Appendix B

Field Data Collection Procedures

Various field data collection methods have been mentioned in portions of this report. This appendix supplements the forgoing discussions by describing in detail the data collection procedures which were followed in the Mashudda Strip Mine Investigation. It is divided into eight separate sections as follows:

- Air Rotary Boring
- Geophysical Logging
- Borehole Piezometer Installation
- Backhoe Pit Piezometer and Lysimeter Installation
- Pulse Testing Methods
- Groundwater Sampling Procedure
- Surface Water Sampling Procedure
- Surface Flow Measurement Procedure

The contents of each section are self-evident.

AIR ROTARY BORING

Thirteen exploratory air-rotary boreholes were drilled, in the Mashudda Strip Mine area, ranging in depth from 49 feet to 192 feet. An air-rotary rig with a 650 cubic feet per minute capacity compressor was used to drill these holes. The rig was equipped with an automatic dust control system, which was in operation during all drilling phases. Sedimentation control in the form of settling pits adjacent to each borehole was used to control drilling effluent. A full size stabilizer of 10 foot minimum length was used for all drilling operations. The casing in all boreholes is used threaded and coupled steel casing with a minimum inside diameter of six inches. The drilling procedure was as follows:

1. A 10-inch diameter hole was drilled into competent bedrock, using a tri-cone roller bit.

2. Six-inch steel casing was centered in this hole.

3. The base of the casing was sealed with bentonite, and grout with a two to four percent bentonite content was pumped into the annular space to prevent surface water from entering the well.

4. A 5-5/8-inch diameter hole was drilled to total depth, using a tri-cone roller bit.

5. The well was developed using rig air and water. This was accomplished by flushing the well with water and then blowing the well with air, with the tools at total depth. The well was considered developed when a maximum yield was obtained, and the groundwater effluent was relatively free of turbidity, and pH and specific conductance were relatively stable.

The accompanying figure at the end of the piezometer installation section shows an idealized representation of the boreholes as constructed at the Mashudda Strip Mine.

Due to unforeseen geological conditions, bor ehole s B-3, B-5, B-8, and B-10 were constructed somewhat differently from the other boreholes. These boreholes were constructed as follows:

1. The 10-inch hole was advanced to competent bedrock.

2. Six-inch casing was set but not grouted.

3. The 5-5/8-inch diameter hole was drilled to total depth.

4. The six-inch casing was removed from the borehole and vertical, one-sixteenth-inch torch slots were cut around the casing at appropriate intervals.

5. The slotted casing was then reset, and non-calcareous gravel was packed in the annular space to one- to two-feet above the highest slot.

6. A bentonite seal was placed over this gravel pack and the remainder of the annular space was backfilled.

7. The final well was then cleaned to total depth and developed as above.

GEOPHYSICAL LOGGING

Upon completion of the 13 boreholes, a suite of four geophysical logs was run on each well. The equipment utilized was a Well Reconnaissance, Inc. #9616 logging system, capable of performing down-hole geophysical logging to 1000-foot well depths. All probes used by the 9616 system are slim-line tools, having a diameter of 1-1/4 inches. The following tools were utilized in the Mashudda borehole logging:

- Resistivity
- Spontaneous Potential - Gamma Ray
- Caliper

Logs produced by the 9616 system are recorded on a Texas Instruments 210 Strip Chart Recorder. The recorder is synchronized with the hoist mechanism, and graphically records depth versus parameter run. This entire system is mounted in a four-wheel-drive GMC Suburban.

Each log requires a separate pass through the borehole. Therefore, logging time is dependent upon the depth of the well and number of logs run. In general, the Mashudda wells required between one and two hours of logging time per well.

All boreholes were geophysically logged, and the information was correlated with geologic logs and used to determine stratigraphy and water-bearing zones within each well.

The gamma log shows changes in natural gamma radiation emitted by formations penetrated by the borehole. Changes in gamma counts indicate changes in lithology. Every rock material generally has a characteristic gamma emission pattern which can serve to identify it. In general, shales tend to have the highest concentrations of radioactive minerals, while coals and clean sandstones have the lowest. The gamma log was invaluable in stratigraphic and lithologic thickness control on the well logs.

The resistance tool measures an earth material's resistance to an electrical current (in ohm-meters). The spontaneous potential tool measures the change in electrical potential generated primarily by electrochemical means in the well-bore. Due to the conductance of water, "tight" formations tend to show high resistivity, while water-bearing horizons are much lower. More porous zones tend to have a more negative spontaneous potential. Both logs need water in the borehole in order to be used, and cannot be run inside steel casing. Used in conjunction with each other, the two logs indicate areas of increased porosity, and can serve to confirm the field geologist's water-bearing-zone logs.

The caliper log shows an actual physical profile of the borehole. Variations in size of the borehole are obvious, while spikes associated with water-bearing zones are also apparent. Well construction such as casing seat, can be also examined with this log.

BOREHOLE PIEZOMETER INSTALLATION

In general, the borehole piezometers were constructed in accordance with the technical specifications contained in the Bid Documents for the Mashudda Strip Mine Project, prepared by REWAI and filed with the Pennsylvania Department of Environmental Resources. Once all the geologic horizons of interest were determined, the most economical means of piezometer nesting was devised. In this plan, some boreholes were left open to function as a piezometer, while in other boreholes, up to two plastic piezometers were nested at different intervals. The accompanying table summarizes the construction of all borehole piezometers.

The materials used for construction of all piezometers at the Mashudda site were as follows:

1. Five to 15-foot sections of two-inch Johnson PVC 0.020- slot well screen.
2. Brainard-Killman Tri-Loc riser pipe.
3. Peltonite bentonite seals.
4. Morie grade "0" sand.

The first step in the borehole piezometer installation procedure was to seal the bottom hole, if necessary, and bring the base of the hole up to the proper depth using sand. The lower most screen and riser pipe was then set on this base, and sand-packed to at least one foot above the top of the screen. A minimum of one foot of peltonite seal was then placed over this pack. If a second screen was to be installed, the intervening borehole was filled with sand and peltonite seals, and brought up to the proper depth. The second piezometer was then constructed as above. At least one foot of sand was placed over all peltonite seals to act as a stabilizer. The accompanying figure at the end of this section shows an idealized representation of the borehole piezometer construction.

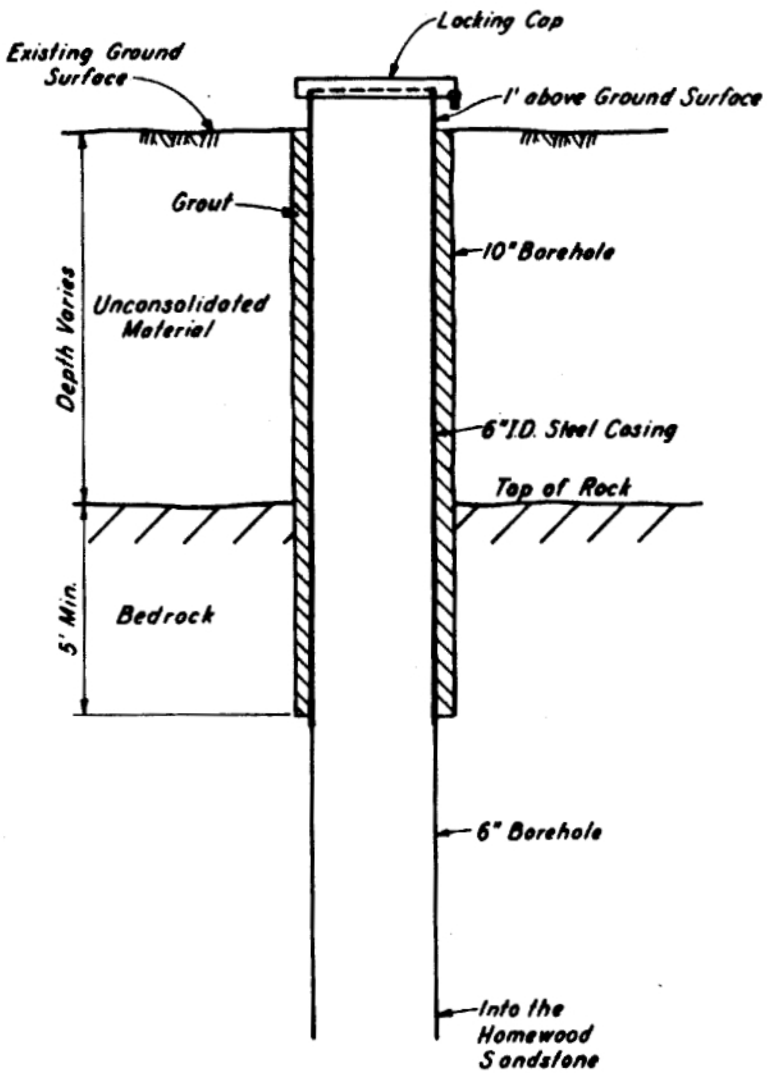
The piezometers were then developed by blowing with compressed air until relatively clear water was obtained. The piezometer was considered developed when yield, pH, and specific conductance stabilized. A minimum of three well volumes were removed during the development process. Actual development time lasted from one-half to over four hours, depending upon the yield of the piezometer.

Borehole Data Summary

Borehole Number	Total Depth	Casing Depth (s=slotted)	Approx. Water Level	Water-Bearing Zone (depth in feet)	Estimated Yield (gpm)	Piezometer Screen Interval	Pipe Length (approx.)	Comments	Rationale
B-1	192'	13'	172'+	Various coal seams	<1/10	NA	NA	Apparent yield and development potential of coals is too low to justify nested piezometers.	
B-2	90'	16'	12.5'	20-28' major coal seam	25 (12 gpm @ 4.1'dd)	NA	NA	Open borehole functions as a piezometer, isolated from the deeper horizons	Provides for background water quality and hydrology
				60-65' minor coal seam	1/3	60-65'	61'	Good water-bearing potential	
				82' Homewood sandstone	<1/10	80-85'	81'	Good water-bearing potential	
B-3	70'	19.5' (s)	20.3'	9.5-17' coal/overburden	1/7	NA	NA	Open borehole functions as a piezometer	Provides for shallow and deep groundwater quality and hydrology in strip area
				25-27' minor coal	1/10	25-30'	26'	Good water-bearing interval	
				48-53' Homewood sandstone	1/8	48-53'	49'	Good water-bearing potential	
B-4	110'	17.8'	95'	25-55' shallow aquifer sandstone and claystone	1/2	NA	NA		
				67-71' major coal	<1/10	67-72'	68'	Water-bearing interval	Provides for background water quality and hydrology
				95-97' Homewood sandstone	0	94-99'	95'	Zone of anomolous very low head potential	
B-5	53'	36' (s)	10.6'	18-24' coal/overburden	40-50 (20 gpm @ 4.9' dd)	NA	NA	Interval isolated from deeper horizons; borehole functions as piezometer and provides easy access for further testing	Provides for shallow groundwater quality and hydrology in strip area
B-6	63'	30'	45.2'	35' Homewood sandstone	1/10	33-38'	34'	Shallow water-bearing interval	Provides for groundwater quality and hydrology beneath strip area
				53-59' Homewood sandstone	1/10	50-60'	51'	Deep water-bearing interval	

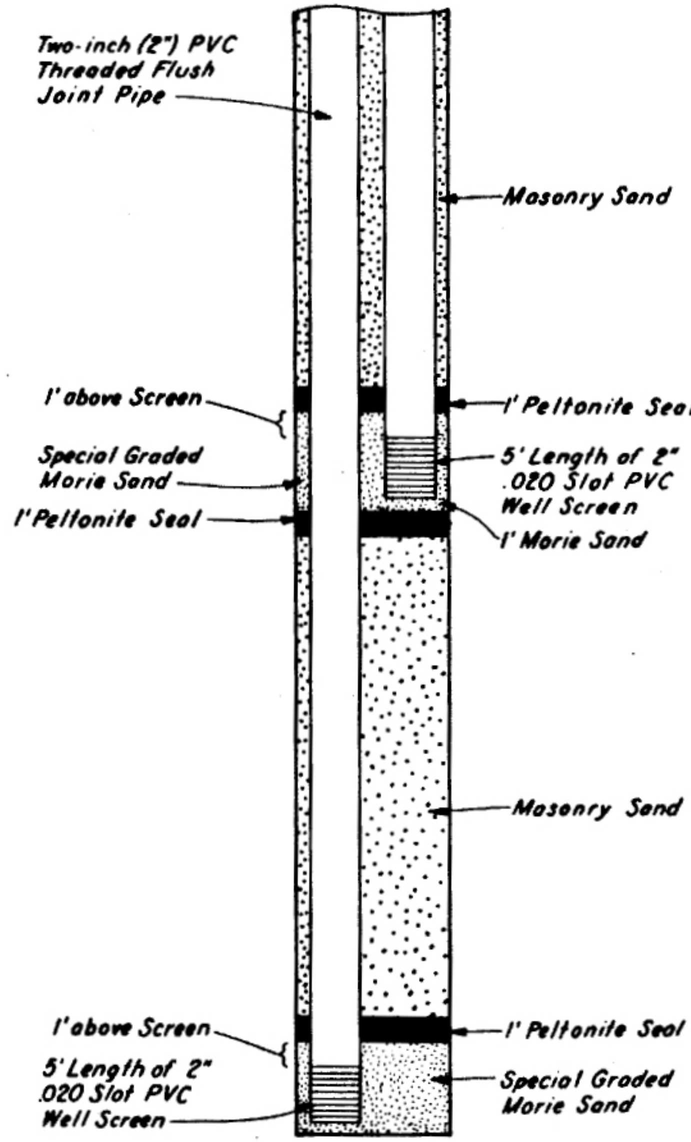
B-7	53'	11'	34'	45-50'	Homewood sandstone	3.5	NA	NA	Only one significant water-bearing zone; borehole functions as piezometer	Provides for ground-water quality and hydrology below strip and backfill area
B-8	60'	34' (s)	6'	13-25'	overburden	70 (30 gpm @ 0.8' dd)	NA	NA	Interval isolated from deeper zone; borehole functions as piezometer	Provides for shallow and deep groundwater quality and hydrology
				39'	Homewood sandstone	1/10	38-43'	39'	Good water-bearing interval	
B-9	65'	20'	40.7'	48-51' 54-62'	Homewood sandstone	2 1/2	48-63'	49'	Interval isolated from shallower portion of borehole	Provides for deeper groundwater quality and hydrology below strip area
B-10	49'	26' (s)	8.5'	13-24'	overburden	50 (10 gpm @ 1' dd)	NA	NA	Interval isolated from deeper zones; borehole functions as piezometer	Provides for both shallow and deep groundwater quality and hydrology
				32-42'	Homewood sandstone	<1/10	32-42'	33'	Good water-bearing potential	
B-11	65'	18.5'	41.5'	55-59'	Homewood sandstone	6	NA	NA	Only one significant water-bearing zone; borehole functions as piezometer	Provides for ground-water quality and hydrology below strip area
B-12	80'	17.5'	17.9'	18-30'	shallow aquifer clay and shale	1/3				
				50-54'	major coal	1/10	50-55'	51'	Water-bearing interval; borehole functions as shallow horizon piezometer	Provides for back-ground water quality and hydrology
				72-75'	Homewood sandstone	1/10	71-76'	72'	Water-bearing interval	
B-13	80'	13.5'	28.7'	51-55'	major coal seam	1/4	50-55'	51'	Water-bearing interval; borehole functions as	Provides for back-ground water quality
				24 piezometers total						

NOTE: All measurements are in feet below ground surface.



DETAIL FOR AIR ROTARY BOREHOLES

NOT TO SCALE



DETAIL FOR PIEZOMETER INSTALLATION IN BOREHOLES

NOT TO SCALE

BACKHOE PIT PIEZOMETER AND LYSIMETER INSTALLATION

In general, the backhoe pit piezometers and lysimeters were constructed in accordance with the technical specifications for the Mashudda Strip Mine project, contained in the Bid Documents prepared by REWAI and filed with the Pennsylvania Department of Environmental Resources. The materials used in the backhoe pit piezometers were the same as those used for the borehole piezometers. The procedure for installation was as follows:

o The pit was excavated to total depth, which occurred either at bedrock refusal, or at the deepest reach of the backhoe bucket. The piezometer screen and riser pipe were then set at the bottom of the pit, inside a six-inch PVC protector pipe. Sand was then packed in the annular space, and the six-inch protector pipe was slowly raised as the pit was backfilled. Sand was kept in the annular space at all times to ensure a good pack for the entire length of the screen. If necessary, a Peltonite seal was placed over the pack. The protector pipe was then removed from the hole as the hole was finally backfilled to ground level. The accompanying figure at the end of this section shows an idealized representation of the backhoe pit piezometer construction.

Protection devices for the pit piezometers were not on-site at the time of installation, and settling of the disturbed material prevented any type of caps to be installed. These were installed at a later date, constructed from a short phase of six-inch casing grouted in place, with a locking cap.

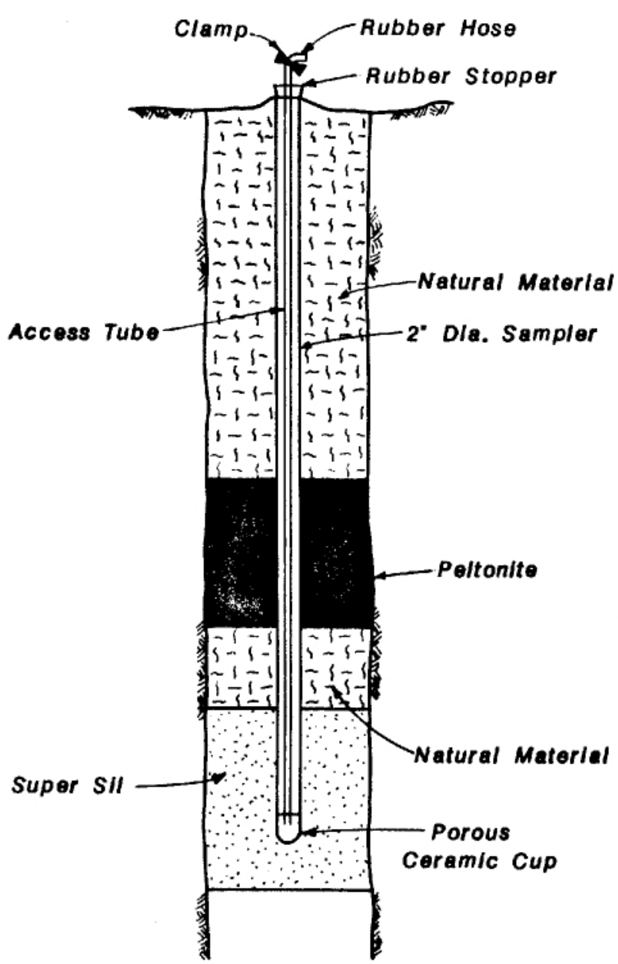
The piezometers were later developed by REWAI by bailing with a 1 1/2-inch stainless steel bailer. When possible, three well volumes were removed from each piezometer.

The soil water sampling devices, or lysimeters, were installed adjacent to the backhoe pits in relatively undisturbed soils. The materials used for these installations are as follows:

1. Soil Test 36-inch model A-25 soil water sampler.
2. Super silica sand.
3. Peltonite bentonite.

To install the lysimeters, the top one-half to one foot of frozen ground was removed with the backhoe bucket. A four-inch auger hole was then bored to total depth. A bed of super-sil was laid in the bottom of the hole, and the lysimeter set on this. The annulus was then filled with super-sil to cover the bottom porous cup in the lysimeter to at least three inches. A six-inch thick Peltonite seal was then placed over the super-sil, and the remainder of the hole backfilled with natural material. The accompanying figure at the end of this section shows an idealized representation of the lysimeter installations. Lack of materials prevented protector pipes from being installed at this time; however, they were installed later.

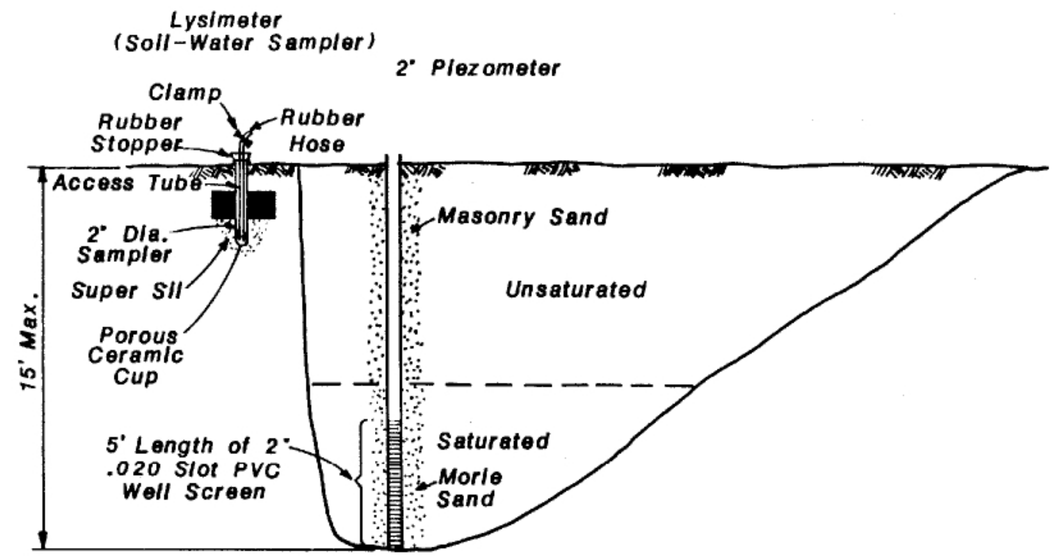
The lysimeters were "developed" by applying a vacuum to the lysimeter tube. This drew soil water from the undisturbed zone into the tube body. This development water was removed with a suction pump, and a vacuum was then reapplied to the tube to get the actual sample.



DETAIL FOR LYSIMETER CONSTRUCTION

(SOIL-WATER SAMPLER)

NOT TO SCALE



DETAIL FOR PLACEMENT OF LYSIMETERS AND PIEZOMETERS IN BACKHOE EXCAVATION

NOT TO SCALE

PULSE TESTING METHODS

The pulse testing procedure performed at the Mashudda Strip Mine is as follows:

1.An initial static water level was taken.

2. A cylindrical tube of measured volume was quickly, but smoothly lowered below the water level, raising the fluid surface.

3.The initial water level rise and subsequent recovery to static conditions over time were continuously monitored by a pressure transducer, with readings displayed graphically on a strip chart recorder. At times, manual measurements may also have been made in place of the pressure transducer/recorder.

4. Once this initial test was complete, the tube was smoothly withdrawn from the well, and the water level drop and subsequent recovery similarly monitored, thus completing a second test. A minimum of two such tests were run per piezometer.

5. The data was then plotted on semi-log paper and analyzed by the Bouwer and Rice method to find hydraulic conductivity.

6. This data was compiled by aquifer, and a range and mean for each was calculated. The aquifers so evaluated are the Brookville/Clarion coal, Homewood sandstone, overburden, and various clastic rocks occuring above and below these primary aquifers.

GROUNDWATER SAMPLING PROCEDURE

The piezometers sampled at the Mashudda Strip Mine, excluding B-I, had at least one well volume of water evacuated prior to sampling. The amount of water to be removed was calculated by use of the equation:

$$\pi r^2 h = \text{well volume in cubic feet}$$

Where: r = radius of the piezometer in feet;
h = height of the water column in feet.
(1 cubic foot = 7.481 gallons of water)

Various methods of evacuation were employed in order to remove the well volumes and subsequent sample. The shallow, low-yielding two-inch wells were bailed by hand, using a bottom-plugged stainless steel bailer. High yielding wells with shallow water levels were pumped using a small centrifugal suction pump, with a check valve on the bottom of the intake line. The six-inch diameter wells with deep water levels were pumped with a one-half horsepower submersible pump on black PVC coil pipe. Due to accessibility problems from heavy rain and mud, it was not possible to pump B-I, and so it was necessary to hand bail this well. However, during dryer conditions, it should be possible to pump this well.

The actual sampling technique for taking groundwater samples is identical to that for surface water sampling (See Surface Water Sampling Procedure).

SURFACE WATER SAMPLING PROCEDURE

Stream samples for pH, acidity, alkalinity, and sulphate determinations were collected in 16-ounce plastic bottles, being sure to allow no air space. Samples collected for metal analyses were filtered through a 0.45 micron cellulose membrane and acidified to pH 2.0 with nitric acid before filling a 4-ounce plastic bottle with no air space. All sample bottles were labeled with the sampling location, project number and date, refrigerated or kept on ice, and returned to DER for analysis. All plastic bottles were provided by the Department, and lab analyses were performed by the Hawk Run Treatment Plant in Hawk Run, Pennsylvania, at the expense of the Department.

During the August 1982 and February 1983 sampling runs, an extra 16-ounce bottle was collected in the field and kept on ice for acidity and alkalinity analyses, which were performed that same evening. Methyl orange and phenolphthalein acidity and phenolphthalein and total alkalinity measurements were determined by titrating to a color endpoint following the procedure indicated in Standard Methods, 13th ed., 50 and 52 (1971).

SURFACE FLOW MEASUREMENT PROCEDURE

A Teledyne gurley pygmy-type flow velocity meter was used by REWAI personnel to measure all stream flows during the August 1982, February 1983, and April 1984 site visits. This meter contains a cup-type bucket wheel mounted on a vertical shaft. Use of the pygmy meter is limited to velocities up to three or four feet per second. Such velocities were met while measuring the high flows in February 1983 and were only exceeded at Station GR-53 with a measurement of 4.33 feet per second.

The width of the stream was measured and then, advancing in one-foot intervals across the stream, the depth and mean velocity in each vertical segment were measured. Therefore, the depth and mean velocity were measured for each of a number of segments along the stream's cross-section. The product of the mean velocity and the respective cross-sectional area gives the flow for that given area. The total flow of the stream is a summation of these flow components. Greater width intervals, and therefore fewer segments, occurred only when the current was high and very forceful, making it difficult to cross.

The method used to determine mean flow velocity in each vertical segment was the six-tenths depth method, which consists of measuring the velocity at 0.6 of the total depth below water surface. Whenever the water depth is between 0.3 and 2.5 feet, this method gives very reliable results. The maximum depth of water encountered during REWAI flow measurements was 2.0 feet.