



An Overview of the Upper Jefferson Groundwater Investigation

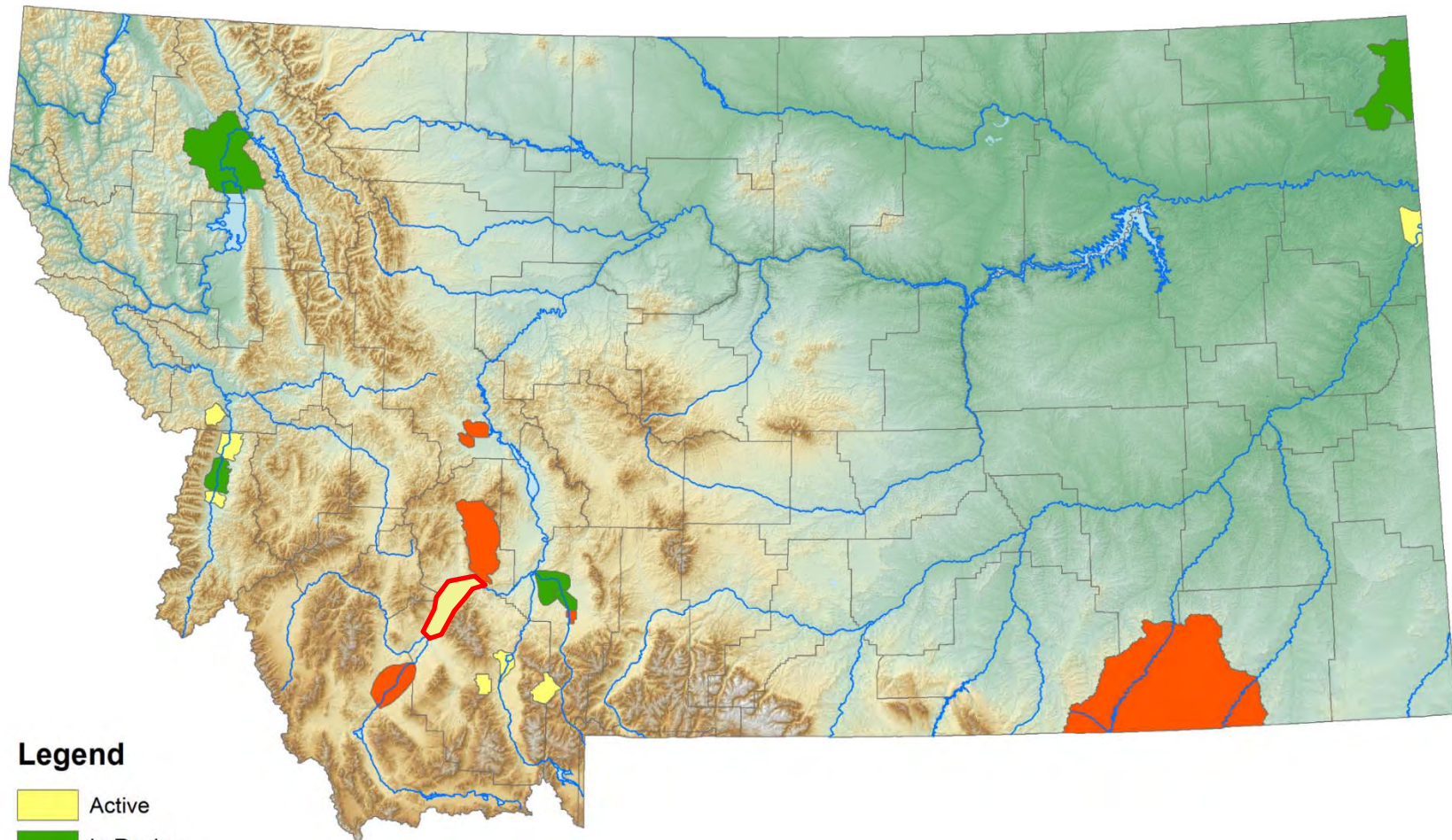
Andy Bobst – Sr. Hydrogeologist/Team Lead

Montana Bureau of Mines and Geology (MBMG)
Ground Water Investigations Program (GWIP)

406-496-4409; abobst@mtech.edu

Ground Water Investigation Program

Specific groundwater questions that are ranked as the most urgent within the State



Legend

- Active
- In Review
- Completed

- Housing development
- Expansion of Agriculture
- Industrial and Commercial Growth



Acknowledgements

Supporters:

Jefferson County

Madison County

Golden Sunlight Mine

Landowners:

Dean Hunt

Gary Nelson

John Kountz

Mark Hoyt

Lazy TP Ranch

many others

MTech Students:

Nicole Decker, Mike Shirley, and Corey Swisher

MBMG Help:

Ali Gebril, Julie Butler, Camela Carstarphen, Jeremy Crowley, Tom Michalek, James Rose, Dean Snyder, Mary Sutherland, and Mark Wolfram

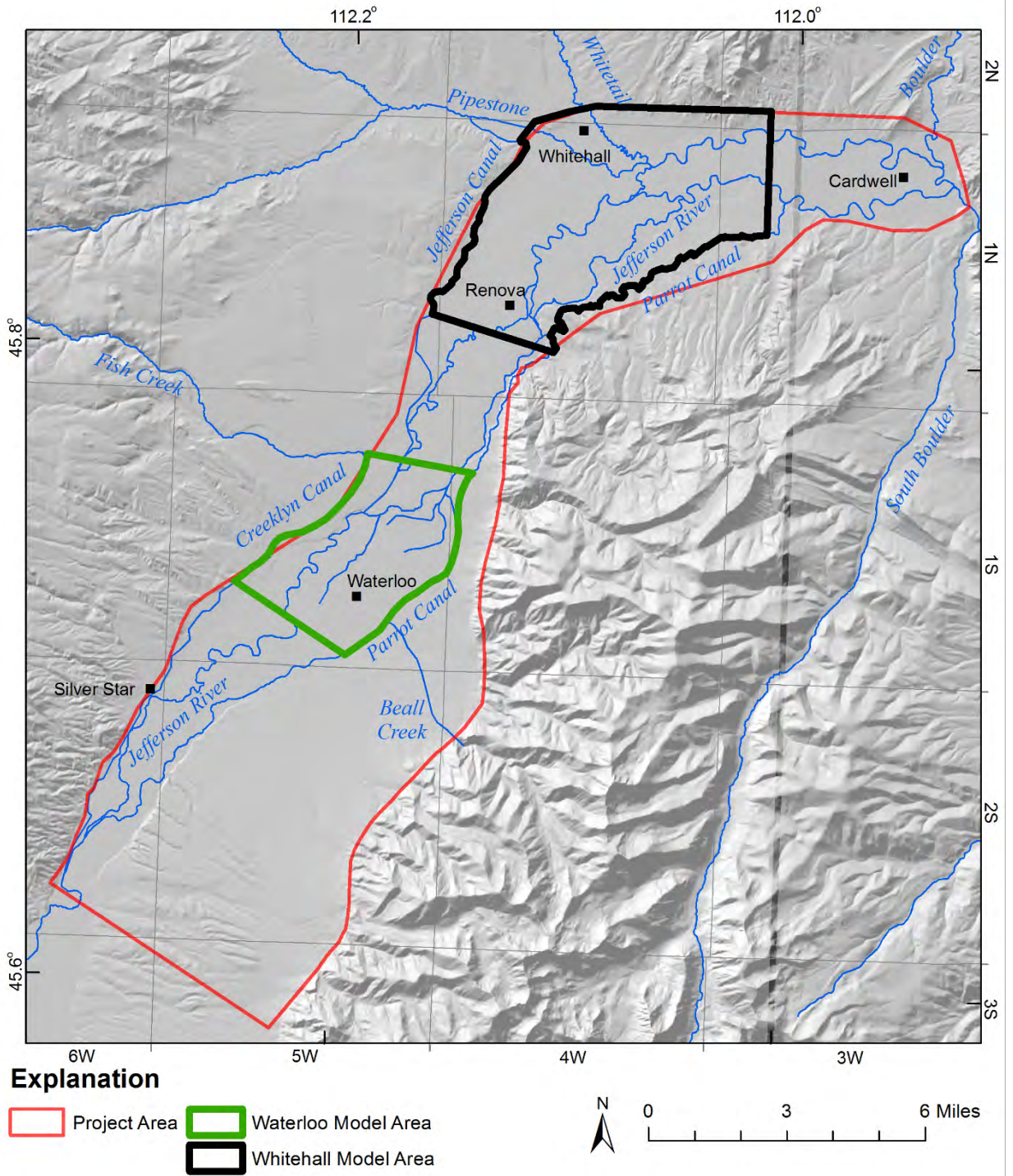
Upper Jefferson Groundwater Investigation

Effects to surface water
flows from land use
changes in the Waterloo
Area

- Lining Canals
- Conversion from flood to pivot irrigation.

Effects to surface water
flows from housing
developments in the
Whitehall Area

- Groundwater Pumping
- Change in land use





Study Approach

Monitoring

Groundwater

Surface Water

Understand Stream Gains and Losses

Geologic Model

Aquifer Tests

Groundwater Budgets

Develop and Calibrate Numerical Models

Network of Related Equations

Use Models to make Predictions

Groundwater Monitoring



Drilling

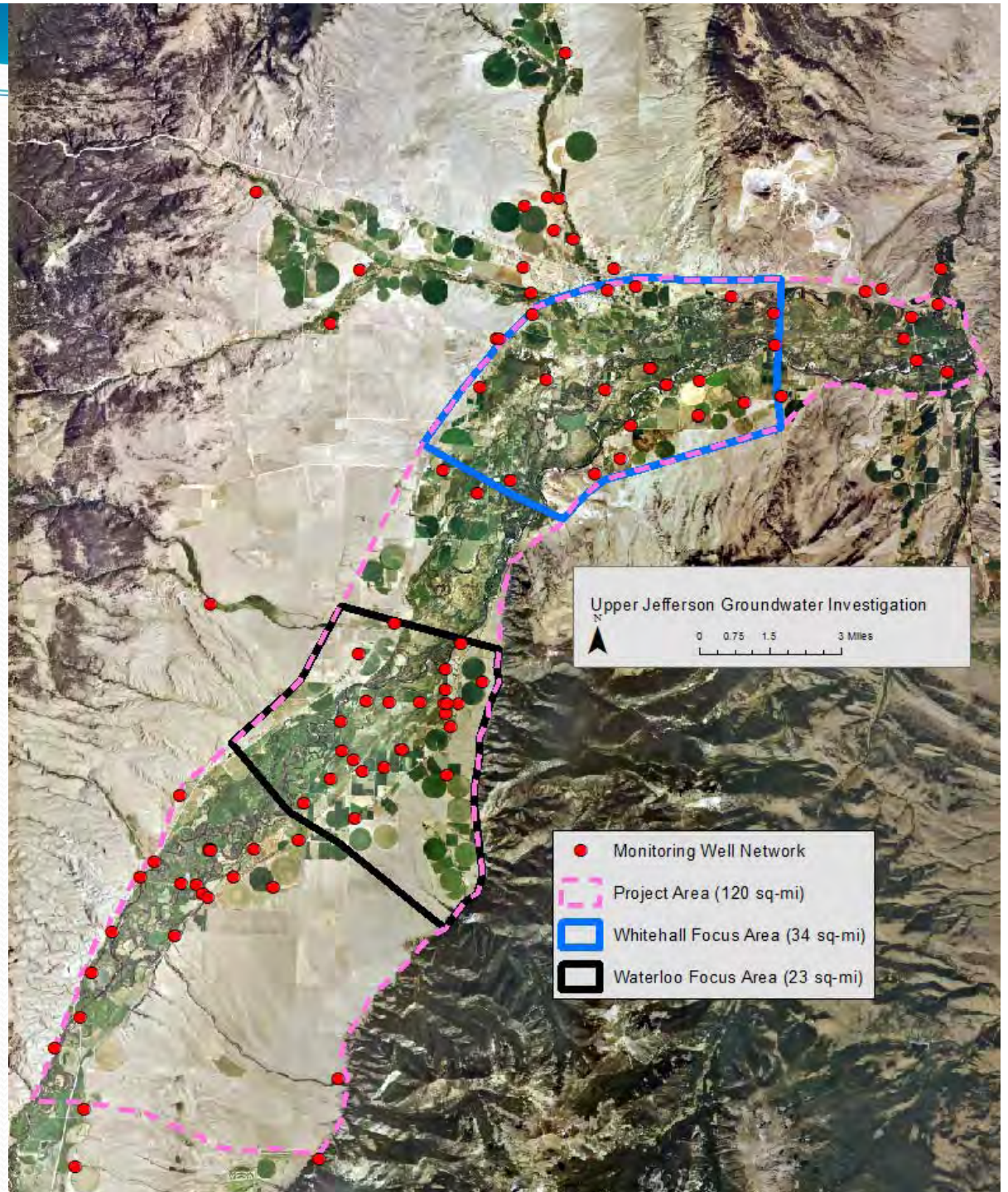


Monitoring
Wells

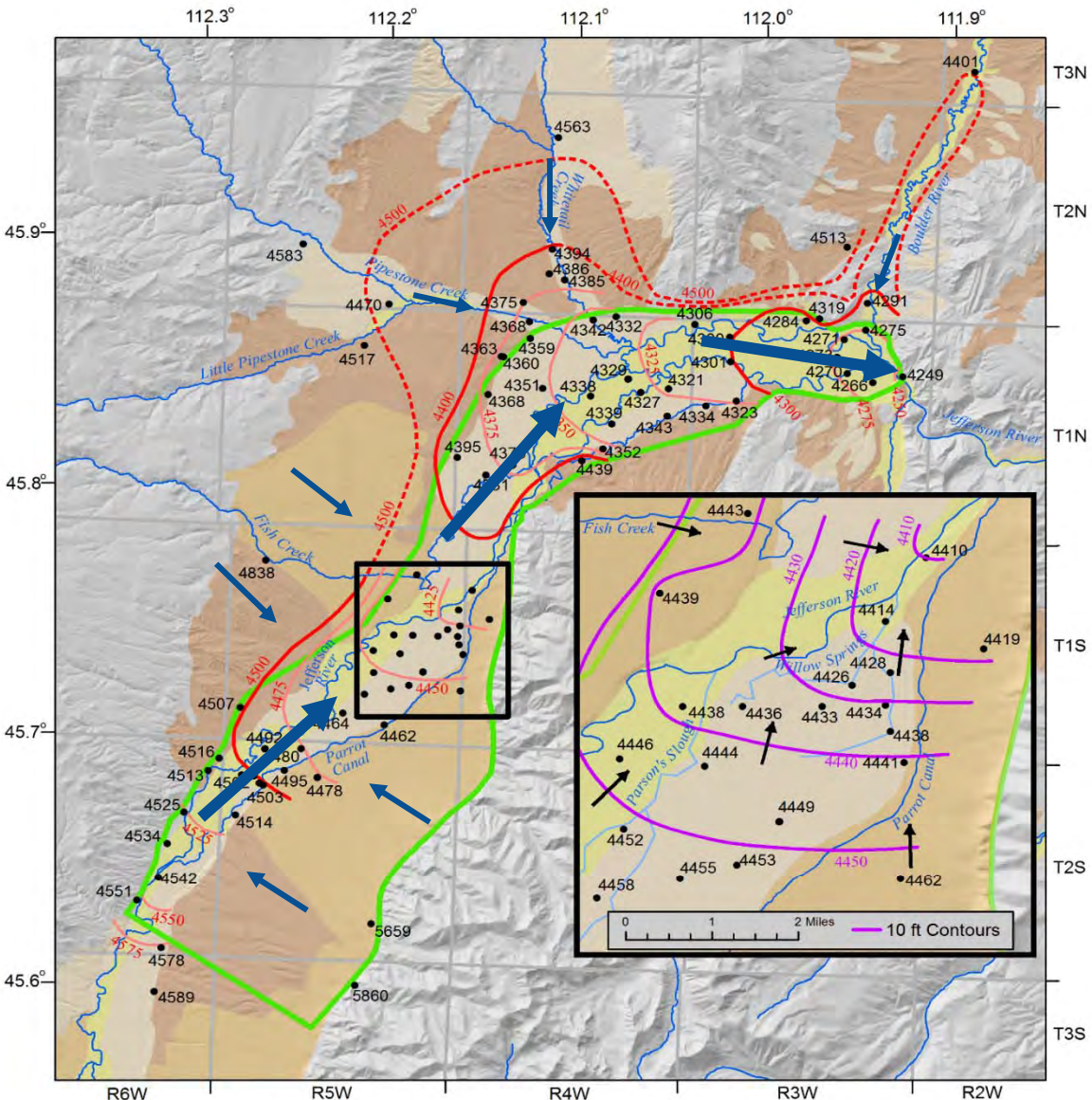
Aquifer Test
Sites

Groundwater Monitoring Network

- 103 wells
- Monthly
- July 2013 to May 2015



Potentiometric Surface

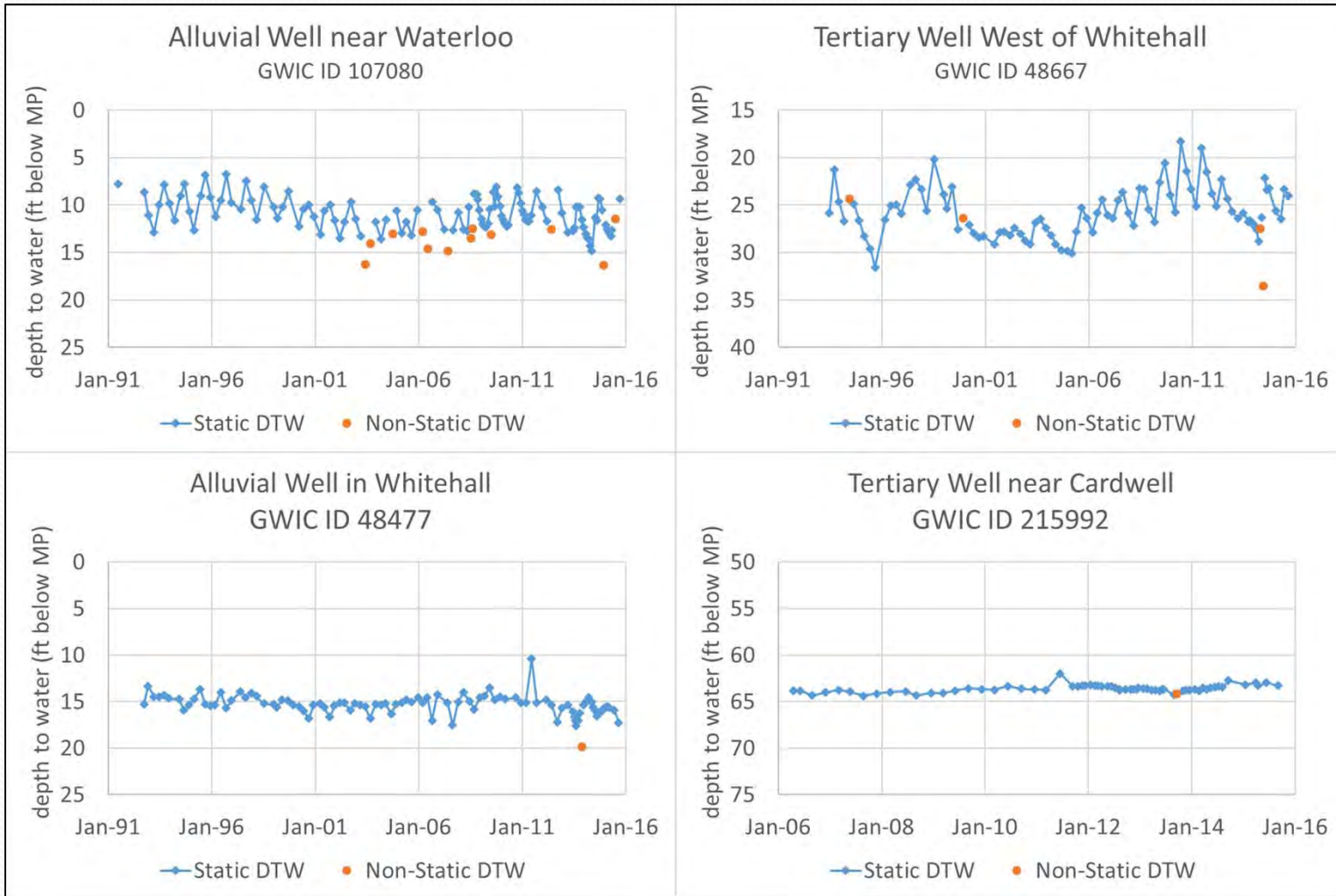


Explanation

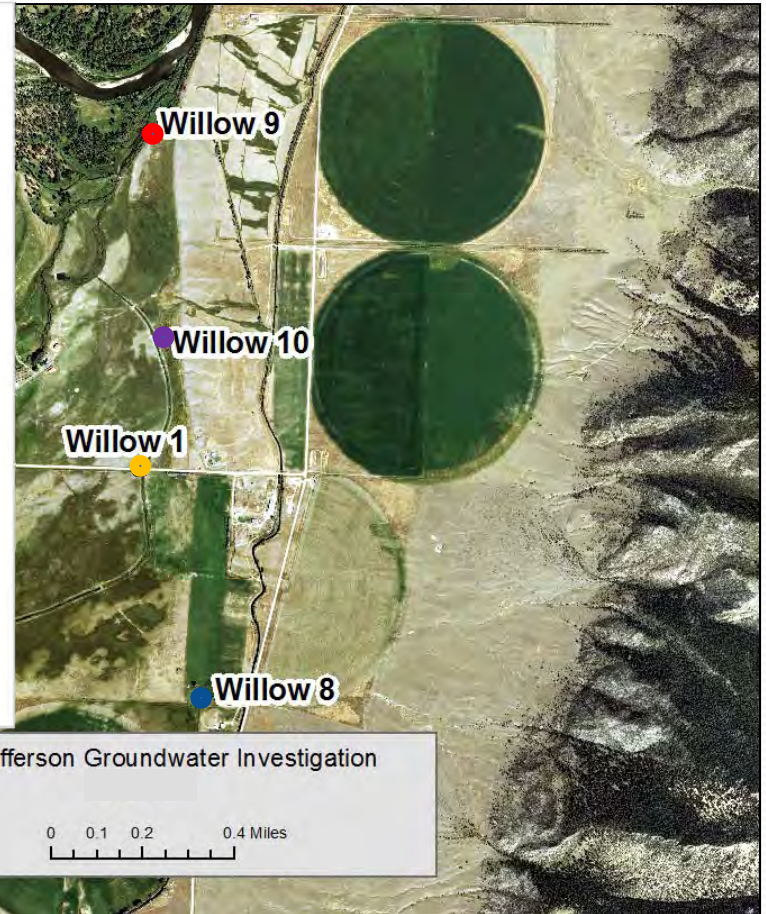
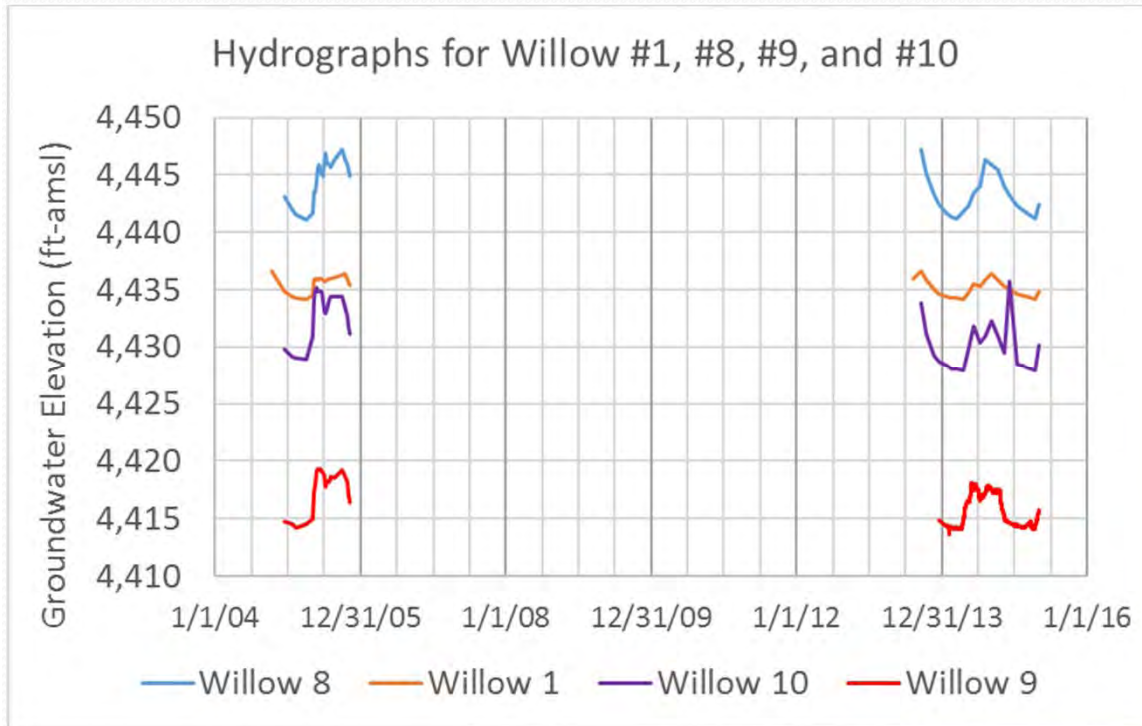
- April 2015 Monitored Wells
- Potentiometric Contours**
 - 100 ft Contours
 - - - Interpolated 100 ft Contours
 - 25 ft Contours
- Hydrogeologic Units**
 - Quaternary Alluvium
 - Quaternary Gravel
 - Quaternary Fan Deposits
 - Tertiary Sediments
 - Bedrock
- Quaternary Fan Deposits
- Tertiary Sediments
- Bedrock
- Upper Jefferson Study Area

Preliminary

Long-Term Hydrographs (MBMG's GWAAMON Network)



Selected sites near Willow Springs



2005 data from WET

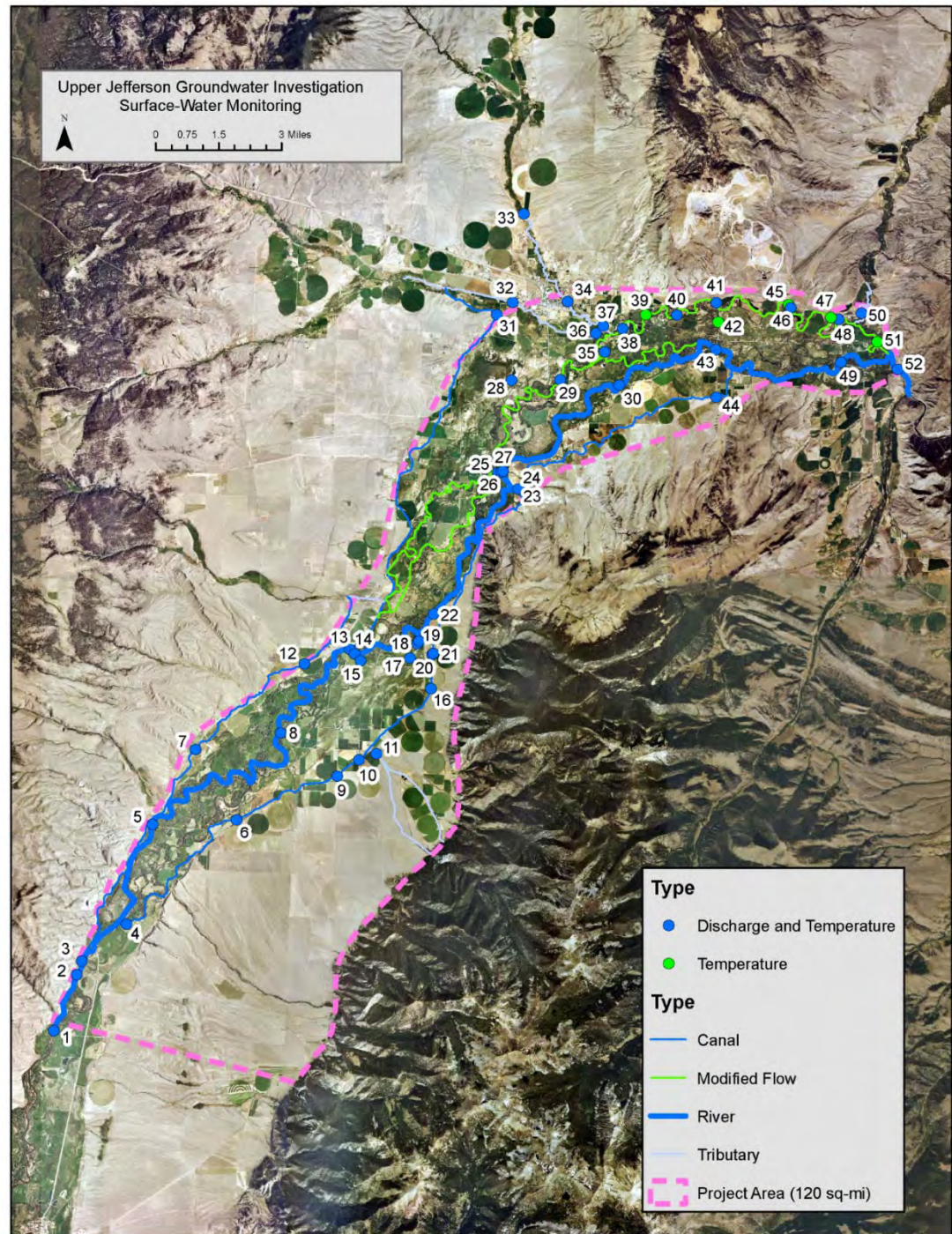
Flow is toward the river
No noticeable change from 2005 to 2014

Surface-Water Monitoring



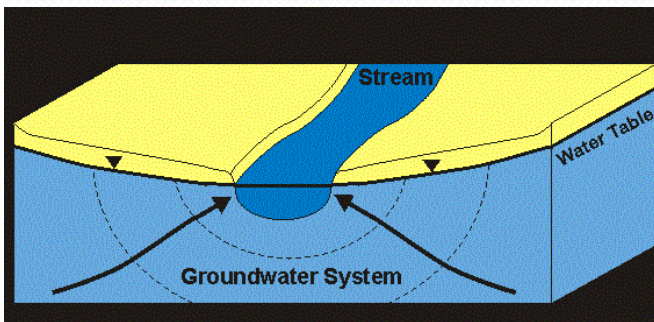
Surface-Water Monitoring Network

- 52 sites
 - MBMG 39
 - Confluence 11
 - USGS 2

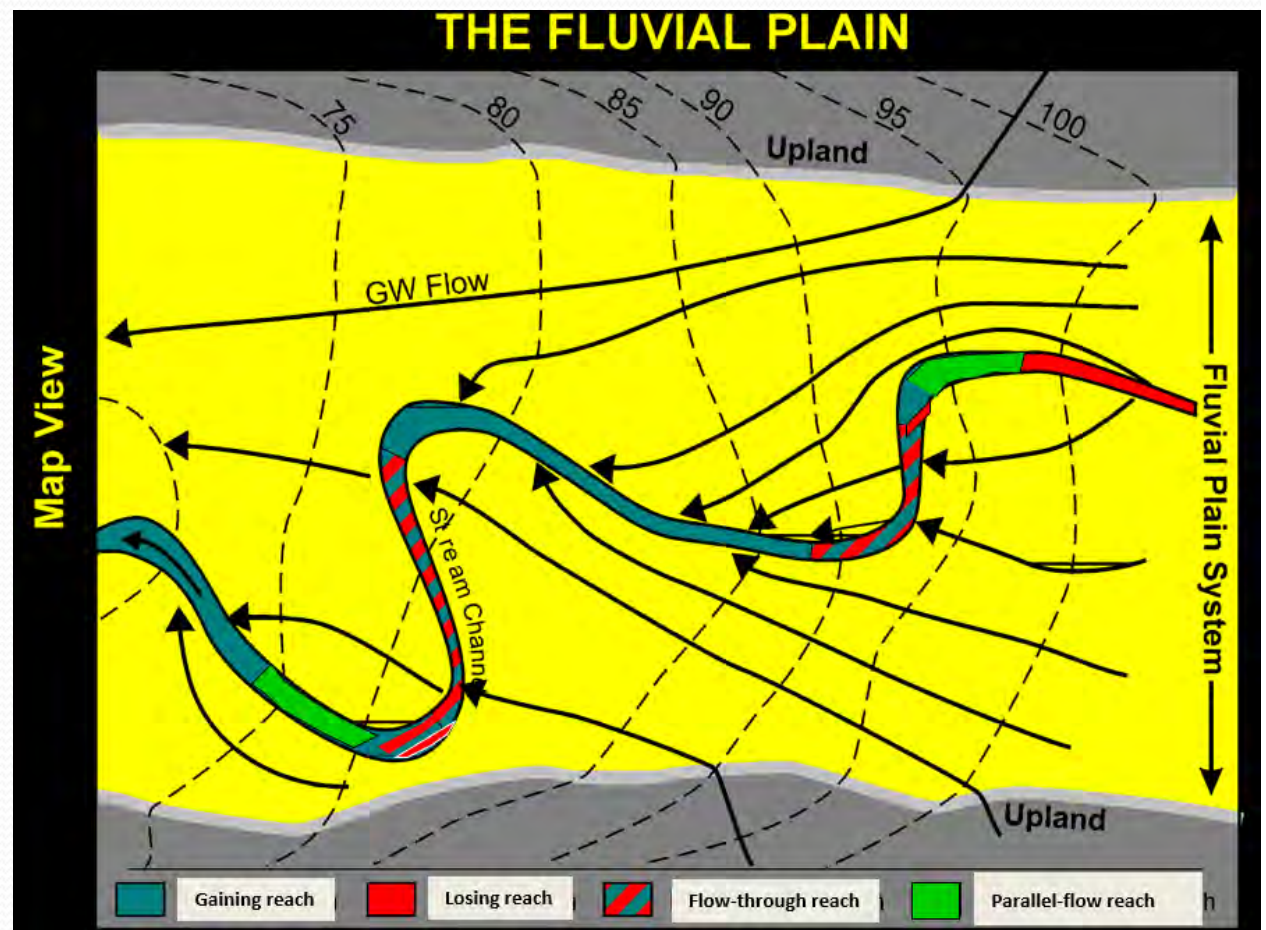
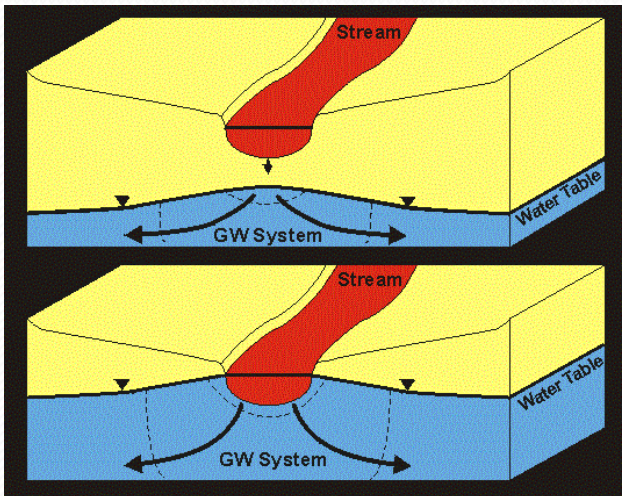


Surface-Water/Groundwater Interactions

Gaining Stream

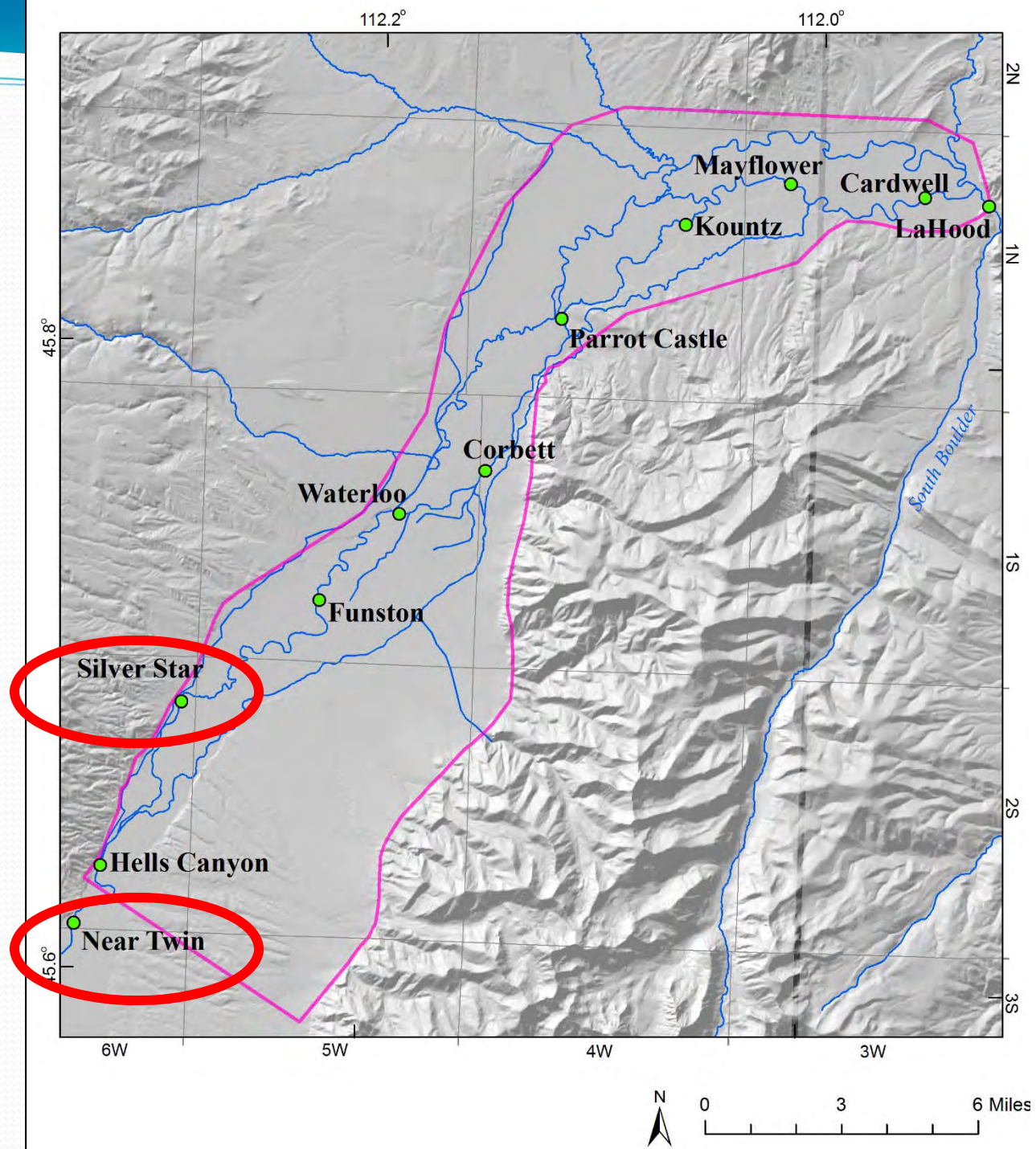


Losing Stream

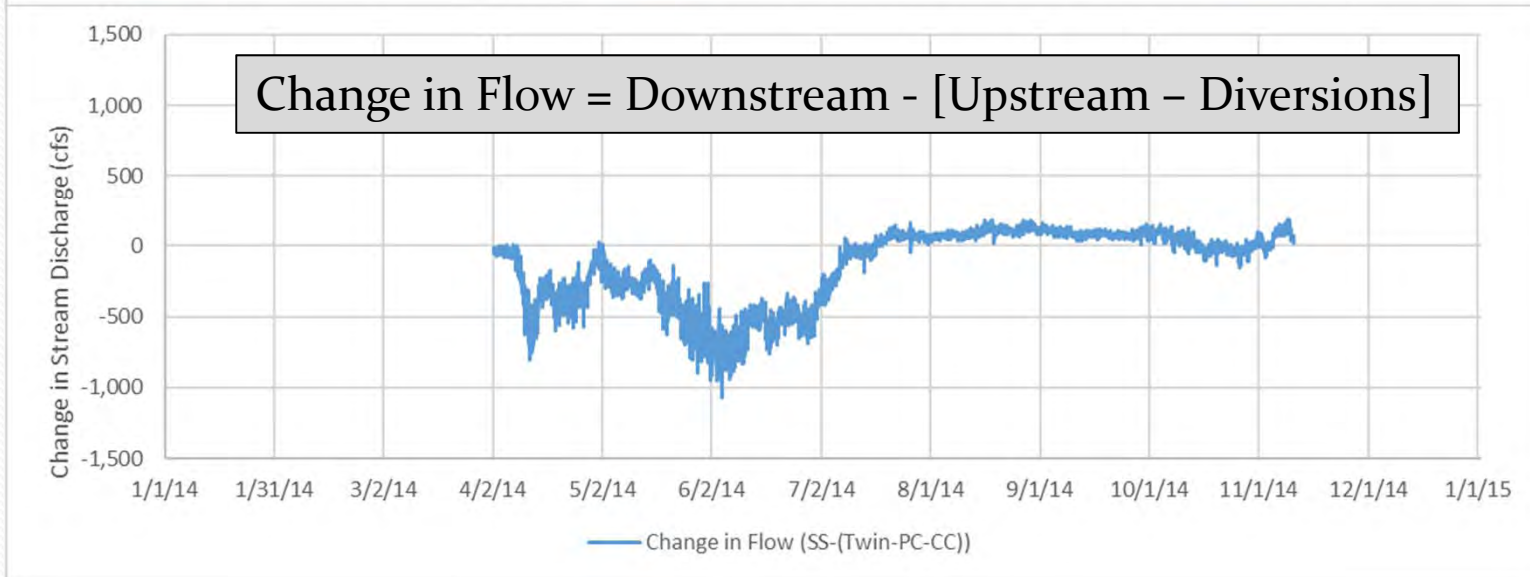
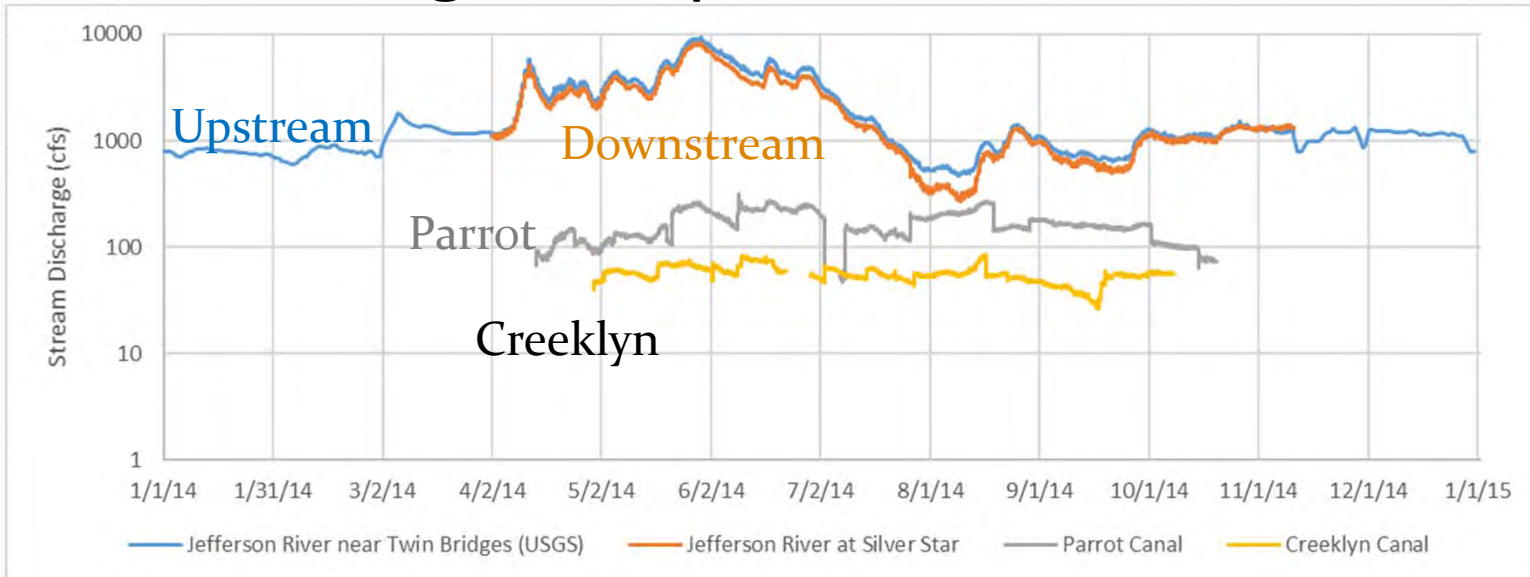


Figures from W. Woessner

Jefferson River Sites

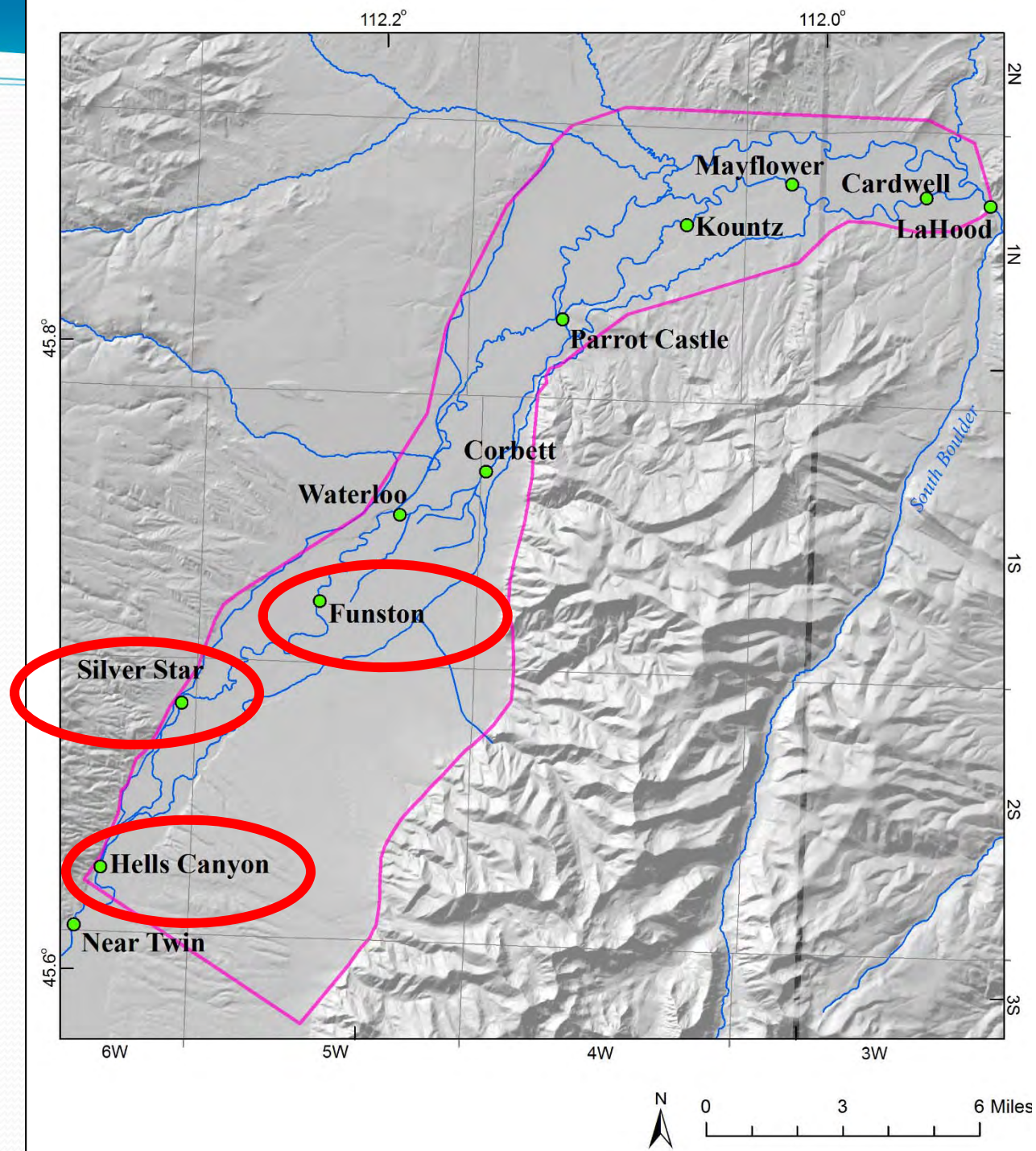


Discharge Comparison

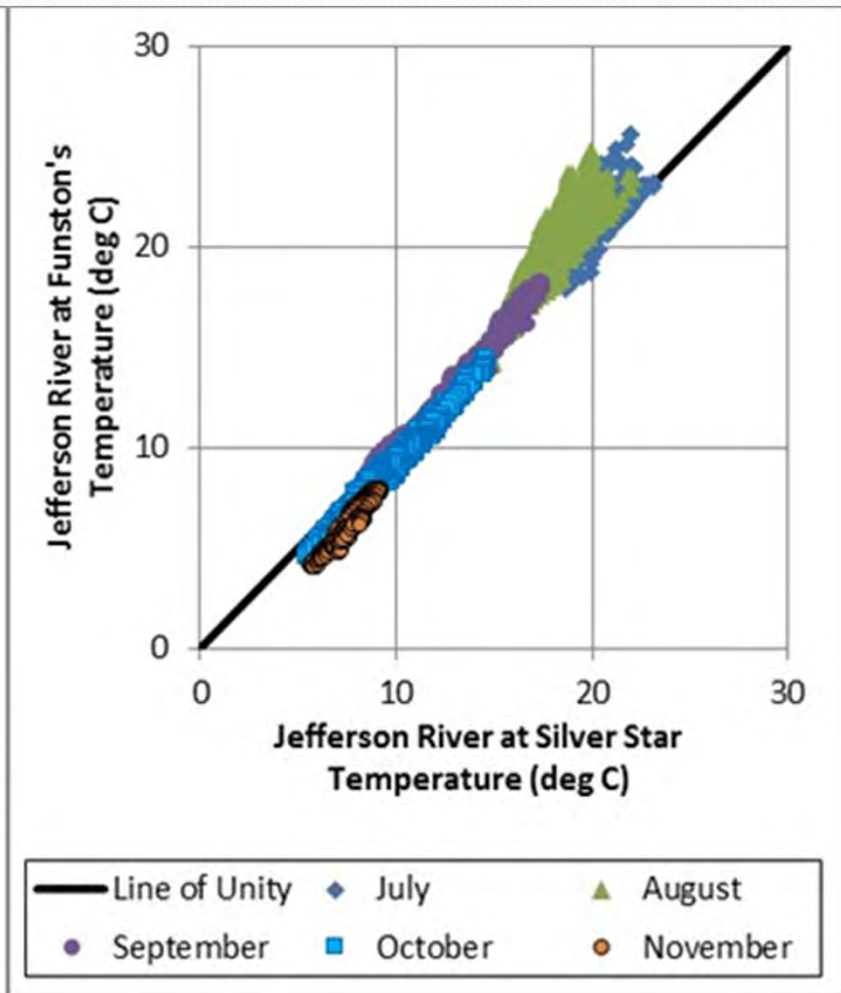
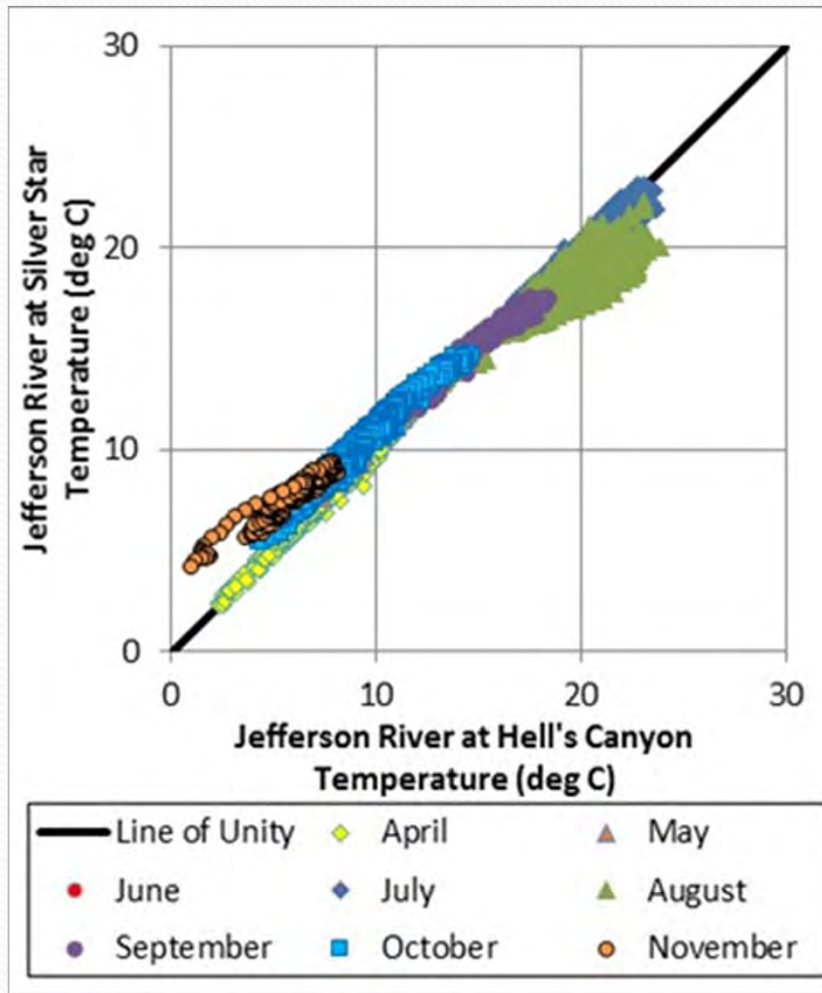


Preliminary

Jefferson River Sites

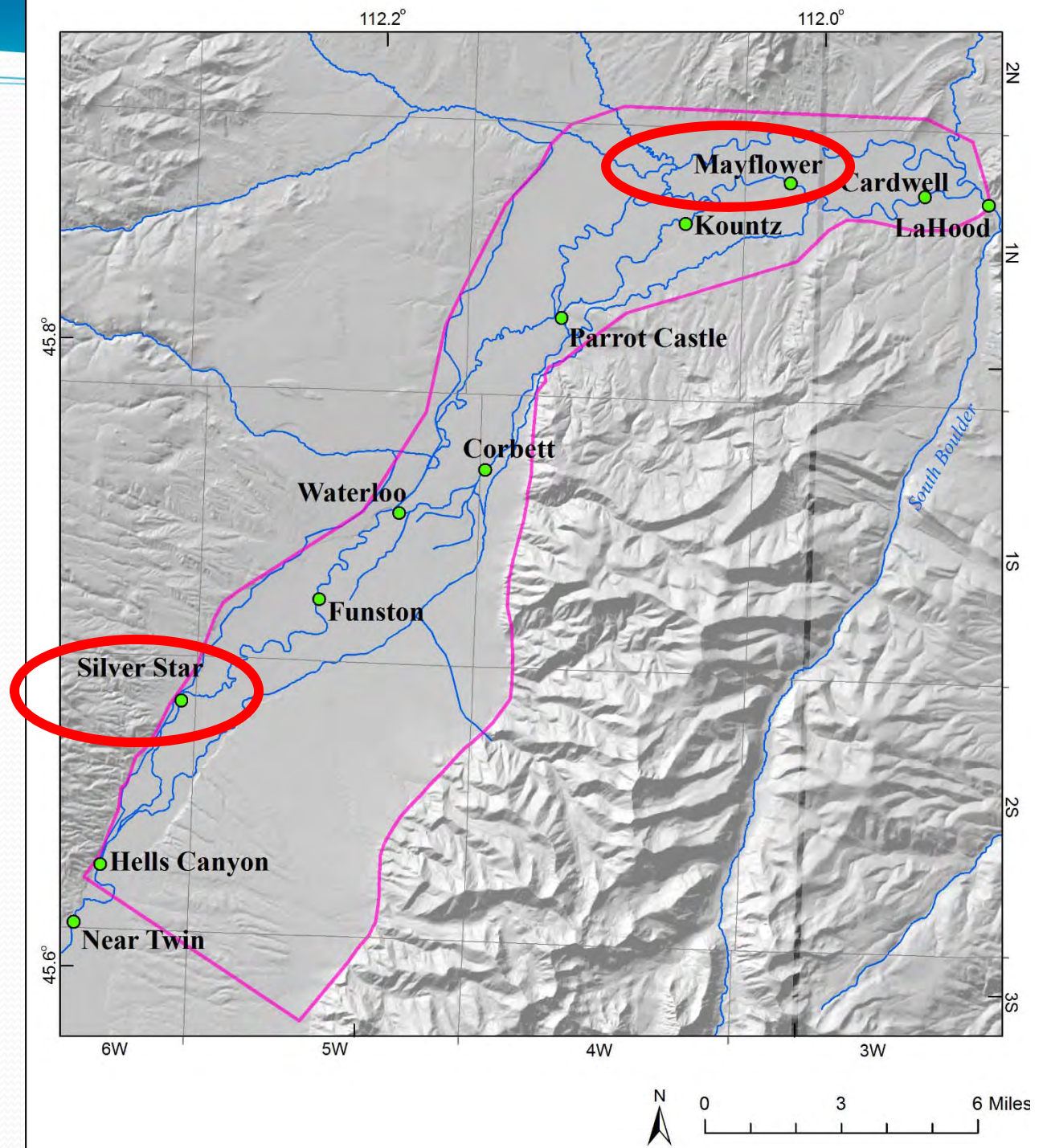


Stream Temperature

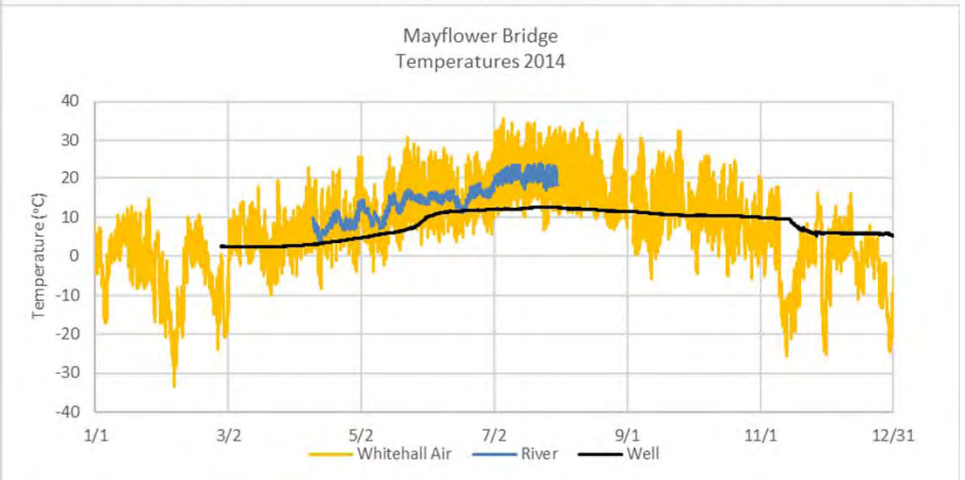
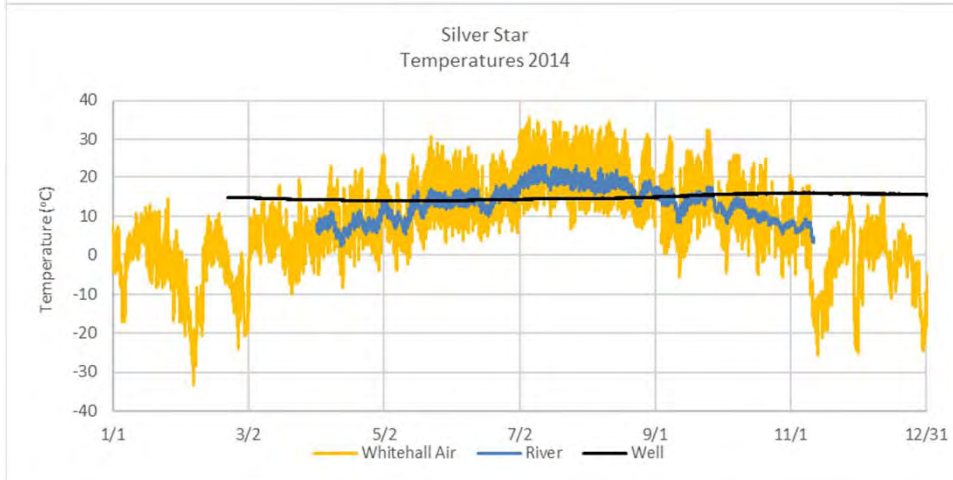
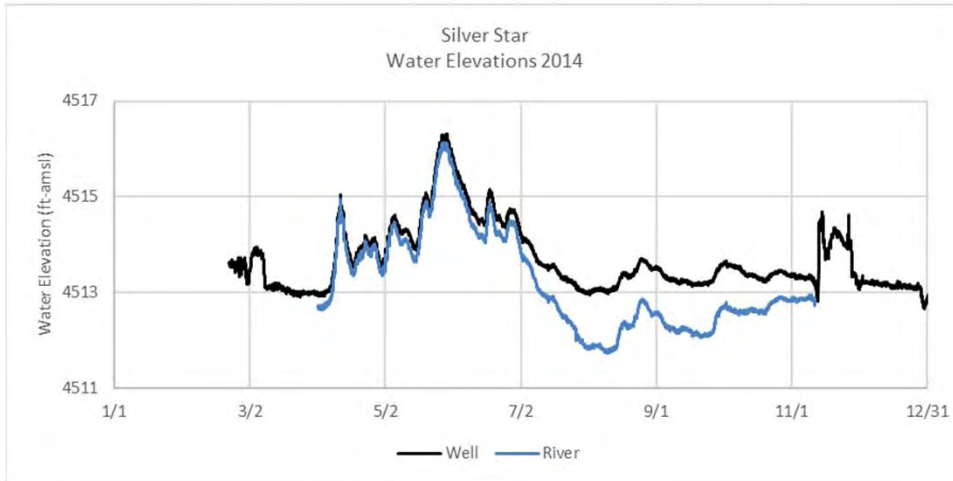


Preliminary

Jefferson River Sites

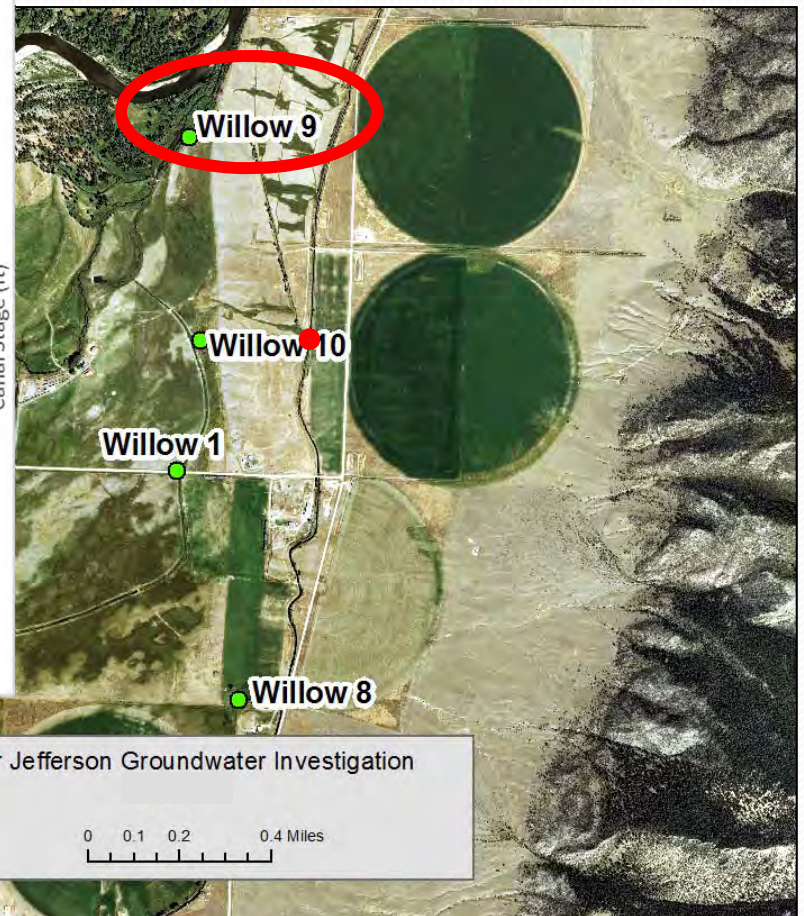
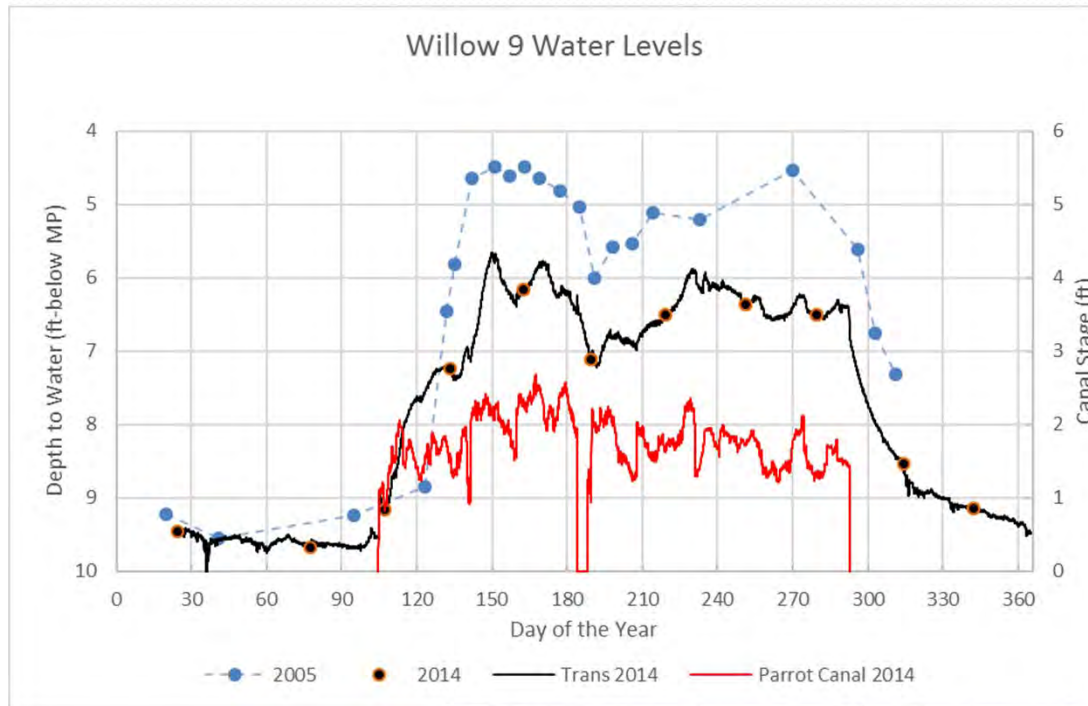


Stream and Groundwater Elevations and Temperatures



Preliminary

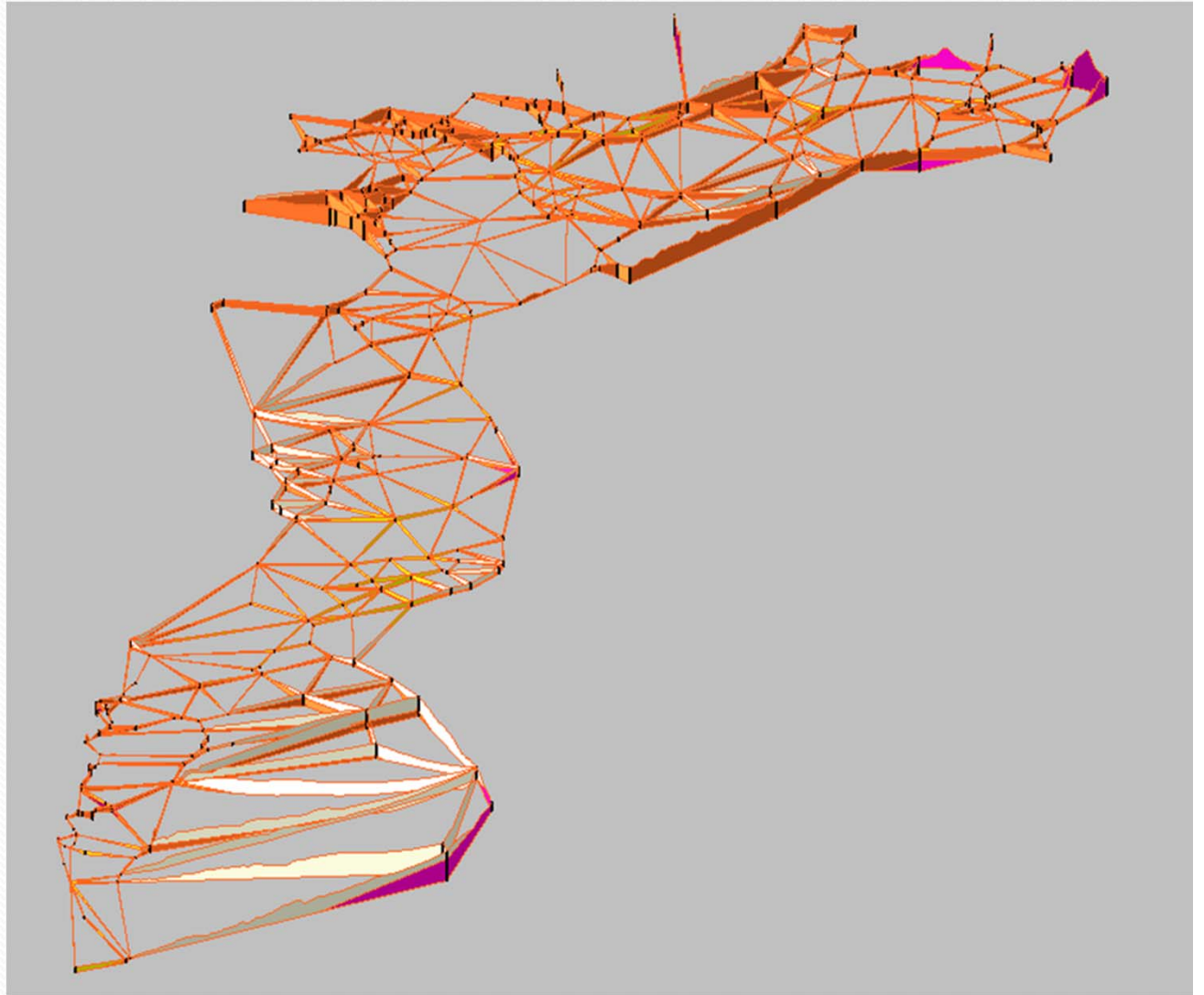
Selected sites near Willow Springs



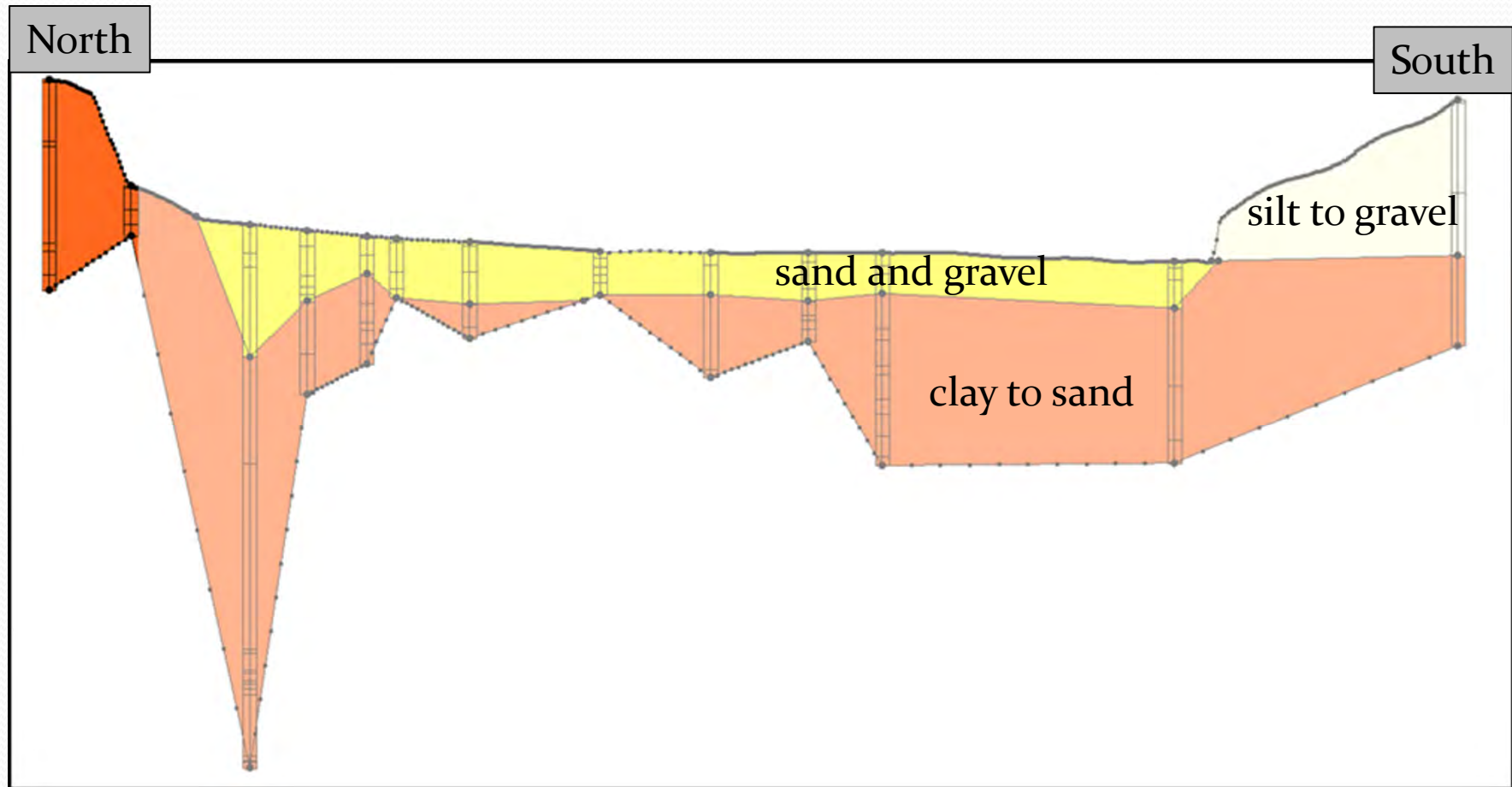
Levels peak in May through September
Lowest levels in Winter

Hydrogeologic Model

- 1,247 Wells in GWIC used to develop a network of cross sections

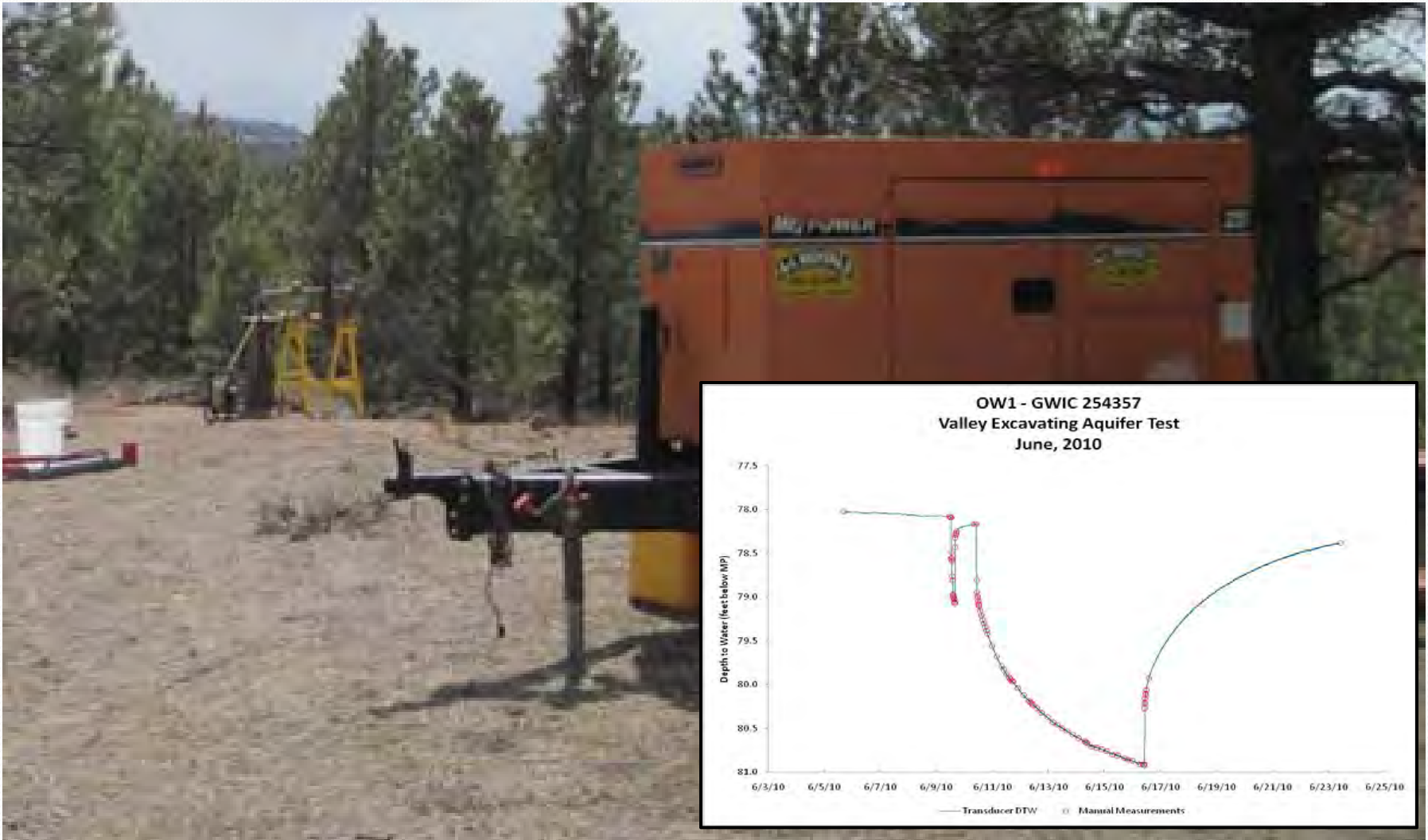


Hydrogeologic Model Example Cross-Section

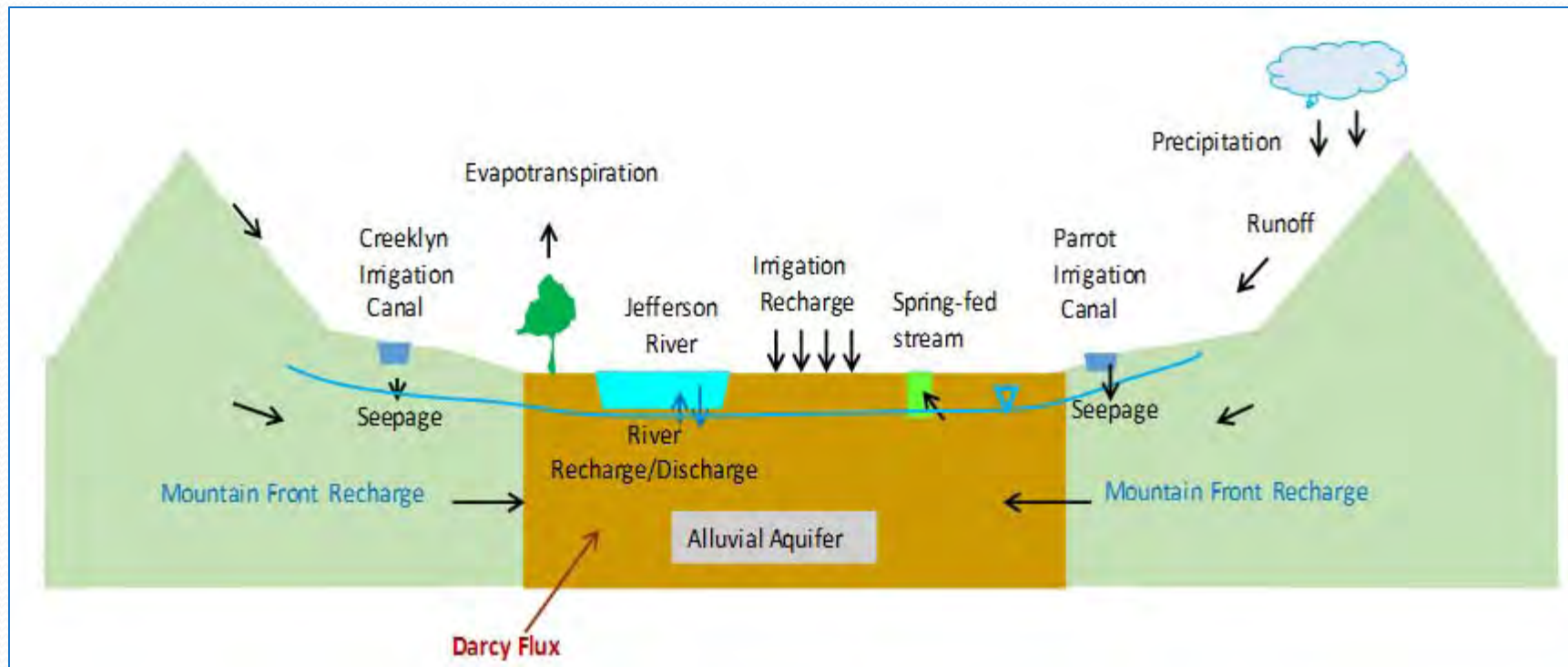


Preliminary

Aquifer Tests



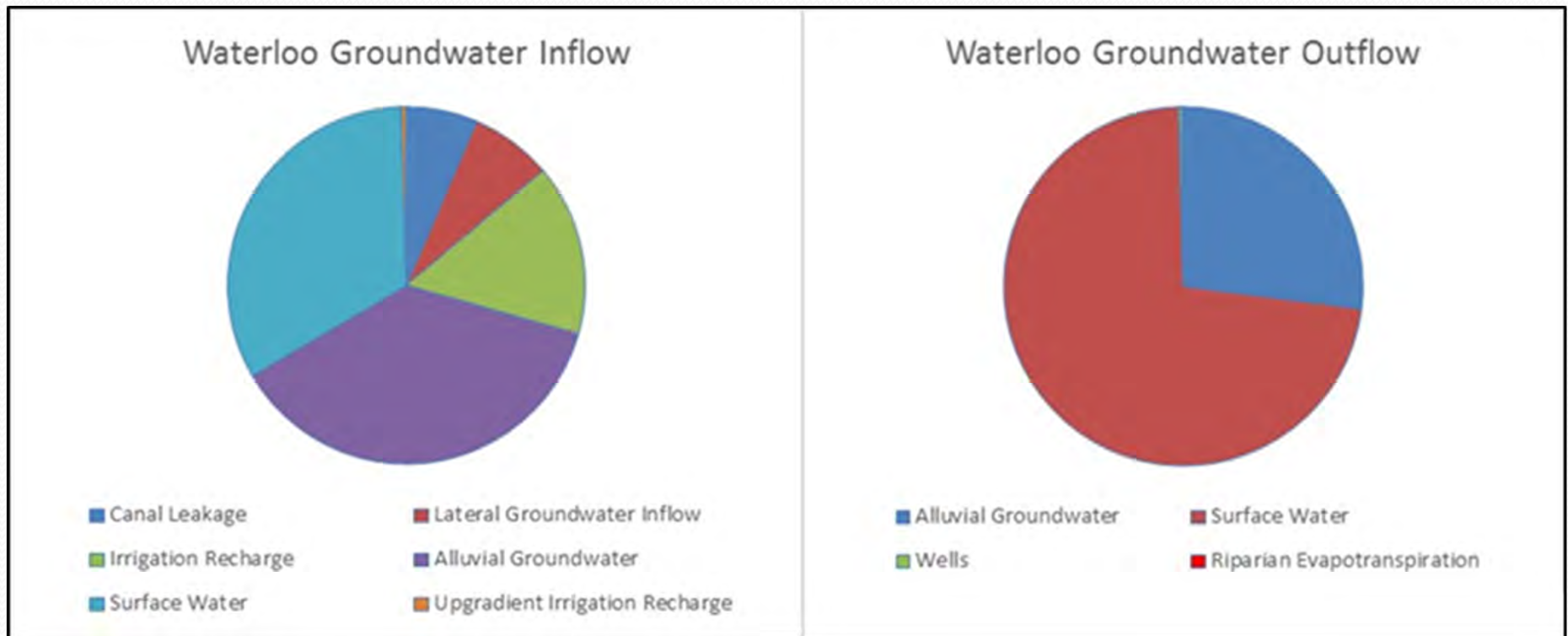
Annual Groundwater Budget



Flow In = Flow Out \pm Changes in Storage

Stable Groundwater Levels, so Change in Storage ~ 0

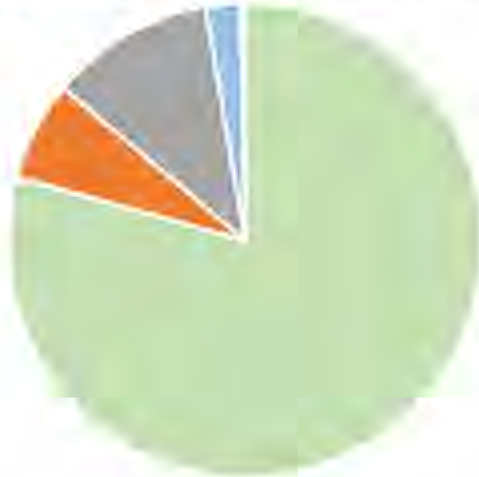
Groundwater Budgets



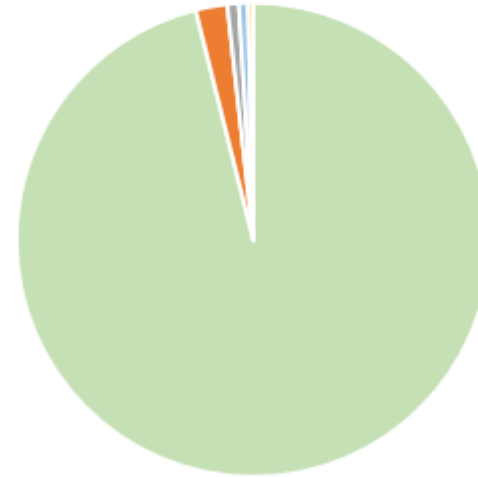
Preliminary

Groundwater Budgets

Whitehall Steady-State Model Inflows
Gains and Losses from SW Separated



Whitehall Steady-State Model Outflows
Gains and Losses from SW Separated



- Recharge from Surface Waters
- Irrigation Recharge
- Canal Leakage
- Groundwater Inflow
- Mountain Front Recharge

- Discharge to Surface Waters
- Pumping Wells
- Groundwater Outflow
- Pond Evaporation
- Riparian Evapotranspiration

Preliminary



Groundwater Flow Modeling

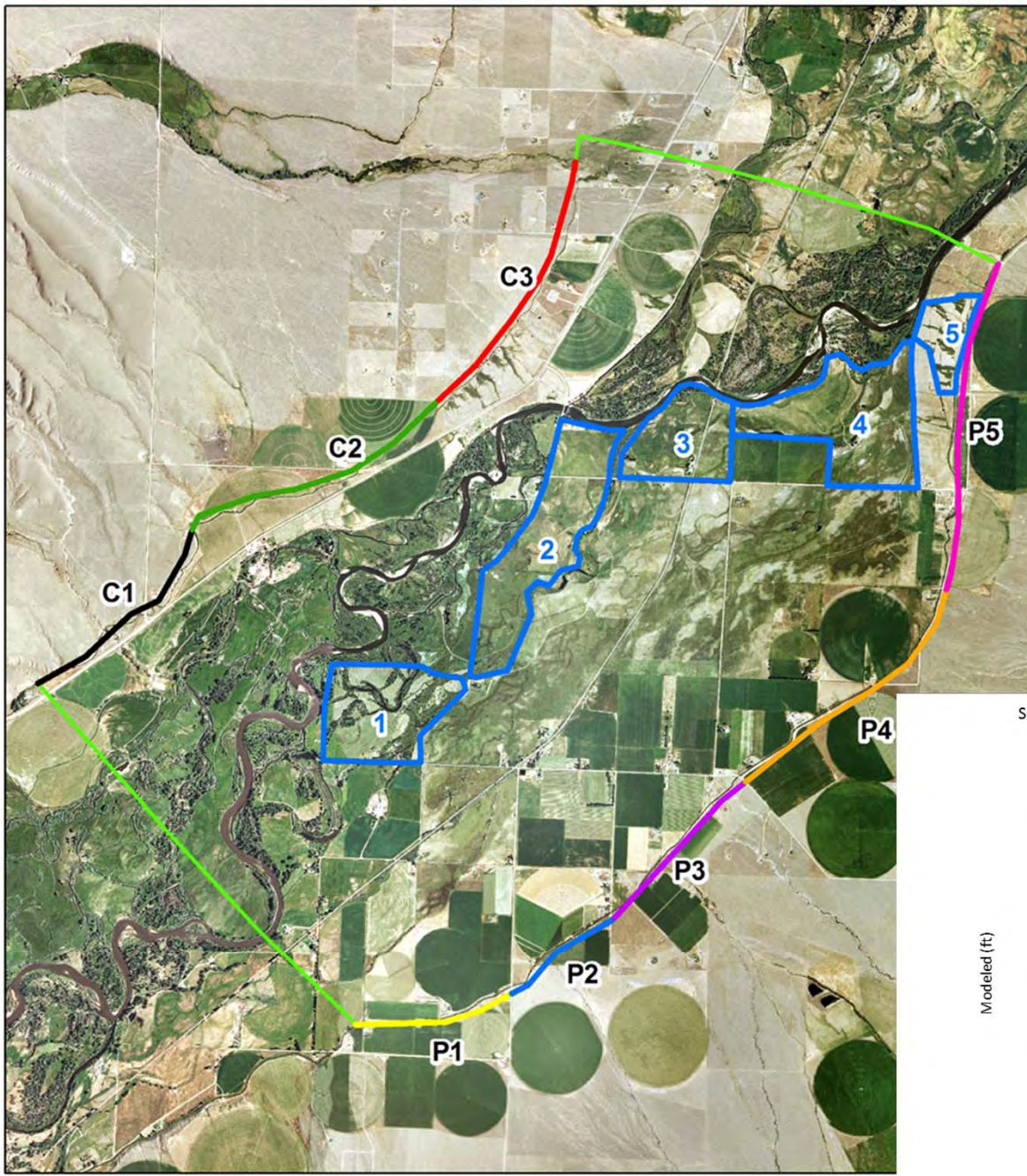
- Conceptual Model
 - Hydrogeologic Model/Aquifer Properties
 - Potentiometric Surfaces
 - Hydrographs
 - Groundwater/Surface-Water Interactions
 - Budget
- Numerical Model
 - Develop a numerical representation of the system
 - Calibrate using:
 - distribution and properties of the hydrogeologic units
 - groundwater levels, and
 - groundwater budget



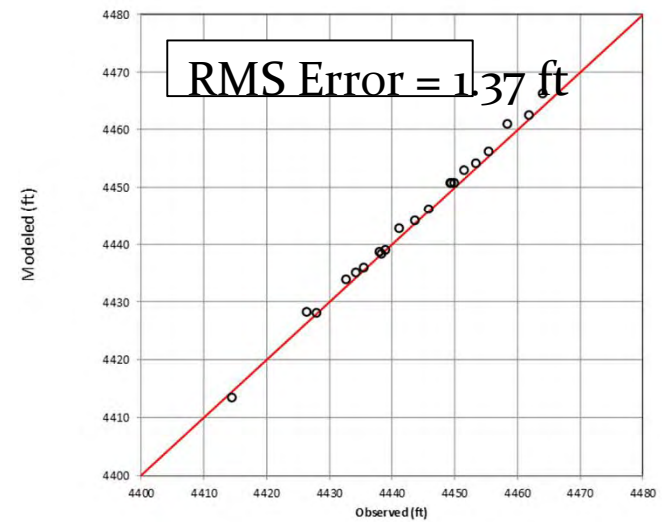
Models

- Waterloo Area
 - Groundwater/Surface-Water Interactions
 - Willow Springs
 - Parson's Slough
 - Jefferson River
 - Changing from Flood to Pivot Irrigation
 - Lining Canals
- Whitehall Area
 - Groundwater/Surface-Water Interactions
 - Jefferson River
 - Jefferson Slough
 - Other Tributaries
 - Impacts from increased groundwater development
 - Housing Developments

Waterloo Model



Steady-state Calibration - Modeled vs. Observed Groundwater Elevations

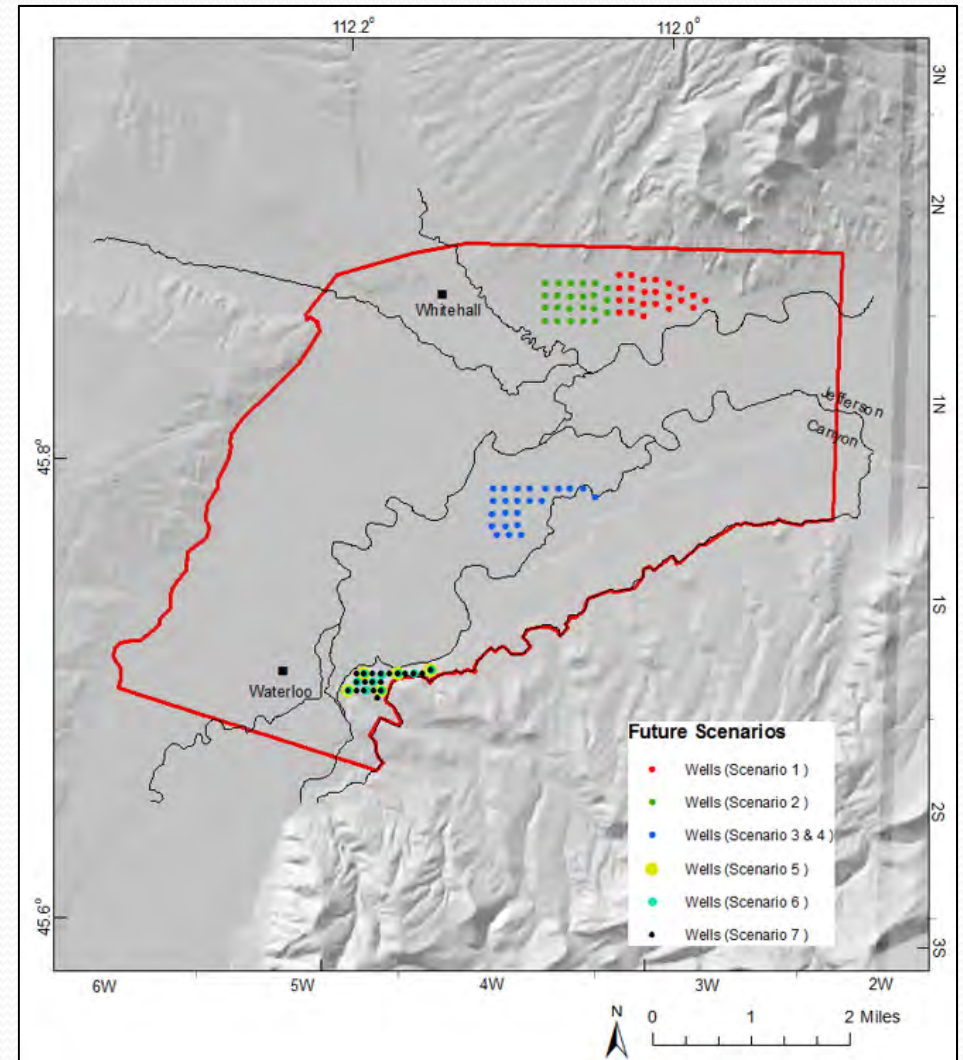
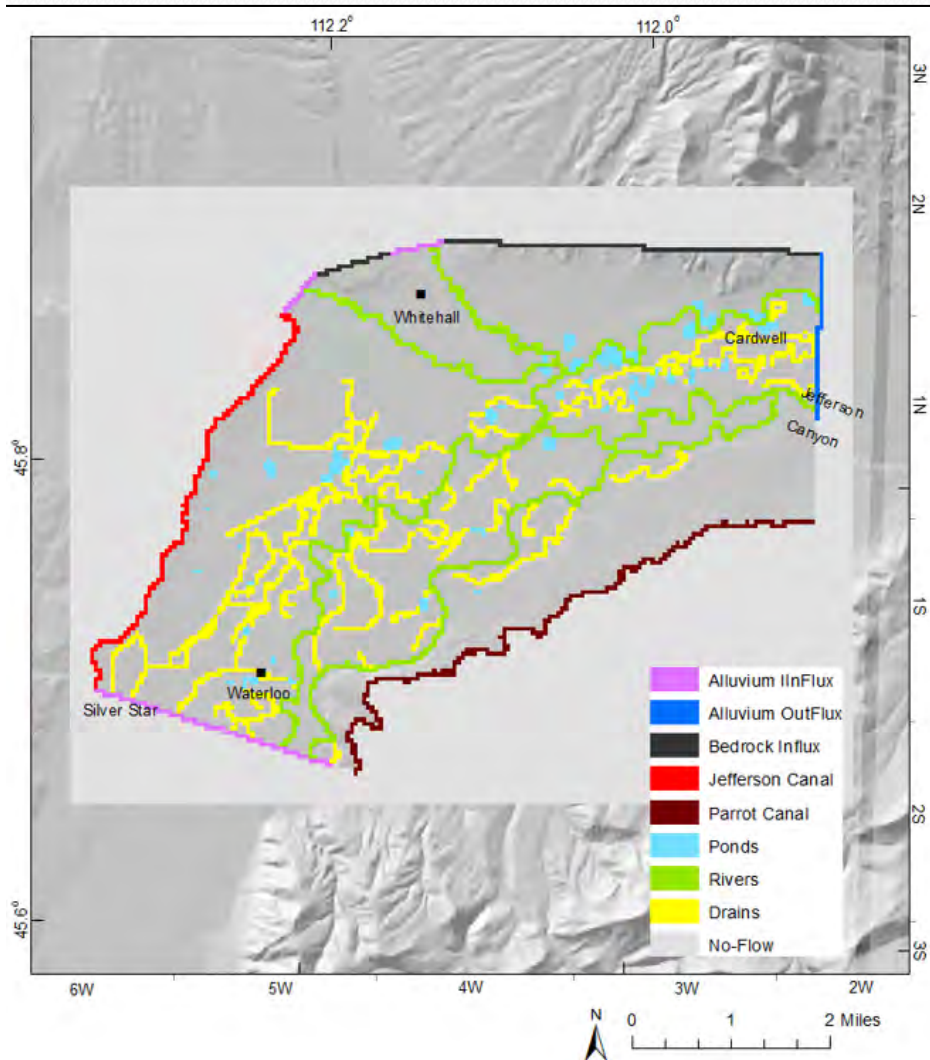


DRAFT Waterloo Model Results

Changes in Mean Monthly flow in the Jefferson River

Scenario	Description	July Reduction in Net Stream Gain (cfs)	August Reduction in Net Stream Gain (cfs)
1	No Canal Leakage	11.9	17.0
10	Areas 1-5 – Convert Flood to Pivot	10.2	12.8
16	Convert Areas 1-5 and No Leakage	22.0	29.7
17	Areas 1-5 - Split Season Irrigation	7.4	12.1
18	All Fields - Split Season Irrigation	0.6	10.3

Whitehall Model



DRAFT Whitehall Model Results

Changes in Surface-Water outflow

Changes in Mean August Stream Flows after 10 years

Scenario	Description	Change in Flow		
		ft ³ /d	cfs	gpm
1	23 homes - Non-Irrigated Bench	812	0.009	4.2
2	23 homes - Irrigated Bench	14,437	0.167	75.0
3	23 homes - Non-Irrigated Alluvium	2,351	0.027	12.2
4	23 homes - Non-Irrigated Tertiary	2,241	0.026	11.6
5	5 homes - Non-Irrigated Bench	92	0.001	0.5
6	10 homes - Non-Irrigated Bench	196	0.002	1.0
7	20 homes - Non-Irrigated Bench	400	0.005	2.1

Preliminary Conclusions

- Groundwater and Surface Waters are tightly coupled in the Jefferson Valley – A single resource
- Changes in irrigation management can noticeably affect low flows in the Jefferson River.
 - Loss of Groundwater Recharge
 - Less Aquifer Storage
- To increase/maintain Late-Summer Stream Flows
 - Emphasize groundwater recharge when water is abundant
 - Increase Aquifer Storage
 - Emphasize efficient irrigation methods when flows are low
 - Pivot Irrigation – Apply just what the crop needs
 - Biodegradable canal sealant?
 - Split-Season Irrigation can help mitigate effects of conversion

Questions?

The logo for MBMG is displayed in a blue rectangular box. The letters 'M', 'B', and 'G' are in a white, bold, sans-serif font. The letter 'B' is stylized with a white pickaxe icon integrated into its vertical stroke. To the right of the 'B' is a small, realistic-looking golden nugget. To the right of the 'G' is a white water droplet icon. The background of the logo box is a solid blue color.

MBMG