

JRWC Meeting; 8/4/16; Whitehall, MT; Andy Bobst - MBMG

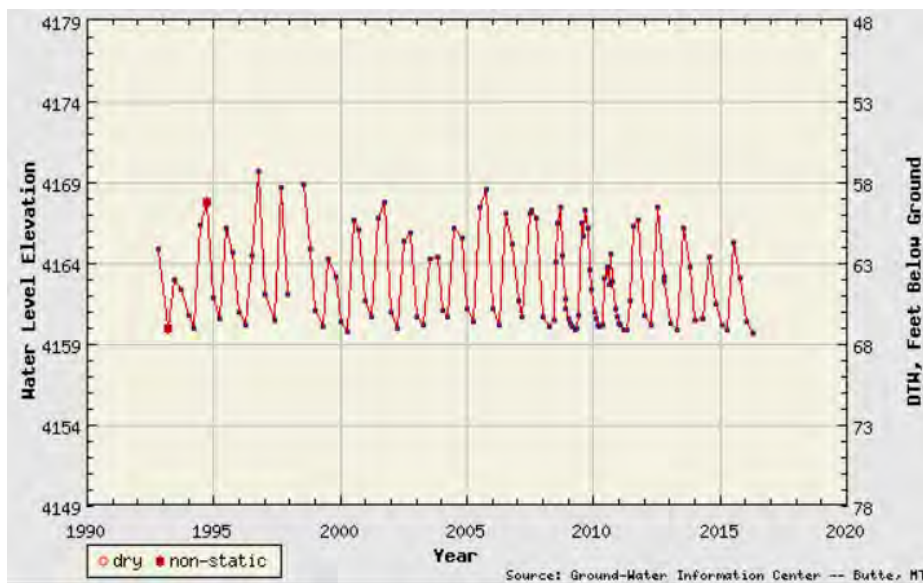
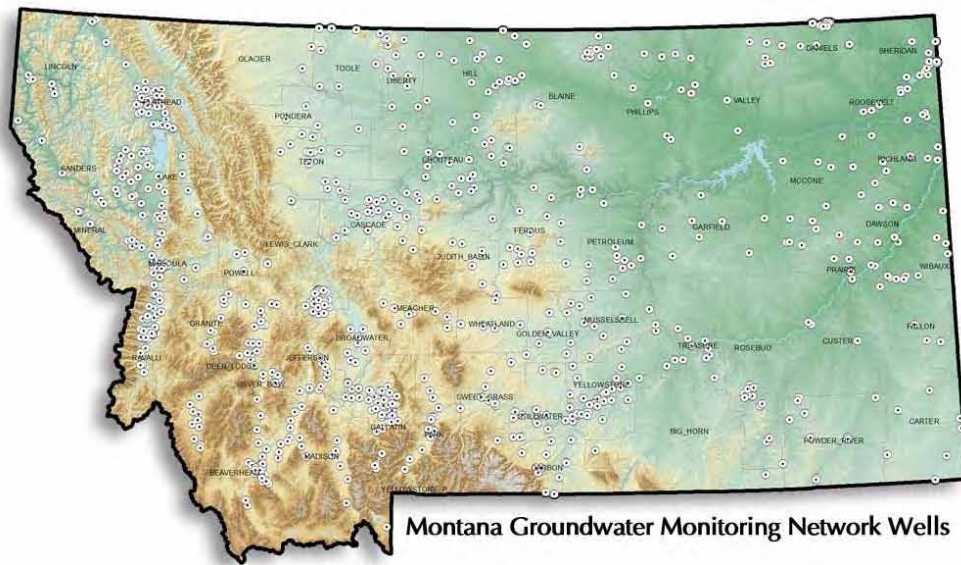
MBMG Mandate: *“Collect and publish information on Montana's geology to promote orderly and responsible development of the energy, groundwater, and mineral resources of the State.”*

Groundwater

Groundwater Assessment Program (GWAP)

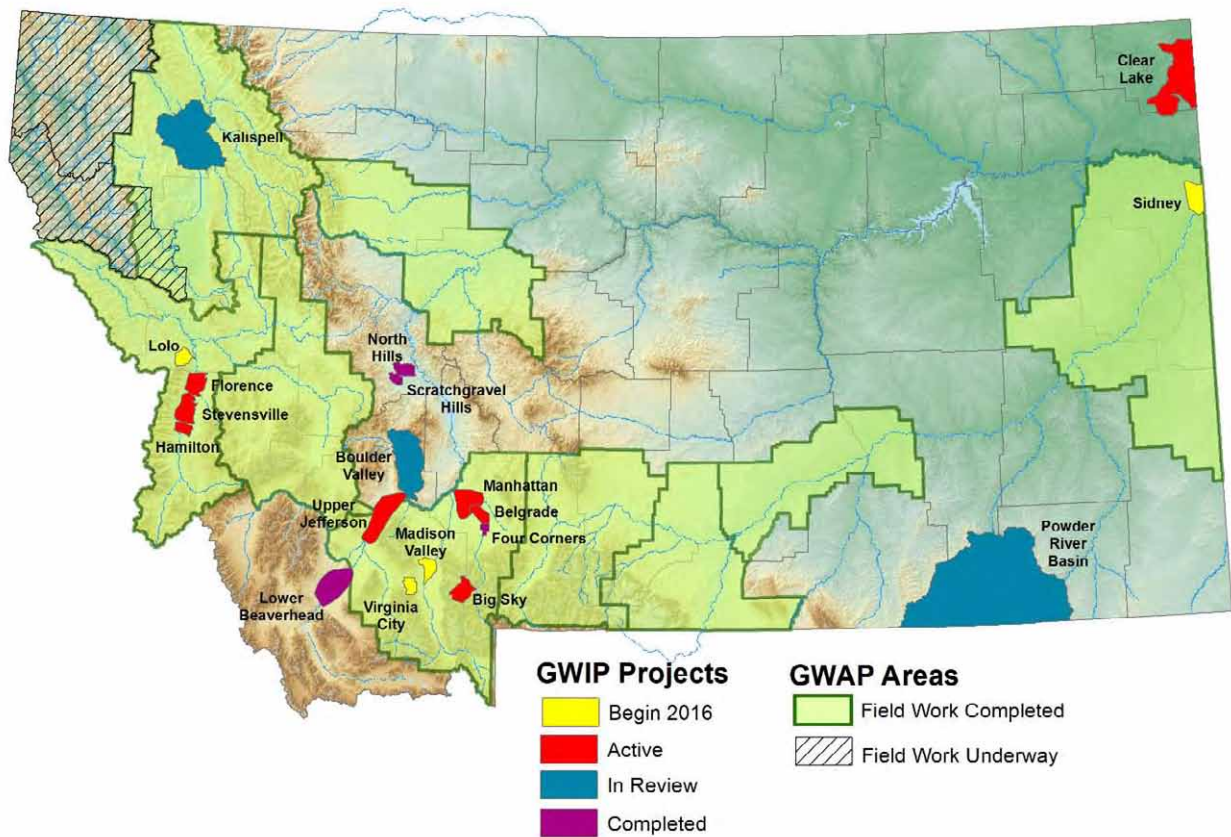
Long-Term Monitoring – 954 wells throughout the state

Systematic data collection since 1991



Groundwater Characterization – Describe groundwater conditions in different parts of the state.

- Work split up by groups of counties.
- Field work done in 9 areas (24 counties)
 - >8,300 wells inventoried
 - >2,000 wells sampled
 - >60 maps and reports released
 - Deer Lodge, Granite, Powell, and Silver Bow
 - Well Data Report (GWAA 5B-01; 2004)
 - Groundwater Resource development (GWOFF 21; 2007)
 - Hydrogeologic Framework (GWAA 5B-02; 2009)
 - Potentiometric Surface (GWAA 5B-03; 2011)
 - Groundwater Quality (GWAA 5B-04; 2013)
 - Madison and Gallatin
 - Hydrogeologic Framework (in prep.)
 - Groundwater Quality (in prep.)
 - Potentiometric Surface (in prep.)



Groundwater Investigations Program (GWIP)

- Answering specific hydrogeologic questions in particular areas
- Projects proposed by anyone, then ranked by the Groundwater Steering Committee
- Not Characterization – Focused on answering specific questions
- Typically includes numerical groundwater flow models (need to know your questions)
- Intended to be 3-year projects from initiation to reports into review

Upper Jefferson Investigation

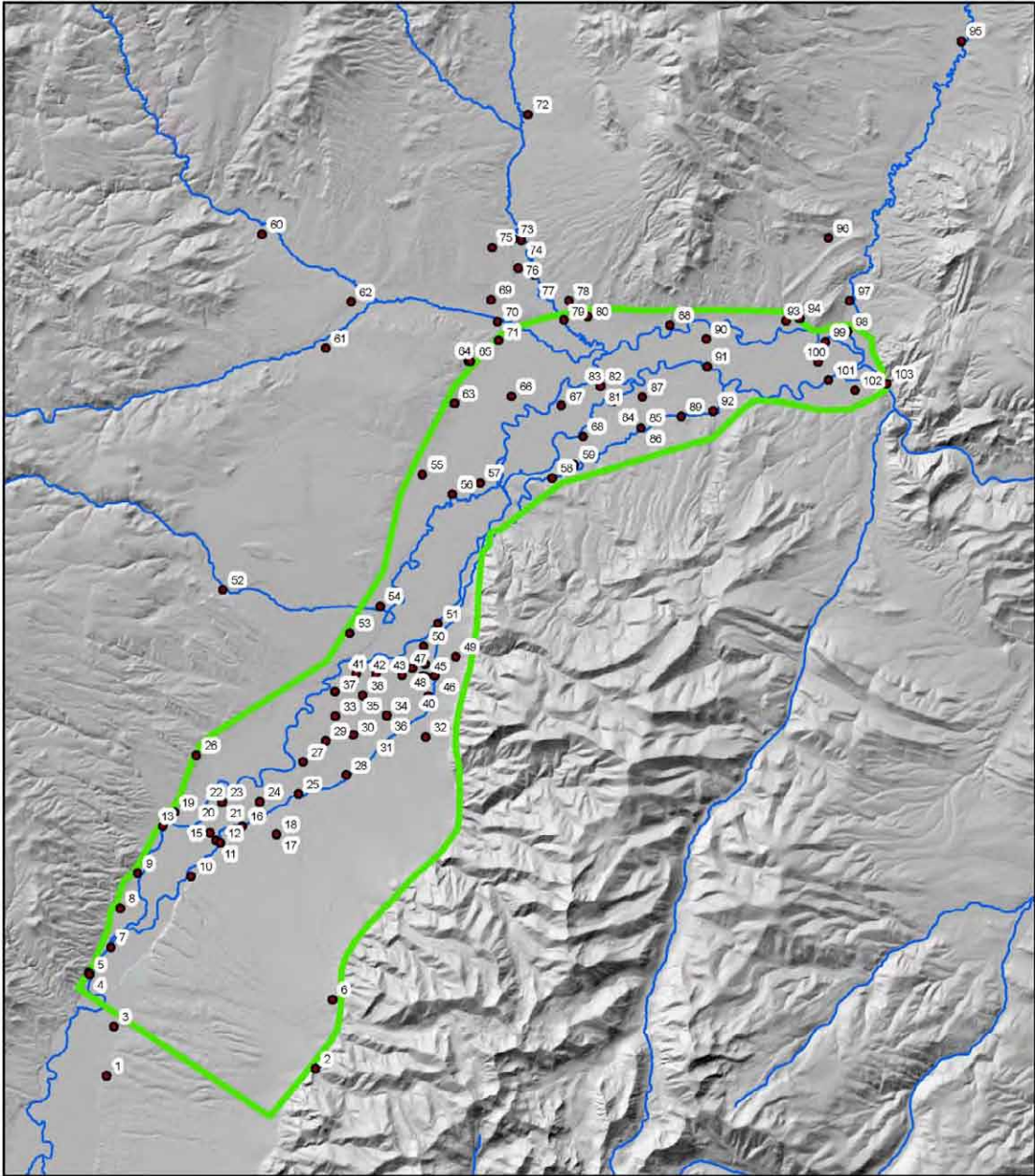
- Waterloo
 - Willow Springs and Parson's Slough – Spring Fed Streams – Groundwater
 - ~40 cfs of cool surface water to Jefferson River
 - ~40 cfs of cool groundwater to Jefferson River
 - Groundwater levels strongly affected by canal leakage and irrigation
 - *What are the potential effects of changes in irrigation practices and canal management in the Waterloo area on groundwater flow to the spring fed Streams and the Jefferson River?*
 - *In what areas would changes have the greatest effect?*
- Whitehall
 - Potential for increased groundwater development (residential, agricultural, industrial, commercial) outside of incorporated areas.
 - *What are the potential effects to flow in the Jefferson River and Jefferson Slough from increased groundwater development in the Whitehall area?*

Groundwater Monitoring Network (103 wells)



Groundwater levels over space and time

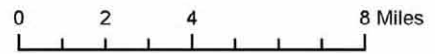
Potentiometric Surface

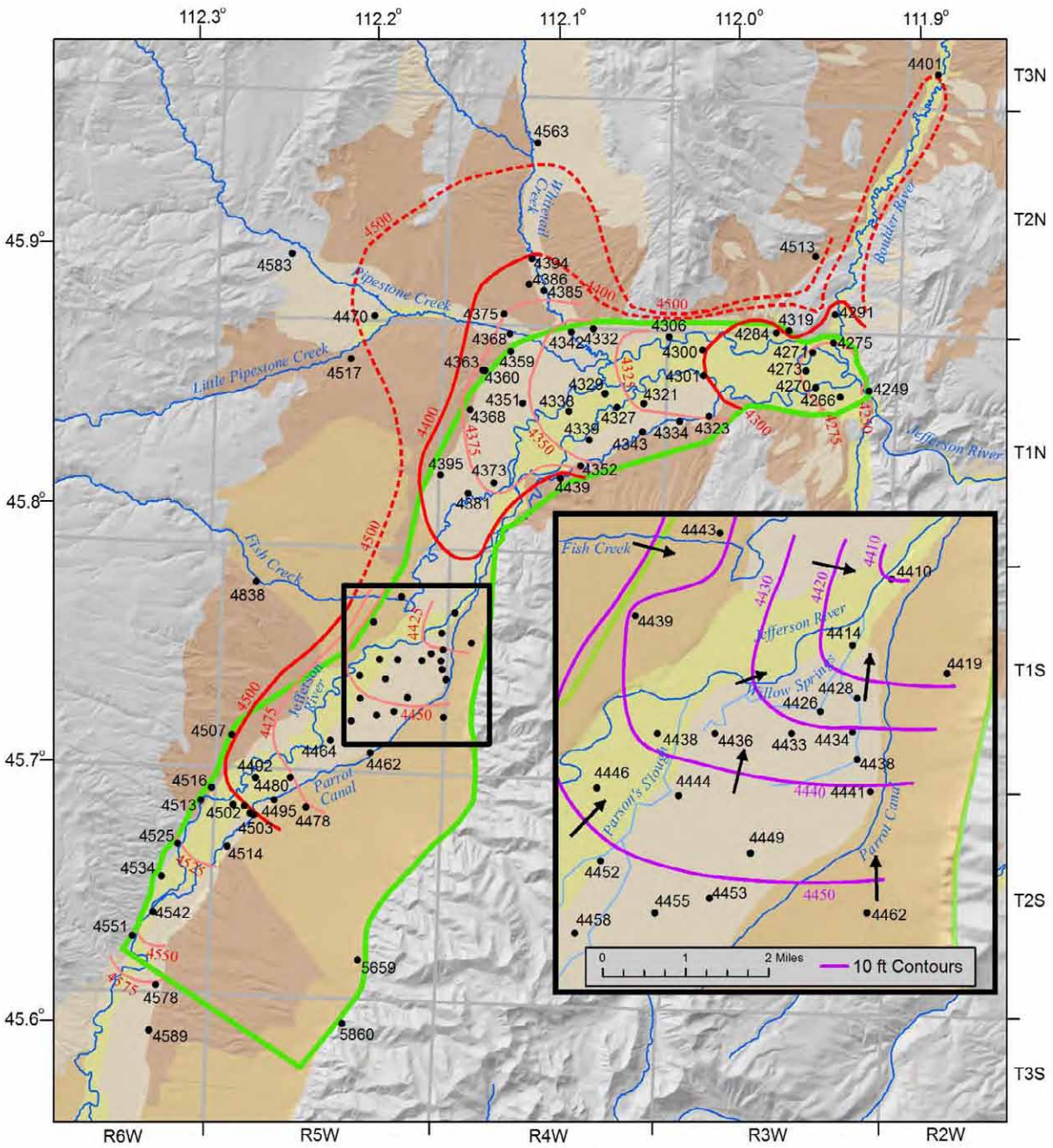
Hydrographs



Explanation

-  Upper Jefferson Study Area
-  Mon Wells



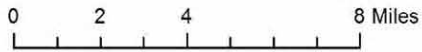


Explanation

- April 2015 Monitored Wells
- Potentiometric Contours**
- 100 ft Contours
- - - Interpolated 100 ft Contours
- 25 ft Contours

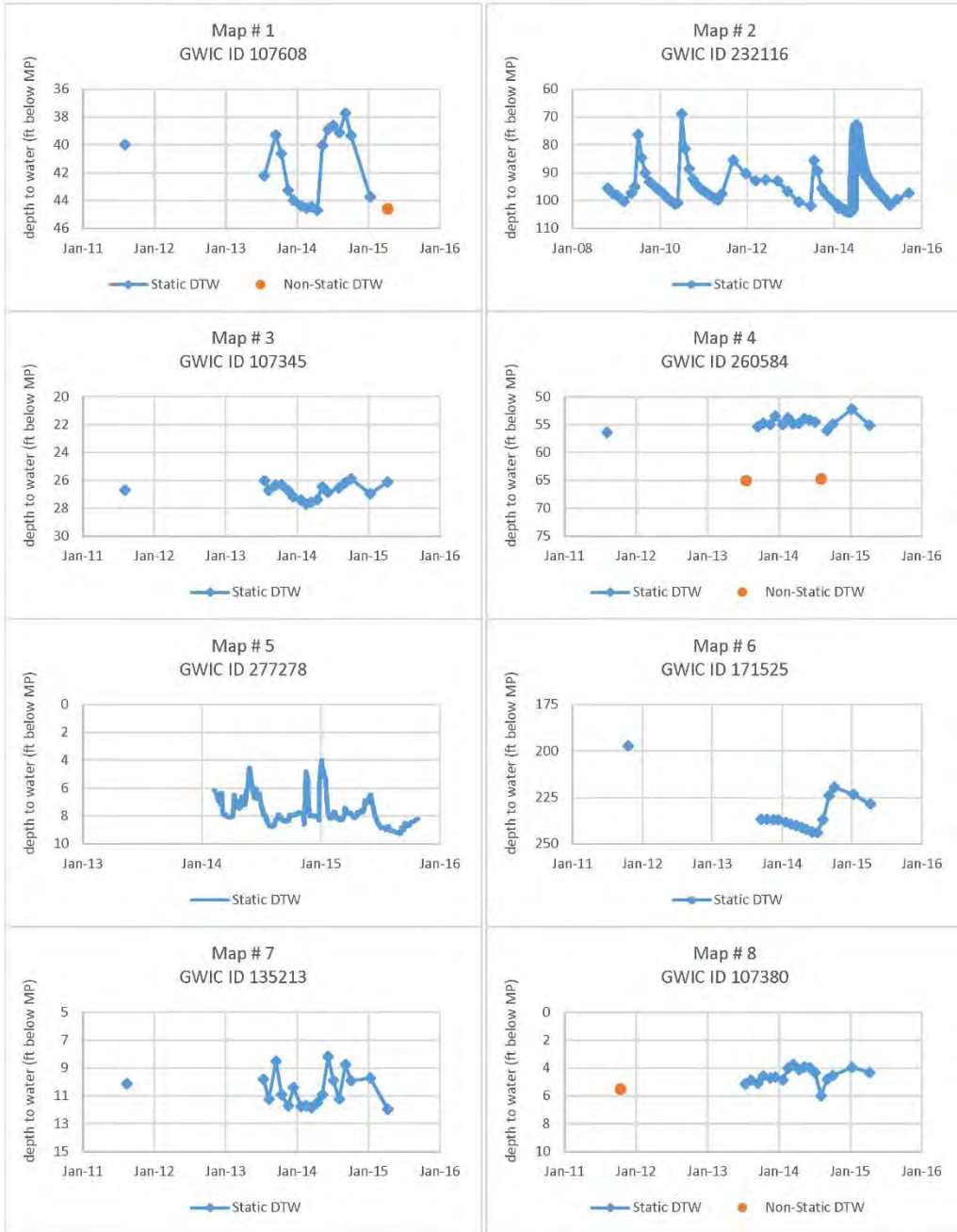
- Hydrogeologic Units**
- Quaternary Alluvium
 - Quaternary Gravel

- Quaternary Fan Deposits
- Tertiary Sediments
- Bedrock
- Upper Jefferson Study Area



DRAFT

Groundwater Hydrographs. Note that x and y scales vary site to site.



Surface-Water Monitoring Network (52 sites – MBMG, Confluence, USGS)

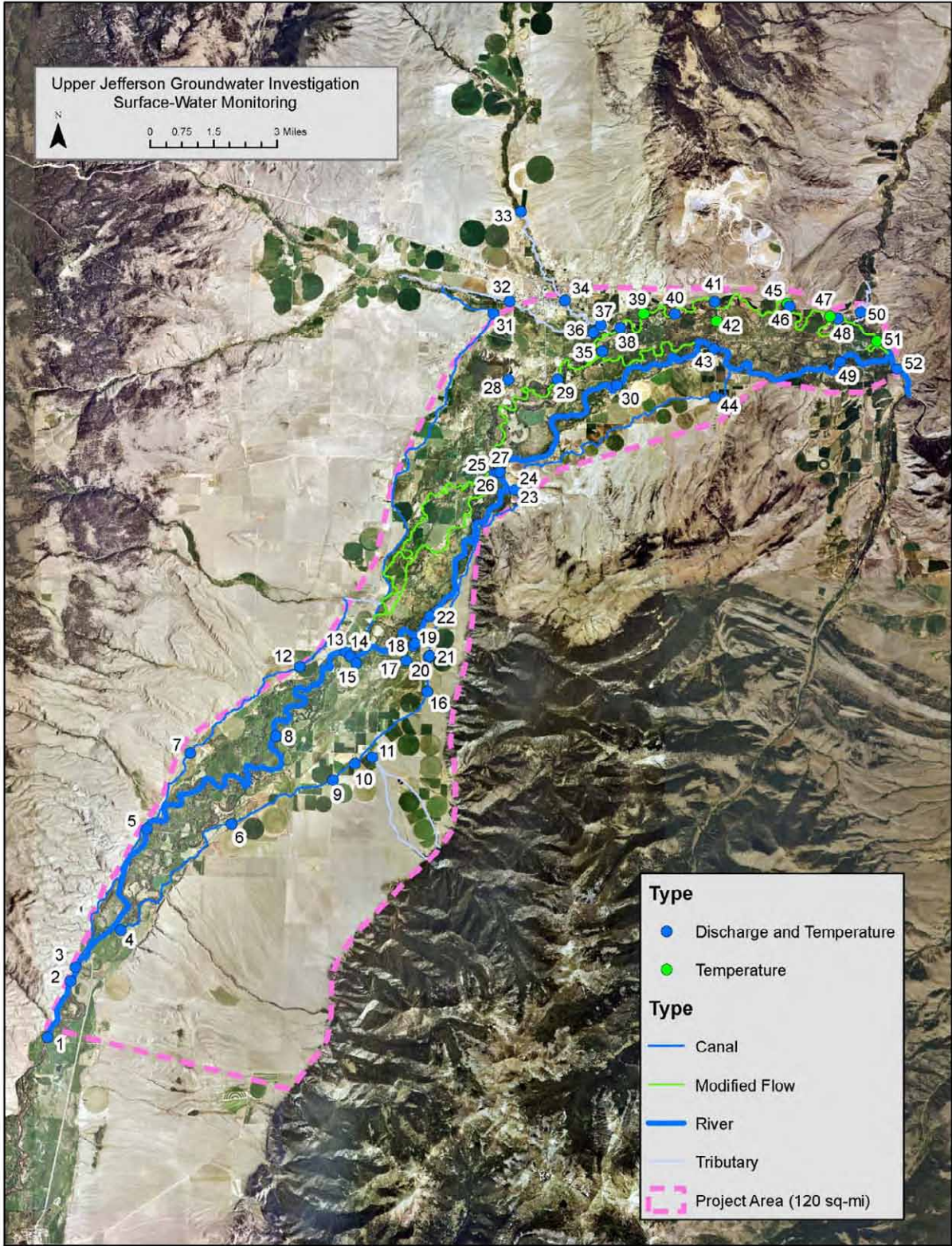
Stage, flow and stream temperature over space and time (linear network)

Flow Difference

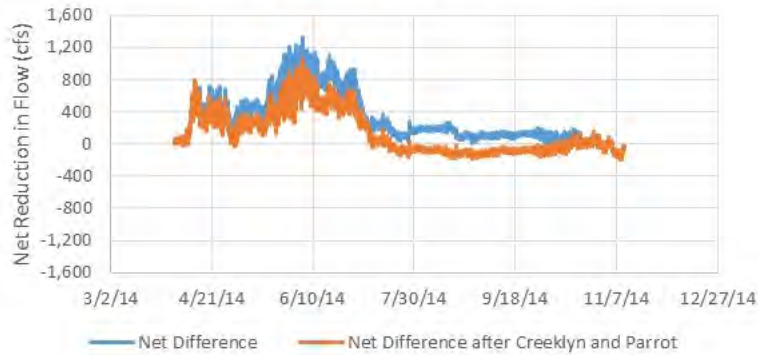
Temperature Difference

Groundwater Elevation vs. Surface-Water Elevation

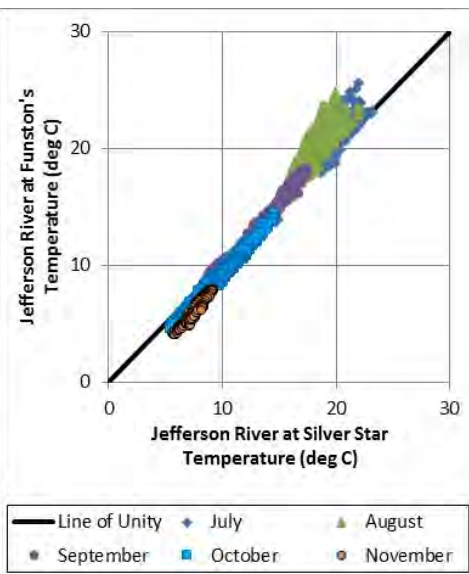
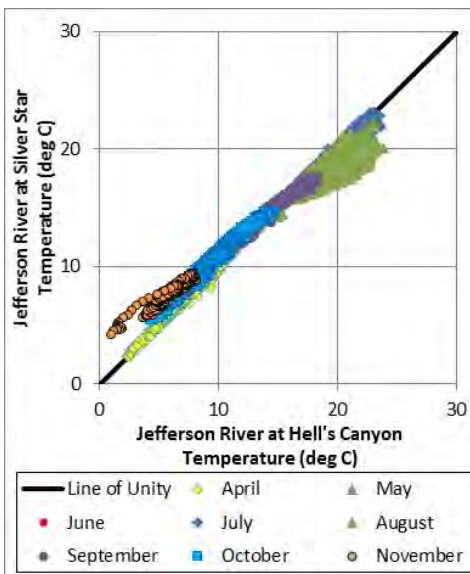
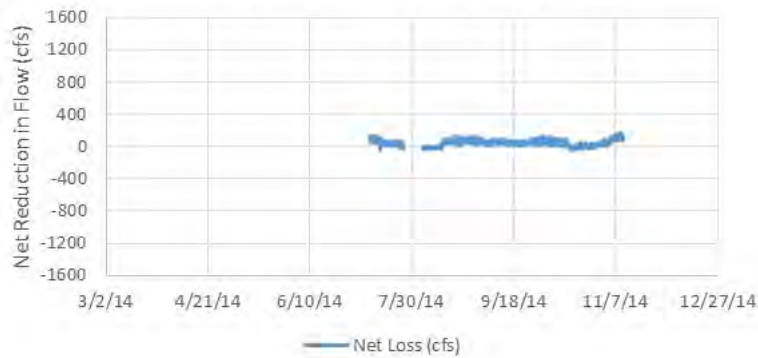
Groundwater Temperature vs. Surface-Water Temperature

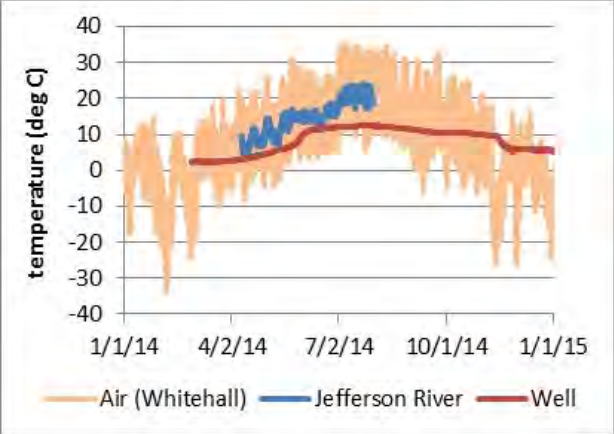
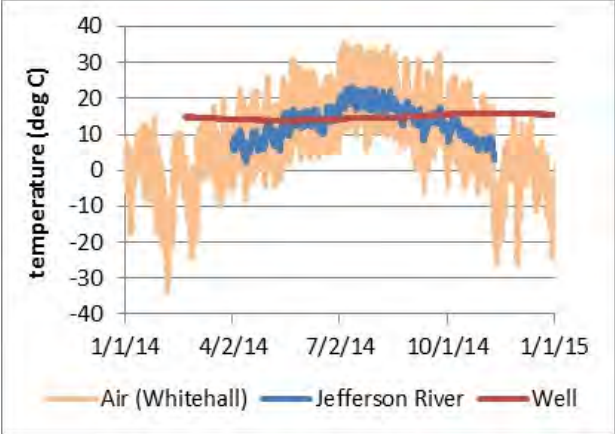
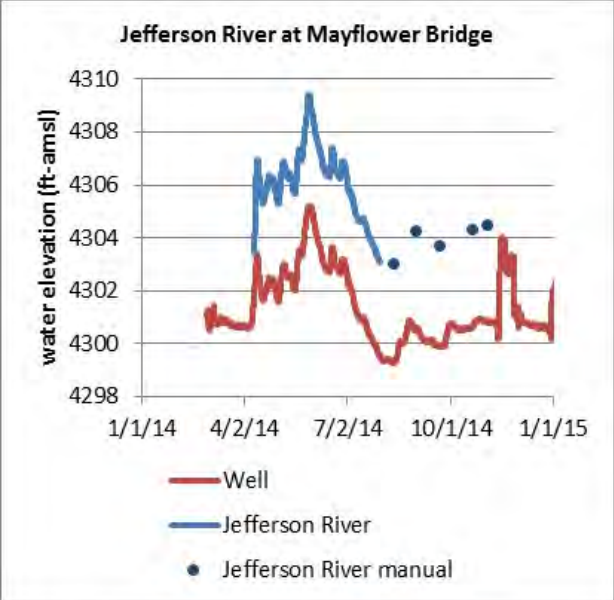
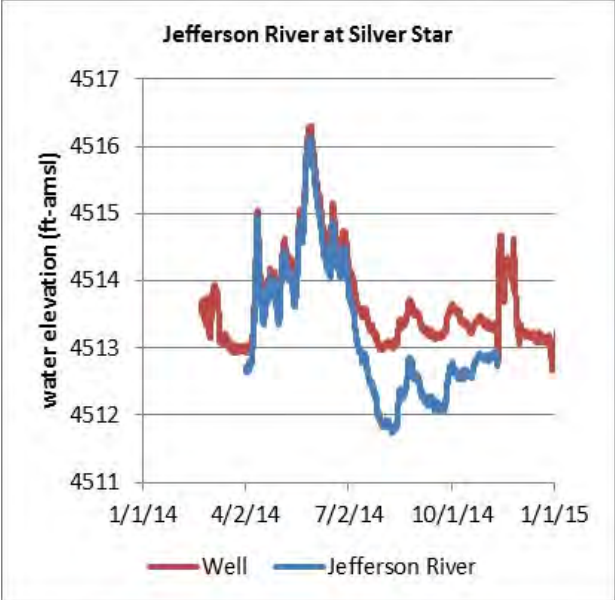


Jefferson River near Twin Bridges vs.
Jefferson River at Silver Star



Jefferson River at Silver Star vs.
Jefferson River at Funston's



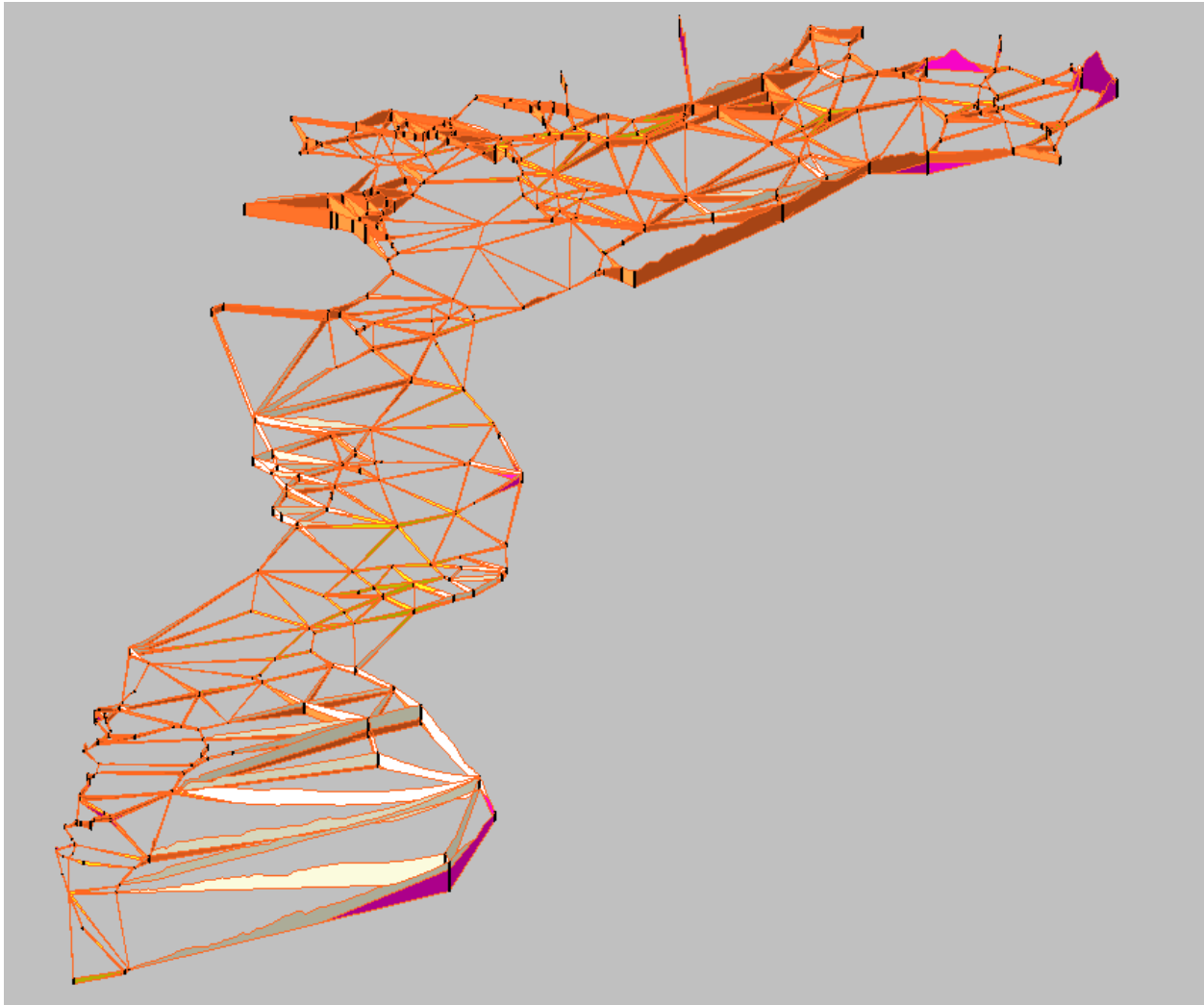


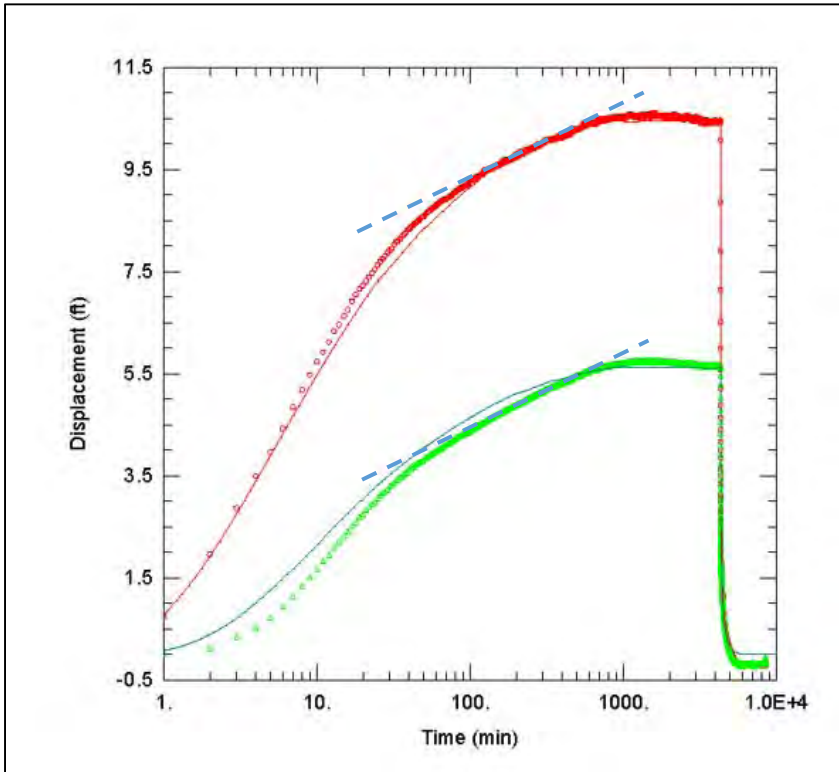
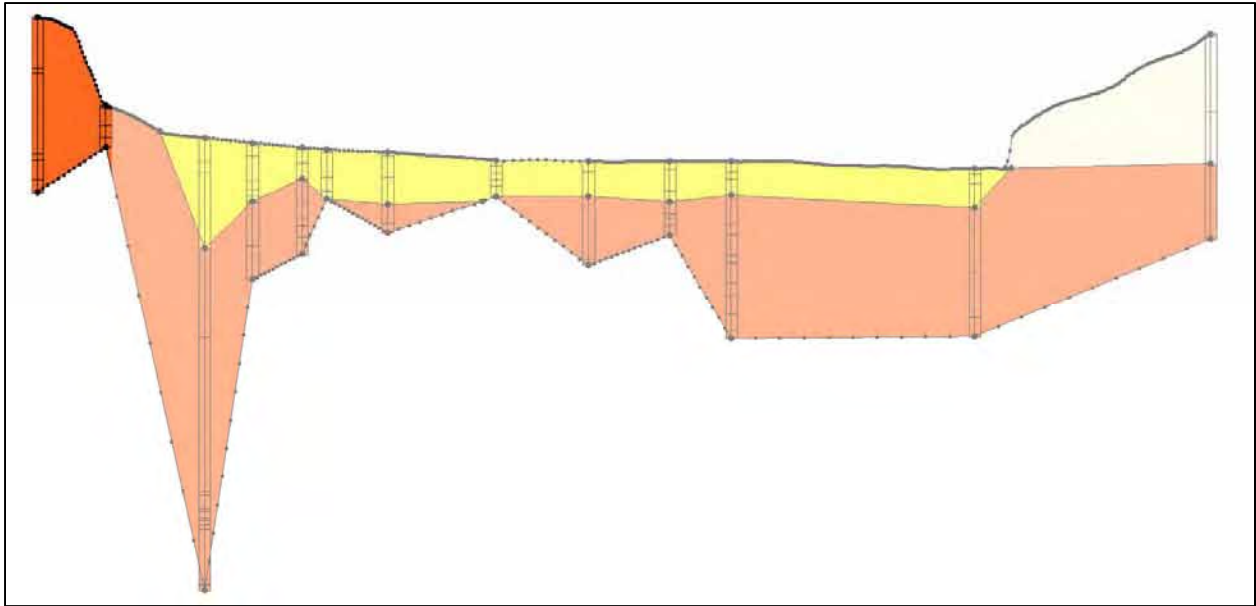
Geologic Model and Aquifer Tests

3D distribution of the hydrogeologic units

Determination of site specific aquifer properties

Information on hydrogeologic connections

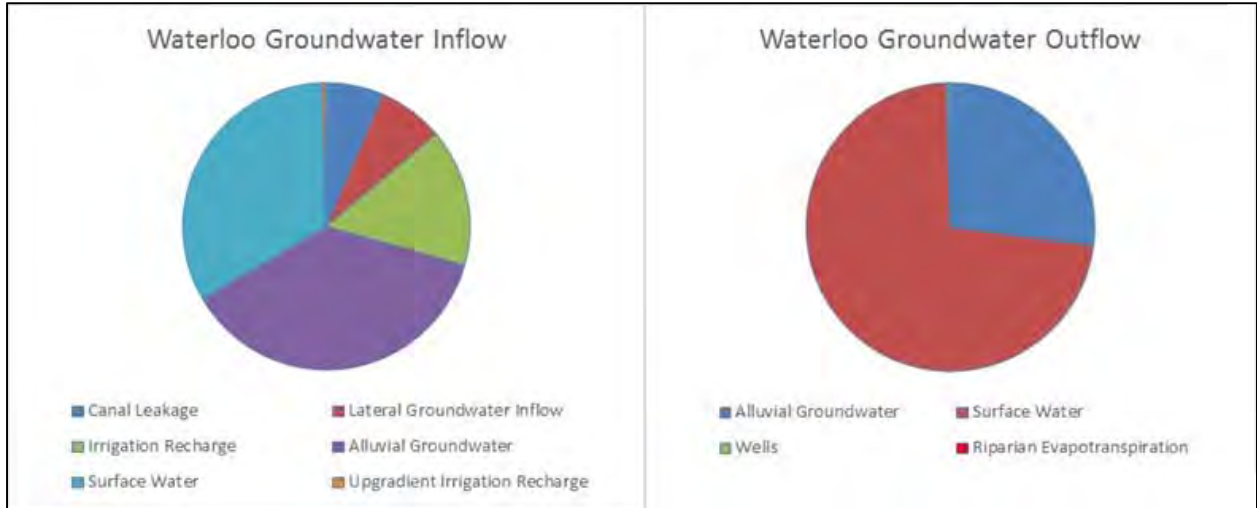




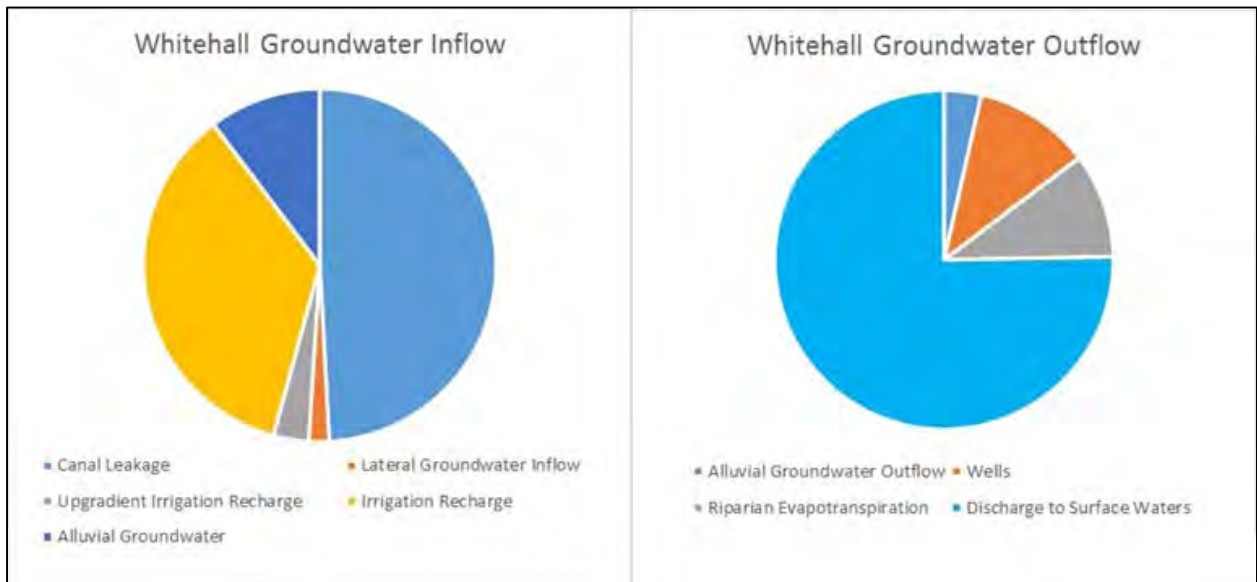
Groundwater Budgets for Waterloo and Whitehall Focus Areas

Nicole Brancheau Thesis from Montana Tech

Waterloo Budget



Whitehall Budget



Numerical Modeling

Combine observed groundwater levels, stream flows, aquifer test results, geologic model, and water budget to develop a single consistent model of the hydrogeologic system.

Once it is calibrated so that it replicates observations it can be used to answer complex questions.

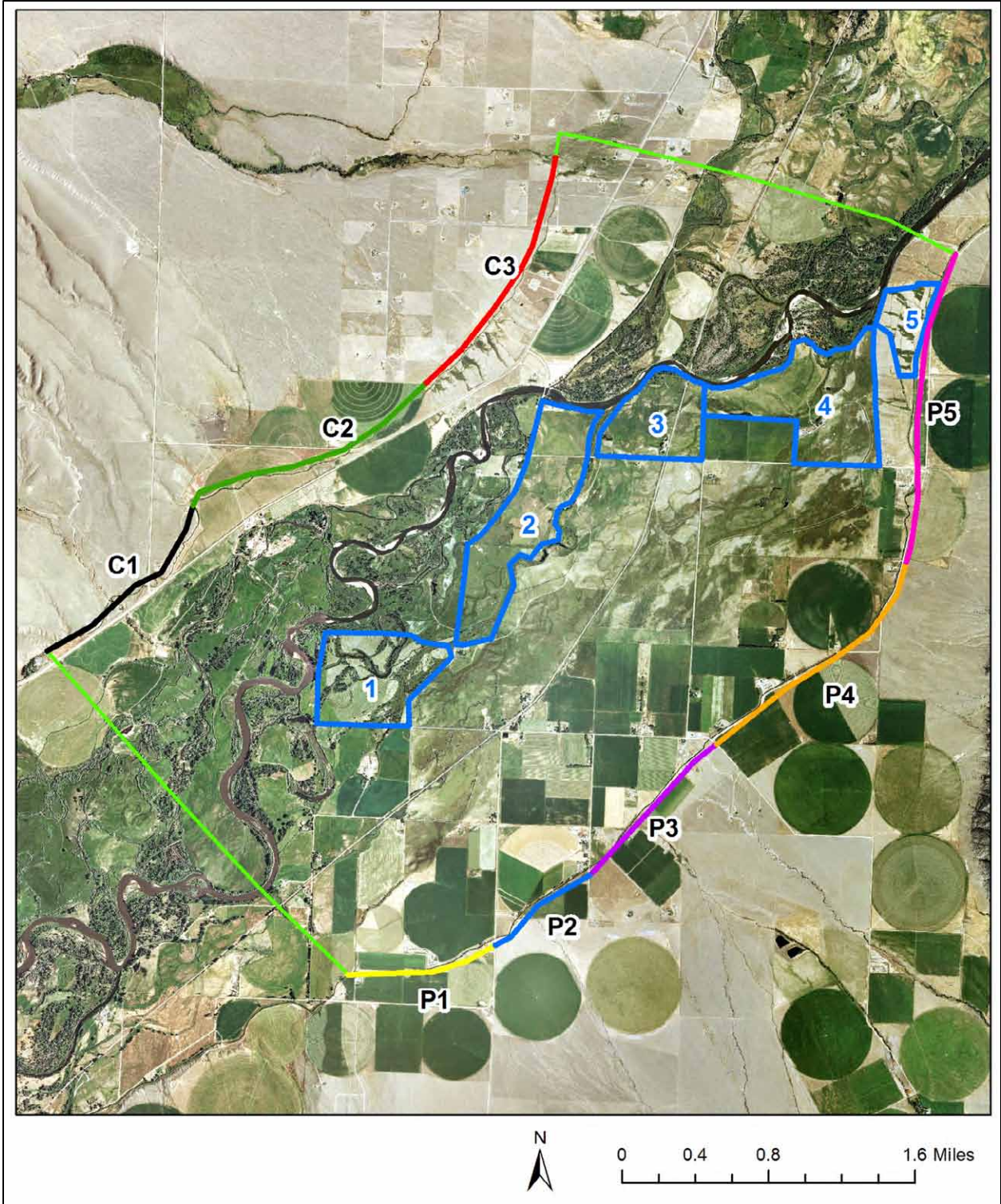
Waterloo Numerical Model

The Question: *What are the potential effects of changes in irrigation practices and canal management in the Waterloo area on groundwater flow to the spring fed Streams and the Jefferson River?*

- *In what areas would changes have the greatest effect?*

Run #	Scenario
0	Baseline
1	No Leakage – All Canals
2	No Leakage – Parrot 1
3	No Leakage – Parrot 2
4	No Leakage – Parrot 3
5	No Leakage – Parrot 4
6	No Leakage – Parrot 5
7	No Leakage – Creeklyn 1
8	No Leakage – Creeklyn 2
9	No Leakage – Creeklyn 3
10	Convert Flood to Pivot – Areas 1-5
11	Convert Flood to Pivot – Area 1
12	Convert Flood to Pivot – Area 2
13	Convert Flood to Pivot – Area 3
14	Convert Flood to Pivot – Area 4
15	Convert Flood to Pivot – Area 5
16	Combined #1 and #10 – No Leakage, all areas converted

Run #	Scenarios	Reduction in Jefferson River outflow (cfs)
0	Baseline	0.0
1	No Leakage – All Canals	17.0
2	No Leakage – Parrot 1	1.7
3	No Leakage – Parrot 2	4.1
4	No Leakage – Parrot 3	2.7
5	No Leakage – Parrot 4	3.3
6	No Leakage – Parrot 5	6.3
7	No Leakage – Creeklyn 1	4.9
8	No Leakage – Creeklyn 2	5.4
9	No Leakage – Creeklyn 3	4.8
10	Convert Flood to Pivot – Areas 1-5	12.8
11	Convert Flood to Pivot – Area 1	4.2
12	Convert Flood to Pivot – Area 2	3.6
13	Convert Flood to Pivot – Area 3	3.3
14	Convert Flood to Pivot – Area 4	9.4
15	Convert Flood to Pivot – Area 5	3.6
16	Combined #1 and #10	29.7



Waterloo Scenarios Map

Preliminary Waterloo Scenario Results

- #1 – No Canal Leakage
 - Willow Springs ~ 4 cfs reduction in August
 - Parson's Slough ~ 1.6 cfs reduction in August
 - Jefferson River ~ 16.6 cfs reduction in August
- #10 – Areas 1-5 convert to pivot
 - Willow Springs ~ 6.3 cfs reduction in August
 - Parson's Slough ~ 0.3 cfs reduction in August
 - Jefferson River ~ 12.6 cfs reduction in August
- #16 - #1 and #10 combined
 - Willow Springs ~ 10.1 cfs reduction in August
 - Parson's Slough ~ 1.8 cfs reduction in August
 - Jefferson River ~ 29.1 cfs reduction in August

Currently writing up Waterloo model, developing Whitehall model, and preparing interpretive report.