were taken at all other locations (41), water areas measured, velocities obtained by Gurley meter, or the "floating chip" method, and flows computed. The cross sections were taken at one foot horizontal intervals, plotted on cross section paper and used throughout the course of the study.

Water samples were collected at each station and flow measurements taken twelve times during the year. Sampling and measuring was accomplished monthly, with some rounds omitted during the hard freeze period and additional rounds added during periods of high flow.

Stations were established for regular sampling and measuring at mine drainage discharge points and selected stream locations. There were thirty-four (34) stream stations and thirty-five (35) pollution source stations sampled, but these numbers varied slightly during the study due to the various contingencies. U . S . G . S . stream gaging station data was used for flow values at two stations on Clearfield Creek.

Rainfall records were studied and climatology data included to reference the twelve month study to a "normal" year. The ultimate goal of the study did not warrant the sophistication usually associated with an academic type study. The purpose of this study was to provide sufficiently accurate data to develop conclusions and recommendations for abatement of acid mine drainage and restoration of aquatic life to a desired level.

All water samples were analyzed for pH, acidity, alkalinity, iron and sulfates. Selected samples were also analyzed for aluminum.

All pH values presented in the sample data tabulation were measured with a laboratory potentiometer. Many field pH's were taken in the course of field surveillances in order to achieve better definition of problem areas. Hot acidity was measured by potentiometric titration to a pH 8.3 end point. Alkalinity was measured by the potentiometric method of titration to pH 4.5. Sulfate was measured by precipitation with benzidine-dihydrochloride. Total iron was measured by atomic absorption. The results

of the chemical analyses were converted to loadings in pounds per day at each station by multiplying the chemical analysis results (ppm) by the computed flows, using the appropriate mathematical conversion factors.

Throughout the duration of the one year water sampling and flow measuring study, the analyses and loadings were examined to locate areas where deviations occurred in the quantities of acid produced. Possible "sluggers" were delineated by selective sampling when suitable hydrological conditions prevailed.

Sampling stations were relocated during the course of the study in cases where it was felt that data correlation could be improved. New coordinates were computed and the new locations re-plotted.

All water quality and flow data, as well as geographic coordinates of the sampling and measuring stations, were coded for inclusion with the STORET computer system, so that the data may be retrieved at any time.

Local citizens were employed to help with the weir construction. Field explorations and sampling and measuring were accomplished by employing local people to assist.

Monthly narrative progress reports (and other interim reports) were prepared and submitted to indicate status of work, developing trends, or unusual occurrences.

DETAILED FIELD EXPLORATIONS

Detailed field explorations were conducted to gather hydrologic and geologic information, to verify previously collected information, and to catalog the pollution sources.

The field explorations included walking of streams too account for all sources of water. These explorations also entailed walking the outcrop lines and lands above underground mines to map the mining (shafts, drifts, slopes, airways, caved areas, etc.). Detailed descriptions of all pollution sources were logged as discovered. Complete logs of all field data were filed and made available for use or inspection at any time.

The extent of the stripping operations, both active and abandoned, subsidence areas and other photo interpreted features, as defined from current aerial photos, were verified in the field.

Area well drillers and private home owners were contacted to acquire information on ground water levels and quality. Such data is essential to determine present effects of pooled mine waters and a profile of ground water conditions. Much was learned from local residents about the history of area mining and the locations of difficult to find points of importance.

When the data review and field exploration phases of the study were essentially completed, and a mine sealing program was tentatively decided upon, feasibility test borings were undertaken to provide the following information.

Where available mine maps indicated the location and extent of entryways to be sealed, tentative seal locations were selected in the field and a minimal number of conventional core borings and pressure tests taken to determine: (1) accurate depth to mine and accurate coal structure contours (these were necessary in order to determine what the mine water flow patterns will be after abatement measures have been completed); (2) thickness of the seam mined; (3) character of rock above and below mine (type, thickness, jointing, fracturing, permeability -- these parameters will determine the efficiency of a seal placed at that point); (4) condition of mine floor (if underclay --its type and thickness) and mine roof; (5) accurate inclination of coal; and (6) water level in mine.

These borings were also to help establish the extent of grouting required, optimum seal needed, and more accurate cost estimates.

MINE DEVELOPMENT DRAWINGS

Complete and comprehensive mine development and pollution

source drawings were prepared. All existing data and study results were collated and used: U . S . G . S . topo maps; aerial photography; deep mine maps; coal structure contours; photogrammetry; geological publications; County and State road maps; projected highway plans; tax maps; and other pertinent information.

These drawings were prepared as mylar overlays (in ink) on base drawings developed by enlarging U .S .G .S . topographic quadrangle sheets. The topo sheets were enlarged to 1" = 1000' scale as screened (half tone) reproductions on mylar. The overlay technique permitted final printing in color to produce easily read drawings which emphasize the most important features of the watershed study.

The drawings incorporated surface contours, coal structure contours, roads, streams, and other planimetric features, strip -mined areas, pollution sources, coal storage and refuse areas, location of water sampling and flow measuring stations, deep mine openings and extent of underground workings, the names and limits of individual mines, subsidence areas, and other unusual physical features which are pertinent to the water pollution problem.

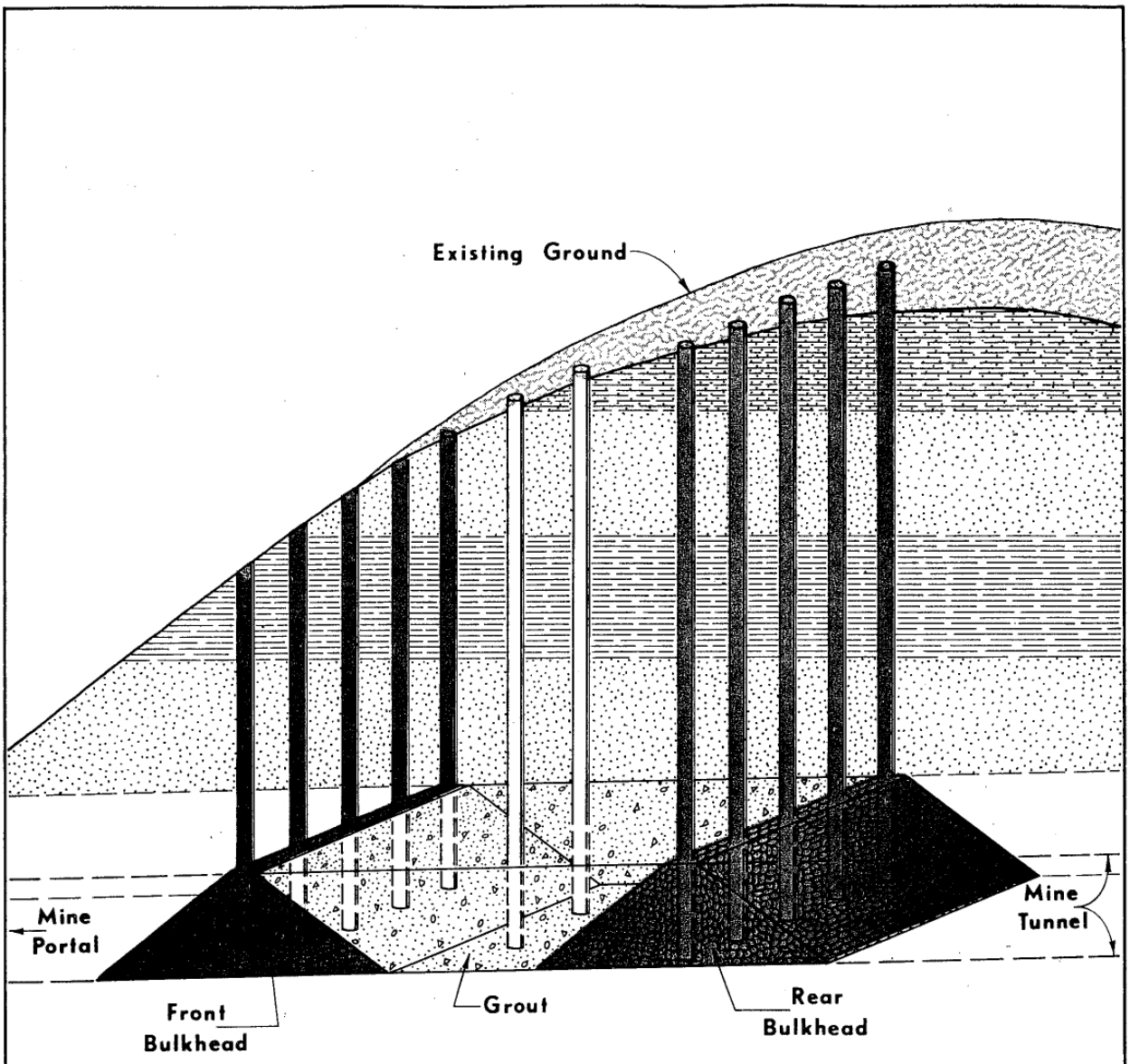
The U . S . G .S . topo sheets used to form the base drawing were brought up to date by incorporating changes to the planimetric features made since the quadrangle sheets were published. Road maps, new road

plans, field investigations, aerial photographs, and all other collected information was used in the updating process.

Due to the large area encompassed by this watershed study, considerable thought and attention was given to establishment of scale, layout of drawings, working and final sheet sizes and intermediate and final reproduction processes. This ensured a final product which should help facilitate study of the narrative descriptions in the report. The mine development drawings can be found in back of this report in a pocket on the inside cover. Four separate mine development drawings were made for additional clarity and to emphasize strip and deep mining on the particular coal seams. Included are separate drawings on the Clarion, Lower Freeport, Lower Kittanning, and a composite for all coal seams mined.

EVALUATION OF SOURCES AND CORRECTIVE MEASURES

After the location, size, source and physical condition of each polluting discharge was determined, they were individually ranked in terms of pollutional magnitude, probability of abatement success and cost of feasible pollution abatement measures. This evaluation strove for maximum improvement of the stream at minimum cost.



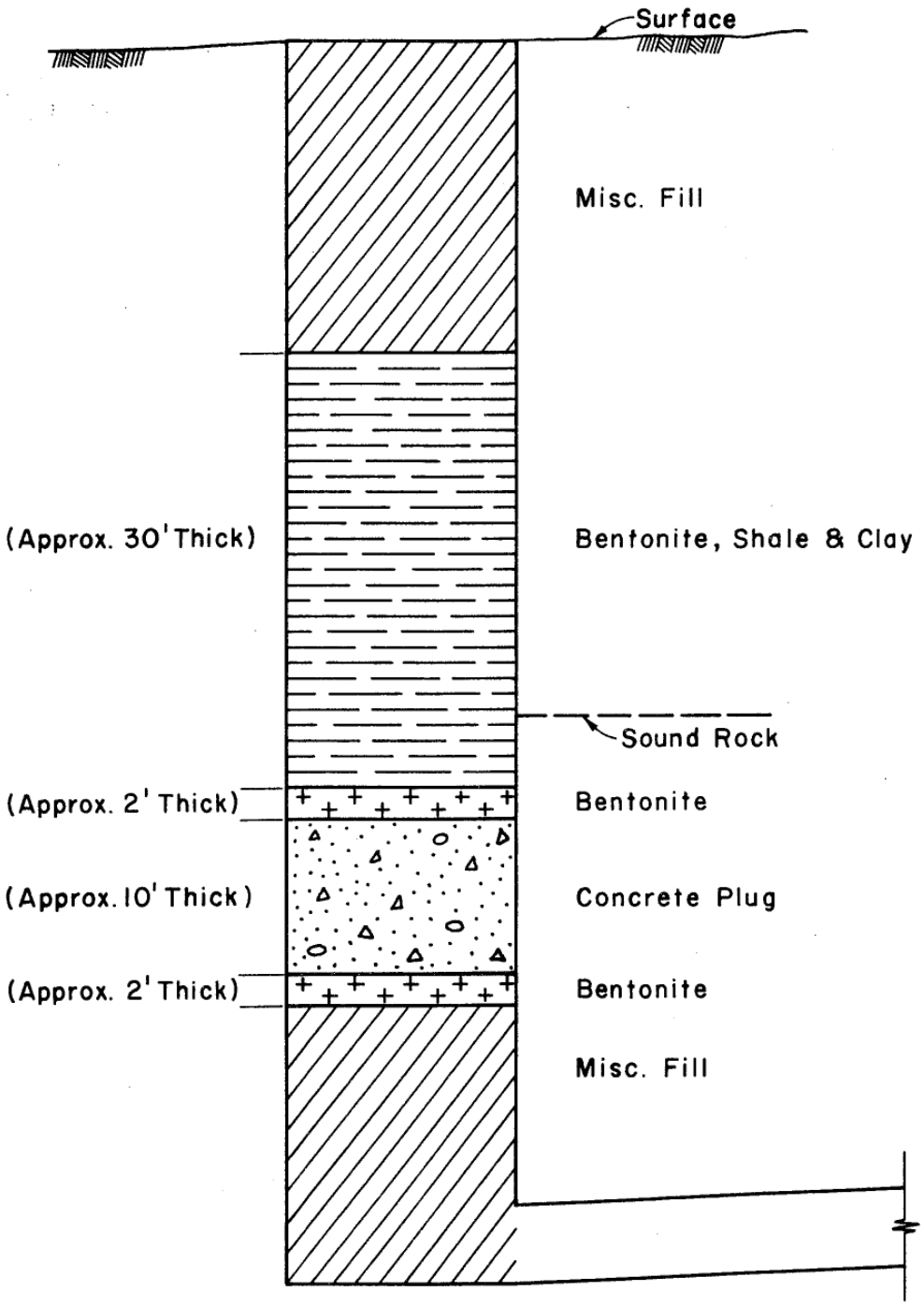
TYPICAL DEEP MINE SEAL

No Scale

Six (6) "Quick Start" projects were proposed after several months of study. It was determined that these Quick Start projects would have significant impact on abating the pollution within the watershed. Attention was focused on those early projects that can show great improvement in the watershed, and that would also lend themselves to a favorable public relations program. Favorable public relations lend impetus to an important program, and also have an affect on future efforts in the mine drainage field. Any pollution source involved in a Quick Start project (one recommended prior to completion of the study and report) was continually monitored and re-evaluated for seasonal variation. It was recognized that this evaluation should be a continuing process as the study progressed, and early evaluations were revised as new information was obtained.

The latest technology in the mine drainage field was considered for use in the abatement techniques to be applied to each pollution source.

Various adaptations and combinations of the following techniques were considered for use in this watershed. Diversion of surface waters around strip mine cuts and deep mine fractures; stream re-channeling to promote retention of good quality water in the stream bed; backfilling, soil treatment and planting of strip pits; surface treatment or removal of refuse piles, old coal storage areas and refuse based roadbeds; sealing



TENTATIVE METHOD OF SEALING MINE SHAFTS

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of deep mine openings; grouting, or complete stripping out of small deep mines which cannot be successfully sealed; and mine drainage treatment.

New techniques in mine drainage abatement now in the experimental stage (such as extensive use of limestone waste products or ungraded limestone to treat surface water percolation through a strip mine :and encourage vegetation growth)* will be recommended during construction plan preparation if appropriate and if judgement indicates a high probability of success.

REPORT

All of the preceding study information and results were incorporated into this report. Each pollution source is described in detail, the cause and amount of pollution stated, the abatement measures and their consequences considered. The probable effectiveness of each measure considered is discussed.

All study results are presented, including stream quality sampling and measuring results, test boring results, and costs of abatement vs. pounds of acid abated. Construction cost estimates of feasible abatement measures for each pollution source were prepared. Every reasonable effort was made

* See Appendix A

to produce accurate cost estimates. Actual cost of comparable projects in other locations have been translated to this project area, inflation and escalation of costs considered. Strip mine highwall heights and lengths of strip cuts were measured or estimated. Photogrammetrics were used in Quick Start areas to determine volumes of earth to be moved or to refine cost estimates.

A cost-benefit ratio for each pollution abatement measure was computed. Conclusions were drawn, priorities established, and final recommendations for abatement measures made. A pollution abatement plan for the entire watershed was prepared and is included with this report. Alternate priorities are listed to provide for flexibility in implementation.

Drawings, charts, tables and other illustrations needed to make the report comprehensive and easily readable were prepared. These exhibits include sampling and measuring data tabulations, materials balance schematics, typical stream cross sections and weirs, geologic cross sections and columns, the Mine Development Drawings (reduced in scale), a location map, deep mine maps where appropriate, and exhibits showing location and specific data relative to recommended abatement areas.