CHAPTER VI

GEOLOGIC DESCRIPTIONS

The geologic description of the proposed permit and adjacent areas is the culmination of the background data search, geologic sampling and analysis programs, and the construction of maps and cross sections. Once the raw data have been collected, analyzed, and diagramed, a narrative of the existing geology can be easily made and predictions of impacts assessed. However, such narrative and predictive interpretations should be completed by, or under the direction of, a professional qualified in the subject to be analyzed (i.e., a qualified professional geologist). Applied geology, such as engineering applications to slope stability, may be prepared by an engineer or engineering geologist.

The following sections describe a progressive format for the preparation of a geologic description. While this format is not mandatory, the use of this format will satisfy the requirements of the Act and regulations. Any reference materials utilized in the writing of the geologic description should be properly cited, with a complete bibliography being provided at the end of the narrative.

> ***Note: The examples used in the following sections are intended to provide guidance on format and content. These examples are not to be construed as a minimum standard, as most permit applications will require more detail than is provided in these brief descriptions.***

A. PHYSIOGRAPHY

The terms physiography and geomorphology can be used interchangeably for the description of the surface features of an area. This would include a classification of geomorphic region, the physical description of the area, and any unique surface expression related to any underlying geologic structure. For surface mining applications, the description of physiography and topography are closely related. An example of a physiographic description follows:

> <u>*EXAMPLE*</u>
>
> *The proposed permit area is located in the Kanawha Section of the Appalachian Plateaus physiographic province. The area is characterized by deep steep-sided valleys and narrow winding ridges. The ridgelines are undulating and generally trend in a northeasterly direction. The valley floors are narrow with little or no flood plain development. Although the Warfield Anticline is present in the vicinity of the proposed operation, no surface effects on the area physiography or topography were noted.*

B. TOPOGRAPHY

The topography of the proposed permit and adjacent areas directly affect runoff, infiltration, subsidence, and slope stability. Therefore, a basic knowledge of the area topography is needed to determine how it affects the mining and reclamation plan. A description of the area topography should include, at a minimum, the following information:

- Elevation of the mine site
- Relief of the area
- Depth of cover (underground operations)
- Land slope information
- Stream channel slope information

EXAMPLE

The proposed permit area is located in the Little Coal River watershed, at an approximate elevation of 1620 feet (above msl). Area relief averages 1500 feet, with elevations ranging from approximately 1000 feet (above msl), along the stream bottoms, to more than 2700 feet (above msl) along the major ridgelines. Average land slopes in the area are considered to be the steepest in the State, exceeding 40 percent. Land slopes of 20 percent or less are confined to ridgeline and footslope areas. Stream channel slopes are greatest in the low-order headwater streams and areas of greatest relief. In the general vicinity of the proposed operation, stream slopes average from 60 to 100 feet/mile.

C. GEOLOGIC STRUCTURE

The structural geology of a region or area may be described by using the general geometry, orientation, spatial distribution, or relative positions of the rock masses. For a surface mining application, a description of the structural geology should include both a regional and site-specific identification of any faults, folds, fracture patterns, and the general attitude of the geologic strata. Structural features should be identified and described in sufficient detail to determine the control of, or effect on, surface- and ground-water resources (See section G of this Chapter).

EXAMPLE

Regionally, geologic strata dip to the northwest at less than 1° in a broad monoclinal structure. However, superimposed on the regional structure is the Warfield Anticline and the Coalburg Syncline. These two structures parallel each other with a general trend to the northeast. No known major faulting has occurred in the area. In the proposed permit and immediately adjacent areas, geologic strata dip to the southeast, off the Warfield Anticline, at approximately 3°. Fracture patterns, measured in exposed highwalls, tend to parallel the topography as is common with stress-relief fracturing in West Virginia.

D. LITHOLOGY AND STRATIGRAPHY

The area stratigraphy and lithology should be broken into regional and site-specific descriptions. The regional description is more related to the overall position of the mine site, with regards to relatively extensive, mapped, stratigraphic units, such as the Monongahela or Conemaugh Groups. Each major stratigraphic unit should briefly be identified by the age and lithologies involved in each group or formation.

> *EXAMPLE 1*
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> *The mine site is located on the top of Briery Mountain, near the western edge of the Allegheny Mountains. The rocks of Briery Mountain are comprised primarily of Pennsylvanian age strata that, in descending order, represent the Conemaugh Group, Allegheny Formation, and Pottsville Group. Mississippian limestones and shales are also exposed on the eastern slope of Briery Mountain near its base. The Conemaugh Group is characterized by sandstones, shales,limestones and coals. The Allegheny Formation and Pottsville Group are more characterized by conglomeratic sandstones, shales, and coals.*

Once the regional setting is described, a site-specific discussion of the area stratigraphy is provided, which identifies all rock units that will be disturbed by the mining operation. For underground mining operations, the description should extend through the highest stratigraphic unit, under which mining will occur. Depending upon the geologic structure of the area, this may or may not correlate with the maximum depth of cover. The description should also extend down to, and include, the first potentially affected aquifer below the lowest coal seam to be mined. All coal seam and marine zones to be disturbed should be named using a nomenclature presently recognized by the West Virginia Geologic and Economic Suvey.

> *EXAMPLE 2*
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> *In the proposed permit area, all disturbance is confined to geologic strata of the Conemaugh Group. These include, in descending order, the Buffalo Sandstone, Brush Creek Shale, Brush Creek coal, Brush Creek Fire Clay, Upper Mahoning Sandstone, Mahoning Red Shale, Mahoning ("six-foot") coal, Thornton Fire Clay, and the Lower Mahoning Sandstone. The Sutton Limestone was not identified in the permit area. The Lower Mahoning Sandstone is the first potentially impacted aquifer below the Mahoning coal seam.*

After the site-specific stratigraphy has been established, the lithology of each geologic unit or member should be briefly described. This description should extend from the upper-most strata proposed for disturbance, down to and including, the stratum immediately below the lowest coal seam to be extracted, or the first potentially impacted aquifer below the lowest coal seam to be extracted. In either case, the site-specific description should extend to a minimum of 20 feet below the lowest coal seam, so that an assessment of the downward migration of ground water can be made. For underground mining operations requiring a subsidence control plan, this type of detail may be required for all strata above the proposed workings.

EXAMPLE 3

Only the lower 15 to 25 feet of the Buffalo Sandstone would be disturbed by mining activities in the proposed permit area. Where disturbed, the sandstone is light gray, massively-bedded, coarse- to medium-grained, and moderately sorted. Minor amounts of muscovite appear to be disseminated throughout the unit. The sandstone appears to be cemented primarily with silica, although a significant clay fraction is also present.

E. GEOCHEMICAL PROPERTIES

A summary of the geochemical analyses of the coal and geologic strata should be presented in narrative form. The narrative should describe the relative position of all acid- or toxic-forming zones along with the levels of potential acidity and/or toxicity that might be generated. The description should also discuss the significance of these acid/toxic zones, as compared to the overall geochemical composition of the proposed permit area. Zones of special interest, such as rock units exhibiting exceptionally high neutralization potential or units proposed for use as a topsoil substitute, should also be described.

EXAMPLE 1

Based on the results of the analysis of geologic strata and coal, it was determined that two potentially acid-forming strata are present on site. The first is a black shale horizon located immediately above the Bakerstown coal seam. This zone is approximately 3 feet thick and has a net acid-base (NAB) account of -97.4 tons of $CaCO_3$ equivalents/1000 tons of material. The second zone is located approximately 80 feet above the Bakerstown coal seam and can be identified as a dark gray shale parting in the massive sandstone unit overlying the Portersville Limestone. The parting is discontinuous over the permit area, although where present it averages 2 feet thick. This zone has an NAB value of -34.2 tons of $CaCO_3$ equivalents/1000 tons of material. The over all site exhibits an excess neutralization potential, with the NAB for the noncarbonate strata averaging around +34 tons of $CaCO_3$ equivalents/1000 tons of material. The 15 feet of Portersville Limestone greatly enhances the neutralization potential by adding carbonate strata with an NAB of +845 tons of $CaCO_3$ equivalents/1000 tons of material.

In areas where weathering of geologic strata has or can significantly skew the data provided in the geochemical analyses of rock and coal materials, a description of weathering effects should also be included. This description should include information on the depth and degree of weathering, along with the possible effects this might have on the interpretation of the net acid-base account.

> *<u>EXAMPLE 2</u>*
>
> *Based on the results of drilling and soil sampling programs, it appears that significant weathering has occurred to depths averaging 15 feet. This is documented by the relatively low paste pH values in the upper samples collected from test borings, and the relatively low neutralization potential associated with these same zones. However, the major neutralizing strata, the Portersville Limestone, is located near the base of the section (approximately 10 feet above the Bakerstown coal) and will be relatively unaffected by weathering except at the outcrop area. As a result, the toxic materials handling plan has been designed to prevent any disposal of acid-forming materials in all outcrop areas where this limestone may have been removed by weathering. However, to ensure that adequate neutralizing material is available in these areas, agricultural-grade lime will be added at a rate of 30 tonsil tons of spoil. A detailed discussion of disposal techniques is described in the toxic material handling plan section.*

F. ENGINEERING PROPERTIES

Where engineering properties of rocks or refuse materials are required, a brief description of the results should be included that identifies what materials were tested and their relative position in the overburden column. This type of discussion is usually restricted to applications involving the use of durable rocks, subsidence control plans, and zones of interest related to foundation studies or slope stability.

> *<u>EXAMPLE</u>*
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> *Based on the results of rock durability testing, the only rock unit suitable for use in underdrain construction is the Upper Freeport Sandstone. This sandstone is positioned directly above the Lower Freeport coal seam, and averages 15 to 25 feet thick across the permit area.*

G. SITE HYDROLOGY

The level of detail needed for an accurate description of the site hydrology will vary, based on the site-specific needs and considerations. Also, the emphasis on the types of hydrologic information needed will depend on the type of mining operation and the topographic and geologic setting. A description of the site hydrology should identify all aquifers, both perched and regional, and their position relative to the proposed mining activity. The aquifers should be identified by name, where applicable, and include detailed information on the thickness, areal extent, lithology, current use, and any hydrologic characteristics (e.g., hydraulic conductivity, yield, seasonal head fluctuations) needed to determine site-specific impacts.

EXAMPLE 1

The only potentially impacted aquifer identified in the vicinity of the proposed permit area is the Homewood Sandstone. The Homewood Sandstone averages 150 feet thick, in this area, and outcrops in the valley floors at an approximate elevation of 1300 feet (above msl). This sandstone is recognized as a regional aquifer throughout this section of Kanawha County because of its thickness and accessible position along the valley floor. The Homewood Sandstone is a well cemented, medium- to coarse-grained, often conglomeratic sandstone, with little primary porosity or permeability. Therefore, the primary source of ground-water movement and storage is along joints and bedding plane surfaces. Within a one-mile radius of the mine site, approximately 15 residents were identified as using water from this aquifer unit.

EXAMPLE 2

The hydraulic characteristics of the Homewood Sandstone are directly controlled by the number of water-bearing fractures encountered by the well. In the vicinity of the mine site, well yields range from 3 to 40 gallons/minute (gpm), although the average is less than 5 gpm. Water-level measurements made during the background ground-water monitoring period, show that seasonal water-level fluctuations average around 4 feet. Hydraulic conductivities were not calculated for this aquifer.

Hydrologic characterization of these aquifer units will normally require field testing using slug, pump, or down-hole pressure testing. Such hydrologic testing should only be conducted by a competent, qualified driller and person(s) with experience in these types of testing procedures. Such techniques are beyond the scope of this handbook, although detailed information and references can be obtained through most current hydrology texts. Current titles in ground-water hydrology can be acquired through most major bookstores, or by contacting the:

National Ground Water Association
601 Dempsey Road
Westerville, Ohio 43081
(800) 551-7379

The geologic description should specifically address the directions of ground-water movement in the permit and adjacent areas and the affect of the geologic structure on this movement. Directions of ground-water movement are determined from water-level measurements made in the same aquifer unit in the area. Based on the elevations of these water levels, a potentiometric surface map can be constructed. Using the premise that ground water moves from areas of high hydraulic head to areas of low hydraulic head, the direction of ground-water movement can be determined. More details on the construction of potentiometric surface maps can be obtained from the aforementioned sources of ground-water information.

EXAMPLE 3

Based on water-table elevations, measured for area wells, a potentiometric surface map was developed for the Homewood Sandstone aquifer. The results indicated that ground-water movement is generally toward the southeast, following a decline in hydraulic head, toward the center of the main Elk River valley.

The discussion of existing site hydrology should also address the effects of geologic structures on the storage and movement of ground and surface water. Geologic joints and fractures are often the primary avenues for contaminant transport, and any recognizable or mapped pattern should be described. Also, attitude of bedding, resulting from regional dip or local folding, can have a direct influence on the direction of ground-water movement. Any such documentable evidence of ground-water movement, attributable to geologic structure, should be included. However, unsupported casual statements like "ground water moves down-dip" are often misleading and incorrect. Such unsupported observations should not be included in the hydrologic description, unless it can be documented through measured data.

EXAMPLE 4

Ground water in the vicinity of the proposed operation is controlled by two different mechanisms. First, ground water moves from areas of high elevation (ridgelines and slope areas), to areas of low elevation (valley bottoms), following a stair-step pattern established by stress-relief fractures. These stress-relief fractures basically parallel the surface topography, with the more open fractures being confined to the more competent rocks such as the sandstone and limestone units. However, the Homewood Sandstone aquifer follows a more regional flow pattern, with the ground-water movement more closely following the area dip toward the Elk River.

H. GEOLOGIC/HYDROLOGIC IMPACTS

Once the existing hydrology and geology have been established, the potential impacts resulting from mining can be determined. The potential impacts identified in this section should also be identified in the permit application, under the sections dealing with prediction of the probable hydrologic impact (PHC) and the hydrologic reclamation plan.