A Hydrologic Study of the North Hills, Helena, Montana

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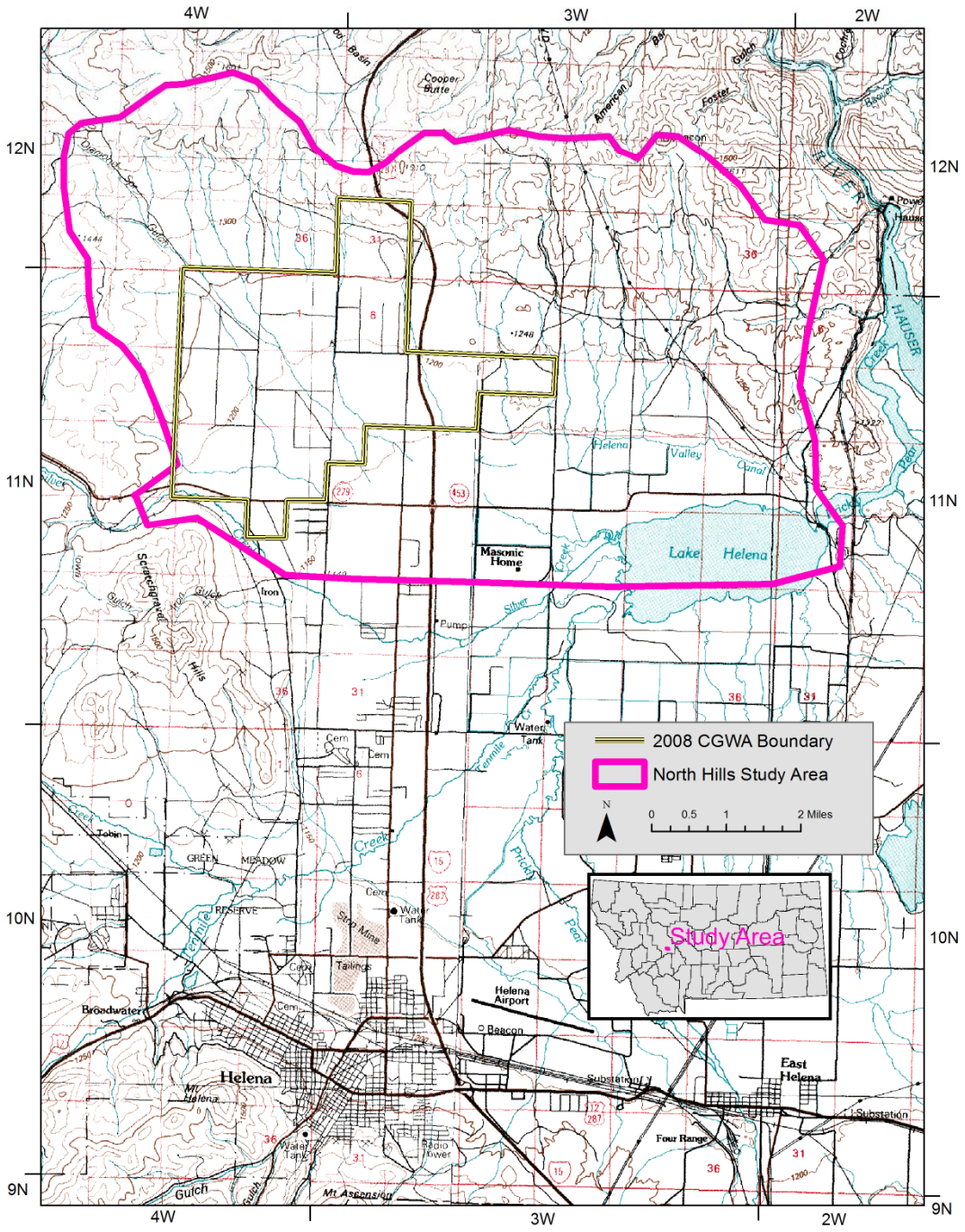
MBMG Groundwater Investigations Program

12/6/11 - Lewis and Clark County Water Quality Protection District Board

Background

- Groundwater Steering Committee Selected North Hills as #1 priority for groundwater investigation
- Controlled Groundwater Area (CGWA)
  - Increased Subdivisions
    - 1995 – 1,077 homes
    - 2009 – 2,150 homes
  - Observed Water Level Declines
  - Concerns regarding nitrate
- Purpose and Scope of Study
  - Provide a scientific basis for evaluating water availability and water quality.



Study Area

Southern Lewis and Clark County

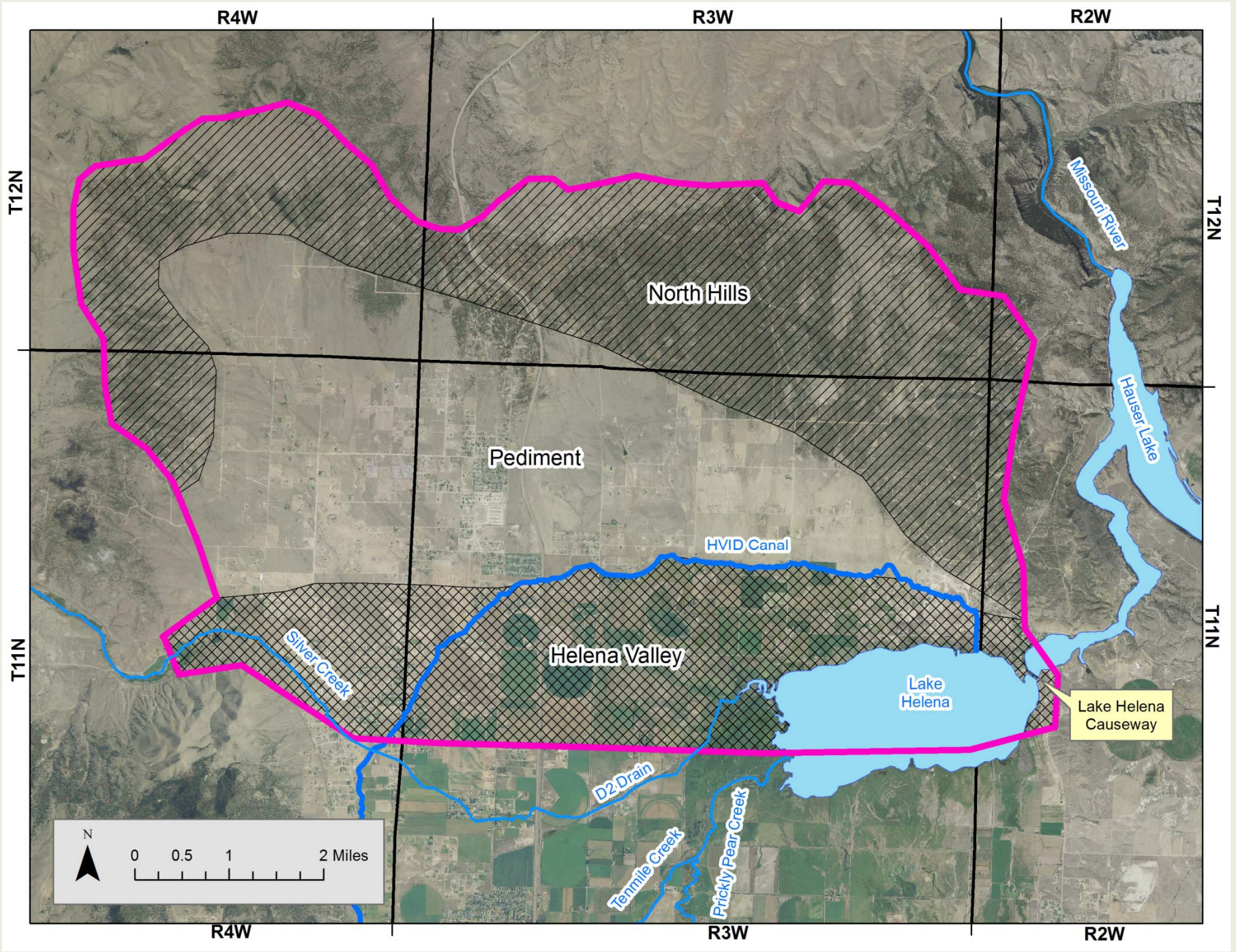
~8 miles north of Helena

On the northern edge of the Helena Valley

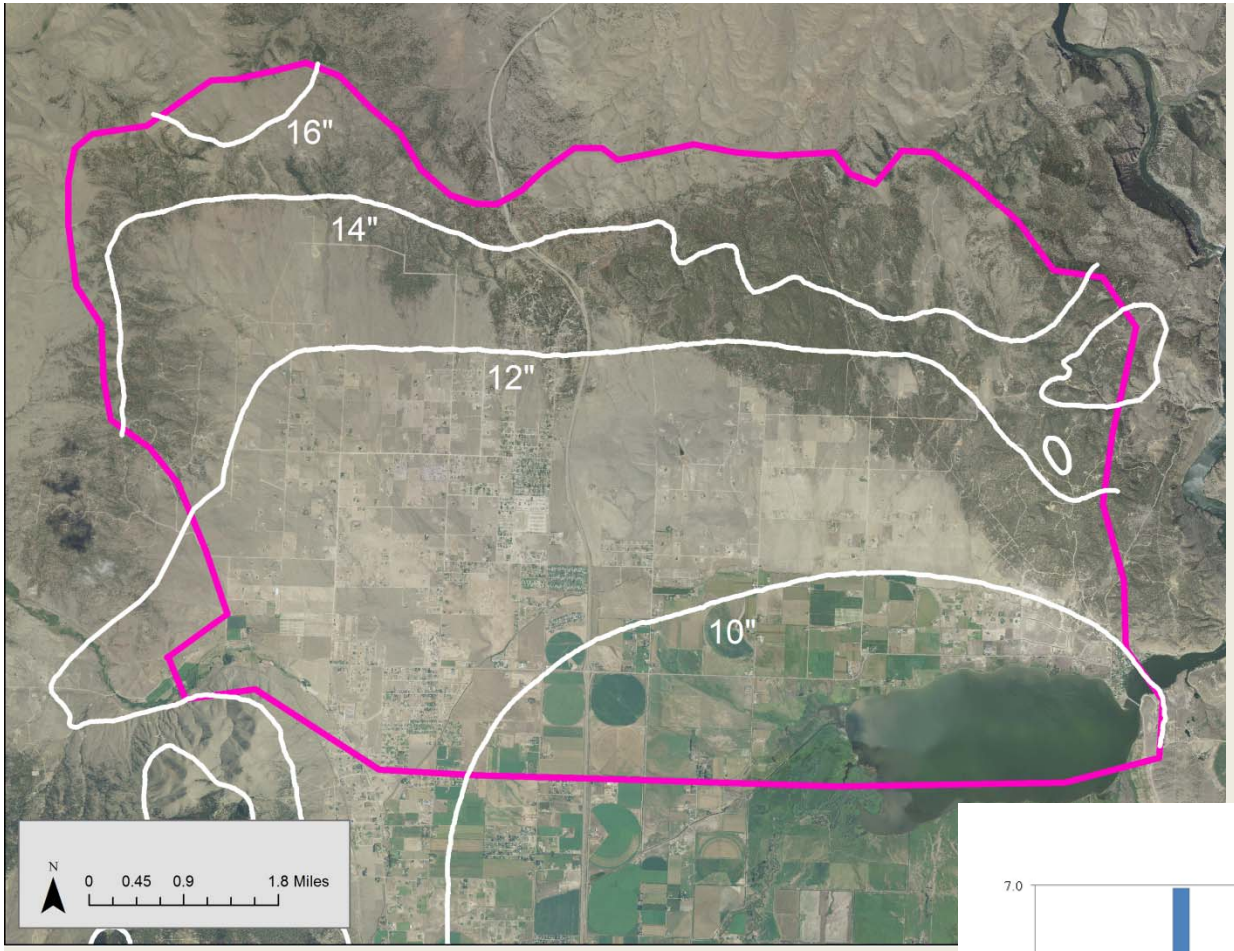
~ 55 square miles

Study area boundary

Surface water divides on the west, north and east, and a groundwater flow line on south.


R4W
R3W
R2W
T12N
T11N
North Hills
Pediment
Helena Valley
Missouri River
Hauser Lake
HVID Canal
Silver Creek
Lake Helena
Lake Helena Causeway
D2 Drain
Tenmile Creek
Prickly Pear Creek
N
0 0.5 1 2 Miles

Setting: Climate

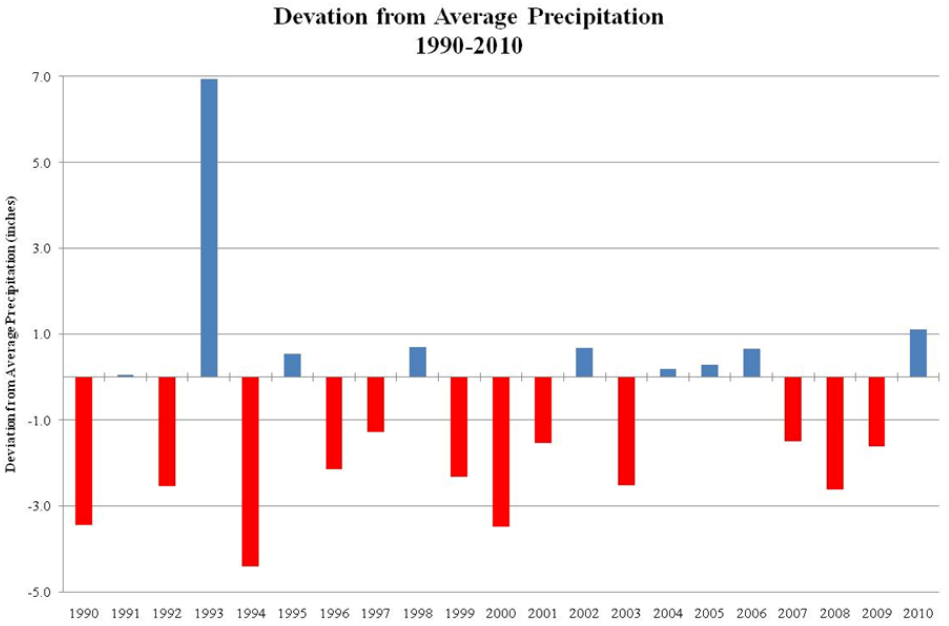


Average precipitation ranges from less than 10” in the Valley to over 16” in the hills.

Substantially below average over the last 20 years.

1993 Wet

2010 and 2011 have been wet

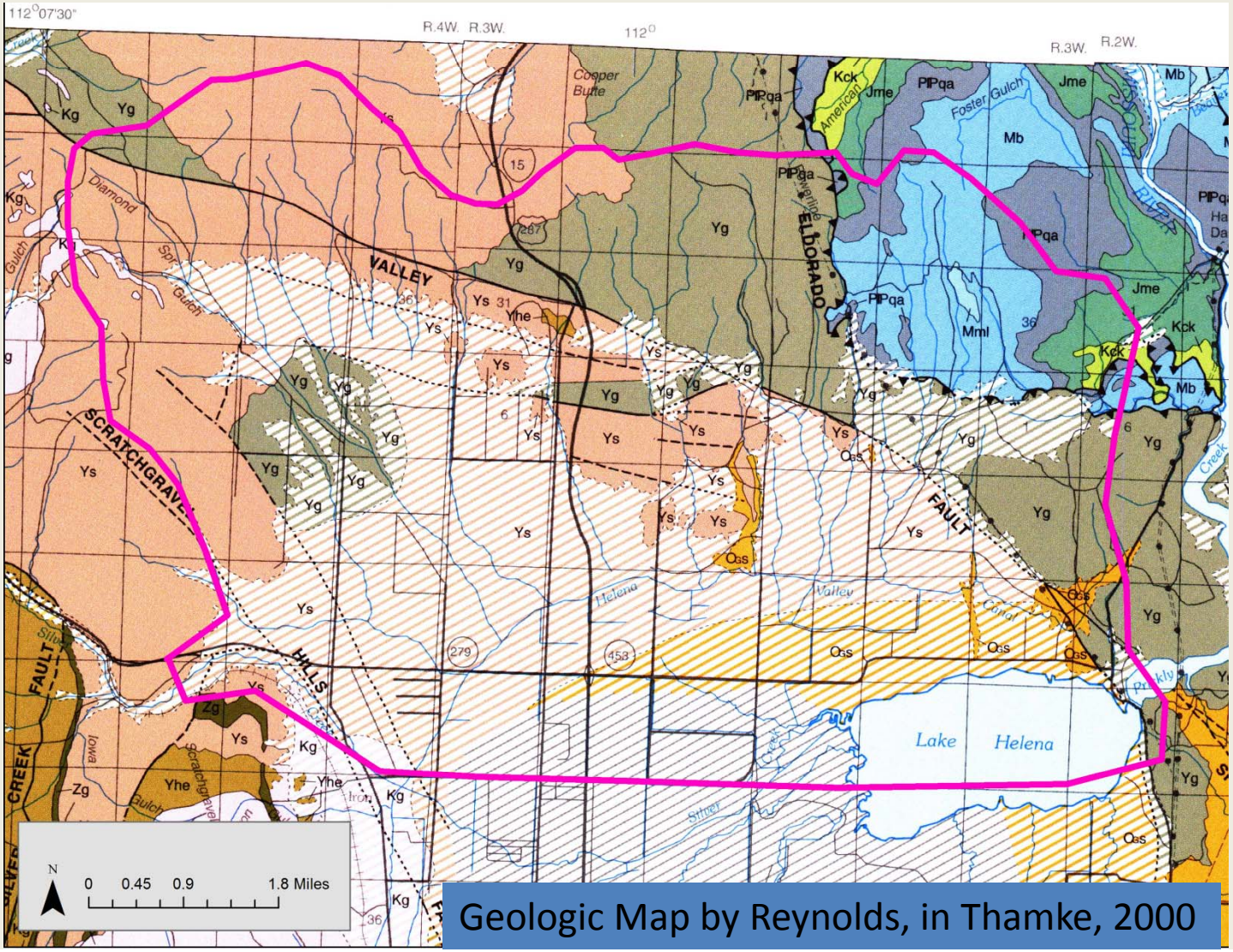


Setting: Geologic Map

Fractured and Faulted Argillite Bedrock in Hills

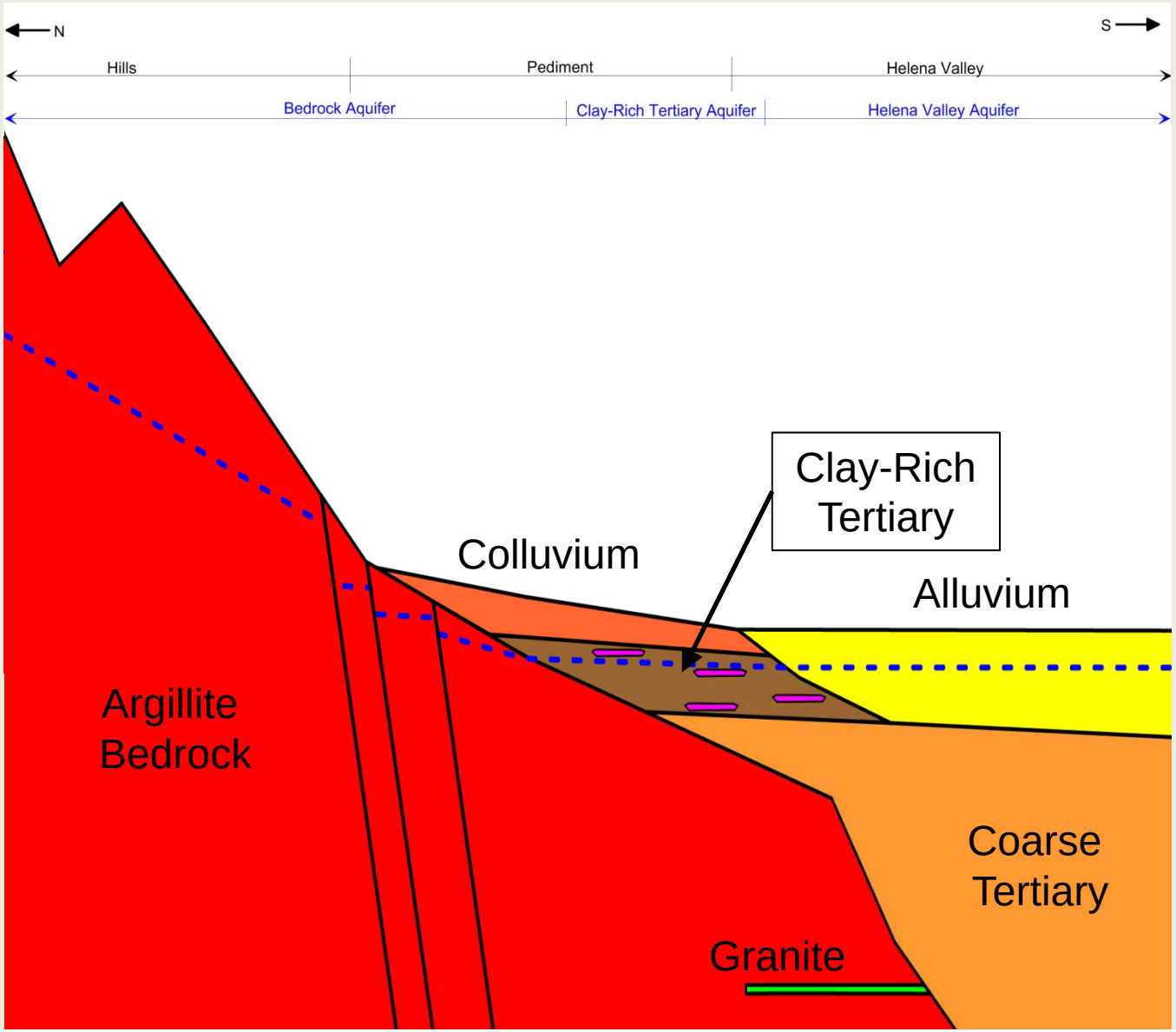
Tertiary unconsolidated clay rich materials overlain by colluvium on pediment

Sand and Gravel of the Helena Valley Aquifer (Quaternary and Tertiary)

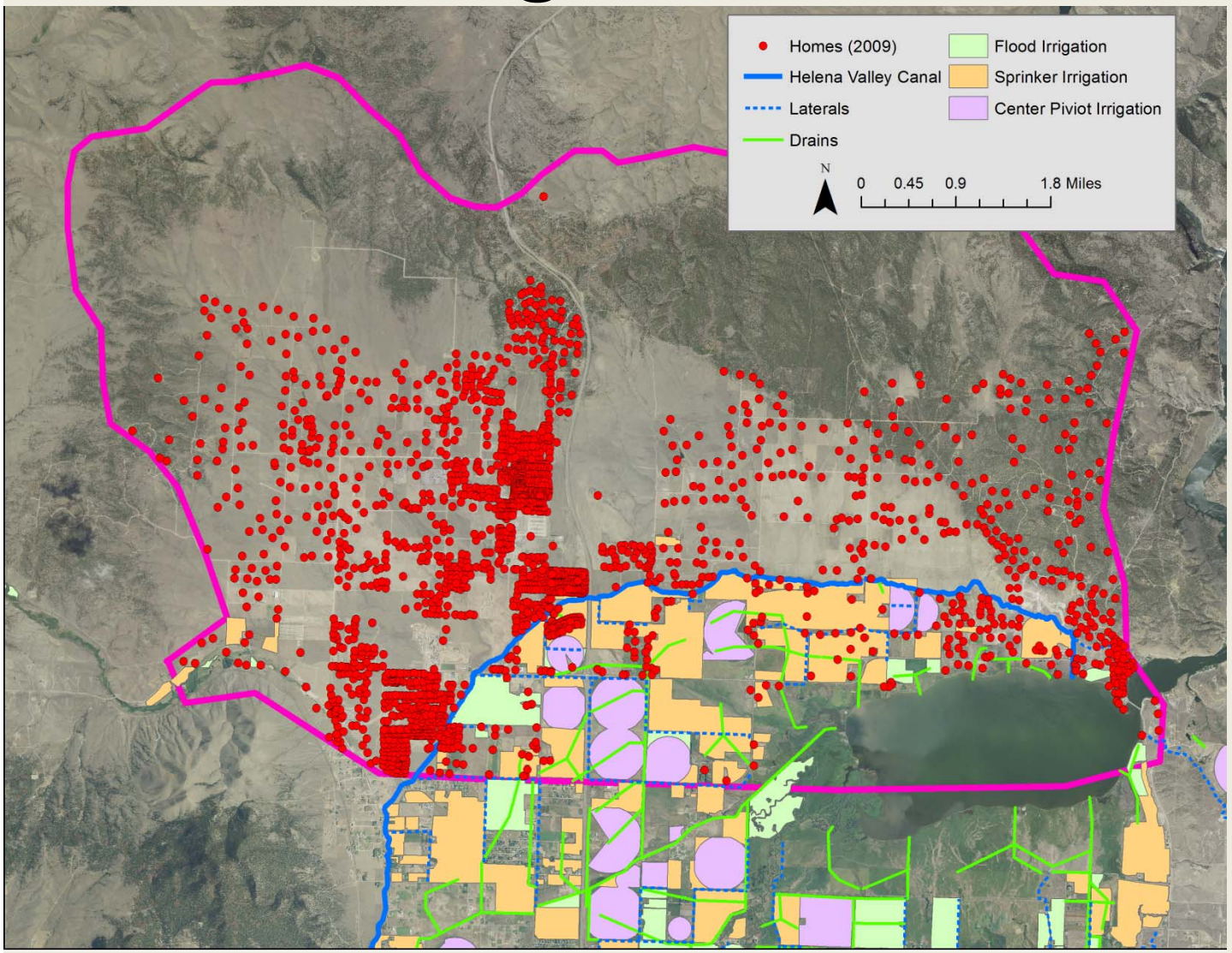


Geologic Map by Reynolds, in Thamke, 2000

Setting: Geologic Conceptual Cross Section



Setting: Human Influences



Lake Helena & Hauser Lake

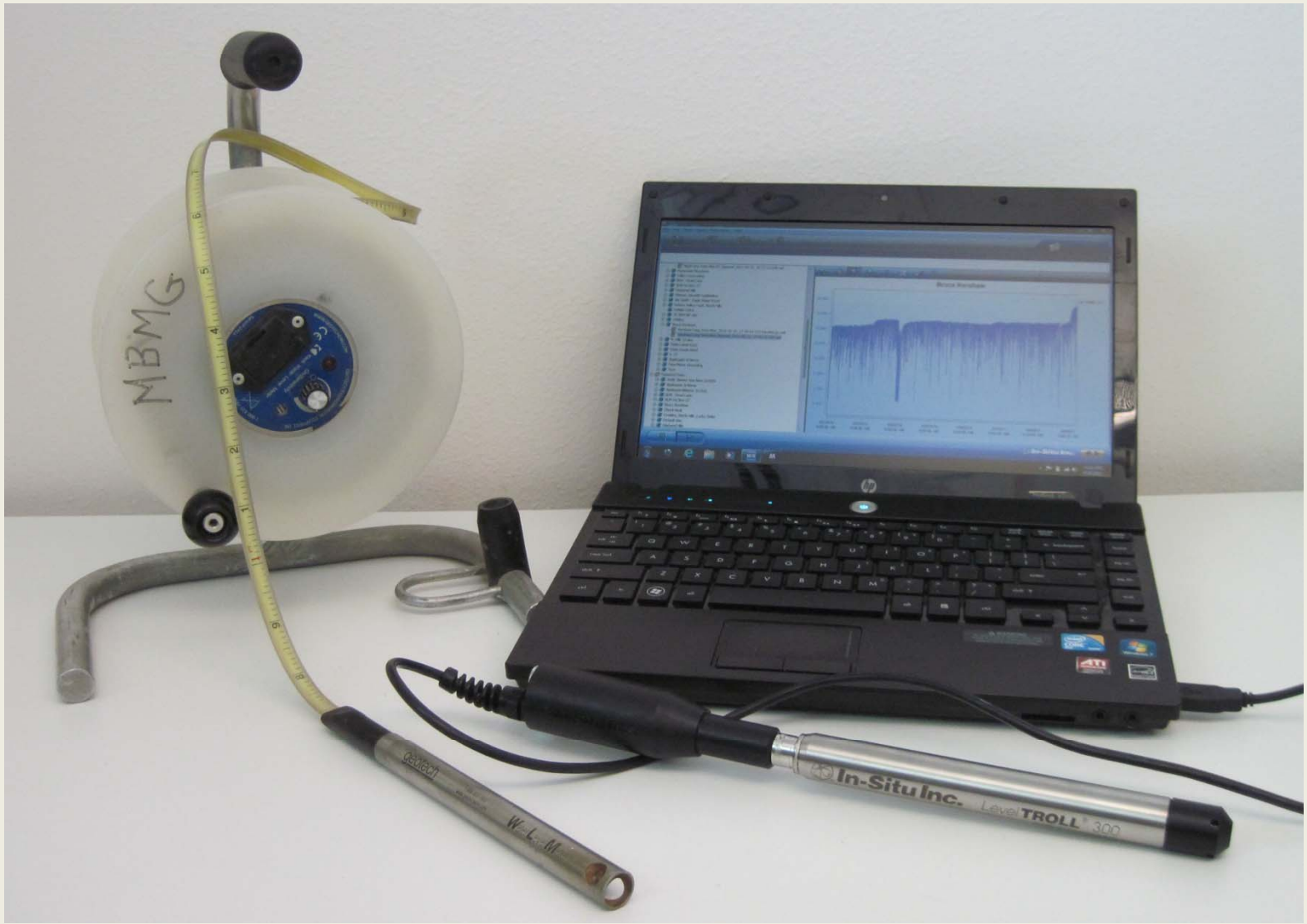
Canal and Laterals Leek to recharge groundwater with surface water from the Missouri River

Irrigation water in excess of crop demand recharges groundwater

Drains installed to prevent water logging

Homes remove water and discharge septic effluent

Methods: Measure Water Levels

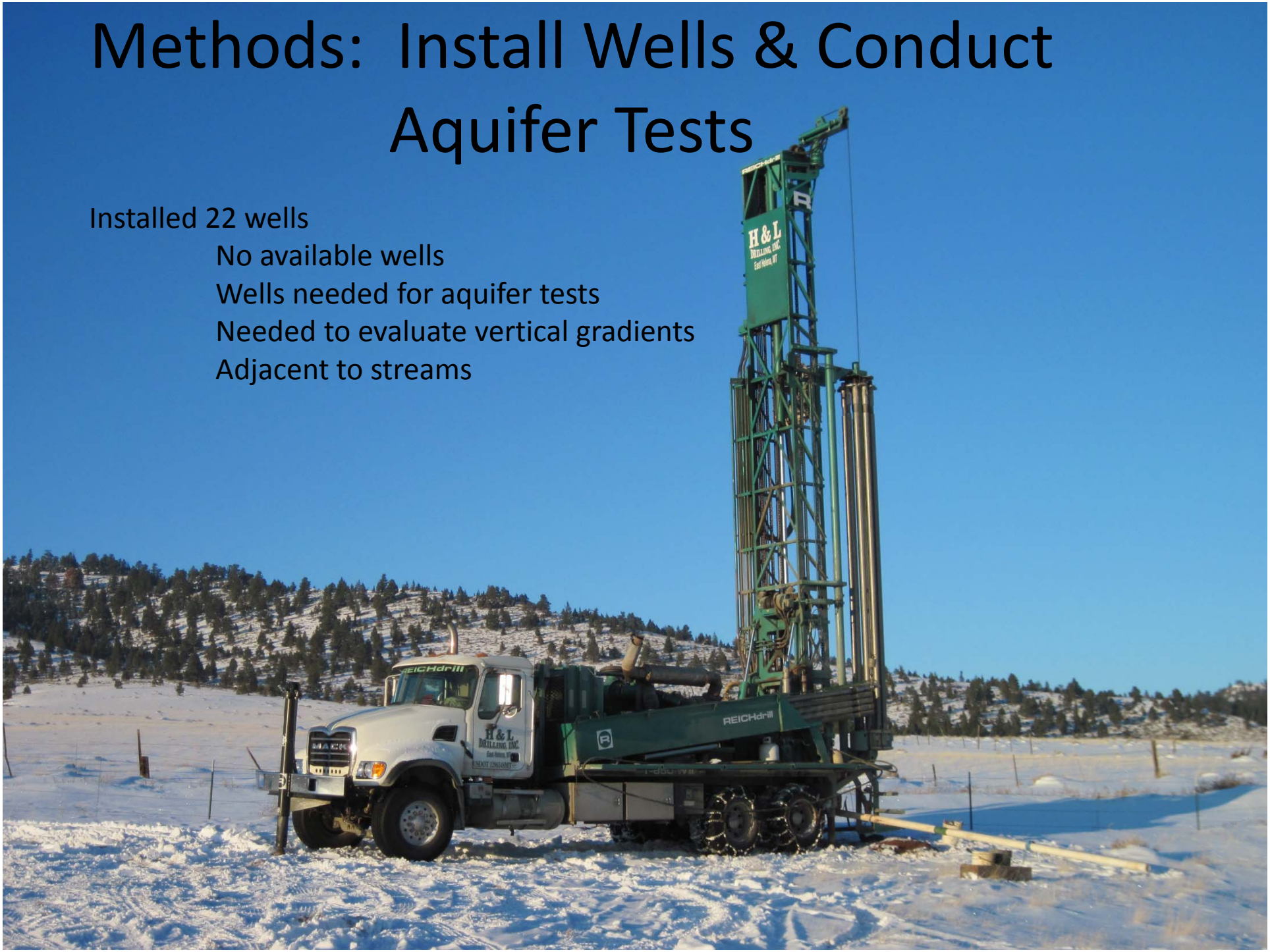


Electronic Tapes (e-tapes) and Pressure Transducers; hourly to monthly
Obtain Depth to Water below a Surveyed Measuring Point – Convert to Groundwater Altitude

Methods: Install Wells & Conduct Aquifer Tests

Installed 22 wells

- No available wells
- Wells needed for aquifer tests
- Needed to evaluate vertical gradients
- Adjacent to streams

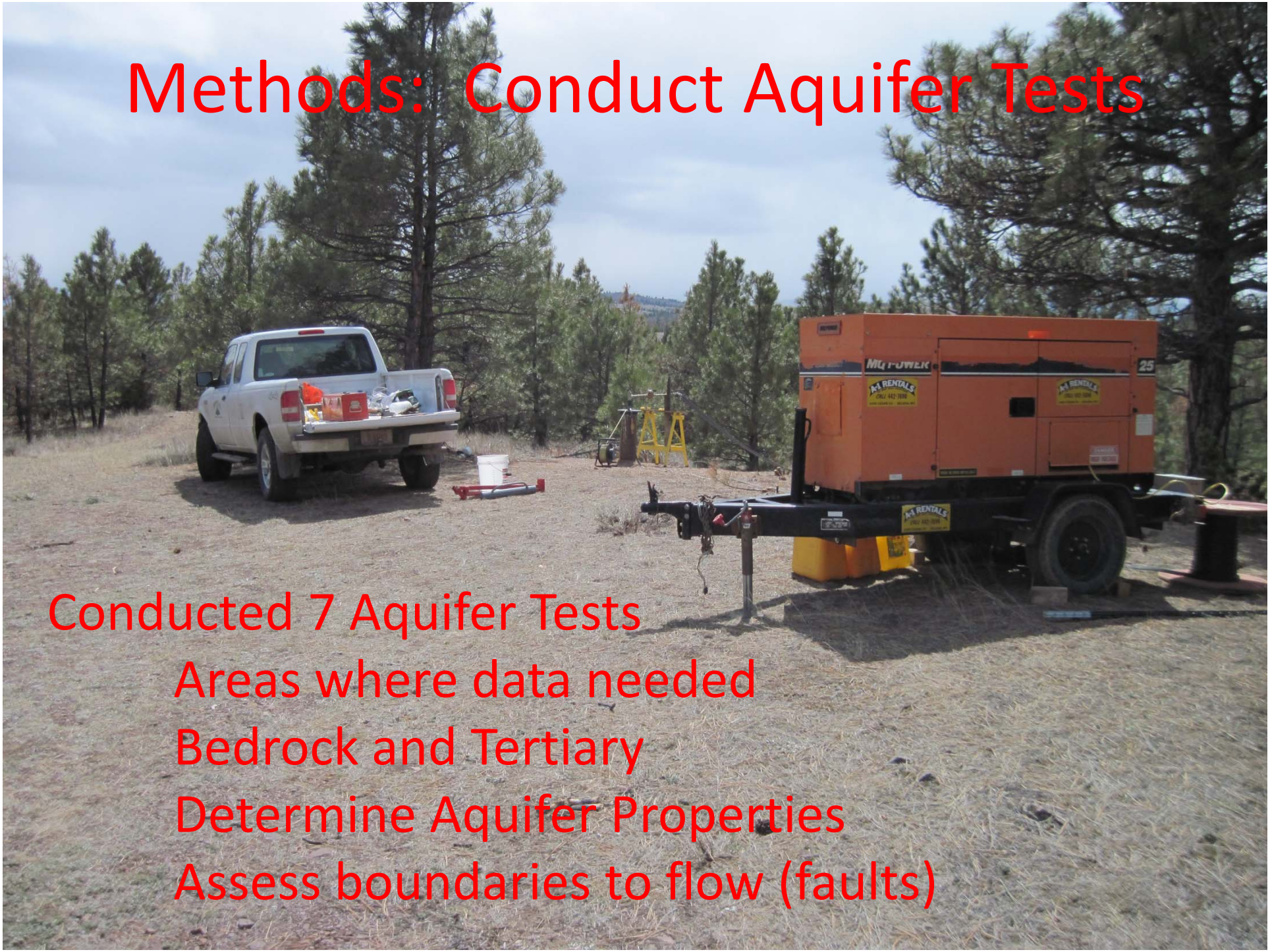


Methods: Surface Water – Groundwater Sites

Stilling Well in Stream
- Surface Water Altitude
- Surface Water Temperature

Well Adjacent to Stream
- Groundwater Altitude
- Groundwater Temperature

Methods: Conduct Aquifer Tests



Conducted 7 Aquifer Tests

- Areas where data needed
- Bedrock and Tertiary
- Determine Aquifer Properties
- Assess boundaries to flow (faults)

Methods: Water Sampling

Three main events
- Early April 2010
- August 2010
- October 2010

87 Groundwater samples from 31 sites

25 Surface Water samples from 12 sites

Standard Suite

Field Parameters
- pH, SC, Temp

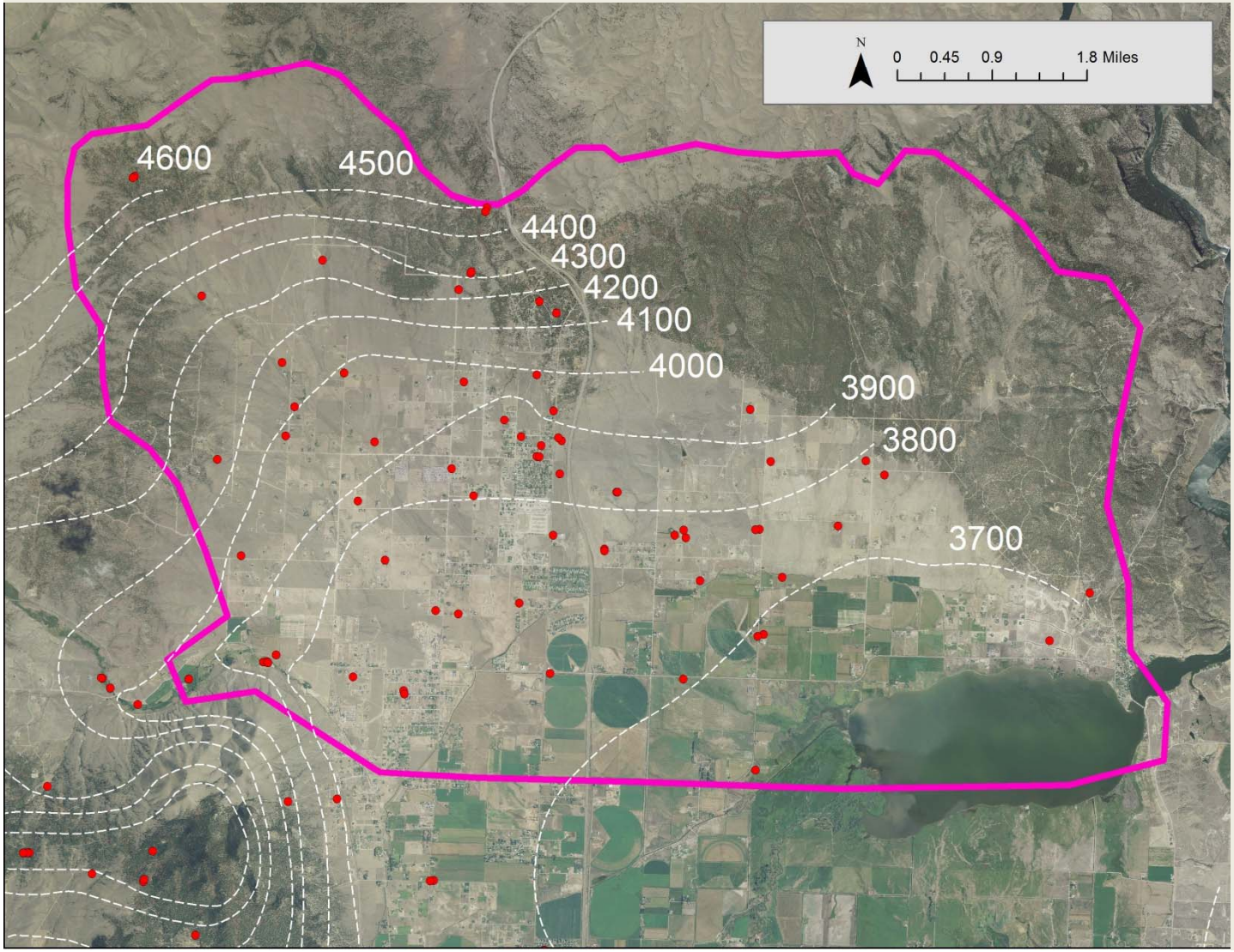
Major Ions
- Ca, Mg, Na, K, Fe, Mn, SiO_2
- HCO_3, CO_3, Cl, SO_4,

Nutrients
- Nitrate, Fluoride, Orthophosphate

Trace Metals
- Al, Sb, As, Ba, Be, B, Br, Cd, Ce, Cs, Cr, Co, Cu, Ga, La, Pb, Li, Hg, Mo, Ni, Nb, Nd, Pd, Pr, Rb, Ag, Se, Sr, Tl, Th, Sn, Ti, W, U, V, Zn, Zr

Observations & Interpretations: Potentiometric Surface Map

(October 2010)



Water Flow from high to low:

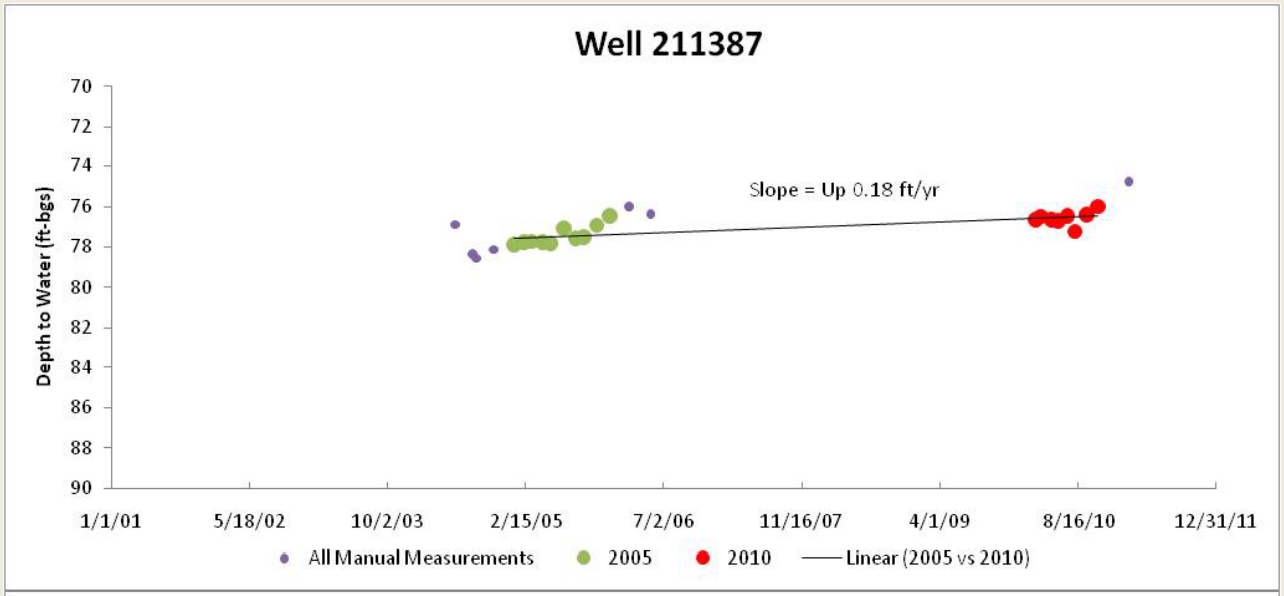
From the hills to Lake Helena

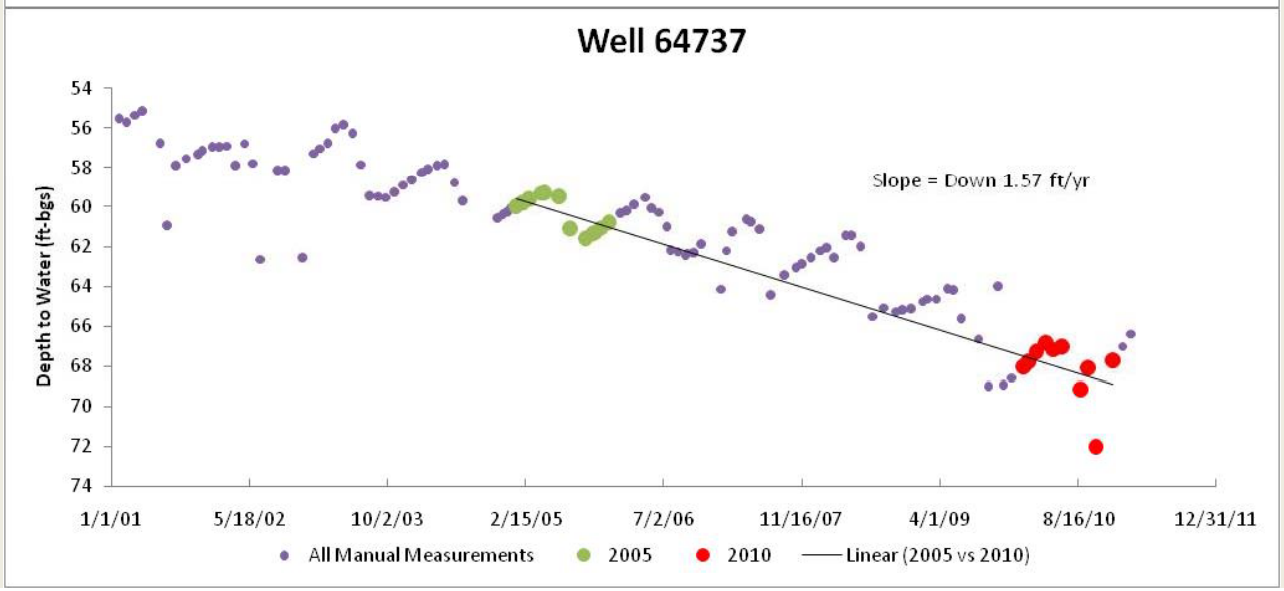
Tighter spacing of contours in Hills indicates lower transmissivity

The surface can be contoured, indicating that at this scale the bedrock can be treated as porous media

Supports conceptual model & provides quantitative targets for numerical model calibration

Observations & Interpretations : Hydrographs





Hydrographs are evaluated for overall trend

Best Fit Line of 2005 and 2010 Data used for quantification

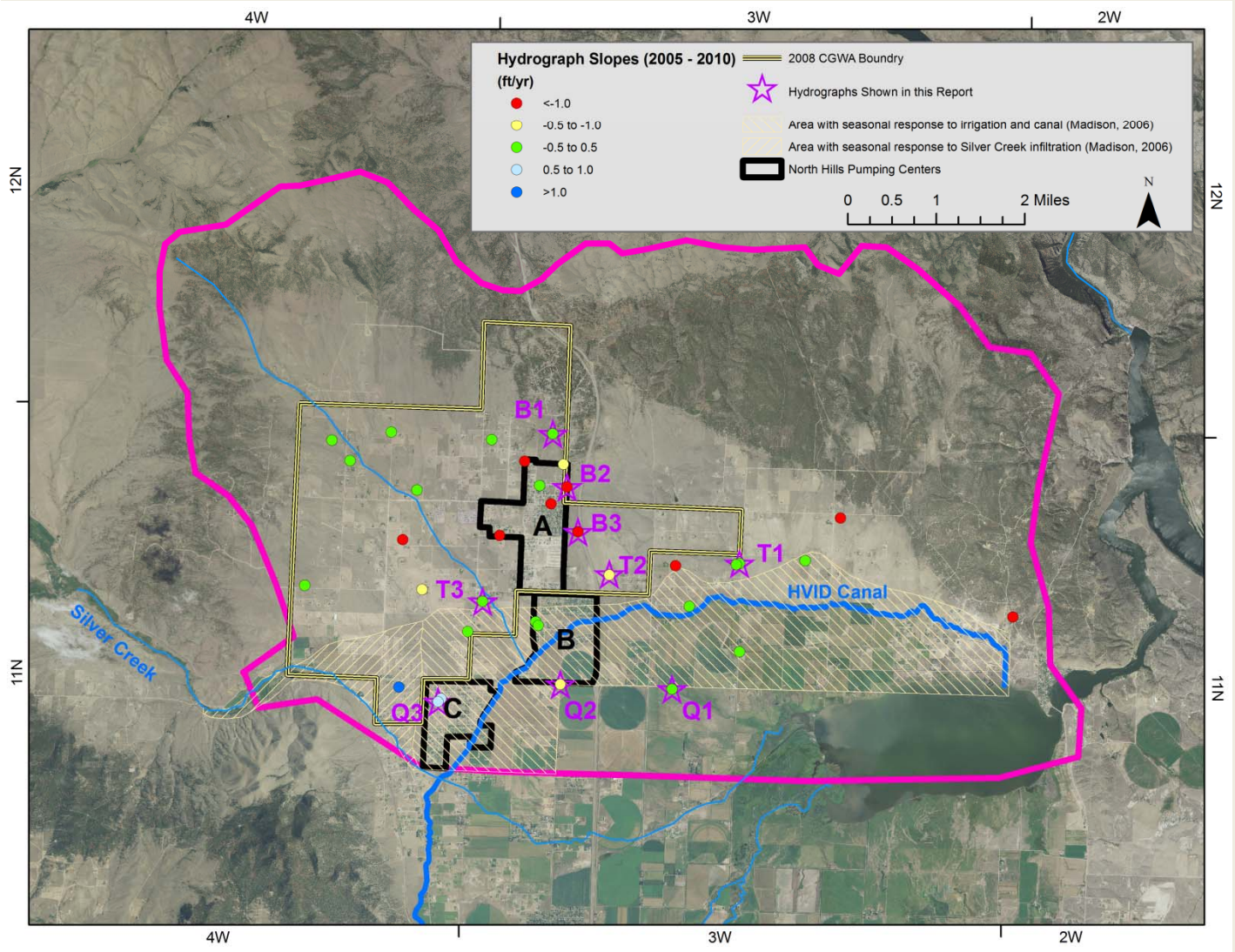
Other data is used to evaluate the result

34 Hydrographs Evaluated
11 up; 23 down

Slope Breakdown:
>1'/yr down = 9
0.5-1'/yr down = 4
±0.5'/yr up or down = 18
0.5-1'/yr up = 2
>1'/yr up = 1

Observations & Interpretations :

Hydrograph Slope Geographic Distribution

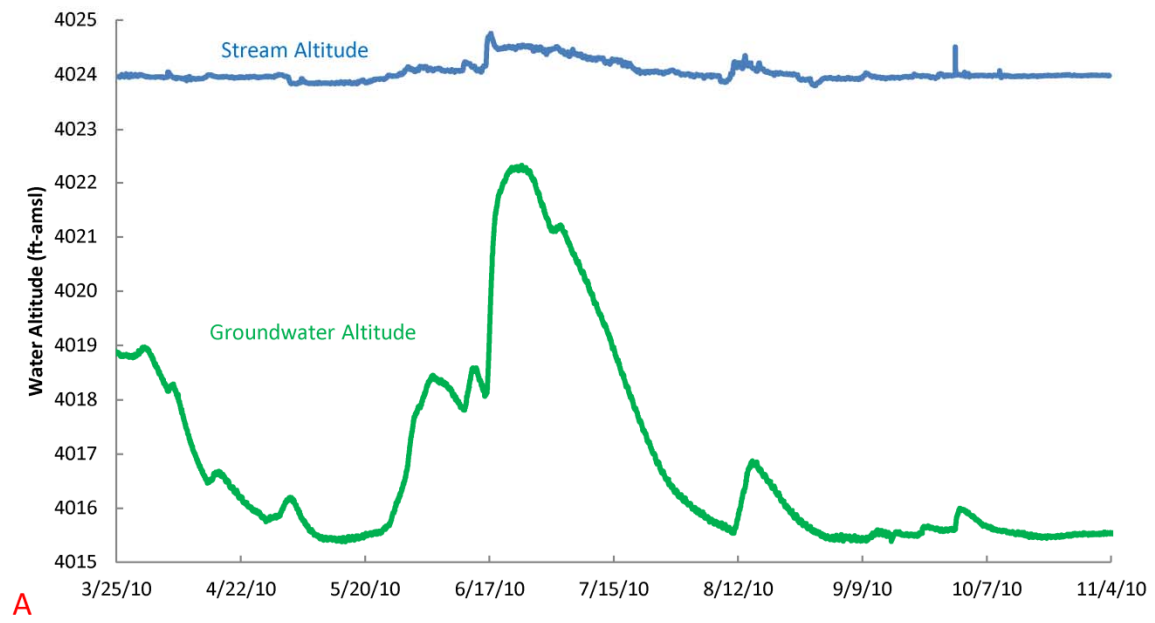


No change or upward In the areas identified by Madison as influenced by irrigation or Silver Creek

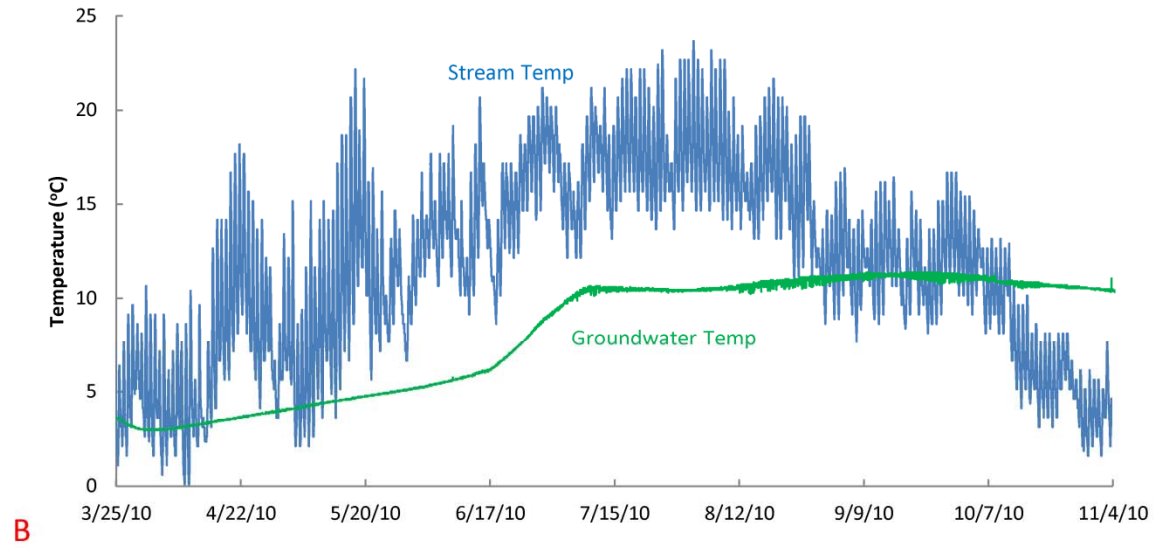
Noticeable declines in wells in the bedrock area with highest development (Pumping Center A)

Scattered wells with declines in areas of lower density development. Likely a due to level of use and aquifer properties at that location

Observations & Interpretations : Surface Water – Groundwater Interactions



A



B

Silver Creek:
Groundwater levels are consistently below surface water levels.

Changes in surface water elevation is rapidly transmitted to groundwater.

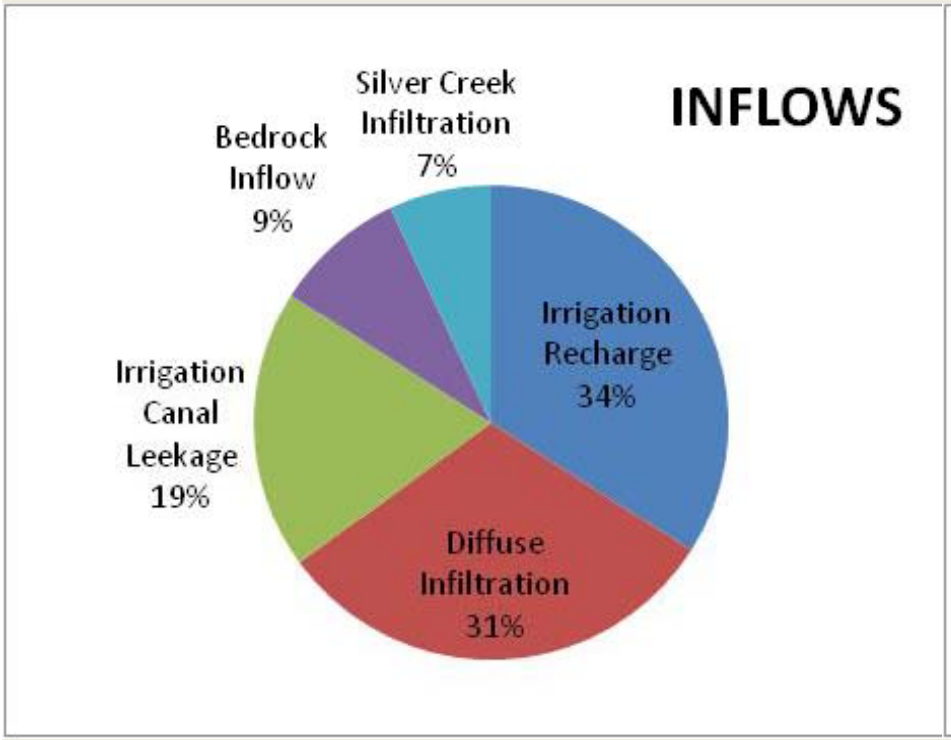
Diurnal temperature variations are not transmitted, however seasonal variation is seen.

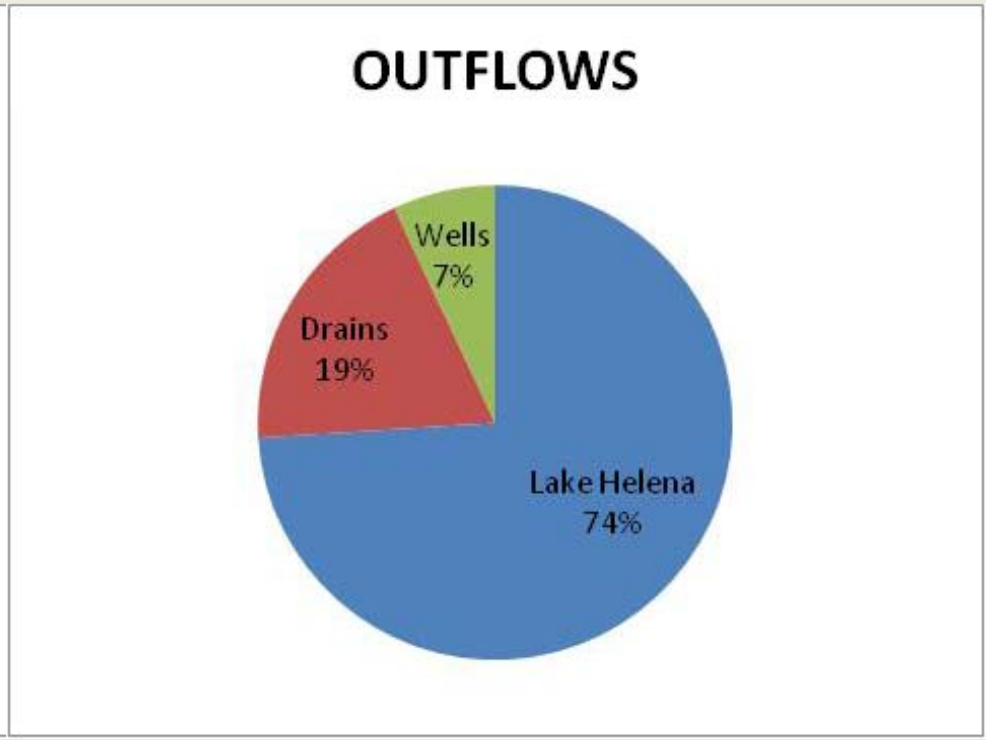
This shows that Silver Creek is a contiguous losing stream, but that the amount of loss is relatively small.

The pattern is the same for all sites on Silver Creek.

Observations & Interpretations: Water Budget

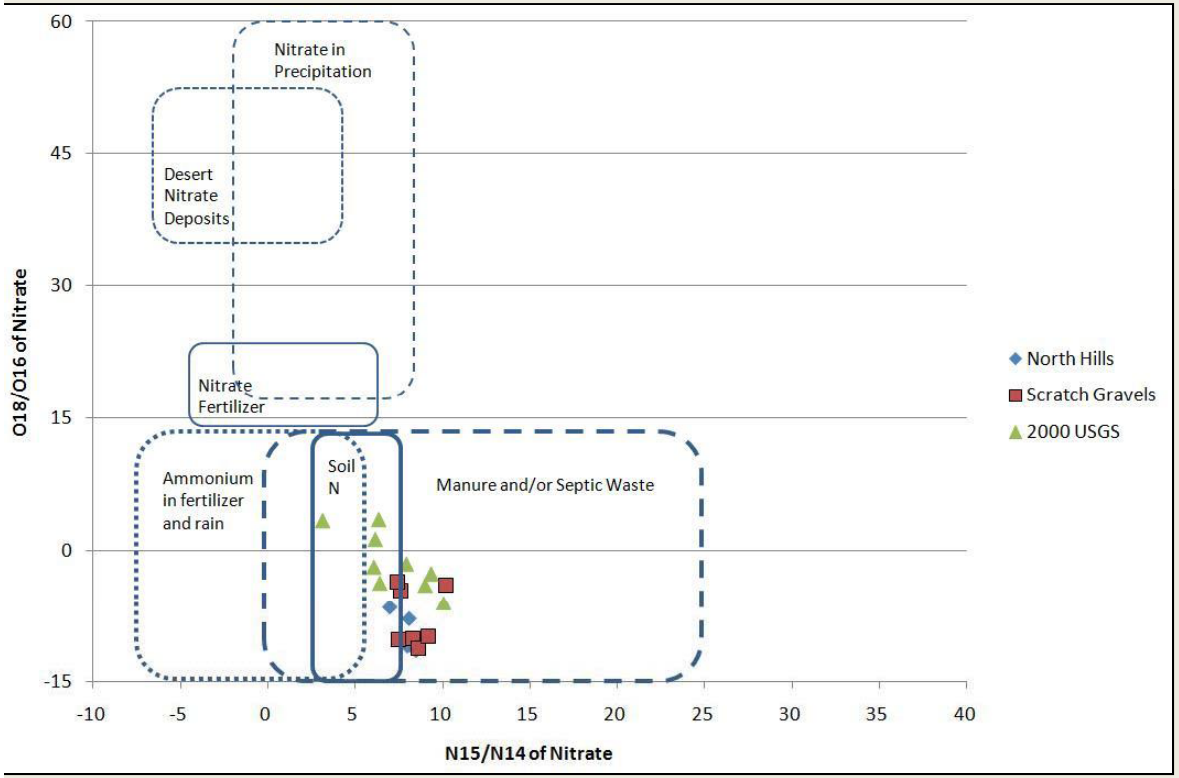
Inflow = Outflow ± Changes in Storage





Analysis shows that ~98% of consumptive use by wells is for the irrigation of lawns and gardens.

Observations & Interpretations: Water Chemistry



Groundwater:
One sample exceeded the drinking water standard for nitrate. All other standards were met.

Natural nitrate is typically less than 2 mg/L (Mueller and Helsel, 1996).

24 of 87 samples had >2 mg/L of Nitrate.

Based on nitrate isotopes, septic systems are the most likely source of the nitrates.

No major livestock operations, but reported past feed lots.

Disturbance relates to release of soil nitrate.

Observations & Interpretations: Water Chemistry

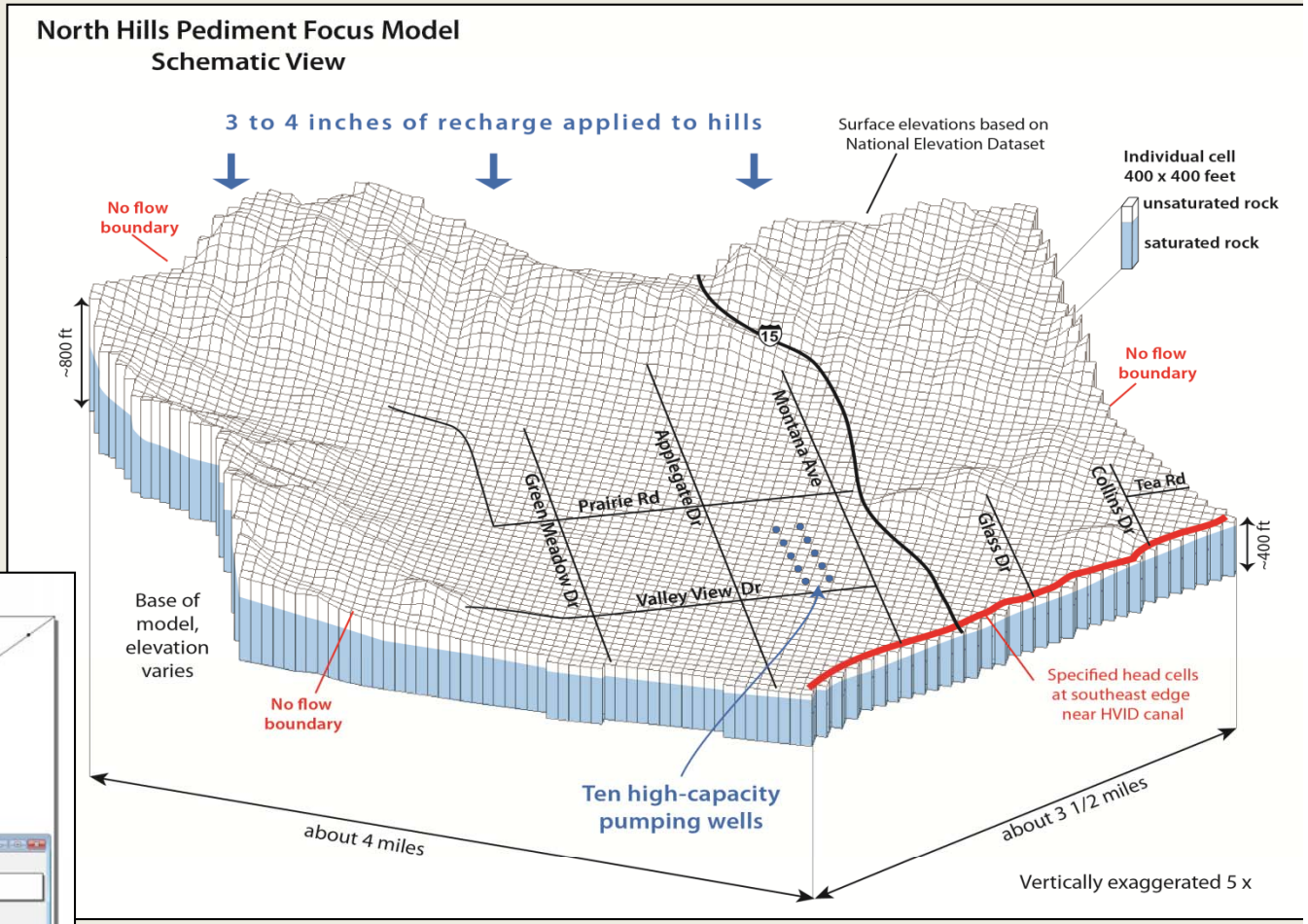
Surface water:

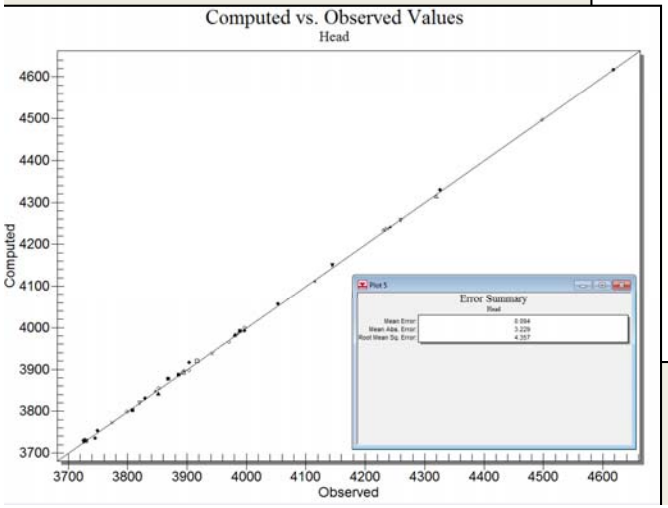
- Arsenic often above drinking water standard
- Cadmium – 2 exceedences of Aquatic Life Standard in Tenmile Creek
- N – Often above Aquatic Life Standard

Data Analysis & Interpretation: Numerical Groundwater Modeling

Numerical models quantitatively combine the components of system & allow for predictions to be made concerning potential future scenarios

Kirk will discuss in detail





Summary

- Groundwater flow is from the hills to Lake Helena and the drains.

- Recharge rarely occurs on the pediment, ET is essentially equal to precipitation.
- Episodic recharge occurs in the hills (3-4 inches per year),
- Recharge from HVID Canal and its laterals, and beneath irrigated fields
    - Only available below canal

- The Bedrock is the least productive aquifer.
    - Fracture Flow (variable)
    - Inhibited by bedrock faults
- The Clay-Rich Tertiary materials are somewhat more productive
    - Depends on gravel layers (west more productive than east)
- Helena Valley Aquifer (sand and gravel) is the most productive aquifer.

- Sustained drawdown is seen north of the HVID canal, and west of the interstate.
- No declines are seen in areas influenced by irrigation or Silver Creek.

Recommendations

- Monitor
  - Existing Dense Development (Pumping Center A)
  - New Development < 10 acre lots where water is from Bedrock
  - Low development density (background patterns)
  - Monitor water use, groundwater levels & water quality
    - document actual timing and magnitude of drawdown
    - allow for Adaptive Management

- Consider PWS wells in the Helena Valley Aquifer
  - Physical Availability vs. Legal Availability

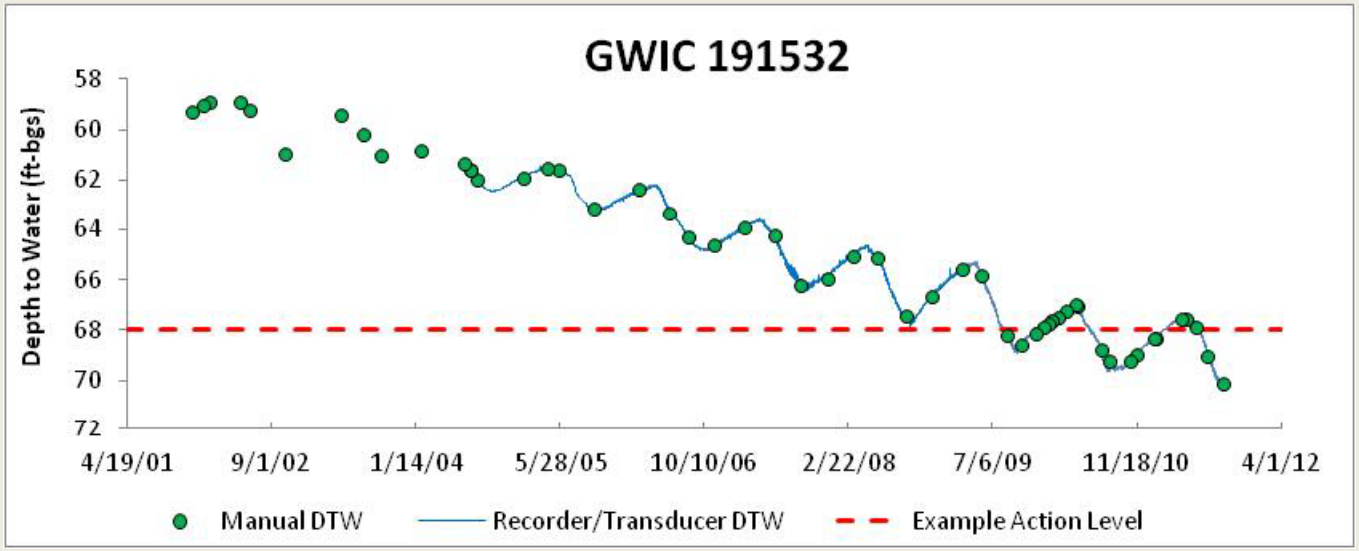
- Consider limits on landscaped area (98% of consumptive use)

- Consider shallow soils, and fractured bedrock when designing septic systems

- Incorporate site specific data as much as possible (faults and fractures) if site specific decisions are needed.

Adaptive Management

1. Specify the objective
2. Establish initial Action Levels based on key indicators (modeling)
3. Establish initial Actions (changes in management) based on Action Levels (modeling)
4. Monitor key indicators, and implement actions as needed.
5. Assess results relative to the objective
6. If needed modify the action levels, actions, indicators, or objective.



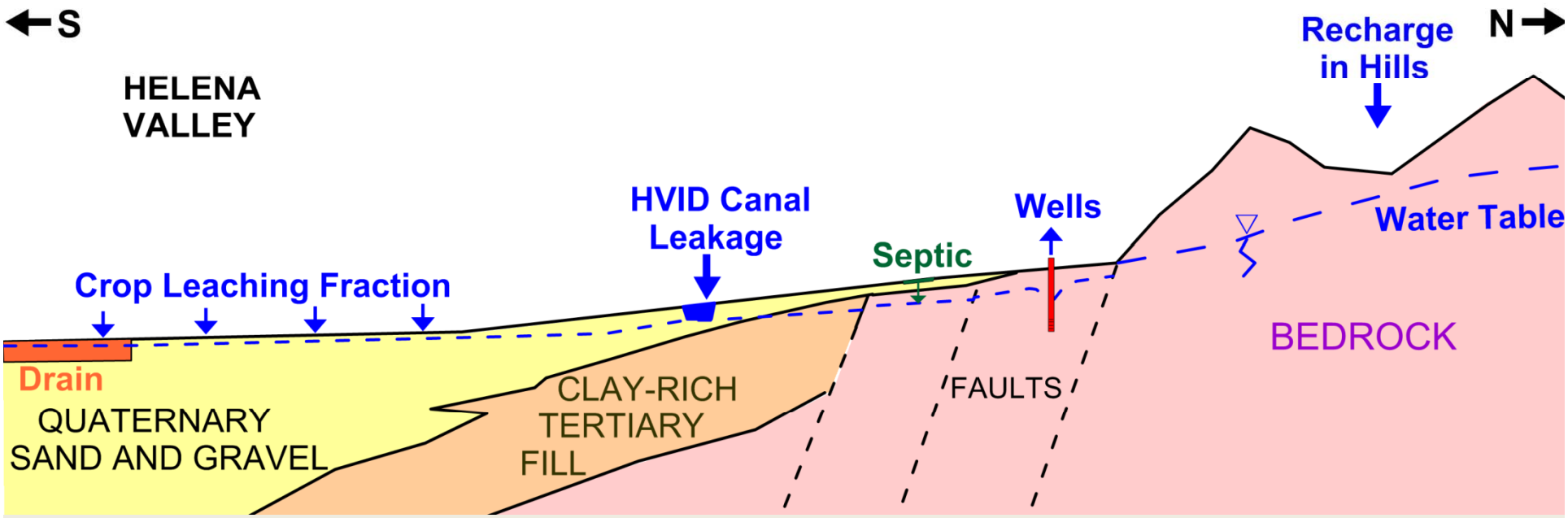
Example:

•**Objective**: Stabilize water levels in the area of the North Hills showing drawdown.

•**Action Level & Action**: If the static water level in the North Hills well drops below 68' then watering of lawns and gardens in the Northern Lights, North Star and Sky View Subdivisions can only occur every other day.


Questions?

Setting: Conceptual Cross Section with Human Influences



Wells and Drains Remove Water

Septic Systems, Canals and Laterals, and Crop Leaching Fraction Add Water

Drains installed to remove excess water:

Prevent Waterlogging & Accumulation of Salts

Observations & Interpretations: Water Budget

	Best Estimate		Probable Range	
		%	Minimum	Maximum
INPUTS				
Silver Creek Alluvium Inflow	21	0.1%	14	28
Bedrock Inflow	1,252	9%	834	1,669
Diffuse Infiltration	4,380	31%	3,942	4,818
Silver Creek Infiltration	1,012	7%	876	1,071
Irrigation Canal Leakage	2,701	19%	2,339	2,858
Crop Leaching Fraction	4,778	34%	4,138	5,057
TOTAL INPUTS	14,144	100%	12,143	15,501
OUTPUTS				
Drains	2,894	19%	2,704	3,304
Lake Helena	11,075	74%	10,344	12,643
Wells	1,033	7%	949	1,136
TOTAL OUT	15,001	100%	13,977	17,083