Digital Databases and CD-ROM for the Boulder River Watershed

By Carl L. Rich, David W. Litke, Matthew Granitto, Richard T. Pelltier, and Tracy C. Sole

Chapter G of

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Abstract

A large amount of digital data was produced as part of the Boulder River watershed study. Included are biologic, hydrologic, geochemical, geologic, and base cartographic data. Most were collected in the Basin Creek, Cataract Creek, and High Ore Creek subbasins of the Boulder River watershed, and in the portion of the Boulder River into which these creeks flow. A lesser amount was collected throughout the remainder of the Boulder River watershed. The data were converted to a common projection. Hydrography and road features, sample-site locations, and inactive mine and mine-related site locations were revised using digital orthophoto quadrangle (DOQ) imagery. The data are available, in formats compatible with widely used commercial software, on a CD-ROM that accompanies this volume. The data and the CD-ROM are described in this chapter.

Introduction

Digital datasets were an integral component of work conducted by U.S. Geological Survey scientists to understand issues related to inactive mines in the Boulder River watershed in southwest Montana. A large amount of information was produced as part of this multidisciplinary study. Analyses of the digital data layers have produced many results that are described and illustrated in the numerous maps and images that are provided in other chapters of this volume.

Data were obtained as part of various topical studies of the Boulder River watershed. During these studies, samples of many media, including rocks, soils, water, and aquatic life, were collected and analyzed. Other data sources used in this investigation included previous USGS regional studies, and the work of other Federal and State agencies. The different types of information were gathered from several different platforms including helicopters, fixed-wing aircraft, satellites, and ground fieldwork.

To make this information useful to others, the various datasets have been converted to a common map projection, and to formats compatible with widely used commercial software. The localities of the sample-site data were revised using digital orthophoto quadrangle (DOQ) image files. The data are organized in descriptive tables presented in this chapter, and in a digital relational database and a geographic information system (GIS) database on a CD-ROM that accompanies this volume. In addition, the CD-ROM provides data viewing software for elementary spatial comparisons and analysis of the various layers.

Purpose and Scope

The purpose of this chapter is to provide a comprehensive review of the digital data that were generated as part of the Boulder River watershed study, and which are placed on the CD-ROM that accompanies this volume. Included are a relational database, a GIS database, map, image, and graphic products created during the study, and two data viewers that allow visual spatial comparisons and analysis of the data. The relational database contains biologic, hydrologic, geochemical, and geologic sample-site data collected and produced for the Boulder River watershed study, and an inventory and description of mine-related sites located and compiled for the study. The GIS database contains the same sample-site data and mine-related site information stored as data layers and associated tables, as well as base cartographic, geologic, hydrologic, geochemical, and geophysical data in vector and raster formats.

The base cartographic data cover the Basin, Bison Mountain, Chessman Reservoir, Jefferson City, Mount Thompson, Three Brothers, Thunderbolt Creek, and Wickes 7.5-minute quadrangles at a level of detail similar to U.S. Geological Survey 1:24,000-scale topographic maps. Geologic, geochemical, and geophysical data (collectively referred to in this chapter as “Geoscientific Data”) also exist within these same eight quadrangles. The sample sites and mine-related

sites are located primarily within the Basin Creek, Cataract Creek, and High Ore Creek watersheds, and along the approximately 9-mile reach of the Boulder River that extends from just upstream to just downstream of these tributaries. There are also less detailed base data, and some sample-site data, throughout the remainder of the entire Boulder River watershed.

The Boulder River watershed GIS database contains data for various layers and scales over areas of varying extent, including the Boulder River watershed study area as previously defined in Church, Nimick, and others (this volume, Chapter B), an eight-quadrangle area which includes the "Boulder River watershed study area," and the Boulder River watershed in its entirety. Figure 1 shows the area of the

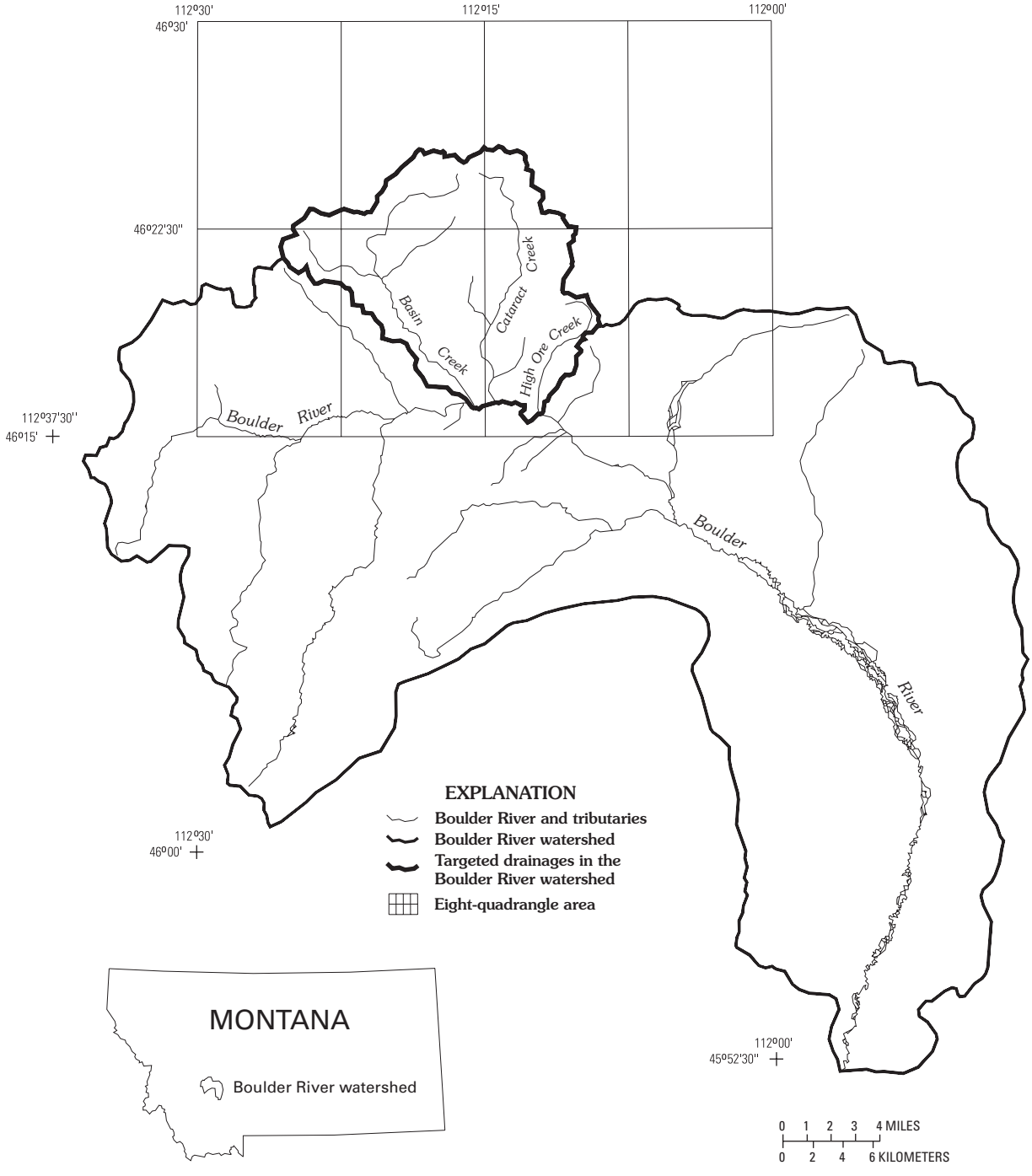

Figure 1. Geographic extent of database for Boulder River watershed study.

targeted drainages of the northern part of the Boulder River watershed.

The data are available on the CD-ROM in formats from the software used to create them, and in several other formats including ASCII textfiles, ESRI shapefiles, .dbf files, and TIFF image files. The *x,y* coordinates of the ArcInfo coverages, ESRI shapefiles, and TIFF image files are in UTM (Universal Transverse Mercator) meters, zone 12, and are cast on the North American Datum of 1927 (NAD27). The FieldSites table in the relational (Access) database also contains the longitude and latitude values of the field site locations in decimal degrees, also in NAD27.

The main body of this chapter begins with a synopsis of the various data layers organized under three broad themes, including (1) base cartographic data, (2) sample-site data and mine-related site data, and (3) data layers pertaining to geologic, geochemical, biologic, geophysical, and remote sensing information. (This third group of data layers is collectively referred to in this chapter as "Geoscientific Data.") A brief description of the utility of the data is given followed by a descriptive table that includes relevant information about individual data files. This synopsis of the data is followed by an explanation of the relational database. The report concludes with a description of the data viewer software that is provided on the CD-ROM and an explanation of the content and format of the CD-ROM itself.

Acknowledgments

The authors acknowledge the assistance of Paul Martin, Rick Poss, Stewart Wright, John Erickson, Steve Howard, Earl Wilson, and Eric Wong in the creation of the base cartographic data for the Boulder River watershed GIS database.

Base Cartographic Data

In general, the base cartographic data were initially collected from the eight 7.5-minute U.S. Geological Survey topographic maps mentioned previously, and then revised where possible using 1993 and 1998 digital orthophoto quadrangles (DOQ's). DOQ's were not available for the Wickes and Jefferson City quadrangles; however, the Boulder River watershed study area is entirely contained within the remaining six quadrangles. When available, U.S. Geological Survey Digital Line Graph (DLG) files were used as the initial source, but where necessary, data were scanned or digitized from stable-base separates of the appropriate 7.5-minute topographic map. These topographic maps were all 1985 Provisional Editions. During the 5-year period of this study, newly revised (1996) versions of the Thunderbolt Creek, Basin, Mount Thompson, and Wickes quadrangles were released to the public. A visual inspection of these maps was performed, and information in the GIS database was updated where appropriate.

Base cartographic layers created as just described include hydrography, roads and trails, miscellaneous transportation, hypsography (vector topographic contours), administrative and political boundaries, Public Land Survey System (PLSS), and cultural features. The hydrography and roads and trails layers were revised using DOQ files as just described. The remaining layers were not, and thus their content reflects the content of the 7.5-minute topographic maps. The location and description of inactive mines and mine-related features were of utmost importance to this study, and are described separately later in this chapter and in detail in the Mine Inventory chapter (Martin, this volume, Chapter D3). The Boulder River watershed study area boundary layer was created from the hypsography and hydrography layers. Figure 2 shows selected base cartographic data and the outline of the target drainages in the Boulder River watershed.

The base cartographic data vector layers exist on the Boulder River watershed CD-ROM as export files of ArcInfo coverages in the /bldr_cd/gis_db/basecart/e00 directory, and as ESRI shapefiles in the /bldr_cd/gis_db/basecart/shape directory. A complete list of base cartographic data coverages and the data themes they contain is in table 1. Due to shapefile naming restrictions, the names of some of the shapefiles are abbreviated versions of their corresponding ArcInfo coverage names. For a complete listing of the shapefile names, see the /bldr_cd/gis_db/basecart/README.txt file on the CD-ROM which accompanies this volume.

The first 16 coverages listed in table 1 contain data that lie entirely within the eight-quadrangle area. The Administrative Boundaries theme contains USDA Forest Service boundaries but does not include inholding boundaries. The Political Boundaries theme contains county boundaries, those being the only political boundaries that exist in the eight-quadrangle area.

In addition to the naturally occurring features contained in the Hydrography theme, there are lines labeled as "network flow lines," which connect streams where they flow into and out of lakes and marshes. These lines and all lines representing streams have been created from beginning to end in the downstream direction. Thus, by using all the linear features that represent streams, along with the "network flow lines," one can perform network flow modeling. The Springs theme contains all springs shown on the 7.5-minute topographic maps for the eight-quadrangle area, plus 13 others located as part of this study.

A typical USGS DLG Miscellaneous Culture Features file would contain the contents of the Miscellaneous Culture Features theme, the Miscellaneous Culture Point Features theme, and the Mine-related Point Features from Topographic Maps theme. Because of the importance of mine-related sites to this study, they were separated from the other cultural point features and stored in a separate coverage called MINE_TOPO_PTS. This coverage contains all mine-related point features exactly as they are shown on the 7.5-minute topographic maps. A separate coverage, MINE_SITES, which was created using the digital orthophoto quadrangle files and

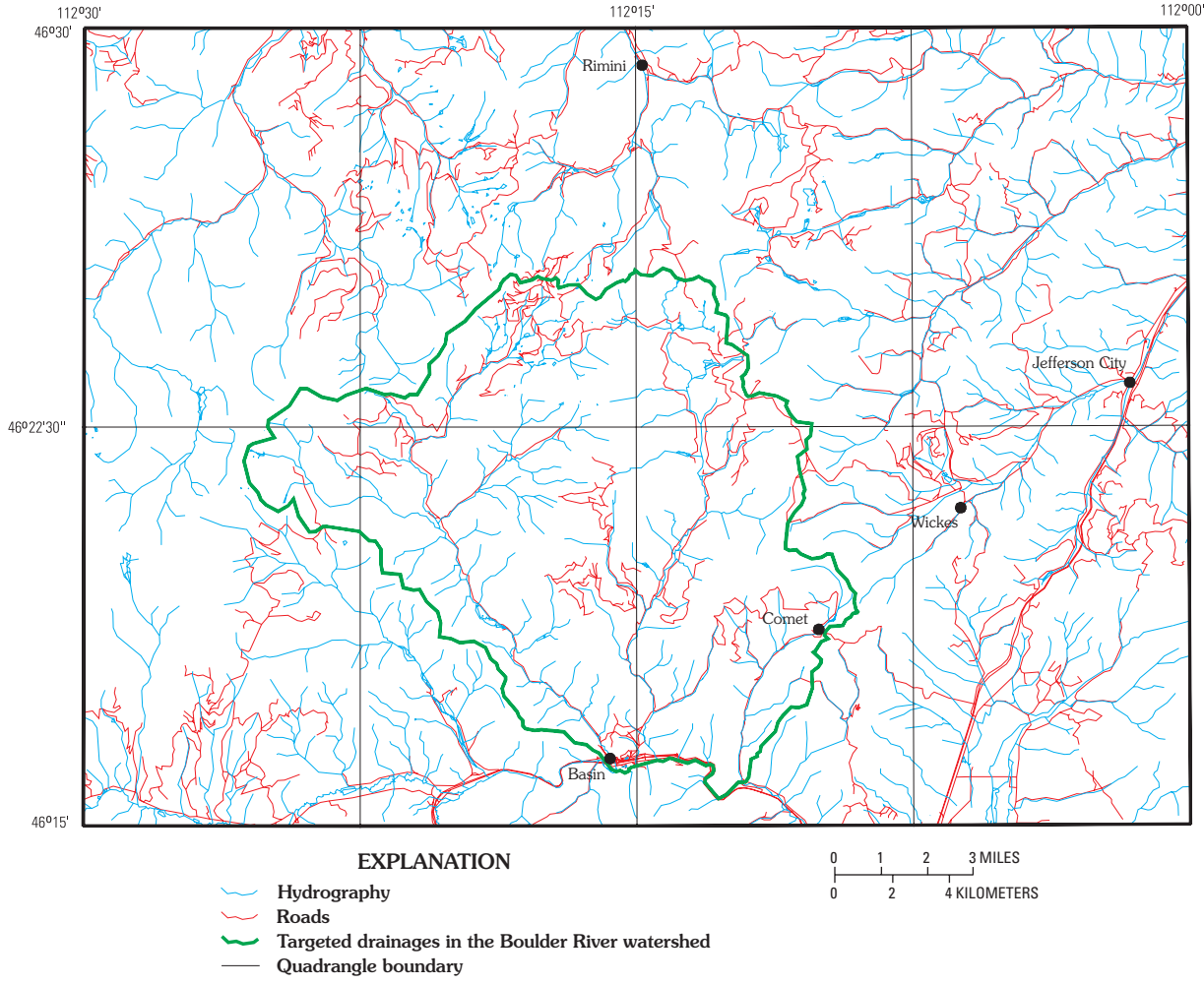

Figure 2. Selected data within the eight-quadrangle area from the Boulder River watershed GIS database.

a wide variety of other sources, is described briefly in this chapter under the "Site Data" section, and in greater detail in Martin (this volume, Chapter D3).

As previously mentioned, most of the data gathered for the Boulder River watershed study was collected within the eight-quadrangle area. However, a few samples were collected within the portion of the Boulder River watershed that lies outside the eight-quadrangle area. The last seven coverages listed in table 1 contain less-detailed data that cover the entire Boulder River watershed. These coverages were created to serve as visual reference for the data collected outside the eight-quadrangle area. The vast majority of the Boulder River watershed lies within Jefferson County, except for one very small portion of Broadwater County at the southeast edge of the watershed. The Basin-wide County Boundaries theme delineates this small section of county boundary. The Basin-wide Hydrography theme contains the Boulder River and selected tributaries, and the Basin-wide Highways theme contains major highways within and near the Boulder watershed. The Jefferson River theme contains a section of the Jefferson River that lies just upstream and just downstream from the mouth of the Boulder River. The Subbasins theme contains selected subbasin boundaries within the watershed, as selected by project scientists for the purpose of meaningfully interpreting the data collected for the study.

Other related base cartographic data in the GIS database include an elevation grid created directly from USGS 10-meter Digital Elevation Model (DEM) files, and individual Digital Raster Graphic (DRG) files of the topographic maps. Slope grids in percent and degrees, and aspect and shaded-relief grids were also derived from the elevation grid. All of the elevation-related grids are listed in table 2. The elevation and elevation-derived grids exist on the CD-ROM in the /bldr_cd/gis_db/basecart/elev directory as a compressed tar file (elevation.tar.gz), which when uncompressed produces an entire ArcInfo workspace containing all of the elevation-related grids. The elevation and elevation-derived data also exist as TIFF files on the Boulder River watershed CD-ROM in the /bldr_cd/gis_db/basecart/elev directory. Additionally, the raw elevation data values also exist in that directory in a flat, ASCII file called elevation.ascii.

For more detailed information describing the sources, creation and content of the base cartographic data in the Boulder River watershed GIS database, see the metadata located

Table 1. Base cartographic data coverages in the Boulder River watershed GIS database.

Coverage name	Theme	File name	Data format
ADMINBND	Administrative Boundaries	adminbnd.e00	ArcInfo vector coverage
HYDRO	Hydrography	hydro.e00	ArcInfo vector coverage
HYPSO	Hypsography	hypso.e00	ArcInfo vector coverage
MINE_TOPO_PTS	Mine-related Point Features from Topographic Maps	mine_topo_pts.e00	ArcInfo vector coverage
MISC_CUL	Miscellaneous Culture Features	misc_cul.e00	ArcInfo vector coverage
MISC_CUL_PTS	Miscellaneous Culture Point Features	misc_cul_pts.e00	ArcInfo vector coverage
MISCTR	Miscellaneous Transportation Features	misctr.e00	ArcInfo vector coverage
PLACE_NAMES	Place Names	place_names.e00	ArcInfo vector coverage
PLSS	Public Land Survey System	plss.e00	ArcInfo vector coverage
POLBND	Political Boundaries	polbnd.e00	ArcInfo vector coverage
QUADS	Quadrangle Boundaries	quads.e00	ArcInfo vector coverage
Q8OUTLINE	Outline of Eight-Quadrangle Area	q8outline.e00	ArcInfo vector coverage
ROADS	Roads	roads.e00	ArcInfo vector coverage
SPRINGS	Springs	springs.e00	ArcInfo vector coverage
STUDY_AREA_BD	Study Area Boundary	study_area_bd.e00	ArcInfo vector coverage
USFS_CFF_OWN	USDA Forest Service Cartographic Feature File (CFF) Ownership Lines	usfs_cff_own.e00	ArcInfo vector coverage
ALL_BLDR_COBD	Basin-wide County Boundaries	all_bldr_cobd.e00	ArcInfo vector coverage
ALL_BLDR_HY	Basin-wide Hydrography	all_bldr_hy.e00	ArcInfo vector coverage
ALL_BLDR_RD	Basin-wide Highways	all_bldr_rd.e00	ArcInfo vector coverage
ALL_BLDR_USFS	Basin-wide USDA Forest Service Boundaries	all_bldr_usfs.e00	ArcInfo vector coverage
ALL_BLDR_WSHD	Boulder River Watershed	all_bldr_wshd.e00	ArcInfo vector coverage
JEFFRIVER	Jefferson River	jeffriver.e00	ArcInfo vector coverage
SUBBASINS	Subbasins	subbasins.e00	ArcInfo vector coverage

Table 2. Elevation and elevation-derived grids in the Boulder River watershed GIS database.

Grid name	Theme	File name	Data format
ELEVATION	Elevation	elevation.tar.gz	ArcInfo grid
HILSHD	Shaded Relief	elevation.tar.gz	ArcInfo grid
SLOPE_DEGREE	Slope in Degrees	elevation.tar.gz	ArcInfo grid
SLOPE_PERCENT	Percent Slope	elevation.tar.gz	ArcInfo grid
ASPECT	Slope Aspect	elevation.tar.gz	ArcInfo grid

on the CD-ROM accompanying this volume, in the /bldr_cd/gis_db/basecart/meta directory. Because the ESRI shapefile versions of the base cartographic data were created from the ArcInfo coverages, and due to shapefile naming limitations, the shapefiles in some cases have abbreviated versions of the coverage names listed in table 1. These differences are fully described in the README.txt file in the /bldr_cd/gis_db/basecart directory on the CD-ROM. The CD-ROM is described at the end of this chapter in the Boulder River watershed CD-ROM section.

Site Data

As part of the watershed approach, many kinds of scientific data were collected in the Boulder River watershed study area for site characterization, analysis, and monitoring purposes. A wide range of rock, sediment, water, and biological samples was collected, measured, and analyzed, and an inventory of mine-related sites and descriptions was compiled. In order to have a single, integrated and standardized collection of project information, all data were integrated spatially using a GIS, and conceptually using a relational database. Field sampling sites that should be considered co-located for analysis purposes were grouped together resulting in 425 Analysis Sites. Inactive mines and other mine-related features are represented as 143 Mine Sites. Associations between Field Sites and Mine Sites were defined and represented as relationships in the databases. The sample-site and mine-site data are available on the Boulder River watershed CD-ROM in a relational (Access) database, in a GIS (ArcInfo) database, and in several other formats.

Sample-Site Data

Figure 3 shows the distribution of the sample sites for the Boulder River watershed study. The majority of sites are in the area of targeted drainages in the Boulder River watershed; some are elsewhere in the Boulder River watershed; a few are outside the Boulder River watershed, but within the eight-quadrangle area. (See figure 1 for the spatial relationship of these three areas.) For detailed localities of specific sample sites, see the appropriate chapter of this volume, as listed in table 5 in the "Relational Database" section, or extract the FIELD_SITES data from the accompanying CD-ROM.

As previously mentioned, the sample-site data and mine-related site data exist in a number of different formats on the CD-ROM accompanying this volume. The file names of the data as they exist in the various formats are shown in table 3. Owing to differences in the allowed lengths of file names and attribute names, some of the ArcInfo, ESRI shapefile, and .dbf file names and attribute names are abbreviated versions of those that exist in the analogous relational (Access) database tables. These differences are delineated in the README.txt file on the Boulder River watershed CD-ROM in the /bldr_cd/gis_db/sitedata directory.

The coverage, file, and attribute names used in the remainder of this section are from the ArcInfo GIS database. Access relational database table and attribute names are used in the "Relational Database" section later in this chapter.

The sample data exist in the GIS database as two point feature data layers (FIELD_SITES and ANALYSIS_SITE) and 10 associated tables. The FIELD_SITES data layer contains one point feature for each sample site. Attributes for each site include a unique identifier called SITENUMBER, various information provided by the person who collected the sample(s) at the site, and locational information generated by the GIS. A table called LOC_MASTER contains the attributes ELEVATION, TOWNSHIP, RANGE, SECTION, LITHOLOGY, STRAT_UNIT (stratigraphic unit), GEOL_AGE (geologic age), and SUBBASIN for each sample site. Values for these attributes were assigned by using the GIS to perform spatial overlays with the FIELD_SITES coverage and the appropriate base cartographic and geologic coverages.

Sample sites that are considered co-located for purposes of spatial analysis are assigned the same value for an identifier called AMLI_ANALYSIS_ID. Because the location chosen to represent the "analysis site" is not always exactly the same as that of the sample sites that are logically considered to be co-located there, a second point feature data layer, ANALYSIS_SITE, is used to contain the locations of the analysis sites. The same attributes that were added to the FIELD_SITES data layer using spatial overlay were also added to the ANALYSIS_SITE data layer.

Because the AMLI_ANALYSIS_ID exists in the attribute tables for both the FIELD_SITES and ANALYSIS_SITE data layers, the two can be related to each other and to other data tables containing actual sample data and results. The relationship between the two point feature data layers is one-to-many, since more than one field site can have the same AMLI_ANALYSIS_ID. In order to aid GIS users not familiar

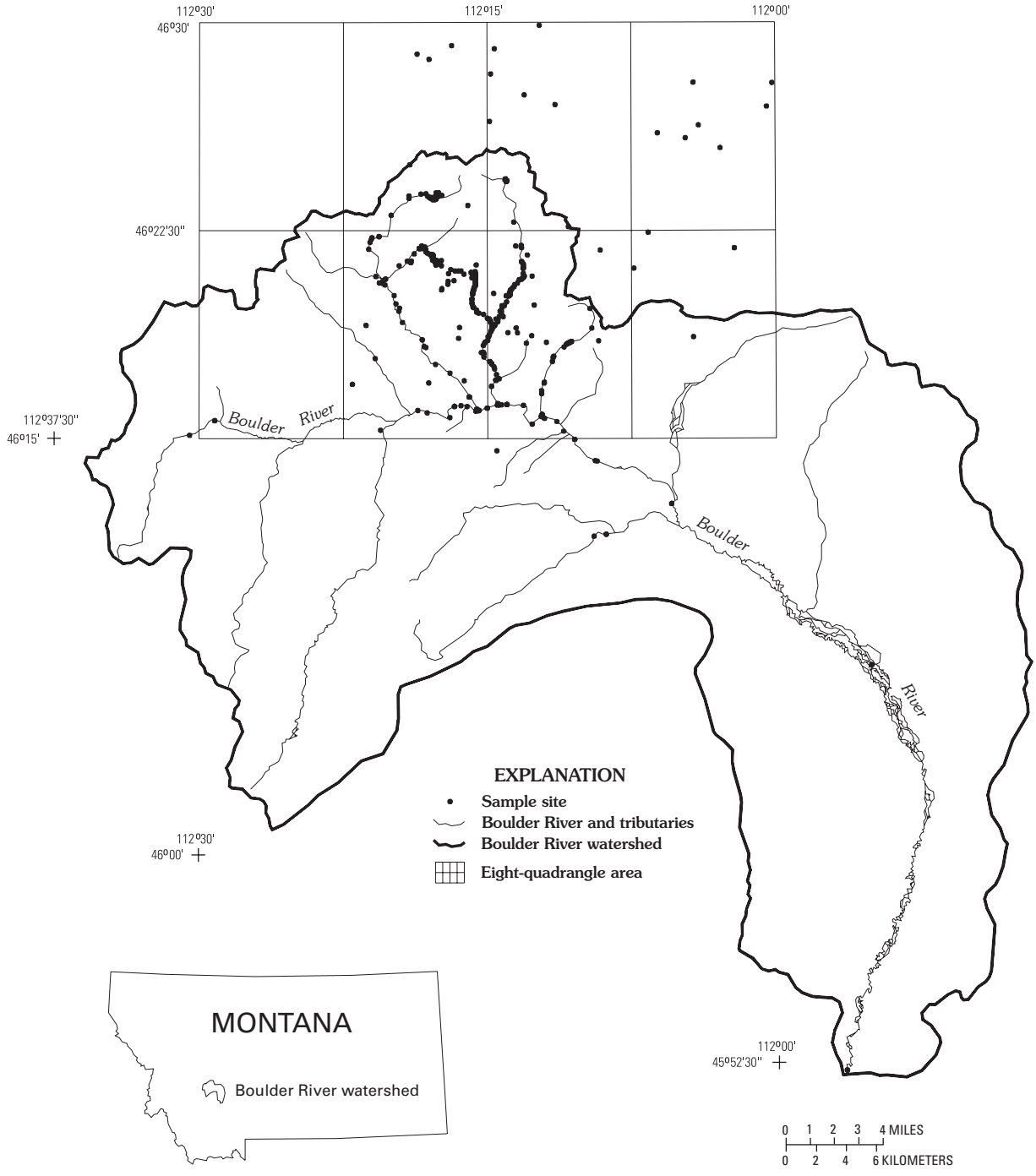

Figure 3. Distribution of Boulder River watershed study sample sites.

with techniques for dealing with one-to-many relationships, the attribute table for the ANALYSIS_SITE data layer also contains the SITENUMBERs of the field sites associated with each analysis site.

A table called FS_MS_ASSOCS contains a list of field sites that are associated with specific mine-related sites. There are 18 such relationships in the table, with the identifiers SITENUMBER and mine-related site AMLI_MINE_ID listed for each relationship. For a complete description of the inventory of mining-related sites created for this study, see Martin (this volume).

There are eight other tables that contain the actual sample data and results, as well as various characteristics of the samples and results. These tables were initially created using the Access relational database and then converted to INFO files and .dbf files for inclusion in the GIS database. These

Table 3. File names for site data in various formats.

Export files for ArcInfo coverages or Info files	Shapefiles or dBASE files	Access tables	ASCII tables
analysis_site.e00 (coverage)	anlysite.shp	SpatialAnalysisSites	SpatialAnalysisSites.tab
Analytic_meth.e00 (Info file)	an_meth.dbf	AnalyticMethod	AnalyticMethod.tab
field_sites.e00 (coverage)	fldsite.shp	FieldSites	FieldSites.tab
fs_ms_assocs.e00 (Info file)	fmsassoc.dbf	FieldSiteMineSiteAssocs	FieldSiteMineSiteAssocs.tab
lab_name.e00 (Info file)	labname.dbf	LabName	LabName.tab
loc_master.e00 (Info file)	locmastr.dbf	LocationMaster	LocationMaster.tab
mine_sites.e00 (coverage)	minesite.shp	MineSites	MineSites.tab
mine_sites.e00 (mine_sites.aditflow is part of mine_sites coverage)	msadflow.dbf	MineSitesAditFlow	MineSitesAditFlow.tab
parameter.e00 (Info file)	parametr.dbf	Parameter	Parameter.tab
project.e00 (Info file)	project.dbf	Project	Project.tab
qual_result.e00 (Info file)	qualres.dbf	QualitativeResult	QualitativeResult.tab
result.e00 (Info file)	result.dbf	Result	Result.tab
sample.e00 (Info file)	sample.dbf	Sample	Sample.tab
Sample_media.e00 (Info file)	sampmed.dbf	SampleMedia	SampleMedia.tab

tables are described in the "Relational Database" section of this chapter. Effective use of the data in many of these tables requires dealing with one-to-many relationships. The relationships between the primary sample and results tables are shown in figure 4, and explained in the "Relational Database" section of this chapter. A bitmap file (relationship_diagram.bmp) containing a complete diagram of the relationships of all the files in the Boulder River watershed relational database exists on the accompanying CD-ROM in both the /bldr_cd/rel_db and /bldr_cd/gis_db/sitedata directories. Because effective use of the sample-site data requires an understanding of these relationships, this diagram is important for users of the GIS database, as well as for users of the relational database.

The FIELD_SITES and ANALYSIS_SITE coverages exist on the Boulder River watershed CD-ROM as export files in the /bldr_cd/gis_db/sitedata/e00 directory. Ten other tables containing information about, and data collected at, the field sites also exist in that directory as INFO files. These coverages and tables also exist as ESRI shapefiles and .dbf files, respectively, in the /bldr_cd/gis_db/sitedata/shape and /bldr_cd/gis_db/sitedata/dbf directories.

Mine-Related Site Data

An inventory of inactive mines and mine-related sites in the Boulder River watershed study area was compiled from existing State and Federal sources. In some cases, multiple shafts, adits, prospects, and disturbed areas were located at a given site, but in each case a single point location was chosen to best represent the site. The location of each mine-related site was verified where possible with digital orthophoto quadrangle (DOQ) images, and by persons with local knowledge of the area.

A number of descriptive attributes were gathered from a variety of sources and assigned to the mine-related sites wherever available. One hundred forty-three mine-related sites are stored in an ArcInfo coverage called MINE_SITES, which exists on the Boulder River watershed CD-ROM as an export

file in the /bldr_cd/gis_db/sitedata/e00 directory. There is also an ArcInfo lookup table called MINE_SITES.ADITFLOW, which contains information about flowing adits that exist at some of the mine-related sites. The MINE_SITES.ADITFLOW lookup table is part of the MINE_SITES coverage, and is therefore contained in the mine_sites.e00 file. A detailed description of the mine inventory data is in Martin (this volume).

In addition, the MINE_SITES coverage and related tables are also available on the Boulder River watershed CD-ROM as an ESRI shapefile and .dbf files, respectively, in the /bldr_cd/gis_db/sitedata/shape and /bldr_cd/gis_db/sitedata/dbf directories. The mine-related site data are also part of the Boulder River watershed relational database, which is described later in this chapter.

Geoscientific Data

Geologic Data

Two geologic maps were generated from the original geologic map products of Ruppel (1963) and Becraft and others (1963). The first map is a reinterpretation of bedrock geology and is described in O'Neill and others (this volume, Chapter D1). Four data files are provided to create this map. All data are provided in both ArcInfo Export format and ESRI shapefile format. The first data file is the geology polygon and line file (geology.e00, geologyp.shp, and geologyl.shp). This data file updates previously published maps by providing a geologic framework in the context of current geologic nomenclature and modern knowledge for geologic units in the Boulder River watershed. The second data file depicts the geologic structure (faults.e00 and faults.shp). This line file contains the faults that have been mapped in the geologic map area. The third data file is an alteration coverage (alter.e00 and alter.shp). This is a polygon file that shows areas of probable Late Cretaceous alteration. The fourth data file shows the veins that have been mapped for the geologic area (veins.e00 and veins.shp). All of these data files are provided in ArcInfo export format in the /bldr_cd/gis_db/geosci/geology/e00 directory, as well as in ESRI shapefile format in the /bldr_cd/gis_db/geosci/geology/shape directory. O'Neill and others (this volume) provide a comprehensive discussion of geologic features. A PDF format map file also is provided (geol_pl1.pdf). It is located in the /bldr_cd/gis_db/geosci/geology/pdf directory. Throughout this volume, this geologic map is listed and described as plate 1. O'Neill and others (this volume) also contains a second oversize image, which is listed and described as plate 2. The illustration is a fence diagram correlating Quaternary deposits in the area of the inactive Buckeye mine. It is provided on the CD-ROM as a PDF in the /bldr_cd/gis_db/geosci/geology/pdf directory and is named geol_pl2.pdf. The topographic base was simplified for inclusion under the geology in plate 1. A PDF of the complete topographic base is provided in the /bldr_cd/gis_db/geosci/geology/pdf directory and is named topobase.pdf.

The second geologic map provides a reinterpretation of study area geology in a geoenvironmental context, as described by McCafferty and others (this volume, Chapter D2). This map depicts geologic units in terms of their relative acid-neutralizing potential based on mineralogical data and acid-leachate studies. Geologic units with higher acid-neutralizing potential are shown in lighter shades of green, and units with relatively low acid-neutralizing potential are shown in darker greens. This map (e_geo.tif) is provided in GeoTIFF format. It is located in the /bldr_cd/gis_db/geosci/geophys/geotiff directory.

Geochemical Data for Streambed Sediment and Water

Eleven files provided in the geochemistry section depict geochemical data for streambed sediment and water. The original geochemical data consisted of concentration data for trace elements in either sediment or water. These data were reinterpreted as hazard quotients to indicate the relative hazard of the trace elements to aquatic biota. These hazard quotients are presented in "ribbon" maps that illustrate the distribution of hazard quotients of selected trace elements as a band of color that runs along the streams and resembles a ribbon. The relative magnitude of the hazard quotient is depicted with different colors. Development of the hazard-quotient ribbon maps is described in more detail by Finger, Farag, and others (this volume, Chapter C).

The geochemistry section contains five streambed-sediment ribbon maps. The elements shown and their corresponding file names are: cadmium (sed_cd.e00 and sed_cd.shp), copper (sed_cu.e00 and sed_cu.shp), lead (sed_pb.e00 and sed_pb.shp), zinc (sed_zn.e00 and sed_zn.shp) and a combination of cadmium, copper, and zinc data (sed_all.e00 and sed_all.shp). A map is provided that shows the localities of all the streambed-sediment sample sites (sed.e00 and sed.shp). All these files are provided in ArcInfo export format in the /bldr_cd/gis_db/geosci/geochem/e00 directory, as well as in ESRI shapefile format in the /bldr_cd/gis_db/geosci/geochem/shape directory.

This section also contains four water geochemical data maps. The elements shown and their corresponding file names are: cadmium (wat_cd.e00 and wat_cd.shp), copper (wat_cu.e00 and wat_cu.shp), zinc (wat_zn.e00 and wat_zn.shp) and a combination of cadmium, copper, and zinc data (wat_all.e00 and wat_all.shp). A map is provided that shows the localities of all the water sample sites (water.e00 and water.shp). All these files are provided in ArcInfo export format in the /bldr_cd/gis_db/geosci/geochem/e00 directory and in ESRI shapefile format in the /bldr_cd/gis_db/geosci/geochem/shape directory. Chapter D5 (Nimick and Cleasby) in this volume contains a detailed description of the water geochemical data.

Biological Data

The one map provided in this section shows the estimated distribution of trout prior to 1997. This file illustrates the distribution of trout by type in the watershed (fish.e00 and fish.shp). The map is based on two types of biological sample sites. The first type of sample site is the fish abundance and health assessment; the second type is the 96-hour survival experiment. This file is provided in ArcInfo export format in the /bldr_cd/gis_db/geosci/biologic/e00 directory and in ESRI shapefile format in the /bldr_cd/gis_db/geosci/biologic/shape directory. Chapter D10 (Farag and others) in this volume contains a detailed description of the biological data.

Geophysical Data

Images of magnetic anomaly and apparent resistivity data and related interpretive products are part of the work described in McCafferty and others (this volume, Chapter D2) and are provided in the /bldr_cd/gis_db/geosci/geophys/geotiff directory on the accompanying CD-ROM. Vector files that define the extent of the airborne geophysical survey are available in ArcInfo export format (gp_poly.e00) in the /bldr_cd/gis_db/geosci/geophys/e00 directory, and in ESRI shapefile format (gp_poly.shp) in the /bldr_cd/gis_db/geosci/geophys/shape directory.

The images provided on the CD-ROM were derived from grids of data collected along closely spaced (200 m) flightlines as part of a high-resolution airborne geophysical survey over the Boulder River watershed area. The images provide a depiction of the magnetic anomaly and apparent resistivity fields but do not allow for detailed data manipulations or interpretation at specific sites. The reader is referred to Smith and others (2000) for the basic magnetic anomaly and apparent resistivity flightline data and grids that would permit these types of analyses. The following text discusses the various geophysical image files that can be found in the /bldr_cd/gis_db/geosci/geophys/geotiff directory.

Images relating to the magnetic anomaly data include a reduced-to-pole magnetic anomaly map, a high-pass magnetic anomaly map, and an image of a model that illustrates estimates of magnetic susceptibility and volume percent magnetite. Except at the north magnetic pole, magnetic anomalies are distorted in shape and positioned off their causative sources. In order to correct for the distortion and dislocation of magnetic anomalies in the study area, a reduction-to-pole operation was applied to the magnetic anomaly field to produce the reduced-to-pole magnetic anomaly image (rtp_mag.tif). To emphasize magnetic anomalies caused by lateral variations in magnetic properties of rocks from surface elevations to approximate depths of 200 m, a filter was applied to the reduced-to-pole data to create the high-pass magnetic anomaly image (rtp_mag_hipass.tif). From these data, models of magnetic susceptibilities and corresponding values for percent magnetite were calculated (mag_magnetite.tif).

Images that portray apparent resistivity of rocks as measured from the airborne geophysical survey are provided on the CD-ROM. The images represent electrical resistivity of rocks at three frequencies resulting in different depths of penetration. The image produced using the highest frequency (56,000 Hz) shows resistivities of rocks at depths from the topographic surface to a few meters to 10 m. The mid-frequency (7,200 Hz) image (res7200.tif) maps electrical resistivities of rocks from the surface to depths of approximately 30 m. The lowest frequency (900 Hz) image (res900.tif) maps resistivities of rocks at depths to approximately 60 m.

For nearly all the Cretaceous- and Tertiary-age volcanic and plutonic rocks exposed in the Boulder River watershed, increased amounts of acid-consuming calcic and mafic minerals are associated with increased levels of the mineral magnetite. Magnetite is the main source for magnetic anomalies and, in part, resistivity anomalies. McCafferty and others (this volume) have converted the magnetic and apparent resistivity anomaly data to maps of volume percent magnetite to infer places in the watershed with low acid-neutralizing potential. Estimates for volume percent magnetite calculated from the 900-Hz apparent resistivity data are shown in the image file em_magnetite.tif. Volume percent magnetite estimates modeled from the magnetic anomaly data are given in the mag_magnetite.tif file. Low values in both geophysical magnetite models have been combined to produce an integrated product that represents locations of rocks with little to no acid-neutralizing potential (gp_low_ANP.tif).

Remote Sensing Data

The remote sensing section includes three vector files and five raster files. The first vector file represents linear features (lin_f.e00 and lin_f.shp) that were mapped from remote sensing base images. They are assumed to represent the spatial distribution, spatial frequency, and orientation of faults, joints, and fractures associated with structurally controlled ground-water flow. The second vector file is a wet soil coverage (wetsoil.e00 and wetsoil.shp). This coverage shows areas of saturated soils that are associated with shallow ground water. The third file illustrates wetlands (wetland.e00 and wetland.shp) that are defined as areas that have soils with perennial or seasonal high water tables. The vector files are provided in ArcInfo export format in the /bldr_cd/gis_db/geosci/remosens/e00 directory, and in ESRI shapefile format in the /bldr_cd/gis_db/geosci/remosens/shape directory. See Chapter D9 in this volume (McDougal and others) for a detailed description of these files.

The five raster files included in the remote sensing section show the linear features in terms of spatial frequency (frequency.tif), number of intersections (intersect.tif), and total length within a grid cell (length.tif). The contour maps represent zones of least occurrence of linear features, shortest linear features, and least number of intersections with cooler colors, and zones of higher occurrence, greater length, and

greater occurrence of intersections with warm colors. Two derivative maps have been produced from these images. The first is a combination of the spatial frequency and the length of the mapped linear features (frequency_length.tif). The second is a combination of the spatial frequency of the linear features and the number of the linear feature intersections (frequency_intersect.tif). These five files are provided in the GeoTIFF format. See Chapter D9 (McDougal and others) in this volume for a detailed description of the files. The files can be found in the /bldr_cd/gis_db/geosci/remosens/geotiff directory.

The geologic maps and the geochemical, biological, geophysical, and remote sensing data are listed in table 4, and are available on the CD-ROM in the /bldr_cd/gis_db/geosci directory.

Relational Database

The Boulder River watershed relational database was constructed to be used as a tool for data synthesis and analysis, and as an archive of data collected during the Boulder River watershed study. It includes data collected by U.S. Geological Survey biologists, geologists, and hydrologists within or adjacent to the Boulder River watershed during the period 1995 to 2000[1]. It is a tabular relational database containing field measurements made at point locations, and laboratory analyses of samples collected at point locations. Quality-assurance data are not included; information on field and laboratory quality-assurance practices is located in individual chapters in this report or in previously published reports. A Geographic Information System (GIS) representation of the database is discussed elsewhere in this chapter.

Contents of Database

The Boulder River watershed relational database contains data contributed by eight U.S. Geological Survey scientists or teams (table 5). These data sets comprise all of the available data collected as part of the project. Data were collected at 479 sites (fig. 3). Twenty-four media types were sampled, including 1,038 water samples, 1,094 earth material samples, and 79 biological material samples. Water media sampled included surface water (streams), ground water (well water), and springs. Earth media sampled included soils, bedrock, and various types of sediment. Biological media sampled included biofilm, fish tissue, invertebrate tissue, and tree tissue. The database contains 67,366 results, which are quantitative, qualitative, or descriptive measurements; the database contains 776 defined measurement types (parameters).

[1]Forty-eight analyses of bedrock samples collected during 1952–54 also are included in the database.

Database Structure

Because of the scope and complexity of data collected as part of the Boulder River watershed study, a relational database structure was designed for data storage. Data are grouped into logical units (tables), and relationships are defined to link the tables. This structure provides efficient storage of information (that is, the information need not be repeated), and also provides for built-in data-verification checks; for example, a result cannot exist without corresponding site, sample, and parameter information. The relational database structure also is powerful and efficient for retrieving subsets of data to meet user requirements.

The primary tables in the Boulder River watershed relational database (directory rel_db on the accompanying CD-ROM) are the FieldSites, Sample, Result, and Parameter tables (fig. 4). The FieldSites table contains information about each of the 479 sites in the database. A SiteNumber uniquely identifies each site. Sites that are considered co-located for purposes of spatial analysis are assigned the same AMLIAnalysisID. A ProjectCode for each site indicates what project and scientist established the site. The attribute PPSiteLabel contains the label which is used for a field site on figures or diagrams elsewhere in this Professional Paper. These labels are not always exactly the same as the field sites' SiteNumber. Additional characteristics in the FieldSites table include locational coordinates, SiteComment, and a Stream designation which indicates if a site is located on a stream, and if so, which one.

The Sample table contains information about material collected at each site, such as the date and time of collection, and the type of material (sample media) collected at the site. Media type should be carefully noted when data are analyzed, so that data of different types are not mistakenly equated; for example, the database contains analyses for arsenic in fish livers and in fish gills, organs which might have different characteristics relative to the bioaccumulation of metals. Optional characteristics in the Sample table include SamplePreparation, SampleComment, and CollectionMethod.

The Result table contains measurements made at sites. The characteristic measured is identified using a ParameterCode, a succinct 20-character-length field that can be used as a column name in a data report or spreadsheet. Measurements consist of a numeric value and an optional ValueRemarkCode, which is used to qualify results such as nondetections or estimates. Optional characteristics in the Result table include AnalyticMethodShortName and LabShortName.

The Parameter table is a lookup table that contains a complete description of each characteristic measured. Although the Result table contains a short description of the characteristic measured (ParameterCode), a lengthier description is needed owing to the highly specific nature of laboratory measurements. For example, the ParameterCode "Ag_ss" is shorthand for "Silver, sediment, suspended, ground finer than 0.15 millimeters, laboratory, micrograms per gram." The Parameter table also includes a ConstituentName field to

Table 4. Geologic maps and geochemical, biological, geophysical, and remote sensing data in the Boulder River watershed GIS database.

Subject	Description	File name	File format(s)	Chapter
Geology				
	Geology	geology.e00, geologyp.shp (polys), geologyl.shp (lines)	ArcInfo vector coverage	O'Neill and others (D1)
	Structure	faults.e00, faults.shp	ArcInfo vector coverage	O'Neill and others (D1)
	Alteration areas—possible Late Cretaceous alteration	alter.e00, alter.shp	ArcInfo vector coverage	O'Neill and others (D1)
	Veins	veins.e00, veins.shp	ArcInfo vector coverage	O'Neill and others (D1)
	Geologic Map Plate	geol_pl1.pdf	PDF map	O'Neill and others (D1)
	Correlation Diagram	geol_pl2.pdf	PDF map	O'Neill and others (D1)
	GeoEnvironmental Map	e_geo.tif	GeoTIFF	McCafferty and others (D2)
Geochemistry				
	Location map that shows the localities of all the streambed-sediment samples	sed.e00, sed.shp	ArcInfo vector coverage	Church and others (D8)
Sediment Ribbon Maps				
	Ribbon map that shows the concentration of cadmium in the streambed sediment recast as hazard quotient values	sed_cd.e00, sed_cd.shp	ArcInfo vector coverage	Church and others (D8)
	Ribbon map that shows the concentration of copper in the streambed sediment recast as hazard quotient values	sed_cu.e00, sed_cu.shp	ArcInfo vector coverage	Church and others (D8)
	Ribbon map that shows the concentration of lead in the streambed sediment recast as hazard quotient values	sed_pb.e00, sed_pb.shp	ArcInfo vector coverage	Church and others (D8)
	Ribbon map that shows the concentration of zinc in the streambed sediment recast as hazard quotient values	sed_zn.e00, sed_zn.shp	ArcInfo vector coverage	Church and others (D8)
	Ribbon map that shows the concentration of cadmium + copper + zinc in the streambed sediment recast as hazard quotient values	sed_all.e00, sed_all.shp	ArcInfo vector coverage	Church and others (D8)
	Location map that shows the localities of all the water samples	water.e00, water.shp	ArcInfo vector coverage	Nimick and Cleasby (D5)
Water Ribbon Maps				
	Ribbon map that shows the concentration of cadmium in the water recast as hazard quotient values in terms of the EPA water quality standards	wat_cd.e00, wat_cd.shp	ArcInfo vector coverage	Nimick and Cleasby (D5)
	Ribbon map that shows the concentration of copper in the water recast as hazard quotient values in terms of the EPA water quality standards	wat_cu.e00, wat_cu.shp	ArcInfo vector coverage	Nimick and Cleasby (D5)

Table 4. Geologic maps and geochemical, biological, geophysical, and remote sensing data in the Boulder River watershed GIS database.—Continued

Subject	Description	File name	File format(s)	Chapter
Water Ribbon Maps—Continued				
	Ribbon map that shows the concentration of zinc in the water recast as hazard quotient values in terms of the EPA water quality standards	wat_zn.e00, wat_zn.shp	ArcInfo vector coverage	Nimick and Cleasby (D5)
	Ribbon map that shows the concentration of cadmium + copper + zinc in the water recast as hazard quotient values in terms of the EPA water quality standards	wat_all.e00, wat_all.shp	ArcInfo vector coverage	Nimick and Cleasby (D5)
Biological data				
	Estimated distribution of trout population prior to 1997	fish.e00, fish.shp	ArcInfo vector coverage	Farag and others (D10)
Geophysics				
	56K Hz. resistivity	res56K.tif	GeoTiff	McCafferty and others (D2)
	7200 Hz. resistivity	res7200.tif	GeoTiff	McCafferty and others (D2)
	900 Hz. resistivity	res900.tif	GeoTiff	McCafferty and others (D2)
	Reduced-to-the-pole magnetic anomaly	rtp_mag.tif	GeoTiff	McCafferty and others (D2)
	Reduced-to-the-pole high pass magnetic anomaly	rtp_mag_hipass.tif	GeoTiff	McCafferty and others (D2)
	Volume percent magnetite estimated from 900-Hz resistivity	em_magnetite.tif	GeoTiff	McCafferty and others (D2)
	Volume percent magnetite estimated from the high pass magnetic anomaly data	mag_magnetite.tif	GeoTiff	McCafferty and others (D2)
	Geophysically-inferred bedrock with low acid-neutralizing potential	gp_low_ANP.tif	GeoTiff	McCafferty and others (D2)
	Outline of the geophysical study area boundary	gp_poly.e00, gp_poly.shp	ArcInfo vector coverage	McCafferty and others (D2)
Remote sensing				
	The spatial frequency of mapped linear features	frequency.tif	GeoTiff	McDougal and others (D9)
	The combined spatial frequency and intersections of mapped linear features	frequency_intersect.tif	GeoTiff	McDougal and others (D9)
	The combined spatial frequency and length of mapped linear features	frequency_length.tif	GeoTiff	McDougal and others (D9)
	The number of intersections of mapped linear features	intersect.tif	GeoTiff	McDougal and others (D9)
	The length of mapped linear features	length.tif	GeoTiff	McDougal and others (D9)
	Areas that have soils with perennial or seasonal high water tables	wetland.e00, wetland.shp	ArcInfo vector coverage	McDougal and others (D9)
	Areas of saturated soils that are associated with linear features	wetsoil.e00, wetsoil.shp	ArcInfo vector coverage	McDougal and others (D9)
	Linear features that have been delineated from fracture analysis	lin_f.e00, lin_f.shp	ArcInfo vector coverage	McDougal and others (D9)

Table 5. Data sources for sample-site data in the Boulder River watershed relational database.

[Not all data have been published elsewhere in the documents listed in the Reference column. See appropriate chapter in this volume or the accompanying CD-ROM for access to all of the data]

AMLI Project Component	Contact scientist	Media sampled	Number of sites	Number of samples	Number of results	Reference	Chapter in which data are primarily used
Characterization of water-quality conditions	D.A. Nimick	Surface water, ground water	111	858	14,682	Nimick and Cleasby (2000)	D5
Uncle Sam Gulch, Bullion Mine tributary, and Cataract Creek metal-loading study	B.A. Kimball	Surface water	168	172	7,186	Kimball and others (this volume)	D6
Rare earth geochemistry of acidic waters	P.L. Verplanck	Surface water	8	8	429	Verplanck and others (1999)	Data not used
Characterization of ecosystem health	A.M. Farag	Biota	15	67	331	Farag and others (this volume)	D10
Characterization of stream sediment and mine wastes	D.L. Fey	Biota, rock, sediment, soil, mine wastes	95	607	28,226	Fey and Church (1998); Fey and others (1999); Fey, Church, and Finney (2000); Fey and Church (1999); Fey, Desborough, and Finney (2000)	D4, D8, E1
Characterization of tailings core	S.E. Church	Sediment, soil, mine wastes	1	232	8,768	Church, Unruh, and others (this volume)	E1
Chemical and lead isotope compositions of mine wastes and premining sediment	D.M. Unruh	Biota, sediment	21	186	5,691	Unruh and others (2000)	D8
Chemical compositions of mine wastes	D.L. Fey	Rock, soil	21	33	941	Desborough and others (1998)	D1, D2, D4
Rock geochemistry	B.S. Van Gosen	Rock	39	48	1,112	Ruppel (1963); Becraft and others (1963)	D1
TOTAL			**479**	**2,211**	**67,366**		

group results according to the element or compound type (for example, zinc), and a Ppcode field which lists the corresponding measurement code (where available) in the U.S. Geological Survey's National Water Information System and the U.S. Environmental Protection Agency's STORET database.

Relationships between these tables are depicted as lines in figure 4. The FieldSites table is linked to the Sample table by including a common field (Site Number) in both tables; therefore a sample cannot exist without a corresponding site in the FieldSites table. The symbols "1" and "∞" on the relationship line indicate a one-to-many relationship, that is, a site may have many samples. Similarly a sample may have many results, and a parameter may have many results.

The Boulder River watershed relational database contains 10 tables in addition to the 4 principal tables. The Qualitative Result table includes measurements that are text values (as opposed to number values in the Result table). The SpatialAnalysisSites table provides site groupings so that data may be extracted from sites that are logically co-located for analysis purposes. The AnalyticMethod table provides additional information on laboratory techniques used. The LabName table provides additional information about analytical laboratories that produced chemical results. The Project table

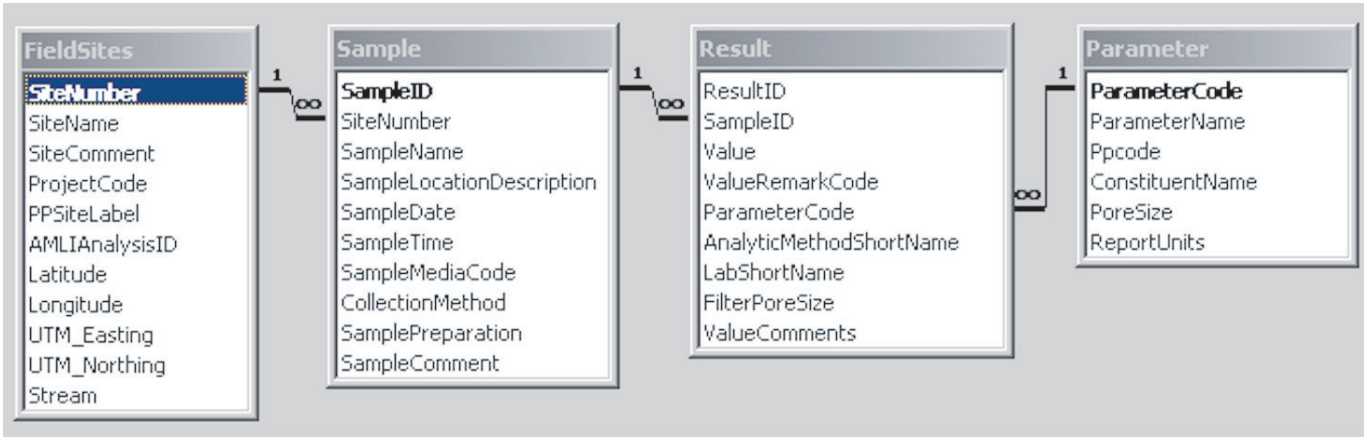

Figure 4. Primary tables in the relational database and the relationships between tables.

provides additional information about projects that provided data to the Boulder River watershed relational database. The SampleMedia table provides additional information about the media types sampled. The LocationMaster table contains characteristics for each field site derived by map overlay using a GIS system. The MineSites table contains information about the mine-related sites located in the study area, and the MineSitesAditFlow table contains data about flowing adits that exist at certain mine-related sites. The FieldSiteMineSiteAssocs table lists certain field sites that are associated with mine-related sites.

A bitmap file (relationship_diagram.bmp), containing a complete diagram of the relationships of all the files in the Boulder River watershed relational database, exists on the accompanying CD-ROM in the /bldr_cd/rel_db directory.

Relational databases can be implemented using a variety of proprietary or nonproprietary software packages. The Boulder River watershed relational database is provided on the CD-ROM attached to this report in a format compatible with proprietary software (Microsoft Access 2000) in the /bldr_cd/rel_db/mdb directory, and in a nonproprietary format in the /bldr_cd/rel_db/ascii directory. A README.txt file on the CD-ROM in /bldr_cd/rel_db provides technical details about how to use the database in these two formats. A more complete discussion of the creation and content of the database is included on the CD-ROM in a Federal Geographic Data Committee-compliant metadata file in /bldr_cd/rel_db/meta.

Data may be extracted from the Boulder River watershed relational database to meet specific user needs. Within relational database software packages, queries may be constructed and saved to retrieve data using user-defined criteria; the Microsoft Access version of the Boulder River watershed relational database on the CD-ROM contains several example queries. Suppose a scientist wishes to examine downstream patterns of zinc concentrations in water along the mainstem of Cataract Creek during August 1997. To extract the necessary data from the database, a series of linked queries is constructed. The initial query is used to select the database fields of interest and to place conditions on retrieving the data. For the Zinc Synoptic data, the user would like a table that includes the site name, the instantaneous water discharge, the zinc concentration and the distance of the sampling point from the starting point on the stream. The query qselZnSynopticData (fig. 5) selects the fields of interest.

The query combines data from three tables, the FieldSites table (which contains the SiteName and Stream), the Sample

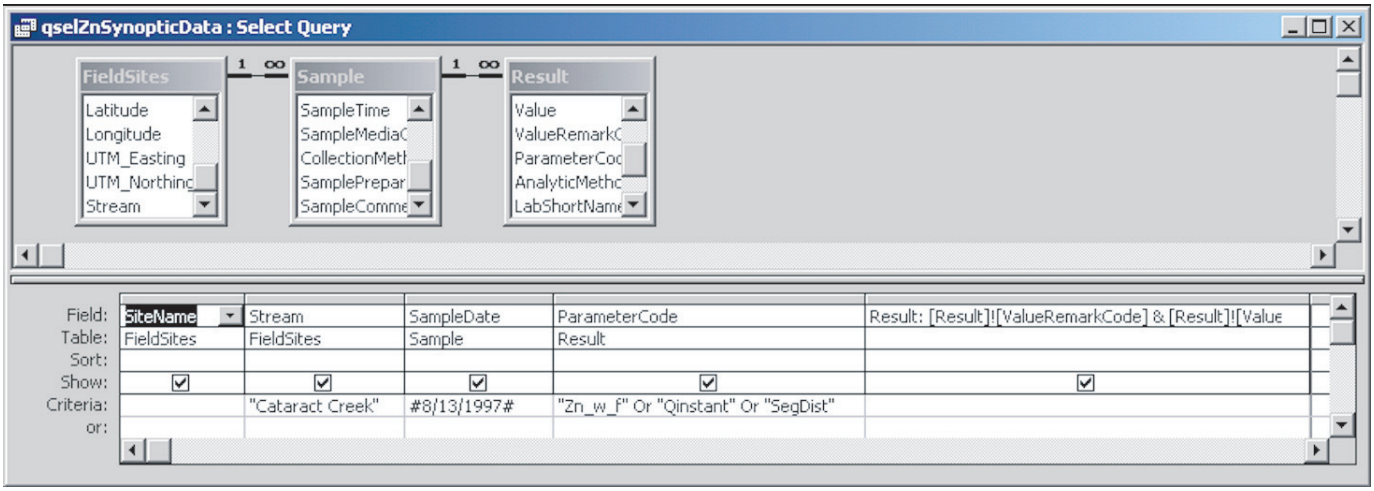

Figure 5. Graphical view of the qselZnSynopticData query.

table (which contains the SampleDate), and the Result table (which contains result information). Conditions are placed on this query so that only data with a Stream of "Cataract Creek" are selected, only samples taken on 8/13/97 are selected, and only results for water discharge, zinc concentration, and downstream distance are selected. This query also constructs the Result value as a concatenation of the numerical result along with any remark code. The graphical view of the query shown in figure 5 is translated into a Structured Query Language (SQL) statement as follows:

SELECT FieldSites.SiteName, FieldSites.Stream, Sample.SampleDate, Result.ParameterCode, [Result]![ValueRemarkCode] & [Result]![Value] AS Result FROM (FieldSites INNER JOIN Sample ON FieldSites.SiteNumber = Sample.SiteNumber) INNER JOIN Result ON Sample.SampleID = Result.SampleID WHERE (((FieldSites.Stream)="Cataract Creek") AND ((Sample.SampleDate)=#8/13/1997#) AND ((Result.ParameterCode)="Zn_w_f" Or (Result.ParameterCode)="Qinstant" Or (Result.ParameterCode)="SegDist"));

The second query in this example (qselZnSynopticData_Crosstab) is a crosstab query which pivots the results of interest so that they appear as columns rather than rows. The third query (qmakZnSynopticResults) makes a new table containing the results sorted by downstream distance. A portion of this table is shown in figure 6.

Data Viewer Software

Two freeware GIS data viewer software packages are provided on the accompanying CD-ROM. These products are GIS data explorers. The purpose of the data viewer software is to give the user the capabilities to perform elementary GIS analysis on the digital data. The vector coverages and raster images provided on the CD-ROM are useful for illustrating the processes and dynamics, in terms of mine drainage, that occur in the watershed.

ZnSynopticResults : Table

SiteName	Discharge	Zinc Concentration	Distance
CC-150	4.13	<10	150
CC-850	4.27	<10	850
CC-1370	4.38	<10	1370
CC-1610	4.45	<10	1610
CC-1690	4.59	<10	1690
CC-2490	4.55	<10	2490
CC-3450	6	<10	3450
CC-3850	6.14	<10	3850
CC-4660	6.43	33	4660
Cataract Creek below Hoodoo Creek	6.53	53	4940
CC-5940	6.6	47	5940
CC-6800	6.67	36	6800
CC-7900	6.74	35	7900
CC-8700	6.81	45	8700
CC-9220	6.99	45	9220
CC-10380	7.24	47	10380
CC-11055	7.59	42	11055
CC-12115	7.91	56	12115
CC-13255	8.16	57	13255
CC-14055	8.33	52	14055
CC-14855	8.44	60	14855
CC-15655	8.55	56	15655
CC-16845	8.83	58	16845
CC-17645	9.22	53	17645
CC-18545	9.53	30	18545
CC-19245	9.75	30	19245
Cataract Creek above Uncle Sam Gulch	9.57	31	19700
Cataract Creek below Uncle Sam Gulch	11.51	470	20050
CC-20730	11.69	460	20730
CC-21130	11.86	457	21130
CC-21715	11.93	422	21715

Record: 2 of 46

Figure 6. The reformatted results of the qselZnSynopticData query.

The two data viewer software packages are ArcExplorer 2.0 and MapSheets Express 1.3. ArcExplorer 2.0 was written by Environmental Systems Research Institute, Inc. MapSheets Express was written by ERDAS, Inc.

Using these two products, the spatial data can be displayed, queried, and overlaid to produce map output. MapSheets Express enables the user to generate maps that can be imported into PowerPoint presentations. In addition, Word and WordPerfect documents can be output from MapSheets Express.

The two software packages have some important differences. ArcExplorer is better at handling vector files than raster files. Raster images can be displayed in ArcExplorer, but one cannot query the images. The raster images can only be displayed one at a time as a background for vector files. Basically, this image is a static backdrop with no inherent analysis properties.

In contrast, MapSheets Express has more functionality for raster images than ArcExplorer provides. The user is able to query pixels of the raster images. The attributes of these pixels are accessible in the data tables for user output. In addition, MapSheets Express allows the user to control the transparency of the images, which allows several raster images to be displayed on top of one another. In summary, for vector data work, ArcExplorer is a more effective tool, and for raster data work, MapSheets Express is better.

The two packages have similar platform requirements. ArcExplorer 2.0 requires a PC with Windows 98/2000/NT/XP operating systems. It requires Internet Explorer 4.0 for the internet capabilities of the software. MapSheets Express 1.3 requires Windows 95 or Windows NT version 4.0 operating system or later. Both ArcExplorer 2.0 and MapSheets Express 1.3 need 16 MB RAM and an IBM/PC or compatible system with 486-class processor or better.

Boulder River Watershed CD-ROM

The directory structure for the data and information contained on the Boulder River watershed CD-ROM is shown in figure 7.

The rel_db directory contains the relational database version of the sample-site data collected for the study, and the mine-related site inventory compiled for the study. The directory itself contains a README.txt file which describes the contents of the directory, and a bitmap file (relationship_diagram.bmp) which is a diagram of all the tables in the relational database, and the relationships between them. The mdb subdirectory contains the Microsoft Access version of the relational database (BoulderAMLI.mdb), the ascii subdirectory contains relational database tables in the form of flat, ASCII files, and the meta subdirectory contains metadata for the relational database.

The gis_db directory contains three subdirectories (basecart, sitedata, and geosci), each of which contains different types of data in formats suitable for use in Geographic Information Systems. The basecart subdirectory contains base cartographic data used as reference for the other data. The basecart subdirectory itself contains a README.txt file describing the base cartographic data. Below this subdirectory, the e00 subdirectory contains ArcInfo export files of base cartographic data stored as ArcInfo coverages. The shape subdirectory contains ESRI shapefiles and .dbf files of the data contained in the ArcInfo coverages. The elev subdirectory contains a compressed tar file, which when uncompressed creates an ArcInfo workspace containing an elevation grid, and slope, aspect and shaded relief grids derived from the elevation grid. The elev subdirectory also includes TIFF image file representations of the elevation data, and TIFF

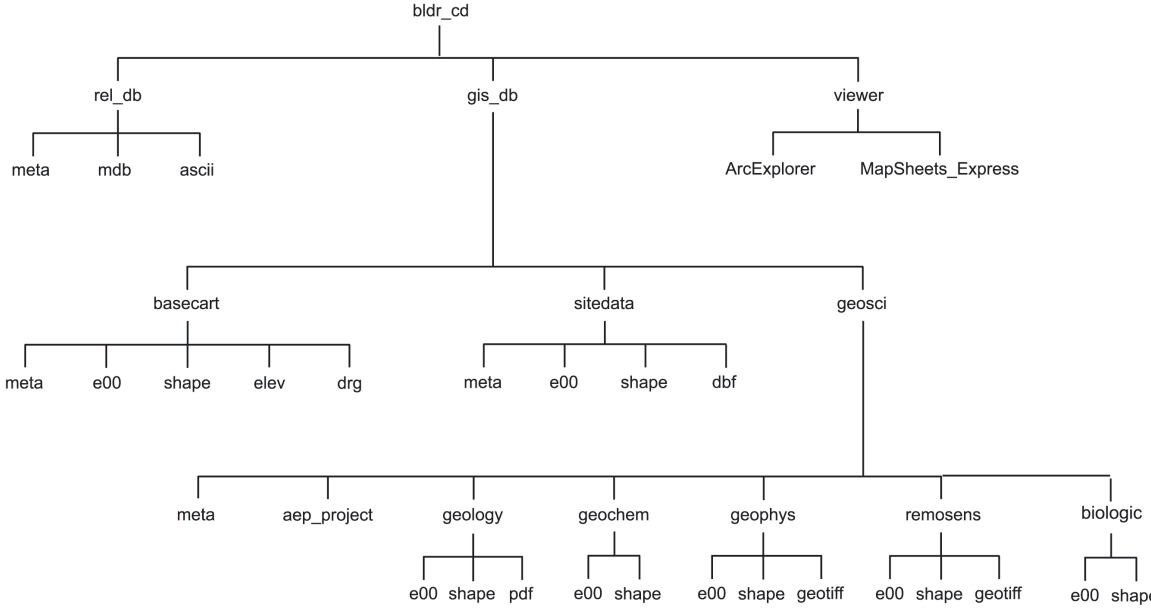

Figure 7. Directory tree structure for the Boulder River watershed CD-ROM.

images of legends for the elevation data image files. The meta subdirectory contains metadata for the data in the e00, shape, and elev subdirectories. The drg subdirectory contains U.S. Geological Survey Digital Raster Graphic (DRG) image files for the eight 7.5-minute quadrangles which contain the majority of the data in the Boulder River watershed study.

The second subdirectory under the gis_db directory, the sitedata subdirectory, contains the sample-site and mine-related site data from the relational database, but in formats directly compatible with Geographic Information Systems. A README.txt file at the sitedata level provides descriptive information about the data stored beneath it. The e00 subdirectory contains the site data as ArcInfo export files of coverages and ArcInfo export files of INFO files. The shape subdirectory contains three site data layers (field sites, analysis sites, and mine-related sites) as ESRI shapefiles. The dbf subdirectory contains 11 tables which contain information about the sites, and data collected at the sites. These tables are in the form of .dbf files. The meta subdirectory contains metadata about the data in the e00, shape, and dbf subdirectories.

The third subdirectory under the gis_db directory, the geosci subdirectory, contains geoscientific and hydrologic data sets, as well as a sample ArcExplorer project file. A README.txt file in the geosci subdirectory lists the contents of the directory. There are seven subdirectories: geology, geochem (geochemistry), geophys (geophysics), remosens (remote sensing), biologic, meta (metadata), and aep_project (ArcExplorer project file). The meta subdirectory contains metadata about all of the interpretive geoscientific data. In each of the data subdirectories, an e00 subdirectory contains data as ArcInfo export files of coverages, a shape subdirectory contains data as shape files, and a geotiff subdirectory (if one exists) contains data in the GeoTIFF format. The pdf subdirectory under the geology directory contains the geology map of Chapter D1 in a PDF format. It also contains a PDF of a fence diagram showing correlation of Quaternary deposits in Buckeye meadow, in the Basin Creek drainage, which is a second plate discussed in Chapter D1. A PDF of the complete topographic base also is included in this directory.

The viewer directory contains two data viewer software packages. The directory itself contains a README.txt file which summarizes the directory's contents. There are two subdirectories: ArcExplorer and MapSheets_Express. The ArcExplorer subdirectory contains a file (ae2setup.exe) which is an executable file that allows one to install the ArcExplorer 2.0 data viewer software. The ArcExplorer.pdf file, created when the ae2setup.exe file is run, is a User Guide for ArcExplorer which includes a tutorial. Similarly, the MapSheets_Express subdirectory contains an executable file (mxsetup.exe) that allows one to install the MapSheets Express 1.3 data viewer software. The Readme.txt file, created when the mxsetup.exe file is run, provides various types of information about the MapSheets Express program.

An ArcExplorer project file (boulder_aml.aep, located in the /bldr_cd/gis_db/geosci/aep_project directory on the CD-ROM) is available as an example of how to use the ArcExplorer software to display and use the data on the CD-ROM. The data files have been organized, and their attributes have been displayed, in the legend defined in the project file.

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