Montana Ground-Water Assessment Atlas No. 2, Part B, Map 11
December 2004

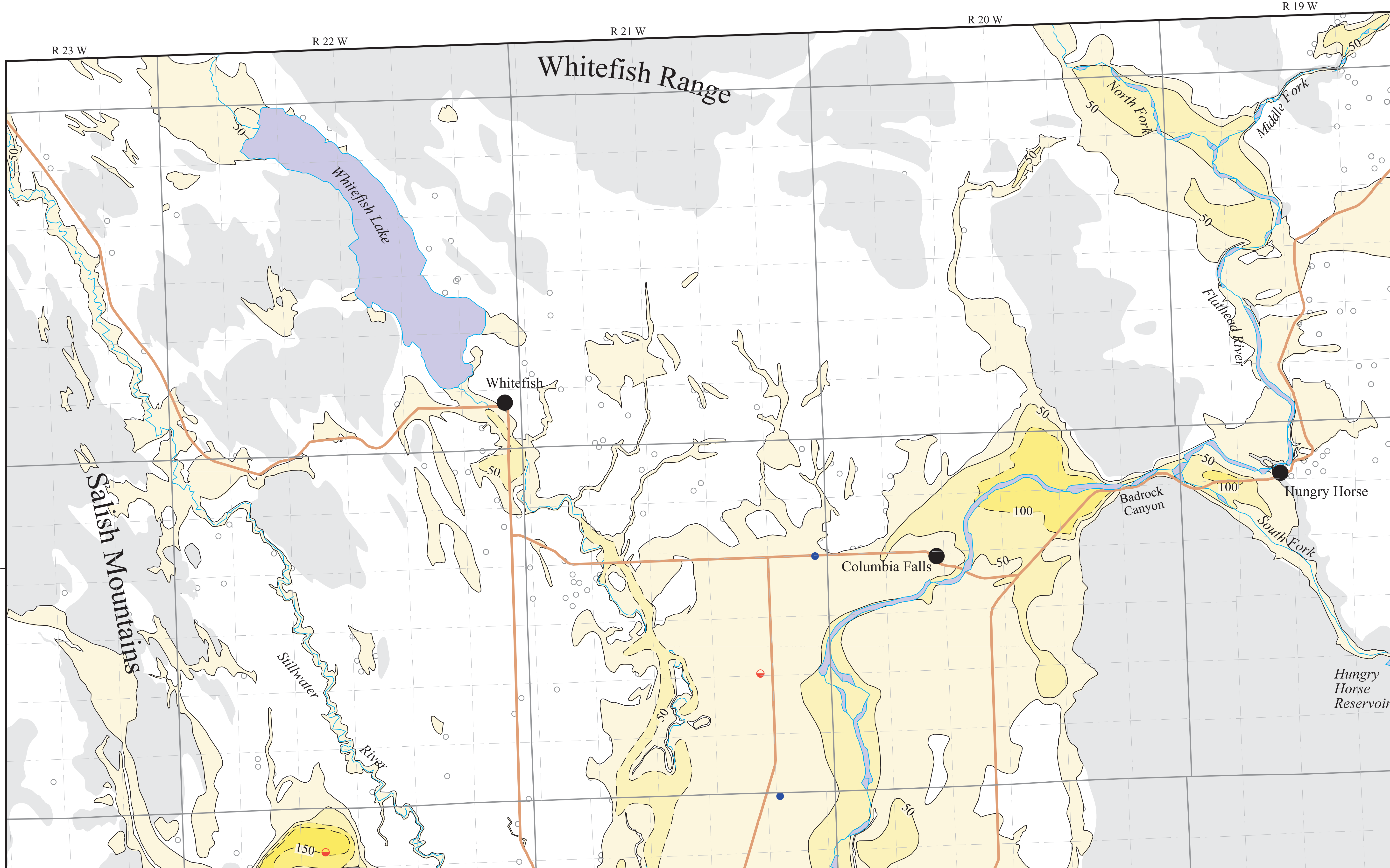
Montana Bureau of Mines and Geology
A Department of Montana Tech of The University of Montana

Thickness of Shallow Alluvium, Flathead Lake Area, Flathead, Lake, Missoula, and Sanders Counties, Montana

by

Larry N. Smith

Note - this map was originally published at a scale of 1:100,000 but the page sizes have been modified to fit the size of the paper in your printer. A full sized 36" X 48" colored print of this map can be ordered from the Office of Publications and Sales of the Montana Bureau of Mines and Geology, 1300 West Park Street, Butte, MT 59701.
Phone: 406-496-4167 Web Address: www.mbmg.mtech.edu


R 23 W
R 22 W
R 21 W
R 20 W
R 19 W
T 32 N
T 31 N
T 31 N
T 30 N
T 30 N
48° 22' 30"
48° 22' 30"
Whitefish Range
Whitefish Lake
Whitefish
Salish Mountains
Stillwater River
Columbia Falls
Badrock Canyon
Hungry Horse
North Fork
Middle Fork
Flathead River
South Fork
Hungry Horse Reservoir
50
100
150

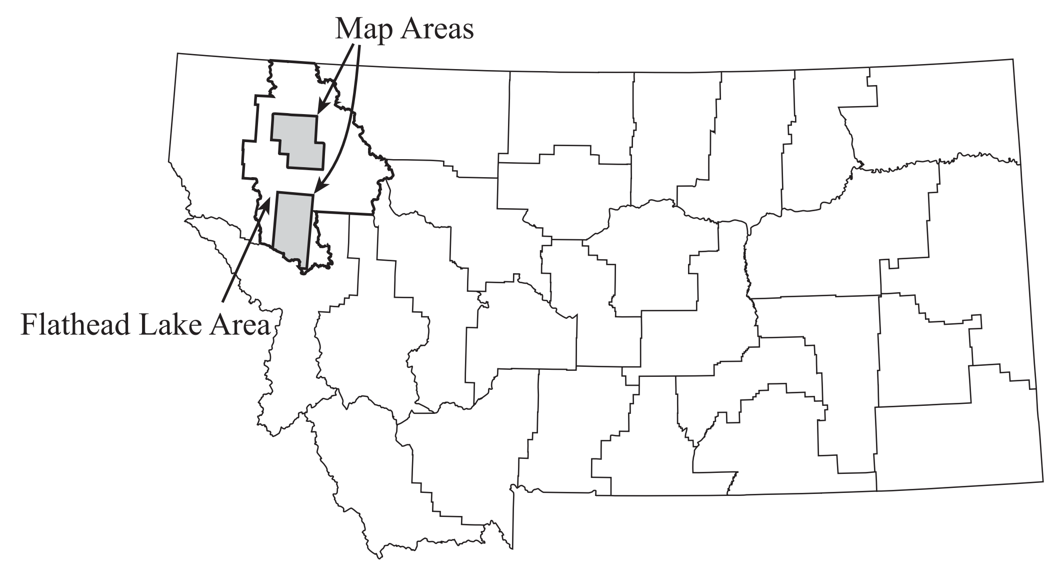
Explanation

- Location of well with >5 ft of shallow alluvium
- Thickness of shallow alluvium (ft), dashed where approximate, hachures denote closed areas where unit is thin
- 0 - 50’
- >50’ - 100’
- >100 - 150’
- >150’ - 200’
- >200’

Nitrate concentrations - mg/L as N

- 0-<1.5
- 1.5-3
- >3-10
- >10

- Nitrate research site
- Major roads
- Principal streams and water bodies
- Township boundaries
- Section boundaries
- Cross-section location
- Belt Supergroup bedrock at land surface



Ground-Water Characterization Program Study Areas

Scale 1:100,000
Universal Transverse Mercator Projection
Zone 11
Horizontal Datum: NAD 27
Vertical Datum: Land Surface

0 1 2 3 4 5
Miles

N

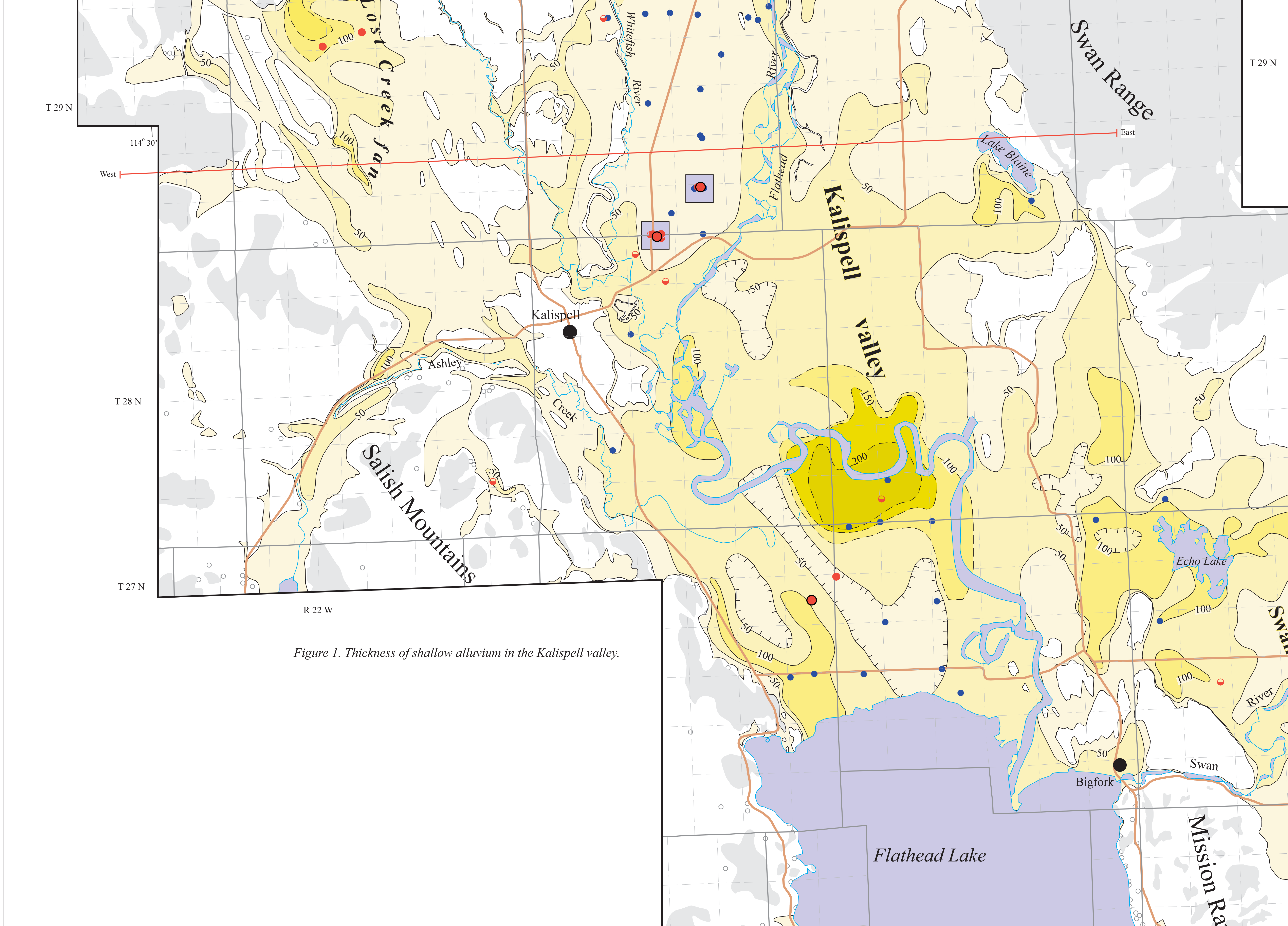
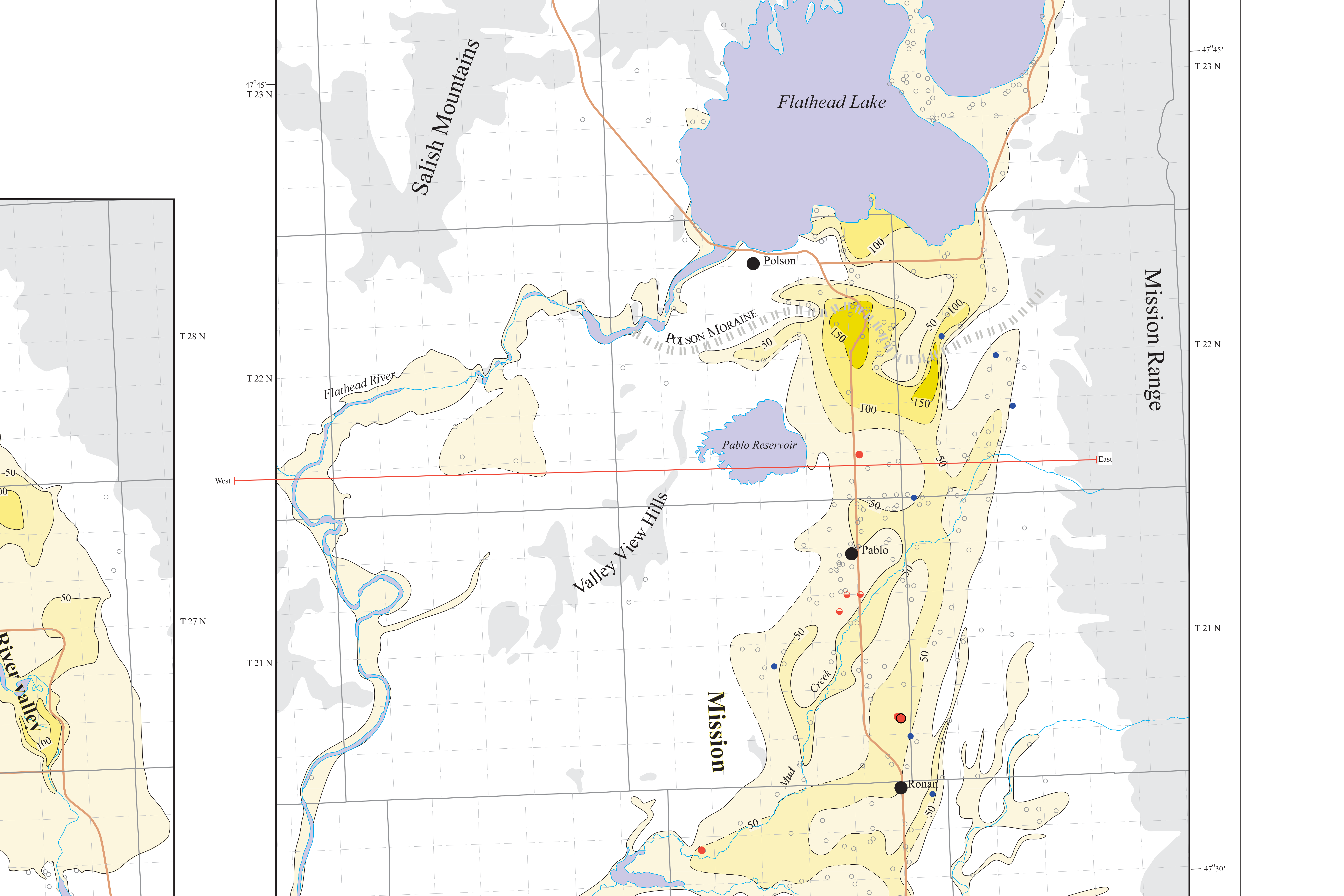
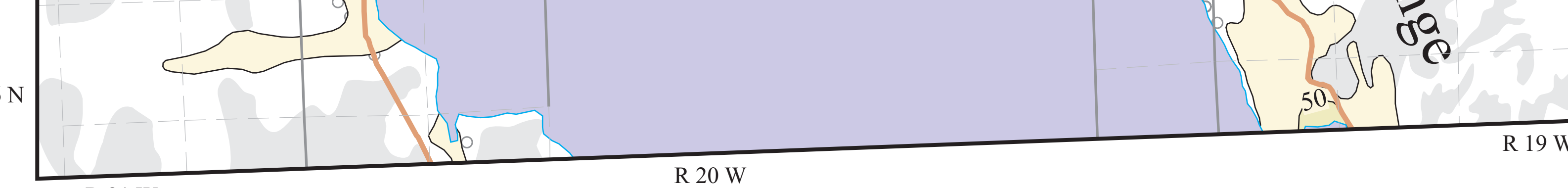


Figure 1. Thickness of shallow alluvium in the Kalispell valley.



Flathead Lake
Salish Mountains
Polson
Polson Moraine
Flathead River
Pablo Reservoir
Mission Range
Valley View Hills
Pablo
Mud
Creek
Mission
Ronan
West
East
47°45'
T 23 N
T 22 N
T 21 N
T 28 N
T 27 N
47°30'
River Valley
50
100
150



Thickness of Shallow Alluvium, Flathead Lake Area, Flathead Lake, Missoula, and Sanders Counties, Montana

by

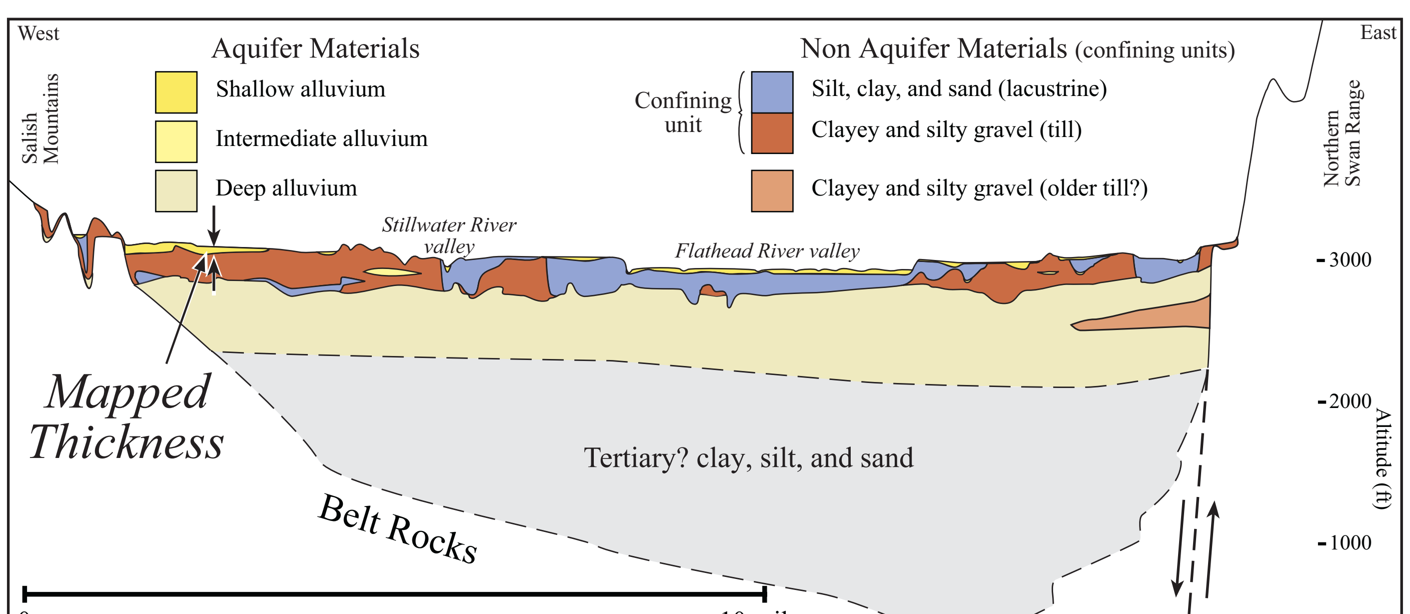
Larry N. Smith

Author's Note: This map is part of the Montana Bureau of Mines and Geology (MBMG) Ground-Water Assessment Atlas for the Flathead Lake 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 Flathead Lake Area the reader is referred to Part A (descriptive overview) and other Part B maps of the Montana Ground-Water Assessment Atlas No. 2.

INTRODUCTION

This map shows the generalized thickness of sand and gravel (including minor amounts of silt and clay and wind-blown sand) that are present near land surface in the Flathead Lake area. These surficial deposits are called the "shallow alluvium." The extent of shallow alluvium in the Kalispell and part of the Swan River valleys is shown in figure 1; the extent of these deposits in the Mission and Jocko valleys is shown in figure 2.

The shallow alluvium occurs within stream valleys, on alluvial fans, in stabilized wind-blown (eolian) dune fields, in previous beach and deltaic positions of Flathead Lake, or in areas of glacial outwash (sand and gravel deposits of streams in front of former glaciers). The shallow alluvium overlies older deposits and bedrock, including Proterozoic Belt Supergroup (bedrock) and Tertiary sedimentary rocks in the mountains, and glacial and post-glacial unconsolidated sediments in the mountains, foothills, and valleys (fig. 3; Johns, 1970; Harrison and others, 1986, 1992; Ostenaa and others, 1990; Smith, 2002b; Smith and others, 2000). Interpretation of drillers logs of water wells and examination of surface exposures in the field show that the shallow alluvium is widespread, but can be correlated with confidence in the subsurface only where thicknesses reported on the logs are greater than 5 ft.



ft of shallow alluvium. Deltaic sandy and silty sediments in the area between Kalispell and Flathead Lake (Noble and Stanford, 1986) and glacial meltwater deposits (outwash) overlie glaciolacustrine deposits and till in areas outside active river valleys. Greater than 50 ft of shallow alluvium, such as along the incised modern valleys of the Flathead, Whitefish, Stillwater, and Swan Rivers (fig. 1) and along Mud Creek (south of Flathead Lake; fig. 2), were deposited as the rivers partially cut through the glacial deposits and the valleys were partially backfilled with alluvium. This shallow alluvium unit may contain shallow ground water that is generally not hydraulically connected to the deep aquifer.

The sequence of unconsolidated geologic units (from older to younger—deep alluvium, till, glaciolacustrine deposits, and shallow alluvium) represents deposition during one or more glacial advance and retreat cycles. Although the stratigraphy can be generalized as a layered sequence, intertonguing between either the deep or the shallow alluvium units and the intermediate confining beds complicate the relationships between the geologic and hydrologic units. Intertonguing between the shallow alluvium and glaciolacustrine units occurs in the northern Swan River valley, Lost Creek fan area (fig. 1), and in the Mission valley (fig. 2) where glacial outwash was deposited in glacial lakes, as described below. In these areas, permeable (aquifer) and impermeable (non-aquifer) sediments are interlayered. Because few wells penetrate the entire sequence of aquifer and non-aquifer materials, correlations between well logs are problematic, making maps of these areas imprecise.

VARIATION IN THICKNESSES

Thickness variations in the shallow alluvium were caused by erosion of underlying units before its deposition, by intertonguing between the shallow alluvium and finer-grained glaciolacustrine sediments, and by irregularities in the land surface. Thicknesses are generally less than 50 ft and decrease laterally toward the edges of the shallow alluvium, which are defined by the mapped geologic boundaries of various sand and gravel bodies (Ostenaa and others, 1990; Smith, 2002b; Smith, unpubl. mapping). Although thicknesses generally increase near some major streams in the area, notably the Whitefish, Flathead, and Swan Rivers, due to backfilling of river scours with sand and gravel, the thickest accumulations of shallow alluvium are apparently related to other processes.

Thicknesses of shallow alluvium are greatest in the southern part of the Kalispell valley, at the Lost Creek fan area, in the northern Swan River valley, and just southeast of Polson. In the southwestern portion of the Kalispell valley (fig. 1; T. 27–28 N., R. 21 W.) the shallow alluvium reaches thicknesses greater than 100 ft in two elongate areas that may represent paleochannels along a prior course of the Flathead River. The greatest thicknesses of alluvium are in the south-central Kalispell valley (centered on sec. 31, T. 28 N., R. 20 W.) where a subcircular accumulation of sand and gravel exceeds 200 ft in thickness. This deposit, like similar-sized accumulations on the Lost Creek fan (T. 29 N., R. 22 W.), in the Columbia Falls area (centered on secs. 2, 3, 10, and 11, T. 30 N., R. 20 W.), and south of Lake Blaine (centered on sec. 35, T. 29 N., R. 20 W.) may be related to

of sand and gravel at the surface
is mapped at a depth of about 10
ground water could flow from th
The map may also show whe
about 50 ft. Some of these locatio
resources for mining. Additional w
and map the volumes of the depo

MAP CONSTRUCTION

Thicknesses of shallow alluvi
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reported to a precision of 1/4 of a
locations are those reported by dri
by comparison of anomalous geo
the property or by talking to the w
by field visits. The depth to the ba
to altitudes above sea level values
altitudes. Land-surface altitudes
Geological Survey digital elevation
software. Comparison of well-loc
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differences between calculated v
generally less than 5 ft in the vall
and then digitized. Because of the
were drawn only where multiple
The thickness of the shallow allu
altitude of the base of the unit fro
ArcInfo™ software. The resulting
using ArcInfo™. Thickness cont
redigitized.

DATA SOURCES

Water-well driller logs and we
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Ground-surface topographic data a
Survey DEMs for western Monta
hydrography, and roads were obt
Information System, Helena (http

ACKNOWLEDGEMENTS

This work was supported by th
at the Montana Bureau of Mines
Carstarphen helped in the interpr
were improved due to reviews by
Voast, and Edmond Deal.

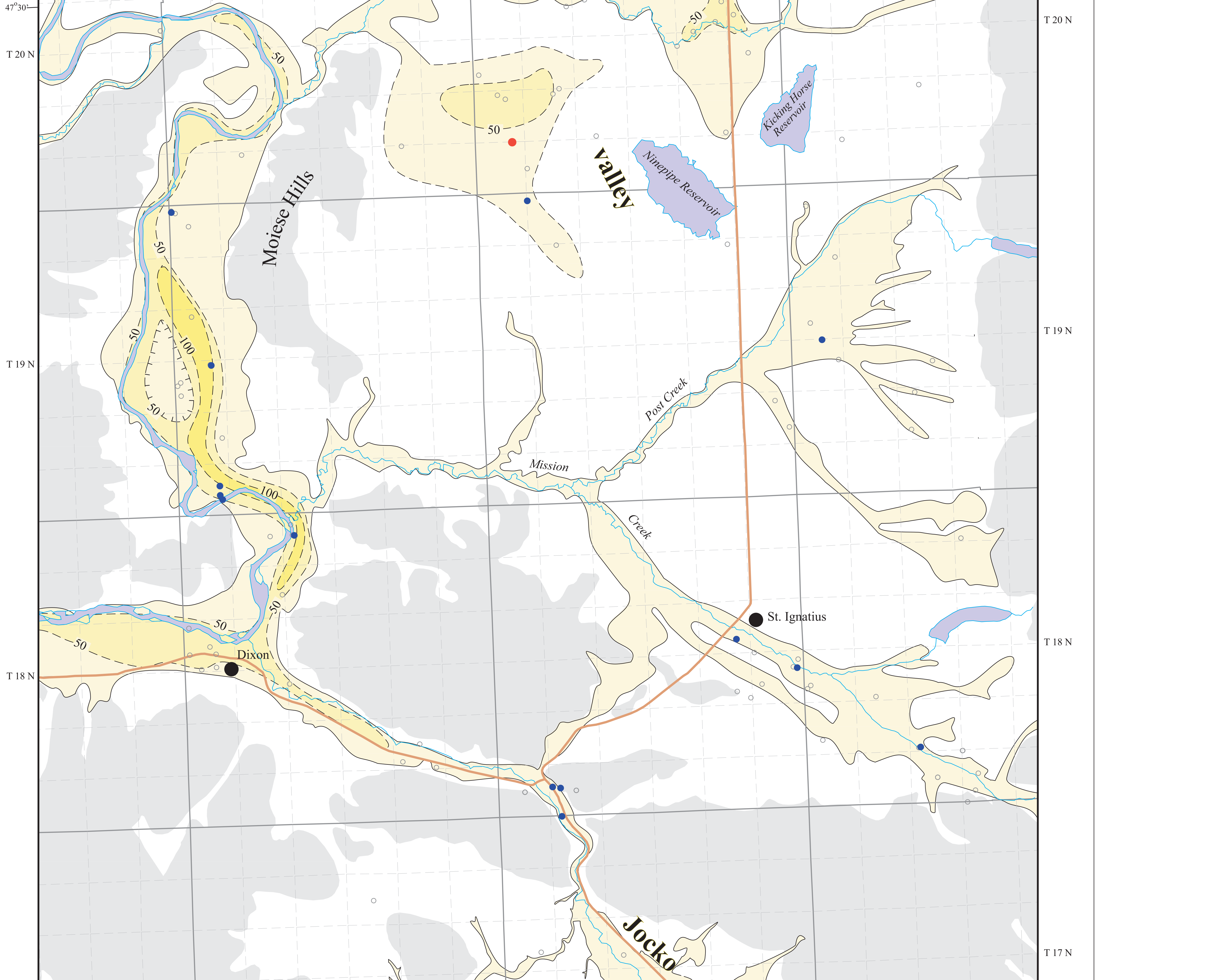
r,

occur in an area where the deep alluvium 0-200 ft (Smith, 2002a), suggesting that e shallow alluvium to the deep alluvium. re shallow alluvium may be greater than ns may contain prospective sand and gravel vork is required to characterize the lithologies osits.

ium were derived from about 9,700 drillers netrated the shallow alluvium, about 4,200 greater than 5 ft. Only wells with locations a section or smaller were used. Most well llers. However, some locations were refined ologic descriptions with street addresses of well owners and about 11% were confirmed ase of the unit for each point was converted by subtracting the depth from land-surface at well locations were obtained from U.S. n models (DEMs) using ArcInfo™ computer cation altitudes determined in the field from ived from the DEMs showed that the alues and field-determined values were leys. The altitudes were contoured by hand imprecise nature of driller log data, contours data points supported the contour location. vium was calculated by subtracting the om the land surface altitude unit using thickness grid was smoothed and contoured ours were then redrawn by hand and

ll locations are stored in the GWIC database l Geology (http://mbmggwic.mtech.edu). are from the 1:24,000-scale U.S. Geological ana. Public Land System Survey data, tained from Montana's Natural Resources p://nris.state.mt.us/).

he Ground-Water Characterization Program and Geology. Don Mason and Cam retation of drillers logs. The map and text Thomas Patton, John LaFave, Wayne Van



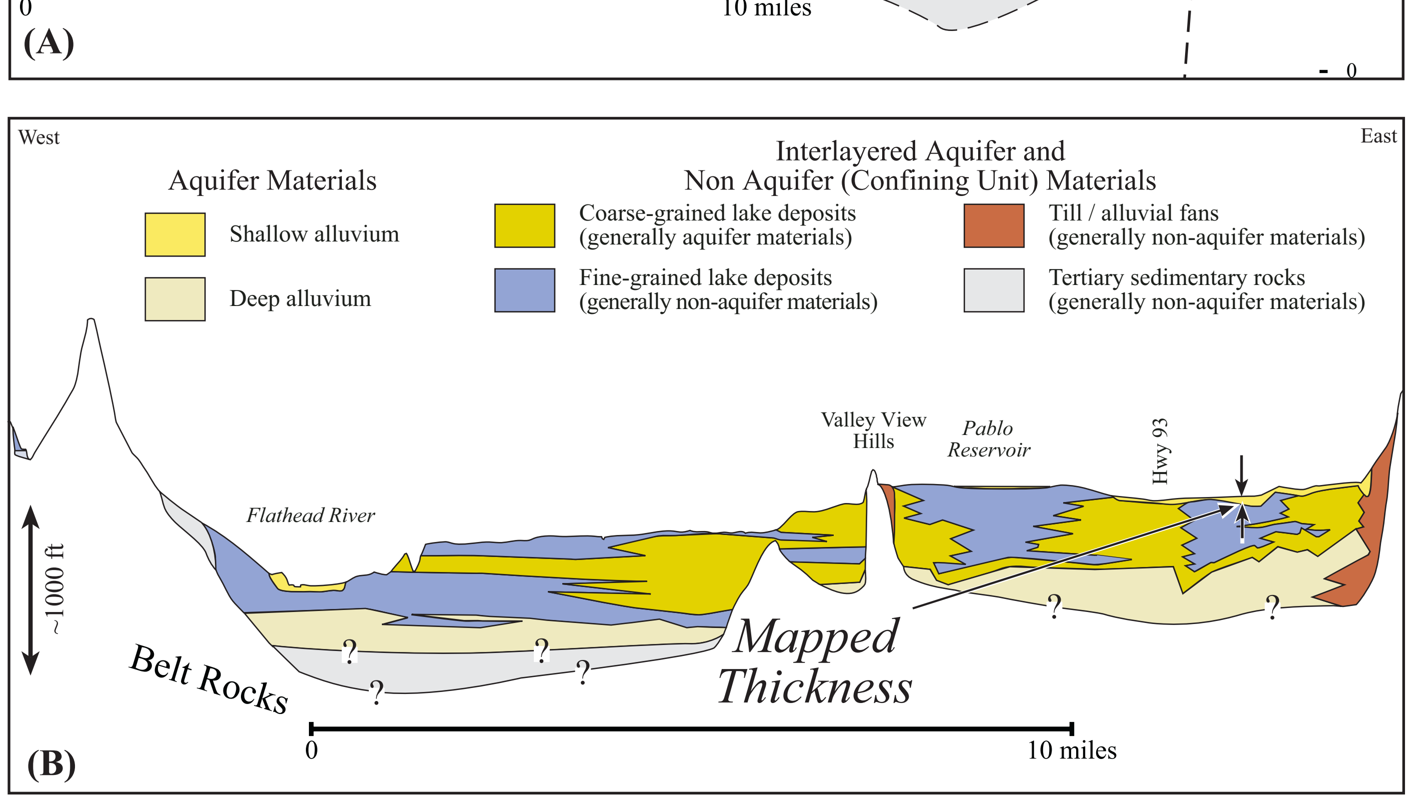


Figure 3. (A) Diagrammatic cross section showing the stratigraphy of basin-fill units in the Kalispell valley, (B) Diagrammatic cross section showing the stratigraphy of basin-fill units in the Mission valley.

OVERVIEW OF BASIN-FILL STRATIGRAPHY

The Kalispell, Mission, and Jocko valleys are areas where the bedrock has been structurally down-dropped relative to neighboring uplifted Salish, Swan, Whitefish, and Mission mountain ranges. Within the valleys, bedrock has been encountered in drill holes mostly near their perimeters. In parts of the Kalispell and Mission valleys bedrock is overlain by a deep alluvial unit from which large volumes of water are produced locally (LaFave, 2002c, d). Deep alluvium was likely deposited both before and during glacial advance into the valley. The deep alluvium is overlain by a complex sequence of till (deposits of glacial ice) and glaciolacustrine sediments (deposits in lakes neighboring glaciers) throughout the Flathead Lake area. Glacier(s) partially or completely filled the Kalispell, Swan River, and Mission valleys, forming a blanket-like deposit of till at depth and a mantle over much of the bedrock in the foothills and mountains. Silty, clayey, and gravely glaciolacustrine sediments were deposited south and west of the glacier terminus near Polson (in Glacial Lake Missoula), and within and north of the present Flathead Lake basin as the glacier receded and the ancestral Flathead Lake covered most of the Kalispell valley. The sediments directly above the deep alluvium in the valleys north of Flathead Lake make up a nearly continuous upper confining unit (fig. 3A), whereas in the Mission valley south of Flathead Lake the glaciolacustrine sediments host aquifers in many locations (fig. 3B).

Glaciolacustrine deposits and till are overlain in many areas by about 50

outwash fan deposition during glacial retreat. Similarly, the thickest accumulation of shallow alluvium south of Flathead Lake (T. 22 N., R. 19–20 W.) may be part of an outwash fan where a glacial stream cut through the Polson moraine. These outwash fans may have been either deposited at land surface or in glacial lakes. Shallow alluvium deposits emanating from the outwash fan along the Polson moraine are distributed to the south-southwest along the Mud Creek drainage, averaging thicknesses of about 50 ft.

NITRATE

Where shallow alluvium is thick enough below the water table, it is a source of ground-water. Because the aquifers are unconfined, near-surface, and unprotected from surface sources of pollutants, water quality in these unconfined aquifers can be compromised. Nitrate concentrations in milligrams per liter as nitrogen (mg/L-N) are often used to illustrate contamination of aquifers by domestic septic and agricultural sources. Nitrate contamination of ground water in the shallow alluvium has been shown in the Flathead River valley north of Flathead Lake (Evergreen aquifer) (Noble and Stanford, 1986) and has been highlighted as a concern in the Mission and Jocko valleys (Makepeace and Mladenich, 1995). High nitrate concentrations are well documented at two sites northeast of Kalispell where 35 wells were sampled in the mid-1980's (fig. 1).

Although recent Ground-Water Characterization Program work for the Flathead Lake area emphasized water quality in the deeper aquifers (LaFave, 2002a, b), data from 127 wells sampled for nitrate are in the Ground-Water Information Center (GWIC) database for water in the shallow alluvium. These nitrate data were collected between 1975 and 2000 and are shown on the maps (figs. 1, 2). Of the 127 wells sampled, 3 had at least one sample that exceeded the health standard of 10 (mg/L-N); 11 wells had samples that were between 3.0 and 10 mg/L-N, a level that suggests possible contamination by surface sources (Madison and Brunett, 1984). Most wells (80%) showed either non-detectable concentrations or concentrations less than 1.5 mg/L-N (figs. 1, 2). Although the available analyses show local nitrate contamination of the shallow alluvium, the geographical coverage and dates of sampling are not sufficient to discern if there is a regional contamination problem.

MAP USE

These maps can be used to evaluate locations where shallow aquifers may exist and to help determine the location of sand and gravel resources near the land surface. Productive water wells occur mostly along stream valleys where the shallow alluvium is continually saturated with water. Most wells completed in the shallow alluvium are along the Flathead River between Columbia Falls and Flathead Lake (fig. 1). Many wells were also completed in areas of outwash south and southeast of Lake Blaine (fig. 1) and along Mud Creek, Mission Creek, and the Jocko River (fig. 2). Aquifers in the shallow alluvium are locally important where alluvium or outwash was deposited on till in isolated areas (e.g., south half T. 31 N. R. 21 W.). In these areas, outwash was deposited by glacier-margin streams (Smith, 2002b). Further mapping of these features may help to locate productive wells.

In areas where the shallow alluvium is greater than 100 ft thick, unconfined aquifers are more likely to be hydraulically connected to deeper aquifers. The presence of thick shallow alluvium over the deep aquifer may delineate areas where the deep aquifer is more sensitive to contamination from near-surface sources. For example, in the Lost Creek fan area, greater thicknesses

REFERENCES

Harrison, J. E., Cressman, E. R.,
structure maps of the Kalispe
Alberta and British Columbia
Investigations Series Map I-2
Harrison, J. E., Griggs, A. B., and
maps of the Wallace 1 x 2-de
Geological Survey Miscellan
scale 1:250,000.
Johns, W. M., 1970, Geology and
Counties, Montana: Montana
182 p.
LaFave, J. I., 2002a, Dissolved co
valley: Flathead County, Mont
Ground-Water Assessment A
LaFave, J. I., 2002b, Dissolved c
Flathead Lake area: Lake, Sa
Montana Bureau of Mines and
2, part B, map 5, scale 1:63,3
LaFave, J. I., 2002c, Potentiometr
valley: Flathead County, Mont
Ground-Water Assessment A
LaFave, J. I., 2002d, Potentiomet
Flathead Lake area: Lake, Sa
Montana Bureau of Mines and
2, part B, map 4, scale 1:63,3
Madison, R. J., and Brunett, O. J
nitrate in ground water of the
1984–Water-Quality Issues:
Paper 2275, p. 93-103.
Makepeace, S. V., and Mladenich,
Flathead Indian Reservation, M
Natural Resource Departmen
Noble, R. A., and Stanford, J. A.
quality of unconfined aquifers
Bureau of Mines and Geolog
Ostenaa, D., Manley, W., Gilbert,
C. W., 1990, Flathead Reserv
evaluation for dam safety: U.
Report 90-8, 161 p., scale 1:4
Smith, L. N., 2002a, Depth to de
Kalispell valley: Flathead Co
and Geology Ground-Water A
1:63,360.
Smith, L. N., 2002b, Surficial ge
valley (Kalispell valley) area
Bureau of Mines and Geolog
B, map 6, scale 1:70,000.
Smith, L. N., Blood, L., and LaF
geomorphology, and hydroge
Flathead County, Montana, *in*,
field trips, western Montana a
of the Geological Society of A

and Whipple, J. W., 1992, Geologic and
ell 1 x 2-degree quadrangle, Montana, and
a: U.S. Geological Survey Miscellaneous
2267, scale 1:250,000.
l Wells, J. D., 1986, Geologic and structure
gree quadrangle, Montana and Idaho: U.S.
eous Investigations Series Map I-1509,

d mineral deposits of Lincoln and Flathead
Bureau of Mines and Geology Bulletin 79,

nstituents map of the deep aquifer, Kalispell
ana: Montana Bureau of Mines and Geology
tlas 2, part B, map 3, scale 1:63,360.
onstituents map of the southern part of the
nders, and Missoula Counties, Montana:
d Geology Ground-Water Assessment Atlas
60.
ic surface map of the deep aquifer, Kalispell
ana: Montana Bureau of Mines and Geology
tlas 2, part B, map 2, scale 1:63,360.
tric surface map of the southern part of the
nders, and Missoula Counties, Montana:
d Geology Ground-Water Assessment Atlas
60.
., 1984, Overview of the occurrence of
United States, in National Water Summary
U. S. Geological Survey Water-Supply

B., 1995, Aquifer vulnerability assessment:
Montana: Confederated Salish and Kootenai
t, 13 p., 5 pls.
, 1986, Ground-water resources and water
s in the Kalispell valley, Montana: Montana
y Open-File Report 177, 112 p.
J., LaForge, R., Wood, C., and Weisenberg,
vation regional seismotectonic study: An
S. Bureau of Reclamation Seismotectonic
48,000.
ep alluvium of the deep aquifer in the
unty, Montana: Montana Bureau of Mines
Assessment Atlas 2, part B, map 8, scale

ologic map of the upper Flathead River
, Flathead County, Montana: Montana
y Ground-Water Assessment Atlas 2, part

ave, J. I., 2000, Quaternary geology,
eology of the upper Flathead valley area,
Roberts, S., and Winston, D., *eds.*, Geologic
nd adjacent areas: Rocky Mountain Section
America, University of Montana, p. 41–63.

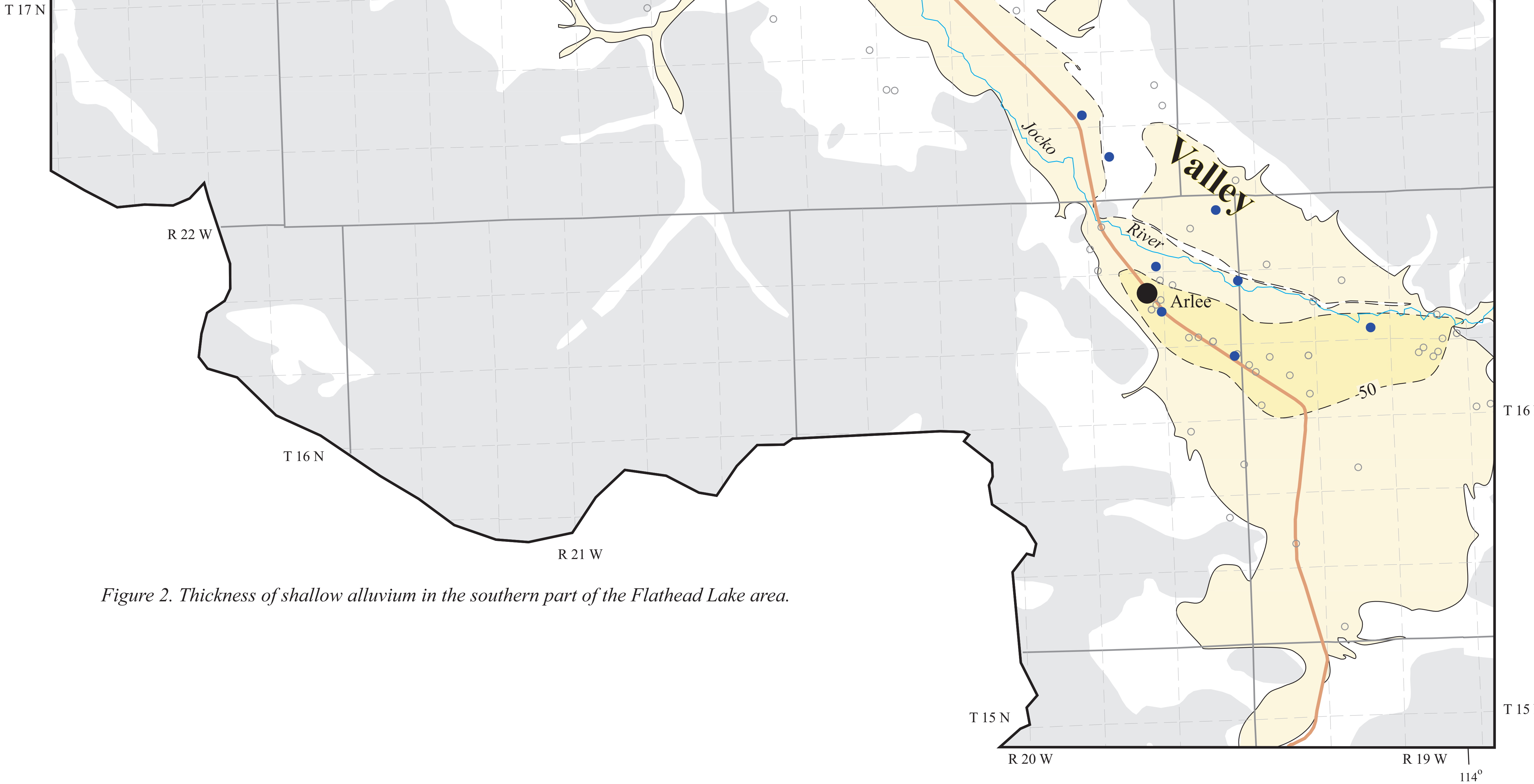


Figure 2. Thickness of shallow alluvium in the southern part of the Flathead Lake area.