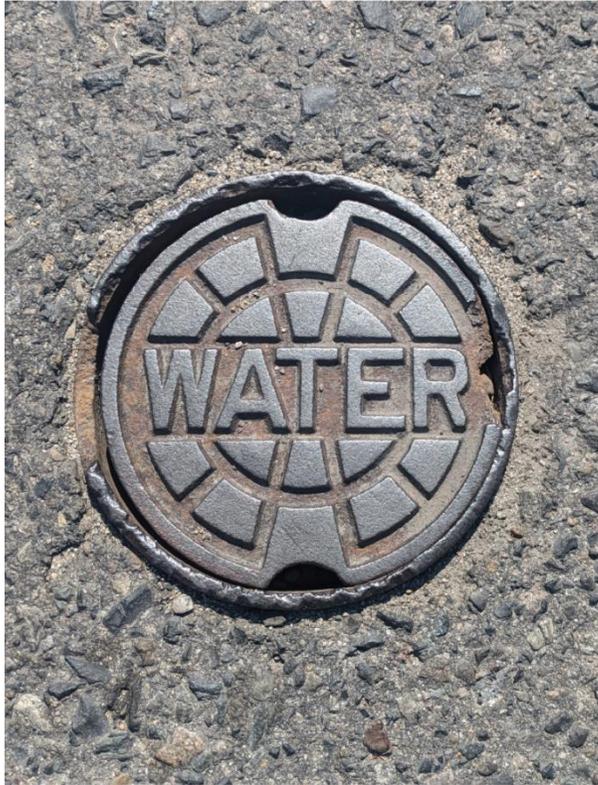


Managed Aquifer Recharge (MAR) for Montana

Montana Bureau of Mines and Geology



Ginette Abdo
WPIC, January 12, 2026

Outline

- Background
 - Managed Aquifer Recharge (MAR)
 - Methods
- MAR Suitability
 - State-wide surface infiltration suitability map
 - Aquifer Storage and Recovery (ASR)
 - Flathead Valley
 - Big Hole River, Wisdom area
- Moving forward...

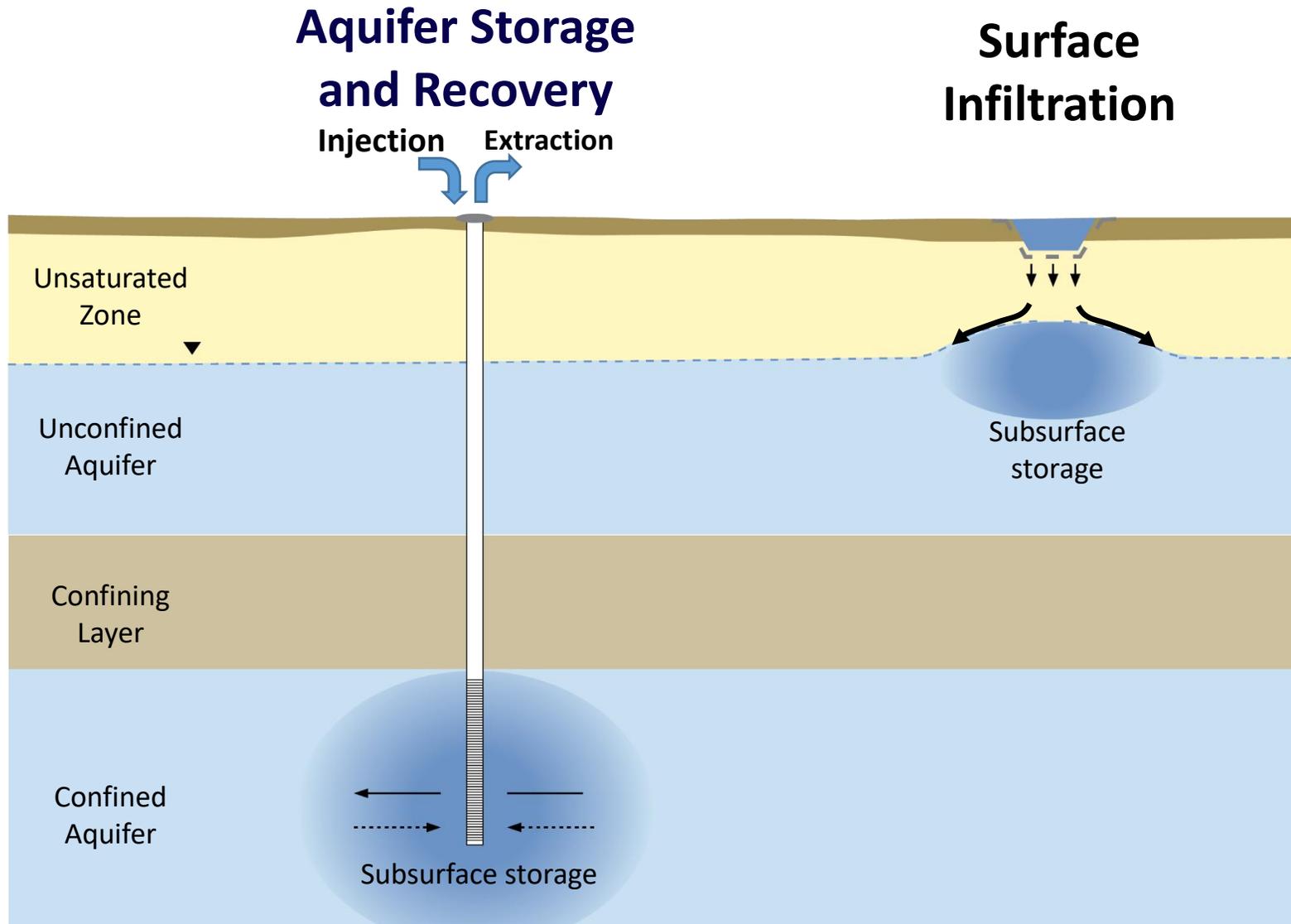


Managed Aquifer Recharge

- supplements water supplies by intentionally recharging aquifers;
- method to “**slow water down**” or store water
- intent of recovering water during times of need

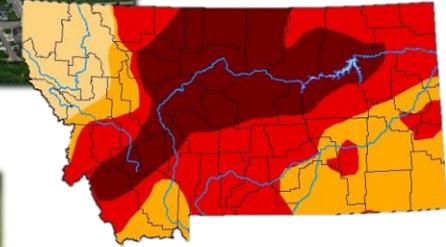
- **Surface infiltration**
Unconfined aquifers

- **Aquifer Storage and Recovery**
Semi-confined/confined aquifers



MAR Benefits

- ✓ Improved water supply reliability for communities and agriculture
- ✓ Aquifer replenishment due to drought and land use changes
- ✓ Ecosystem enhancement
- ✓ Improved water quality
- ✓ Flood risk reduction



Considering MAR

What is necessary to make MAR possible?

Purpose/Scope:

- How much water is needed?
- What is it needed for?
- What time of year is it needed?

Hydrogeology:

- Physical properties



Physical properties

- Type of aquifer
- Transmissivity
- Available Storage
- Soil permeability
- Topography

Location:

- Distance to Source Water
- Land Ownership

Other:

- Water Quality of Source and Aquifer
- Engineering Considerations
- Environmental issues
- Cost/Upkeep
- Regulatory requirements



Suitability Mapping

State-Wide Surface Infiltration Suitability

Purpose and Scope

- Basin-fill and alluvial surficial aquifers
- Hydrogeologic properties
- Publicly available information
- **First-level screening tool**



Hanson, A.E.H., Bobst, A.L., Abdo, G., LaFave, J.I., and Sutherland, M., 2024, Managed Aquifer Recharge (MAR): An initial hydrogeologic screening for surface infiltration suitability in Montana: Montana Bureau of Mines and Geology Report of Investigation 37, 26 p., 1 sheet.



Methods

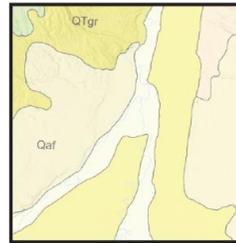
Multi-Criteria Decision Analysis (MCDA)

A method of evaluating and combining geospatial data

Four Criteria were chosen:

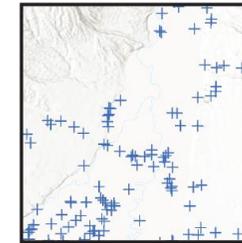
1. Geologic/Aquifer Properties
2. Depth to Groundwater
3. Soil Permeability
4. Topographic Slope

Statewide Geology
MBMG 1:500K



Source data

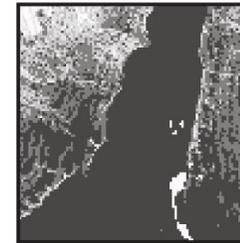
GWIC
Groundwater
Levels



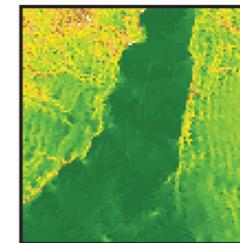
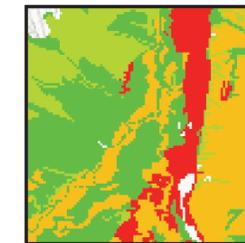
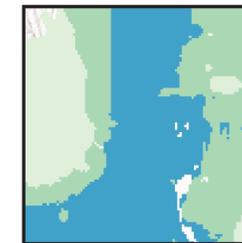
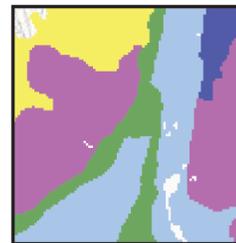
USDA Soil Survey
Geographic Data (K_{sat})



USGS 10-meter DEM



Create/
rasterize
data



Classify/
Rate

Geologic / Aquifer Properties	Rating
Qgl, Qlk, Qtr, Tk, Ttr	1
Tar, TKw	5
TKb, Tsm	25
Qgt, QTs, Tw, Ts, Tsu	50
Qaf	75
Qal, Qgr, QTgr, Tgr	100

Depth to Groundwater (ft bgs)	Rating
0-20	1
20-50	50
>50	100

Soil Permeability (ft/day)	Rating
0-2	25
2-5	50
5-10	75
>10	100

Topographic Slope (degrees)	Rating
>20	1
10-20	25
5-10	50
2-5	75
0-2	100

Weight and Combine



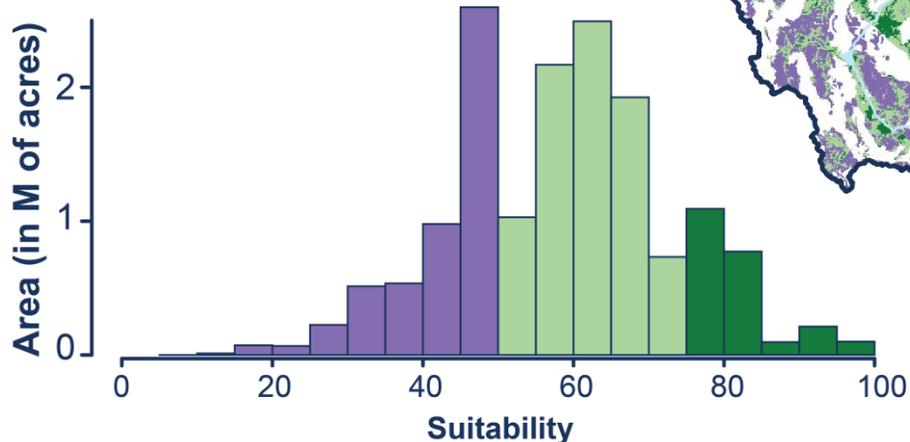
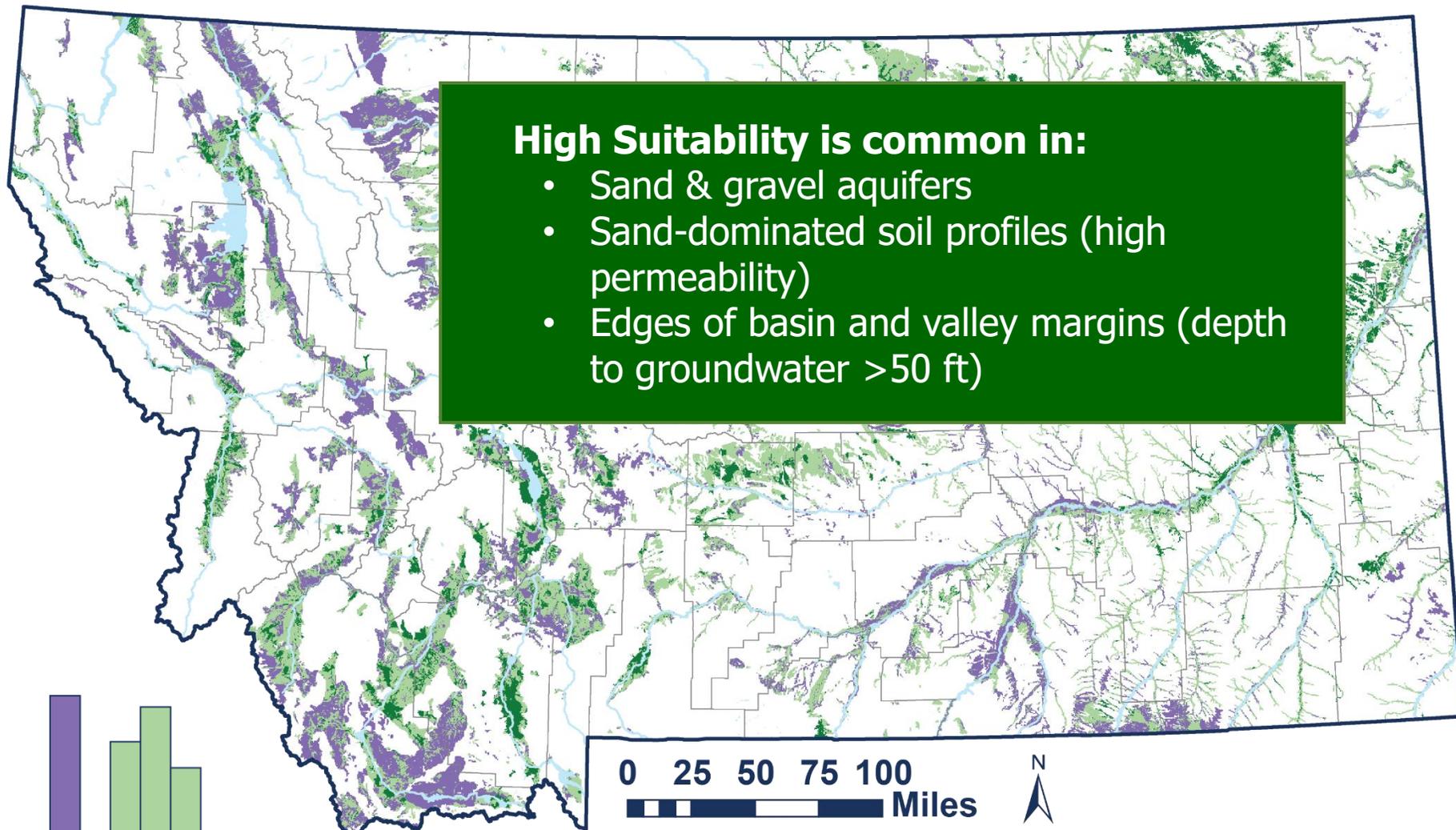
Results

16.5% of the state analyzed

15% High
(2.3 million acres)

53% Medium
(8.3 million acres)

32% Low
(5.0 million acres)



Suitability

High (>75 and ≤100)

Medium (>50 and ≤75)

Low (≤50)



Publication and Web App



Geologic / Aquifer Properties

Montana's Managed Aquifer Recharge (MAR) Surface Infiltration Suitability

Summary Analysis Explore

Purpose & Scope MT Aquifers & MAR Analysis Steps Criteria Combining Criteria Suitability Map Results

Geologic Unit

- Quaternary alluvium (Qal)
- Quaternary gravel (Qgr)
- Quaternary alluvial fan deposits (Qaf)
- Quaternary lacustrine deposits (Qlk)
- Quaternary glacial lake deposits (Qgl)
- Quaternary glacial deposits (Qgt)
- Quaternary travertine (Qtr)
- Quaternary-Tertiary sediments and basin-fill (QTs)
- Quaternary-Tertiary gravel (QTgr)
- Tertiary gravel (Tgr)
- Tertiary sediment of...

Montana's 1:500K Geology Map was used to rate the geologic/aquifer properties for surface infiltration. Geologic units that are coarser grained generally enable water to flow quicker through them and were rated higher for surface infiltration.

Explore the map by zooming in, dragging the swiper, and clicking on the colors to see the geologic unit and the rating it received.

October 2024 Montana Bureau of Mines and Geology Report of Investigation 37

Managed Aquifer Recharge (MAR):
An Initial Hydrogeologic Screening for Surface Infiltration Suitability in Montana

Ann E.H. Hanson, Andrew L. Bobst, Ginae A. Abdo, John I. LaFave, and Mary Sutherland
Montana Bureau of Mines and Geology

MBMG
MONTANA BUREAU OF MINES AND GEOLOGY

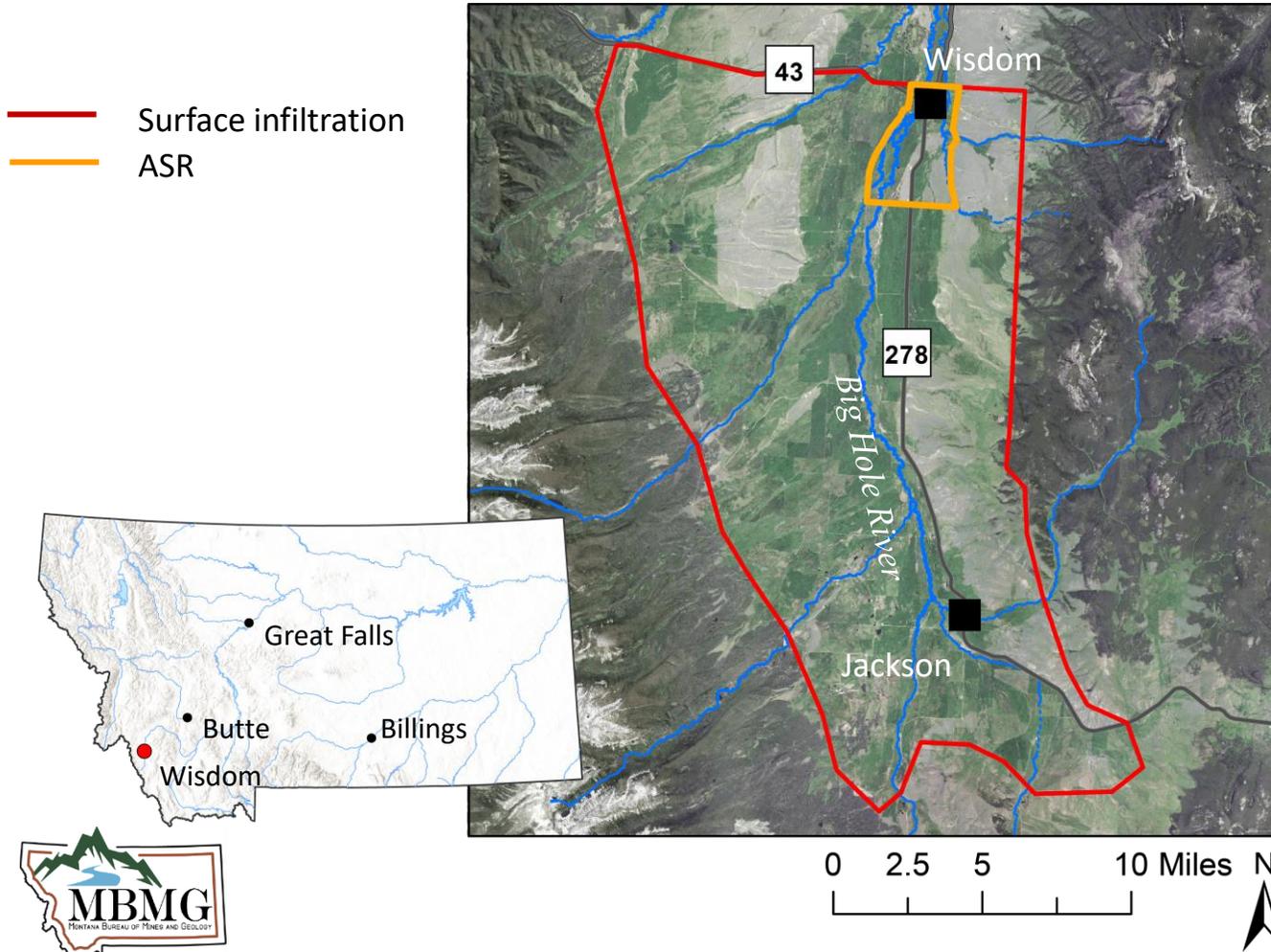
MBMG Report of Investigation 37, Plate 1
Managed Aquifer Recharge (MAR)
Surface Infiltration Suitability

Ann E.H. Hanson, Andrew L. Bobst, Ginae A. Abdo, John I. LaFave, Mary Sutherland
2024



Big Hole River

Enhancing River Flow: a suitability analysis



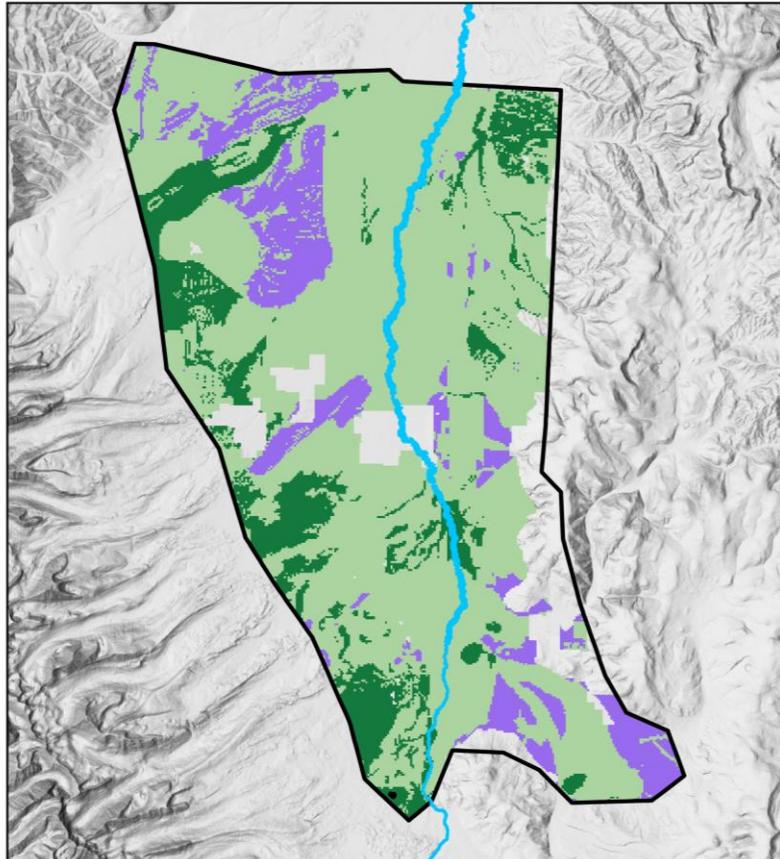
Is MAR is a viable option for mitigating low flow conditions that threaten fisheries, agriculture, and the recreational industry?

Capture high spring flows when water is available to recharge groundwater and subsequently augment low summer season flows.

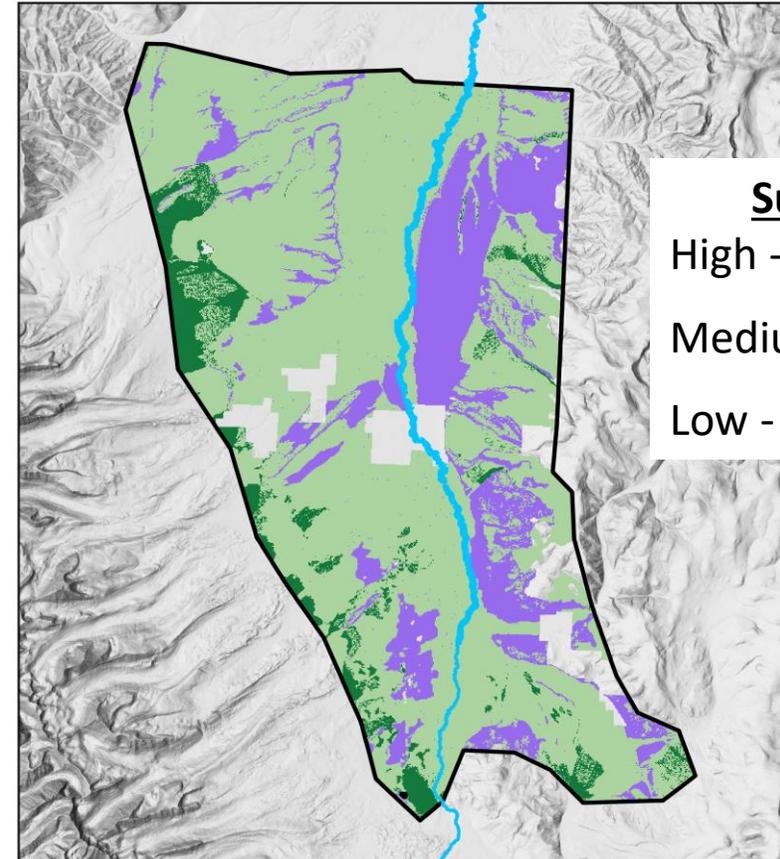
Proposed by the Big Hole Watershed Committee

Surface infiltration

State-Wide Analysis



Focus Analysis



Suitability change
High - Decreased 8%
Medium - Stayed the same
Low - Increased 8%

Suitability
High (>75 and ≤100) Medium (>50 and ≤75) Low (≤50)

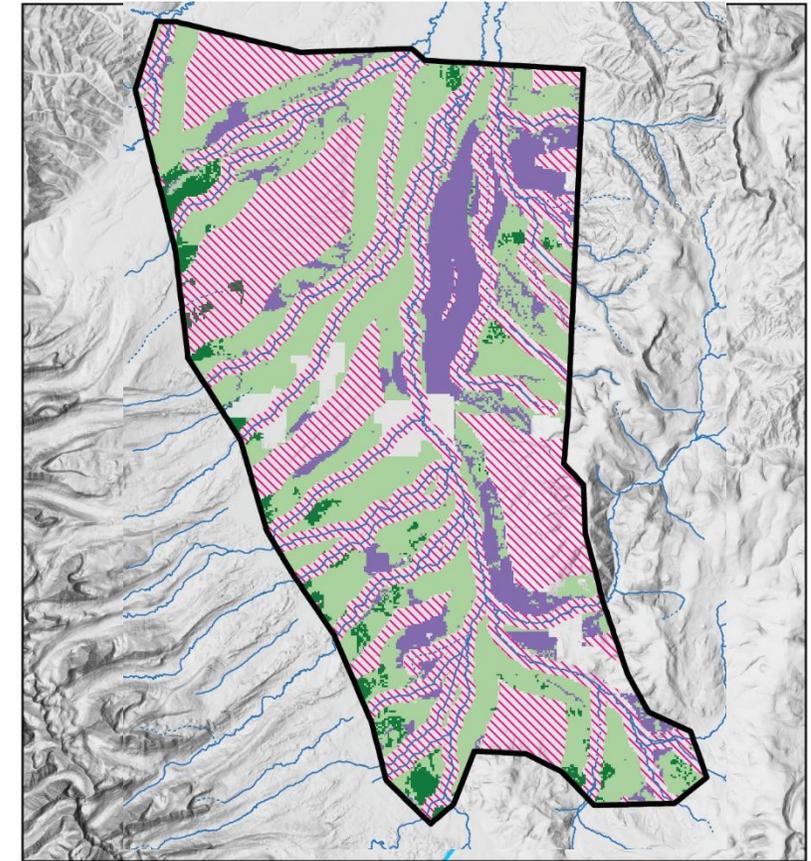
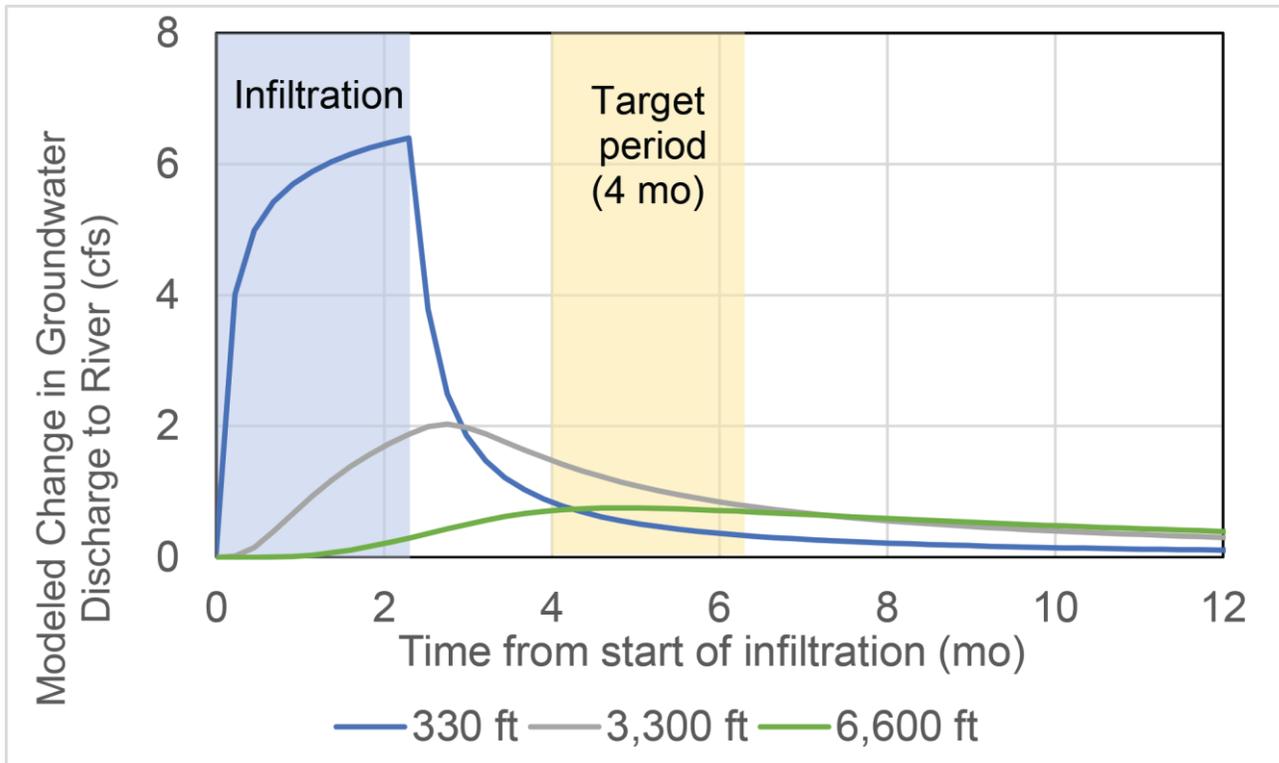
0 2.5 5 10 Miles



*Provisional
information not for
distribution*



Timing of recharge



Suitability

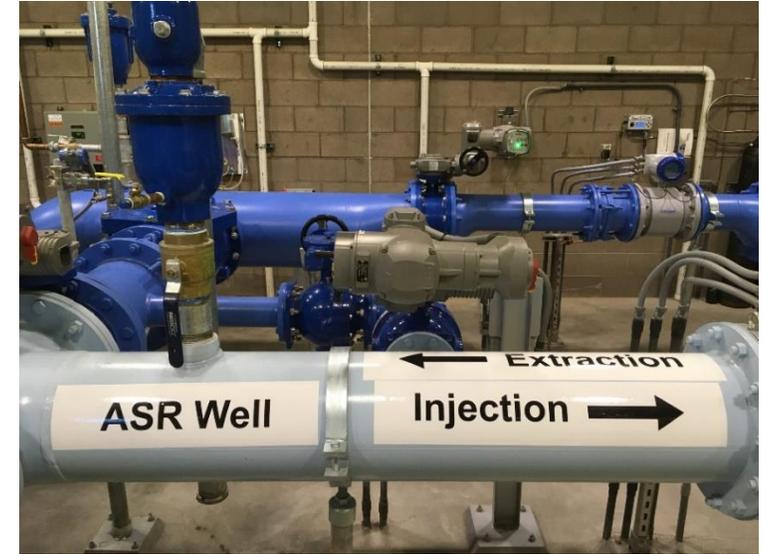
- High (>75 and ≤100)
- Medium (>50 and ≤75)
- Low (≤50)
- Precluded based on distance from surface water

Provisional information not for distribution

Aquifer Storage and Recovery

Flathead Valley

- Several hydrogeologic studies
- Understanding of the stratigraphy
- Target aquifer '**Deep Aquifer**'
 - ✓ Thick, confined to semi-confined
 - ✓ Primary water source
 - ✓ Can produce over 1,000 gpm



Aquifer Storage and Recovery - Summit Water Resources (summitwr.com)

Approach

- Hydrogeologic Properties
- Publicly Available Information
- First-Level Screening Tool

Methods

Multi-Criteria Decision Analysis (MCDA) – method of evaluating and combining geospatial data

Three Criteria:

1. Rechargeability

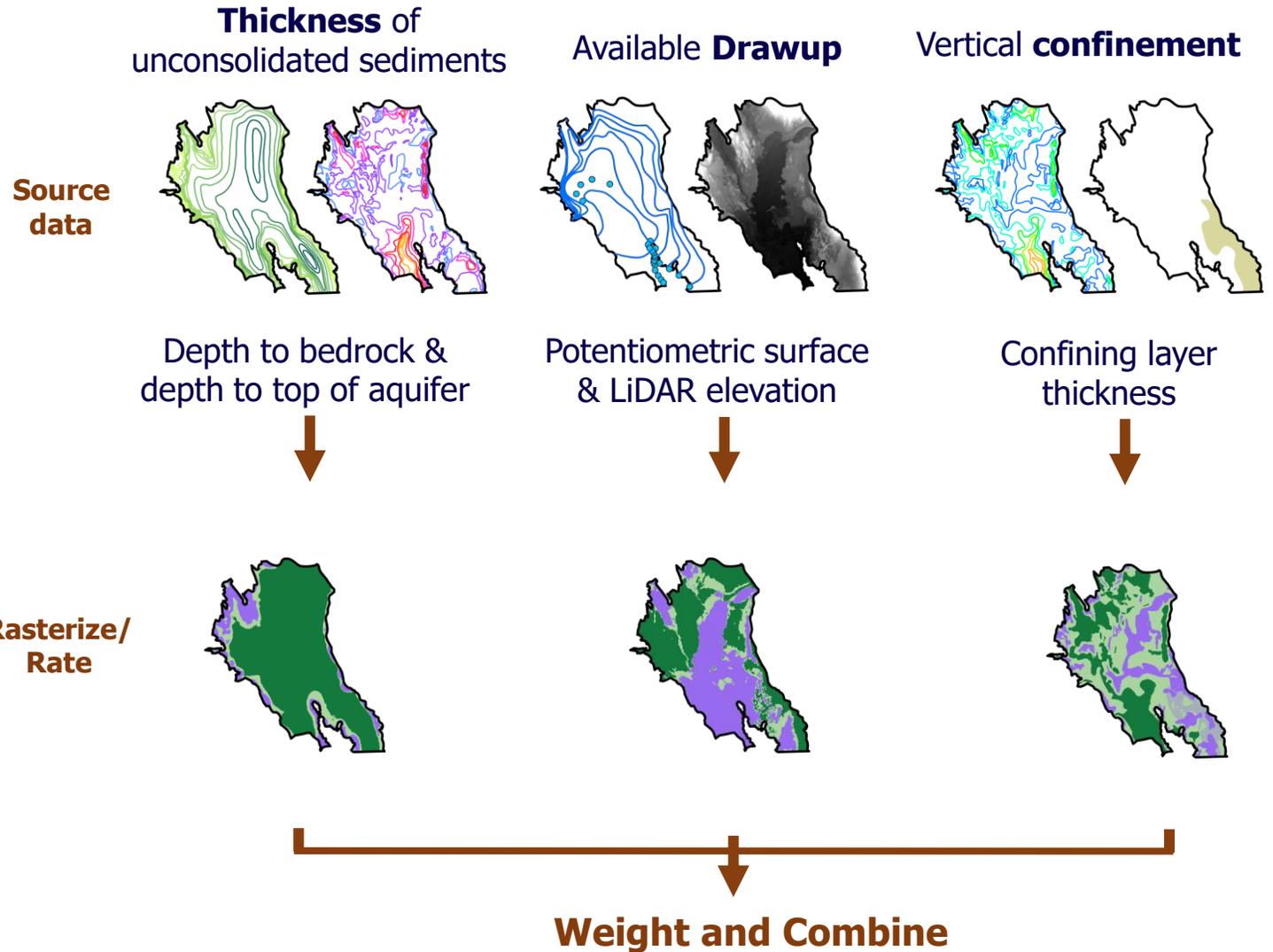
Thickness of sediments below the confining layer

2. Available Storage

Drawup

3. Recoverability

Vertical confinement



ASR Suitability

Deep Aquifer

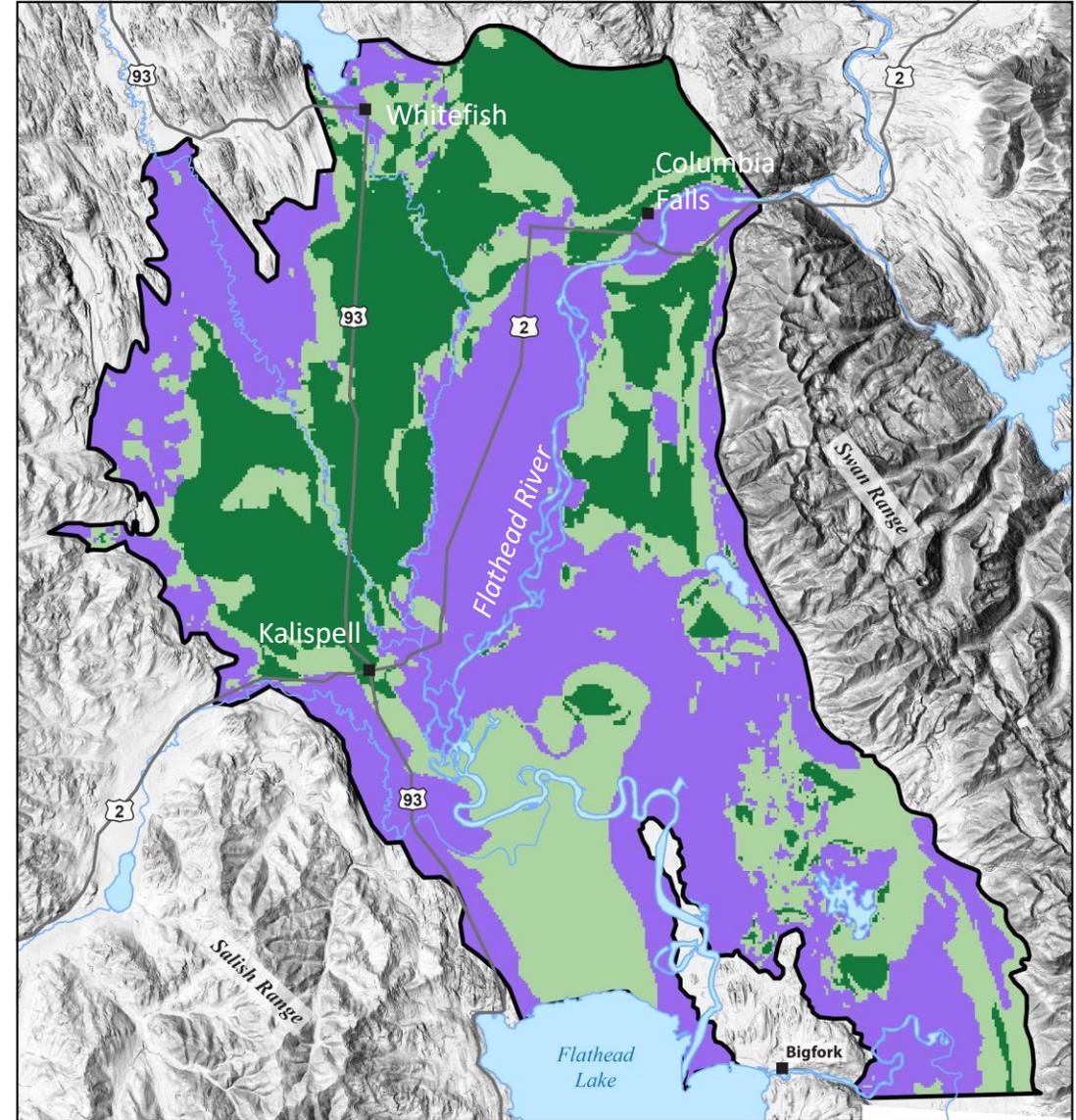
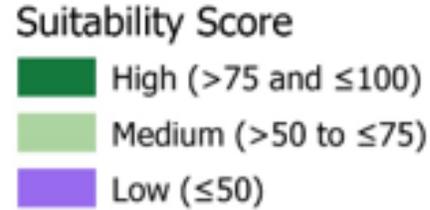
222,000 acres analyzed

26% High
(~59,000 acres)

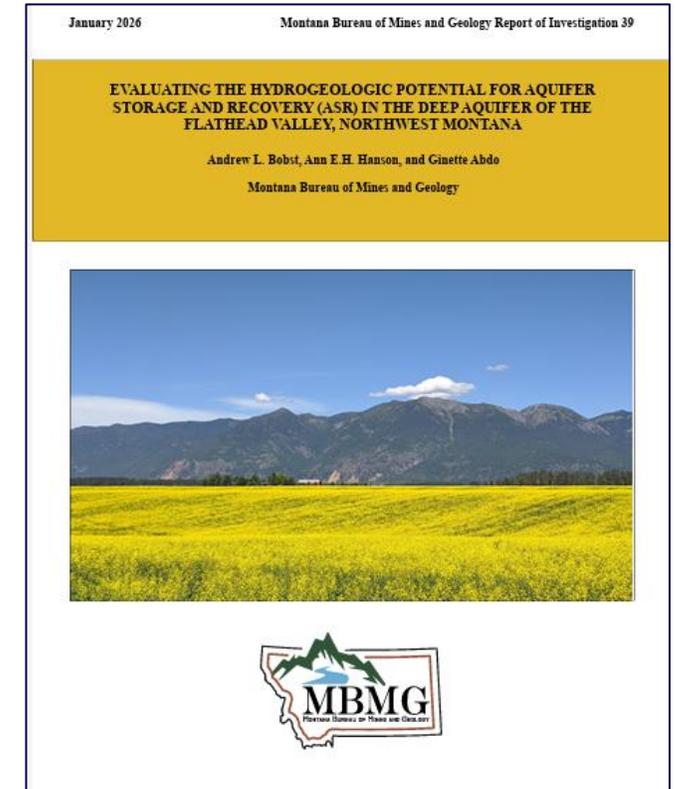
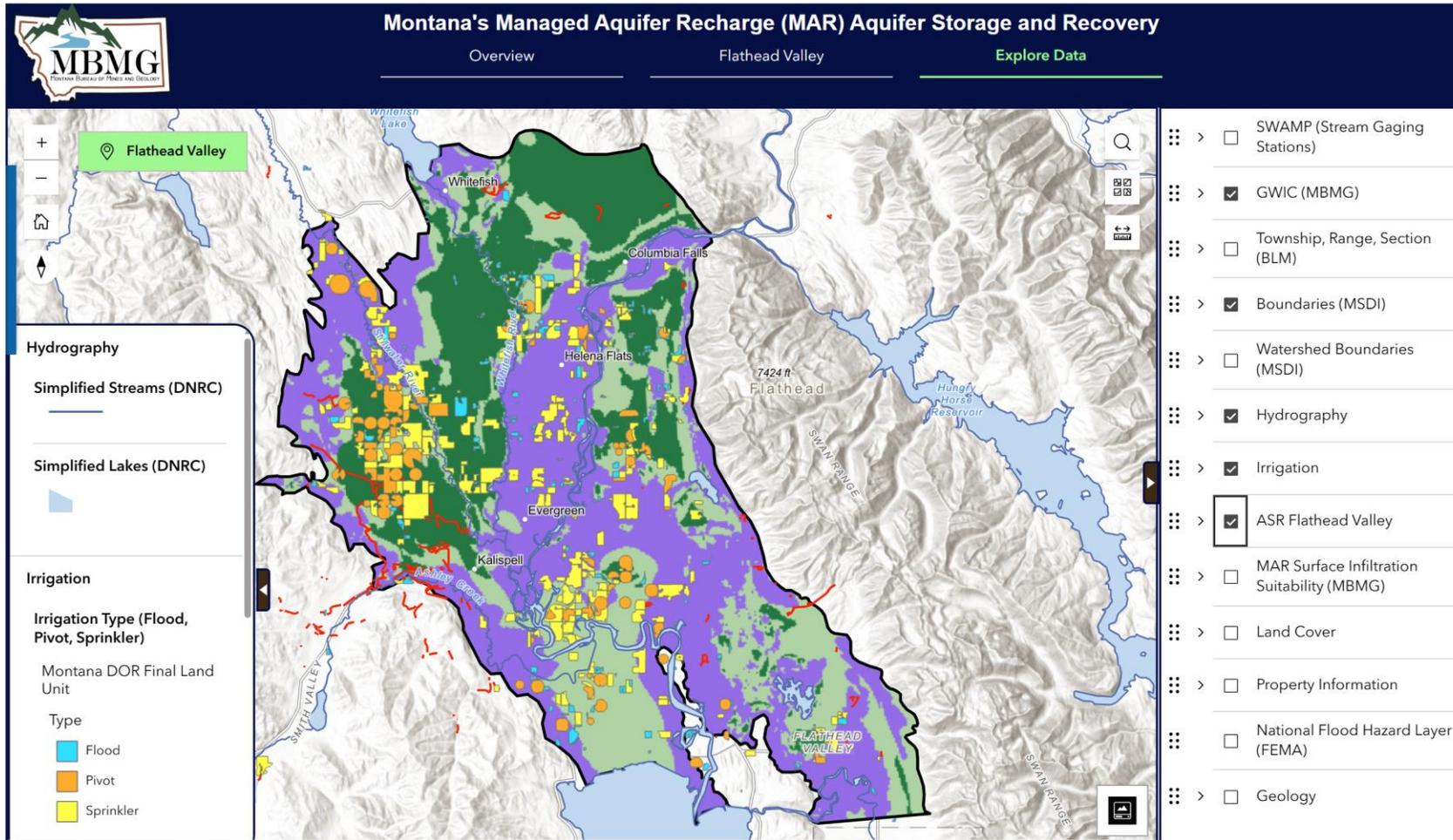
28% Medium
(~63,000 acres)

45% Low
(~100,000 acres)

- Thick aquifer
- Greater storage
- Moderate to thick confining layer



Publication and Web App

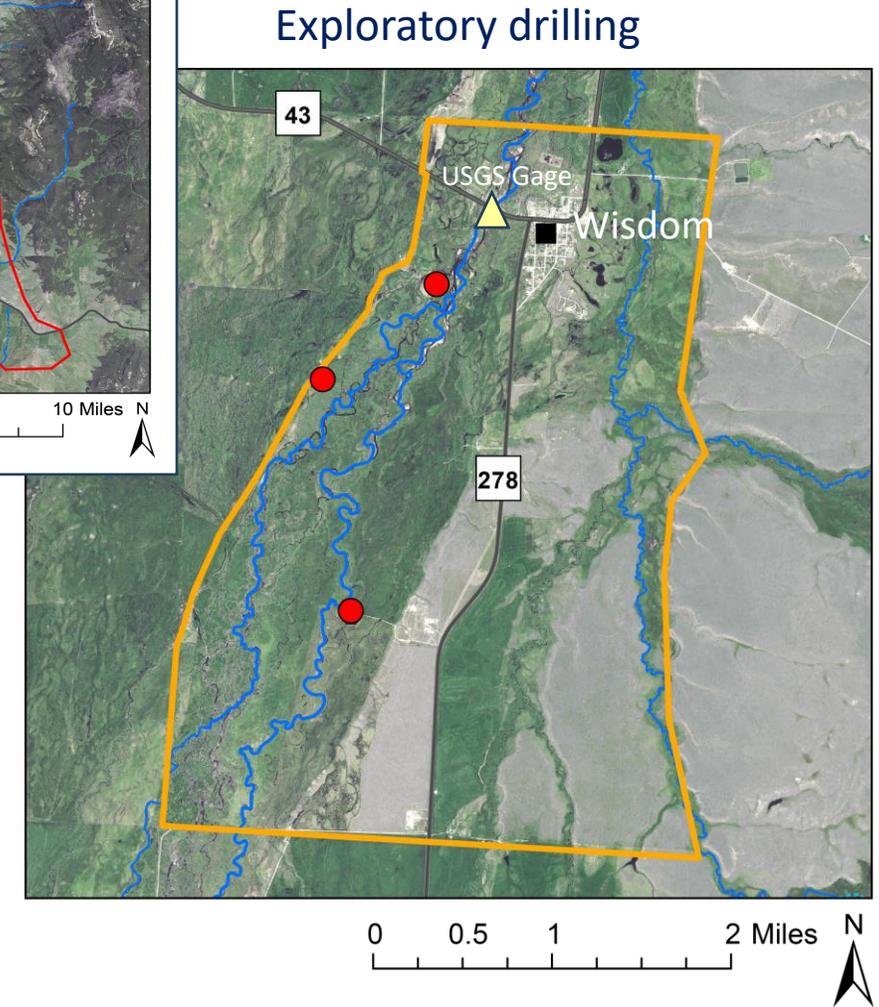
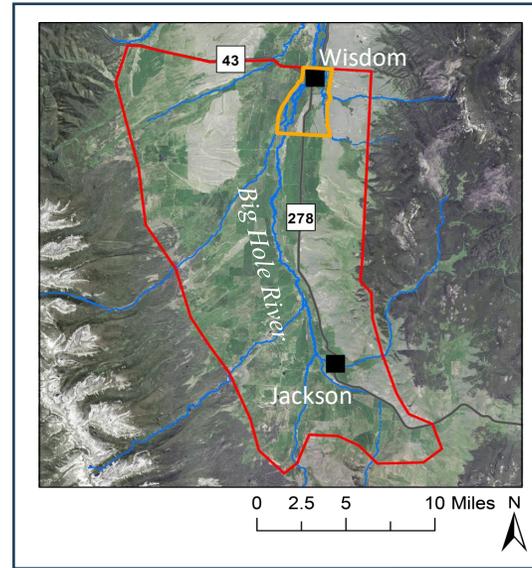


[Managed Aquifer Recharge \(MAR\) Aquifer Storage and Recovery Suitability | GIS Data Hub Site](#)



Big Hole River ASR

- Willing landowner
- Above the Wisdom USGS stream gage
- Approximately 12 miles downstream until the next headgate



Proposed by the Big Hole Watershed Committee

Moving Forward

First-level screening tool

- ✓ Do your homework

ASR Potential

- ✓ Publish results for the Flathead Valley
- ✓ Gallatin Valley
- ✓ Wisdom area

Focused area suitability

- ✓ Detailed GIS evaluations, select areas

Questions???

