Measuring Success – Metrics for Monitoring and Evaluating Outcomes of Shallow Aquifer Recharge Projects

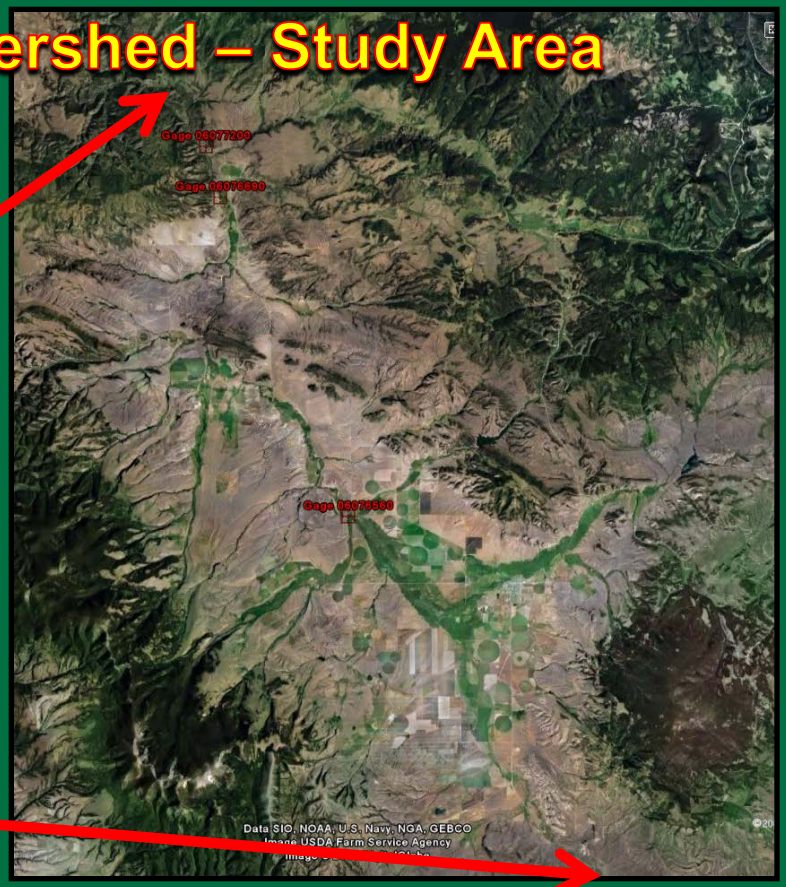
Technical Meeting: Enhancing Streamflows through Shallow Aquifer Recharge

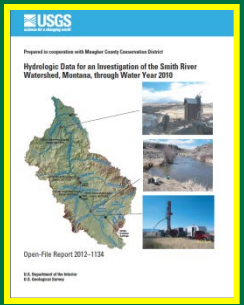
October 21, 2015
Helena, MT

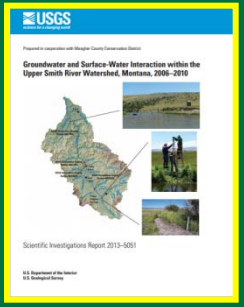
Rod Caldwell
U. S. Geological Survey
WY-MT Water Science Center
Helena, Montana

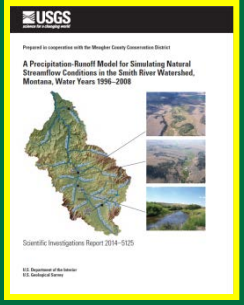
Outline - Methods to Measure Success

- Baseline monitoring
- Streamflow
- Groundwater levels
- Water temperature
- Water quality
- Electrical resistivity
- Time-lapse photography
- Remote sensing
- GW/SW modeling
- Coupled GW/SW gage





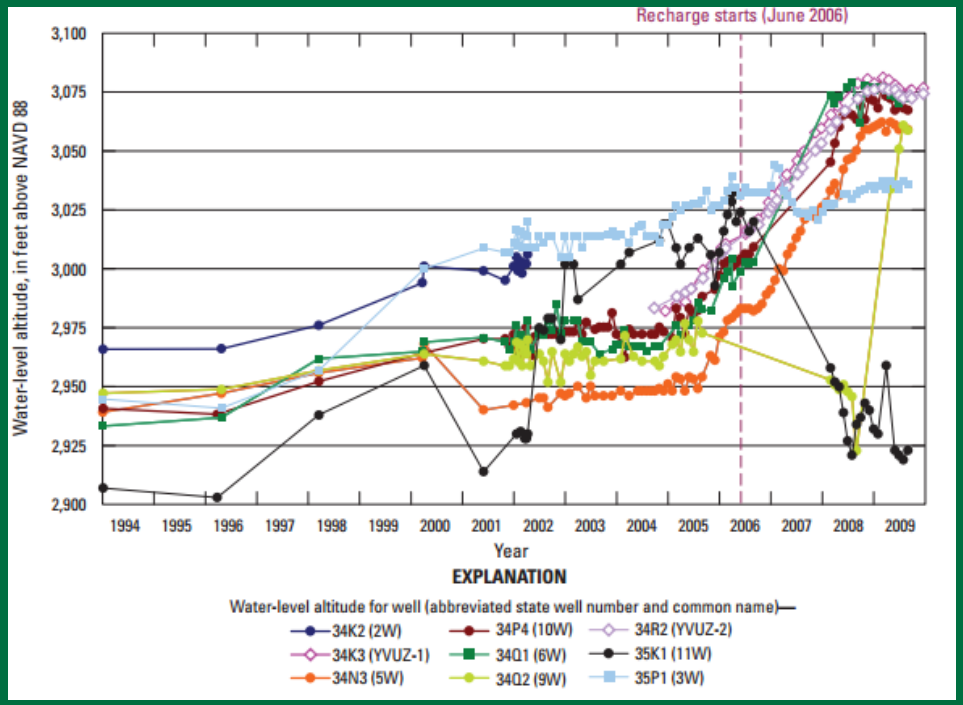


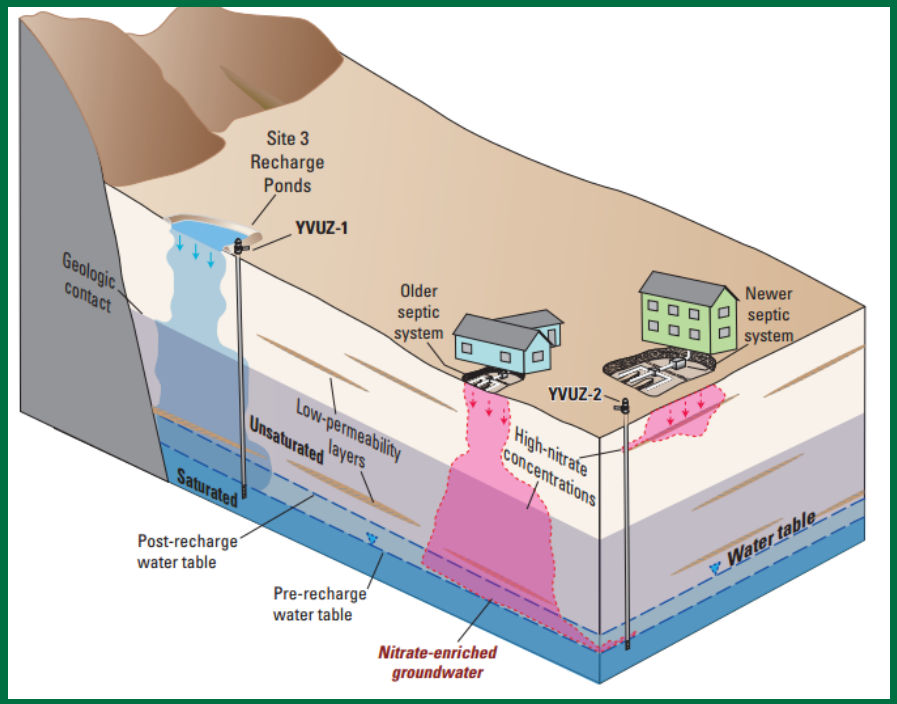


Baseline Conditions

Ideally, baseline conditions are established prior to SAR

- Existing wells, stream gages, water quality, etc.
- May have to establish a new monitoring network

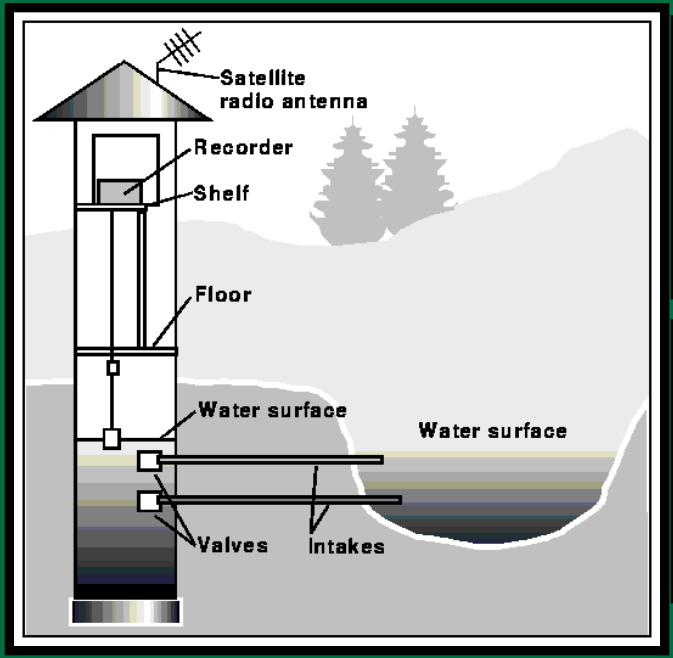


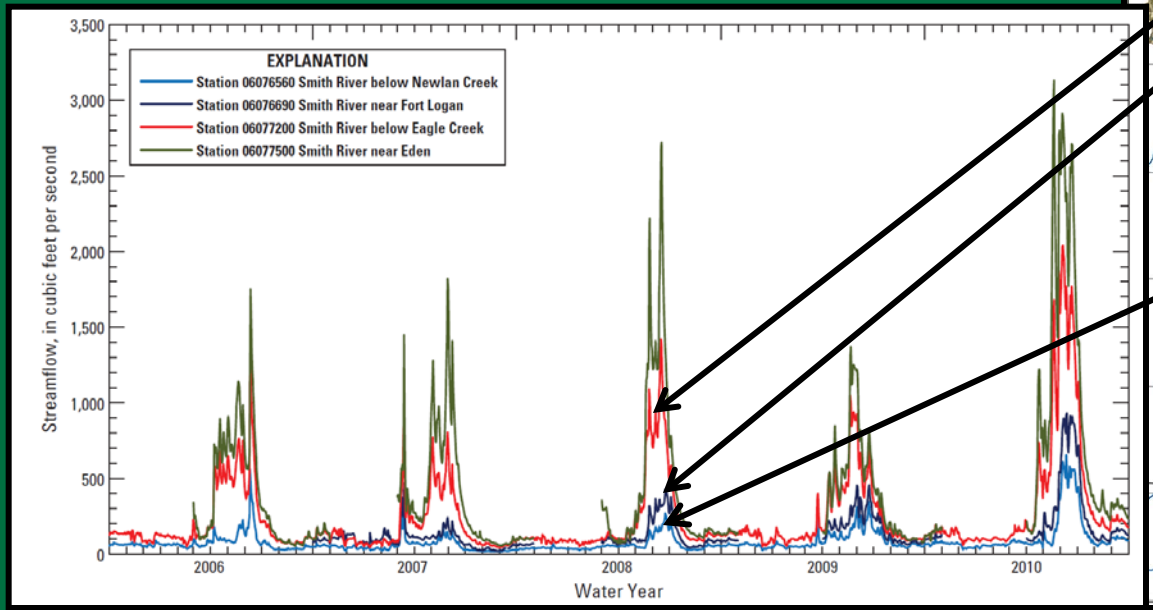


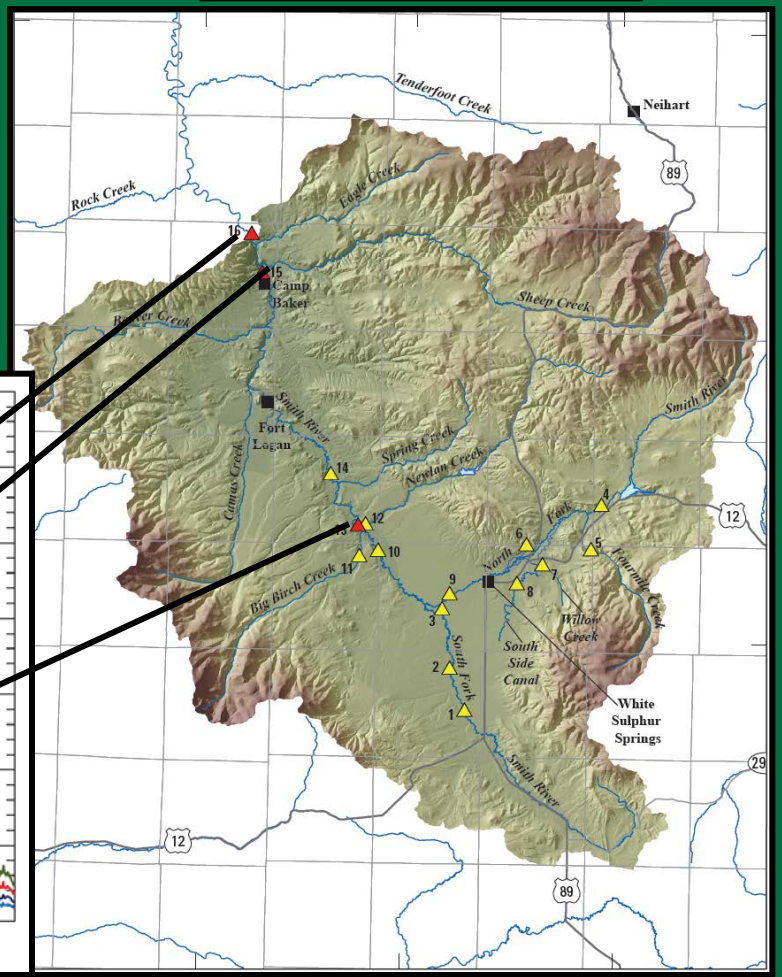
Stamos and others, 2013, The effects of artificial recharge on groundwater levels and water quality in the west hydrogeologic unit of the Warren subbasin, San Bernardino County, California: U.S. Geological Survey Scientific Investigations Report 2013–5088, 88 p.

USGS

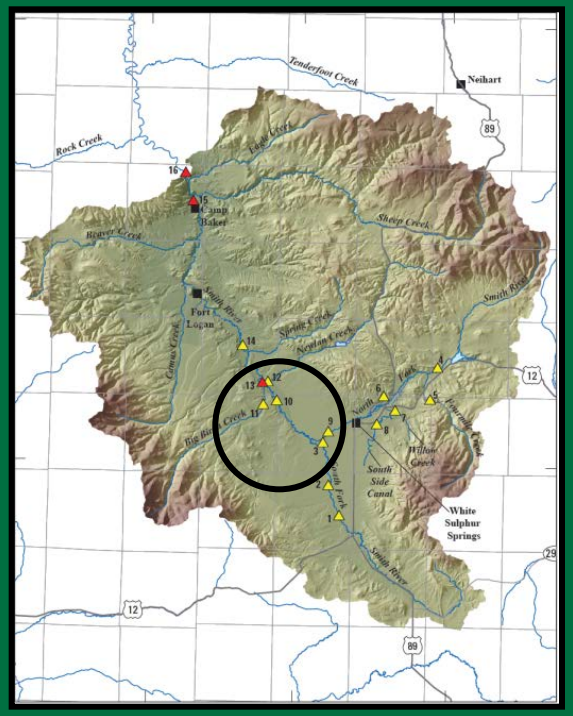
Methods – Streamflow Gaging Stations

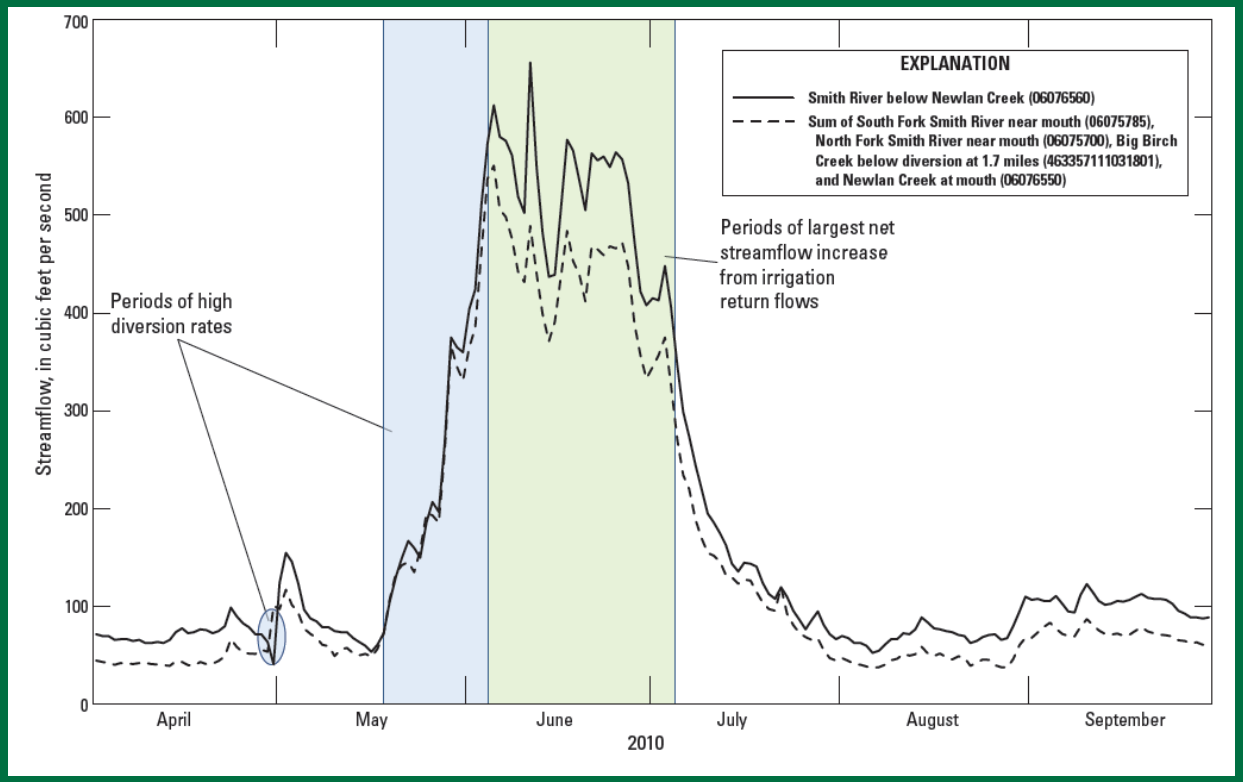






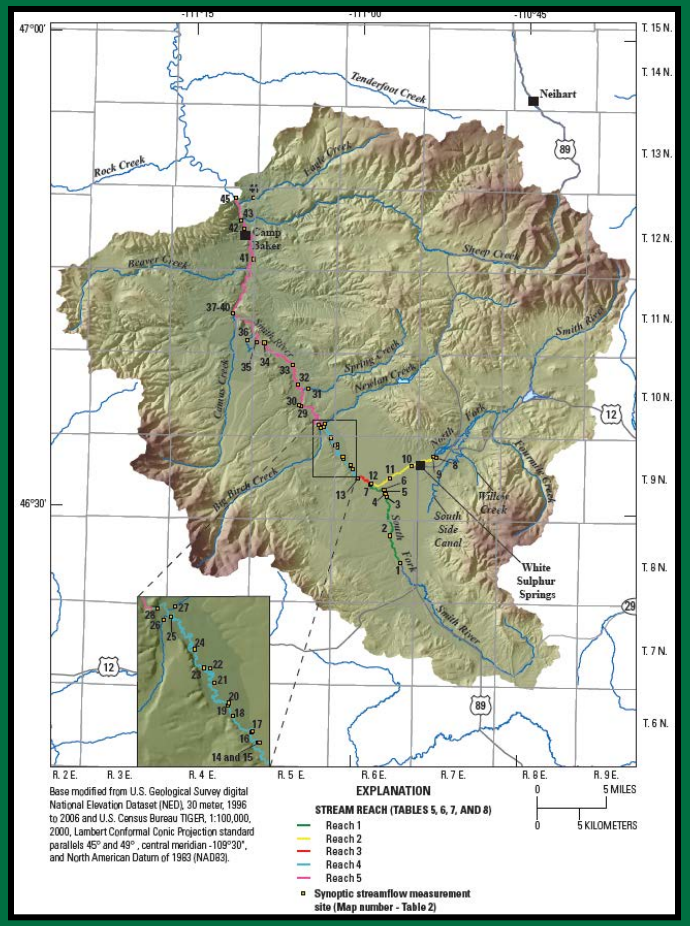
Methods – Temporary Streamflow Gages

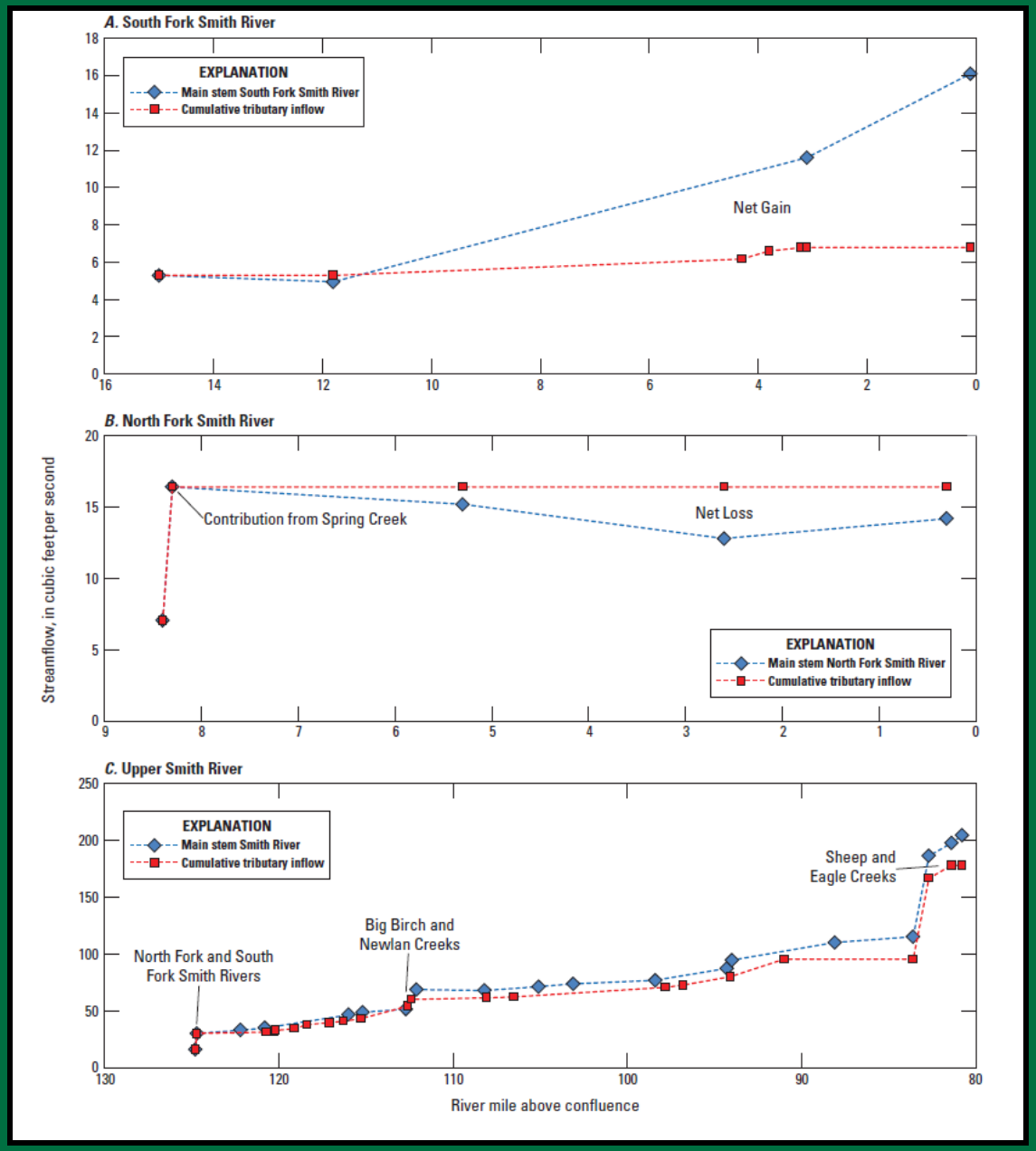




- **Continuous streamflow record of tributaries and mainstem streams**

Methods - Seepage Run – Gain/Loss





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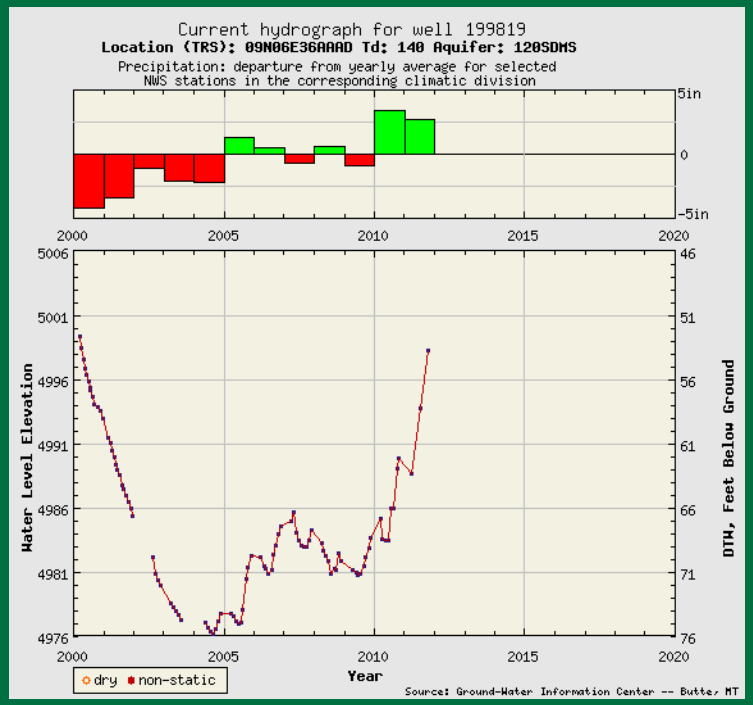
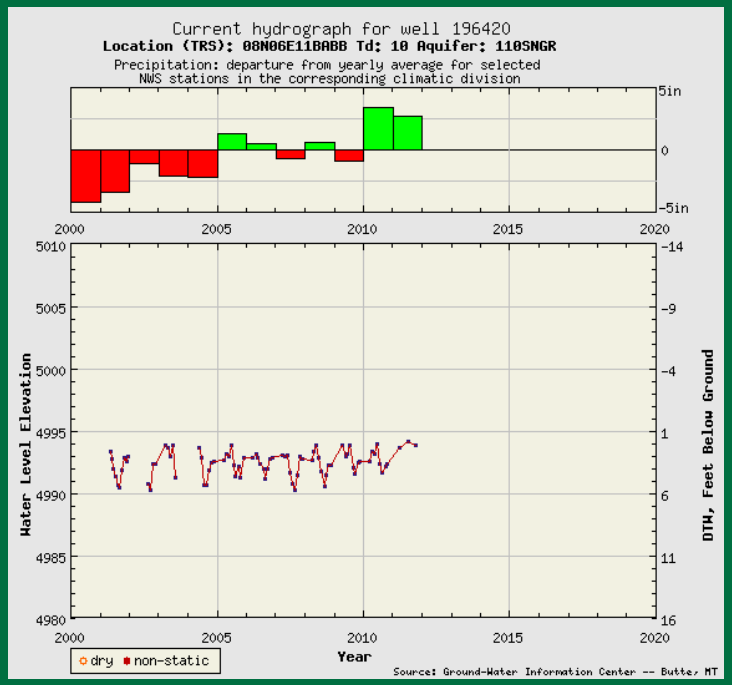
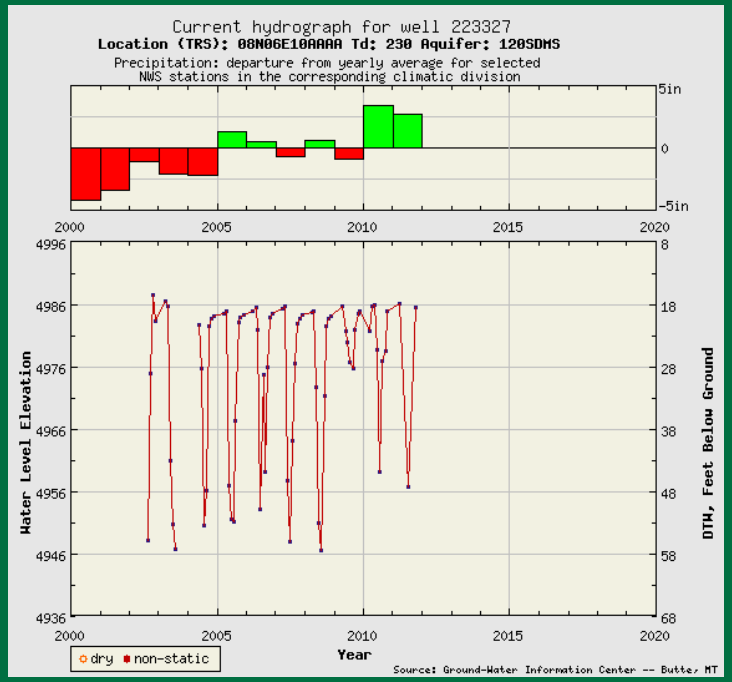
Methods – Groundwater-level Monitoring

- Examples – affected by climate and water use







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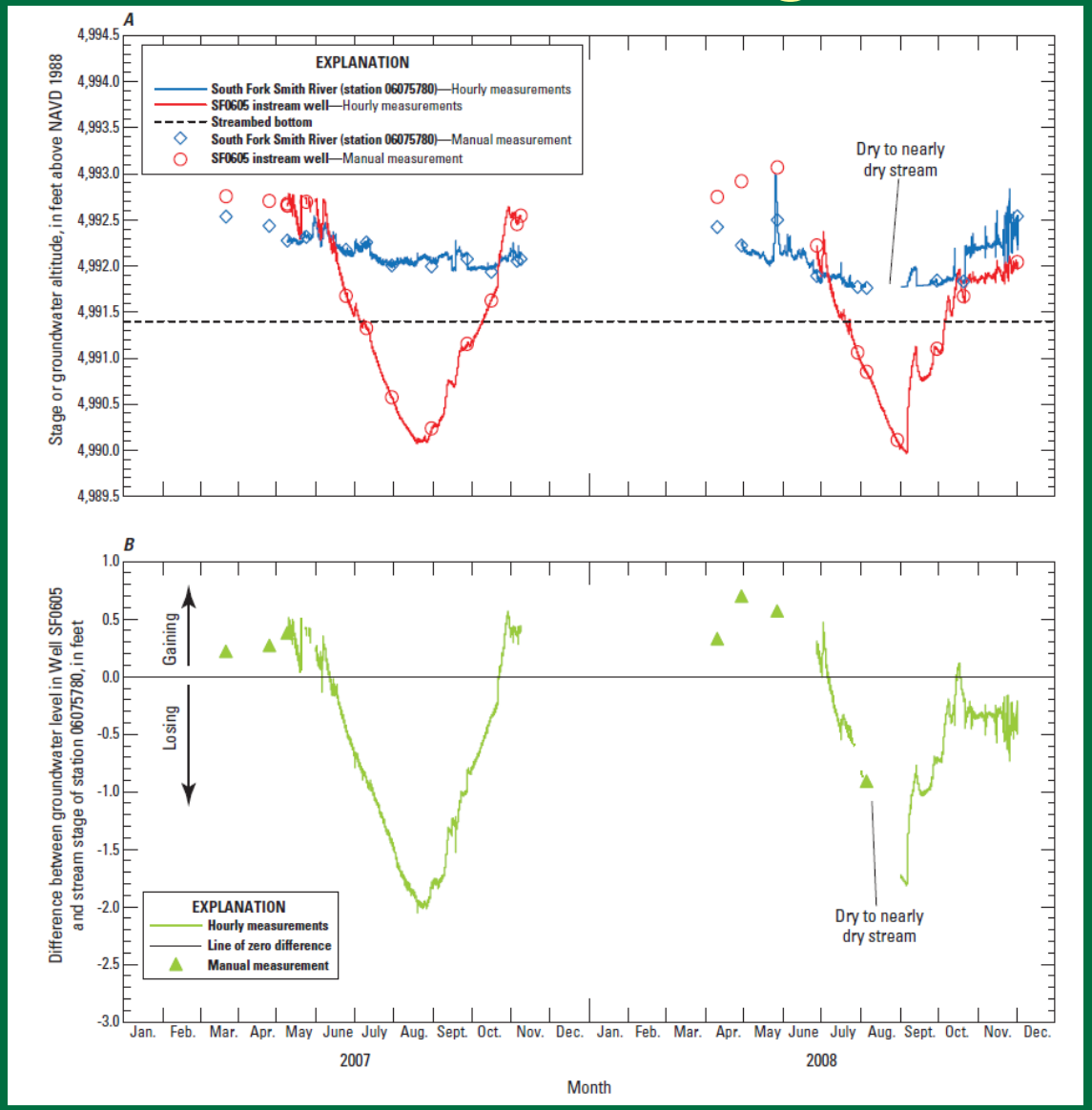
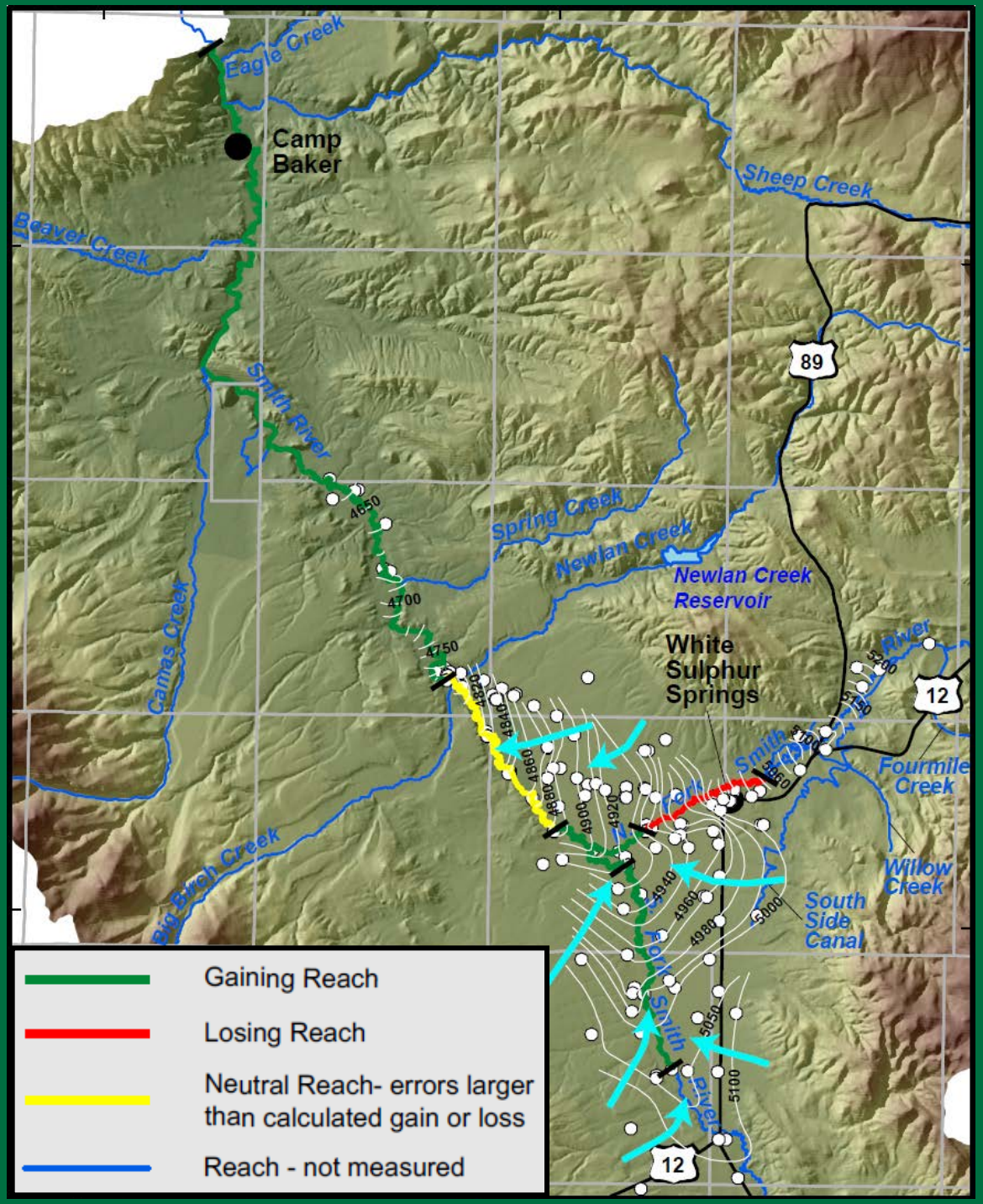
Methods – Combined Stream Stage and Groundwater-Level Monitoring



Water Table and Gain / Loss Maps



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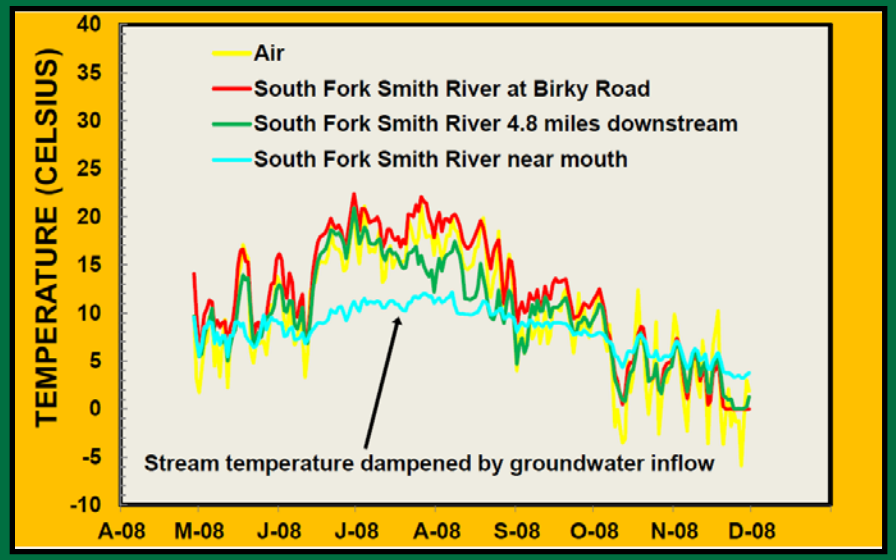
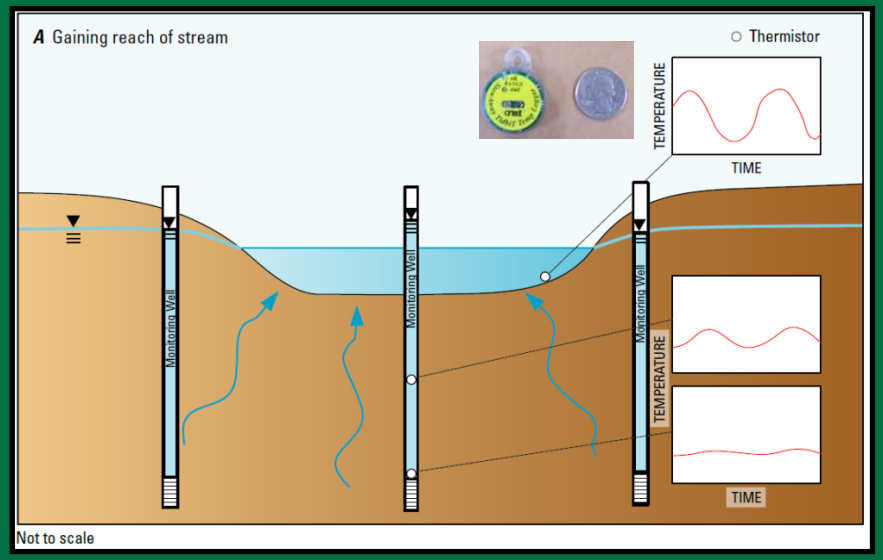
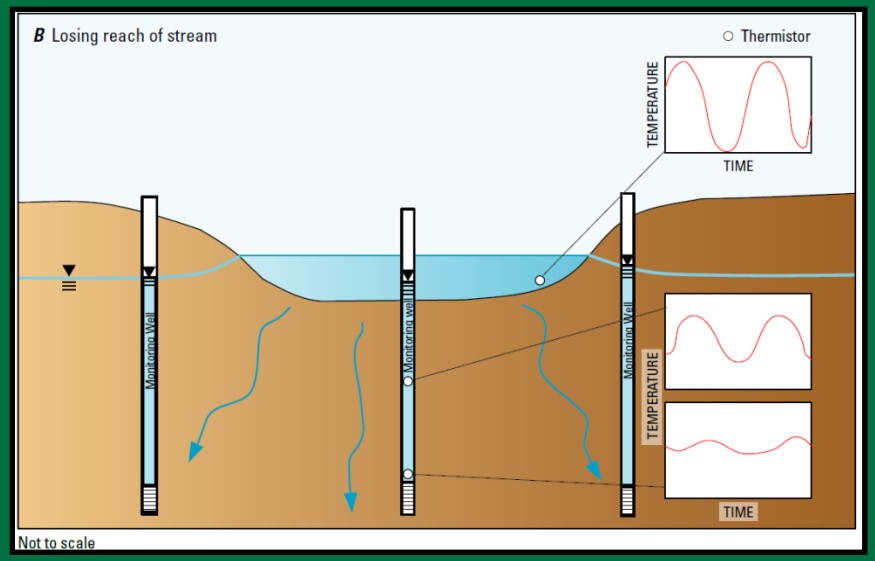
Method - Heat as a Tracer for Groundwater / Surface-Water Interaction







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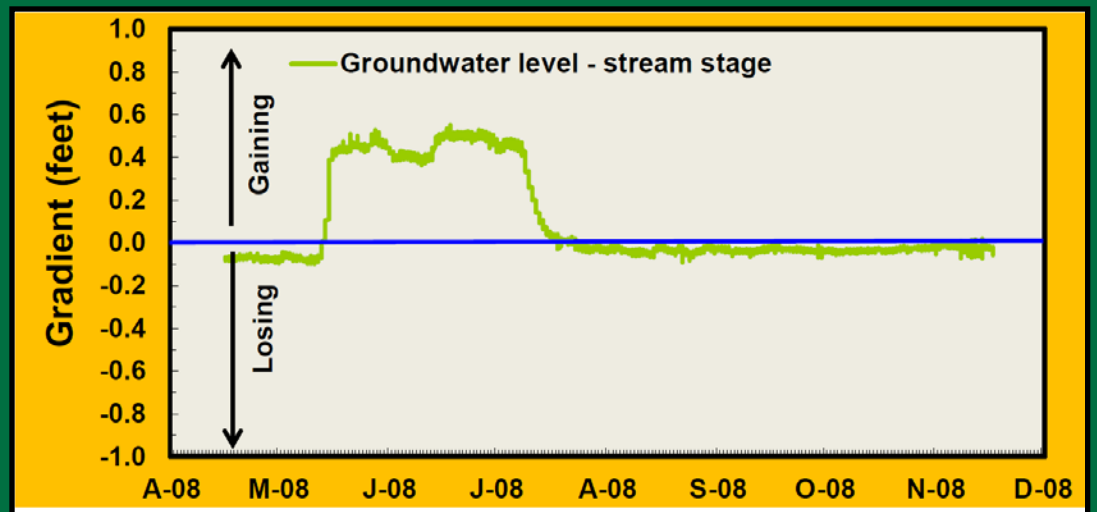
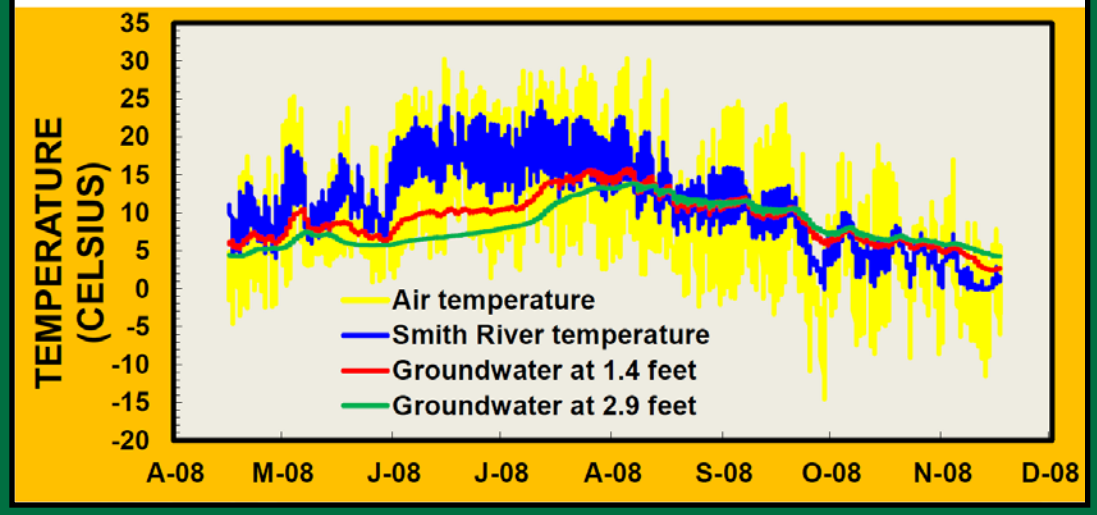
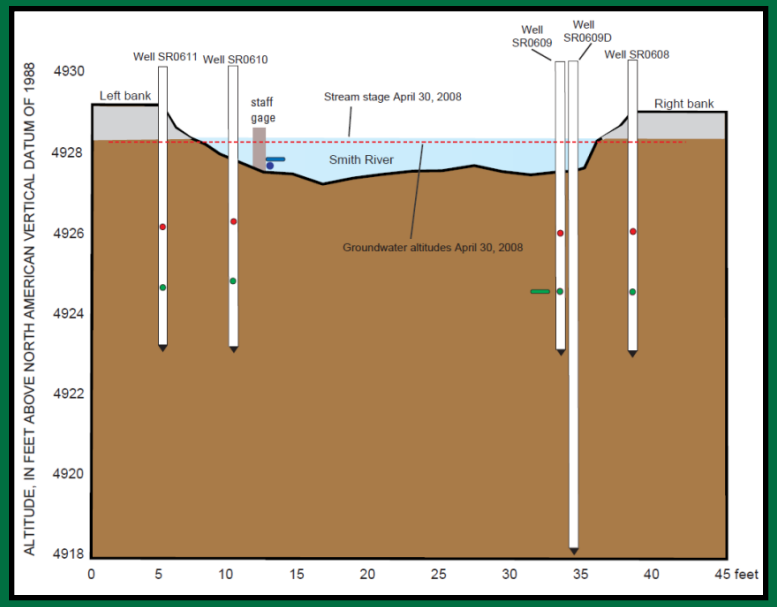
Method – Combined Water-Level and Temperature Data at a Cross Section







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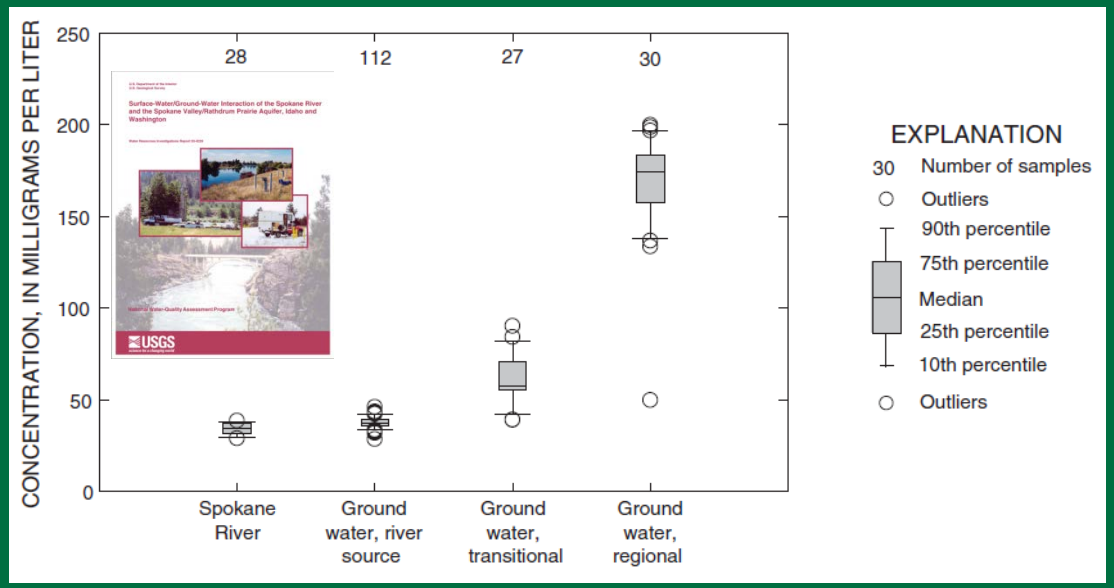
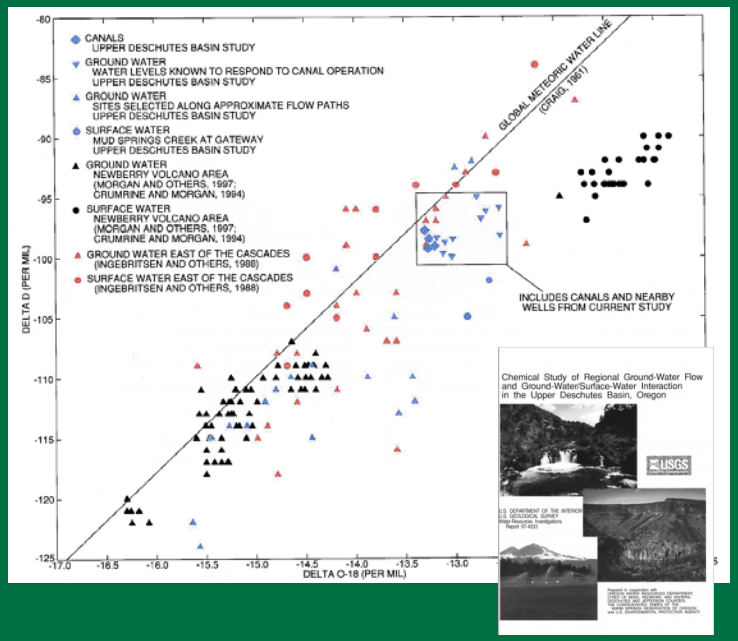
Methods – Water Chemistry

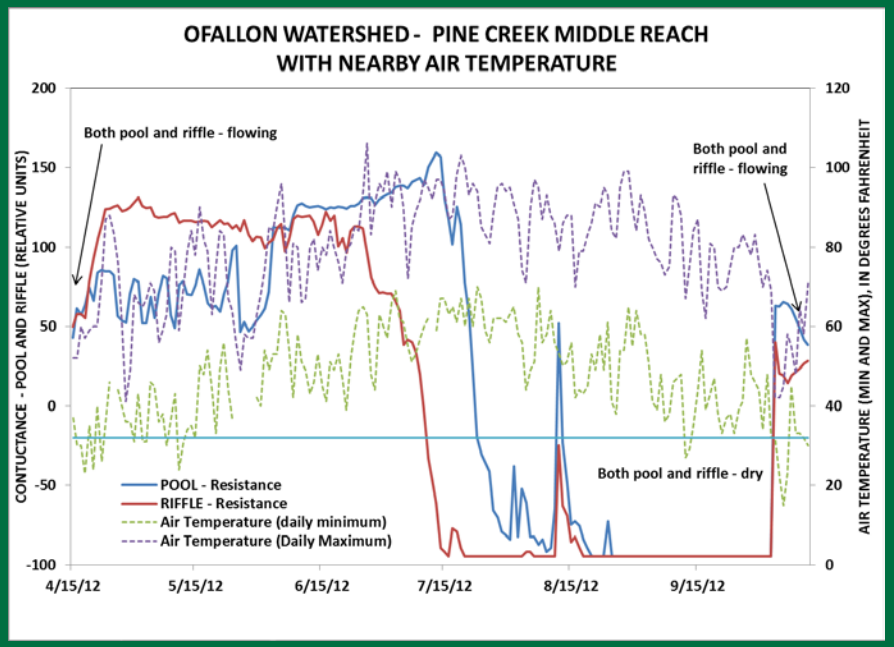
- Potential unique chemistry of artificially-recharged water versus ambient groundwater
- Potential tracers
  - General chemistry (selected major ions, trace elements, total dissolved solids, etc.)
  - Stable isotopes
  - Groundwater age dating
- Concerns
  - Potential water-quality effects (mobility of trace elements, transport of emerging contaminants)

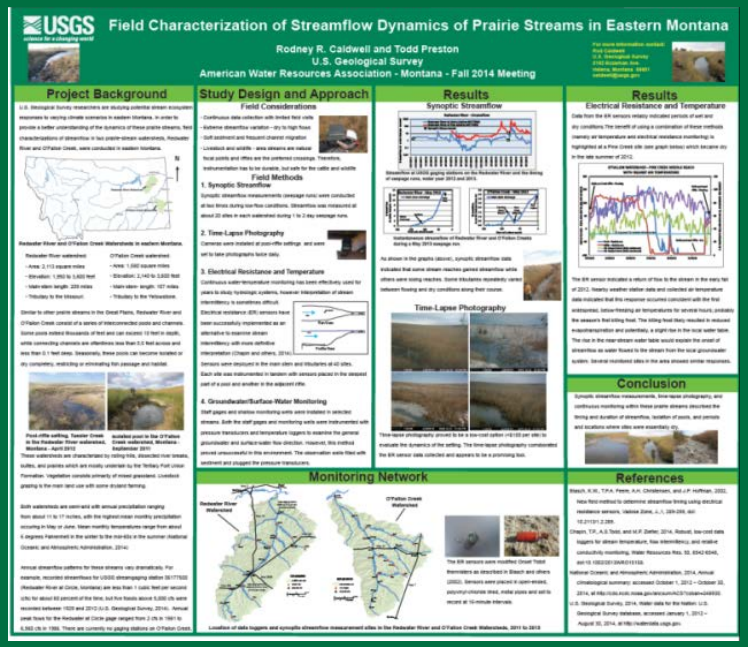




Methods – Electrical Resistance

- **Inexpensive instrumentation to determine presence or absence of water (saturation)**





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Method – Time lapse Photography

- Inexpensive qualitative method – assist with data interpretation

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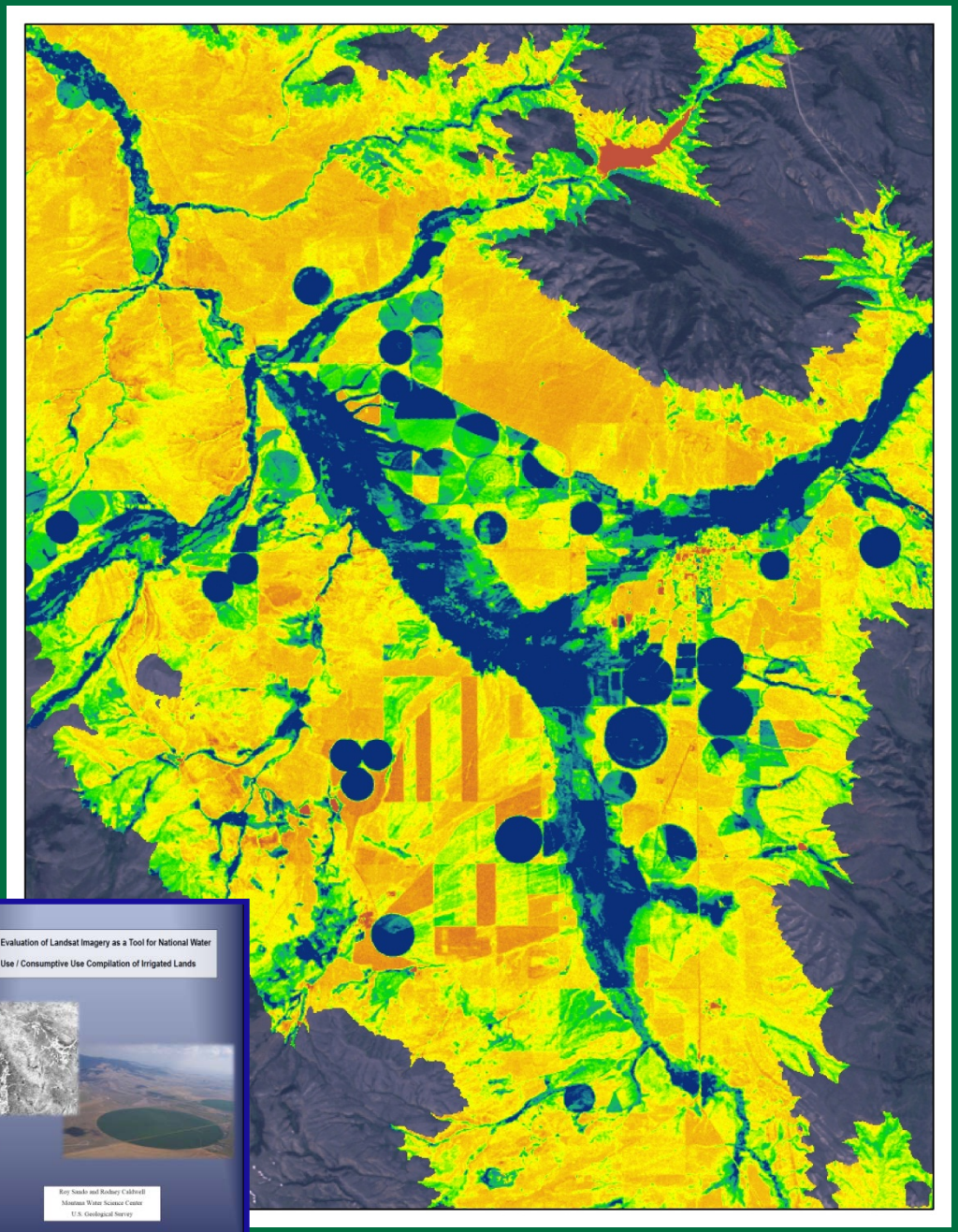
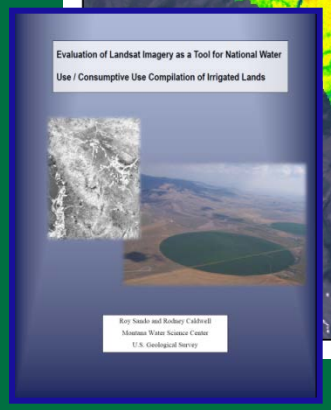
Remote Sensing

- LANDSAT - thermal and optical satellite imagery
- Qualitative – temporal variations in vegetation
- Thermal signature related to evapotranspiration
    - Hot pixels – minimal ET
    - Cold” pixels, latent energy is set to the potential evapotranspiration of the reference crop (alfalfa). This is obtained from the nearby AgriMet station.





Evapotranspiration on 07/18/2007, below 5500'

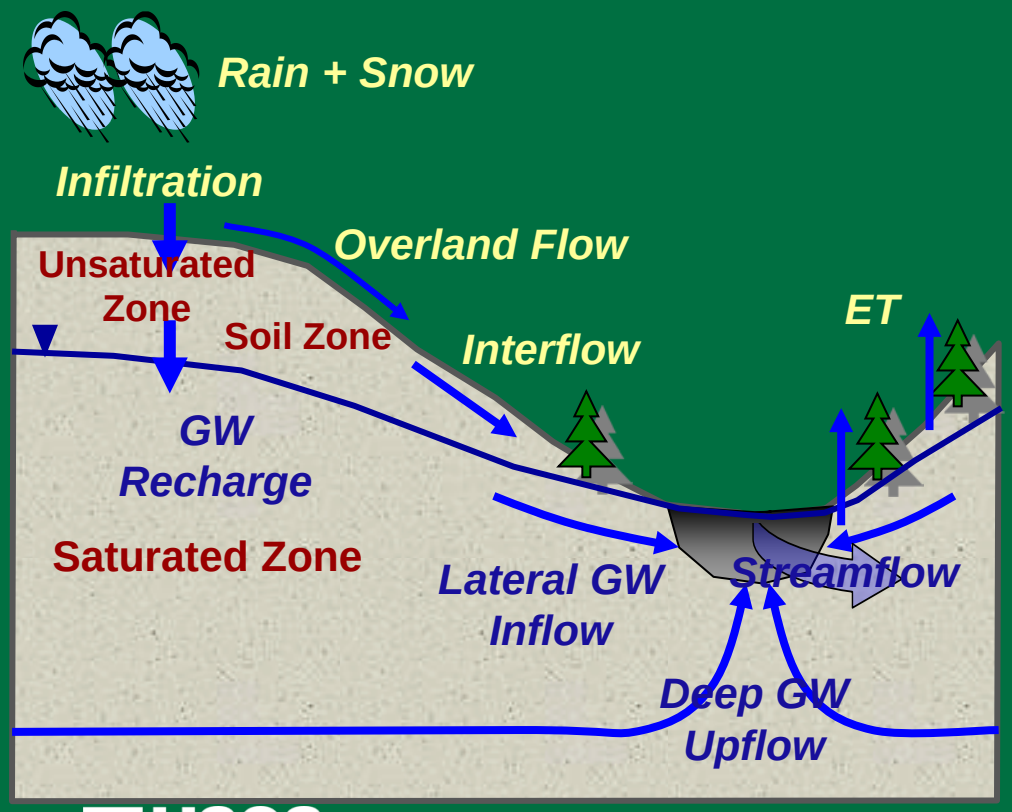
Inches

High : 0.34

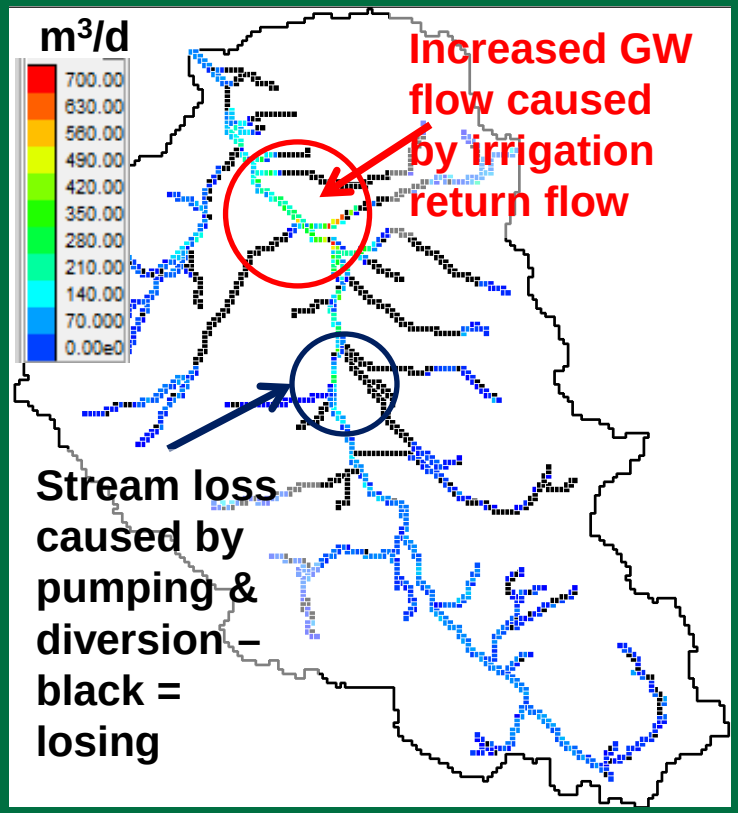
Low : 0

GSFLOW Watershed Modeling

- A tool for modeling coupled surface water - groundwater flow
- USGS coupled surface water - groundwater flow model (Markstrom et al., 2008) integrating the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW).



Irrigation season simulation



USGS

Hedeff Essaid, USGS, Menlo Park, CA

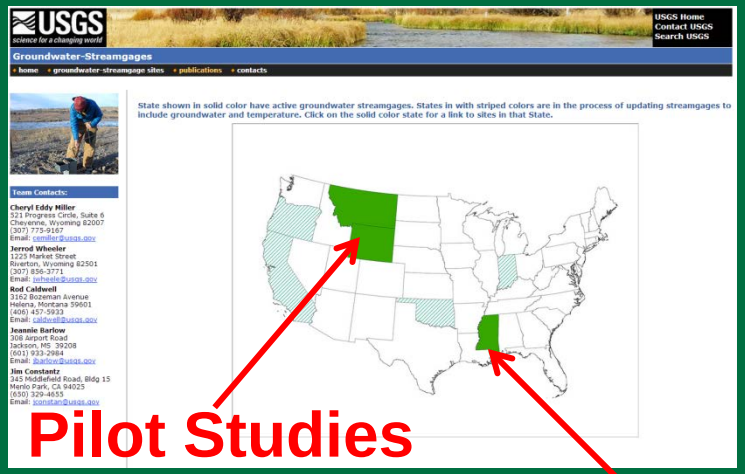
In collaboration with Rod Caldwell and Jim Constantz

Groundwater Streamgages: Low-cost Streamgage Enhancement Coupling Groundwater and Surface-Water Monitoring

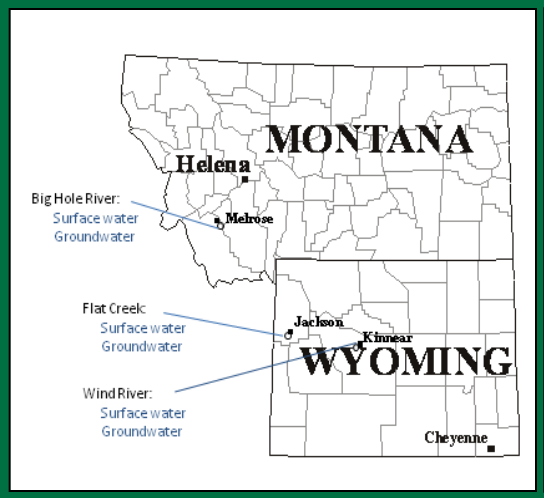
Cheryl Eddy Miller, Jerrod Wheeler, and Rod Caldwell, WY-MT WSC

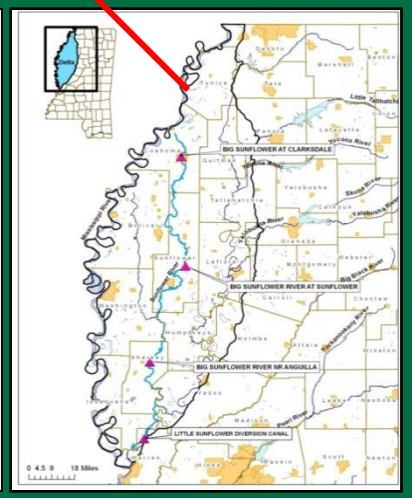
Jeannie Barlow, MSTN WSC

Jim Constantz, USGS National Research Program



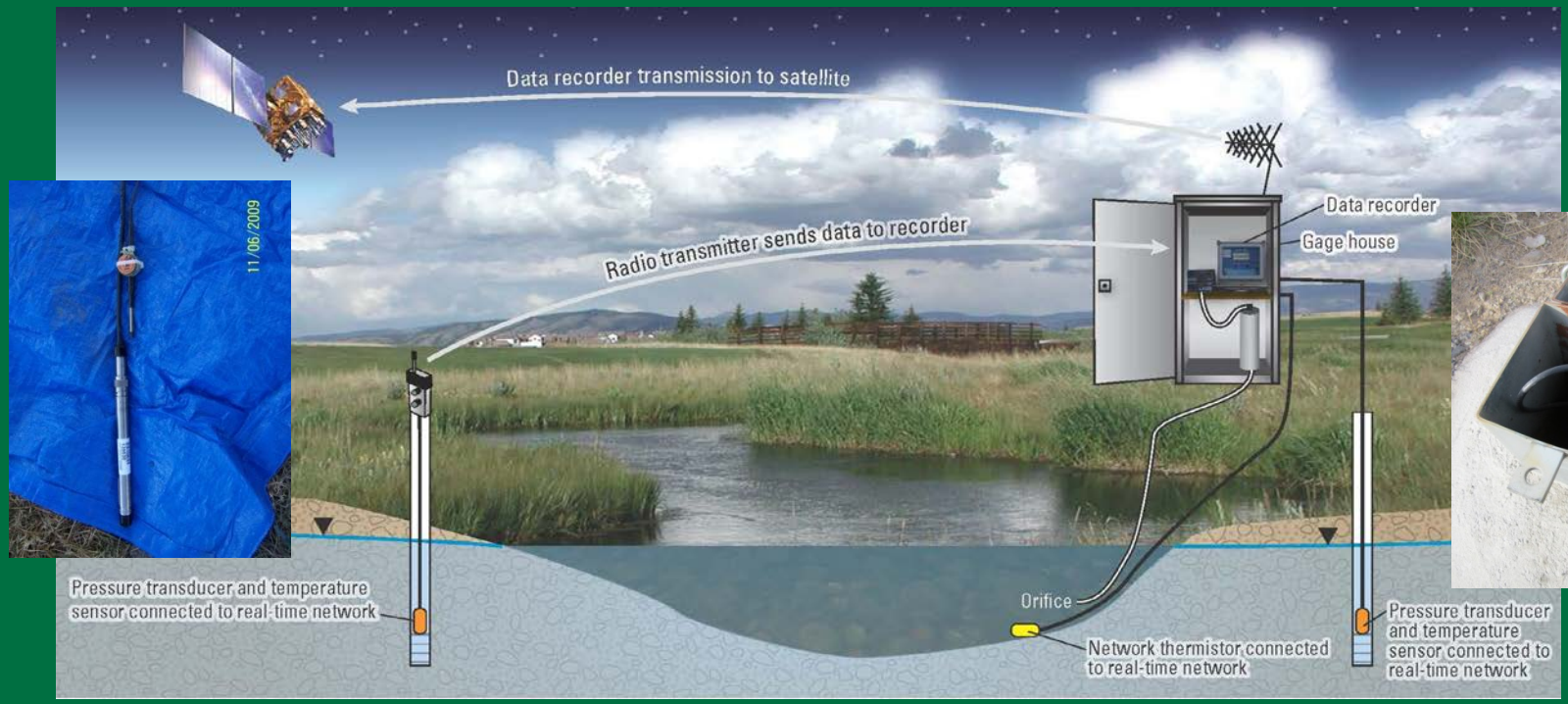
Pilot Studies





http://wy-mt.water.usgs.gov/projects/ogw/index.htm

USGS Groundwater Streamgage



2009 – 2010: Pilot study to determine cost and add-on value of upgrading USGS streamgages

Minimum data components

- **GW elevation and temperature**
- **SW elevation and temperature**

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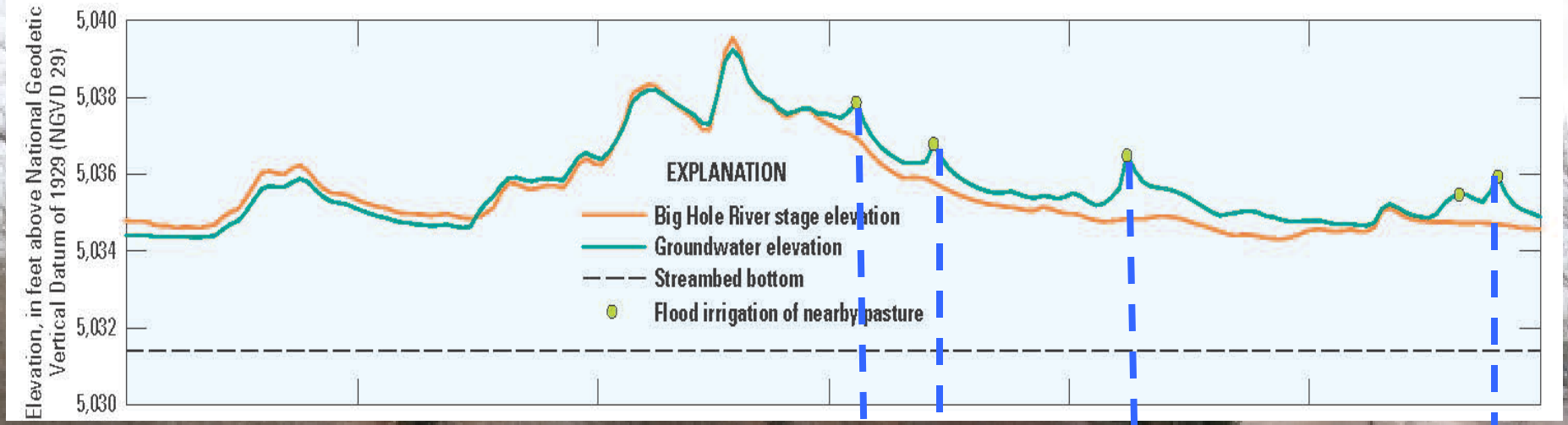
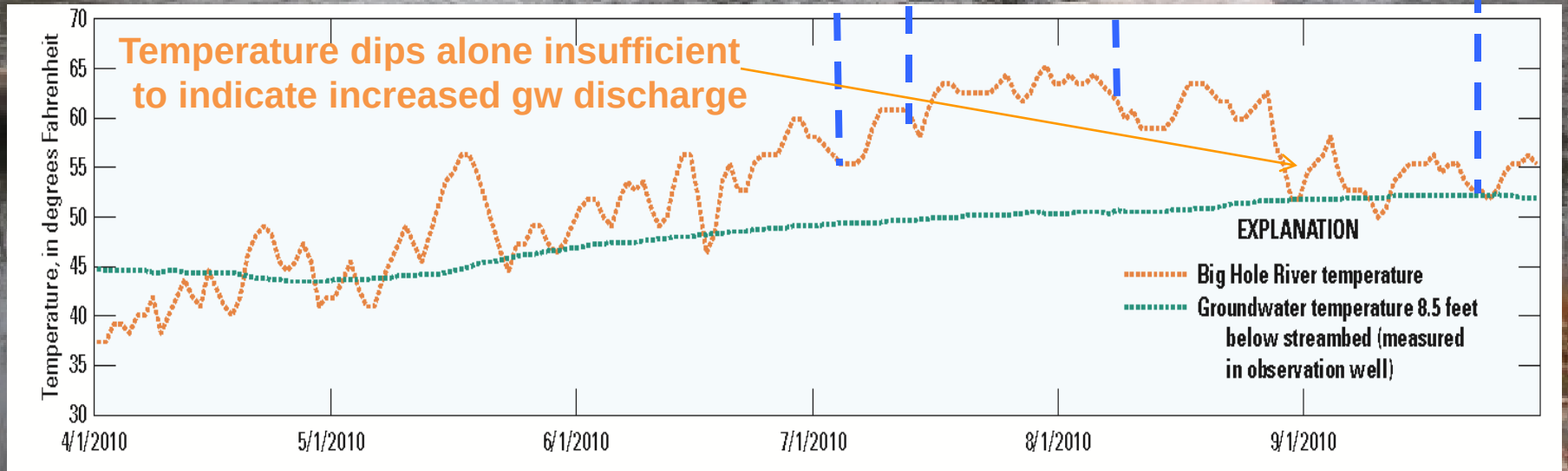
Big Hole River, Montana
Data download from USGS Groundwater Streamgage