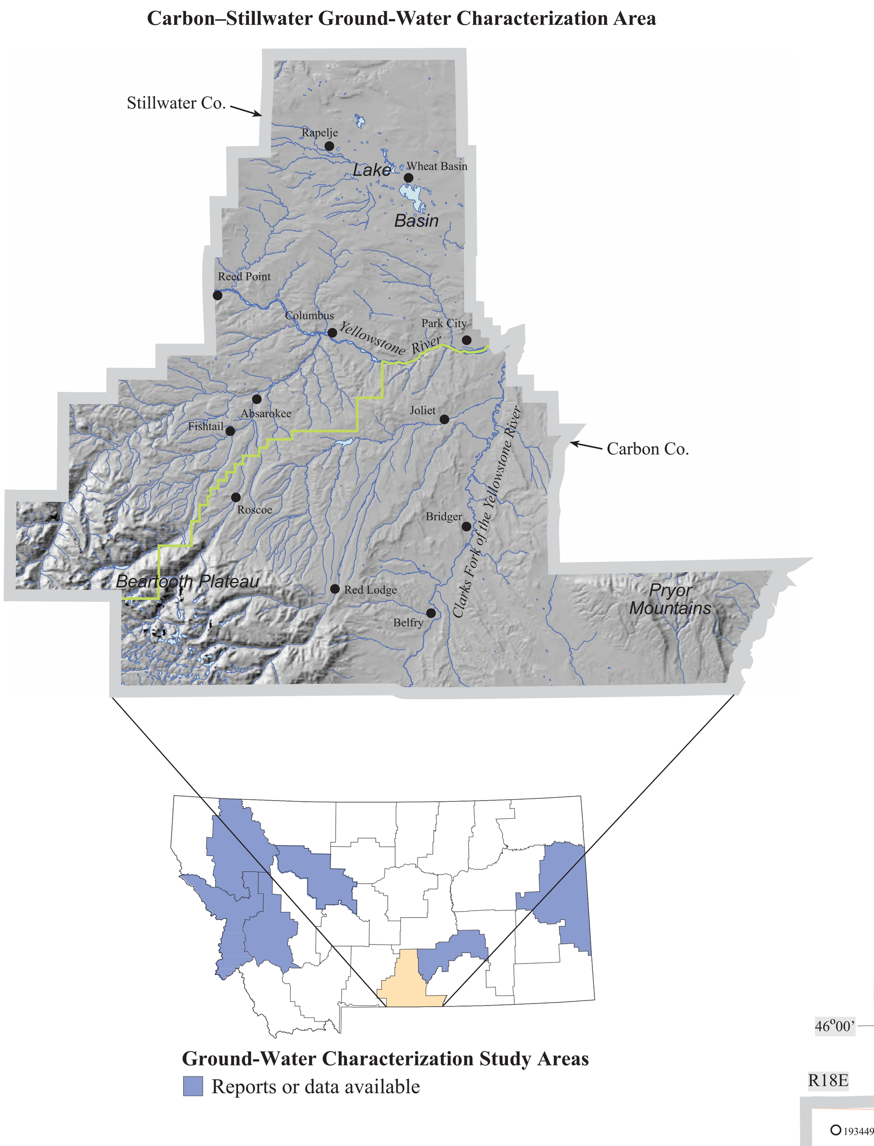
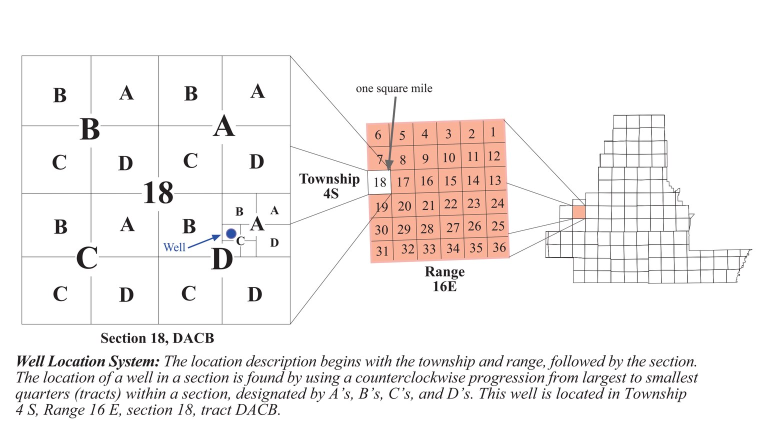
Data for Sites Visited during the Carbon–Stillwater Ground-Water Characterization Study

by
Camela A. Carstarphen, Larry N. Smith, Donald C. Mason, John I. LaFave, and Michael G. Richter

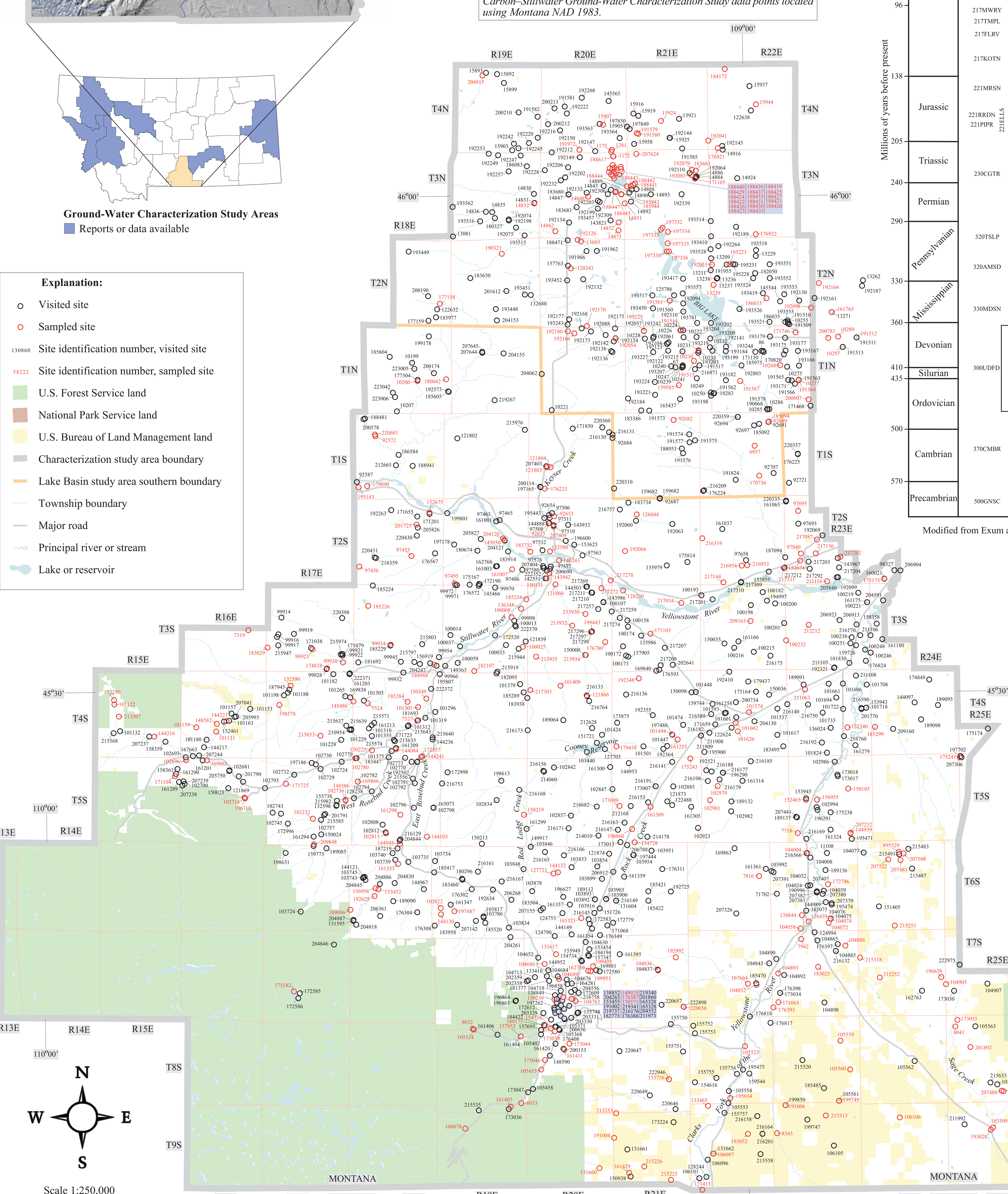
Carbon–Stillwater Ground-Water Characterization Area





Well Location System: The location description begins with the township and range, followed by the section. The location of a well in a section is found by using a counterclockwise progression from largest to smallest quarters (tracts) within a section, designated by A's, B's, C's, and D's. This well is located in Township 4 S, Range 16 E, section 18, tract DACB.

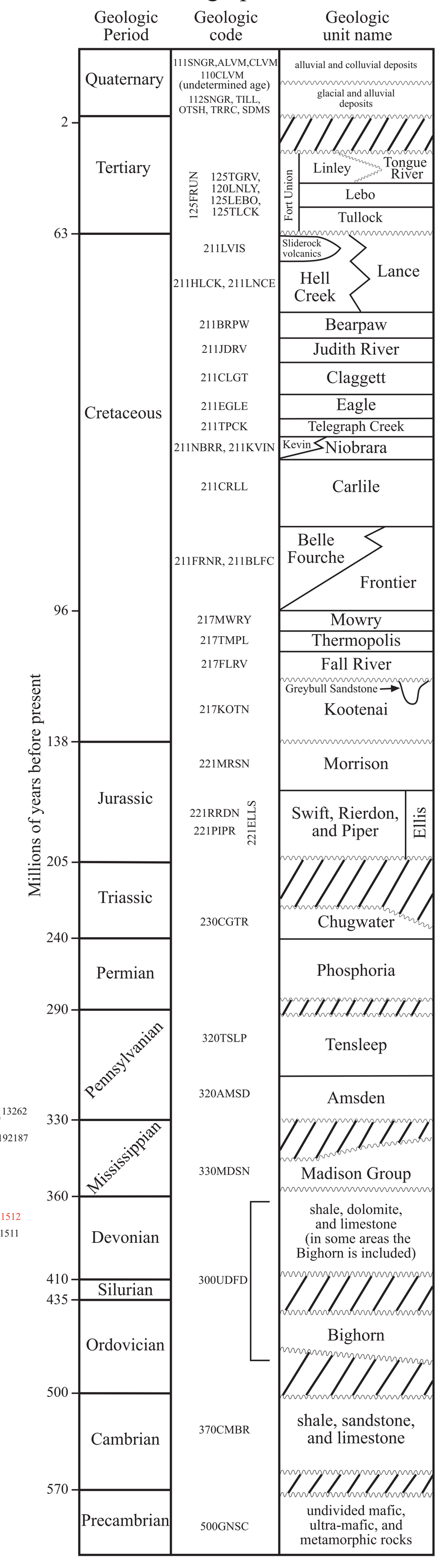
Note: Lake Basin Study data points located using Montana NAD 1927. Carbon–Stillwater Ground-Water Characterization Study data points located using Montana NAD 1983.



Explanation:

- Visited site
- Sampled site
- Site identification number, visited site
- Site identification number, sampled site
- U.S. Forest Service land
- National Park Service land
- U.S. Bureau of Land Management land
- Characterization study area boundary
- Lake Basin study area southern boundary
- Township boundary
- Major road
- Principal river or stream
- Lake or reservoir

Stratigraphic column



Modified from Exum and George (1975)

Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Assessment Atlas for the Carbon–Stillwater Area ground-water characterization. It is intended to stand alone and describe a single hydrogeologic aspect of the study area, although many of the area's hydrogeologic features are interrelated. For an integrated view of the hydrogeology of the Carbon–Stillwater Area, the reader is referred to Part A (descriptive overview) and other Part B maps of Montana Ground-Water Assessment Atlas No. 6.

INTRODUCTION

Visits to 891 water wells, 56 springs, and 3 surface-water sites were completed as part of the Montana Ground-Water Characterization Program's Carbon-Stillwater Area study. The study area includes all of Carbon and Stillwater Counties. A complementary project, located in northern Stillwater County, the Lake Basin 319 Project, occurred at the same time and MBMG staff visited 225 wells or boreholes, 36 springs, and 2 surface-water sites. Characterization program staff visited sites between August 2002 and November 2005, and other MBMG personnel visited sites in the Lake Basin Project between June 2001 and November 2003. Locations for sites visited from both projects are displayed on the map and selected field data are listed. Visited wells were chosen from about 8,200 known wells. Ground-water characterization staff targeted previously inventoried wells (McDermott, 1966; Darlinton, 1969; Waren, 2000) for additional data collection.

GEOLOGIC UNITS

Geologic units for the completion interval of each well (Tables 1 and 2) were assigned by comparing the driller's lithologic log and perforation records to geologic maps by Berg and others (1999), Lopez (2000ab, 2001, 2005), and Wilde and Porter (2000, 2001). Important stratigraphic distinctions between units have been described and mapped by Ritter (1967), Flueckinger (1970), Jobling (1974), and Exum and George (1975). The stratigraphic column illustrates the ages and relationships between the various rock units. The study area includes parts of several major geographic/geologic provinces: the Beartooth Plateau, the Pryor Mountains, the Yellowstone River valley and its tributaries, and the Lake Basin area.

The Beartooth Plateau, a geologically uplifted area, contributes significant surface water to major tributaries to the Yellowstone River and is an important ground-water recharge area for the southwestern part of the study area. Precipitation on the Beartooth Plateau ranges from 24–70 inches per year. Precambrian igneous and metamorphic rocks core the plateau, and younger sedimentary rocks are upturned along its flanks. Aquifers are typically shallow sand and gravel along large stream valleys, fractured zones in bedrock, and various sedimentary rocks. Few wells in the study area (only 3 percent of inventoried wells) are completed in rocks that are older than Cretaceous.

The Pryor Mountains in southeastern Carbon County receive less than half as much precipitation as the Beartooth Plateau. Ground water issues from large springs peripheral to the mountains, which are sources for a number of streams. Ground-water characterization staff visited 25 springs. The springs and numerous wells produce water from the Madison, Tensleep, and Chugwater Formations. Wells in the hills near the mountains are generally completed in various Cretaceous Formations.

The Yellowstone River flows west-to-east through Stillwater County; large southern tributaries are the Stillwater, Rosebud, Red Lodge, Rock, and the Clarks Fork of the Yellowstone rivers. Northern tributaries are numerous but have much lower flows than the southern tributaries. Wells in the river valleys are completed in near-surface Holocene or Pleistocene alluvial sand and gravel or in bedrock immediately below the alluvial deposits. Bedrock that produces water includes various members of the Fort Union Formation; the Hell Creek, Lance, Judith River, and Eagle Formations; and volcanic rocks of the Livingston Group.

The northern Stillwater County area is topographically subdued and contains internally-drained areas, such as the Lake Basin near the towns of Rapelje and Wheat Basin. The northernmost portion of Stillwater County drains northward to the Musselshell River, and subsequently to the Missouri River. Most wells are completed in either shallow sand and gravel or near-surface Cretaceous sedimentary rocks, mostly the Judith River and Eagle Formations.

SITE VISITS

Visited sites were selected to provide baseline data for alluvial and bedrock aquifers. Coordinates for each visited site were determined using a hand-held global positioning system receiver and USGS 1:24,000 topographic maps. Where possible, data collected included the static-water level, temperature, pH, and specific conductance of the water. The parameters reported represent stabilized readings attained after an average 30-minute pumping duration. Staff collected samples from selected wells and springs after field parameters stabilized and/or three well volumes of water were discharged. Some wells either could not be pumped to measure water parameters or not accessed to measure the water level. Selected data for the inventoried wells are included in Table 2; well locations and their Ground-Water Information Center (GWIC) identification numbers are shown on the map. Selected wells were sampled as indicated in Table 2; results for complete water-analyses (major ions and trace metals) and nitrate analyses are available from GWIC.

DATA SOURCES

All data and water-quality analysis results are available from the GWIC database at the MBMG (http://mbmggwic.mtech.edu). Land ownership, hydrography, public land survey, and road data were obtained from the Natural Resources Information System, Helena (http://nris.state.mt.us/).

ACKNOWLEDGMENTS

We thank all property owners who gave permission to inventory their wells. Reviews of the map by Tom Patton, Kirk Waren, John Metesh, and Ed Deal are greatly appreciated.

REFERENCES

Berg, R.B., Lonn, J.D., and Locke, W.W., 1999, Geologic map of the Gardiner 30' x 60' quadrangle, south-central Montana: Montana Bureau of Mines and Geology Open-File Report 387, 9 p., 2 sheet(s), 1:100,000.
Darlinton, E.V., 1969, Groundwater inventory Carbon County Montana: Helena, Montana Water Resources Board, 40 p.
Exum, F.A., and George, G.R., eds., 1975, Geology and mineral resources of the Bighorn Basin: Casper, Wyoming Geological Association 27th Annual Field Conference Guidebook, 302 p.
Flueckinger, L.A., 1970, Stratigraphy, petrography, and origin of Tertiary sediments off of the front of the Beartooth Mountains, Montana-Wyoming: State College, Pennsylvania State University, Ph.D. dissertation, 249 p.
Jobling, J.L., 1974, Stratigraphy, petrography, and structure of the Laramide (Paleocene) sediments marginal to the Beartooth Mountains, Montana: State College, Pennsylvania State University, Ph.D. dissertation, 102 p.
Lopez, D.A., 2000a, Geologic map of the Big Timber 30' x 60' quadrangle, south-central Montana: Montana Bureau of Mines and Geology Open-File Report 405, 1 sheet(s), 1:100,000.
Lopez, D.A., 2000b, Geologic map of the Bridger 30' x 60' quadrangle, Montana: Montana Bureau of Mines and Geology Geologic Map 58, 1 sheet(s), 1:100,000
Lopez, D.A., 2001, Geologic map of the Billings 30' x 60' quadrangle, Montana: Montana Bureau of Mines and Geology Geologic Map 59, 1 sheet(s), 1:100,000.
Lopez. D.A., 2005, Geologic map of the Red Lodge area, Carbon County, Montana: Montana Bureau of Mines and Geology: Open-File Report 524, 15 p., 1 sheet(s), 1:48,000.
McDermott, A.D., 1966, Water Resources Survey, Carbon County, Montana, Part 1: History of land and water use on irrigated areas: State Conservation Board, Helena, Montana, p 1–85.
Ritter, D.F., 1967, Terrace development along the front of the Beartooth Mountains, southern Montana: Geological Society of America Bulletin, v. 78, p. 467–484.
Waren, K., 2000, Groundwater levels at the south end of the Red Lodge bench near Red Lodge, Montana: Montana Department of Natural Resources and Conservation, unpublished report.
Wilde, E.M., and Porter, K.W., 2000, Geologic map of the Roundup 30' X 60' quadrangle, central Montana: Montana Bureau of Mines and Geology Open-File Report 404, 1 sheet(s), 1:100,000.
Wilde, E.M., and Porter, K.W., 2001, Geologic map of the Harlowton 30' x 60' quadrangle, eastern Montana, Montana Bureau of Mines and Geology: Open-File Report 434, 1 sheet(s), 1:100,000.

Table 1. Summary of geologic distribution of wells and springs
Wells and springs visited are identified by the geologic source of their water, noted by the geologic code. This code consists of a set of three numbers that indicates the time period that the geologic unit was deposited (e.g., 111, 120, 370) followed by four letters that are abbreviations for either the name of that geologic formation, or a sediment description (e.g. sand and gravel, SNGR; colluvium, CLVM). These codes are also listed in the adjacent stratigraphic column (modified from Exum and George, 1975) that displays the vertical distribution (oldest at the base, youngest at the top) of all the geologic units within the study area, regardless of their aquifer viability. Only those geologic units that have visited wells are annotated with a geologic code.

Geologic unit	Geologic codes	Inventoried wells or boreholes	Median depth (ft)	Inventoried springs
Holocene sand and gravel, alluvium, and terrace deposits	111SNGR, 111ALVM, 111TRRC	157	28.5	2
Holocene silt and sandy slope deposits	111CLVM	8	20.5	
Pleistocene till	112TILL	1	40	
Pleistocene alluvium, terrace deposits, outwash, and sediments	112SNGR, 112TRRC, 112OTSH, 112SDMS	195	38	5
Holocene or Pleistocene landslide deposits	110CLVM	1	26	
Tertiary consolidated sedimentary rocks				
Fort Union Formation, undiff.	125FRUN	20	65	
Linley Member	120LNLY	11	105	2
Tongue River Member	125TGRV	81	70	7
Lebo Member	125LEBO	27	60	1
Tullock Member	125TLCK	60	75	3
Mesozoic rocks				
Upper Cretaceous volcanic rocks, Sliderock Mountain (Livingston Group)	211LVIS	13	60	1
Cretaceous sedimentary rocks				
Hell Creek and Lance Formations	211HLCK, 211LNCE	116	56	14
Bearpaw Shale	211BRPW	19	69	6
Judith River and Claggett Formations	211JDRV, 211CLGT	187	80	14
Eagle and Telegraph Creek Formations and Kevin Member	211EGLE, 211TPCK, 211KVIN	137	230	13
Niobrara and Carlile Formations	211NBRR, 211CRLL	12	99.5	
Frontier, Belle Fourche, Mowry, Thermopolis, and Fall River Formations	211FRNR, 211BLFC, 211MWRY, 211TMPL, 211FLRV	21	80	
Kootenai Formation	211KOTN	13	200	2
Jurassic sedimentary rocks				
Morrison and Chugwater Formations and Ellis Group (Rierdon and Piper Formations)	221MRSN, 230CGTR, 221ELLS, 221RRDN, 221PIPR	14	92.5	9
Paleozoic sedimentary rocks				
Tensleep, Amsden, and Madison Formations and Paleozoic undiff.	320TSLP, 320AMSD, 330MDSN, 300UDFD	16	190	19
Cambrian undiff.	370CMBR	2	20	
Precambrian metamorphic rocks	500GNES	3	120	
Unknown aquifer				
Total sites		1,116		98

Holocene sand and gravel, alluvium, and terrace deposits (111SNGR, 111ALVM, 111TRRC) — Sand and gravel, mostly alluvial, in recent river valleys and on abandoned floodplains (terraces) about 5–15 ft above streams.

Holocene colluvial deposits (111CLVM) — Sandy silt and clay deposited by slope wash from alluvium and older lake deposits.

Pleistocene till (112TILL) — Mixture of silt, clay, and gravel deposited by, or near to, glaciers.

Pleistocene alluvium, terrace deposits, outwash, and sediments (112SNGR, 112TRRC, 112OTSH, 112SDMS) — Mostly gravel and some sand at or near the land surface. Commonly occurs as 20–60-ft thick deposits on abandoned Pleistocene floodplains (terraces) 20–150 ft above stream valleys. The unit was deposited by glacial meltwater streams (glacial outwash) and is locally buried by till.

Holocene or Pleistocene colluvial deposits (110CLVM) — Mixture of sand, silt, and rock fragments in deposits formed by mostly by landslide failure of bedrock units.

Fort Union Formation, undiff. (125FRUN) — Tan- to yellowish-gray sandstone, sandy claystone, claystone, shale, and coal beds, mostly in the area between the Beartooth Mountain front and the Yellowstone River. Where possible, wells were designated as completed in one of the four members of the formation.

Linley Conglomerate (120LNLY) — Reddish-brown to gray-brown, interbedded conglomerate, coarse-grained sandstone, siltstone, and mudstone; coarser grained near the Beartooth Mountain front; as much as 2,500 ft thick (Lopez, 2001). Wells are completed in sandstones and conglomerates.
Tongue River Member (125TGRV) — Gray to yellow, fine- to medium-grained sandstone, brownish carbonaceous shale, siltstone, and coal beds; as much as 2,800 ft thick. Wells are completed in sandstones and coal beds.
Lebo Member (125LEBO) — Dark gray to olive shale, yellowish-gray sandstone, siltstone, and minor yellowish-gray claystone; 200–500 ft thick. Wells are typically completed in sandstones, a few completions reported in fractured shale beds.
Tullock Member (125TLCK) — Yellowish fine- to medium-grained, ledge-forming sandstone, gray to greenish-gray claystone, siltstone, and minor carbonaceous shale; as much as 1,500 ft thick. Wells are completed in sandstones.

Sliderock Mountain unit of the Livingston Group (211LVIS) — Volcanic rocks from the Sliderock stratovolcano, which was located northwest of the map area. Mostly gray, pale purple-gray, and pale greenish-gray mudflow breccias (lahars) containing dominantly andesitic clasts in a matrix that is lighter in color and finer grained; very resistant, forming cliffs and rugged topography. Near the town of Fishtail, contains interbeds of conglomerate and coarse-grained sandstone; at least 1,000 ft thick. Wells are completed in sand and gravel interbeds in volcaniclastic rocks and in fractured volcanic rocks.

Hell Creek and Lance Formations (211HLCK, 211LNCE) — Interbedded light-brownish-gray, cliff- and ledge-forming, fine-grained, thin- to thick-bedded sandstone, grayish mudstones, and fissile shale; sandstone beds are thicker in the Lance than in the Hell Creek; the Lance occurs generally southeast of Joliet and Rock Creek; thickness ranges from about 350–1,000 ft. Wells are completed in sandstone.

Bearpaw Shale (211BRPW) — Dark-gray, fissile shale, thin, mostly greenish-gray bentonite beds in the middle, and thin sandstone beds near the top; at least one 6–10-ft-thick, water-producing sandstone occurs near the formation top in the Columbus area. The Bearpaw thins from about 800 ft thick in the eastern part of the map to 100 ft in the west.

Judith River and Claggett Formations (211JDRV, 211CLGT) — Brownish-gray sandy shale and light-brown to pale yellowish-brown, clayey, very-fine- to fine-grained lenticular sandstone in beds as much as 10 ft thick. Sandstones are friable to moderately hard. Greenish- and maroon-gray mudstones, poor quality coal, sandstones occur near the top; the Judith River Formation is 700–1,000 ft thick. The Claggett is 100–300 ft of brownish-gray, fissile shale and minor clayey sandstone. Most wells are completed in Judith River sandstone, a few are in Claggett sandstone.

Eagle and Telegraph Creek Formations; Kevin Member of the Marias River Formation (211EGLE, 211TPCK, 211KVIN) — The Eagle is light gray, brownish-gray, to pale orange, very fine- to medium-grained, sandstone and some interbedded shale. It forms low cliffs and ridges; thickness ranges from 150–300 ft. The Telegraph Creek is brownish-gray to medium dark-gray shale and interbedded sandy shale, siltstone, and sandstone; sandstones thicken and are more abundant upward, grading into Eagle Sandstone; about 150 ft thick. The Kevin Member is a medium-gray, fissile to blocky shale beneath the Telegraph Creek. Most wells are in the Eagle sandstones, a few are in Telegraph Creek sandstones and siltstones, and a few are in the Kevin.

Niobrara and Carlile Shales (211NBRR, 211CRLL) — The Niobrara is olive-gray and dark-brownish-gray, fissile shale that includes a few thin bentonites, sandstones, siltstones, and sandy limestones. The Carlile is dark-gray, fissile shale and thin, silty sandstone beds; total thickness is about 1,000 ft.

Frontier, Belle Fourche, Mowry, Thermopolis, and Fall River Formations (211FRNR, 211BLFC, 211MWRY, 211TMPL, 211FLRV) — Frontier Formation is light-brownish-gray, fine-grained sandstone in three intervals, and interbedded dark-gray shale; total thickness about 350 ft. The Belle Fourche is dark-gray shale and minor sandstone beds near the upper part and near the base; about 350–400 ft thick. Mowry Shale is shale and minor interbedded gray, fine-grained sandstone, siltstone, and bentonite; thickness about 300 ft. The Thermopolis Shale is dark-gray, fissile shale. The Fall River Sandstone is a brownish-gray, thin-bedded, silty, fine-grained, quartz sandstone. The Thermopolis and Fall River have a combined thickness of about 1,000 ft. Most wells are completed in sandstones in the Frontier and Belle Fourche Formations.

Kootenai Formation (211KOTN) — Reddish-brown, olive-gray, and purple mudstone, fine- to coarse-grained sandstone; lenses of Greybull Sandstone are locally present at the top of the formation and 20–60 ft of brown to gray conglomerate and pebbly coarse-grained sandstone are at the base; about 500 ft thick.

Morrison and Chugwater Formations, and Ellis Group (Rierdon and Piper Formations) (221MRSN, 221ELLS, 221RRDN, 221PIPR, 230CGTR) — Morrison Formation is mostly reddish mudstone that contains some interbedded sandstone and coal; about 200 ft thick. The Swift Formation is gray, well-sorted, well-bedded, fine-grained sandstone. The Rierdon Formation is mostly greenish-gray shale and minor limestone. The Piper is gray and reddish-gray limestone, shale, and gypsum. The Ellis Group is about 200–500 ft thick. Chugwater Formation contains reddish-brown sandstone, siltstone, and shale; the thickness increases from 0 to about 100 ft eastward. Most wells are completed in sandstones.

Tensleep and Amsden Formations, Madison Group, and Paleozoic undiff. (320TSLP, 320AMSD, 330MDSN, 300UDFD) — The Tensleep is light-gray to pale-orange, fine-grained, well-sorted sandstone and fine limestone beds; includes a limestone and sandstone in overlying Phosphoria Formation; as much as 250 ft thick. The Amsden has light-red mudstone, limestone, and siltstone developed on an irregular surface on the Madison Group; thickness about 200 ft. Madison contains white to gray limestone and dolomitic limestone. Collapse features and caves are common at the upper karst surface; thickness of 800–1,000 ft. Mississippian, Ordovician, and Devonian rock units (Paleozoic undiff.) include dolomite, minor limestone and minor siltstone or shale along the Beartooth Mountain front; thickness is about 600 ft. Most wells and springs near the Pryor Mountains derive water from the Tensleep and Madison.

Cambrian undiff. (370CMBR) — Undifferentiated sedimentary rocks include light-reddish sandstone and quartzite, greenish shale and sandy shale, and gray-bedded limestone. Units included are the Flathead, Wolsey, Meagher, Park, and Pilgrim Formations; thickness is 600–800 ft. Wells are completed in fractured rock.

Precambrian metamorphic rocks (500GNES) — Granitic gneiss and migmatite, and local inclusions of metasedimentary rocks. Wells are completed in fractured rock.

Table 2. Site inventory data. Data are arranged in ascending township, range, and section order. Blank lines separate townships and gray lines separate ranges within townships; GWIC Id = Ground-Water Information Center identification number (- spring; ** - surface water; *** - borehole); altitude = land-surface altitude (ft); TD = total depth (ft); SWL = static water-level altitude (ft); water temperature = °C (celsius); SC = specific conductivity (micro mhos/cm @ 25°C); pH = acidity of water; geologic unit = geologic-unit code for well completion (primary code is listed, some wells have secondary code which can be retrieved from GWIC database); water quality = indicates either complete water analysis (major ions and trace metals) or nitrate only (blank = sample not collected).*

GWIC Id	township	range	section	tract	altitude	TD	SWL	water temperature	SC	pH	geologic unit	water quality
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]