

# PREFACE

The West Virginia Department of Environmental Protection (WVDEP), Division of Mining and Reclamation, has developed this geologic handbook for the purpose of assuring consistency in the technical review of permit applications. It is also intended to be used as a technical manual for industry representatives preparing a permit application under the West Virginia Surface Mining Program. The document explains the types of information, which may be required in a permit application, including procedures to sample and analyze geologic strata. The format of this document is designed to follow a logical progression from the collection of existing data to the writing of a geologic description. Because the West Virginia surface mining reclamation regulations and the permit application form are subject to change, the handbook was intentionally written to exclude regulatory citations and application cross-references. The checklist identifies the regulatory citation and appropriate handbook section for each item of the current application form. The checklist will be revised and replaced as changes in the application or regulations occur. Also, the handbook itself will be periodically reviewed and updated to accommodate changes in technical procedures and requirements.

A geologic sampling and analysis program designed to meet the requirements of the West Virginia surface mining regulations should never be undertaken without the direct supervision of a qualified individual. This handbook is written with the assumption that the reader has a basic knowledge of geology and geologic principles. However, in addition to this handbook, the reader may find it useful to obtain a copy of the following types of reference materials: a current geologic dictionary, a guide to geology field techniques, a manual on drilling and sampling techniques, a basic geology textbook, a basic ground-water hydrology text, and a guide to well log interpretations.

***Please note that this handbook does not have the force of law.*** It has been prepared solely as a "tool" to promote consistency and efficiency in the preparation and review of the geologic portions of the permit application. Although this handbook provides a thorough discussion of the various procedures, which may be used to satisfy the geologic regulatory requirements, the WVDEP does recognize that alternative methods and procedures are available.

***Also note: All drawings and geologic descriptions used as examples in this text were prepared for the sole purpose of illustrating the types of information, which should be submitted in a permit application along with appropriate construction techniques for drawings. They were not prepared to reflect any actual geologic conditions in the State of West Virginia.***

# TABLE OF CONTENTS

<b>Preface.....</b>	<b>i</b>
1. Introduction.....	1
<b>II. Background Data Search and Planning.....</b>	<b>3</b>
A. Equivalent Information .....	3
B. Sources of Information.....	4
C. Pre-Permit Planning .....	4
1. Mining Method .....	4
2. Site Sensitivity .....	7
3. Geologic Controls .....	7
<b>III. Geologic Sampling Methodology .....</b>	<b>10</b>
A. Sample Collection Techniques .....	10
1. Air Rotary Drilling.....	10
2. Continuous Core Drilling.....	15
3. Highwall/Outcrop Sampling .....	18
4. Summary Comparison of Techniques.....	20
B. Well and Sample Logging Techniques .....	22
1. Site Location .....	22
2. Geologic Logs .....	23
3. Geophysical Logs.....	25
C. Basic Drilling Patterns and Sampling Intervals .....	27
1. Horizontal Spacing.....	29
a. Contour Mining and the Mining of Dipping Beds .....	29
b. Mountaintop Removal .....	31
c. Underground Mining.....	33
2. Vertical Composites and Analysis Intervals .....	34
D. Quality Assurance and Control Issues .....	39

Table of Contents

1.	Reports .....	39
a.	Site Conditions and Personnel .....	39
b.	Drilling Equipment and Methods.....	40
c.	Sample Collection.....	40
d.	Sample Identification .....	40
e.	Sample Preparation .....	40
f.	Sample Site Location .....	41
2.	Chain of Custody .....	41
<b>IV.</b>	<b>Analytical Techniques - Parameters and Methodologies .....</b>	<b>42</b>
A.	Physical Analyses.....	42
1.	Lithology.....	42
2.	Color .....	46
3.	Grain Size.....	46
4.	Mineralogy .....	47
5.	Cementing Agents.....	49
6.	Fossils .....	50
7.	Streak .....	50
8.	Sorting.....	50
9.	Bedding.....	52
10.	Fracturing and Weathering Patterns.....	52
B.	Chemical Analyses.....	55
1.	Net Acid-Base Accounting .....	55
2.	"Simulated Weathering," or Leaching Tests .....	62
C.	Engineering Analyses.....	68
1.	Rock Durability.....	69
2.	Engineering Properties .....	70

<b>V.</b>	<b>Geologic Cross Sections, Maps, and Plans.....</b>	<b>72</b>
A.	Construction and Correction Techniques.....	72
1.	Determination of Strike and Dip.....	72
2.	Correction for Strike and Dip .....	74
B.	Drawing Details .....	77
1.	Geologic Cross Sections .....	77
2.	Geologic Column .....	80
3.	Fence Diagrams.....	83
4.	Hydrogeologic Maps .....	86
5.	Structural-Contour Maps .....	89
6.	Isopach Maps .....	89
7.	Lineament Maps (Fracture Trace Analysis).....	91
8.	Isosulfur and Other Isocon Maps .....	94
<b>VI.</b>	<b>Geologic Descriptions .....</b>	<b>95</b>
A.	Physiography.....	95
B.	Topography .....	95
C.	Geologic Structure .....	96
D.	Lithology and Stratigraphy.....	97
E.	Geochemical Properties .....	97
F.	Engineering Properties .....	99
G.	Site Hydrology .....	99
H.	Geologic/Hydrologic Impacts .....	101
<b>VII.</b>	<b>Geologic Requirements for Ancillary Facilities .....</b>	<b>103</b>
A.	Haulroads .....	103
B.	Tipples and Preparation Plants.....	103

*Table of Contents*

1.	Geologic Logs .....	104
2.	Geologic Cross Sections, Maps, and Plans .....	104
3.	Chemical Analyses of Strata .....	104
4.	Chemical Analyses of Coal Stockpiles .....	104
5.	Geologic Description .....	105
C.	Barge-Loading Facilities .....	105
D.	Refuse Disposal Areas .....	105
1.	Geologic Drilling and Sampling .....	106
2.	Geologic Cross Sections, Maps, and Plans .....	106
3.	Chemical Analyses of Strata .....	106
4.	Chemical Analyses of Refuse Material .....	106
5.	Geologic Description .....	107
6.	Engineering Applications .....	107
7.	Underground Disposal .....	108
E.	Underground Injection .....	108
1.	Geologic Cross Sections, Maps, and Plans .....	108
2.	Chemical Analyses of Injection Materials .....	109
3.	Geologic Description .....	109
F.	Other Waste Disposal Areas .....	109
1.	Sediment Pond Materials .....	110
2.	Coal Ash .....	111
3.	Water Treatment Sludge .....	111
<b>VIII.</b>	<b>Geologic Waivers and the Use of Equivalent Information.....</b>	<b>113</b>
A.	Information Considered For Waiver Requests.....	113
B.	Waiver Approval or Denial.....	113
C.	Types of Equivalent Information .....	114
1.	Geologic Logs .....	114
2.	Geochemical Analyses .....	115
3.	Thickness and Engineering Properties of Clays or Soft Rock .....	115
D.	Examples of Geologic Waiver Requests.....	116
B.	Waiver or Variance Approval .....	118

**BIBLIOGRAPHY .....119**

**APPENDIX A: Standard Abbreviations for Lithologic Descriptions .....124**

**APPENDIX B: Lithologic Symbols for Geologic Cross Sections and Columns .....129**

**APPENDIX C: Standard Geologic Mapping Symbols.....131**

**FIGURES**

I-1 Flow Diagram Showing Relationship of Geologic Information to Other Parts of the Permitting Process .....1

III-1 Diagram of Diverter and Casing for Collection of Rotary Cuttings .....14

III-2 Example of a Geologic Log .....24

III-3 Recommended Drilling Pattern for Specified Mining Methods .....30

    a. Example Drilling Patterns for Area Mining Operations .....30

    b. Example of Drilling Pattern for Contour Mining and Mining in Inclined Strata .....31

III-4 Recommended Drilling Pattern for Specified Mining Methods .....32

    a. Example Drilling Pattern for Mountaintop Removal Operations .....32

III-5 Example of Composite Intervals.....36

IV- 1 Sorting Table.....51

IV-2 Schematic Cross Section Showing Typical Position of High Sulfur and Alkaline Strata Along With Effects of Weathering .....54

V-1 Example of Strike and Dip Calculations Using a Three-Point Problem.....73

V-2 Example of Method for Determining Coal Outcrop Elevation.....75

V-3 Example of Elevation Correction in Inclined Strata .....78

*Table of Contents*

V-4 Typical Geologic Cross Section.....80

V-5 Location of Cross Section X - X' and Drill Holes A, B, C.....81

V-6 Composite Geologic or Stratigraphic Column.....83

V-7 Typical Fence Diagram .....84

    a. Illustration of Fence Diagram .....84

    b. Locations and Relative Positions of Drill Holes  
        Used to Construct Fence Diagram .....84

V-8 Typical Geologic Map.....87

V-9 Typical Geologic Structure Map.....89

    a. Structure Map Drawn on the Base of Coal Seam .....89

    b. Structure Map Drawn Against an Underground Mine Workings Map.....89

V-10 Typical Isopach Map.....92

    a. Isopach Map Showing Depth of Cover.....92

    b. Isopach Map Showing the Relative Thickness  
        of a Potentially Acid-Forming Shale Unit .....92

V-11 Example of a Lineament Map.....94

**TABLES**

II-1 West Virginia State Government Sources of Geologic and Related Information.....5

II-2 Federal Government Sources of Geologic and Related Information .....6

II-3 Nongovernmental Sources of Geologic and Related Information .....7

II-4 Criteria for Recognizing Depositional Environments.....9

III-1 Summary of Geologic Sampling Methods Including Their Applications to  
Different Environmental Situations, Limitations, and Special Requirements .....21

III-2	Summary of Common Geophysical Logging Techniques .....	28
III-3	Example of Dilution or Masking Effect by Over Compositing of Geologic Samples .....	37
IV-1	Grain-Size Classifications and Relative Ranges .....	47
IV-2	"Fizz" Rating Scale .....	57
IV-3	Volume and Normality of HCl used to do NP Digestion Based on the Sample "Fizz" Ratio.....	57