



Groundwater Mapping in Lincoln and Sanders Counties; Study
Area Introduction, Publications, and the Role that Long-Term
Data Sets Play in Answering Local Concerns

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Talk Topics

Introduce you to:

- *MBMG and the Groundwater Assessment Program*
- *The Lincoln and Sanders Counties Study Area and Our Work*
- *First Publications Out and finally*
- *Discuss a local land-owner concern that involves precipitation history and groundwater fluctuation*



Horseshoe Lake, Chain of Lakes, Lincoln County

Montana Bureau of Mines and Geology

A department of Montana Tech

- Established in 1919 to provide reliable and unbiased earth science information
- Non-regulatory, applied research
 - Geologic Mapping
 - Geohazards/Earthquake studies
 - Economic Geology
 - Environmental Assessment
 - Data Preservation
 - Groundwater
- **All data we collect is available to the public**



<http://www.mbmgs.mtech.edu/>



Sara Edinberg, Froid Montana

MBMG Ground Water Assessment Program

“...systematically assess and monitor the state’s ground water and to disseminate the information...”

85-2-902(2) MCA

Mandate accomplished in 3 parts

- Groundwater Information Center
- Long-Term Groundwater Monitoring
- County-Scale Groundwater Mapping



Disseminating Information

Ground Water Information Center (GWIC)

- ...houses all MBMG groundwater data

The screenshot shows the GWIC website interface. At the top, there is a navigation bar with the MBMG logo on the left and the Montana Department of Natural Resources and Conservation logo on the right. The date 9/29/2025 is displayed in the top right corner. Below the navigation bar, the main heading is "Ground Water Information Center Applications".

The page is divided into several sections:

- Web Mapping Application:** This section includes a text description: "Click the image to use the MBMG's new online [web mapping application](#). Currently displayed are statewide monitoring network wells, GWIC wells, and 1:500K geologic maps." It features a map of Montana with numerous blue dots representing monitoring wells.
- Sign In Status:** A dark grey bar indicates "Sign In Status: Signed Out".
- Sign In Form:** Below the status bar, there is a form for signing in. It includes the text: "Enter your User Id and Proposed Data Use. Click **Sign In** to access GWIC's online services." Below this, there is a link: "If you do not have a User Id, click [create one here](#)." The form has two input fields: "User Id:" and "Data Use:" (with a dropdown menu currently set to "Pick One"). A blue "Sign In" button is positioned below the "Data Use" field.
- Statewide Monitoring Network:** This section contains text: "GWIC features current hydrographs for wells that are being measured regularly by the MBMG and our cooperators. [View data collected by the Statewide Monitoring Program](#). Data from other MBMG projects are available through the **SWL Menu** after you sign in." It includes a line graph titled "Daily Average Water Level (2000-02-214315)" showing water level fluctuations over time. Below the graph, there is a link: "[View a list](#) of statewide monitoring network wells. The listing is by number of wells per county."
- Groundwater Monitoring around Energy Development:** This section contains text: "To address requests from citizens concerned with increased development and new development practices, the MBMG collaborated with the Montana Department of Natural Resources and Conservation (DNRC) and the Montana Department of Environmental Quality (DEQ) to [characterize groundwater quality near current oil and gas development](#). Analyses included a wide range of organic constituents, isotopes of carbon and hydrogen of methane, and the standard inorganic analysis. GWIC also houses the results of sampling by the Montana Salinity Control Association (MSCA), who worked with the DNRC to collect domestic-well samples from concerned landowners." It features an image of an oil pumpjack against a sunset sky.
- County-Wide Statistics:** This section includes text: "View statistical overviews of the well data in individual counties. Select the county name from the dropdown box to the right and click the **Go!** button." It features a dropdown menu currently set to "BEAVERHEAD" and a blue "Go!" button.
- Coalbed Methane Groundwater Monitoring Network:** This section contains text: "The MBMG operates the Montana Powder River Regional Coalbed Methane Groundwater Monitoring Network of springs and wells. Data for this program plus site-specific research such as coalbed methane infiltration pond studies can be viewed online or downloaded from GWIC. [Access the MBMG coalbed methane data](#)." It features an image of a monitoring well with blue plastic lining.

MBMG GIS Data Hub: Water Resources

GIS Data Hub

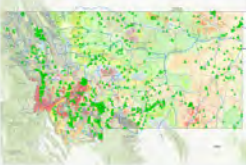
Home | Geology | Geohazards | Water Resources | Environmental | Energy Resources | Mineral Resources

Water Resources

This site presents maps and apps of water resources made by the GIS team at the MBMG. For more information about the MBMG's water programs, please go to the [MBMG website](#).

Ground Water Monitoring Map


The Ground Water Information Center (GWIC) database is the repository for the State's ground water information. It stores all the MBMG ground water data from past to current projects. The map below displays locations of the GWIC wells as well as statewide monitoring network wells (GWAMMON wells).



Groundwater Monitoring
Locations of GWIC wells and GWAAMON wells used by the MBMG to monitor ground water conditions. Data come from the Groundwater Information Center (GWIC) databases...

Surface Water Monitoring Map


This map displays locations of water gaging stations monitored and maintained by the MBMG and other agencies.



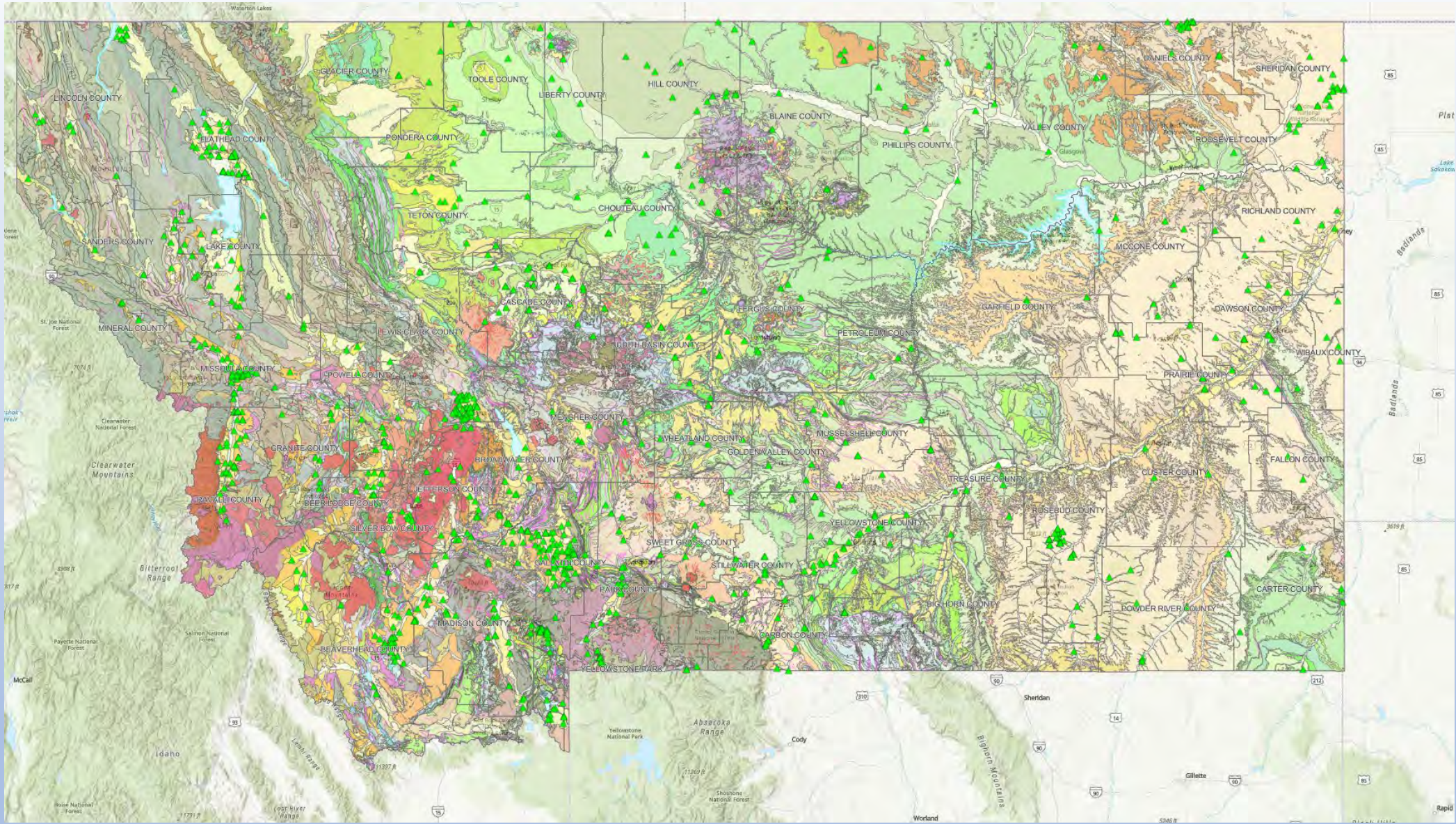
Surface Water Monitoring
Locations of water gage stations managed by the MBMG and other agencies.

Principal Aquifers Map

This is a map showing principal aquifers in Montana, which are geologic units or grouping of geologic units that have similar water-bearing characteristics.

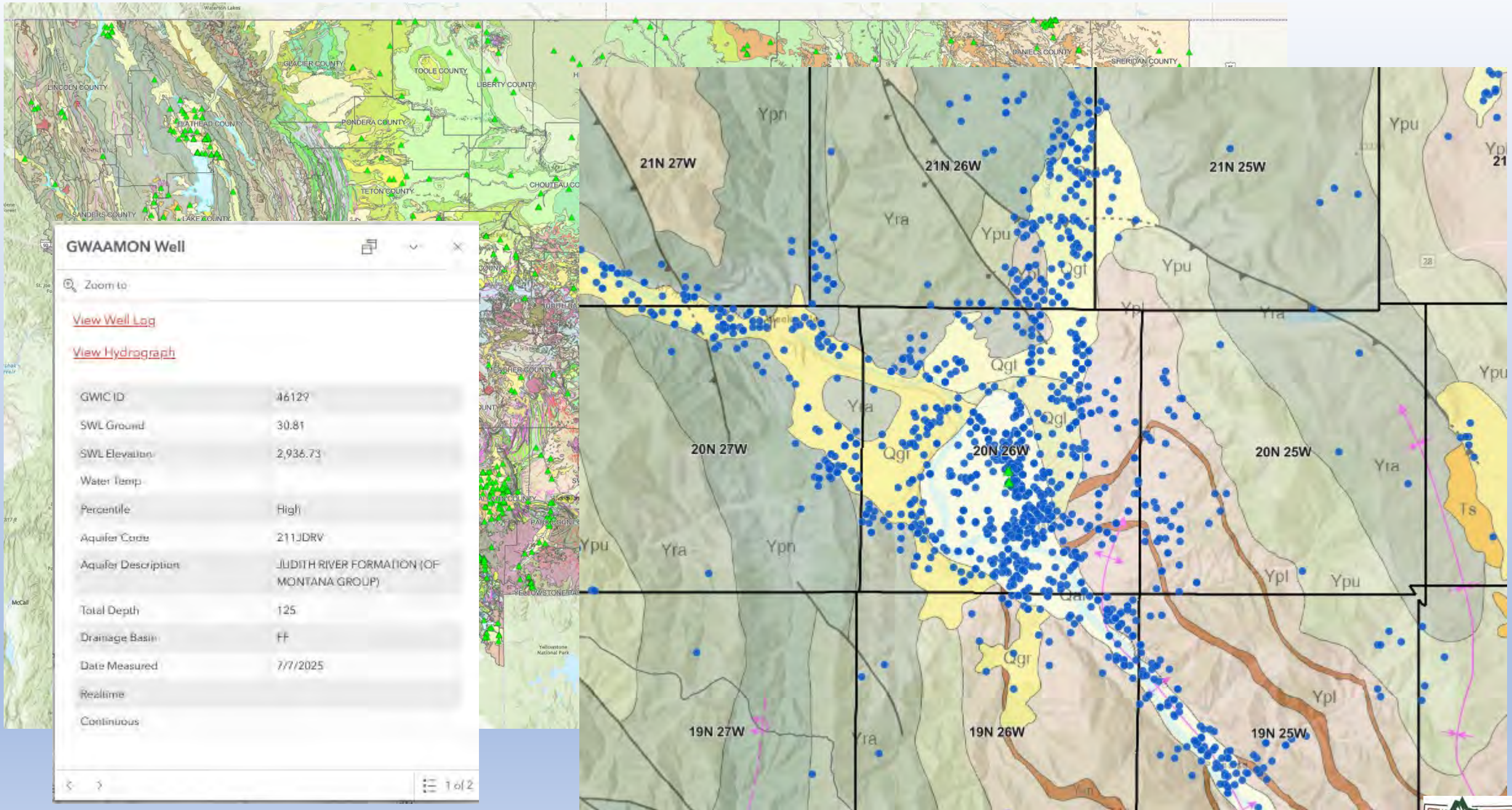


Principal Aquifers of Montana
Principal aquifers in Montana, representing geologic units or groupings of geologic units that have similar water-bearing characteristics.



<https://gis-data-hub-mbmh.gis.com/apps/d226763591a0433285c0057031d22d60/explore>





GWAAMON Well

Zoom to

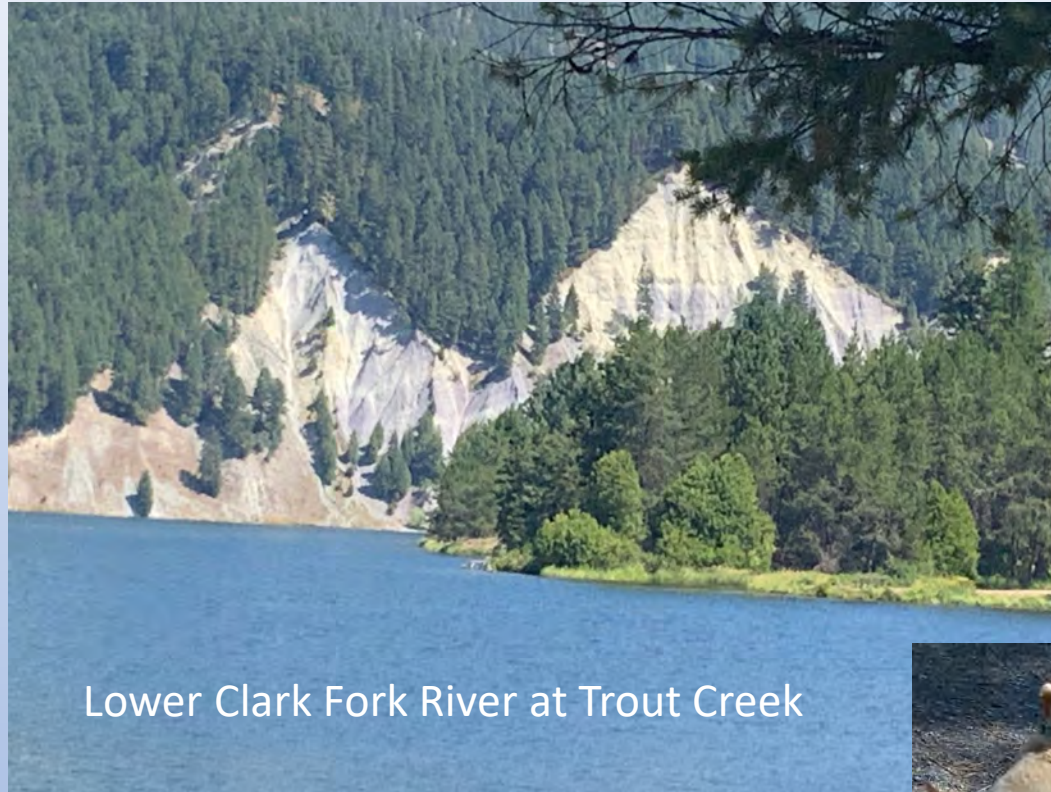
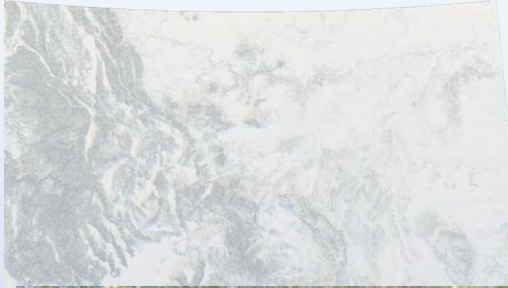
[View Well Log](#)

[View Hydrograph](#)

GWIC ID	46129
SWL Ground	30.81
SWL Elevation	2,936.73
Water Temp	
Percentile	High
Aquifer Code	211JDRV
Aquifer Description	JUDITH RIVER FORMATION (OF MONTANA GROUP)
Total Depth	125
Drainage Basin	FF
Date Measured	7/7/2025
Realtime	
Continuous	

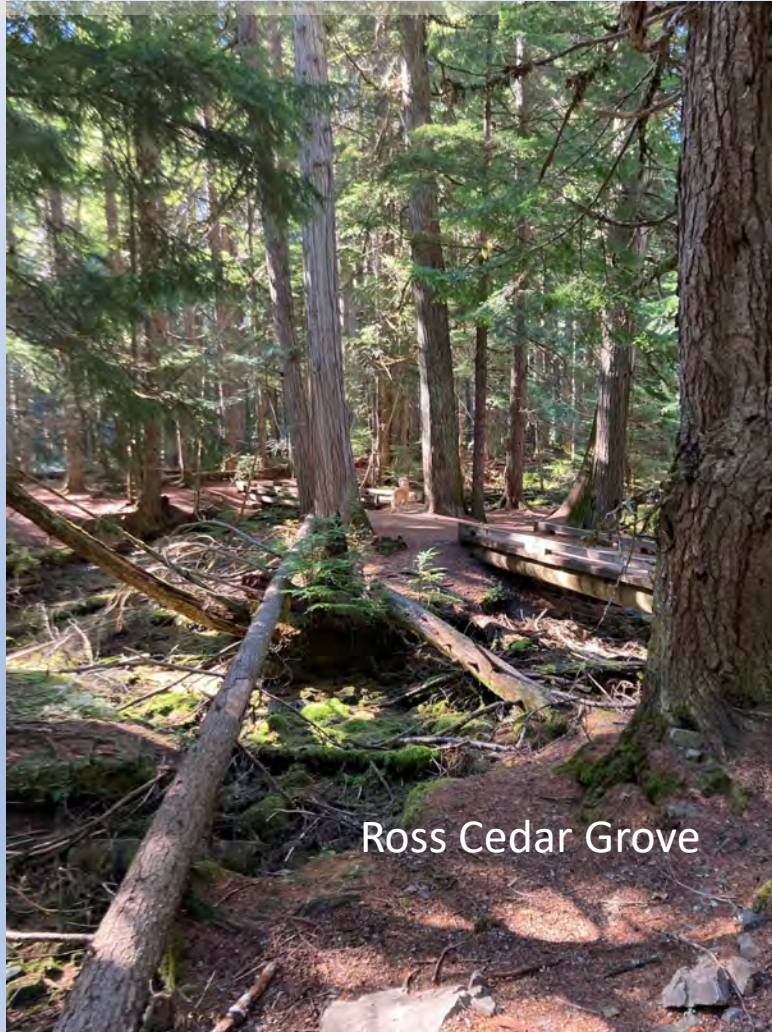
1 of 2

Lincoln and Sanders Counties: A Brief Introduction



Lower Clark Fork River at Trout Creek

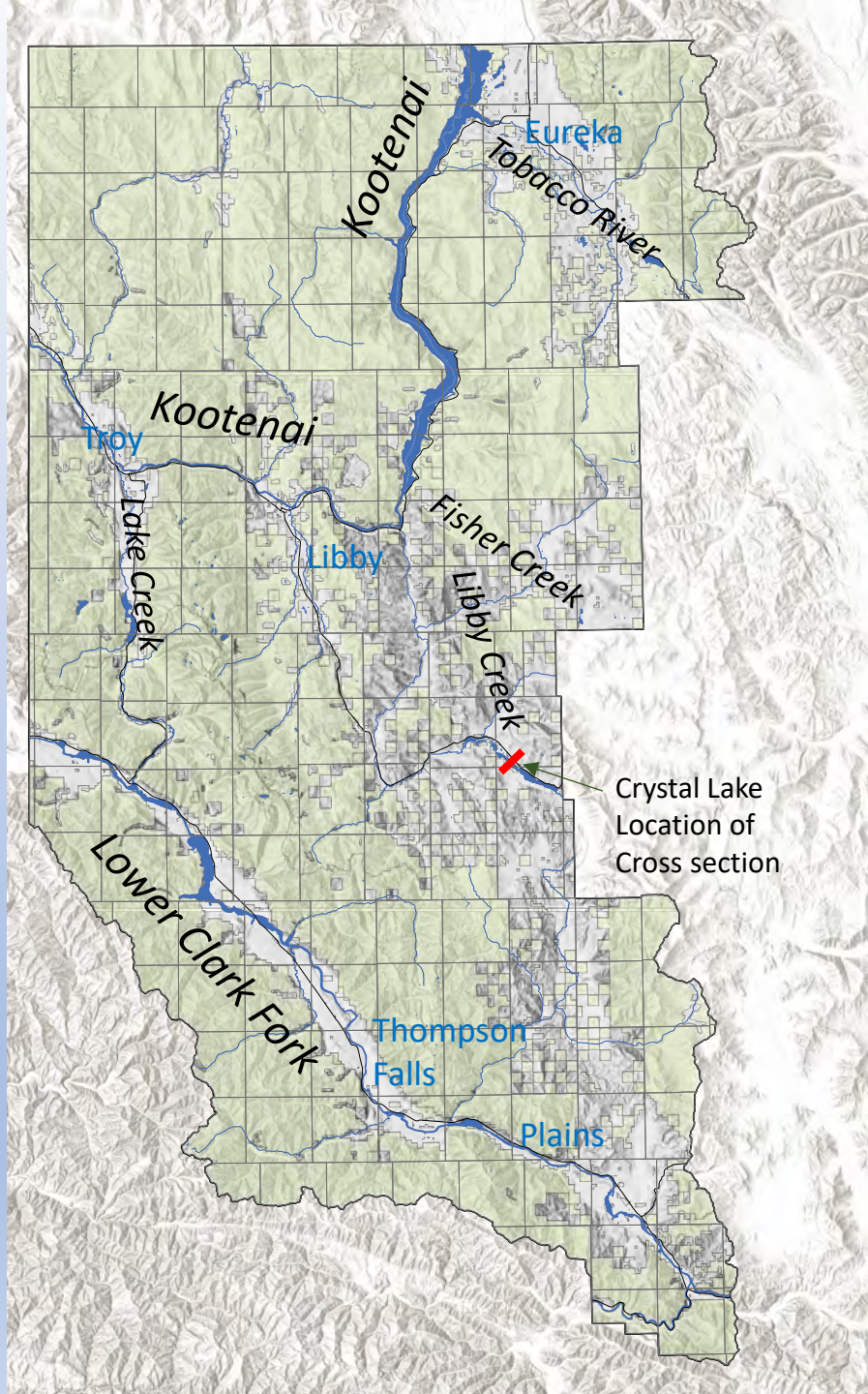
Mountain Topography
Dense Forests
Large River Systems



Ross Cedar Grove



Gnomes running around the forest



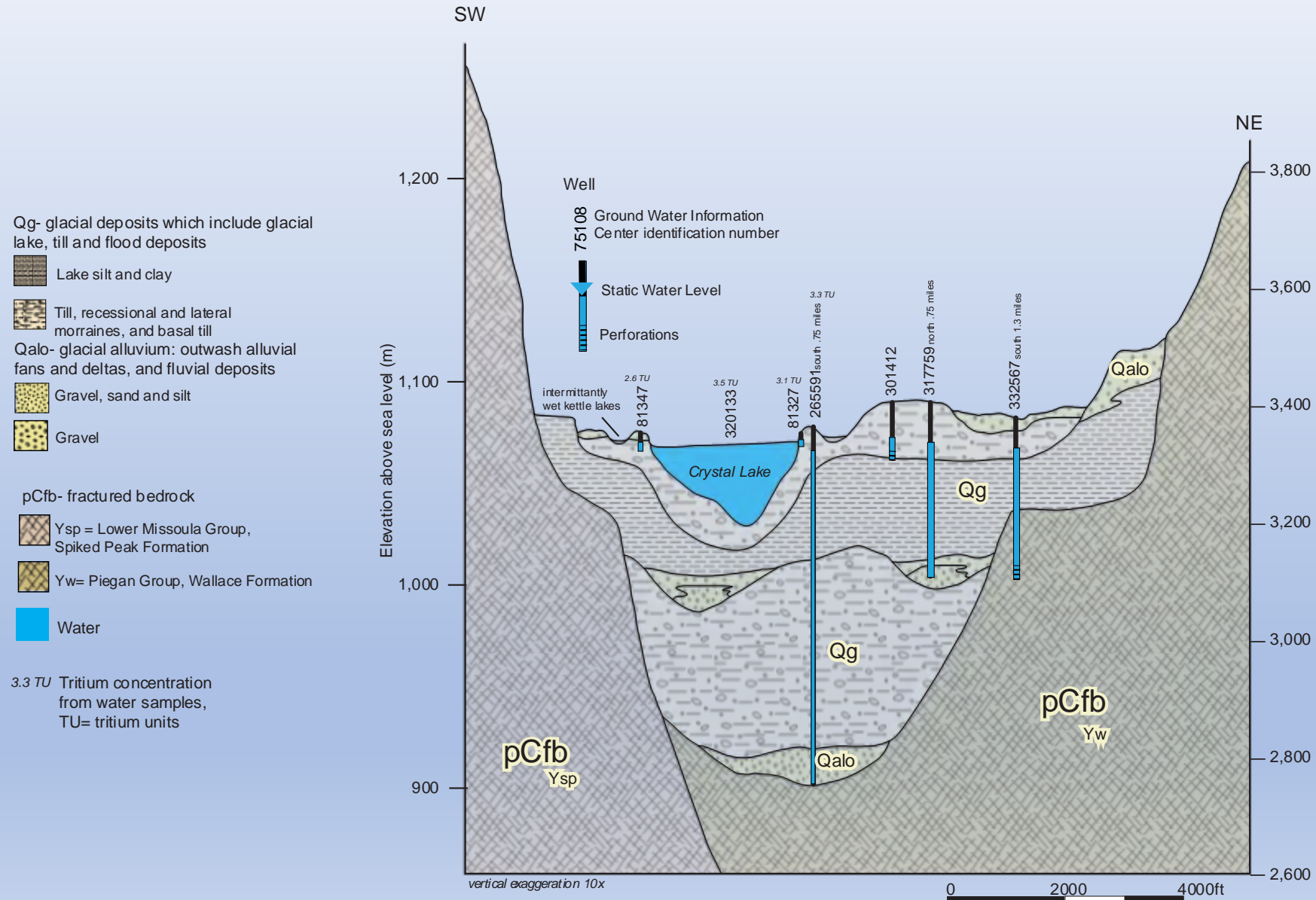
Lincoln and Sanders Counties

Main River Valleys

- Lower Clark Fork River
- Kootenai River
- Lake Creek
- Libby Creek
- Fisher Creek
- Tobacco River

Fault-Bounded Valley Structures

Schematic Cross Section Illustrating Basic Hydrogeologic Units



Frame and Fill!

Fractured Bedrock of the Belt Supergroup Frames Valleys

Thick Sequence of Glacial Deposits Fill Valleys

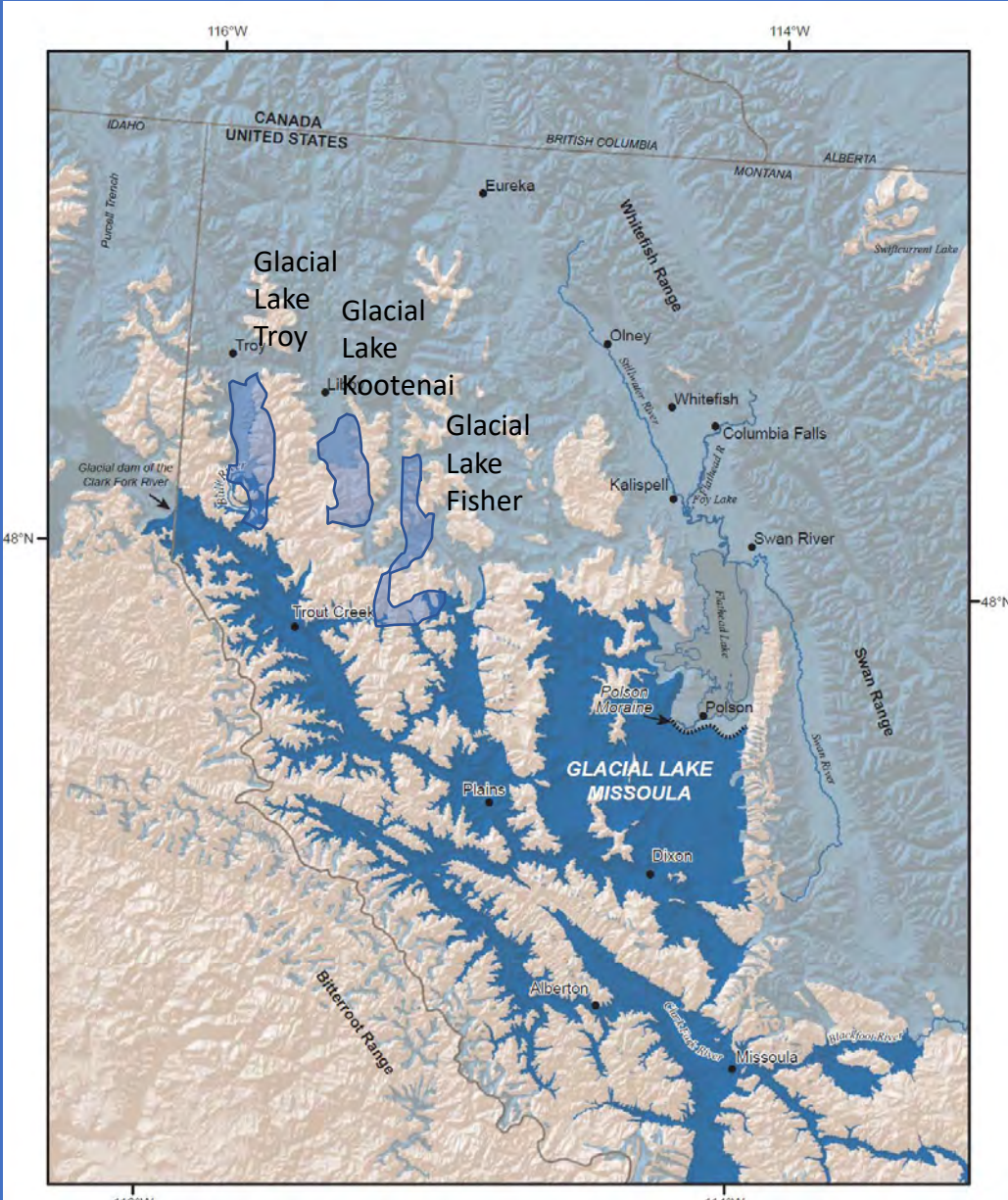
Till

Outwash

Glacial Lake Deposits

Glacial Lake Flood Deposits

Glacial lake Missoula was not alone



modified from Smith and others (2020)



Libby-
Bluff of over 300 feet
Glacial Lake Kootenai
deposits

Lake Creek;
exposure of Glacial Lake Troy
deposits



Stuart Parker, MBMG geologist



Outcrop of Prichard



STRATIGRAPHIC COLUMN			
ERA	GROUP	NORTHWEST MONTANA	
MIDDLE PROTEROZOIC	Missoula	Libby Formation (6,000-7,550 ft)	Garnet Range Formation (0-8,200 ft)
			McNamara Formation (100-5,415 ft)
		Bonner Formation (500-1,900 ft)	
		Mount Shields Formation (1,000-6,560 ft)	
		Shepard Formation (600-3,600 ft)	
		Snowslip Formation (0-5,450 ft)	
	Piegan	Wallace Formation	Helena Formation
	Ravalli	St. Regis Formation (1,000-3,000 ft)	
		Revett Formation (500-2,500 ft)	
		Burke Formation (2,500-7,500 ft)	
Lower Belt	Prichard Formation (16,400 ft)		

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Ravalli Group

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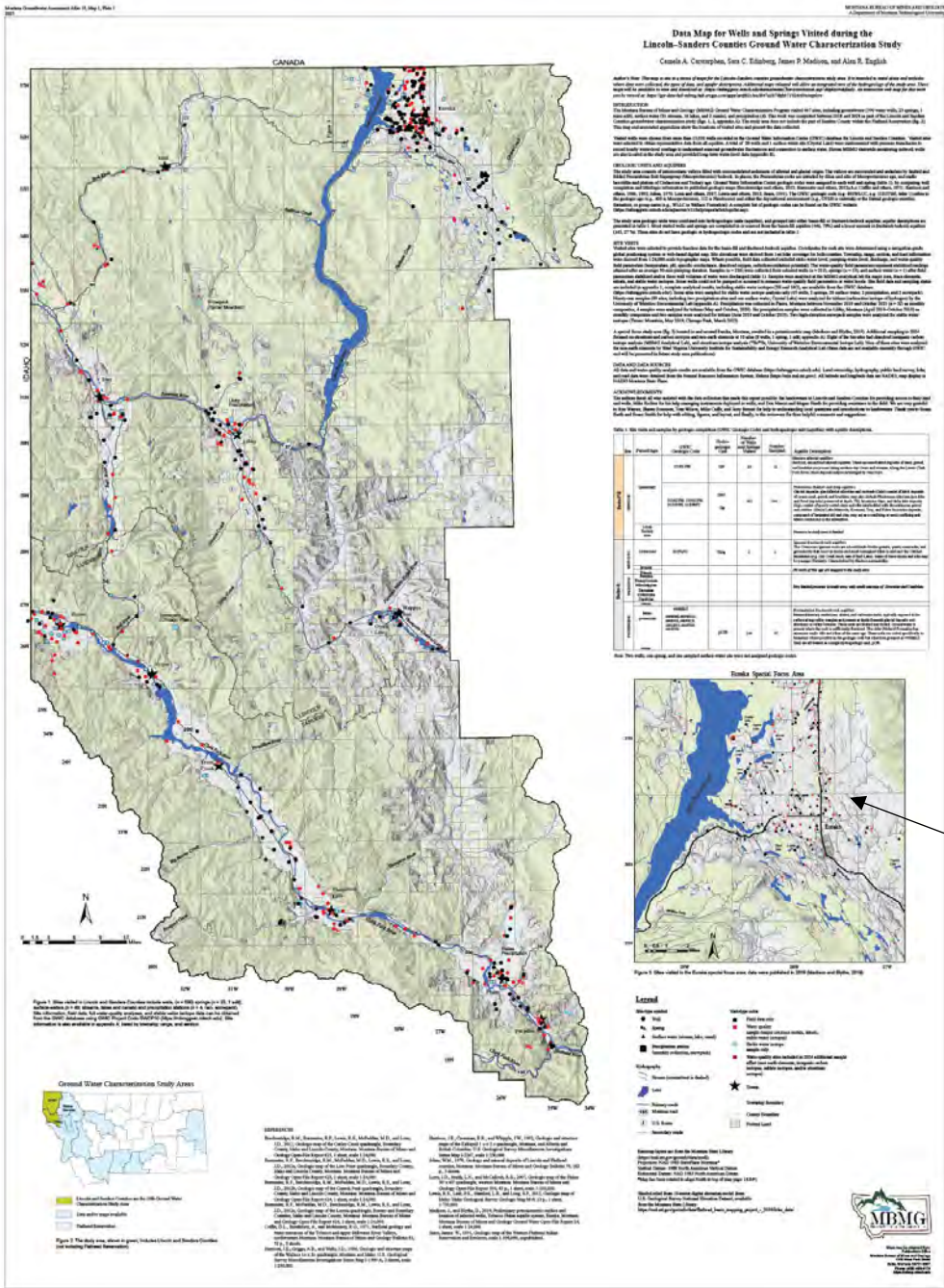


Wallace Formation (Piegan Group)

Kootenai Falls: outcrops of the Missoula Group (Mount Shields Formation)

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Early Products from Our Work

Data Map

Where did we visit?

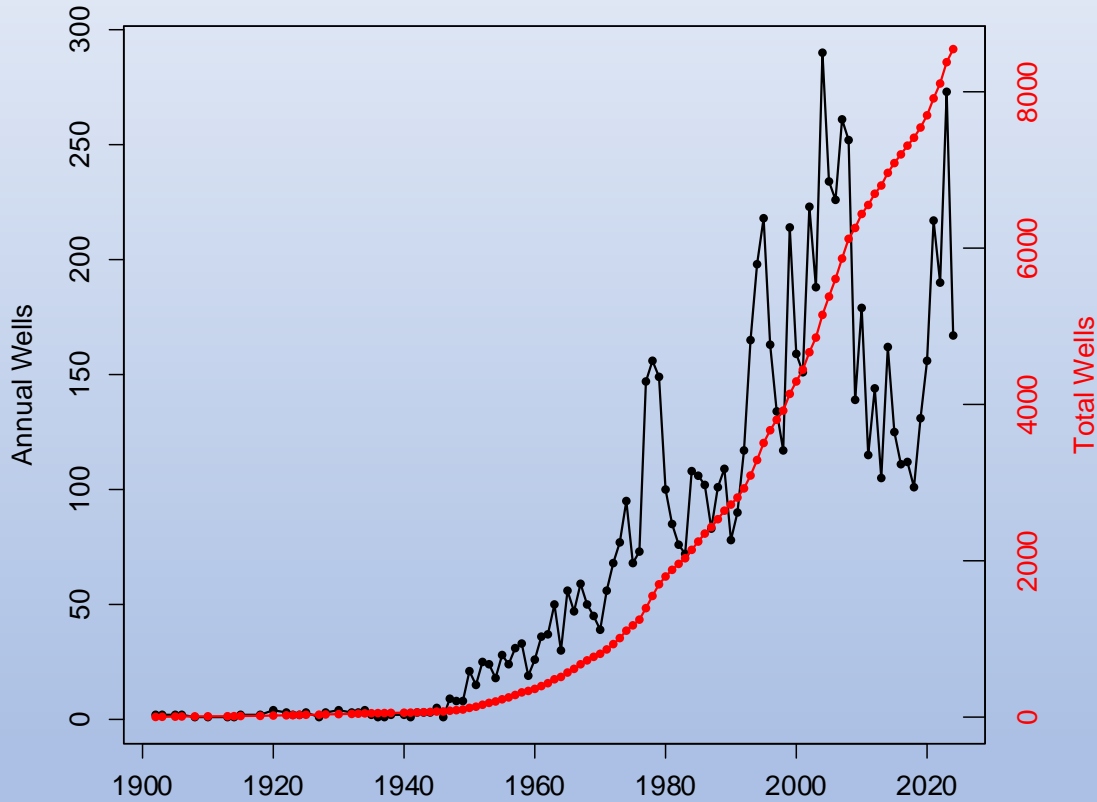
What data did we collect?

Available in paper-form or download from MBMG website
 And as a web map publication at our
MBMG HUB SITE-

showcased during poster session tonight

Early special focus area in Eureka area

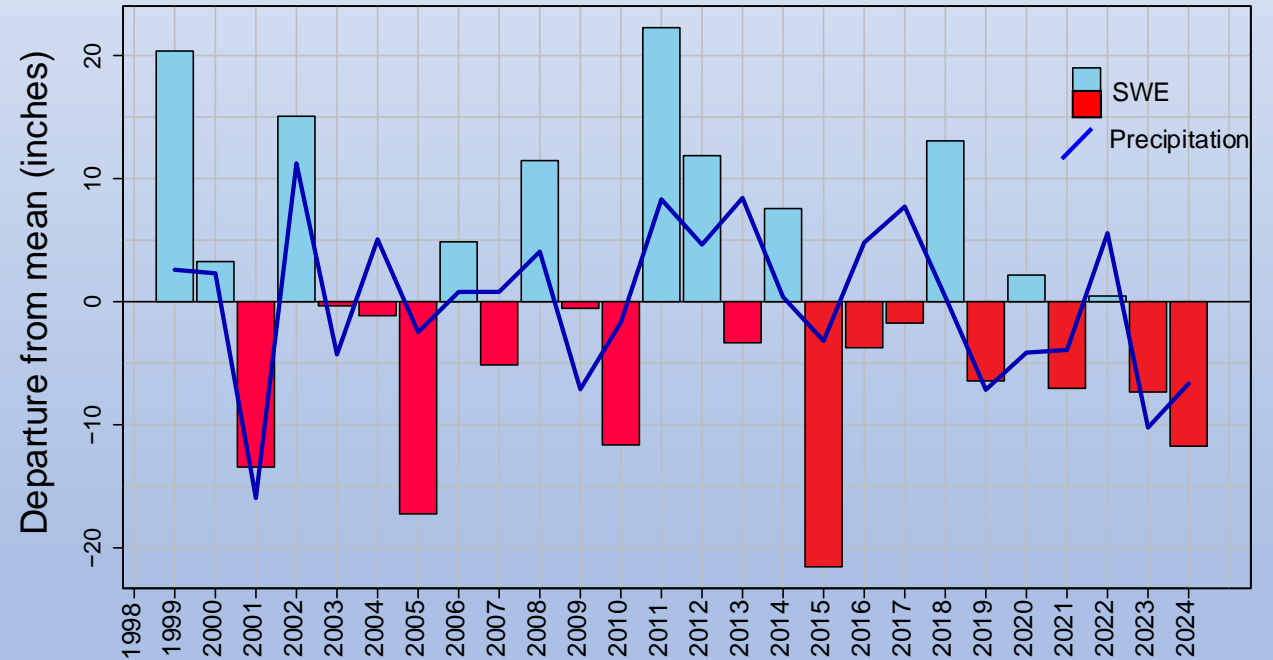
Development



Lincoln County Groundwater wells drilled by year and cumulatively

Drought Conditions

Poorman Creek SNOTEL (#932) Annual Peak SWE and Mean Precipitation Departures (Period of Record: 26 yrs)



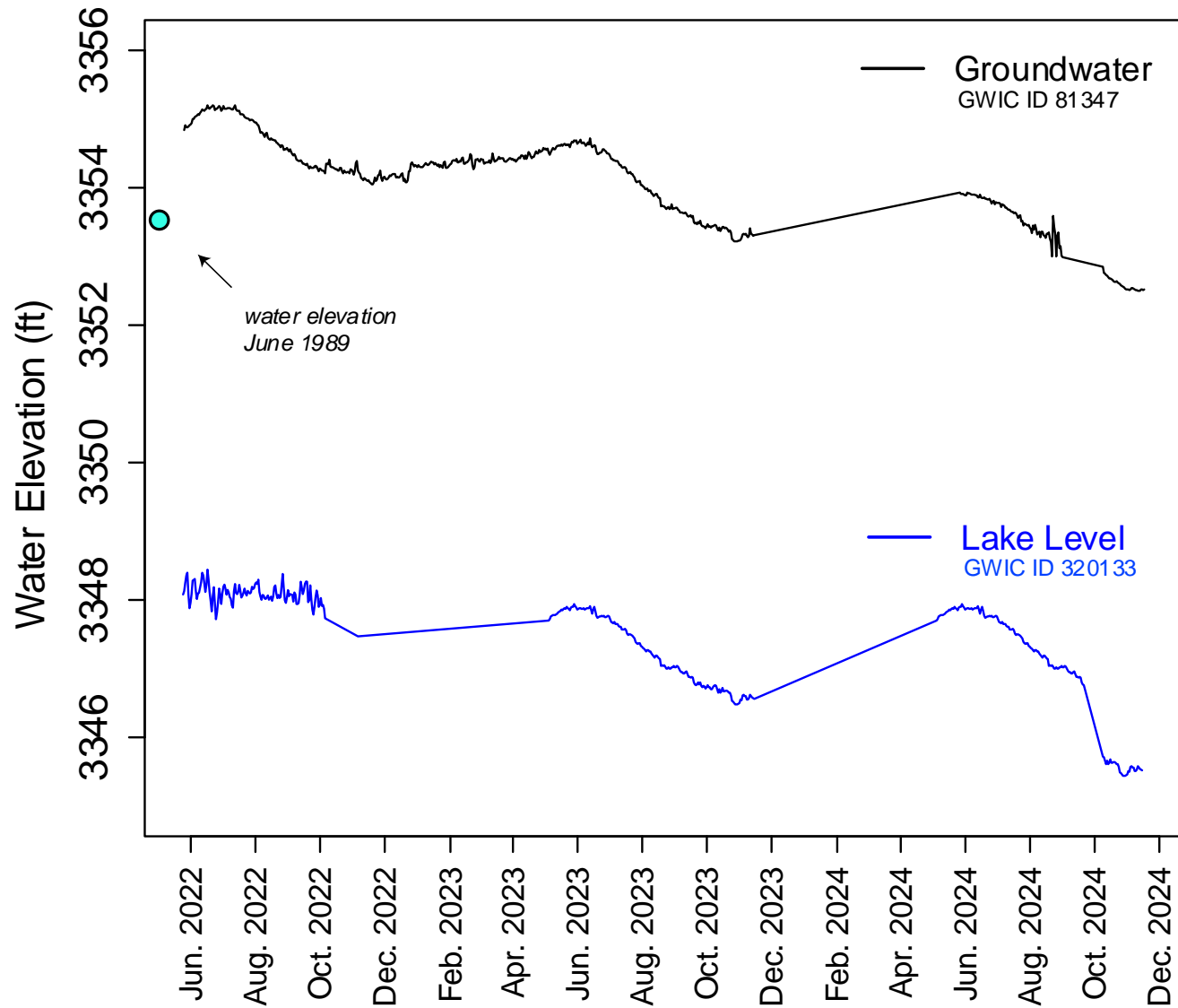
Crystal Lake: installation of a lake staff gage transducer and a groundwater well transducer

May 2022 – November 2024

Gage at southwest end of lake

Well in trees at NW corner





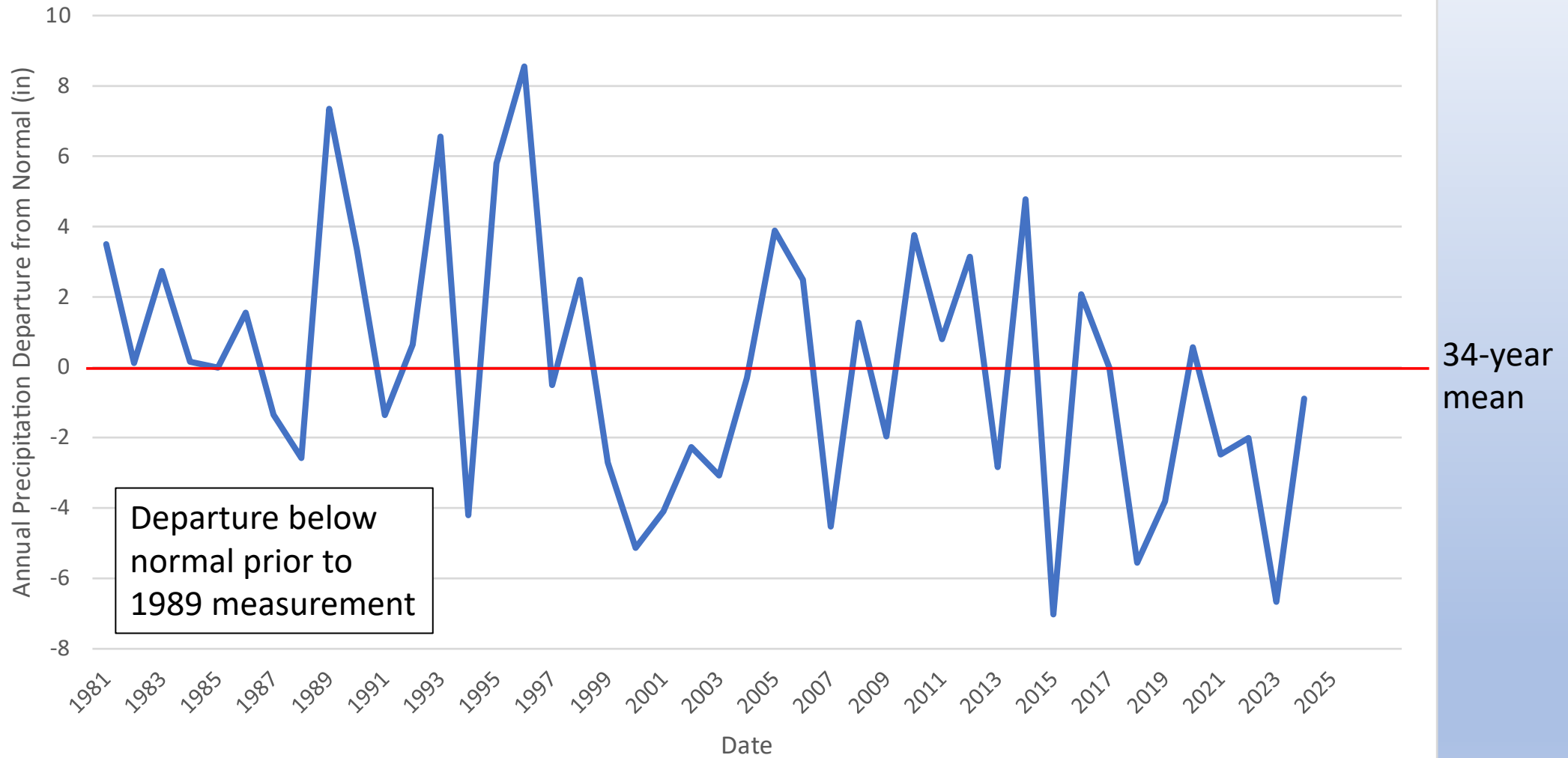
Observations:

- Both groundwater and the Lake fluctuate seasonally by a foot
- Over the two year data period, Water levels dropped in both (2 foot decline)

Historic water level record for well Indicates:

- That there has not been a decline over the thirty-year period, and
- that levels might fluctuate intermittently over several years

Regional Precipitation History: MSU Northwestern Agriculture Center



Northwest Region

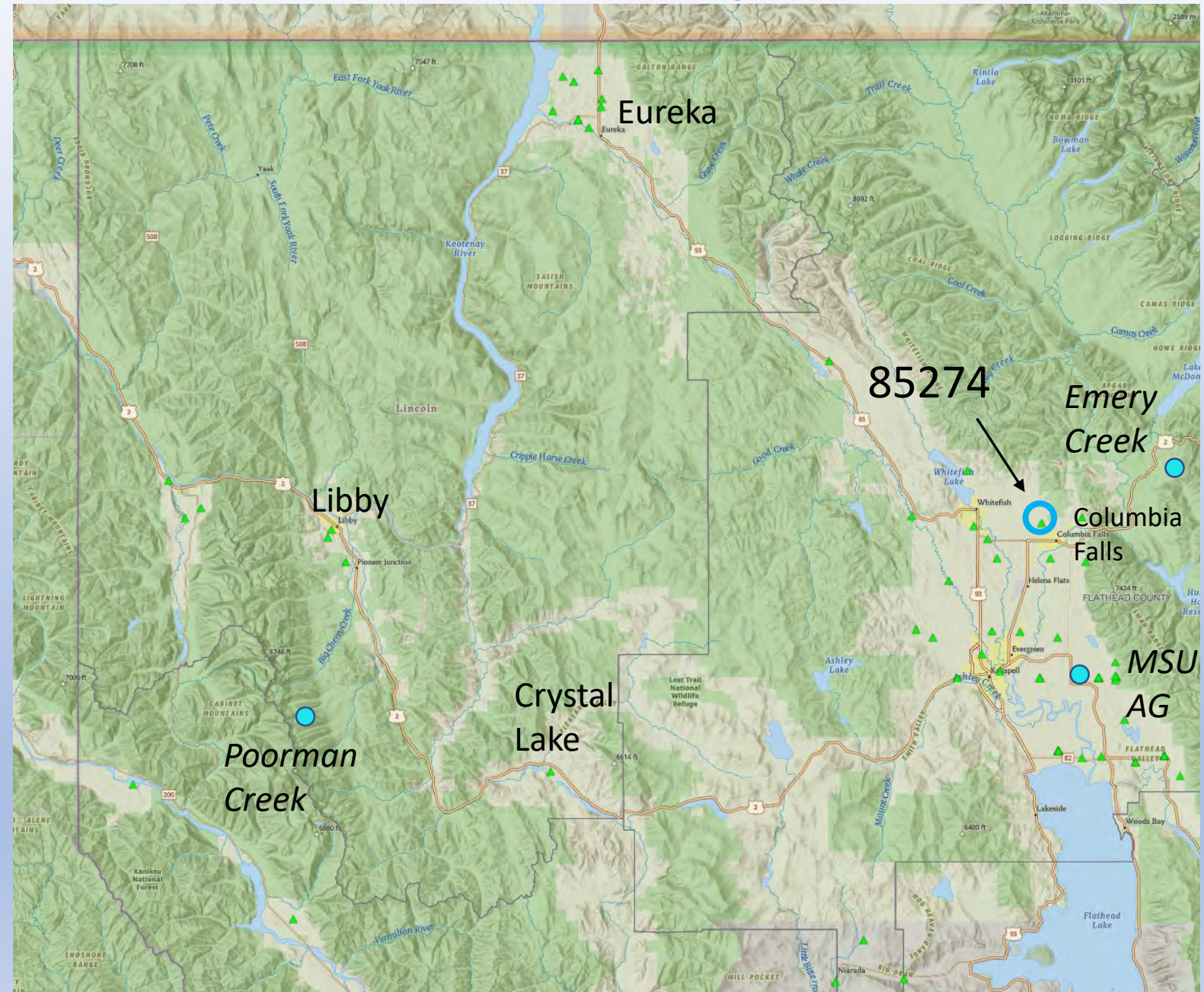
Looking for Long-Term Data Sets

We found!

MBMG has as a regional groundwater data of instrumented (hourly) data with a 30-year record GWIC 85274

Available long-term precipitation included

- Poorman Creek SNOTEL site
- Emery Creek SNOTEL site
- MSU Northwestern Ag Center



Decisions on Data Handling

- Data grouped as annual values and by water year not calendar year
- Data normalized using gamma distribution protocol(anomalies)

Data Analysis

- Produced anomaly graphs for groundwater and precipitation over period of record
- Used Pearson Correlation protocol to compare groundwater values to precipitation over multiple time scales (0 – 120 months)
 - looking for any strong correlation (coefficients close to 1)
 -what time frame of precipitation history best predict groundwater response

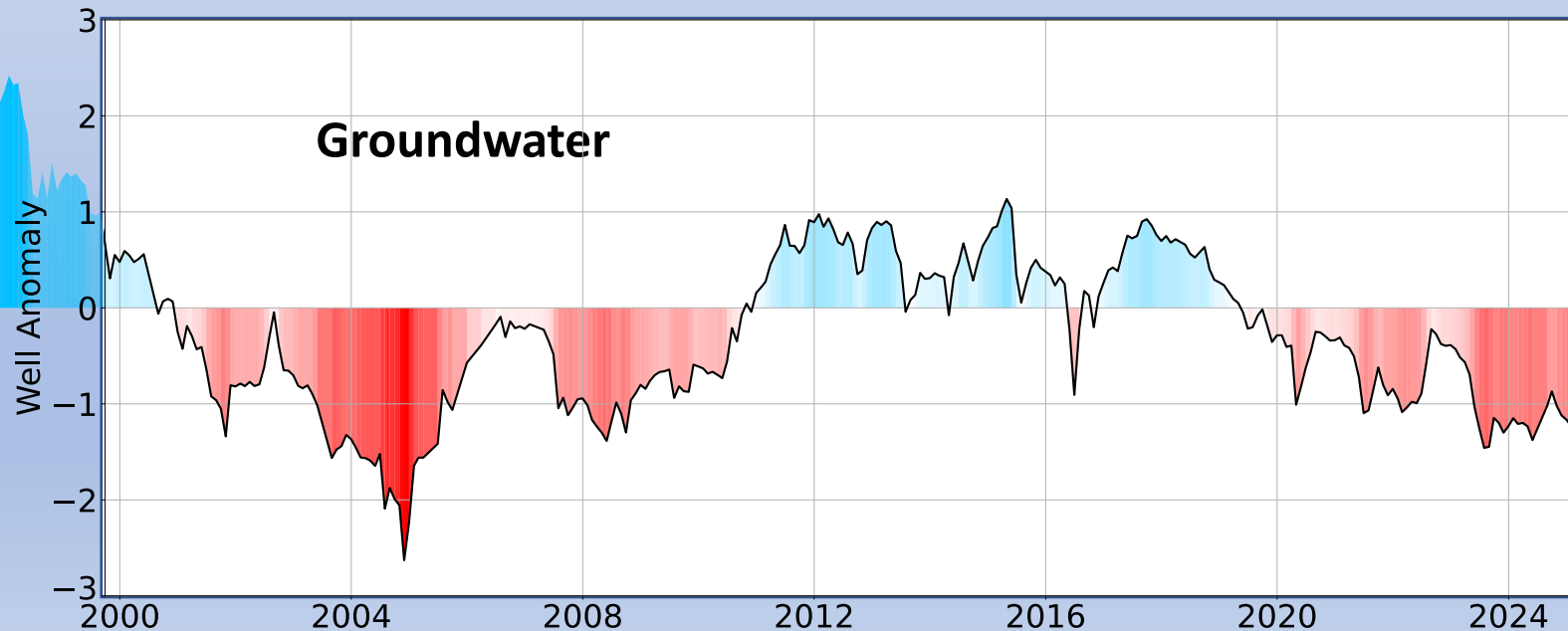
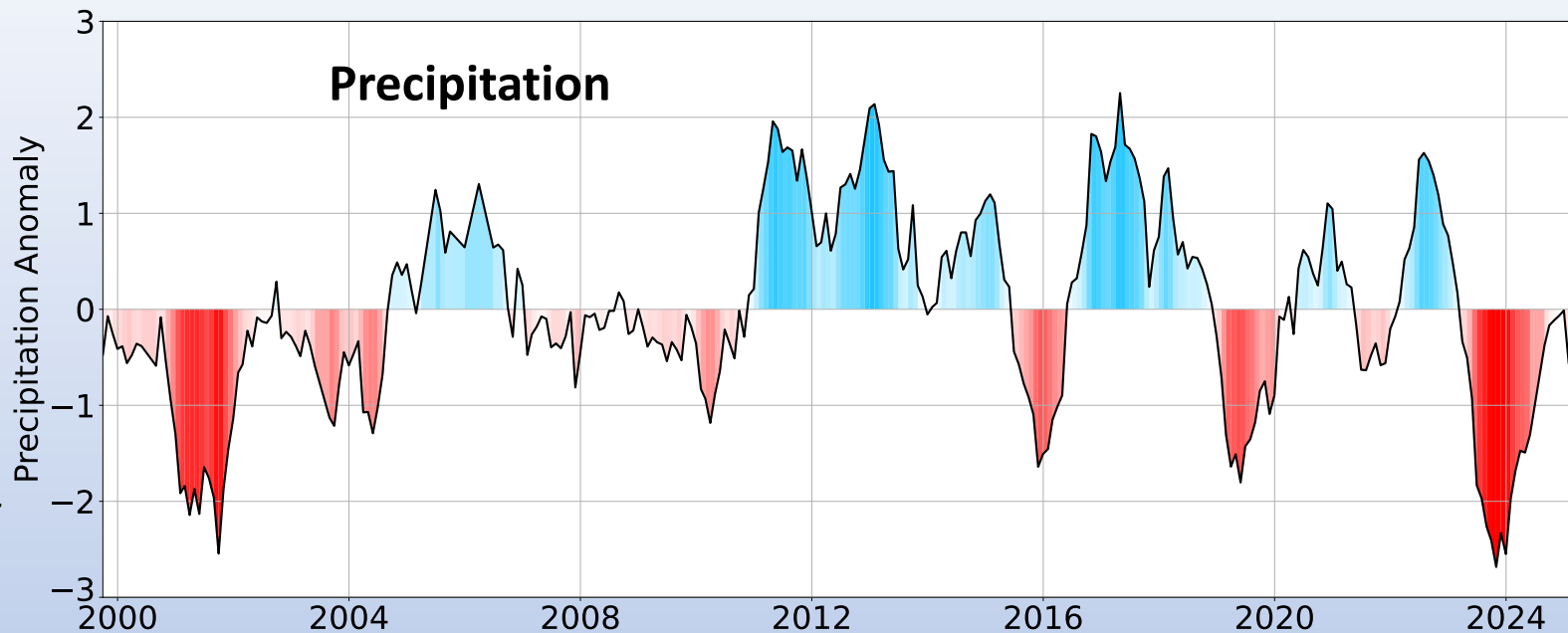
Date	Poorman (Snow Water Equivalent) (in)	Poorman (Precipitation Accumulation) (in)	Poorman (Snow Water Equivalent) (in)
November-98	0	3.5	2
December-98	11.1	18.9	
January-99	24.8	32.3	
February-99	37.9		
March-99	52		
April-99			

DATE	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1981	1.31	1.46	2.17	1.75	1.38	0.86	0.71	1.17	1.71	2.51	1.39	1.39
1982	2.38	1.85	1.71	1.41	1.25	2.98	3.66	2.96	1.55	2.15	1.13	1.99
1983	0.93	0.85	1.21	1.59	2.31	2.07	0.93	1.09	1.02	0.81	0.81	1.23
1984	0.51	1.28	1.81	0.9	1.34	1.89	1.97	1.92	1.62	3.35	1.59	1.59
1985	2.39	2.33	0.46	3.47	1.36	2.7	2.05	2.05	2.34	2.34	2.34	2.34
1986	0.38	1.09	0.46	3.47	1.36	2.7	2.05	2.05	2.34	2.34	2.34	2.34
1987	0.98	1.48	0.41	0.83	1.72	1.53	2.73	5.34	4	0.1	0.1	4.69
1988	1.39	1.85	0.41	0.83	1.72	1.53	2.73	5.34	4	0.1	0.1	4.69
1989	0.96	0.41	0.71	1.19	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79
1990	1.41	1.41	0.61	0.71	1.19	1.79	1.79	1.79	1.79	1.79	1.79	1.79
1991	1.08	1.49	0.6	0.71	1.19	1.79	1.79	1.79	1.79	1.79	1.79	1.79
1992	1.43	1.43	0.6	0.71	1.19	1.79	1.79	1.79	1.79	1.79	1.79	1.79
1993	1.17	1.17	1.02	1.02	0.9	0.59	1.8	1.31	1.31	1.31	1.31	1.31
1994	2.23	0.33	1.34	1.34	1.3	2.31	2.31	2.31	2.31	2.31	2.31	2.31
1995	0.77	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
1996	1.05	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54
1997	1.05	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54	1.54
1998	0.75	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
1999	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21	1.21
2000	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
2001	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2002	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2003	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2004	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2005	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2006	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2007	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2008	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2009	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2010	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2011	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2012	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2013	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2014	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2015	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2016	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2017	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2018	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2019	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2020	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2021	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03
2022	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03	2.03



Normalized Precipitation and Groundwater Data: Departure from Normal Over Entire Period of Record

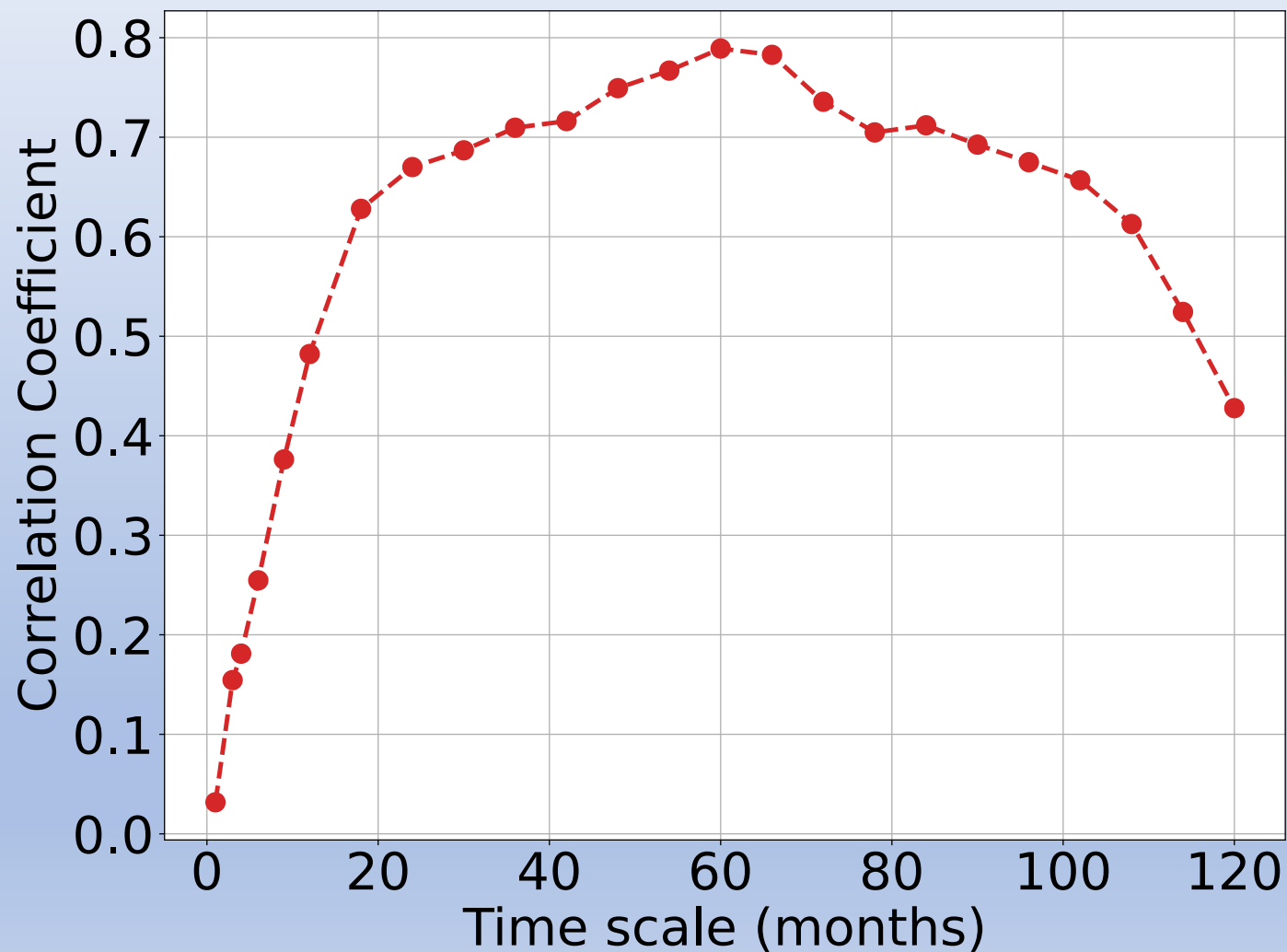
The anomaly graphs highlight, visually, the powerful driver that precipitation history has been for groundwater deficit and surplus



Pearson Correlation Coefficients Groundwater vs Emery SNOTEL

Groundwater anomaly values are correlated to varying precipitation time scales

A strong correlation with 5-year period





Brad Holding, Crystal Lake

Lake and Groundwater levels fluctuate seasonally on the order of a foot, and have seen a 1.5+ ft decline between years

However, inventory evidence suggests that groundwater levels seem to be steady over a 30+ year period

The extended Northwest regional drought is likely the driver for the decline



Crystal Lake Staff Gage

Thank You



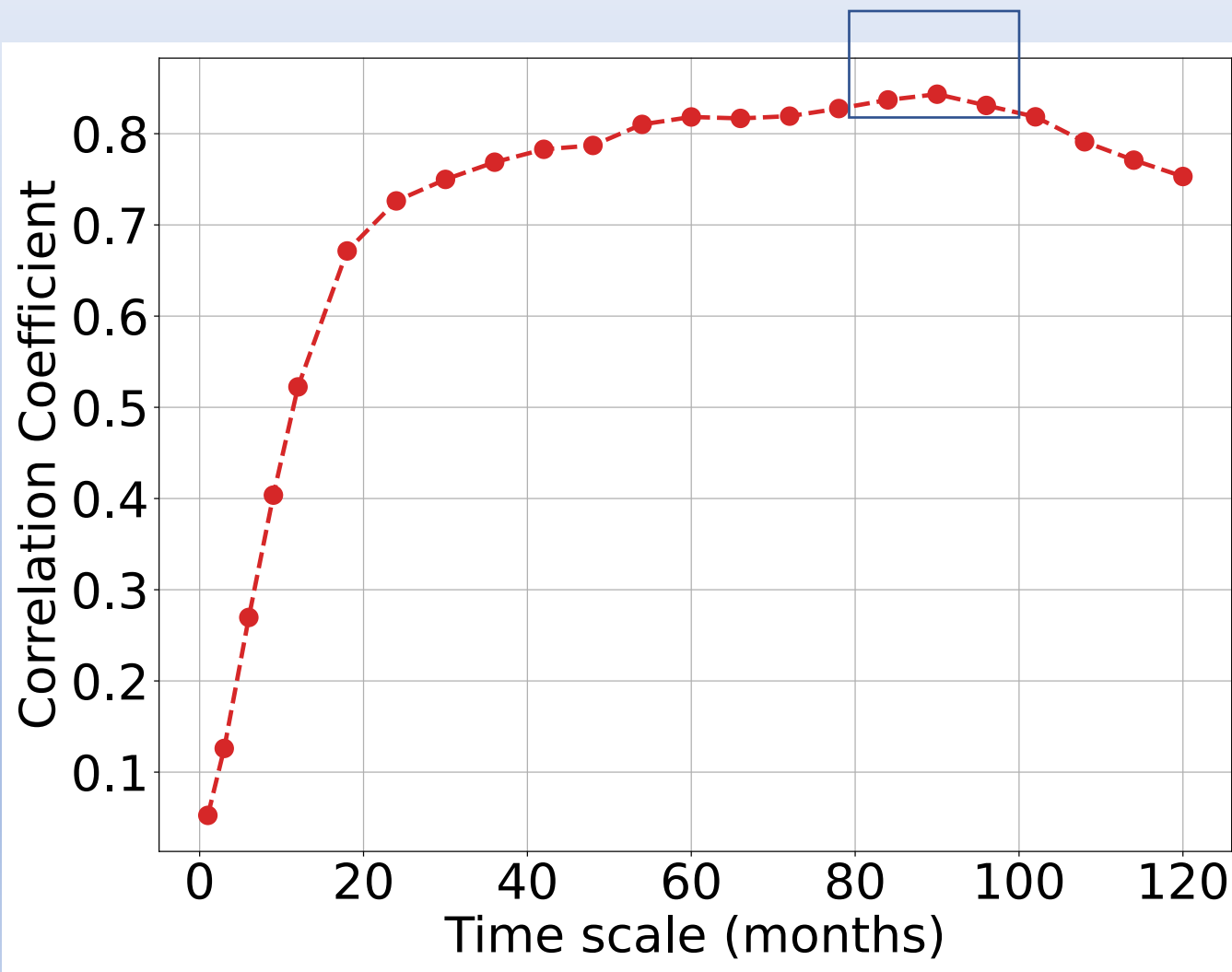
Acknowledgements

- All the gracious landowners of Lincoln and Sanders County
- The help and conversations with local groundwater folks
 - Senator Mike Cuffe
 - County Planner Jesse Haag
 - County Commissioner Jerry Bennet
 - Surveyor Ron Warren
 - County Planner/DEQ Shawn Sorenson

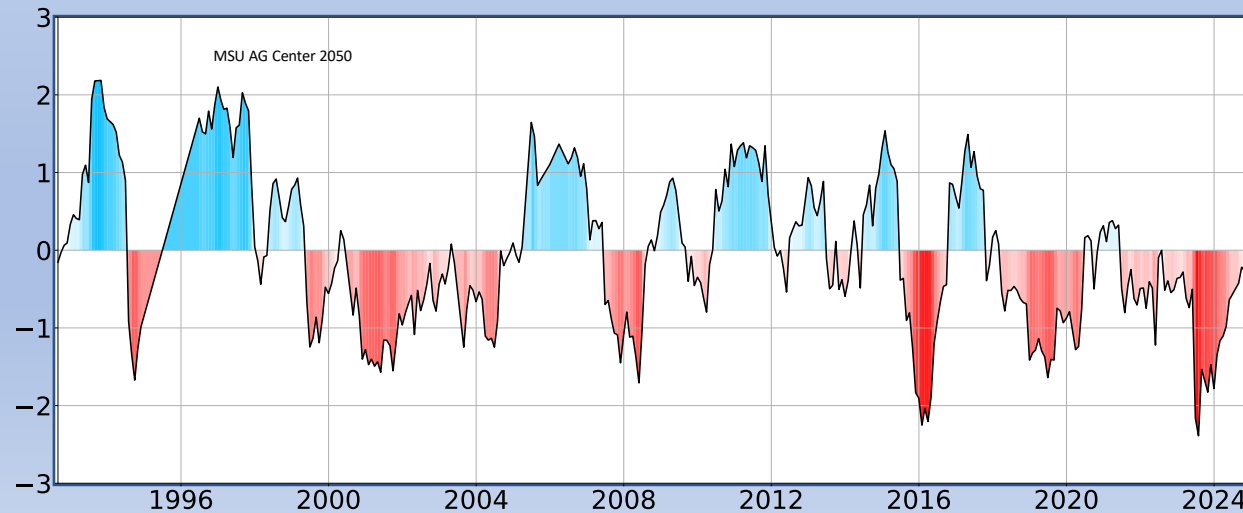
Pearson Correlation Coefficients Groundwater vs MSU AG

Groundwater anomaly values are compared to varying precipitation time scales

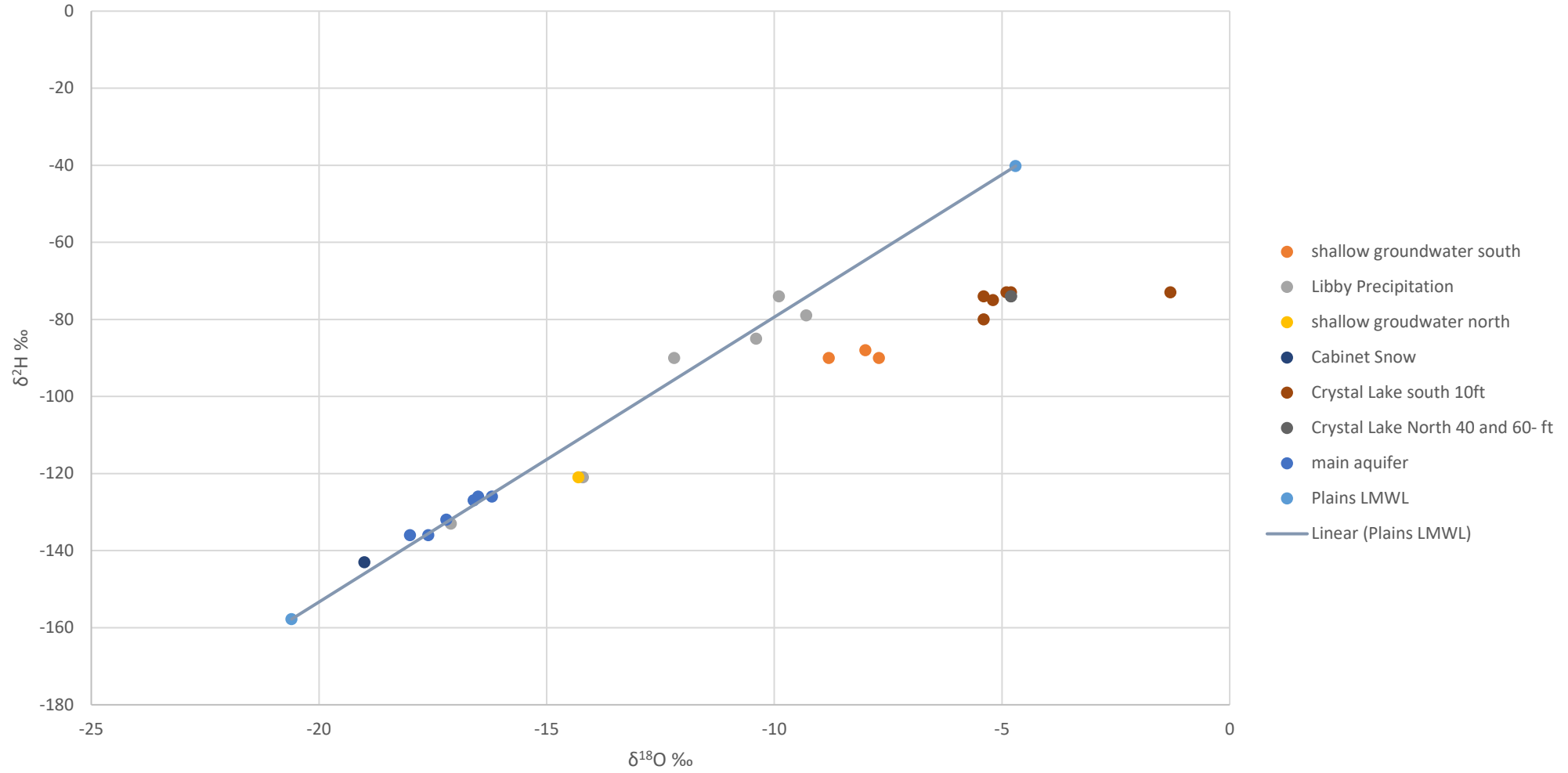
A strong correlation with 7-8 year time period

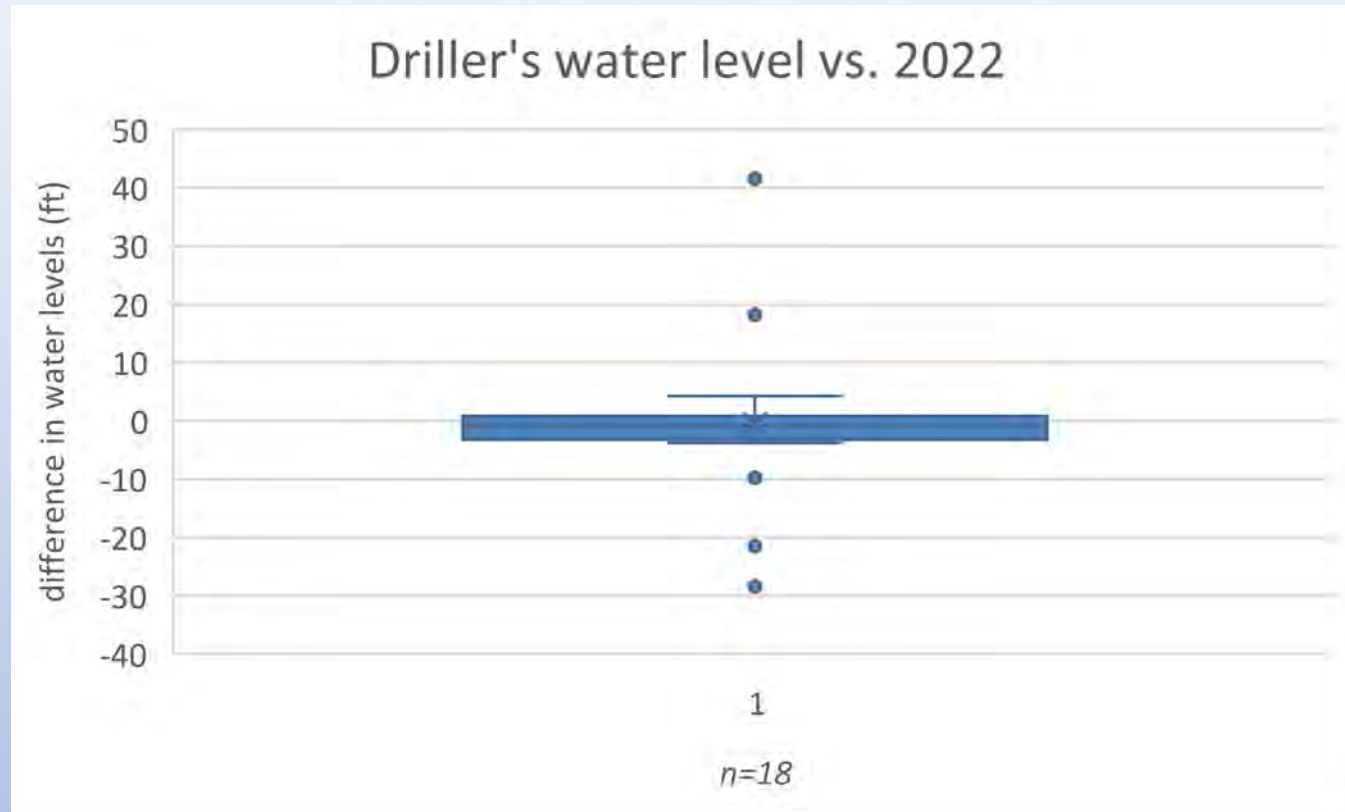


Three Regional Precipitation Data Sets



Happy's Inn: Stable Water Isotopes





mean = -0.81 ft

median = -0.55 ft

