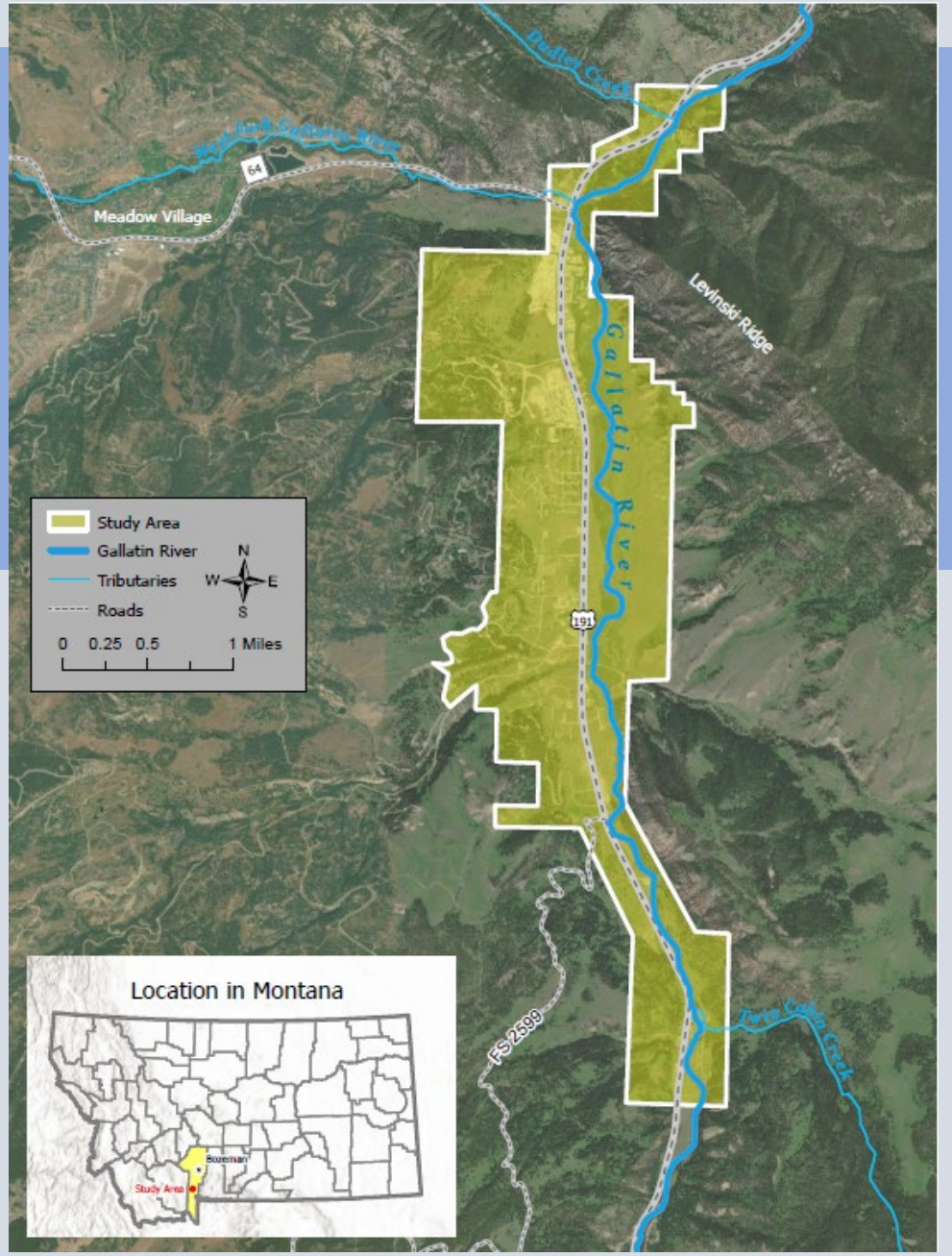
Groundwater Study of the Upper Gallatin River Corridor

Ground Water Investigation Study, Montana Bureau of Mines and Geology

Kurt Zeiler and Elizabeth Meredith

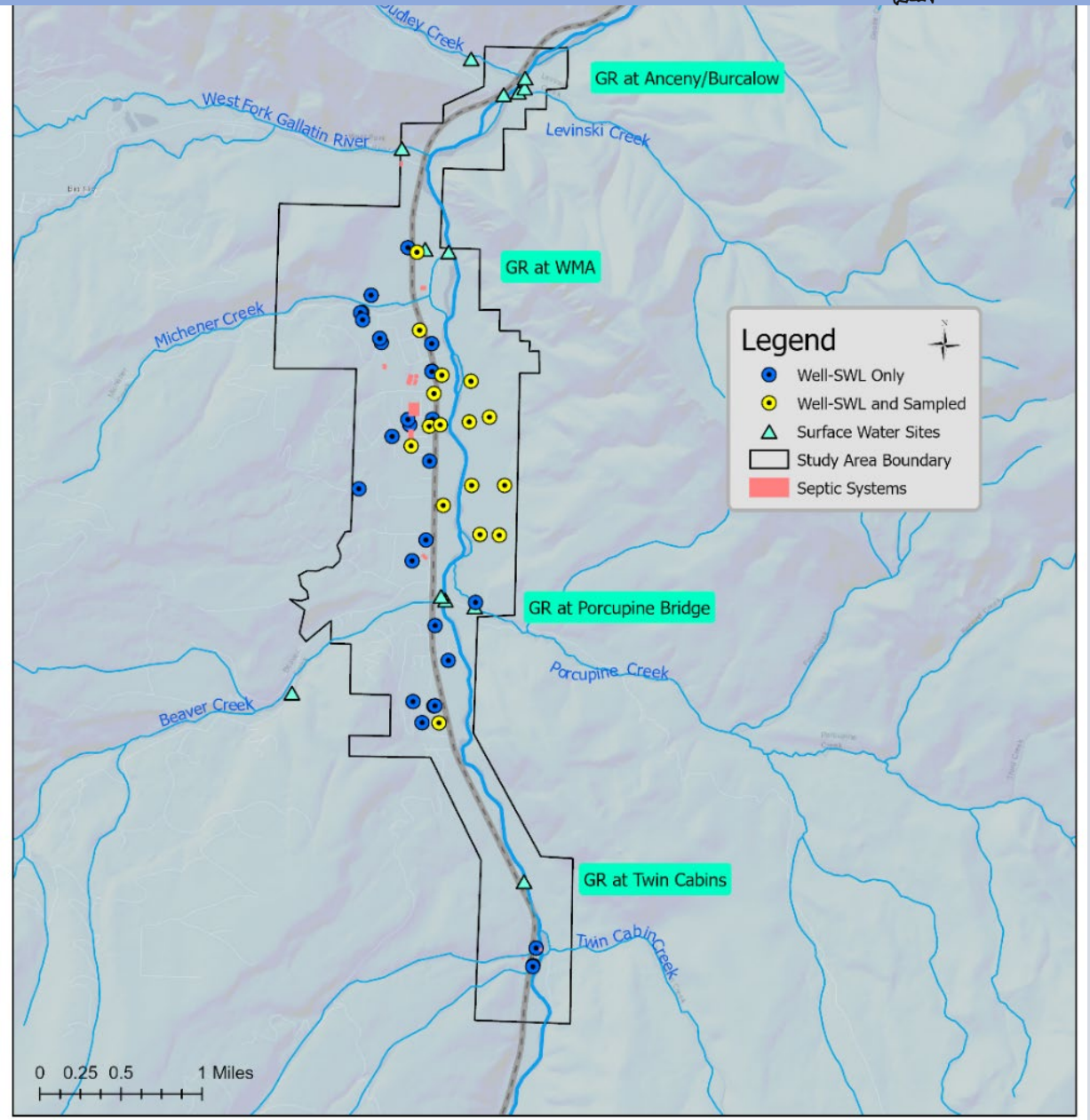
Nominated by the Gallatin River Task Force

- Purpose:
  - Assess the effects of development on the water quality in the shallow alluvial aquifer.
  - Develop a model to identify groundwater flow paths and groundwater/surface-water interaction.



Data Collection

- Field measurements and sampling were completed Summer 2019-Summer 2021
- Groundwater
  - 48 water level sites
    - 27 alluvial, 21 bedrock
  - 17 wells and 1 springs sampled approx. monthly
- Surface water
  - 13 stream gaging sites
  - Sampled during low flows

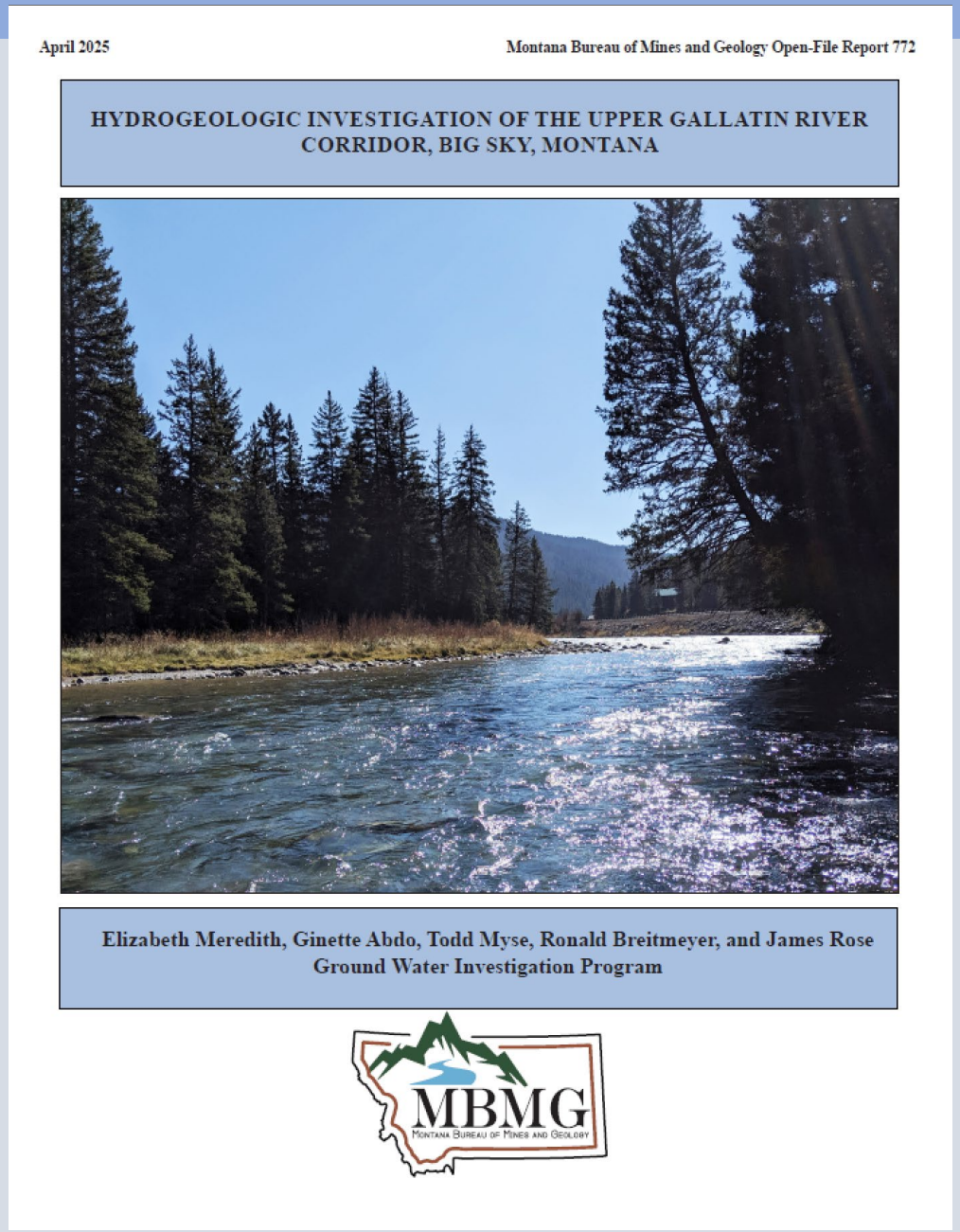


HYDROGEOLOGIC INVESTIGATION OF THE UPPER GALLATIN RIVER CORRIDOR, BIG SKY, MONTANA

Elizabeth Meredith, Ginette Abdo, Todd Myse, Ronald Breitmeyer, and James Rose
Ground Water Investigation Program

GROUNDWATER MODEL OF THE UPPER GALLATIN AQUIFER AT BIG SKY, MONTANA

Kurt Zeiler, Mary Sutherland, and Ronald Breitmeyer
Ground Water Investigation Program

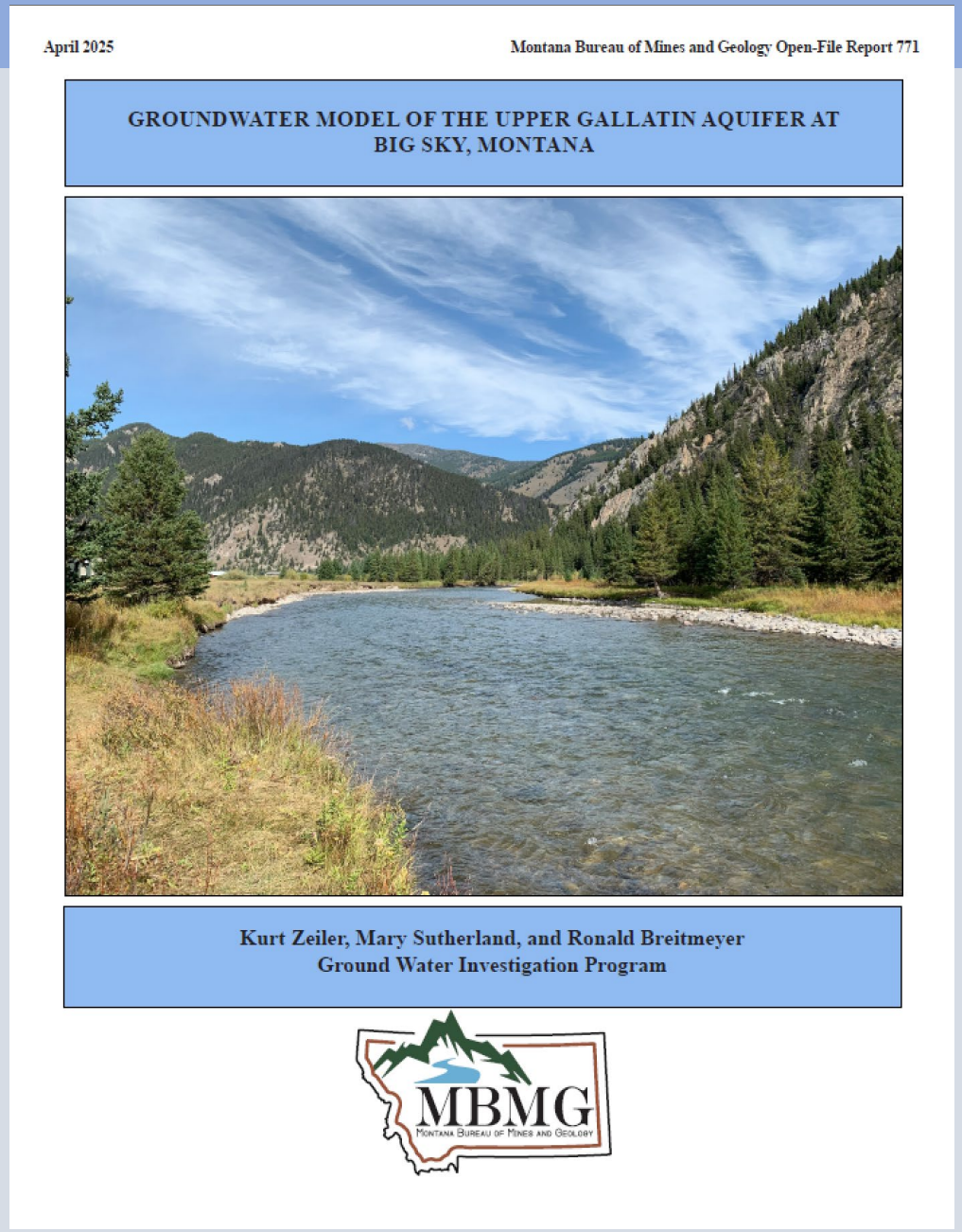


- MBMG OFR 772: *Hydrogeologic Investigation of the Upper Gallatin River Corridor*
  - Introduces the study and field methods
  - Presents the overall hydrogeology
  - Surface-water balance
  - Water chemistry
  - Nitrate trends in the valley

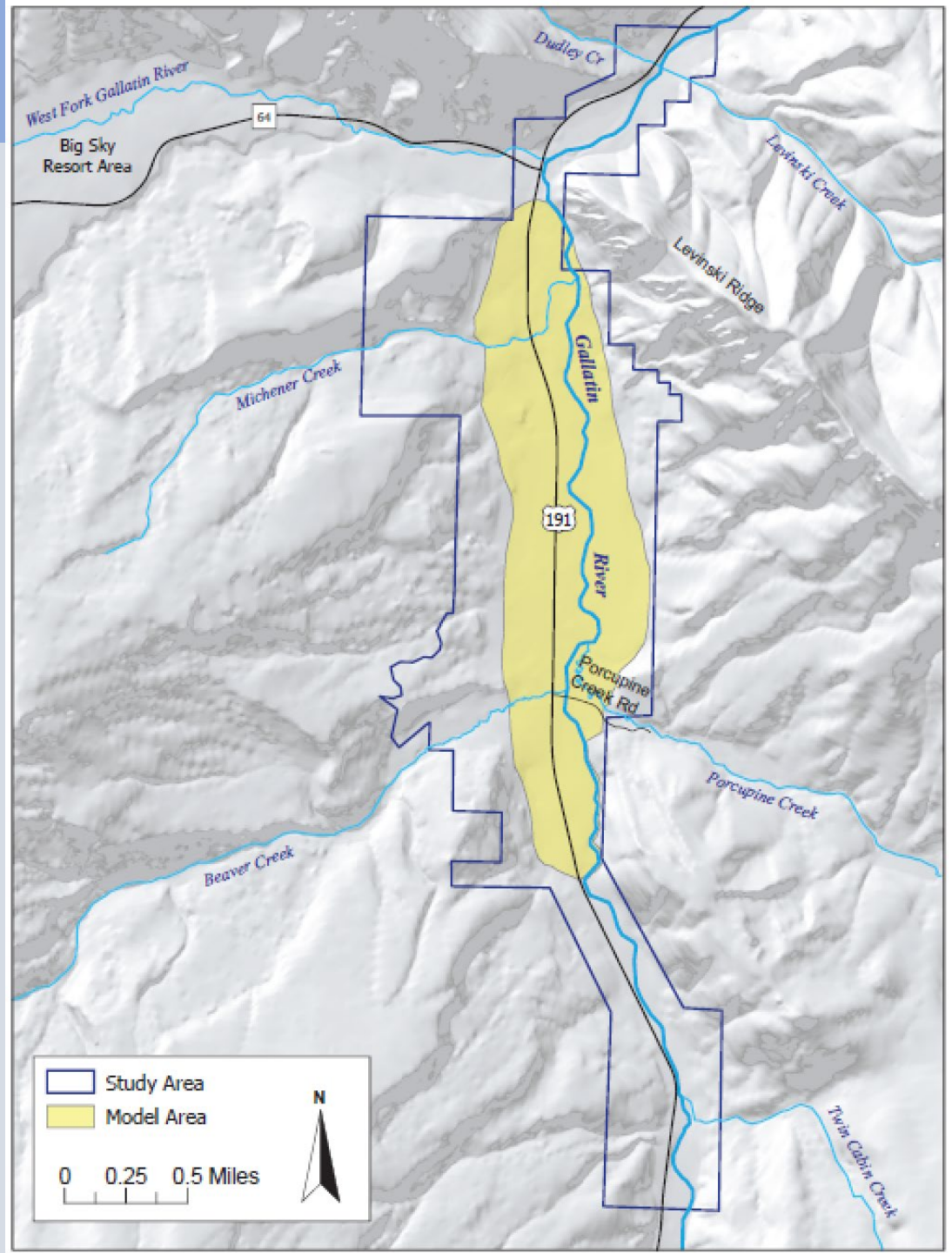
Available online from the MBMG Publications Website:
https://mbmg.mtech.edu

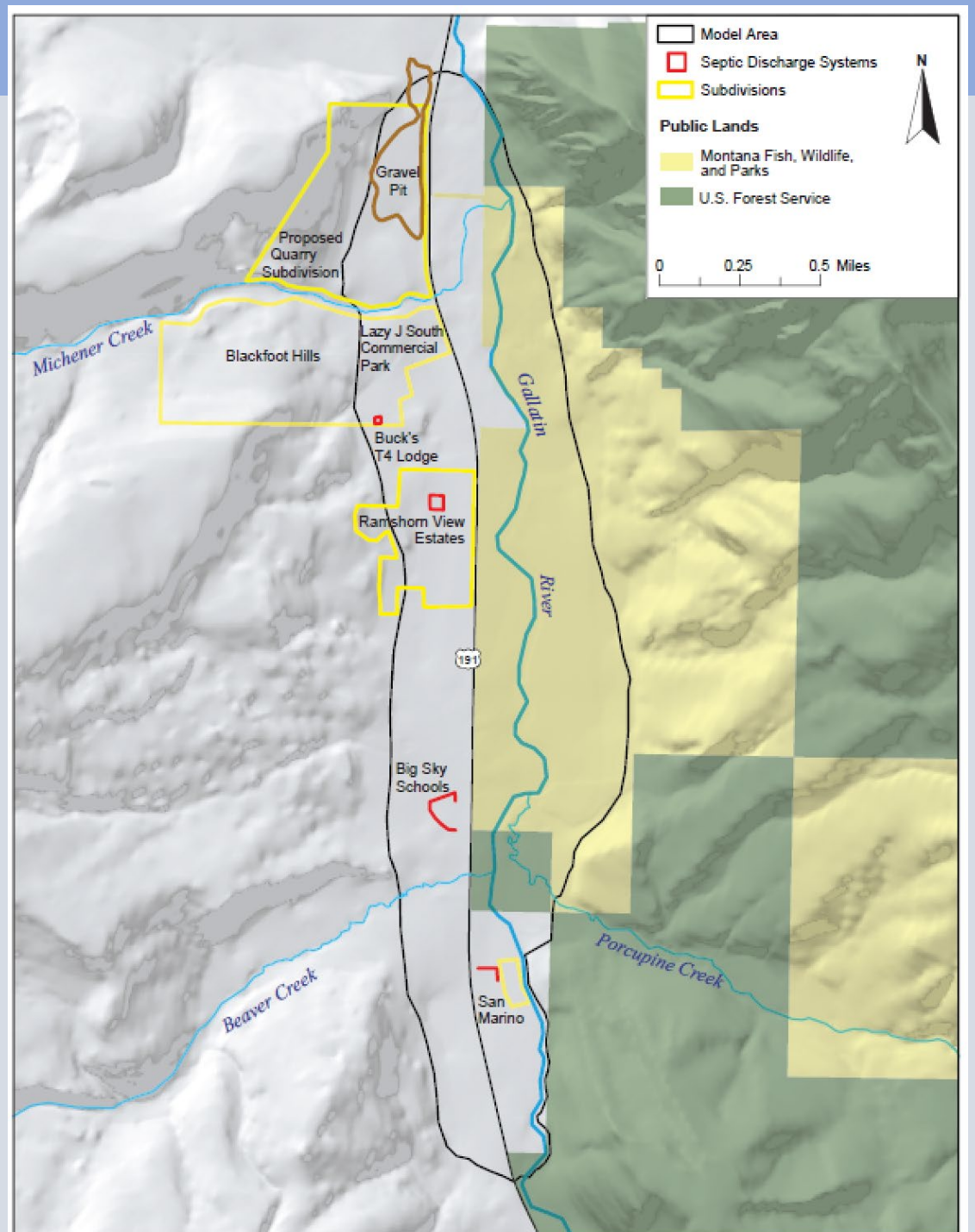
- MBMG OFR 771: *Groundwater Model of the Upper Gallatin Aquifer at Big Sky, Montana*
  - Presents the alluvial hydrogeologic framework
  - Detailed water budget analysis
  - Numerical model construction and calibration
  - Flow path analyses
  - Modeled scenarios of development and climate

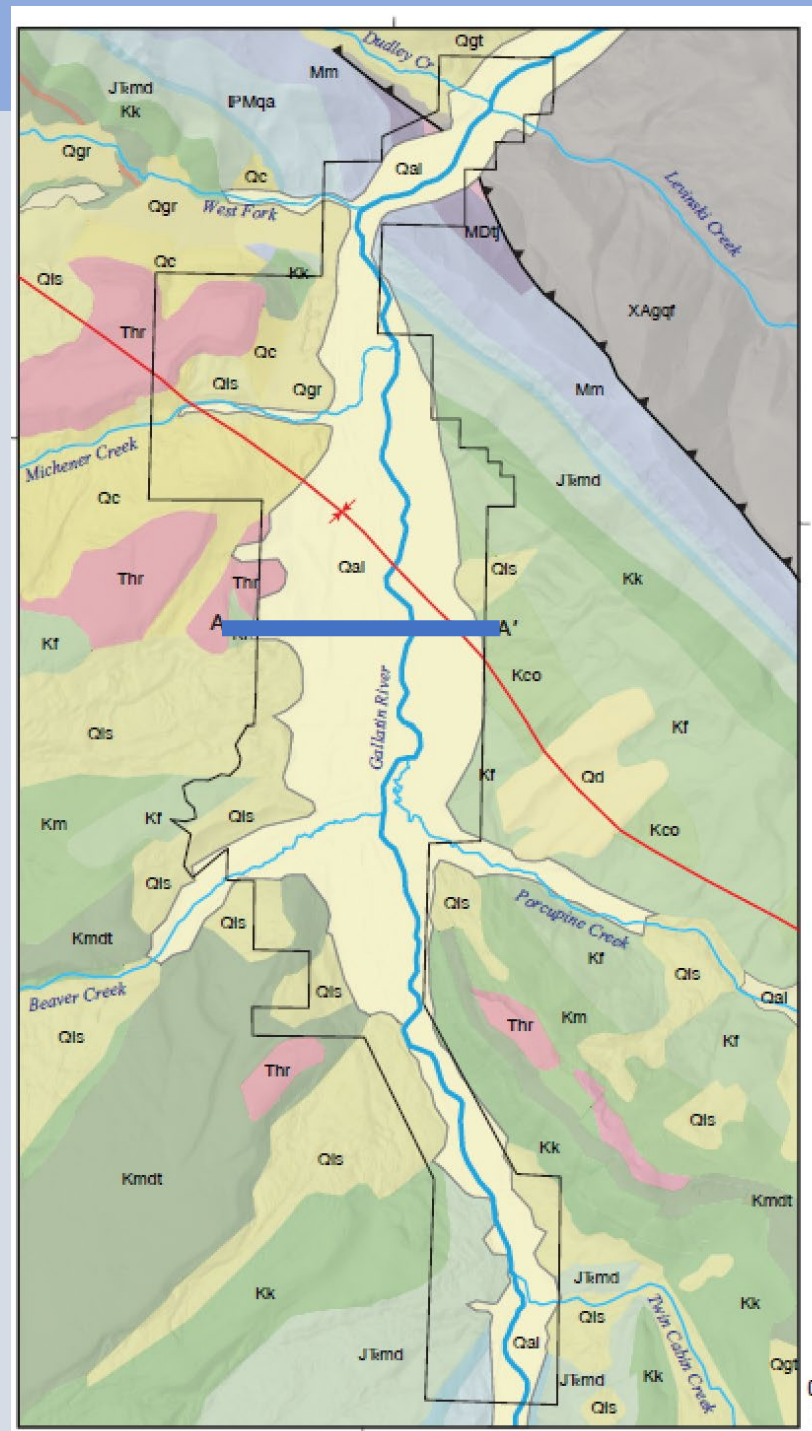
All files, including model files, are available online from the MBMG Publications Website: https://mbmg.mtech.edu

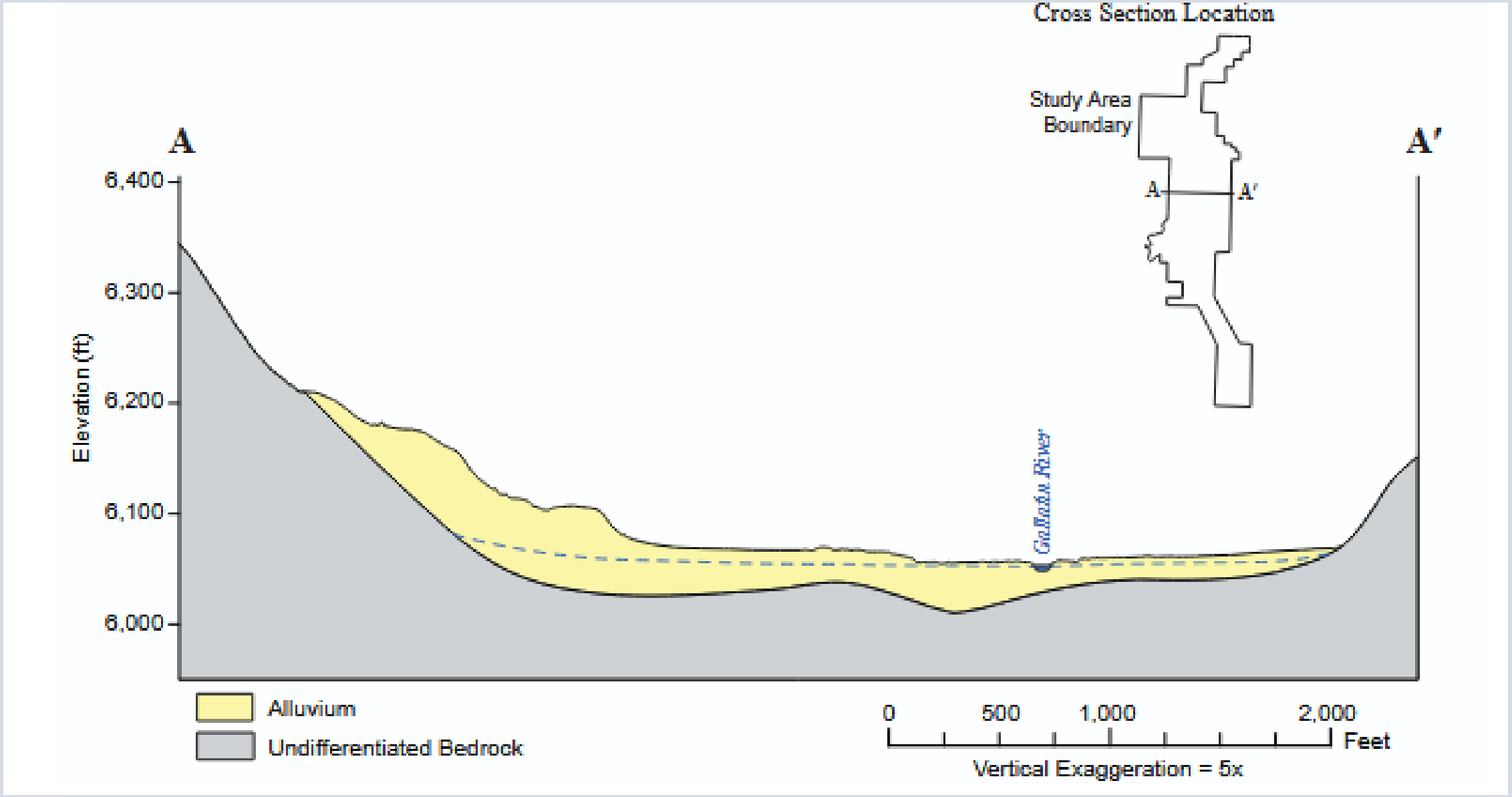


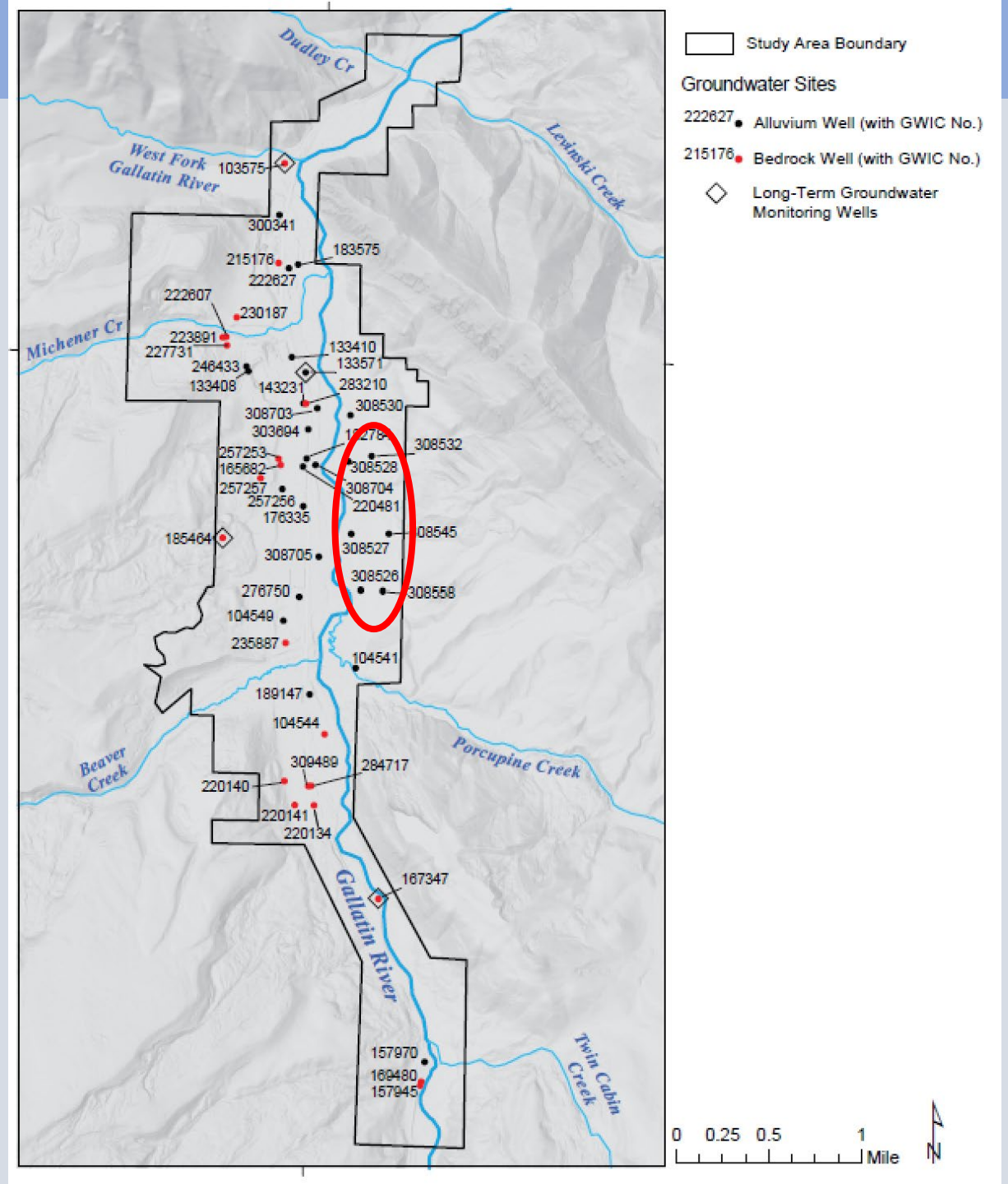
Study area vs. Model area




Model Area
Septic Discharge Systems
Subdivisions
Public Lands
Montana Fish, Wildlife, and Parks
U.S. Forest Service
N
0 0.25 0.5 Miles
Gravel Pit
Proposed Quarry Subdivision
Michener Creek
Blackfoot Hills
Lazy J South Commercial Park
Buck's T4 Lodge
Ramshorn View Estates
Gallatin River
191
Big Sky Schools
San Marino
Beaver Creek
Porcupine Creek


Dudley Cr
Qgt
Mm
JTkmd
Kk
PMqa
Qgr
Qc
Qal
West Fork
Lewski Creek
MDtj
Qls
Thr
XAgqf
Michener Creek
A
A'
Kf
Kco
Gallatin River
Km
Kmdt
Porcupine Creek
Beaver Creek
Twin Cabin Creek
Study Area Boundary
Spanish Peaks Fault
Big Sky Syncline (partially concealed)
Geology
Quaternary
Qal Alluvium
Qc Colluvium
Qd Diamicton
Qgr Gravel
Qls Landslide Deposit
Tertiary
Thr Huckleberry Ridge Tuff
Cretaceous–Cambrian
Kco Cody Formation
Kf Frontier Formation
Km Mowry Shale
Kmdt Muddy and Thermopolis Formations
Kk Kootenai Formation
JTkmd Ellis Group, Morrison and Dinwoody Formations
Psh Shedhorn Formation
PMqa Quadrant and Amsden Formations
Mm Madison Group
MDtj Three Forks and Jefferson Formations
Precambrian
XAgqf Gneiss, Quartz–Feldspar
0 0.25 0.5 1 Miles
N


Cross Section Location
Study Area Boundary
A
A′
A
A′
6,400
6,300
6,200
6,100
6,000
Elevation (ft)
Gallatin River
Alluvium
Undifferentiated Bedrock
0
500
1,000
2,000
Feet
Vertical Exaggeration = 5x



Study Area Boundary

Groundwater Sites

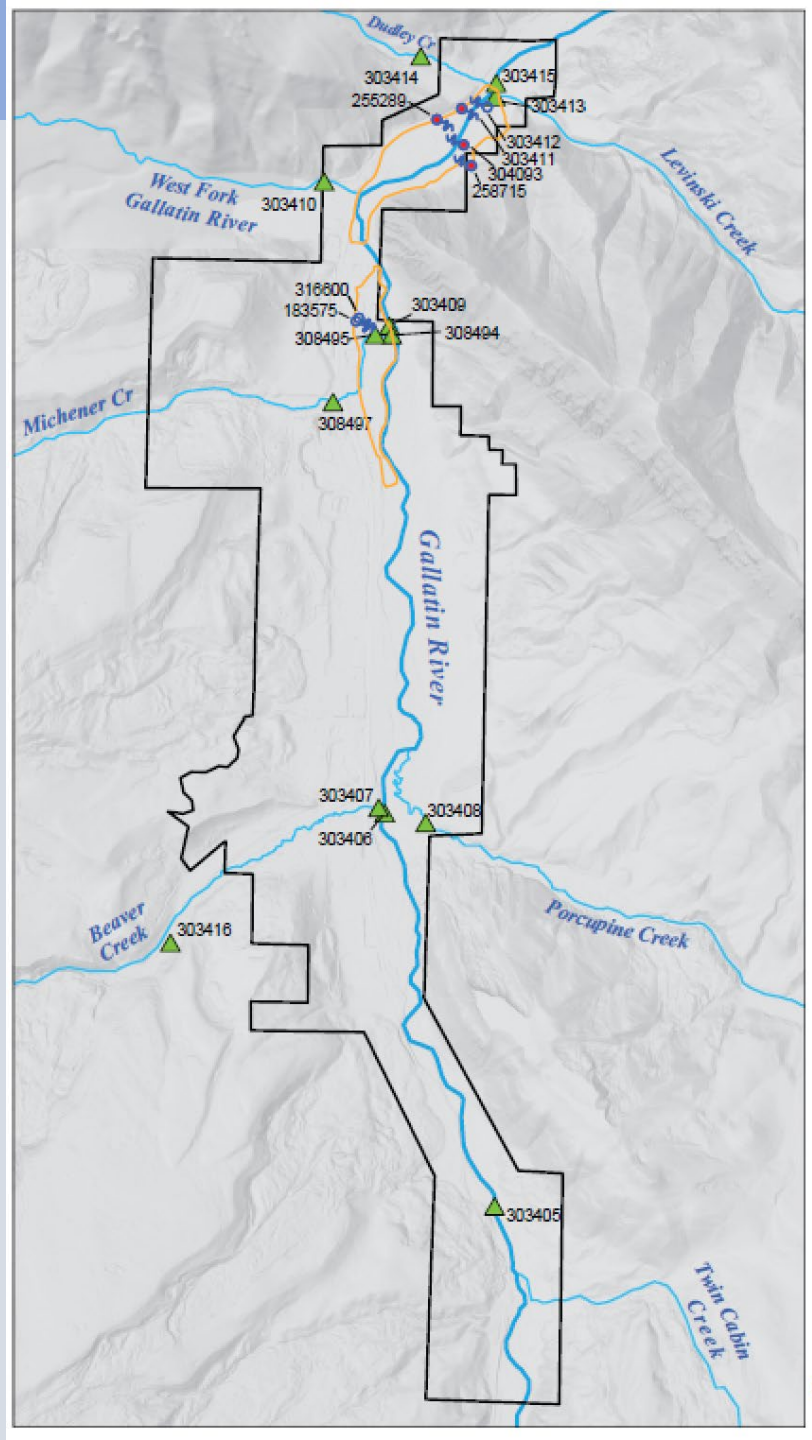
222627 Alluvium Well (with GWIC No.)

215176 Bedrock Well (with GWIC No.)

Long-Term Groundwater Monitoring Wells

0 0.25 0.5 1 Mile

N



Study Area Boundary

303415 Surface-Water Site (with GWIC No.)

Long-Term Spring Site

Spring Site

Spring Area

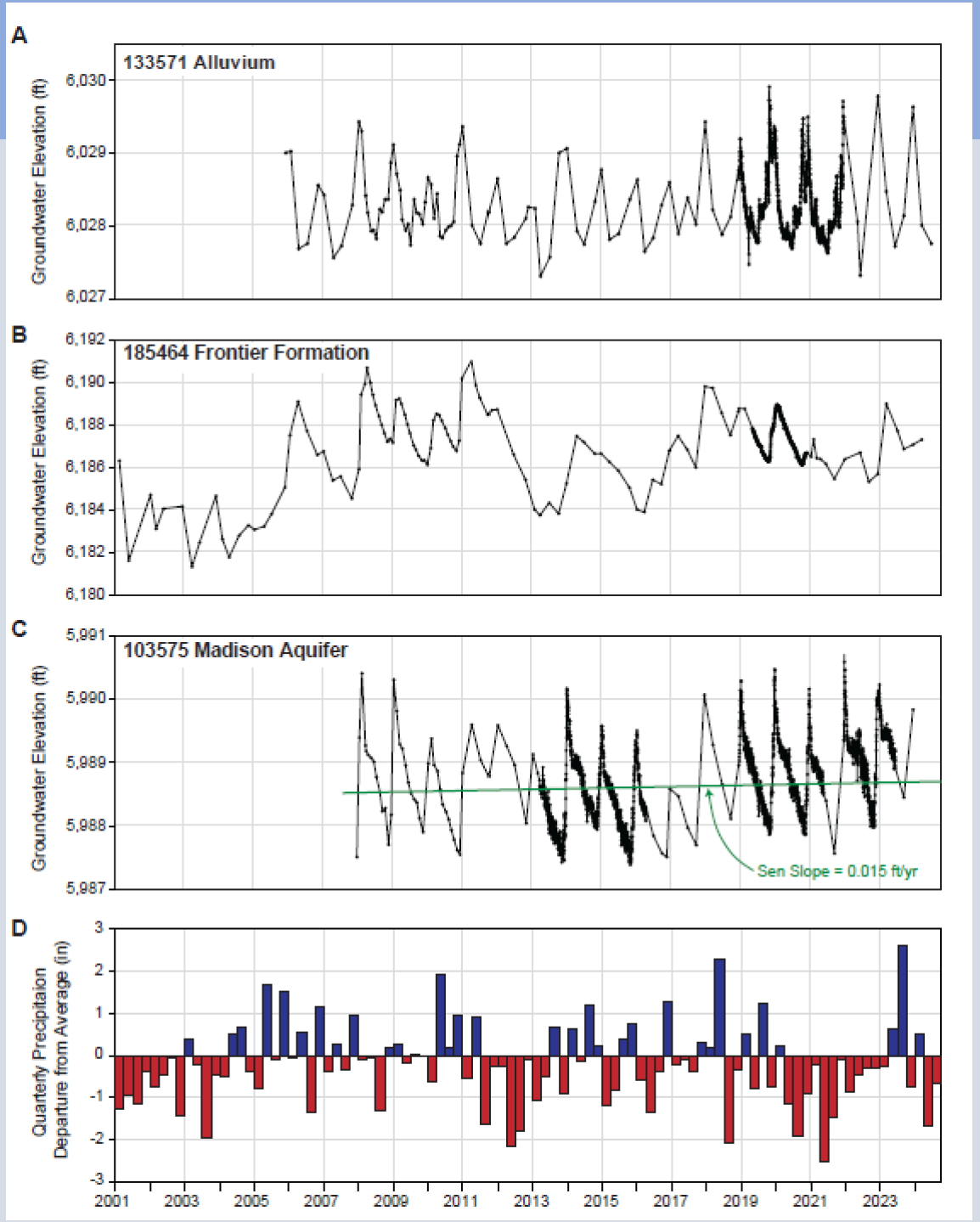
0 0.25 0.5 1 Miles

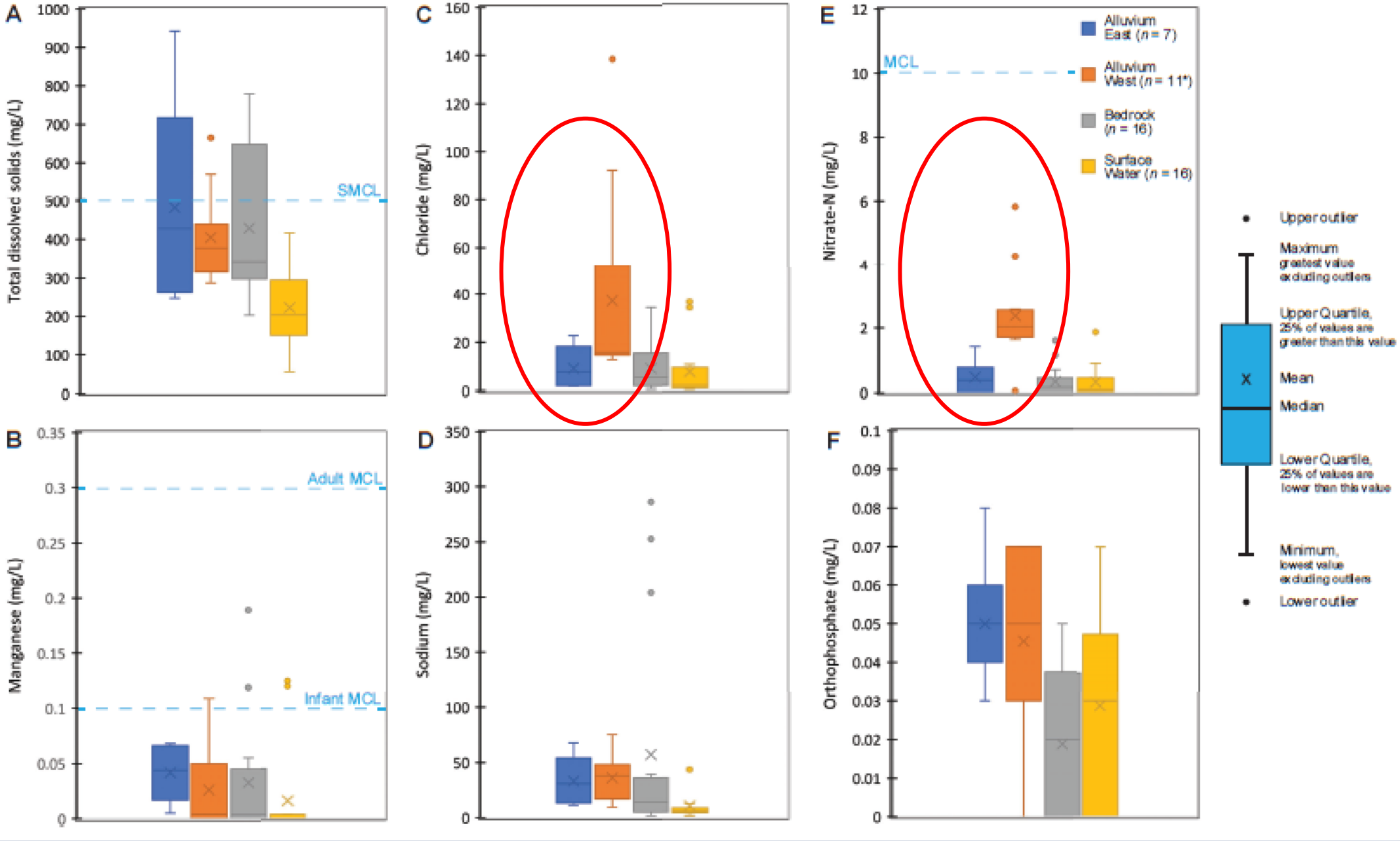
N

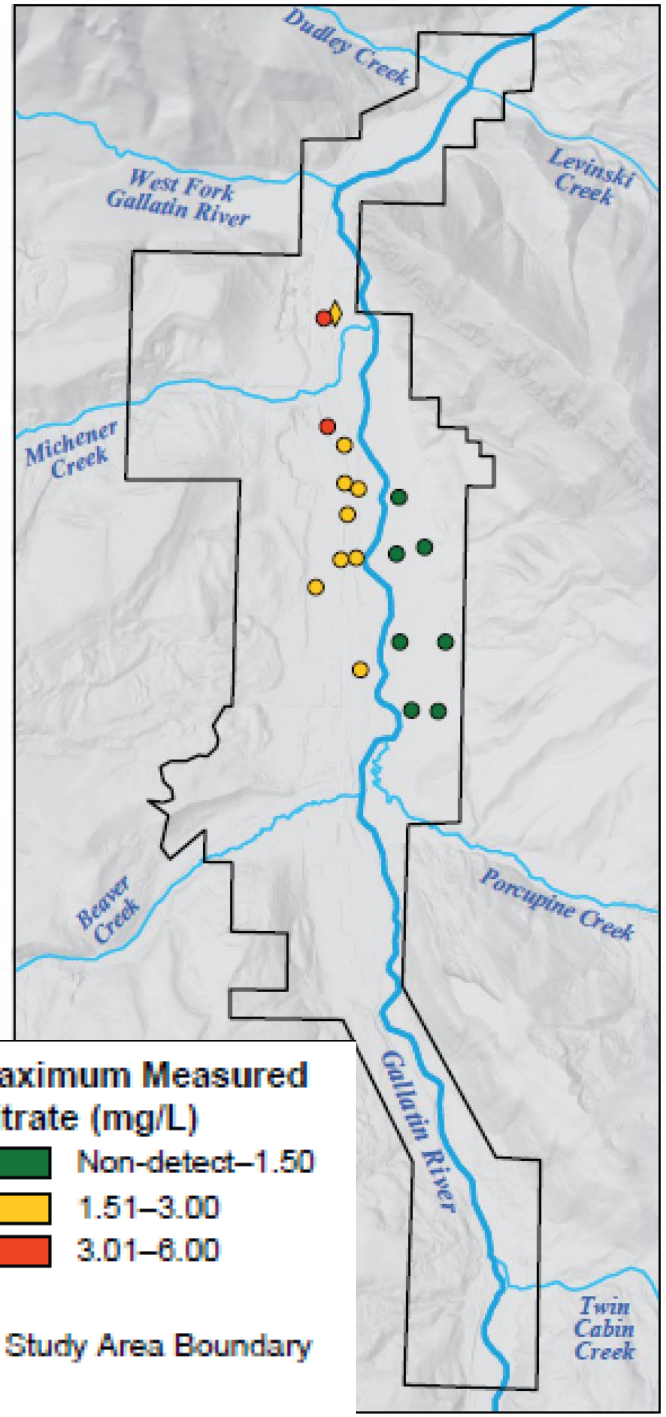
Annual recharge from snow melt

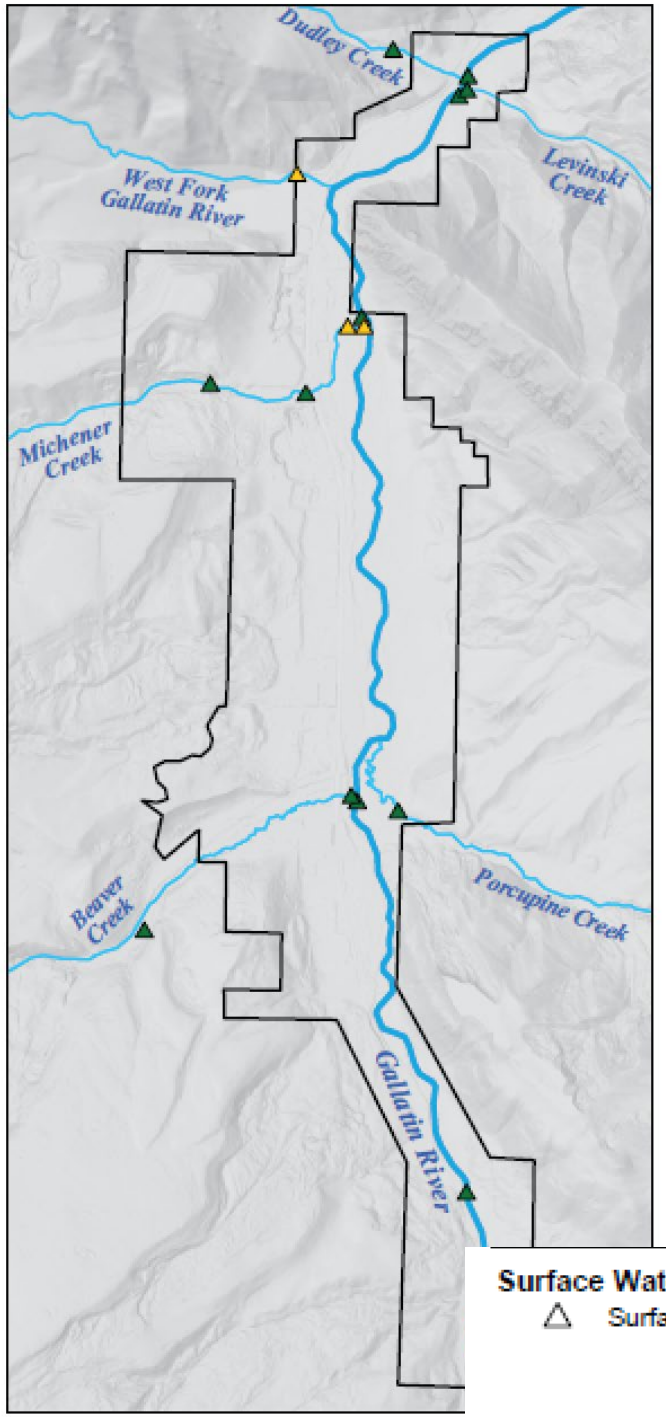
Long-term climate influences

Annual recharge from snow melt




A
Total dissolvec solids (mg/L)
SMCL
B
Manganese (mg/L)
Adult MCL
Infant MCL
C
Chloride (mg/L)
D
Sodium (mg/L)
E
Nitrate-N (mg/L)
MCL
Alluvium East (n = 7)
Alluvium West (n = 11*)
Bedrock (n = 16)
Surface Water (n = 16)
F
Orthophosphate (mg/L)
Upper outlier
Maximum greatest value excluding outliers
Upper Quartile, 25% of values are greater than this value
Mean
Median
Lower Quartile, 25% of values are lower than this value
Minimum, lowest value excluding outliers
Lower outlier





Groundwater Site Type

- Alluvial Groundwater
- Springs

Maximum Measured Nitrate (mg/L)

- Non-detect–1.50
- 1.51–3.00
- 3.01–6.00

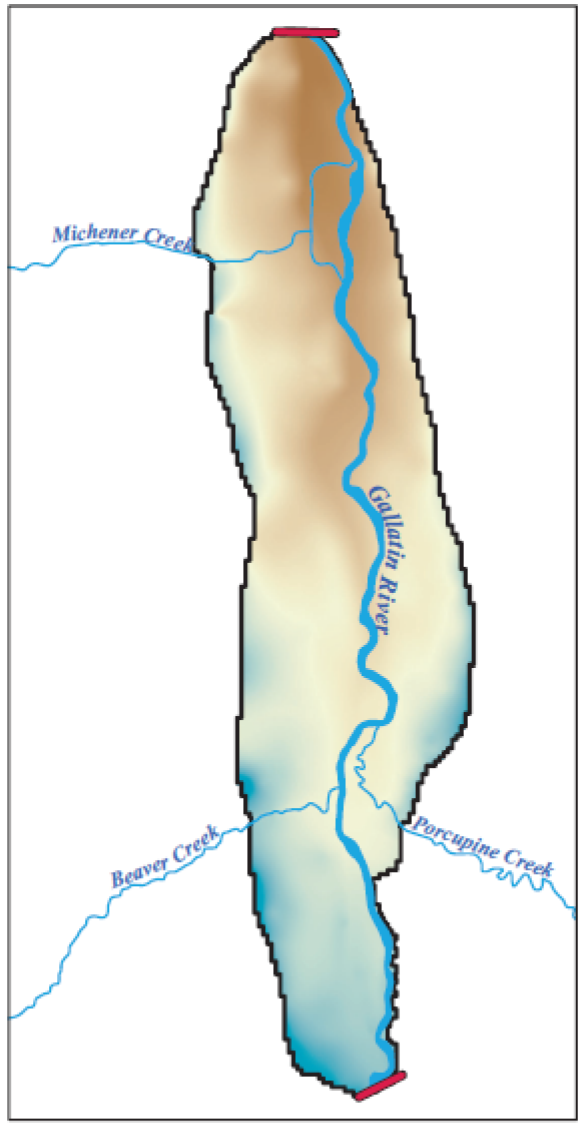
Study Area Boundary

Surface Water Site

- Surface Water

Maximum Measured Nitrate (mg/L)

- Non-detect–0.20
- 0.21–2.00



Interpolated Bedrock Surface Elevation (ft amsl)

6,175

5,950

Streams

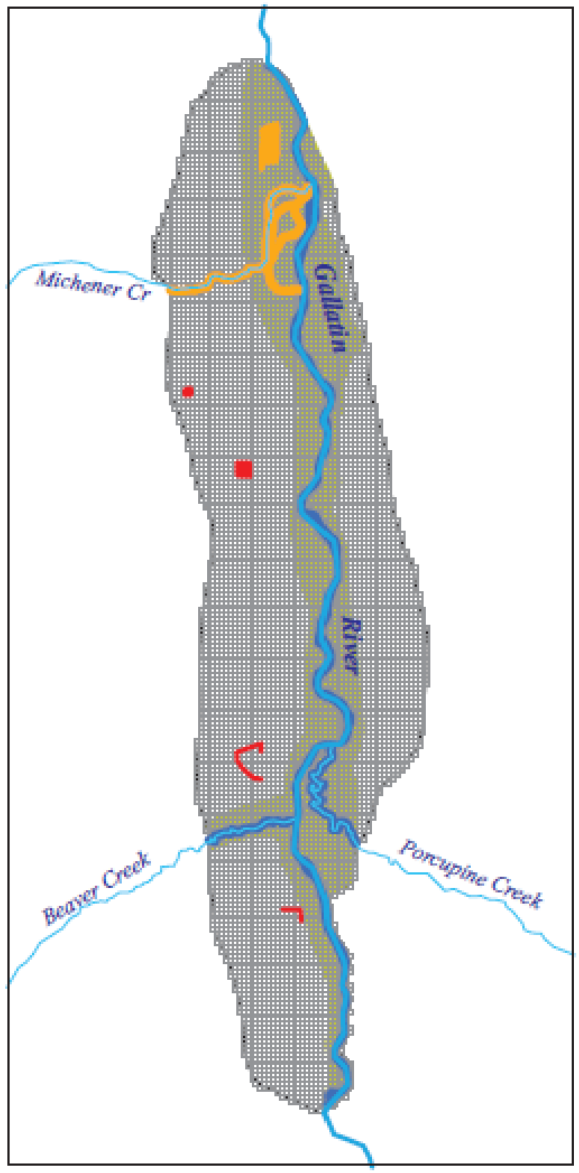
Groundwater Flow Model Domain

Cross-Section Line Locations

0 0.25 0.5 1

Miles

N



MODFLOW Model Boundary Condition Packages

Model Area (R; RCH package)

Riparian Zones (ET; ET package)

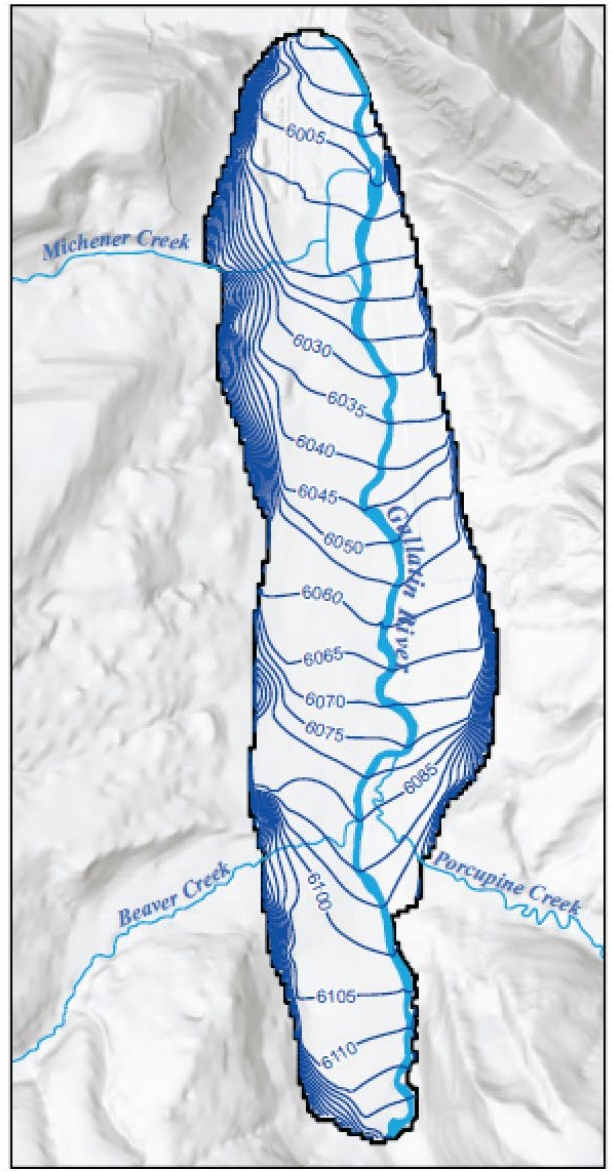
Rivers (SW_{in}/SW_{out}; RIV package)

Springs (SPR; DRN package)

Septic Discharge (Q_{se}; WEL package)

0 0.25 0.5 Miles

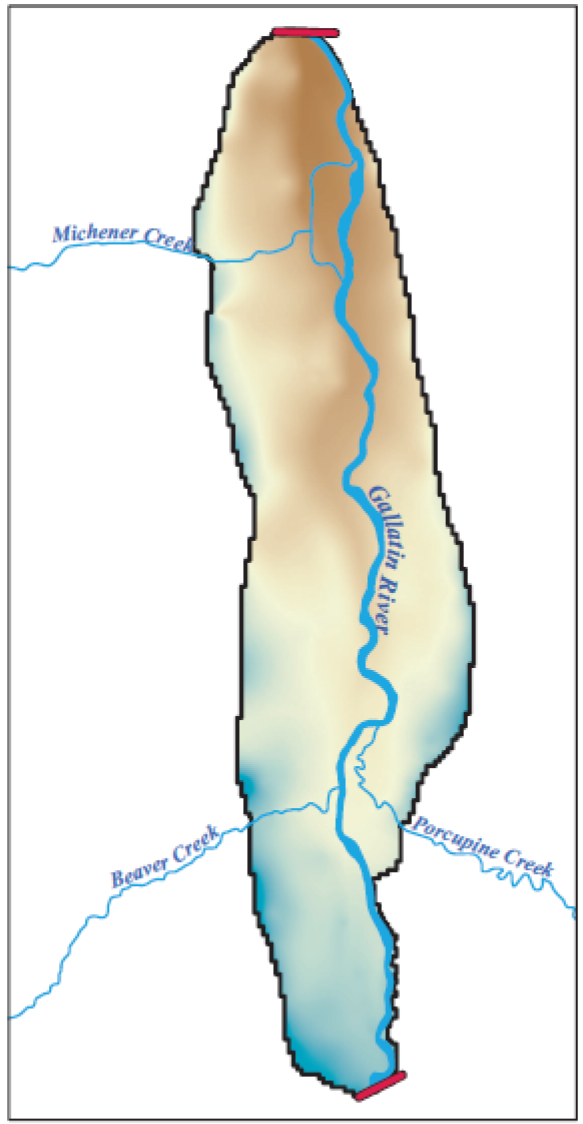
N



Simulated Groundwater-Level Contours (ft amsl)

Groundwater Flow Model Domain

Streams



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Streams

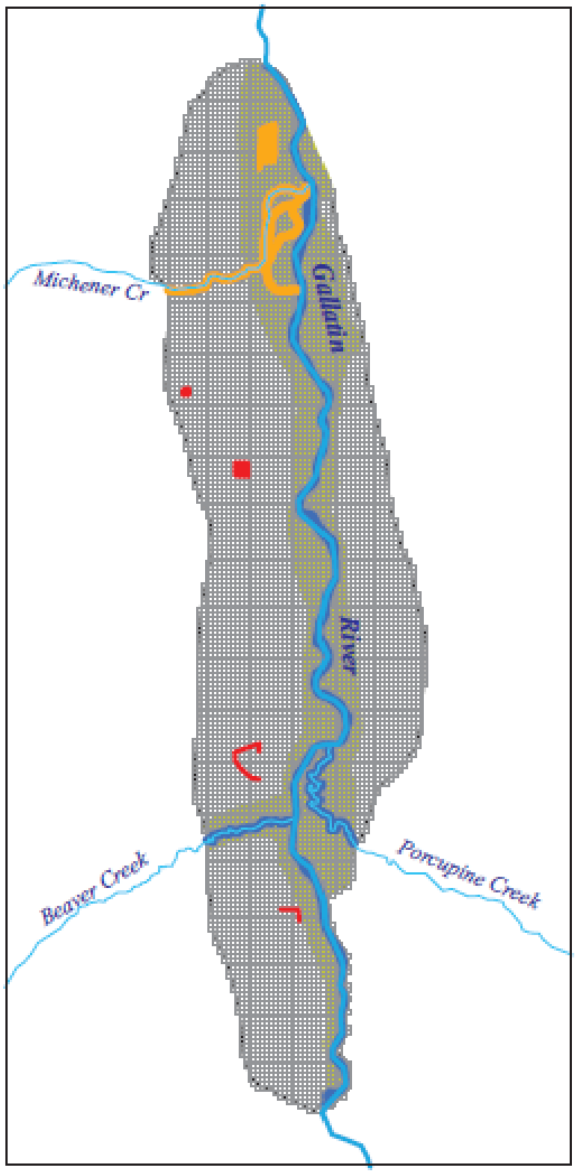
Groundwater Flow Model Domain

Cross-Section Line Locations

0 0.25 0.5 1

Miles

N



MODFLOW Model Boundary Condition Packages

Model Area (R; RCH package)

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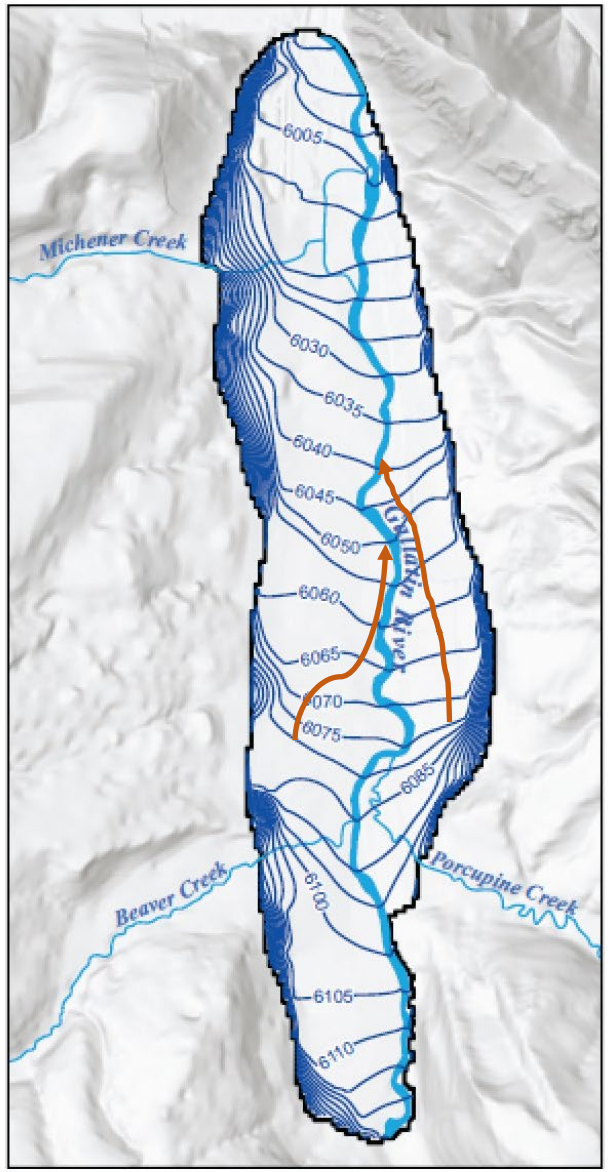
Rivers (SW_{in}/SW_{out}; RIV package)

Springs (SPR; DRN package)

Septic Discharge (Q_{se}; WEL package)

0 0.25 0.5 Miles

N

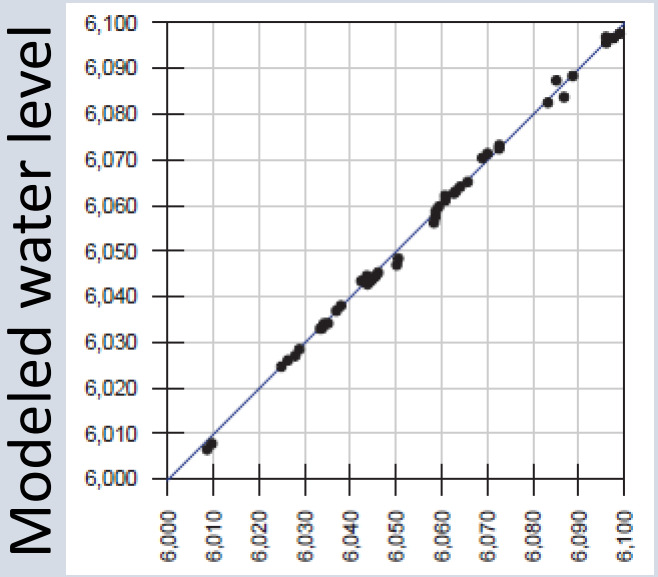


Simulated Groundwater-Level Contours (ft amsl)

Groundwater Flow Model Domain

Streams

Calibration

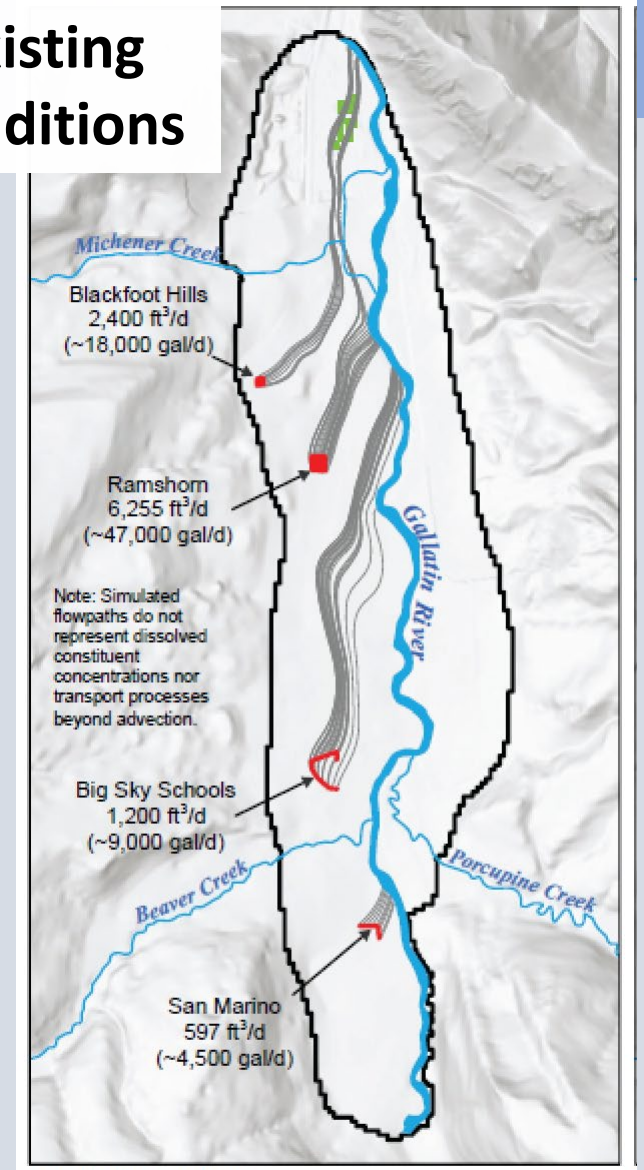


Simulated streamflow gain of 15.8 cfs vs. estimated 18.6 cfs (± 8.8 cfs)

Modeled Water Budget

Groundwater Inflow	Modeled flow (cfs)
Mountain block recharge	17.3
Valley recharge	0.0
Septic effluent	0.1
Inflow from upstream alluvium	0.1
Groundwater Outflow	**Modeled flow (cfs)**
To surface water	17.2
Pumping Wells	0.0
Evapotranspiration	0.1
Springs	0.0
Outflow to downstream alluvium	0.2

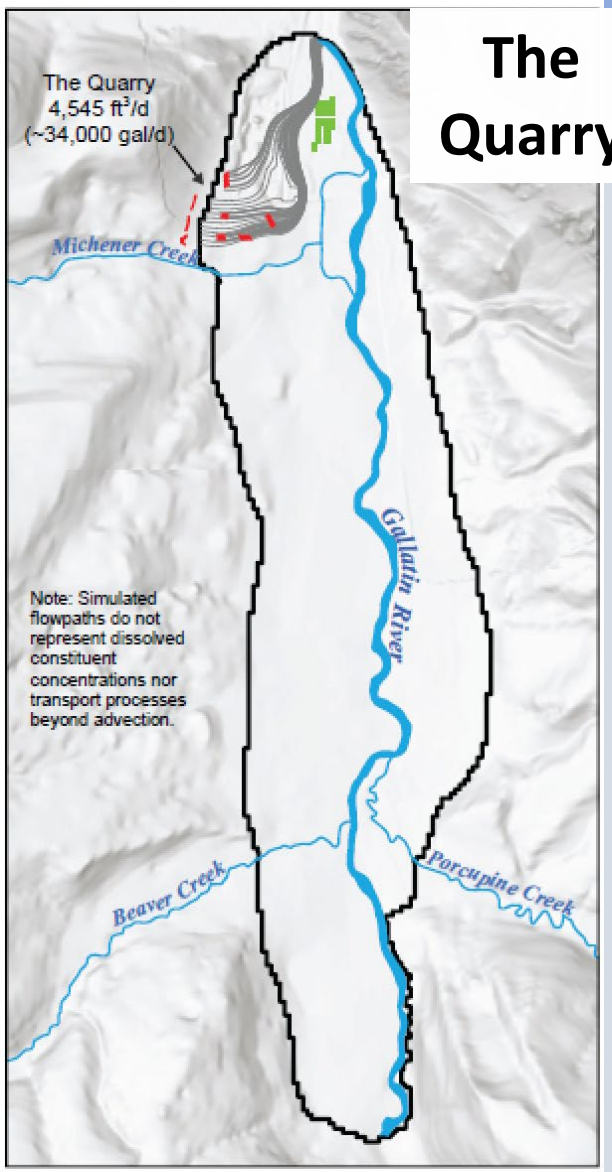
Existing Conditions



A. Low-flow conditions

Streams
Spring Ponds
Locations of Existing Community Septic Systems
Simulated Flowpaths
Groundwater Flow Model Domain

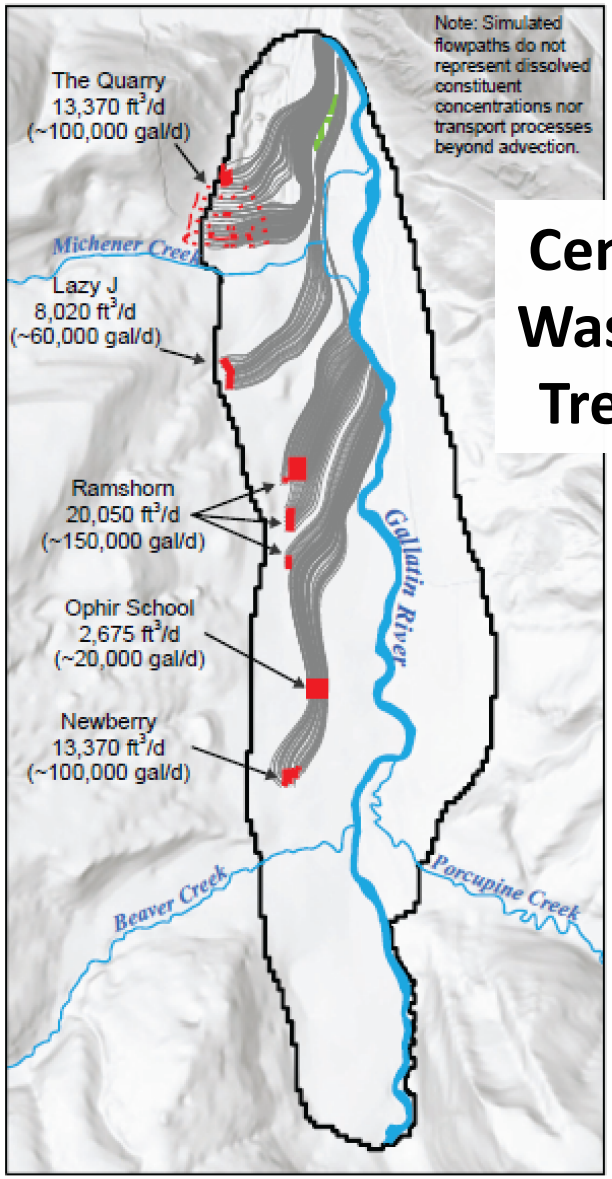
The Quarry



A. Low-flow conditions

Streams
Spring Ponds
Location of the Proposed Quarry Development Septic Effluent Discharge
Simulated Flowpaths
Groundwater Flow Model Domain

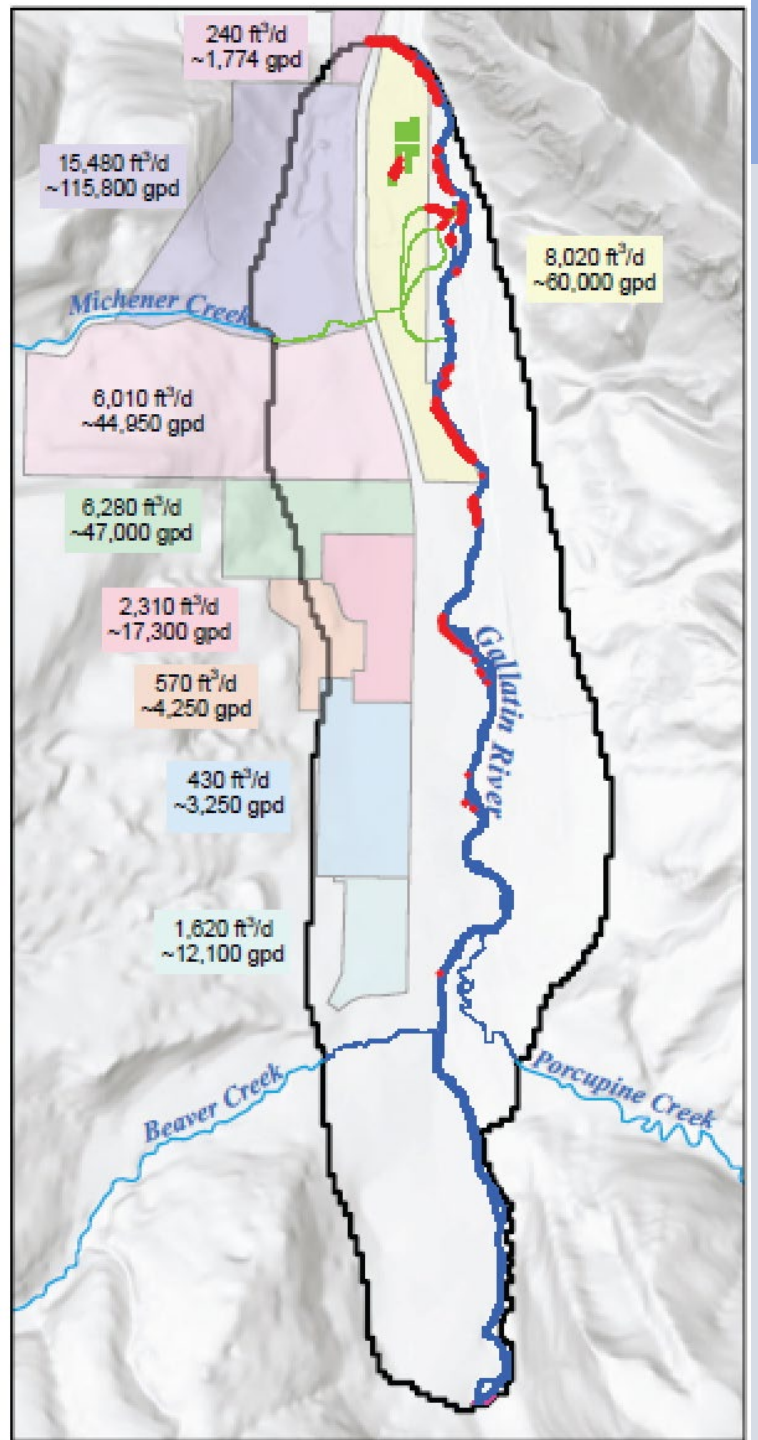
Centralized Wastewater Treatment



A. Low-flow conditions

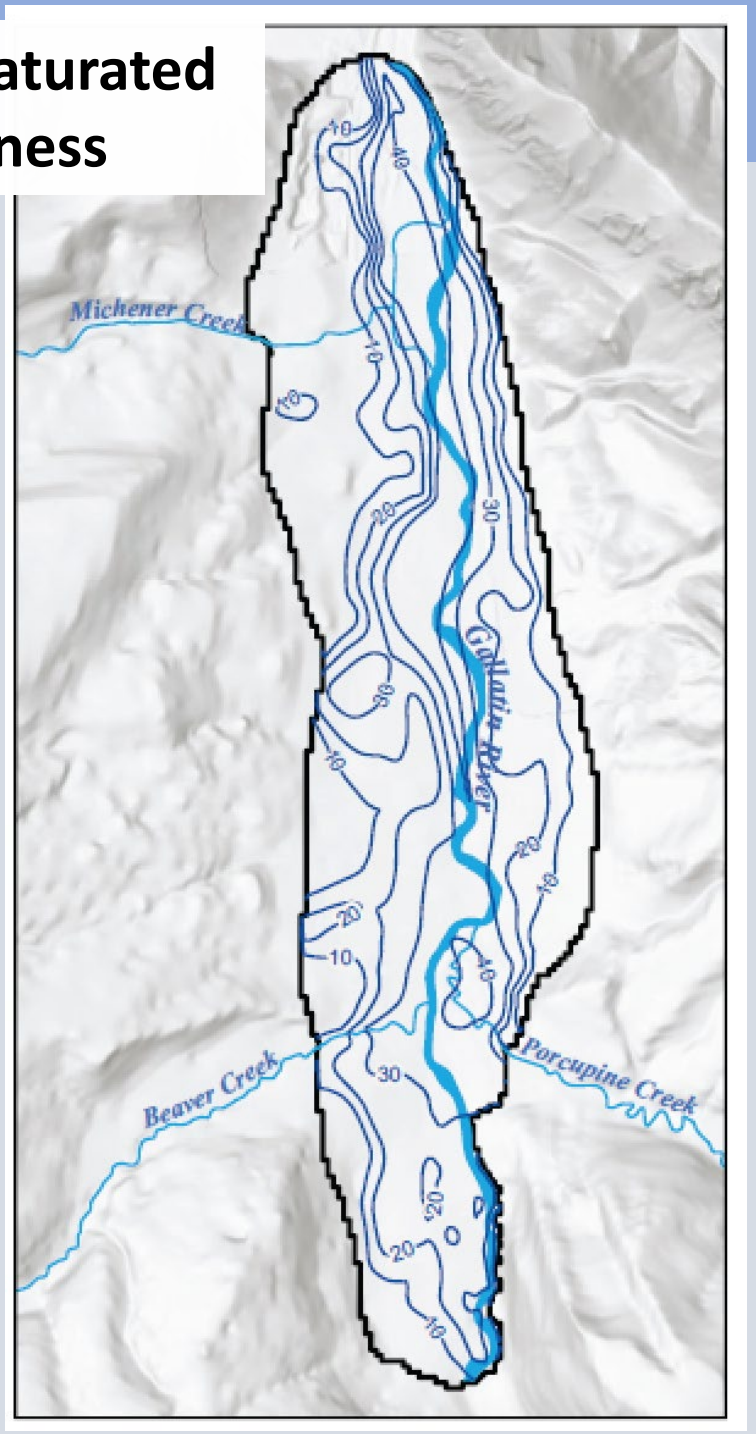
Streams
Spring Ponds
Potential Areas of Treated Water Discharge from a Centralized System
Simulated Flowpaths
Groundwater Flow Model Domain

Broad Development with On-Site Septic

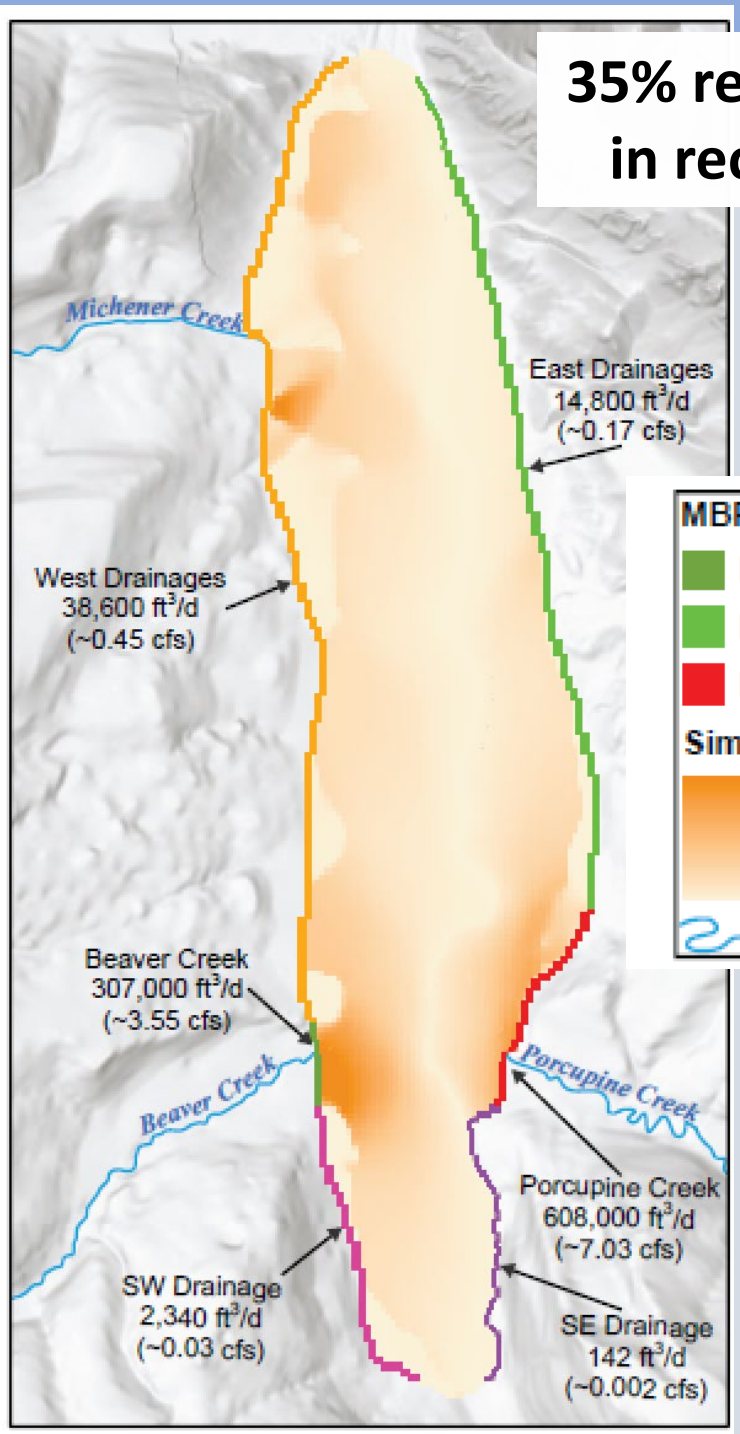


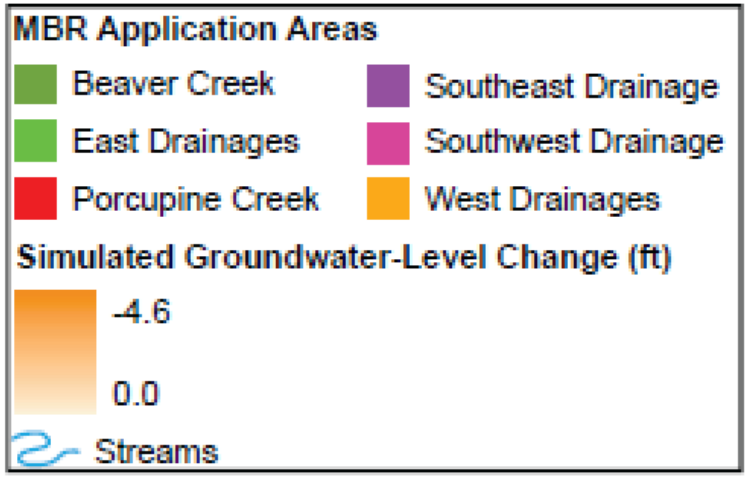
- Simulated Flow Path Discharge Locations
- Rivers and Streams (Sw_{in}/Sw_{out}; RIV Package)
- Michener Creek and Spring Ponds (SPR; DRN Package)
- Alluvial Flow (Gw_{in}/Gw_{out}; GHB Package)
- Potential Areas for Additional Septic System Installation
- Groundwater Flow Model Domain

Alluvial saturated thickness



35% reduction in recharge





Thank you!