

## Plate 2. Lithostratigraphic and Hydrogeologic Units of the Gallatin Local Water Quality District, Gallatin County, Montana.

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Modified from: Hackett et al., 1960; Roberts, 1963; Groff, 1965; Balster, 1971; Kuenz and Fields, 1971; Skipp and McMannis, 1971; Roberts, 1972; Montagne, 1976; Skipp and McGrew, 1977; 1979; Bonnet, 1979; Balster, 1980; Hughes, 1980; Levings et al., 1981; Chadwick, 1982; Smith and Welker, 1982; Smith, 1983; Moore, 1984; Lambing et al., 1987; Custer et al., 1991; Hiza, 1994; Dyman et al., 1995; Vuke et al., 1995; Kendy and Tresch, 1996; Skipp et al., 1999.

Mesozoic																				
Paleozoic		Cretaceous																		
Precambrian		Cambrian		Devonian		Mississippian		Penn.		Jurassic										
Lower	Upper	Penn.	Permian	Jurassic	Penn.	Permian	Jurassic	Lower	Upper	Lower	Upper									
Eratheim System		Cenozoic		Tertiary		Quaternary		Quaternary		Quaternary										
Series	Unit Name	Map Symbol	MBMG Geologic Source Codes	Unit Thickness (meters)	Lithology	Lithologic Description		Hydrogeologic Units	Water-yielding characteristics		Transmissivity Data									
4	West Gallatin River Alluvium	Qwgal	110ALVM	0-100 (0-300 ft)		Unconsolidated gravel deposits interbedded with lenses and some beds of sand, silt, and clay deposited by the West Gallatin River.		West Gallatin Alluvial Aquifer	Yields excellent to good expected to be ample for municipal, commercial, irrigation, domestic, and stock uses.		501	m <sup>2</sup> /day gpd/ft	17 1400	14 1100	11 890	5.6-52 450-4200	16-17 1300-1400			
5	Small Stream and Fan Alluvium	Qssf	110ALVM 110ALVF	0-100 (0-300 ft)		Mixture of unconsolidated lenticular gravel, sand, silt, and clay deposited by streams smaller than the West Gallatin River.		Small Stream and Fan Aquifer	Yields generally good to fair, water supplies for light irrigation, industrial use as well as domestic and		515	m <sup>2</sup> /day gpd/ft	8.5 680	8.0 640	8.0 640	3.4-22 270-1700	8.2-8.9 660-720			
6	Old Alluvium: Fan, pediment, stream deposits	Bozeman Group (includes Sixmile Creek, Madison Valley Formation, and Renova Formation)	QTbf	0-100 (0-300 ft)		Similar to small stream and fan alluvium, but in high landscape position well above other alluvium deposits and sometimes more coarse grained.		Quaternary-Tertiary Basin Fill Aquifer	Variable, generally fair to good, water supplies expected to be good for light irrigation, domestic and stock use.		9 8	m <sup>2</sup> /day gpd/ft	3.4 270	3.9 310	4.0 320	0.75-16 60-1300	2.9-4.0 230-320			
7	0-1525 (0-5000ft)				Sixmile Creek and Madison Valley Fm: Lenticular pebble conglomerate, arkose, and cross-bedded sandstone surrounded by mudstone and siltstone. Locally volcanic ash beds. Some fine-grained ostracode-bearing limestone; less lenticular (more extensive) beds to the west.				Generally fair to good, in channel gravels and sandstones, less so in silty and muddy units.											
8	Renova Fm:				Alternating sequence of fine-grained limestone, montmorillonite mudstone, siltstone, with minor sandstone, arkose, conglomerate. Local virtric ash beds.				No Data											
9	0-2745 (0-9000ft)				Light to dark grayish brown andesite and basalt flows, flow breccia, debris flow deposits, and tuff.				Not an aquifer, except where jointed and fractured											
10	unamed gravels, sands, and siltstone	Tv	124VLCC	0-17 (0-50ft)		Loosely consolidated conglomerate of Precambrian rock and Paleozoic and Mesozoic sedimentary rock. Matrix is poorly sorted sand and silt derived from similar rocks.		Volcanic Aquitard*	No Data											
11	Fort Union Formation		KThf	125FRUN		Massive to thin-bedded, fine to coarse grained, slightly calcareous, andesitic greenish-gray sandstone, and massive olive-gray mudstone. Lower Conglomeratic Sandstone-massive to thin-bedded, cross-bedded fine grained to conglomeratic andesitic yellow green green sandstone with interbedded siltstone and claystone. Pebbles of volcanic rock, quartzite, gneiss and limestone.			Fort Union: Variable , but generally good, conglomerates and sandstones especially where not cemented should be good water yielding units.		8	m <sup>2</sup> /day gpd/ft	0.94 75	0.88 71	19 1500	0.07-13 5.4 - 1100	0.37-2.4 30 - 190			
12	Hoppers Formation	211HPRS	460-735 (1500-2400ft)		Massive to thin-bedded, cross-bedded, poorly sorted andesitic yellow-green sandstone with interbedded claystone and siltstone. Locally conglomeratic. Contains fresh-water mollusks and wood and plant fragments.		Hoppers-Fort Union Aquifer*	Hoppers: Generally good where adequate thickness, possibly poor zones are intermittent claystones and siltstones.				m <sup>2</sup> /day gpd/ft	1.7 140	0.92 74	N/A N/A	0.07-41 5.7-3300	0.27 - 11 22 - 860			
13	Billman Creek Formation	Kbc	211BMCK	765-915 (2500-3000ft)		Massive olive gray to grayish red claystone with interbedded fine to coarse grained andesitic sandstone. Contains fresh-water mollusks and dinosaur bones.			Billman Creek Aquitard*		3	m <sup>2</sup> /day gpd/ft	1.7 380	0.92 150	N/A N/A	0.07-41 22-6500	0.27 - 11 90-1600			
14	Sedan Formation	Livingston Group	Ks	211MRCK		Olive gray to brownish gray volcanoclastic sandstones, mudstones, and minor ash-flow tuff. Formations consist of five members-Lowep Sandstone Mbr., Mudstone Mbr., Middle Sandstone Mbr., Ash-Flow Mbr., Lower Sandstone. Miner Creek:- massive tuffaceous olive-gray siltstone with interbedded fine-grained andesitic sandstone. Contains petrified wood, leaf impressions, spores, and dinosaur bones. Sulphur Flats Sandstone- massive cross-bedded poorly sorted grayish green andesitic sandstone with interbedded tuff and bentonite.		Sedan Aquitard*	Used as a local aquifer, but water quality and quantity is poor to very poor throughout unit.				m <sup>2</sup> /day gpd/ft	4.7 380	1.8 150	N/A N/A	0.27 - 81 22-6500	1.1 - 20		
15	Miner Creek Formation			211SLPF		Cokedale Formation: Massive to thin-bedded, poorly sorted andesitic olive-gray siltstone and sandstone with interbedded conglomeratic, claystone, and tuff. Thin beds of bentonite and lignite in lower part of formation. Contains petrified wood, leaf impressions, spores, fresh water mollusks, and dinosaur bones.			Miner Creek: Variable from poor to good, in the Sulphur Flats mbr. of the Miner Creek Fm.											
16	Cokedale Formation			211CKDL		Cokedale Fm. variable from poor to good, the siltstones and claystones will poor aquifers while the sandstones may be better.			No Data		4	m <sup>2</sup> /day gpd/ft	7.1 380	5.1 150	N/A N/A	0.27 - 81 22-6500	1.1 - 20			
17	Eagle Sandstone			211EGLE		Light gray, thin to thick bedded, locally cross-bedded, fine to medium grained, white and black chert bearing sandstone with some intercalated carbonaceous shale and coal beds.		Telegraph Creek-Eagle Aquitard*	Water yield in the Eagle Sandstone should be good where the sandstone is the thickest.											
18	Telegraph Creek Formation			211TPCK		Medium gray, thin-bedded siltstone containing calcareous concretions and some resistant sandstone beds			Variable from poor to good, poor availability in the siltstones and good in the sandstones											
19	Colorado Group		Kc	211CODY		Medium to dark gray and brown thin bedded shale with some beds of siltstone and sandstone, especially in middle part. Locally fossiliferous.		Cody Aquitard*	Not an aquifer, shales nearly impermeable											
20	Frontier Formation	Kf	211FRNR	15-185 (50-600ft)		Buff to medium gray, thin to medium bedded, fine to coarse grained arkosic sandstone, locally silty.			Frontier Aquitard*		6	7.1 m <sup>2</sup> /day 570 gpd/ft								
21	Mowry Shale	Ktm	217MWRY	10-125 (30-400ft)		Grayish-brown and green shale and siltstone with some sandstone beds. Locally carbonaceous.		Thermopolis-Mowry Aquitard*(basal water)	Not an aquifer, shales nearly impermeable				m <sup>2</sup> /day gpd/ft	0.2 17	0.2 17	N/A N/A	0.045 - 1 3.6 - 80	0.07-0.6 5.7 - 52		
22	Shale		217MDDY	15-120 (50-380ft)		Medium gray to black shale with numerous fine to medium grained gray sandstone beds. Locally arkosic, glauconitic, or carbonaceous. Lower resistant silical cemented quartz sandstone.			Thermopolis-Mowry Aquitard*(basal water)											
23	Shale mbr.		217TMPL	15-120 (50-380ft)		Upper interbedded fine-grained gastropod-bearing limestone interbedded with red or black sandstone. Middle red mudstone with interbedded buff to white chert bearing sandstone. Lower chert pebble conglomerate interbedded with sandstone and red mudstone locally absent.			Kootenai Aquifer*		Not an aquifer.	Upper portion of formation not considered an aquifer.								
24	Lower Sandstone mbr.		Kk	217KOTN		Lower portion of unit is a potential aquifer, sandstone and conglomerate units may be good water yielding units where not cemented.			Not an aquifer.											
25	Kootenai Formation			221MRSN		Upper carbonaceous shale variegated red, locally green, thin to thick bedded mudstone and siltstone with intercalated yellowish-brown calcareous siltstone and sandstone often in lenses. May contain dinosuar bones.		Jurassic Aquitard*	Not an aquifer, locally Swift Formation may contain small amounts of water.											
26	Morrison Formation	Ju	221SWFT	30-140 (100-450ft)		Yellowish-brown, medium bedded, fine-grained, calcareous, glauconitic, sandstone. Local basal chert conglomerate.			No Data											
27	Swift Formation		221RDRN	60 (200ft)		Upper calcareous mudstone and thin-bedded fine limestone, lower resistant oolitic limestone.			No Data											
28	Rierdon Formation		221PIPR	40-60 (120-200ft)		Red calcareous siltstone and limestone with lower (?) fine-grained reddish pelecypod bearing limestone and black shale.			No Data											
29	Piper Formation		MPu	310PSPR		Pale yellowish-brown, carbonate or chert cemented sandstone, may locally contain chert and chert-cemented breccias in Southern Gallatin County near base of formation.			No Data											
30	Phosphoria Formation			320QDRN		White to pinkish-gray, medium to thick-bedded (locally cross-bedded), subrounded, fine to medium-grained silica or carbonaceous quartz sandstone; and a lower dolostone.			No Data											
31	Quadrant Formation	CDIM	320AMSD	0-60 (0-200ft)		Pale yellow to reddish-brown, medium to thick-bedded siltstone with some dolomite and impure fossiliferous limestone beds.		Upper Mississippian-Pennian Aquitard*	Quadrant may be a potential aquifer if the sandstones are not cemented.											
32	Amsden Group		331BGSN	0-80 (0-250ft)		Upper dark-gray to black, cherty, fossiliferous shale and limestone. Middle pink-bluff platy to massive-bedded sandstone and siltstone. Lower pink to buff dolomite and siltstone.			Generally not considered an aquifer. Lower dolomite may contain water of poor quality.											
33	Big Snowy Group		337MSNC	130-290 (430-950ft)		Light gray, massive or poorly bedded, resistant fossiliferous limestone with solution breccias at top. Locally contains chert nodules.			Potential aquifer if solution channels are extensive.											
34	Mission Canyon Limestone (includes Charles Formation, collapse breccia)		337LDGP		Dark gray thin to medium-bedded fossiliferous, limestone. Lower medium to dark gray, thin-bedded, sparsely fossiliferous limestone with occasional chert nodules. Black shale at the base.				No Data											
35	Lodgepole Limestone	Three Forks Formation		337TRFK		Upper gray, thin-bedded silty yellow limestone. Middle buff, medium to thick bedded, brecciated limestone. Basal, red-orange limonite-nodule shale, and siltstone.			Jefferson may contain water, but because of its high hydrocarbon content it is expected to produce poor quality water.											
36	Three Forks Formation			341JFRS		Light and dark brown, medium to thick-bedded, fine to medium grained, commonly glauconitic and fossiliferous limestone and limestone-pebble conglomerate with columnar magmatic beds at base.			No Data											
37	Jefferson Dolomite			344MYWD		Red, yellow or brown, thin-bedded calcareous siltstone with some dolomite, trilobite-brachiopod fossil hash in lower part.			No Data											
38	Maywood Formation			371DRCK		Yellow-brown to olive, thin to medium bedded, fine to coarse grained, commonly glauconitic and fossiliferous limestone and limestone-pebble conglomerate with columnar magmatic beds at base.			No Data											
39	Sage Pebble Conglomerate member			374PLGM		Gray-green shale with intercalated pale-orange to buff calcareous siltstone and sandstone.			No Data											
40	Dry Creek Shale member			374PARK		Dark and light-gray mottled, medium-thick bedded, ledge-forming, oolitic limestone.			No Data											
41	Pilgrim Limestone			374MGHR		Gray to yellow-brown, thin to medium-bedded limestone with limestone-pebble conglomerate and interbedded green shale. Gray, limestone-pebble conglomerate massive oolitic, limestone.			No Data											
42	Park Shale			374WLSY		Light to dark-gray, thin-bedded, fine-grained, trilobite and brachiopod bearing mottled limestone with some interbedded green shale. Dark gray massive resistant limestone. Gray, thin-bedded, fine-grained, limestone with interbedded green shale. Blue and gold mottled.			No Data											

\*Insufficient well data available for statistical analysis. Designation based on regional hydrogeologic interpretation.