MBMG 680 Plate 1

Hydrogeology of the Livingston and Shields River Area, Park County, Montana

Montana Bureau of Mines and Geology

Introduction

This plate presents data collected for a hydrogeological investigation of the Livingston and Shields River area in Park County, Montana between 2003 and 2005. Data collection and interpretation tasks were performed by the Montana Bureau of Mines and Geology. The project was sponsored and administered by Park County. Funding for the project was provided by the Department of Natural Resources through the Renewable Resources Grant Program.

Geologic and Hydrogeologic Units

There are approximately 19,000 ft of exposed sedimentary bedrock in the project area, ranging in age from Mississippian to early Tertiary. The exposed rocks consist primarily of sedimentary limestone, shale, and sandstone. The geologic formations or groups are shown in the Geologic Map explanation (from Roberts, 1972; Berg and others, 2000). The geographic distribution of these units is shown in the Geologic Map. A general summary of the geologic units is provided in the report; however, for detailed description and mapping of the geologic units please refer to Roberts (1972) and Berg and others (2000).

Regional hydrogeologic units were delineated in this study on the basis of grouped geologic units with similar hydrogeologic properties. Throughout most of the project area the Madison Group is generally too deep for conventional water wells, but is accessible at the southern end. The Colorado Group is a poor aquifer overall because of the high shale content; however, the sandstone layers within the Colorado Group are targets for wells in the Wineglass Mountain area. The bedrock aquifers above the Colorado Group, including the Eagle, Livingston, and Fort Union Formation, are used extensively throughout the project area. The Yellowstone River alluvium, and to a lesser extent the Shields River alluvium, provide plentiful, high-quality water.

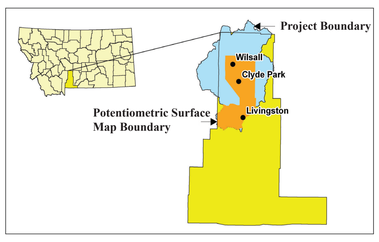
Geologic Structures

The distribution of the geologic units (Geologic Map) is influenced by deformation and faulting. The dominant structure of the region is the Crazy Mountain Basin (Basin Map), which is a large, northwest-trending structural low that is approximately 40 to 75 mi wide by 100 to 130 mi long (Roberts, 1972). The deepest portion of the basin trends northwesterly from Meagher County to Carbon County. However, within the overall basin structure, there are a number of other folds and faults. The most significant of these include the Canyon Mountain Anticline, Fleshman Syncline, Livingston Anticline, Wilsall Syncline, and the Battle Ridge Fault (Structure Map). Also shown are Tertiary-age Crazy Mountain volcanic intrusives. The intrusives include dikes that intrude vertically and sills that intrude parallel to the bedding planes.

Groundwater Elevation and Flow

The potentiometric map depicts groundwater elevation contours (lines of equal elevation) in the relatively shallow (less than 200 ft deep) subsurface. The colors on the contours delineate between groundwater in bedrock aquifers (blue and green lines) and in the Yellowstone River alluvium (red lines). Groundwater flow is directed perpendicular to the contour lines and generally mimics land surface topography. Groundwater is primarily recharged in the higher elevation areas and discharges to the various creeks or the Shields and Yellowstone Rivers. Horizontal hydraulic gradients in bedrock range from about 0.2 to 0.02 ft/ft. The horizontal gradient in the Yellowstone alluvium is about 0.003 ft/ft. The groundwater velocity is estimated to be about 1 to 3 ft per day in the bedrock units and about 1 to 8 ft per day in the Yellowstone River alluvium.

Groundwater flow patterns in deeper zones are controlled by the basin shape, mountain recharge, and the major regional drainages (the Shields and Yellowstone Rivers). The Colorado Group limits downward recharge to the underlying Madison Group aquifers. In the upland recharge areas, groundwater flow will have a downward vertical component. Near the Yellowstone and Shields Rivers groundwater will have an upward vertical component. Vertical relationships of the hydrogeologic units are shown on Cross Sections A–A' and B–B'. The locations of the cross sections are shown on the Geologic Map.

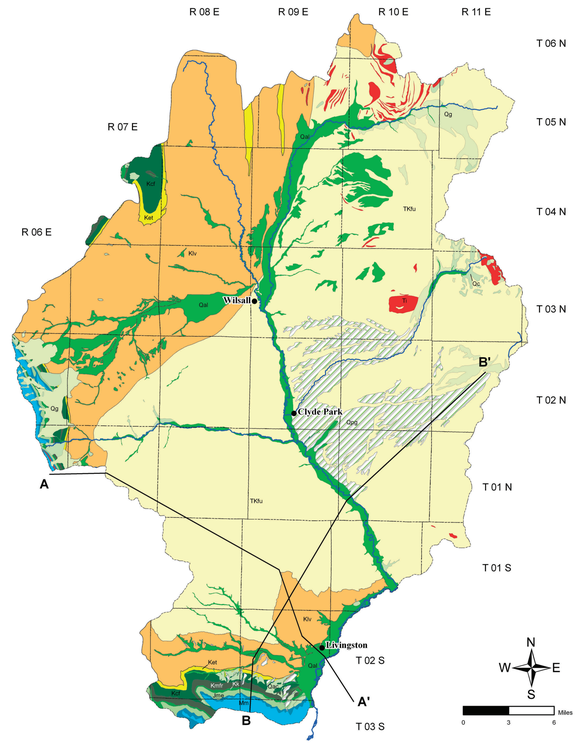


Site Location Map

The project area is located in Park County, Montana and includes the Yellowstone River watershed north and west of Livingston and the Shields River watershed south of Wilsall. Because of the lack of wells in the uplands surrounding the Shields River, the area included in the groundwater elevation map (right) was trimmed to include only the adjacent valley area.

Extent of the Crazy Mountain Basin

The Crazy Mountain Basin is a large structural low that occupies much of the northern part of Park County and most of Sweet Grass and Stillwater Counties to the east.



Geologic Map

This map shows the geographic distribution of the geologic units within the project area. Most of the land area is underlain by either the Livingston Group or by the Fort Union Formation. Older and deeper units crop out near the edge of the basin.

Explanation

Hydrogeologic units	Geologic units	
Quaternary unconsolidated	Qal	Alluvium (Quaternary)
	Qc	Colluvium, and alluvial fan (Quaternary)
	Qpg	Pediment gravel deposit (Quaternary)
	Qg	Glacial deposit (Quaternary)
	Ti	Tertiary Intrusive
Bedrock aquifers — Upper	TKfu	Fort Union Formation (Tertiary and Cretaceous)
	Klv	Livingston Group (Upper Cretaceous)
Lower	Ket	Eagle Sandstone and Telegraph Creek Formation (Upper Cretaceous)
Colorado Group	Kcm	Cody Shale and Frontier Formation (Upper Cretaceous)
	Kmm	Mowry Shale through Fall River Sandstone (Upper and Lower Cretaceous)
	Kk	Kootenai Formation (Lower Cretaceous)
	Jmg	Morrison Formation and Ellis Group (Middle and Upper Jurassic)
	PPms	Phosphoria through Amsden Formations (Permian, Pennsylvanian and Upper Mississippian)
	Mm	Madison Group (Mississippian)

Potentiometric Surface Map

The Potentiometric Surface Map was constructed from measured groundwater elevations from 130 inventoried wells. The location of the inventoried wells is shown on the map in red lettering. Inventory data and groundwater elevation are presented in appendix A. Additional water levels available on the Groundwater Information Center (GWIC) were used to augment the inventory data where necessary.

Groundwater flow direction is perpendicular to potentiometric lines (blue). The bedding strike orientation can influence flow direction. Strike direction is shown by mapping the more resistant sandstone outcrop ridges (gray dashed lines). Groundwater flow in the alluvium is toward and along the river. For more discussion please refer to the groundwater flow section in the text.

Explanation

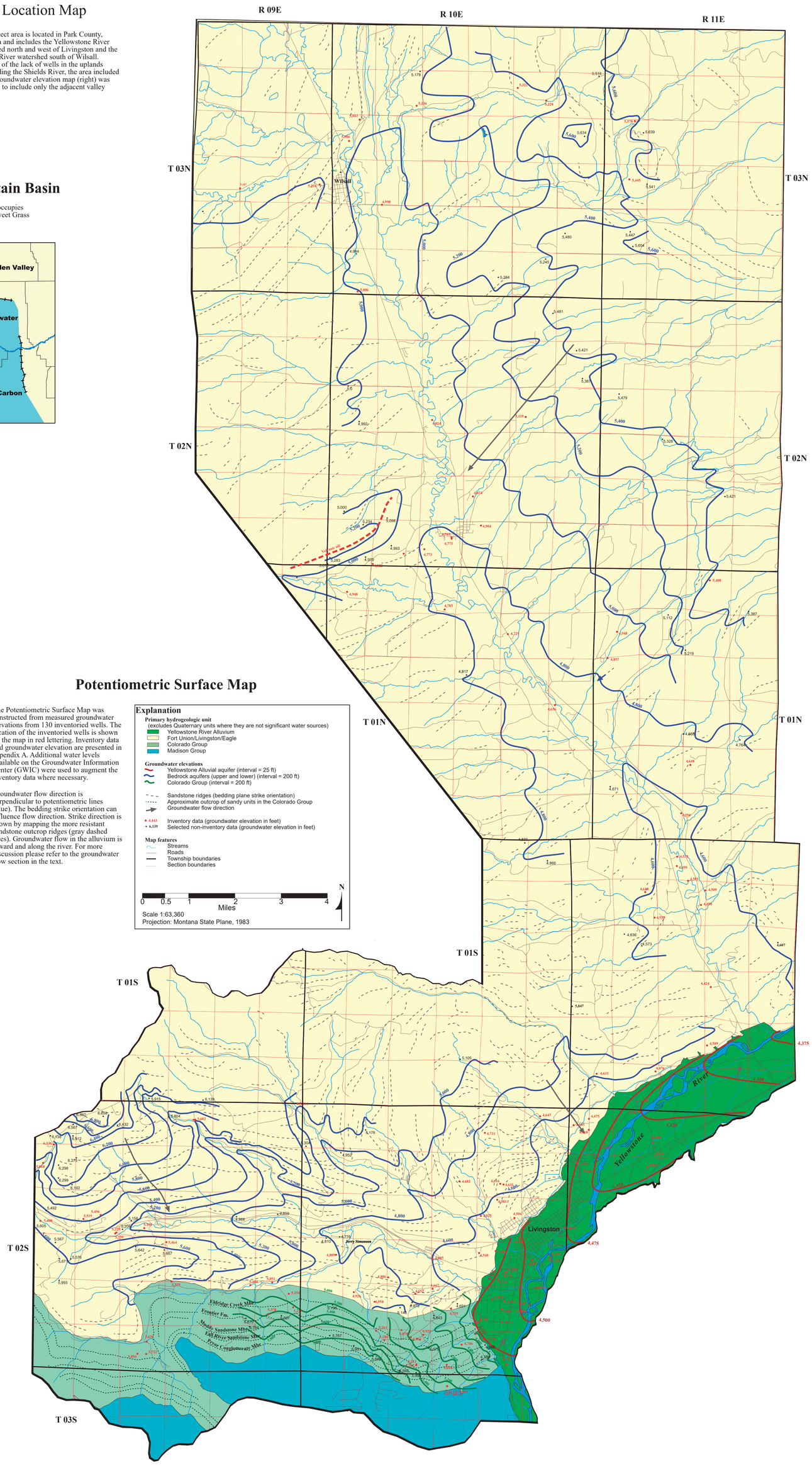
Primary hydrogeologic unit
(excludes Quaternary units where they are not significant water sources)
- Yellowstone River Alluvium
- Fort Union/Livingston/Eagle
- Colorado Group
- Madison Group

Groundwater elevations
- Yellowstone Alluvial aquifer (interval = 25 ft)
- Bedrock aquifers (upper and lower) (interval = 200 ft)
- Colorado Group (interval = 200 ft)

- Sandstone ridges (bedding plane strike orientation)
- Approximate outcrop of sandy units in the Colorado Group
- Groundwater flow direction
- 4,443 Inventory data (groundwater elevation in feet)
- 6,139 Selected non-inventory data (groundwater elevation in feet)

Map features
- Streams
- Roads
- Township boundaries
- Section boundaries

0 0.5 1 2 3 4 Miles
N
Scale 1:63,360
Projection: Montana State Plane, 1983

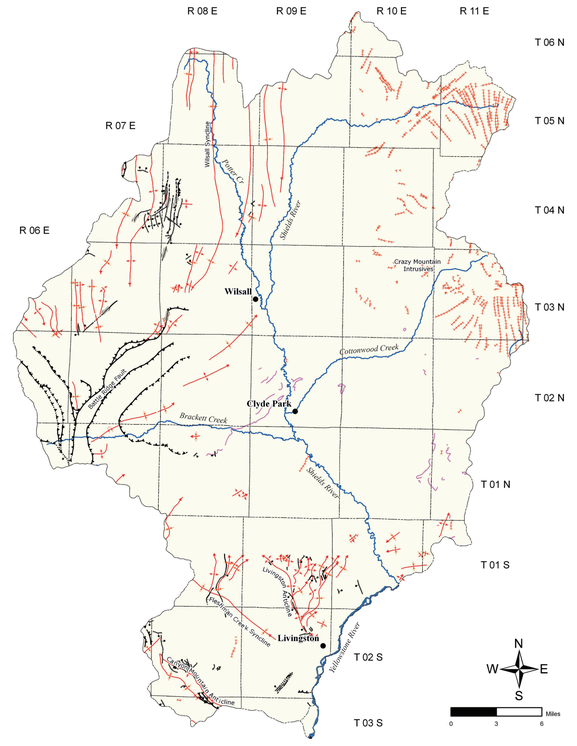


Geologic Structure Map

This map shows the locations of folds, faults, and volcanic intrusives that occur within the larger Crazy Mountain Basin deformation.

Explanation

- Strike slip fault
- Detachment - Semicircles indicate upper plate, dashed where approximately located, dotted where concealed.
- Fault - Dashed where approximately located, dotted where concealed. Bar and ball on down-thrown side.
- Thrust fault - Dashed where approximately located, dotted where concealed. Sawteeth on upper plate.
- Anticline - Showing trace of axial plane and direction of plunge; dotted where concealed. Plunge arrow omitted where not plunging or plunge direction unknown.
- Syncline - Showing trace of axial plane and direction of plunge; dotted where concealed. Plunge arrow omitted where not plunging or plunge direction unknown.
- Overturned syncline - Showing trace of axial plane and direction of plunge; dotted where concealed. Plunge arrow omitted where not plunging or plunge direction unknown.
- Overturned anticline - Showing trace of axial plane and direction of plunge; dotted where concealed. Plunge arrow omitted where not plunging or plunge direction unknown.
- Dike - Shown in red on map.
- Sill - Shown in purple on map.



Hydrogeologic Cross Sections

Two cross sections A–A' and B–B' show the vertical relationships of the hydrogeologic units. The cross sections are based on the surface topography, outcrop patterns, measured formation dips, and general structural trends. The locations of the cross sections are shown on the Geologic Map.

Explanation
- Fort Union/Livingston/Eagle
- Colorado Group
- Madison Group
- Older rocks
- Fault
- Eagle coal seams

Scale 1" = 5,000 ft
No vertical exaggeration