

LIST OF FIGURES

Chapter 1

| | |
|---|----|
| Figure 1.1 Distribution of the 16 FBC Power Plants in Pennsylvania | 3 |
| Figure 1.2 Annual Coal Refuse Consumed by FBC in Anthracite and Bituminous regions..... | 5 |
| Figure 1.3 Cumulative coal refuse consumed by coal region..... | 6 |
| Figure 1.4 Acres of Mine Reclaimed by FBCs in Anthracite and Bituminous regions..... | 8 |
| Figure 1.5 Distribution of 21 Coal-Fired Power Plants | 9 |
| Figure 1.6 Locations of beneficial use sites discussed in this book..... | 11 |

Chapter 2

| | |
|---|----|
| Figure 2.1 Map of Physiographic Provinces of PA. | 20 |
| Figure 2.2 Principal structural features of the Anthracite Coal Fields (from Wood et al., 1986) | 24 |
| Figure 2.3(a). Cross-section of the geologic structure of the Allegheny Plateau (from King 1977) | 25 |
| Figure 2.3(b) Cross-section of the geologic structure of the Ridge and Valley Province | 25 |
| Figure 2.4 Generalized location of surface anticlines in the Appalachian Plateau's Province. (from Beardsley et al.1999) | 27 |
| Figure 2.5 Generalized stratigraphic sections of the Allegheny and Conemaugh Group (from Edmunds et al., 1999) | 28 |
| Figure 2.6(a) Lower Kittanning and Middle Kittanning Coals and brackish overburden strata from Clearfield County, PA. (from Brady et al., 1998)..... | 30 |
| Figure 2.6(b) Upper Kittanning and Lower Freeport Coals and nonmarine overburden strata from Fayette County, PA | 31 |
| Figure 2.7 Generalized columnar sections showing names, average thickness of coals (in ft), and intervals between coal beds in the Pennsylvania Anthracite fields. Figure is primarily from Wood et al. (1986). Information on calcareous zones in the Northern Field has been supplemented by data from Edmunds et al. (1998) and Inners and Fabiny (1997) | 34 |
| Figure 2.8 Stratigraphic interval from the Mammoth Coal zone up to the Primrose coal bed at the Wadesville site Figure 2.4. Generalized location of surface anticlines in the Appalachian Plateau's Province. (from Beardsley et al., 1999)..... | 36 |
| Figure 2.9 A schematic of the outcrop at mile marker 138 along Interstate 81, near McAdoo, PA, showing the contact between the Mauch Chunk and Pottsville Formations (modified from Bolles and Geyer, 1976)..... | 37 |
| Figure 2.10 Block diagram showing shallow, intermediate, and regional (deep) groundwater flow systems in the Bituminous Coal Region of western PA, (from Parizek 1979) | 38 |
| Figure 2.11 Idealized pattern of groundwater flow in the Mercer Quadrangle, PA | 40 |
| Figure 2.12 Bimodal distribution of pH for (a) bituminous mines and (b) anthracite mine discharges in PA. Bituminous data are from Table 8.2 in Brady et al. (1998) and anthracite data are from Growitz et al., (1985). Bituminous data are displayed from stratigraphic group and anthracite data by coal field..... | 41 |

| | |
|---|----|
| Figure 2.13 Map of collieries in Wyoming Basin of the Northern Field (from Hollowell,1973) | 43 |
| Figure 2.14 Schematic diagram of water flow through the mines (eg. Barrier pillar breaches) in the Wyoming Basin, (from Hollowell 1973)..... | 43 |
| Figure 2.15 Jeddo Tunnel drainage system (from Hollowell 1999). | 44 |
| Figure 2.16 Water discharge from the Jeddo Tunnel in Hazleton, and Wapwallopen Creek near Wapwallopen, PA, October 1, 1974 to September 30, 1975 (from Growitz et al. 1985) | 45 |
| Figure 2.17(a) Discharge from the Jeddo Tunnel - water years 1996-1998 (from Ballaron 1999) | 47 |
| Figure 2.17(b) Precipitation data from Hazleton, PA 1996-1998 (from Fox et al., 2001) | 47 |
| Figure 2.18 (a) and (b) Boxplots showing differences in pH and sulfates from the four anthracite fields in eastern PA. (from Brady et al., 1998) | 50 |
| Figure 2.19 Anthracite production, 1890-1995 (from Eggleston, et al., 1999) | 50 |
| Figure 2.20 Typical anthracite underground mining practices (modified from Eggleston et al., 1999). | 51 |

Chapter 3

| | |
|--|----|
| Figure 3.1 USDA Soil Triangle Classification Chart (The Asphalt Institute, 1978)..... | 54 |
| Figure 3.2 Typical display of compaction test data | 55 |
| Figure 3.3(a) Plot of Proctor Density lab test results..... | 56 |
| Figure 3.3 (b) Plot of Proctor Density lab test results..... | 56 |
| Figure 3.4(a) Plot of Maximum Dry Density..... | 57 |
| Figure 3.4(b) Plot of Optimum Moisture Content | 57 |
| Figure 3.4(c) Field compaction tests of ash from various ash sources | 58 |
| Figure 3.5 Map of NEPCO site showing Big Gorilla Pit..... | 60 |
| Figure 3.6 Map of Reading Anthracite Co. Knickerbocker Site..... | 64 |
| Figure 3.7 Coal ash conveyor at left of photo delivers ash from Gilberton Power Company FBC plant to mineral processing equipment shown in center of photo to produce an aggregate which meets PA Department of Transportation specifications..... | 67 |
| Figure 3.8 Effect of lime addition on leachability of minor constituents and trace constituents | 67 |
| Figure 3.9 Effect of lime addition on leachability of minor constituents and trace constituents | 68 |
| Figure 3.10 Effect of lime addition on compressive strength..... | 68 |

Chapter 4

| | |
|---|----|
| Figure 4.1 Location of coal ash beneficial use mine sites in PA | 73 |
| Figure 4.2 Westwood FBC plant near Tremont in Southern Anthracite Field | 74 |
| Figure 4.3 Site map of Northampton Fuels – Alden mine site | 79 |
| Figure 4.4 Reclaimed area at Northampton Fuels – Alden site | 80 |
| Figure 4.5(a) Alkalinity in groundwater monitoring points at Northampton Alden site | 82 |
| Figure 4.5(b) Sulfate in groundwater monitoring points at Northampton Alden site..... | 82 |
| Figure 4.6 Site map of Wheelabrator – Morea mine site..... | 83 |
| Figure 4.7(a) Ash placement in pits..... | 84 |

| | |
|--|-----|
| Figure 4.7(b) Wildlife plantings..... | 84 |
| Figure 4.7(c) Morea minepool and FBC plant..... | 84 |
| Figure 4.7(d) Extensive reclamation area..... | 84 |
| Figure 4.8(a) Acidity in minepool and stream at Wheelabrator site..... | 86 |
| Figure 4.8(b) Calcium concentration in minepool and stream at Wheelabrator site | 87 |
| Figure 4.9 Map of B-D Mining site showing permit boundary, ash disposal areas and monitoring locations | 88 |
| Figure 4.10(a) Culm, fuel processing, and conveyor to Gilberton Power Plant..... | 89 |
| Figure 4.10(b) Silt dam and adjacent ash reclamation area | 89 |
| Figure 4.10(c) Extensive reclamation area | 89 |
| Figure 4.10(d) Gilberton Shaft pumping station..... | 89 |
| Figure 4.11 Aerial photograph of B-D Mining and Reading Anthracite permit areas and monitoring locations | 91 |
| Figure 4.12(a) Culm pile and fuel conveyor to SER power plant | 93 |
| Figure 4.12(b) Shen Penn abandoned pit and SER plant..... | 93 |
| Figure 4.12(c) Ash conveyor from SER plant to abandoned silt dam | 93 |
| Figure 4.12(d) Reclaimed ash placement area and SER plant..... | 93 |
| Figure 4.13(a) Ranges and medians of elements in Gilberton Power coal ash. (all parameters except pH and NP are expressed as mg/kg) | 95 |
| Figure 4.13(b) Ranges and medians of elements in SER coal ash (all parameters except pH and NP are expressed as mg/kg) | 95 |
| Figure 4.14(a) Acidity in groundwater monitoring points at B-D site | 99 |
| Figure 4.14(b) Alkalinity in groundwater monitoring points at B-D site | 99 |
| Figure 4.14(c) Iron in groundwater monitoring points at B-D site..... | 100 |
| Figure 4.14(d) Sulfate in groundwater monitoring points at B-D site..... | 100 |
| Figure 4.15(a) Aluminum content of solid ash, SPLP leachate and groundwater monitoring points (solid ash expressed in mg/kg, all other items expressed as mg/L)..... | 102 |
| Figure 4.15(b) Iron content of solid ash, SPLP leachate and groundwater monitoring points..... | 102 |
| Figure 4.15(c) Arsenic content of solid ash, SPLP leachate and groundwater monitoring points..... | 102 |
| Figure 4.16 Site map of Susquehanna Coal – Mt Carmel Cogeneration site | 105 |
| Figure 4.17(a) Abandoned pits and refuse piles at start of ash placement | 106 |
| Figure 4.17(b) 10 years of ash placement and reclamation of pit..... | 106 |
| Figure 4.17(c) Coal ash deposit greater than 50 feet thick near conveyor | 106 |
| Figure 4.17(d) Scott Overflow monitoring point..... | 106 |
| Figure 4.18(a) Acidity in upgradient monitoring points and downgradient Scott Overflow at the Susquehanna site..... | 108 |
| Figure 4.18(b) Alkalinity increase in downgradient Scott Overflow | 108 |
| Figure 4.18(c) Sulfate in monitoring points at the Susquehanna Coal site..... | 109 |
| Figure 4.19 Alkalinity in upgradient and downgradient monitoring wells at the Westwood FBC power plant site | 113 |

Chapter 5

| | |
|---|-----|
| Figure 5.1 Photograph of the reclaimed portions of the Revloc 1 refuse site. Note the contrast with Figure 5.2 | 123 |
| Figure 5.2 Aerial photo circa 1988 showing the Revloc sites and key associated monitoring reports. The photo was obtained from the permit application for Revloc 1 | 124 |
| Figure 5.3 Graph of acidity, sulfate and iron at MW-1 | 125 |
| Figure 5.4 Graph of selenium and arsenic concentrations at MW-1 | 126 |
| Figure 5.5. Flow, acid load and aluminum load at discharge 4SP..... | 128 |
| Figure 5.6 Comparison of background and recent median acidity, aluminum and sulfate concentrations at monitoring point SP-1, downstream of the Revloc sites | 132 |
| Figure 5.7 Selenium concentrations at down-gradient ash monitoring points at the Revloc sites | 133 |
| Figure 5.8 Map showing the locations of the McDermott Mine monitoring points..... | 139 |
| Figure 5.9 Mine drainage parameters at spring MD-12..... | 139 |
| Figure 5.10. Acidity sulfate and iron at MW-2..... | 140 |
| Figure 5.11 Acidity, sulfate and iron at MW-1..... | 141 |
| Figure 5.12 Calcium, magnesium, aluminum and manganese at MW-1..... | 141 |
| Figure 5.13 Acidity, sulfate and iron at MW-3..... | 142 |
| Figure 5.14 Lead concentrations at various monitoring points on the McDermott Mine site..... | 143 |
| Figure 5.15 Map of the Abel-Dreshman site and monitoring points | 148 |
| Figure 5.16. Graph of pH with time at points 29, 29A and 29B. The two vertical lines bracket the period during which ash placement and reclamation took place | 151 |
| Figure 5.17 Graph of net alkalinity with time at points 29, 29A and 29B. The two vertical lines bracket the period during which ash placement and reclamation took place | 151 |
| Figure 5.18 Graph of aluminum concentrations with time at points 29, 29A and 29B. The two vertical lines bracket the period during which ash placement and reclamation took place | 152 |

Chapter 6

| | |
|---|-----|
| Figure 6.1 Methods of underground anthracite mining (from Wallace 1987)..... | 157 |
| Figure 6.2 Typical mining plan of an anthracite underground mine (from Levitz, 2001)..... | 158 |
| Figure 6.3(a) Narrow cropfall | 159 |
| Figure 6.3(b) View of extensive cropfalls on multiple veins..... | 159 |
| Figure 6.4 Map of Hickory Ridge Colliery showing cropfalls, January 9, 1914..... | 160 |
| Figure 6.5 Composite of attempts to control the Centralia Mine Fire (1980) | 162 |
| Figure 6.6 Site map of Sharp Mountain Reclamation Project | 166 |
| Figure 6.7 Cross-sectional map of Pottsville, 1892 | 167 |
| Figure 6.8 Exposure of the Pottsville Formation, along Rt. 61, Pottsville. Note the vertical stop sign at the bottom of the photo | 168 |

| | |
|--|-----|
| Figure 6.9 An aerial view of Sharp Mountain and the City of Pottsville from above 20 th street looking west. Four lines of subsidence are evident. The demonstration project reclaimed 2.0 acres of in cropfalls in the black highlighted area..... | 169 |
| Figure 6.10(a) Recent and more mature subsidences | 170 |
| Figure 6.10(b) Expanding subsidence, notice the hanging chainlink fence on the left. Wall at the far end represents a stable pillar | 170 |
| Figure 6.11(a) Emergency cropfalls | 171 |
| Figure 6.11(b) Sagging of filled area..... | 171 |
| Figure 6.11(c) Severe collapse and loss of fill..... | 171 |
| Figure 6.11(d) Subsidences. Site of Demonstration Pit A | 171 |
| Figure 6.12(a) Subsidence in 1999 | 175 |
| Figure 6.12(b) Restoration effort, 2000 | 175 |
| Figure 6.12(c) Area resubsides, 2001 | 175 |
| Figure 6.12(d) Demonstration Area, 2002. An orange safety fence surrounds the construction area | 175 |
| Figure 6.13(a) Pit A prepared | 176 |
| Figure 6.13(b) Steel trusses installed in Pit A east | 176 |
| Figure 6.13(c) Grout mixture placement, Pit A east..... | 176 |
| Figure 6.13(d) Pit A east grout complete..... | 176 |
| Figure 6.14(a) Scrap rebar in replaces trusses, Pit A west..... | 177 |
| Figure 6.14(b) Grout added. Notice the mixer is driving on previously poured grout | 177 |
| Figure 6.14(c) Ash bulk fill placed | 177 |
| Figure 6.14(d) Prepared for topsoil. Pit A complete..... | 177 |
| Figure 6.15 Completed Sharp Mountain demonstration project..... | 178 |
| Figure 6.16 Map of McCloskey mine site. Areas already capped and those remaining to be capped are differentiated. T-5 discharge location is included | 180 |
| Figure 6.17 Historical quality of the T-5 discharge for sulfate and acidity. Ash placement began in 1992 The trend line for sulfate is included in the graph..... | 183 |
| Figure 6.18 Historical quality of the T-5 discharge for aluminum and iron. Although not included, manganese follows a similar trend. The trend line for iron is included..... | 183 |
| Figure 6.19 Qualitative benthic macroinvertebrate comparison upstream and downstream of discharge | 185 |
| Figure 6.20 Electrofishing results upstream and downstream of discharge | 185 |
| Figure 6.21 Location of buried pods of pyritic materials and ash grout application sites..... | 187 |
| Figure 6.22 Response in pH monitoring well L25 to pit floor grouting effort | 198 |
| Figure 6.23 Sulfate and acidity response to pit floor grouting effort. Note the temporary effect of the drought during 1995..... | 199 |
| Figure 6.25 Calcium and aluminum response to the pit floor grouting effort. Note the general inverse relationship between Al from AMD and Ca, primarily from the grout..... | 199 |
| Figure 6.26 Long-term calcium concentrations in two monitoring wells..... | 200 |
| Figure 6.27 Long-term behavior of Cd, Cr, and As in well L25 | 201 |

Chapter 7

| | |
|--|-----|
| Figure 7.1 The eastern end of the Western Middle anthracite field, containing the Ellengowan, Knickerbocker, and Shen Penn mines (Danilchik, Rothrock, and Wagner, 1955)..... | 206 |
| Figure 7.2 Lithologic sections of the Ellengowan and Knickerbocker basins (Danilchik, Rothrock, and Wagner, 1955)..... | 207 |
| Figure 7.3 Cross section through the basins mapped on the eastern edge of the Shenandoah quadrangle (Danilchik, Rothrock, and Wagner, 1955) | 209 |
| Figure 7.4 Cross-section through Shen Penn pit (48+00E) showing surface mining locations and dates | 213 |
| Figure 7.5 Projected flow path from mine pool water discharging from the vicinity of the Shen Penn demonstration site (Laslow, pers. comm.)..... | 214 |
| Figure 7.6 Shen Penn site map with locations of chemical sampling. The area of open connection to the deep underground mine is to the southeast | 215 |
| Figure 7.7 X-ray diffraction pattern and identified crystalline phases present in SER bottom ash..... | 217 |
| Figure 7.8 Photograph of test pit dug into end dumped ash. Note the wall structure and the presence of water at the silt/ash interface..... | 219 |
| Figure 7.9 Photograph of the slurry placement facility | 220 |
| Figure 7.10 A D8 operating on the surface of the slurry-placed ash after closure of the demonstration pond..... | 221 |
| Figure 7.11 Strength development in lime kiln dust (LKD) activated fly ash grout as a function of curing time..... | 221 |
| Figure 7.12 X-ray diffraction pattern for a) fly ash grout cured for 90 days and b) slurry placed fly ash..... | 223 |
| Figure 7.13 Strength development in CKD activated fly ash grout as a function of curing time | 224 |
| Figure 7.14 Variation in compaction pressure with depth under a load | 225 |
| Figure 7.15 Aerial photograph of the Shen Penn Pit in relation to the Schuylkill Energy Resources Co-generation facility and to the town of Shenandoah to the west of the pit..... | 227 |

Chapter 8

| | |
|---|-----|
| Figure 8.1 Cross-section through Knickerbocker pit (34 + 00)..... | 231 |
| Figure 8.2 Aerial photograph of the Schuylkill Energy plant, the Knickerbocker pit, and the slurry pipe..... | 233 |
| Figure 8.3 Schematic of cells and locations of sampling..... | 234 |
| Figure 8.4 a) Inlet pipe to cell 1, February 2000. b) Locations of borings in cell 2, the first group of people is near the inlet pipe location, and the farther group is at the boring location closer to the center of the cell. Delta formation is evident, with mudcracks in the remainder of the cell..... | 234 |
| Figure 8.5 Truck parked on recently placed ash..... | 235 |
| Figure 8.6 Blow count plots for samples taken in November 2000..... | 237 |
| Figure 8.7 CaO concentration in test cells..... | 239 |
| Figure 8.8 SEM images from cell 1-2 at 8-10 feet depth and a magnification of a) 120µm, b) 700µm, and c) 3500µm..... | 243 |

Chapter 9

| | |
|--|-----|
| Figure 9.1 Anthracite basins of the Eastern Middle field (Inners, 1988) | 246 |
| Figure 9.2 Aerial photo of the Silverbrook Basin..... | 247 |
| Figure 9.3 Location map for the Big Gorilla mine pool and the Silverbrook outflow within the Silverbrook Basin | 248 |
| Figure 9.4 Regional geologic cross-section, McAdoo area, Pennsylvania (US EPA, 1991) | 249 |
| Figure 9.5 Mining cross-section of Silverbrook Basin. The No. 1 Basin contains the Big Gorilla (original draftsman unknown). The two Mammoth basins show the former location of the removed Mammoth seam | 250 |
| Figure 9.6 Mike Menghini, Tom Owen, and Mike Wehr using Cs-137 densitometer on the lower ash terrace | 253 |
| Figure 9.7 Fly and bottom ash silos for storage until placement on the NEPCO site | 253 |
| Figure 9.8 A truck and bulldozer used to transport and place ash in the Big Gorilla mine pool | 254 |
| Figure 9.9 Boils present approximately 300 feet from the Big Gorilla ash face | 254 |
| Figure 9.10 Photograph of bottom and fly ash from the NEPCO site | 256 |
| Figure 9.11 X-ray diffraction trace from a fly ash sample (pre-placement) and quartz, illite, and muscovite patterns for comparison | 260 |
| Figure 9.12 Three locations where the surface mine pool bottom was sampled on 22 October 1999..... | 261 |
| Figure 9.13 X-ray diffraction trace from a post-placement minepool sample and quartz, illite, and muscovite patterns for comparison | 261 |
| Figure 9.14 Sample EDS scan from post-placement ash..... | 262 |
| Figure 9.15 SEM image of fly ash before placement in the Big Gorilla mine pool | 262 |
| Figure 9.16 SEM image of post-placement ash collected from the Big Gorilla minepool | 263 |
| Figure 9.17 SEM image of post-placement ash collected from the Big Gorilla minepool | 263 |
| Figure 9.18 Plots showing increasing concentrations of chemical constituents in the Big Gorilla mine pool with increasing depth 7/2/93..... | 267 |
| Figure 9.19 Plot of iron concentration in the Silverbrook outflow compared with the pre-ash placement concentration values from the Big Gorilla mine pool | 268 |
| Figure 9.20 Plot of sulfate concentration in the Silverbrook outflow compared with the pre-ash placement concentration values from the Big Gorilla mine pool | 268 |
| Figure 9.21 Plot of acidity concentration in the Silverbrook outflow compared with the pre-ash placement concentration values from the Big Gorilla mine pool | 269 |
| Figure 9.22 Plot of calcium concentration in the Silverbrook outflow compared with the pre-ash placement concentration values from the Big Gorilla mine pool | 270 |
| Figure 9.23 Plot of sodium concentration in the Silverbrook outflow compared with the pre-ash placement concentration values from the Big Gorilla mine pool | 270 |
| Figure 9.24 Plots showing lack of stratification in concentrations of chemical constituents in the Big Gorilla mine pool with depth 10/28/97 | 272 |
| Figure 9.25 The response of pH to monthly ash input in the Big Gorilla mine pool | 273 |

| | |
|--|-----|
| Figure 9.26 a) Ash input (bars) versus alkalinity (points) in the Big Gorilla. Open circles are points where surface samples were collected at the western end of the lake during periods of prolonged ash input. Asterisks represent monthly samples collected at depth, during periods of increasing ash input. Solid diamonds represent samples collected during hiatuses in ash input, and triangles represent samples for which no silica data are available | 273 |
| Figure 9.27 Plot of alkalinity versus silica in the Big Gorilla mine lake. Open circles are points where surface samples were collected at the western end of the lake during periods of prolonged ash input. Asterisks represent monthly samples collected at depth, during periods of increasing ash input. Solid diamonds represent samples collected during hiatuses in ash input. Data collected by PA DEP | 275 |
| Figure 9.28 Photo of Big Gorilla mine pool with rim of calcite on 22 October 1999 | 277 |
| Figure 9.29 X-ray diffraction trace of calcite rim above the water surface. Collected 22 October 1999..... | 277 |
| Figure 9.30 X-ray diffraction trace of calcite rim below the water surface. Collected 22 October 1999..... | 278 |
| Figure 9.31 SEM image of white precipitate from the Big Gorilla mine pool (250um) | 279 |
| Figure 9.32 SEM image of white precipitate from the Big Gorilla mine pool (10um) | 279 |
| Figure 9.33 SEM image of white precipitate from the Big Gorilla mine pool (10um) | 280 |
| Figure 9.34 Eh-pH diagram for sulfur species at standard conditions with total dissolved sulfur activity of 96 mg/L (adapted from Hem, 1985) | 281 |
| Figure 9.35 Sulfate concentrations in the Big Gorilla mine pool | 281 |
| Figure 9.36 Eh-pH diagram at 25°C for aqueous species in the Fe-O ₂ -H ₂ O system at 10 ⁻⁵ mg/kg (Langmuir, 1997)..... | 283 |
| Figure 9.37 Schematic illustration of the effects of pH on the solubility of trace elements occurring in the form of cations or oxyanions (Jones, 1995) | 284 |
| Figure 9.38 Calcium concentrations in the Silverbrook outflow 1989-2002..... | 288 |
| Figure 9.39 Location of the monitoring wells, Silverbrook outflow, Big Gorilla, and power plant on the NEPCO property | 290 |
| Figure 9.40 Sulfate, calcium, and hydrogen ion activity in wells 2 (a) and 3 (b). Corresponding aluminum, iron, hot acidity, and alkalinity concentrations for well 3 (c). Samples analyzed by PA DEP | 292 |
| Figure 9.41 Histogram of sulfate concentrations in well 3. Data collected by the PA DEP..... | 293 |
| Figure 9.42 Solubility plot constructed by Dr. Charles Cravotta, with data from the Silverbrook Basin, provided by the PA DEP. All Al values represent dissolved and suspended constituents combined (total). Red asterisks show data from the test borings..... | 296 |
| Figure 9.43 Compounds in the system CaO-SiO ₂ -H ₂ O (Taylor, 1964)..... | 297 |
| Figure 9.44 SEM image of ash from the eastern test boring in the ash platform at a depth of 50 to 52 feet. Long, thin particles are visible, and show evidence of cementitious phases forming | 298 |
| Figure 9.45 Saturation index values for 12 key minerals with mixing of the Silverbrook outflow and Big Gorilla waters..... | 300 |

Chapter 10

| | |
|--|-----|
| Figure 10.1 How soil pH affects availability of plant nutrients and aluminum..... | 309 |
| Figure 10.2 Plant yields on acidic mines spoil covered with 20 cm depth of borrow topsoil or amended with biosolids (100 Mt ha ⁻¹), FGD (670 Mt ha ⁻¹), or FGD+biosolids (Stehouwer et al., 1998)..... | 311 |
| Figure 10.3 Distribution of exchangeable calcium, aluminum, and iron in the acidic mine spoil profile nine months after treatment application. (Error bars indicate the width of the LSD _{0.1} value for comparison of treatment means at each depth.) (Stehouwer et al.,1998)..... | 312 |

Chapter 11

| | |
|--|-----|
| Figure 11.1 Range in proctor density measurements for a single FBC facility..... | 322 |
| Figure 11.2 Thermodynamic control over the solubility of aluminum in AMD and the Gorilla mine-pit lake waters. Plot constructed by Dr. Charles Cravotta, with an ettringite solubility line altered by the authors to best fit the Big Gorilla data..... | 324 |
| Figure 11.3 Scanning electron micrograph of ettringite growth in FBC ash..... | 325 |
| Figure 11.4 Development of C-S-H in ash..... | 326 |
| Figure 11.5 Model for calculation of hydraulic conductivity..... | 327 |
| Figure 11.6 Effects of leaching on pH of C-S-H-portlandite-silica system as a function continued leaching. (after Atkinson, 1985)..... | 328 |
| Figure 11.7 Percentage leached of the smallest dimension of the Gorilla ash fill as a function of time based on an ash structure-controlled leaching model..... | 330 |
| Figure 11.8 Percentage leached of the smallest dimension of the Gorilla ash fill as a function of time based on a geology-controlled leaching model..... | 332 |
| Figure 11.9 Various possibilities for the interaction of heavy metals in a cementitious matrix (after Gougar et al., 1996)..... | 333 |
| Figure 11.10 Solubility (mg/L) vs. pH plots for selected metallic elements showing Minimum solubilities..... | 337 |