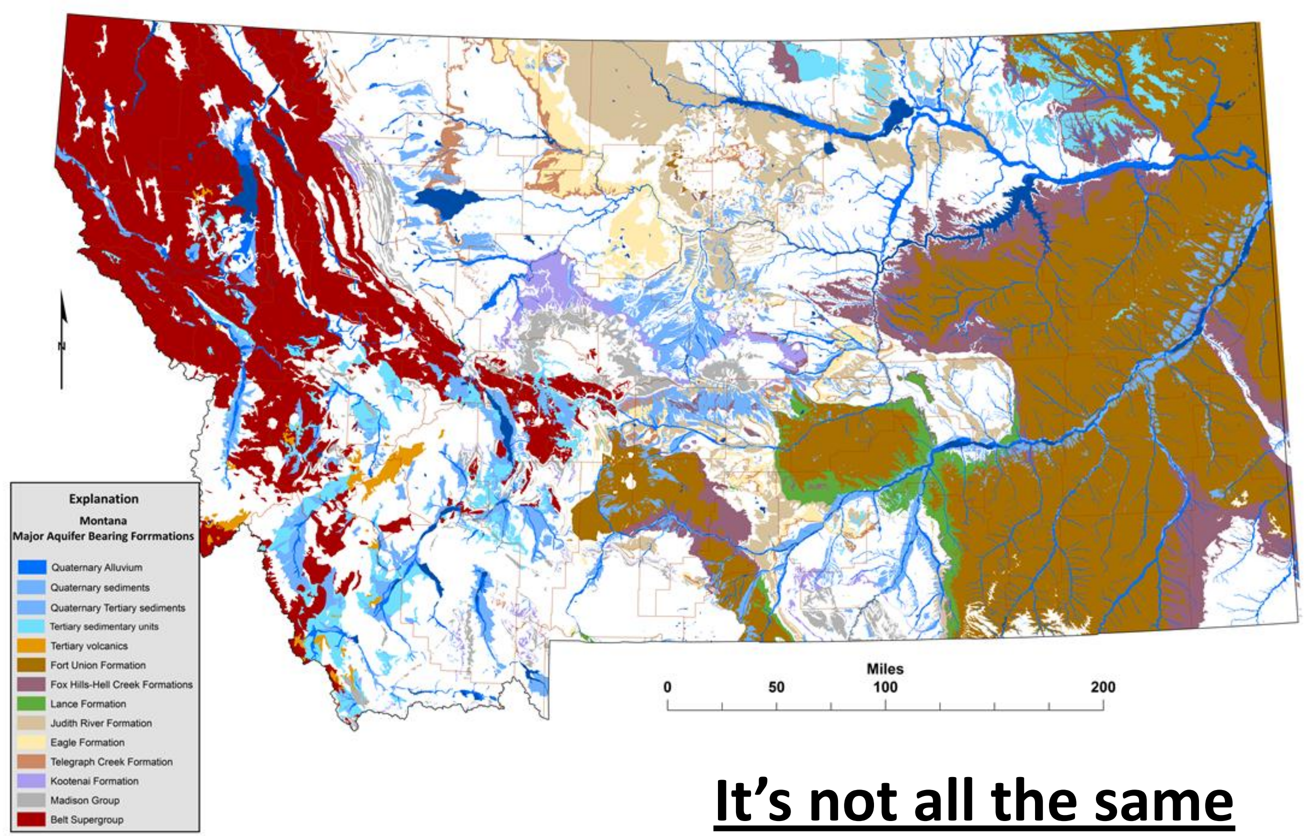
Ground Water Investigation Program (GWIP - MBMG)
Program Status and Update

Presented to the Water Policy Interim Committee
September 10, 2012

Presented by:
John Wheaton
Mary Sutherland
Kirk Waren

Preparation by:
GWIP staff



<u>It's not all the same</u>

Topics for today:

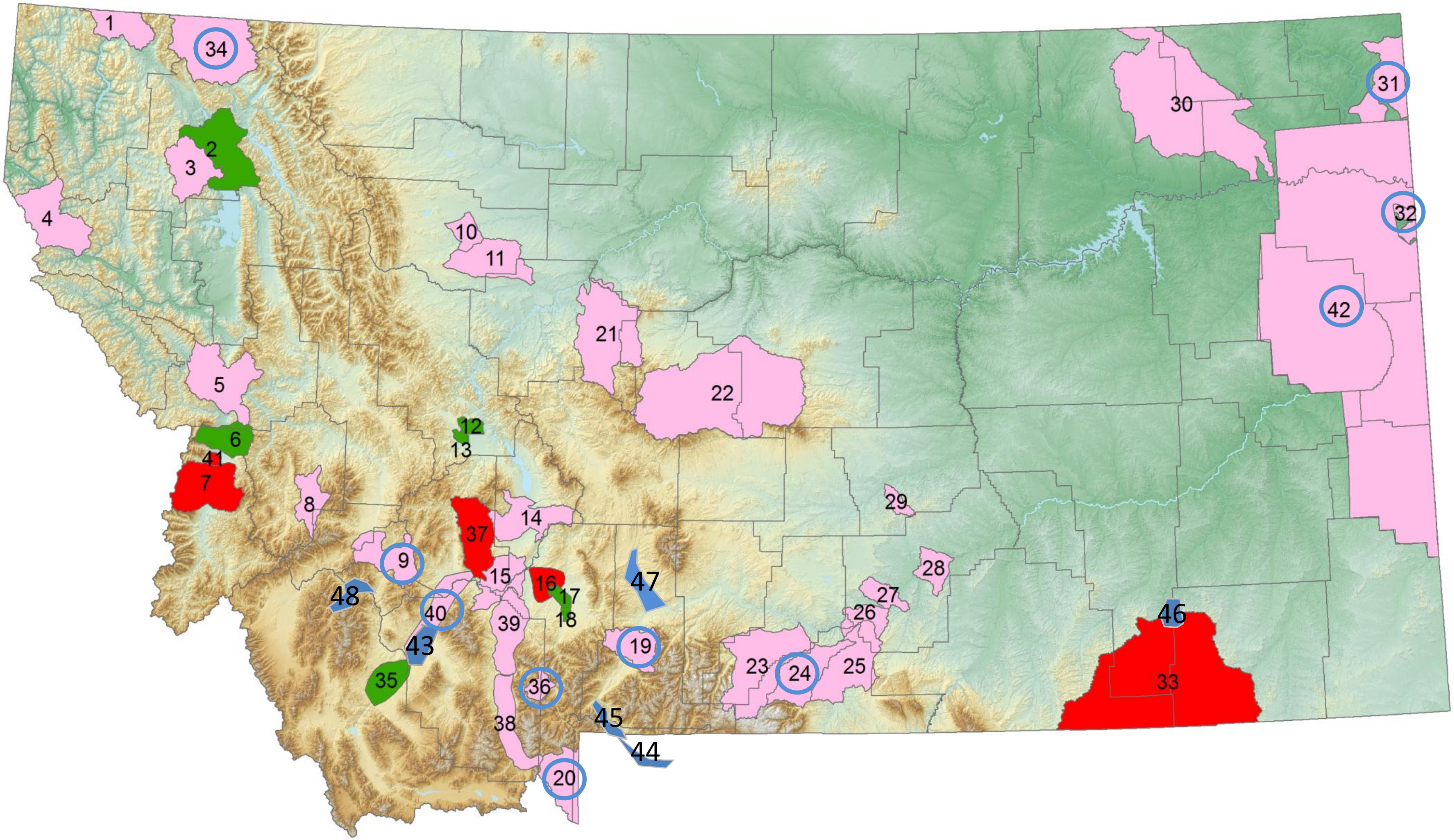
Status of GWIP projects
John Wheaton

Gallatin Valley (4 Corners) model and project results
Mary Sutherland

Review of lessons learned from GWIP
Kirk Waren

Ranking meeting of Ground Water Steering Committee September 26.

New nominations are in blue.



New nominations or re-nominated projects
Issues and concerns nominated and being considered:

9 Summit Valley
- Upper Clark Fork stream depletion
- Land release
- Development – industrial and domestic

19 Small tributaries that feed Paradise Valley (Pine Creek)
- Development stresses
- How these catchments support the main valley
- And now a major fire

31 Clear Lake Aquifer
- Water management
- Ancestral Missouri River valley
- Wetlands, irrigation use

32 Lower Yellowstone River Buried Channel Aquifer
- Resource quantification and management
- Irrigation and water supplies – Sidney area

34 North Fork Flathead River
- Sensitive international river system

Issues and concerns nominated and being considered:

- 45 Yellowstone River north of YNP
  - Groundwater/surface-water interaction
  - Hydrothermal feature recharge
- 44 Soda Butte Creek – YNP
  - Increasing development in a seasonally high use area
- 20 West Yellowstone
  - Nitrate and water supply stress from expanded growth
- 36 Big Sky
  - Potential water resources to meet increasing demand
  - Water management of the resources
- 40 Upper Jefferson River to Whitehall
  - Irrigation stress on streamflow
- 42 Fox Hills aquifer
  - Stress due to oil and gas development
  - Water management in conjunction with multiple uses
- 43 Beaverhead River – Point of Rocks to Twin Bridges
  - Increased groundwater demand for irrigation
  - Increased instream flow rights
  - Water management with multiple uses

Issues and concerns nominated and being considered:

- 46 Otter Creek
  - Coal development
  - Large grazing district dependent on wells and springs
  - Now major fire impacts
  - Finding common ground on management approaches thru science
- 47 Shields River Valley
  - Potential oil and gas development
  - Increased groundwater demands
- 48 Wise River
  - Watershed health and functionality through better management
  - Function of irrigation for groundwater recharge and stream flow

Issues nominated for the 2012 ranking process:

Stream Depletion from groundwater stress

- Land use changes and reduced irrigation in various settings
- Irrigation
- Development in mountainous terrain
- Industrial use

Impacts of major wildfires on aquifers, springs and groundwater dependent ecosystems

Better science for water management

Sensitive international groundwater and surface water system

Hydrothermal feature protection

Nitrate and water quality impacts

Coal, Oil and Gas development

GWIP project data and results are being put to use:
Some of those uses are known to us.

Helena Subdivision

- Planning has changed as a result of GWIP project

Canal Seepage data

- Irrigators
- DEQ
- Bureau of Reclamation

Stream Depletion information

- DEQ
- Consultant

Landowners:

- Receive copy of data collected on their land
- Have contacted us due to concerns which were directly answered on water quality and quantity in several instances.

Aquifer tests and hydrograph data

- Consultants

Exempt well report (Metesh)

Energy and Groundwater in Montana

Co-Sponsored by

Montana Watershed Coordination Council
Ground Water Working Group

Montana Bureau of Mines and Geology

Natural Resource Building, Room 122
Montana Tech campus
Butte - July 31, 2012

10:30 am	**Registration**
11:00 am	**Introduction and Welcome**
11:15 am -12:15 pm	**Unconventional Oil and Gas** moderated by Ginette Abdo Bakken and other tight plays in Montana *Jay Gunderson, Montana Bureau of Mines and Geology* Engineering and fracking wells in tight plays *John Evans, Montana Tech, Department of Petroleum Engineering*
12:15 to 1:00 pm	**Lunch, Natural Resource Building Lobby**
1:00 to 2:00 pm	**Coal development** moderated by John Wheaton Coal-related development in Montana and overview of the groundwater regulations *Angela McDannel, MDEQ, Coal and Uranium Program* Groundwater monitoring program for coal mines and coalbed methane *Elizabeth Meredith, Montana Bureau of Mines and Geology*
2:00 to 2:15	**Break**
2:15 to 3:30 pm	**Geothermal Energy in Montana** moderated by James Rose Types of development and potential around the state *John Metesh, Montana Bureau of Mines and Geology* Associated groundwater issues, permit requirements and implemented examples *Kathi Montgomery, MDEQ, Renewable Energy and Air Quality* Mining Butte's Geothermal Resources *Edmond Deal, Montana Bureau of Mines and Geology*
4:00 pm	**Underground Mine Tour** The underground mine tour is adjacent to a heat-pump project under construction which will harness geothermal energy beneath the Montana Tech campus. *James Rose, Rob McCulloch, John Metesh, Montana Bureau of Mines and Geology*

Groundwater theme workshop

Communicating results

Addressing issues

70 attendees

Plan to continue this forum

Gallatin Valley
Four Corners Investigation Area

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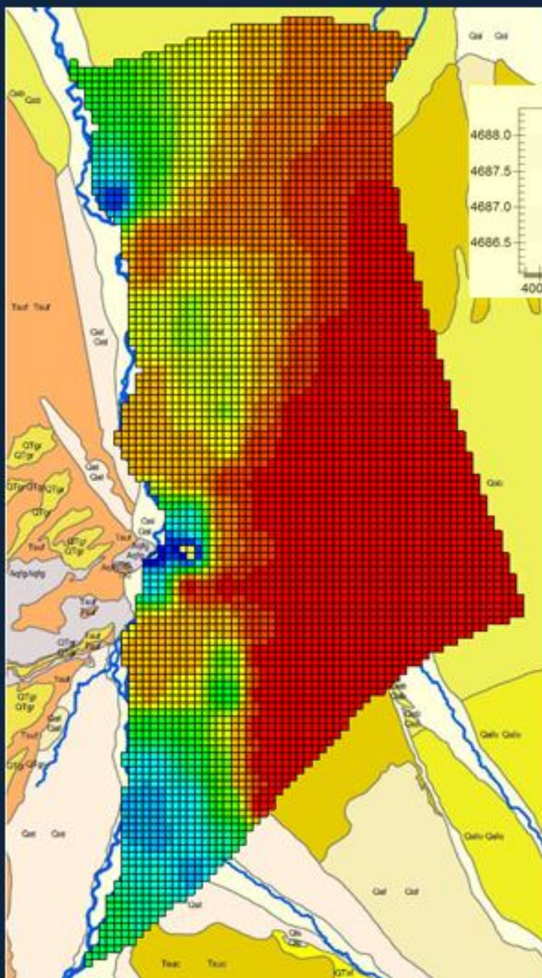
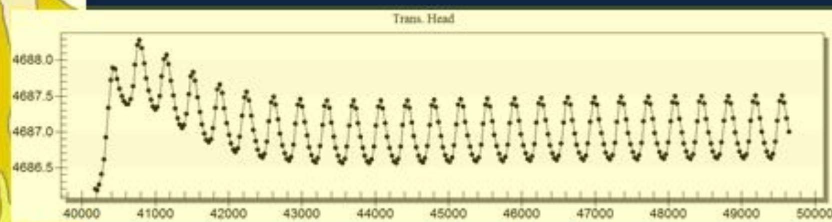




Presented by:
Mary Sutherland

Team Leader:
Tom Michalek

Ground Water Investigation Program

MBMG

Gallatin County

- ✓ Fastest growing county in the state; 32% increase in last census
- ✓ 10,000 more housing units
- ✓ 40% increase in water wells
- ✓ Irrigated acres decreased by 20% from 2002 to 2007
- ✓ Flood irrigation changing to sprinkler and pivot

GWIP Questions:

What are the effects of these rapid changes?

Can we <u>manage</u> future changes through hydrologic <u>science</u>?

Four Corners Ground Water Investigation Project

Objectives / *Results*

- Determine the extent of alteration to the groundwater system in the Four Corners Area over the last 60 years.

  Small water elevation changes, large flux decrease

- Correlate groundwater changes to land use conversion.

  Reduction of irrigated acres has decreased recharge
  Subdivision use has a minimal effect

- Document the effects of irrigation and canal leakage on groundwater recharge.

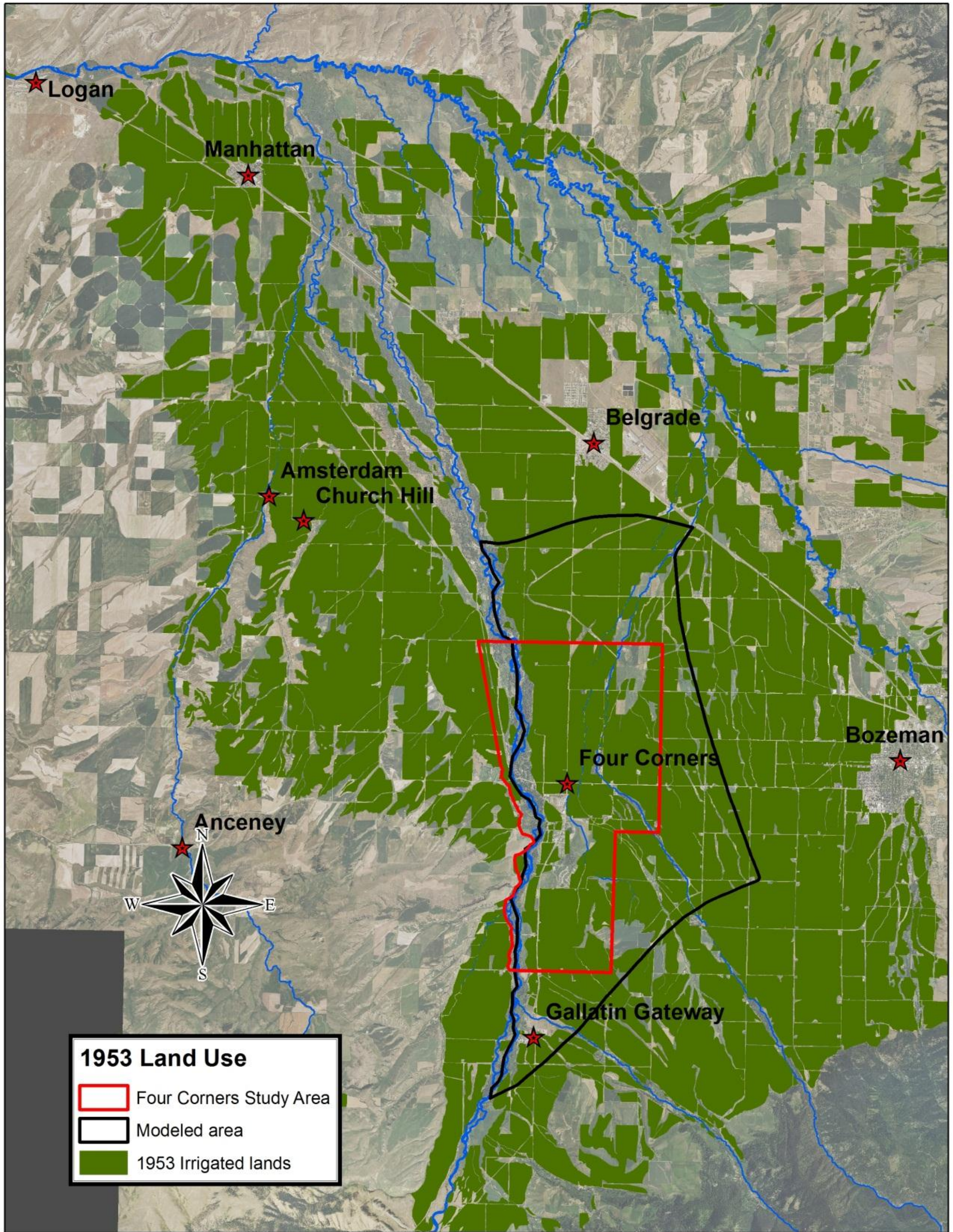
  Typical canal leakage is 1.1 cfs per mile

- Evaluate likely effects of future changes and development.

  At past growth rates, future development will lower the water table about 2.5 feet

Irrigated Land
(1953)

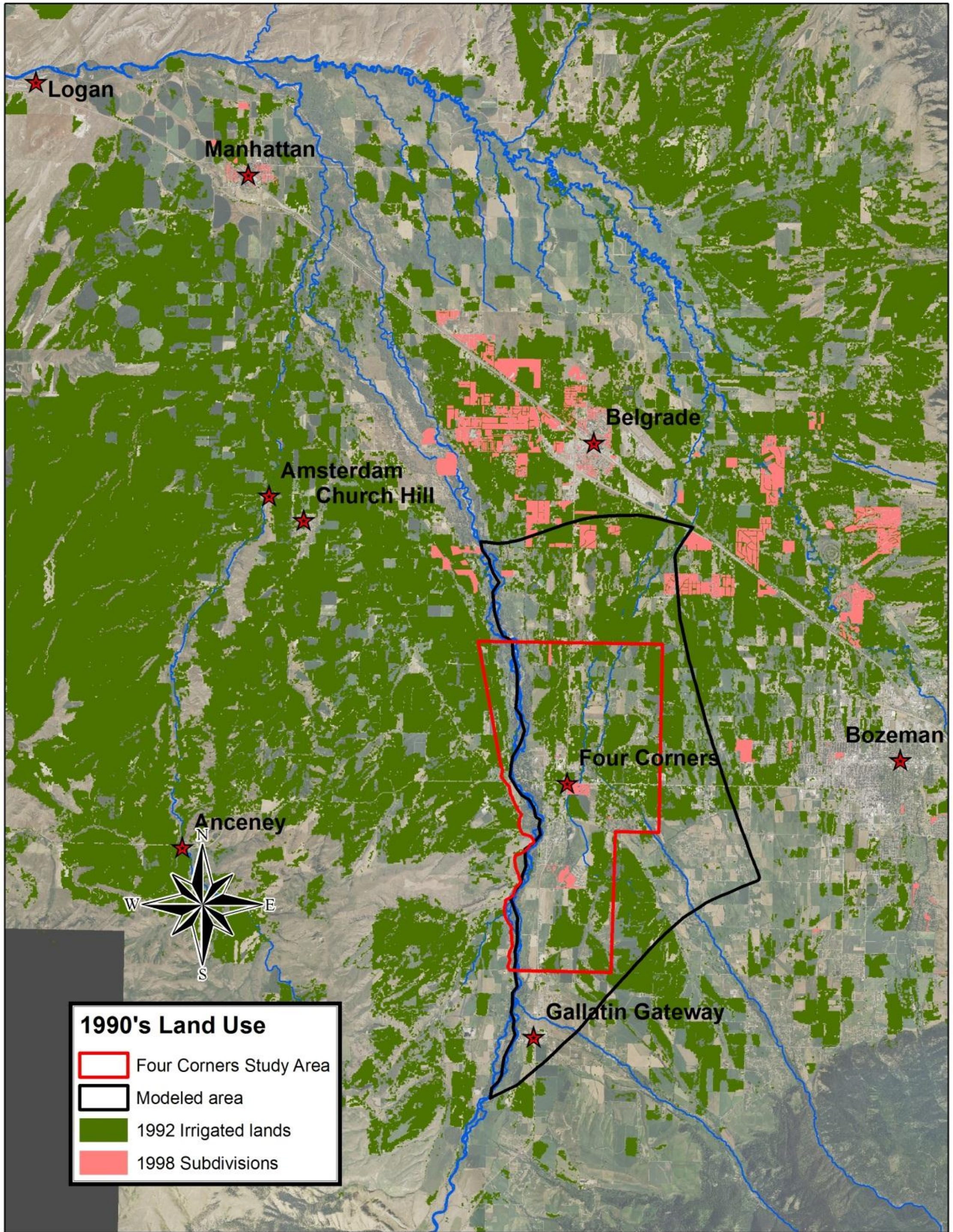
All flood irrigation



Irrigated Land
(1990's)

Irrigated lands decreased

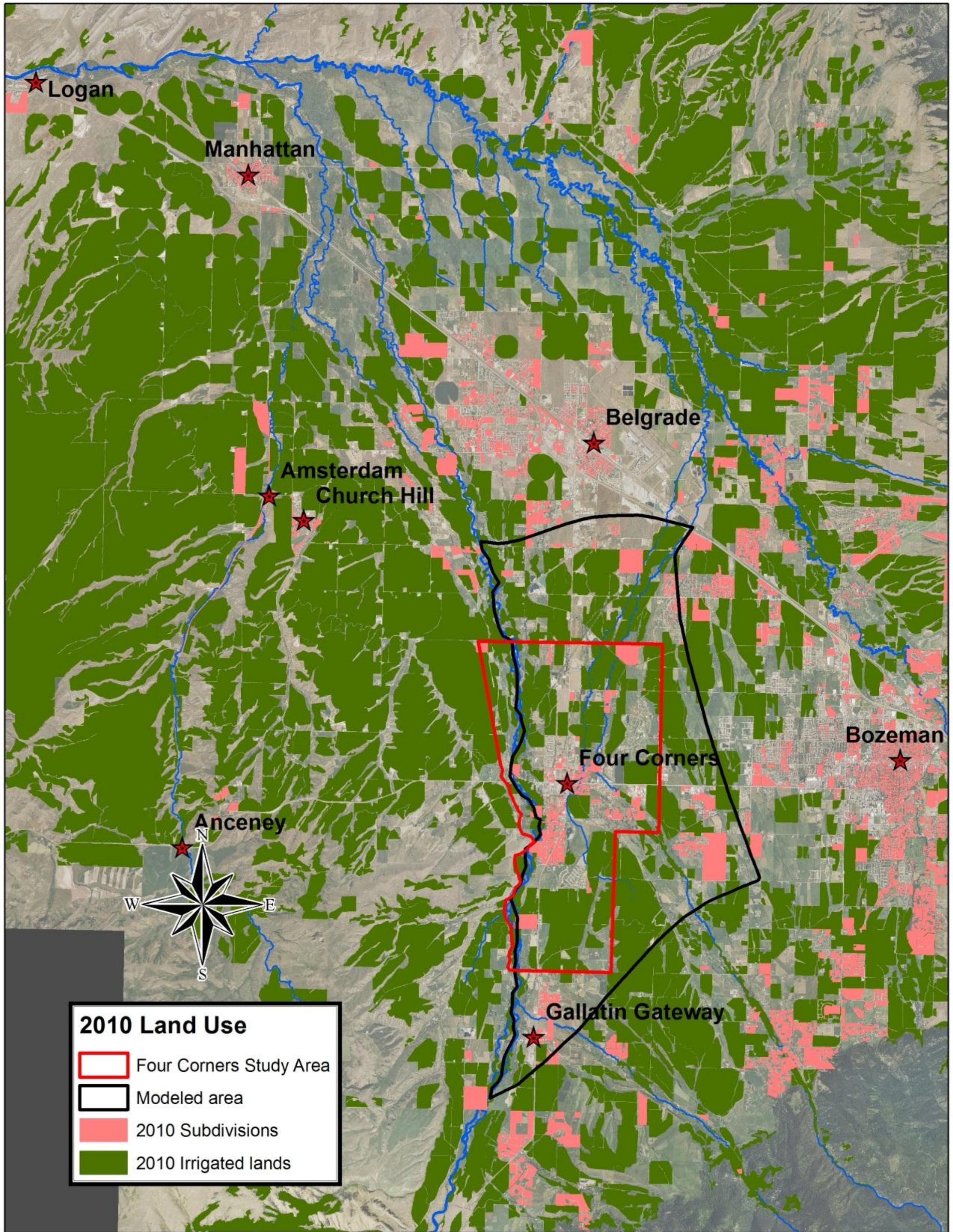
Suburban development

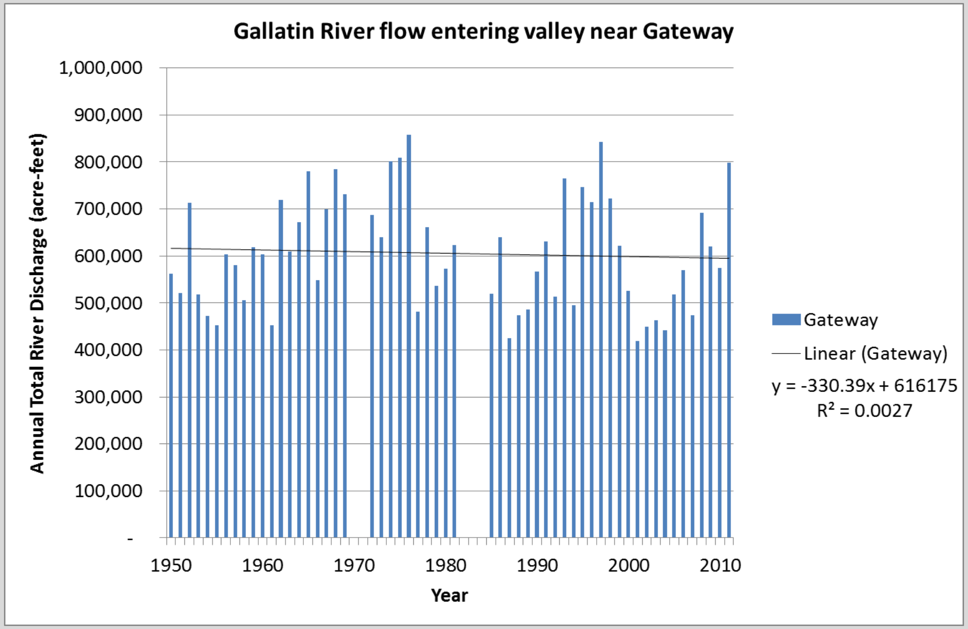


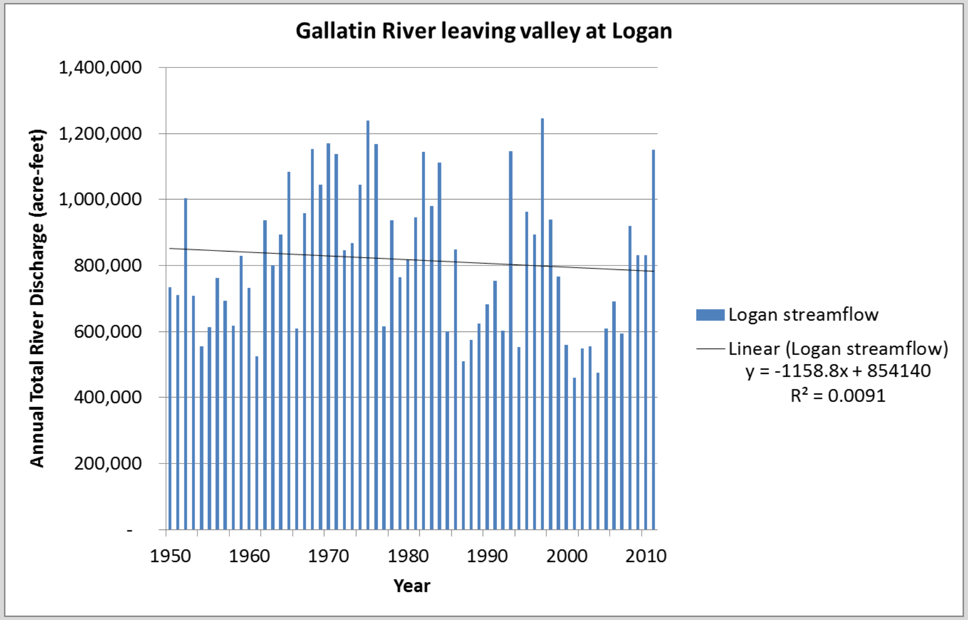
Irrigated Land
(2010)

Irrigated lands decreased at an average rate of 628 acres per year since 1992

Suburban development increasing at an average rate of 535 acres per year since 1998





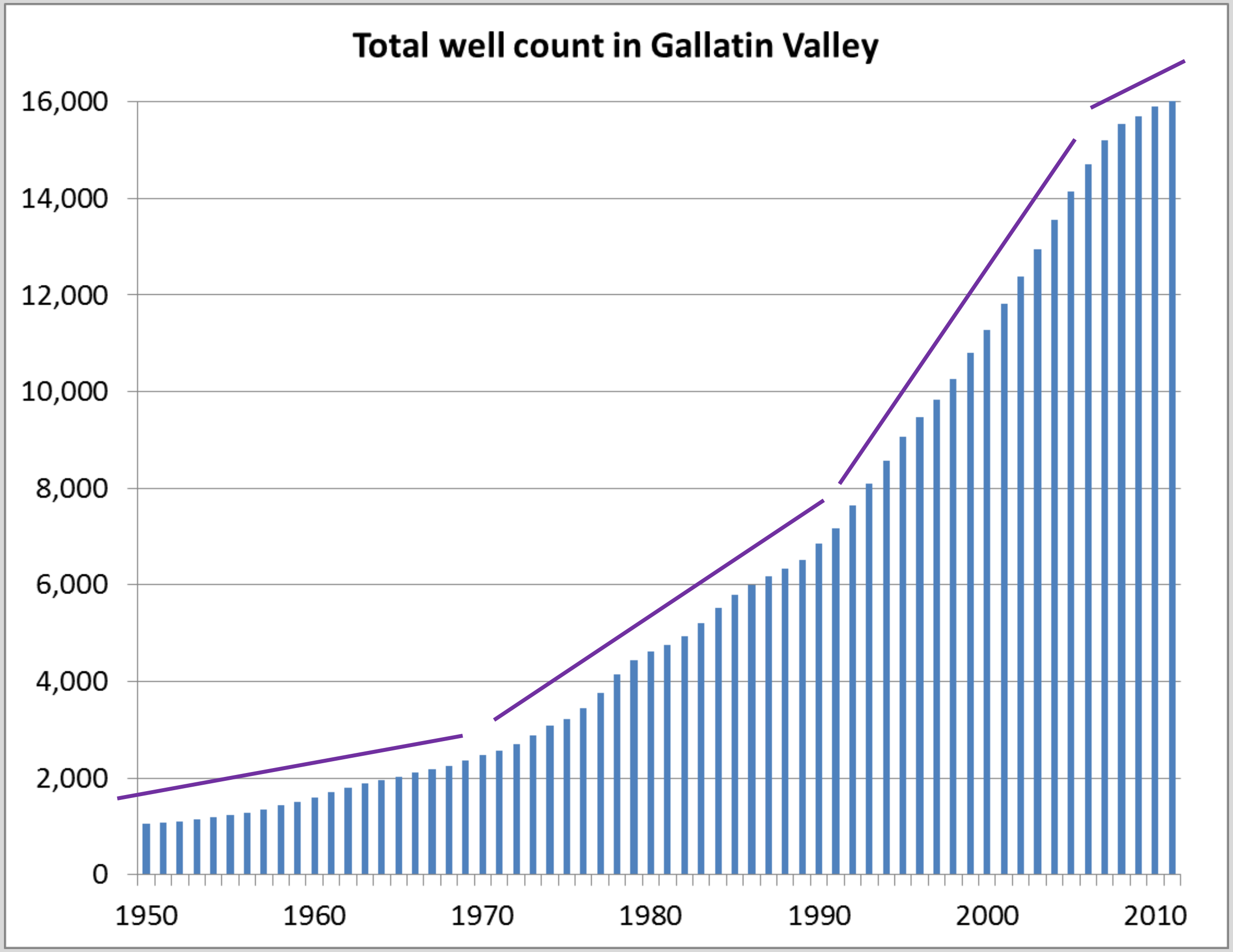


Since 1950:

River flow entering valley has decreased an average of about 330 ac-ft per year.

River flow leaving the valley has decreased an average of about 1,160 ac-ft per year.

Consumptive uses within the valley have increased and recharge from irrigation has decreased during that timeframe.



Since 1950:

The total number of wells in the valley increased slowly until mid-1970's,

Then increased more rapidly until the mid-1980's

And then increased at an even faster rate for about 20 years.

The rate of new well installations has slowed since about 2004.

How we approached the problem:

Monitoring
Modeling
Interpretation

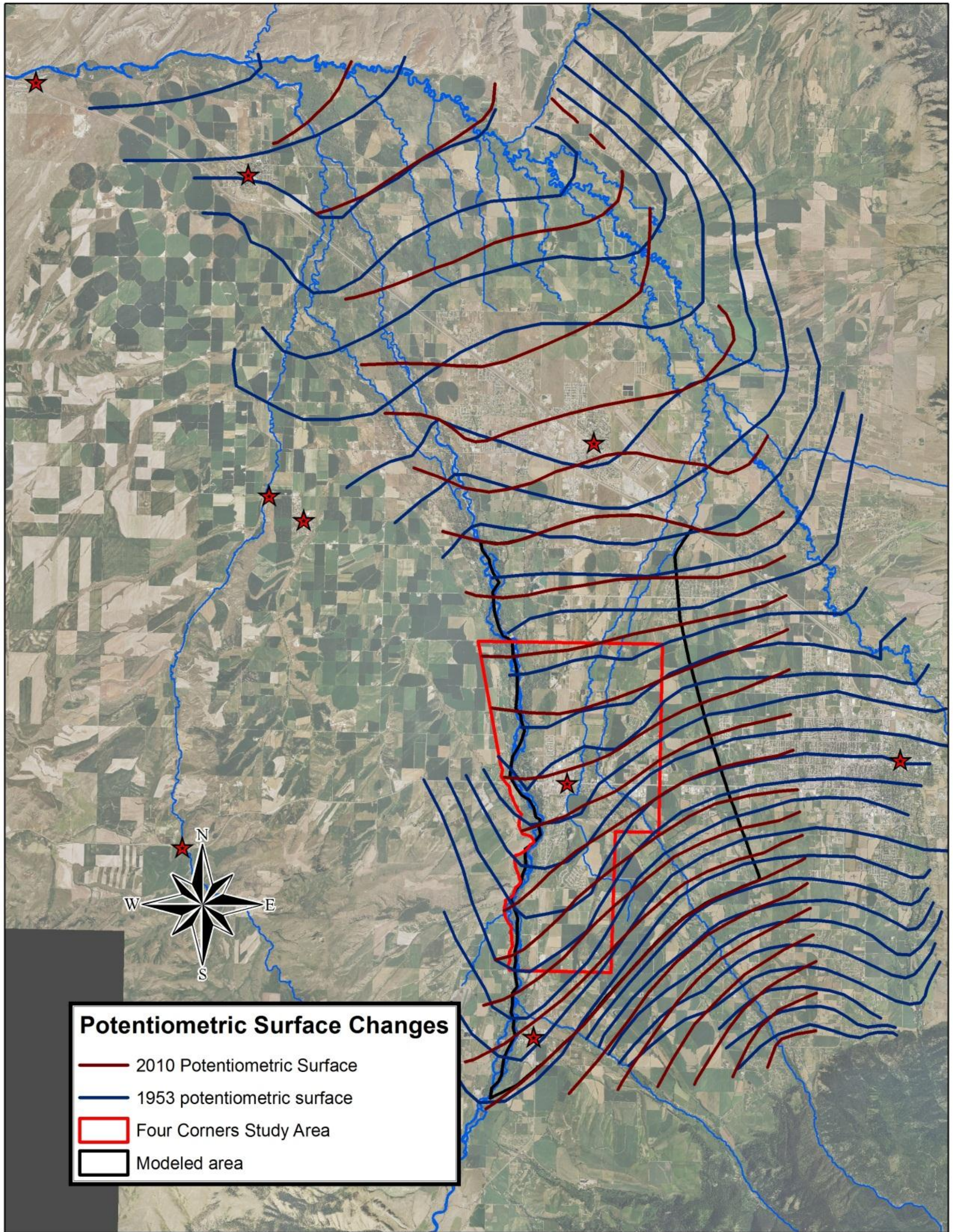
Potentiometric Surface

April 1953

April 2010

Few significant changes

Water table elevations very similar to present

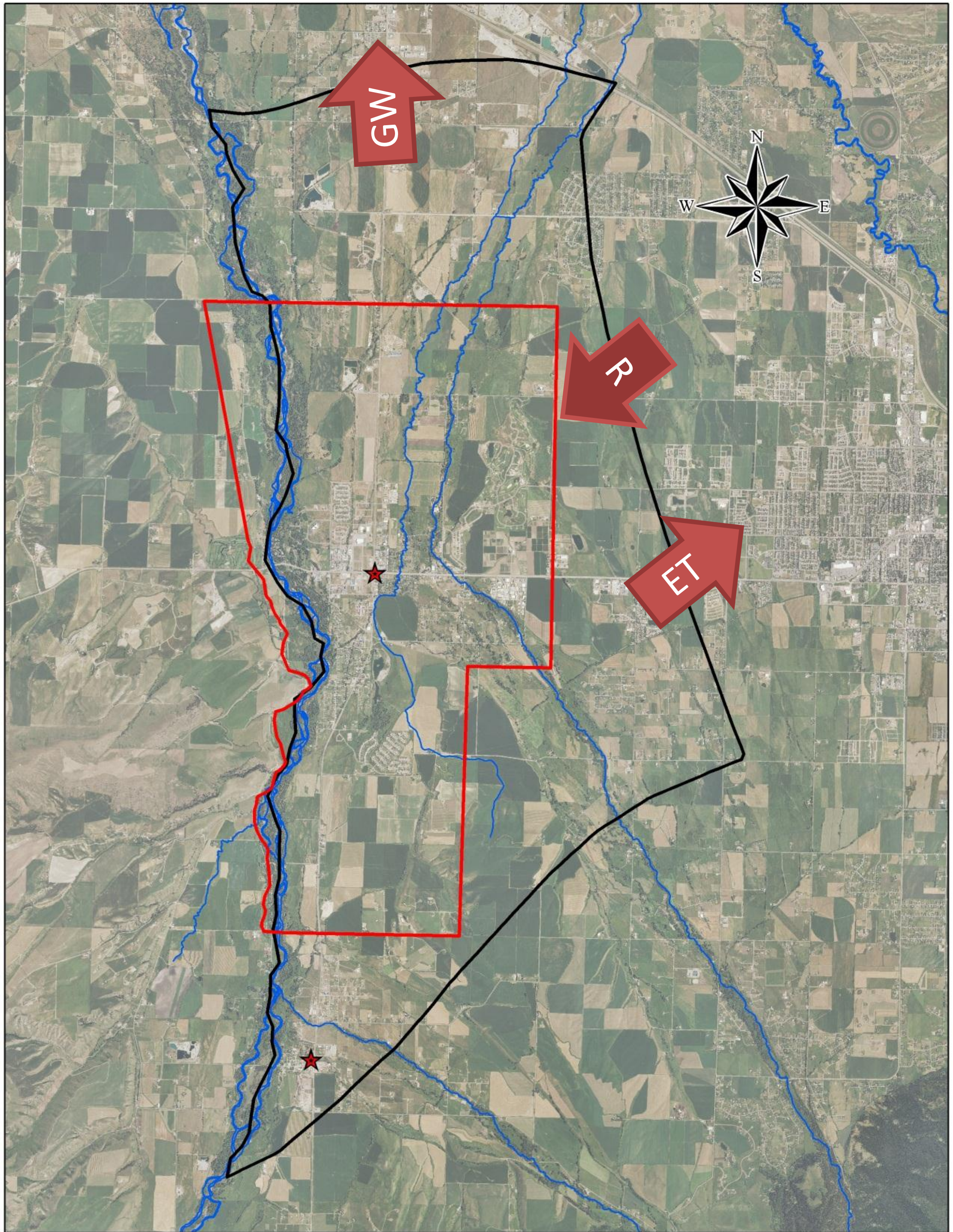


Groundwater flow components:

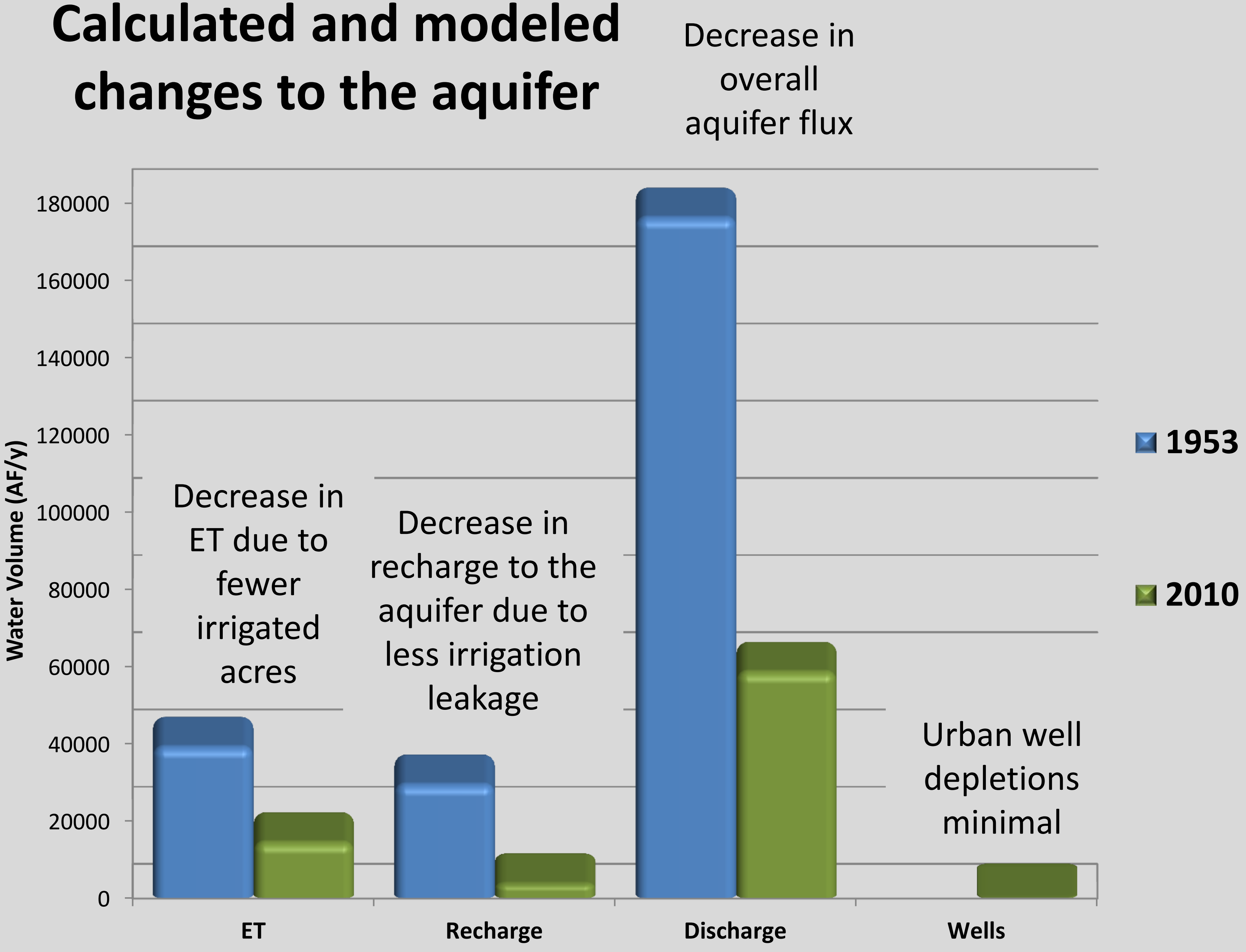
Groundwater (GW) flow out of the area

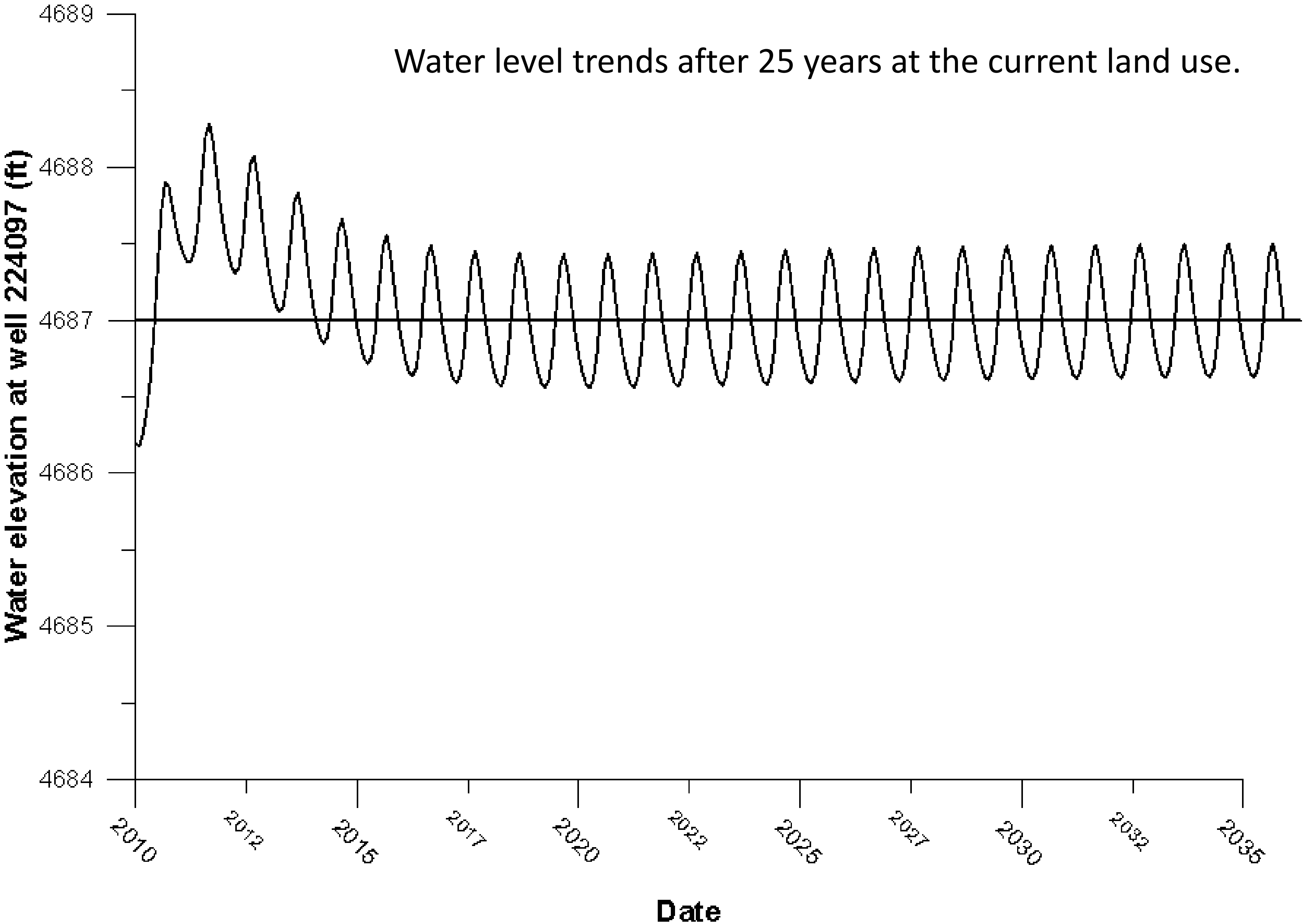
Recharge (R) from irrigation seepage

Evapotranspiration (ET) from crops and lawns



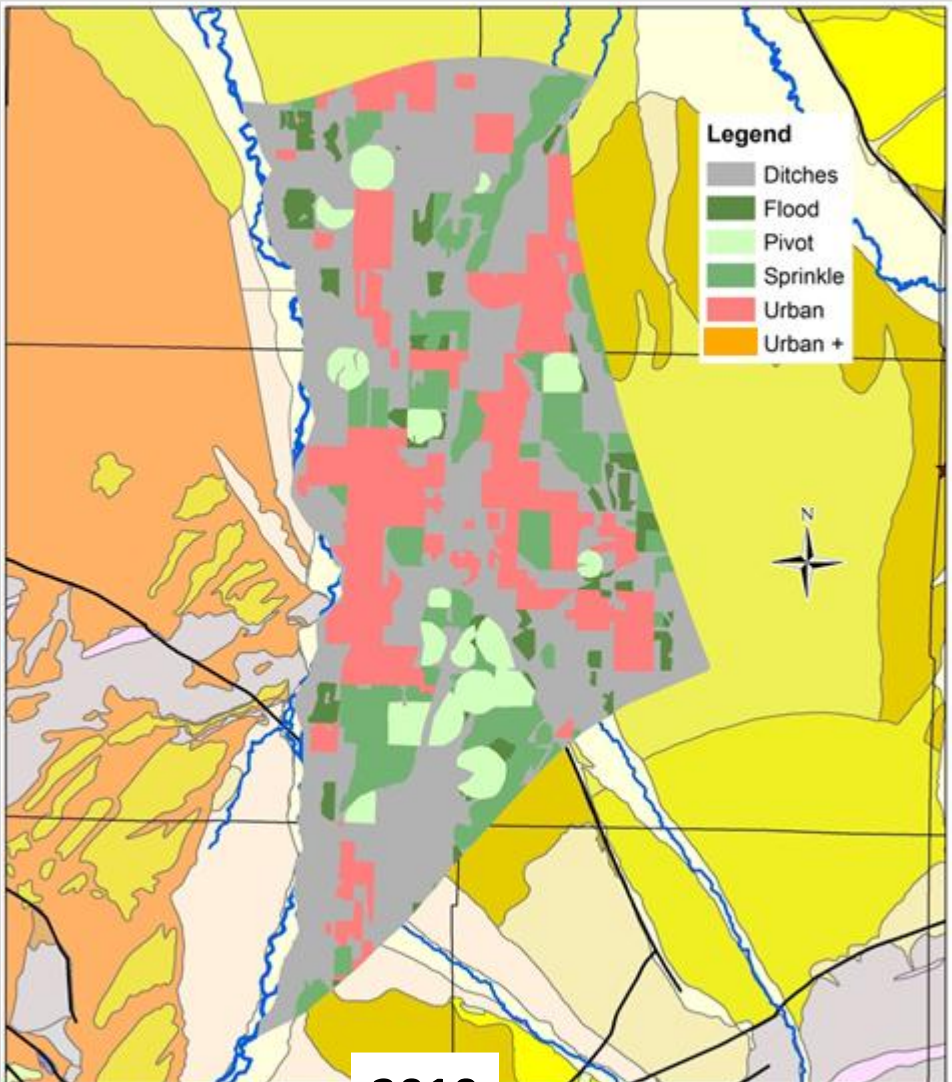
Calculated and modeled changes to the aquifer





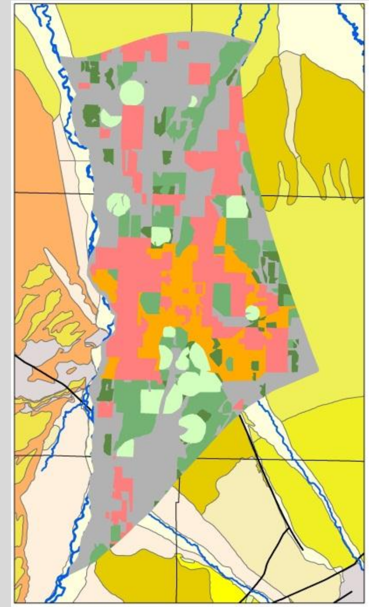
Water level trends after 25 years at the current land use.
Water elevation at well 224097 (ft)
4689
4688
4687
4686
4685
4684
2010
2012
2015
2017
2020
2022
2025
2027
2030
2032
2035
Date

Modeled Urbanization Prediction

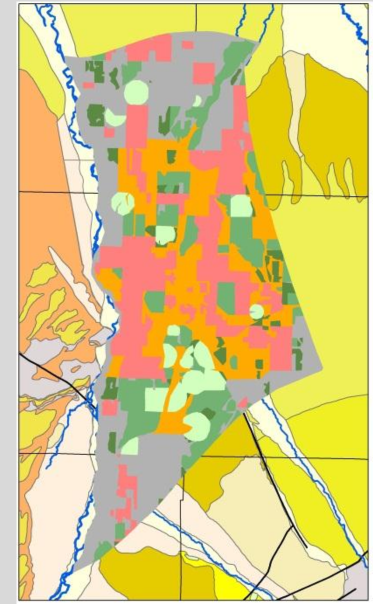


2010

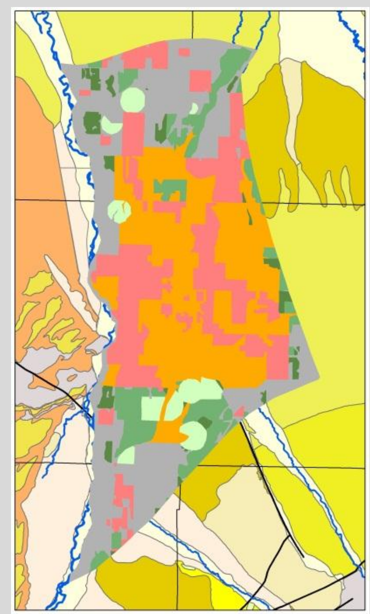
Current conditions and projected urban expansion at a rate of 500 acres/year



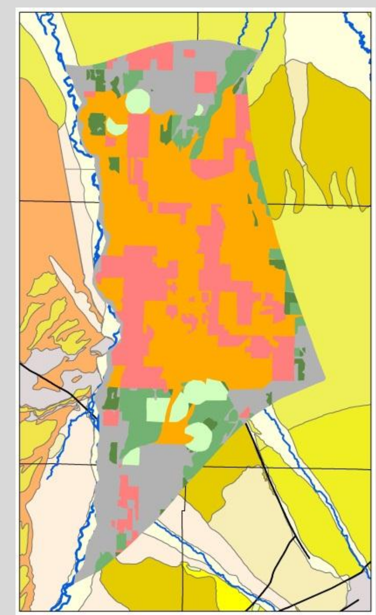
5 years



10 years

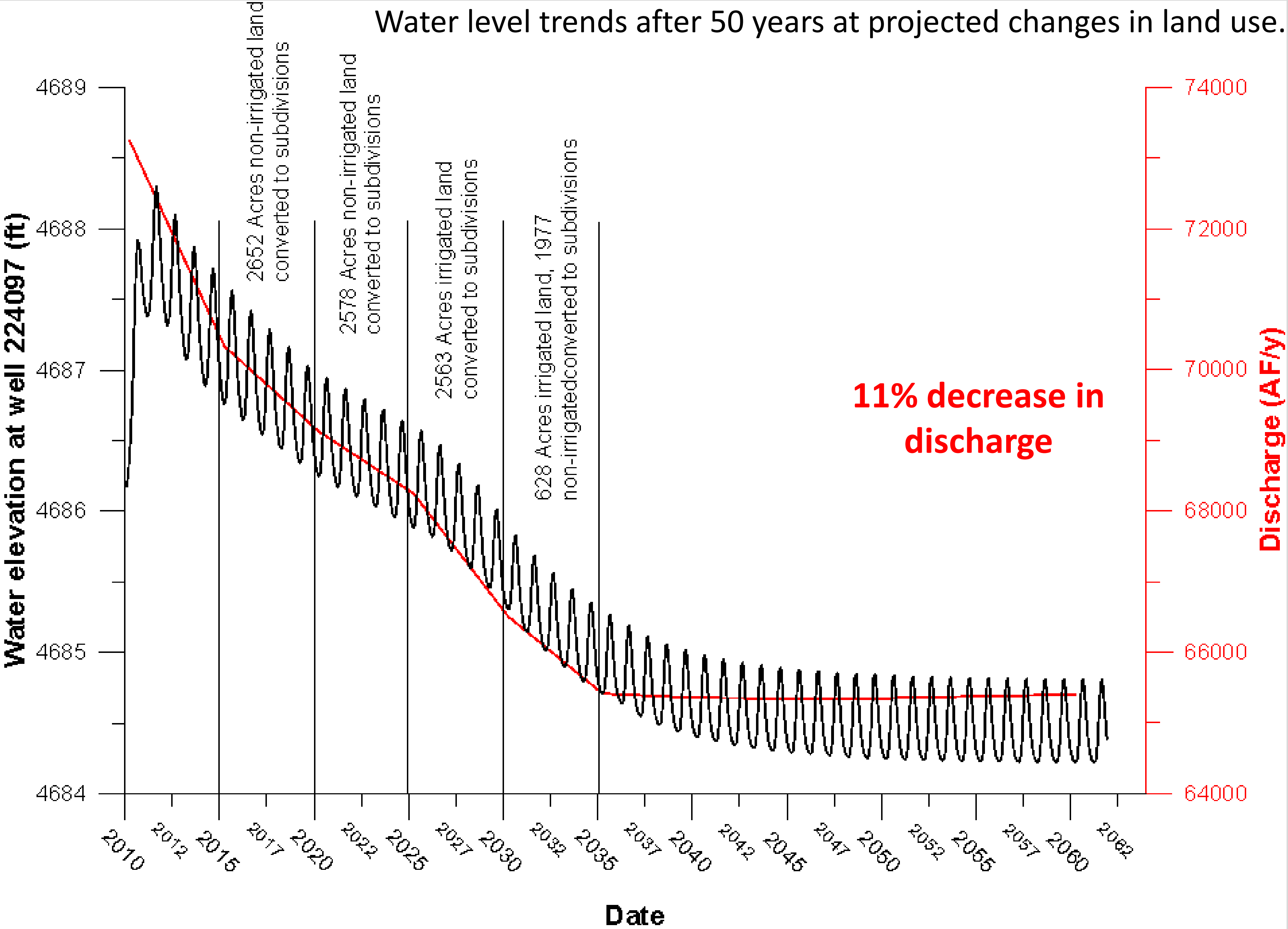


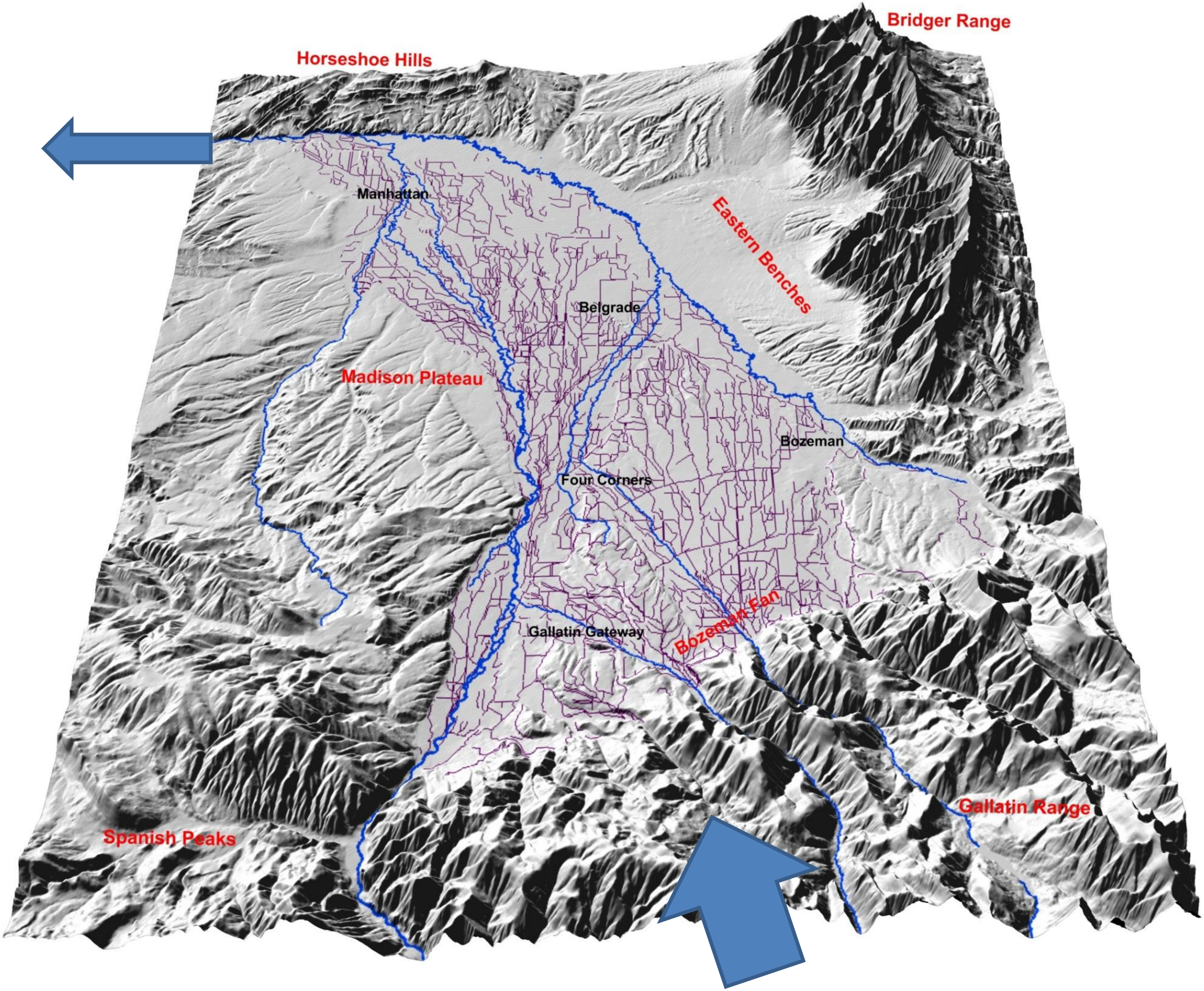
15 years



20 years

Water level trends after 50 years at projected changes in land use.



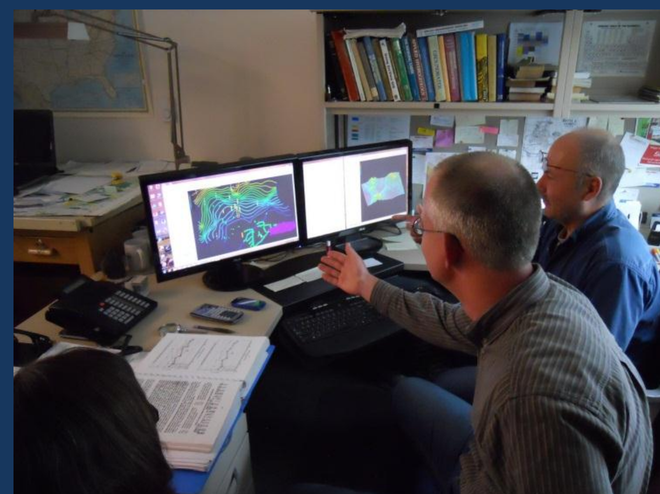


Bridger Range
Horseshoe Hills
Manhattan
Eastern Benches
Belgrade
Madison Plateau
Bozeman
Four Corners
Bozeman Fan
Gallatin Gateway
Gallatin Range
Spanish Peaks

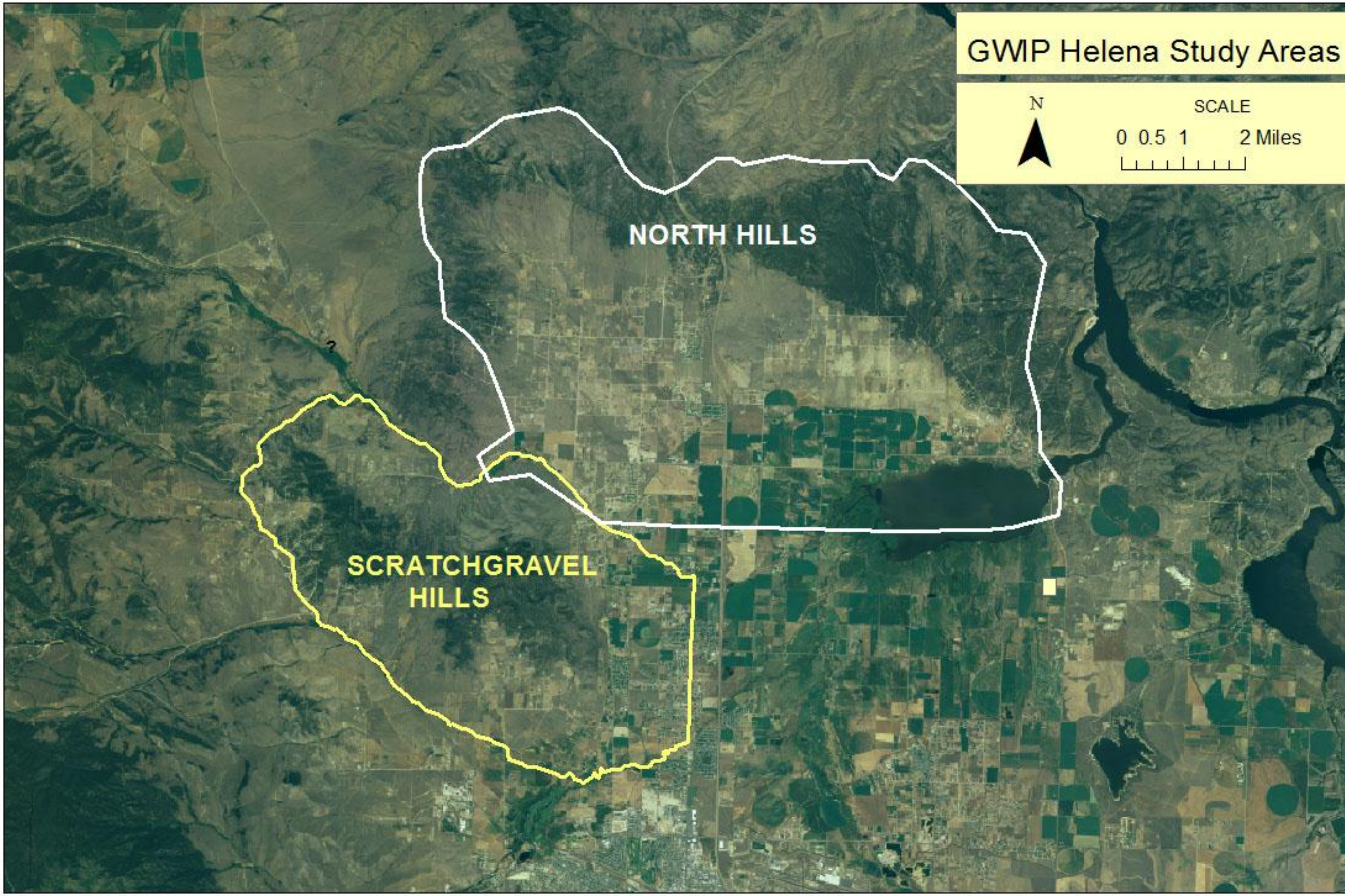
Conclusions:

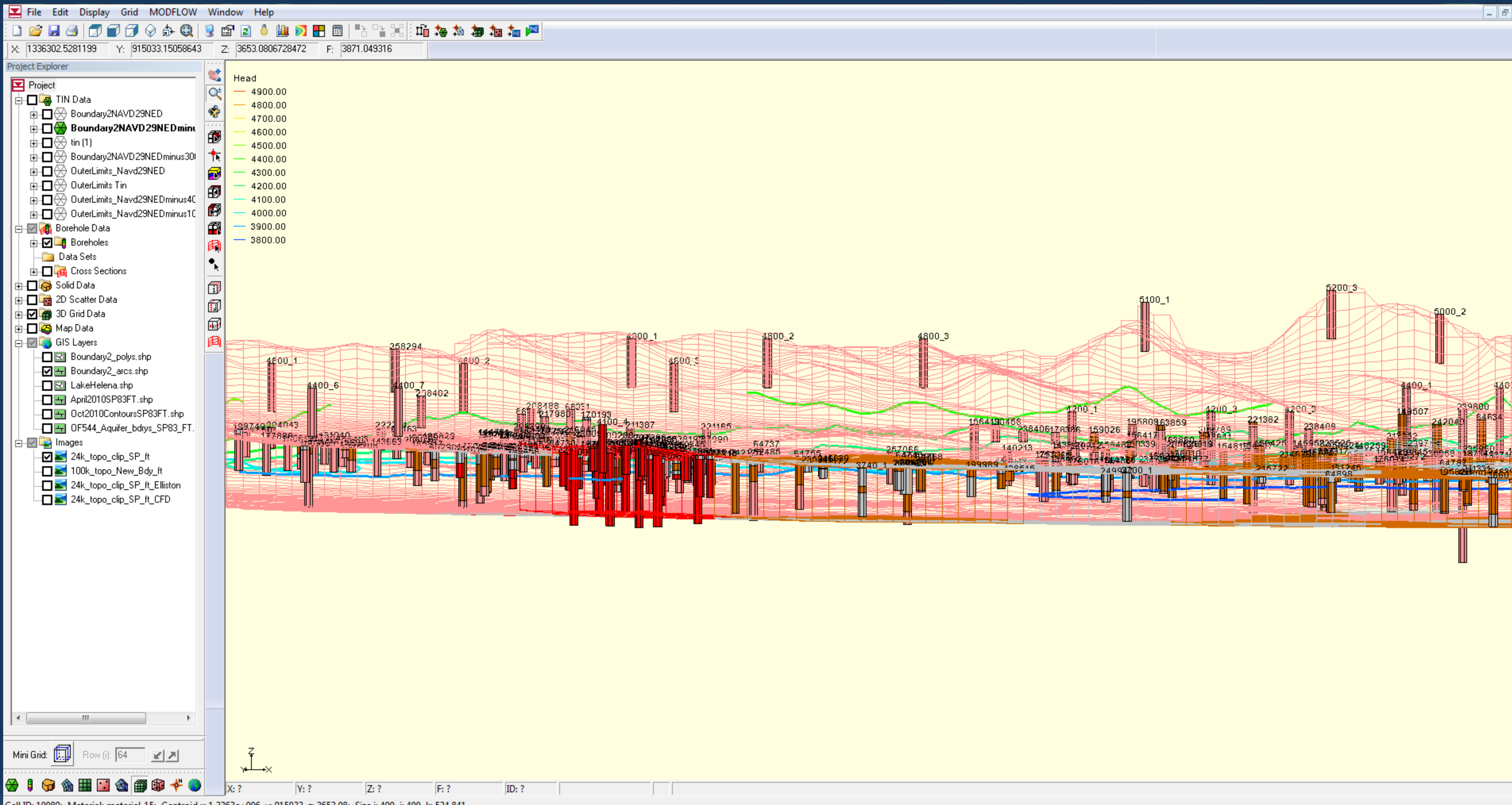
- *Use and recovery due to “bathtub effect”*
- *Water levels artificially elevated from irrigation*
- *Land use changes have decreased flow volume*
- *Water level decrease of approximately 1 foot predicted from current land use changes*
- *Projected future land use changes could decrease the water level approximately 2.5 feet*
- *Groundwater flux is considerably more sensitive to land use changes than water levels*
- *The effect of reducing irrigated acres is significantly greater than increasing suburban acreage*

Ground Water Investigation Program



Highlights of project products, Sept. 2012
presented by Kirk Waren


GWIP Helena Study Areas
N
SCALE
0 0.5 1 2 Miles
NORTH HILLS
SCRATCHGRAVEL HILLS


File Edit Display Grid MODFLOW Window Help
X: 1336302.5281199 Y: 915033.15058643 Z: 3653.0806728472 F: 3871.049316
Project Explorer
Project
TIN Data
Boundary2NAVD29NED
tin (1)
OuterLimits_Navd29NED
OuterLimits Tin
Borehole Data
Boreholes
Data Sets
Cross Sections
Solid Data
2D Scatter Data
3D Grid Data
Map Data
GIS Layers
Boundary2_polys.shp
Boundary2_arcs.shp
LakeHelena.shp
April2010SP83FT.shp
Oct2010ContoursSP83FT.shp
Images
24k_topo_clip_SP_ft
100k_topo_New_Bdy_ft
24k_topo_clip_SP_ft_Elliston
24k_topo_clip_SP_ft_CFD
Head
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4600.00
4500.00
4400.00
4300.00
4200.00
4100.00
4000.00
3900.00
3800.00
Mini Grid:
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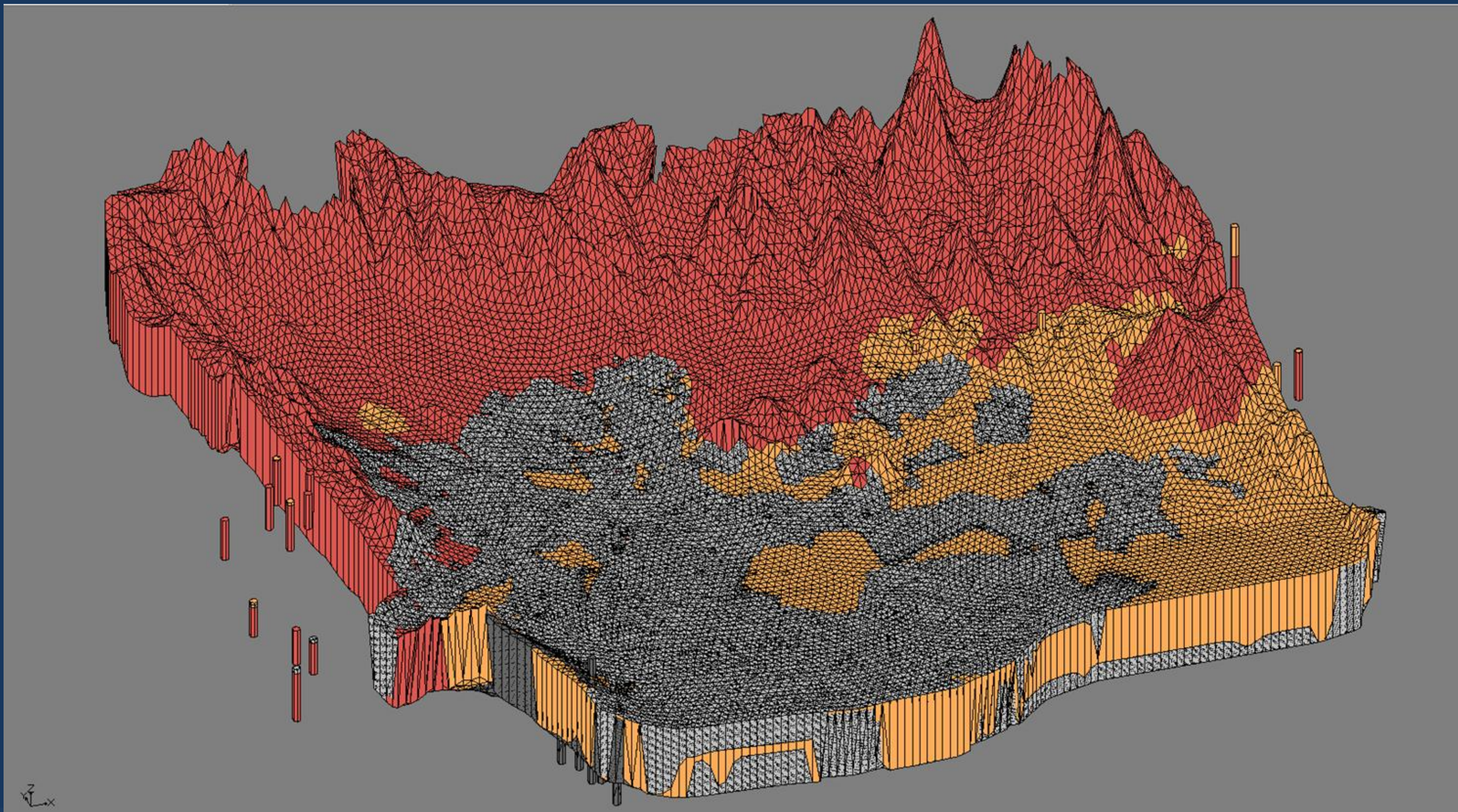
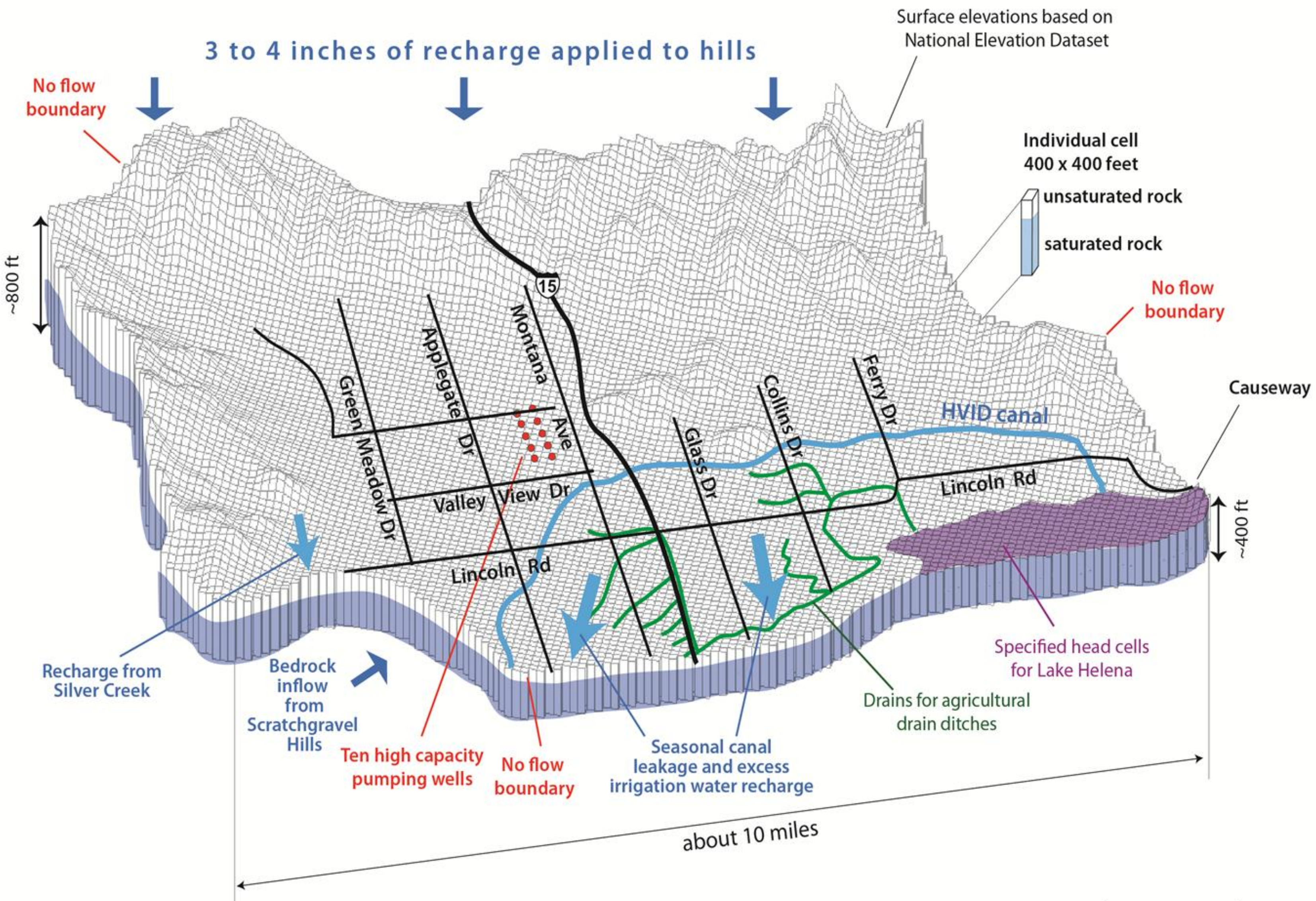
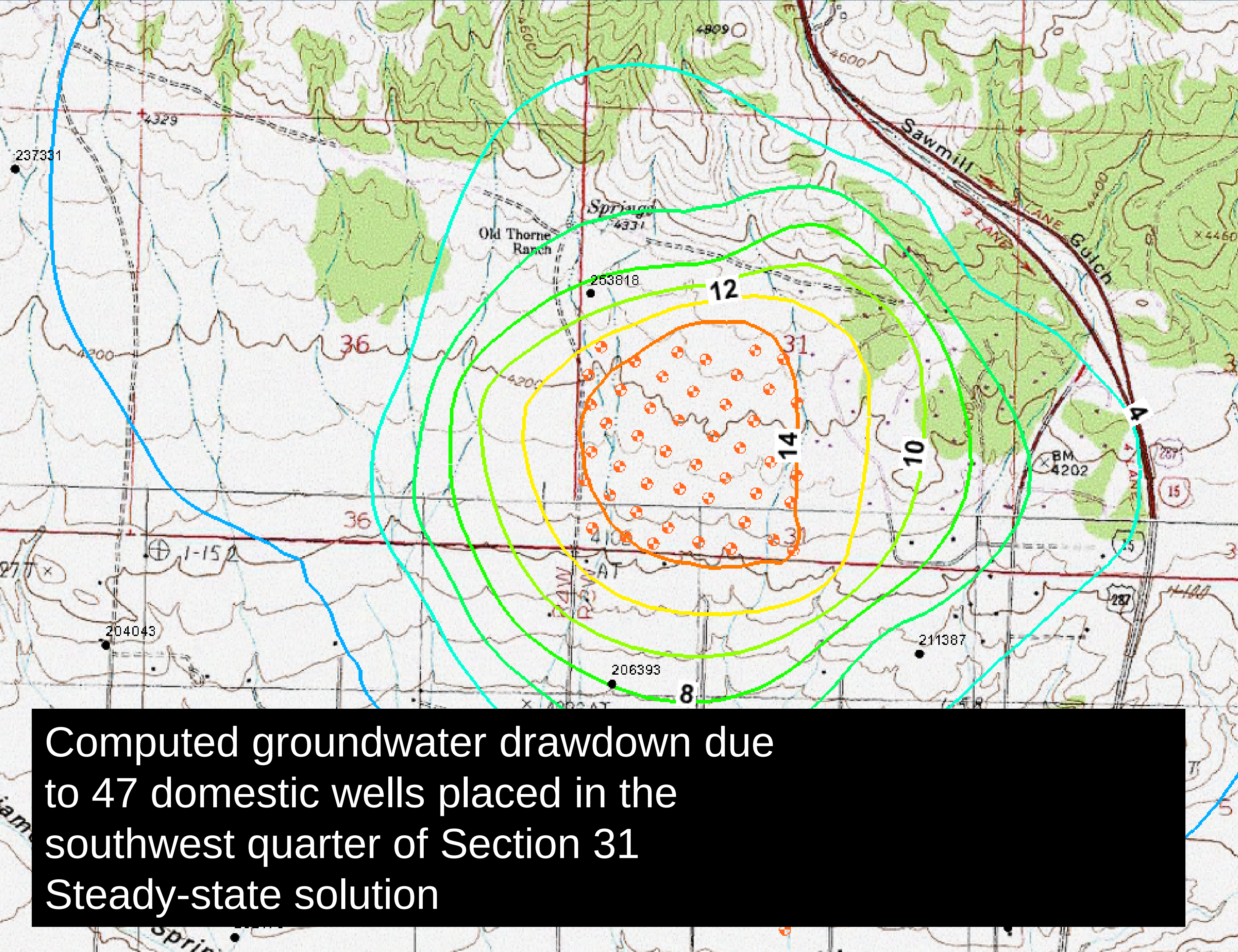
Cell ID: 10089; Material: material_15; Centroid x: 1.3363e+006, y: 915033, z: 3653.08; Size i: 400, j: 400, k: 534.841



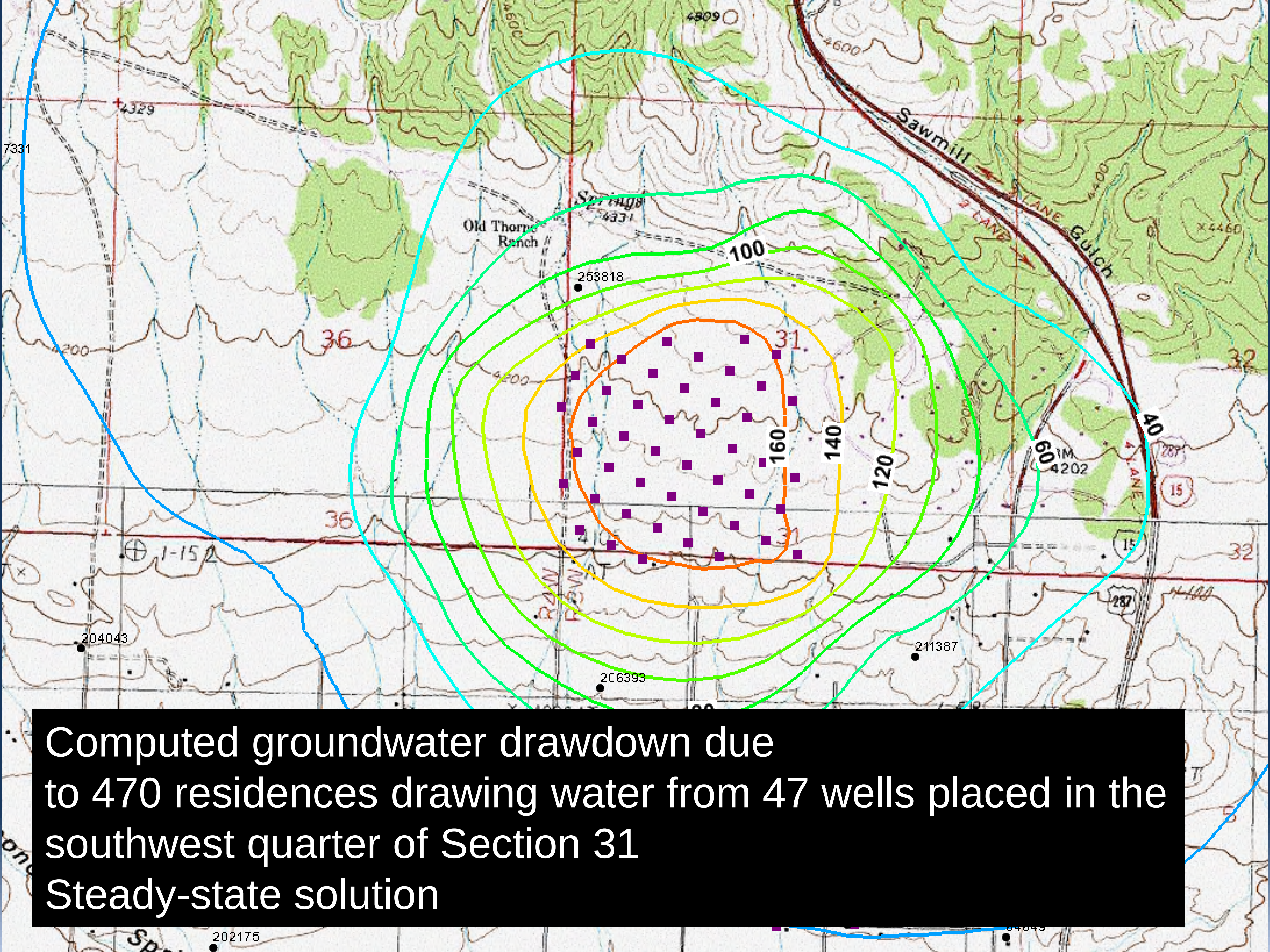
North Hills Area Model
Schematic View



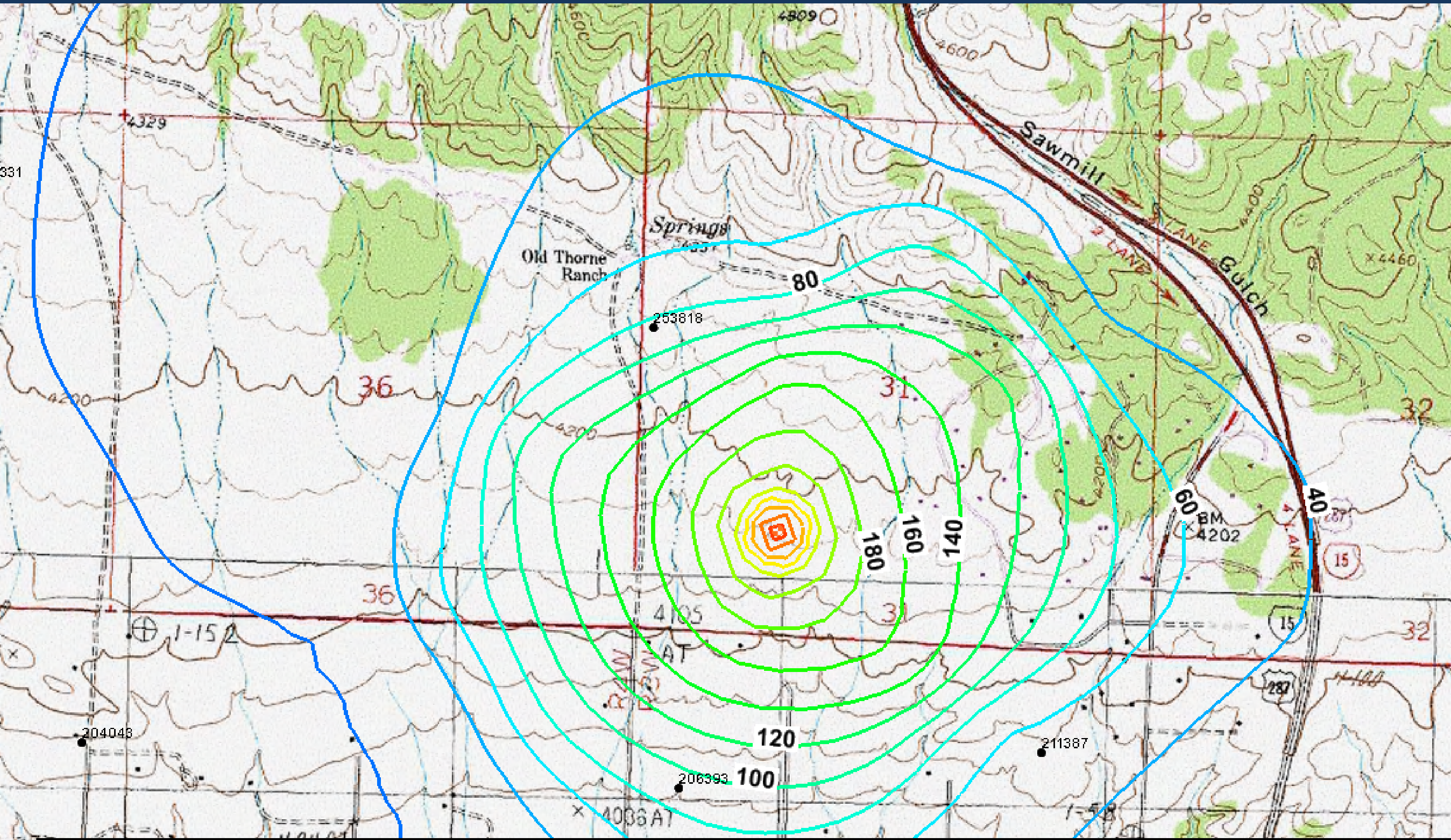
Vertically exaggerated 5 x



Computed groundwater drawdown due to 47 domestic wells placed in the southwest quarter of Section 31
Steady-state solution



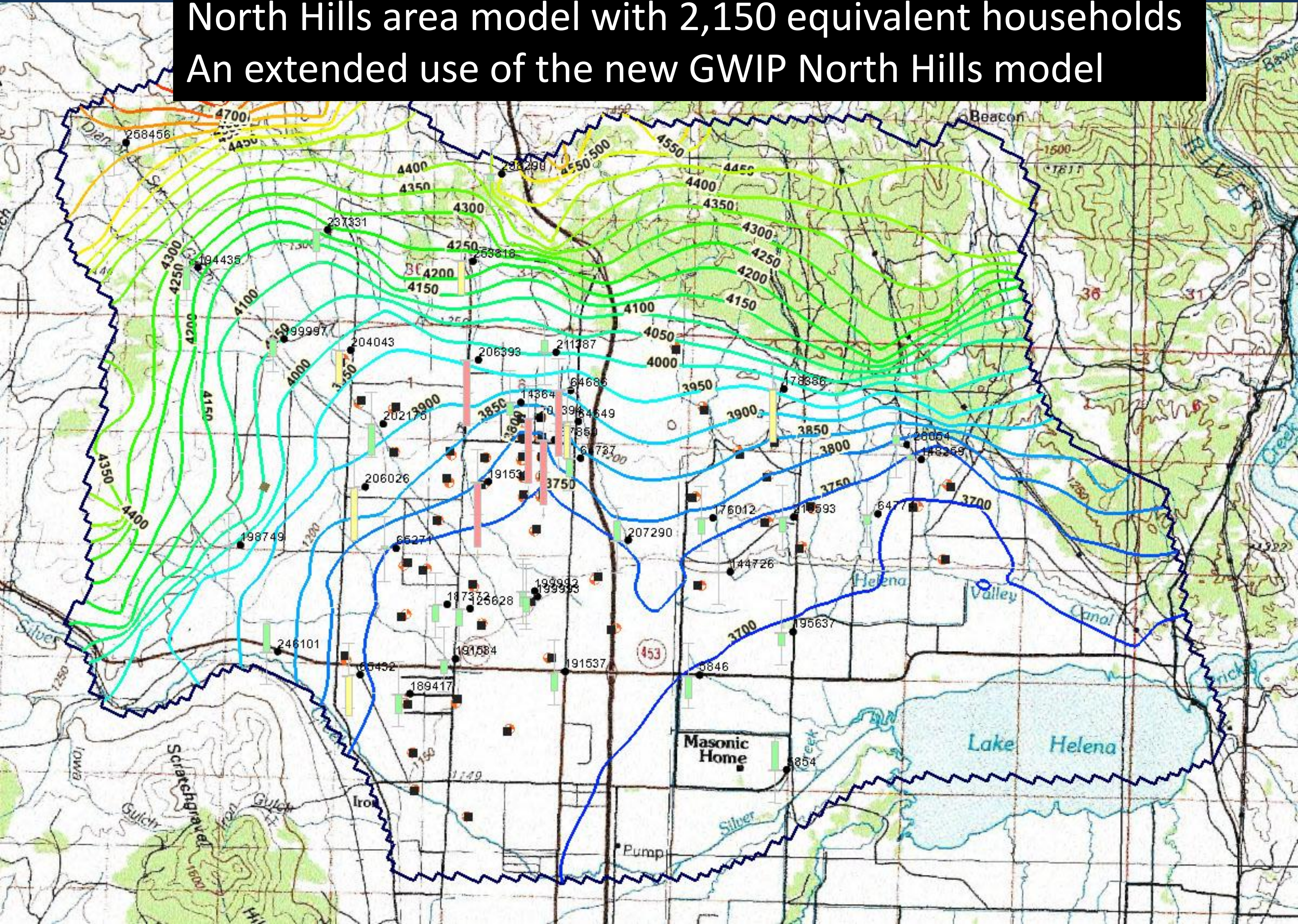
Computed groundwater drawdown due
to 470 residences drawing water from 47 wells placed in the southwest quarter of Section 31
Steady-state solution



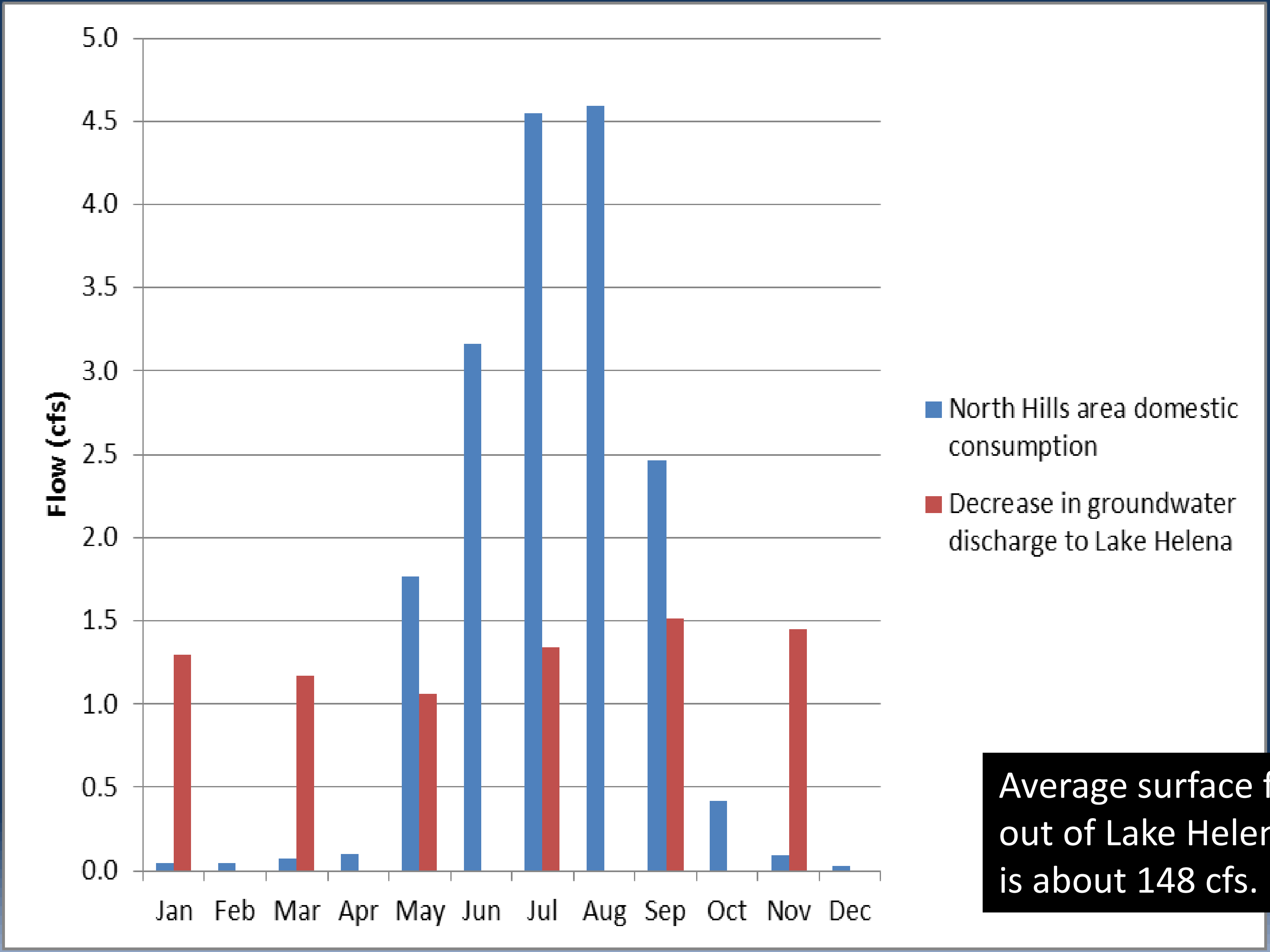
Computed groundwater drawdown due to 470 domestic residences placed in the southwest quarter of Section 31 – with one public water supply well

Steady-state solution

North Hills area model with 2,150 equivalent households
An extended use of the new GWIP North Hills model

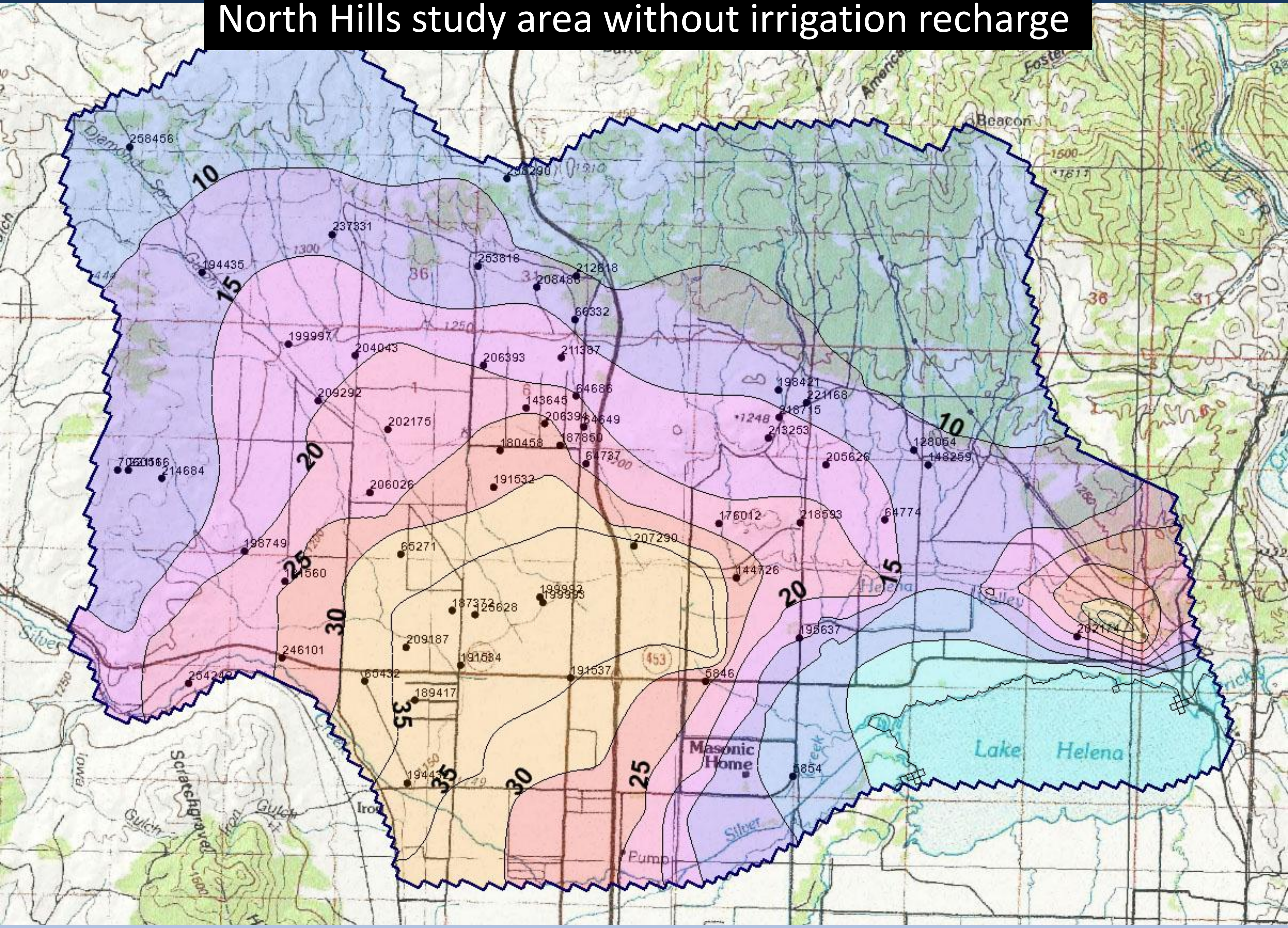


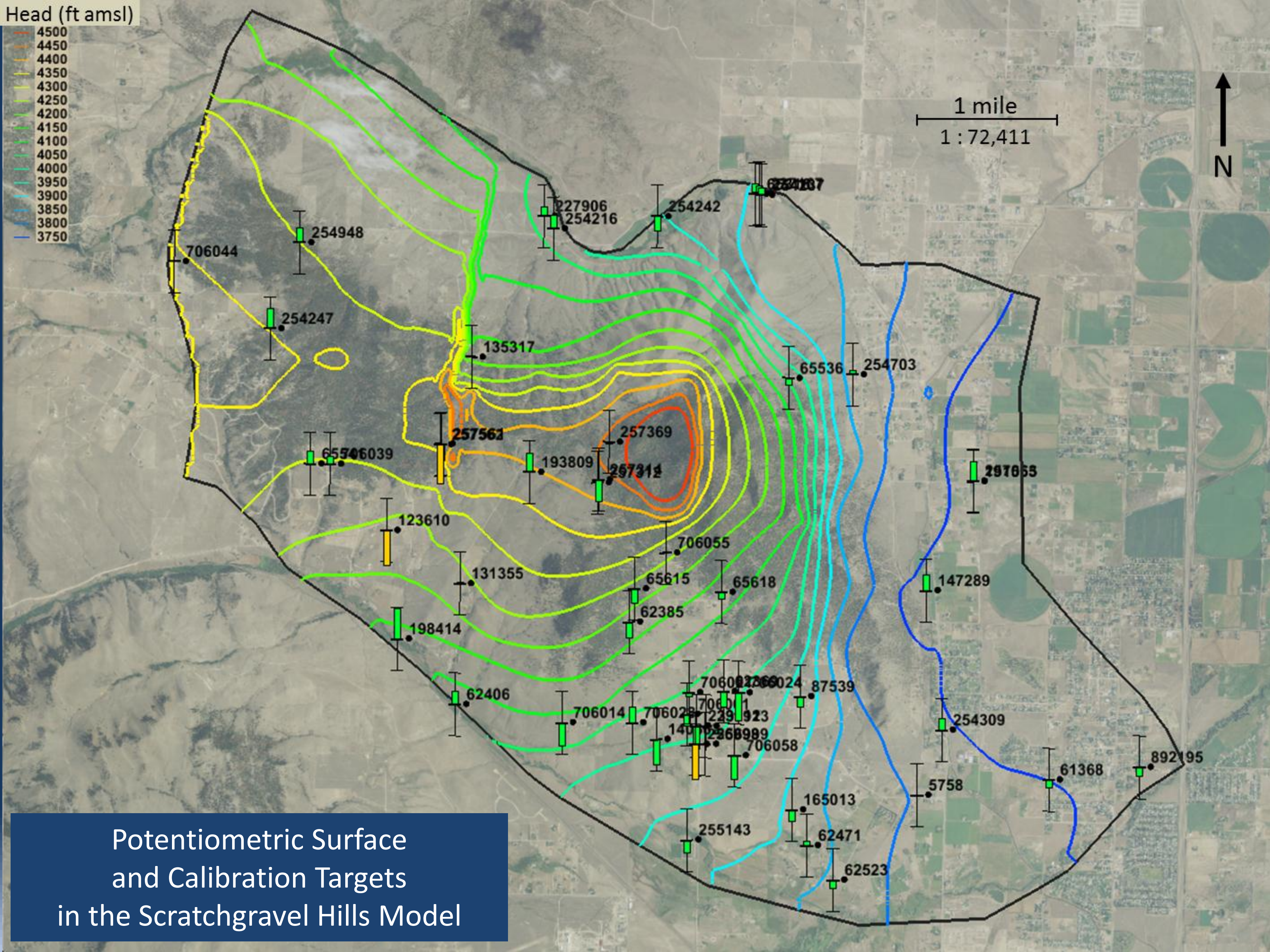
North Hills: 2,150 houses,
Cumulative: 1,048 acre-ft per year



Average surface flow out of Lake Helena is about 148 cfs.

North Hills study area without irrigation recharge



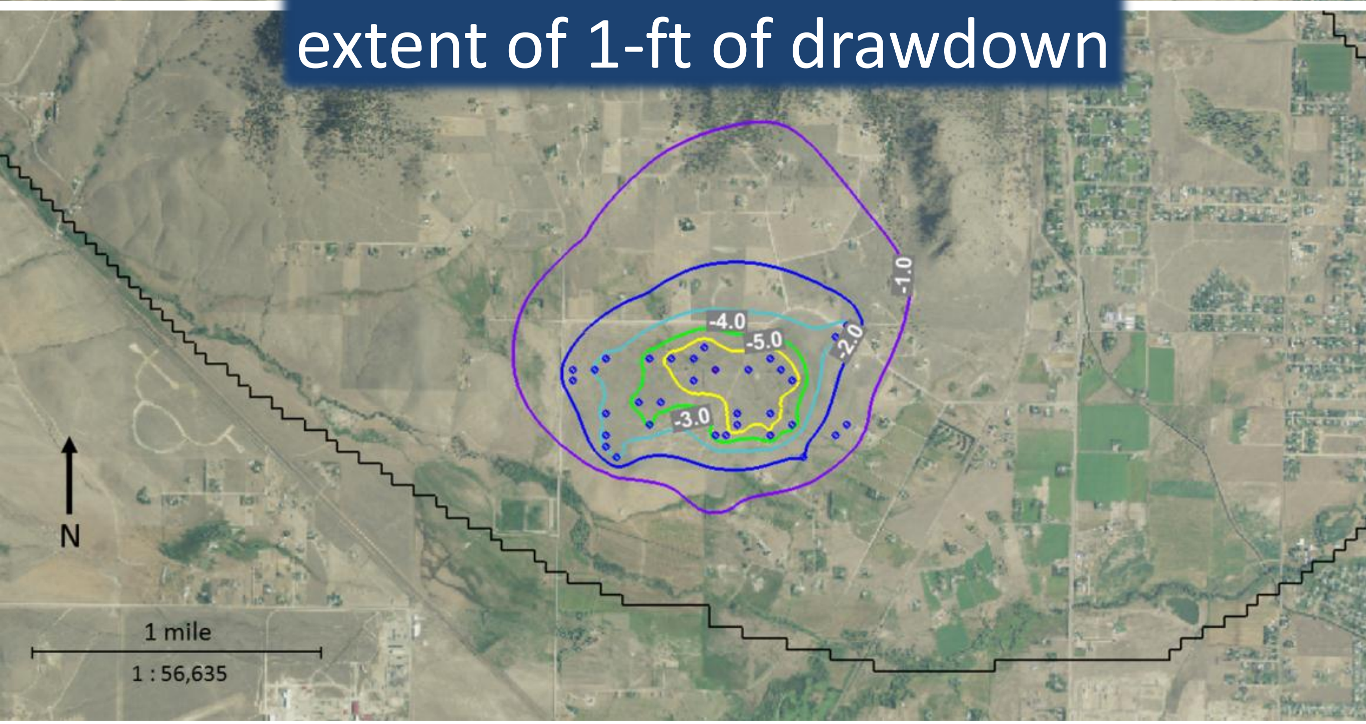


Potentiometric Surface and Calibration Targets in the Scratchgravel Hills Model

Scenario 1:

- 1 PWS Well
- Supply for 10-acre lots
- 10 years of pumping
- 1-ft area of influence extended 0.47 miles

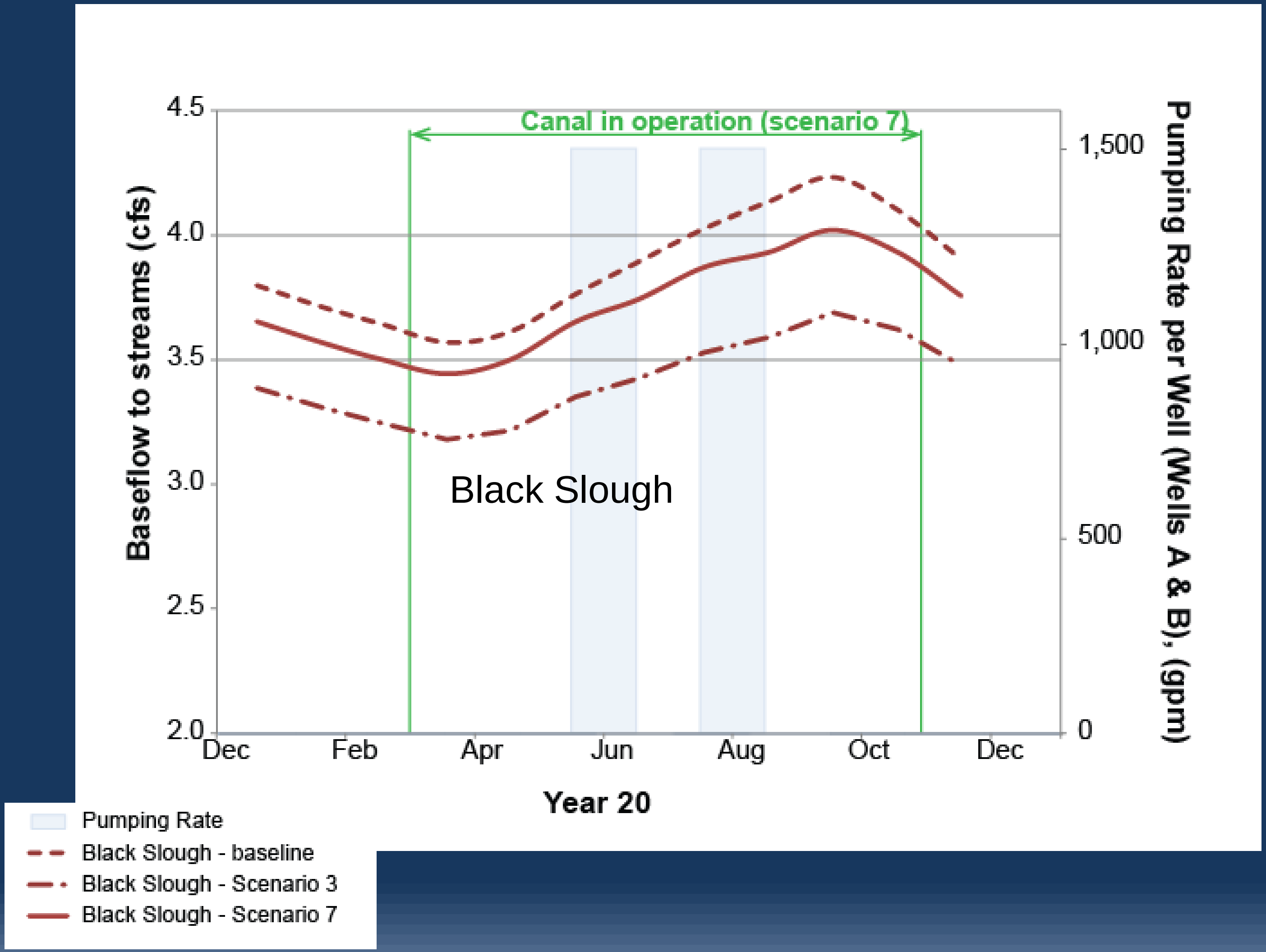
"Area of Influence": extent of 1-ft of drawdown



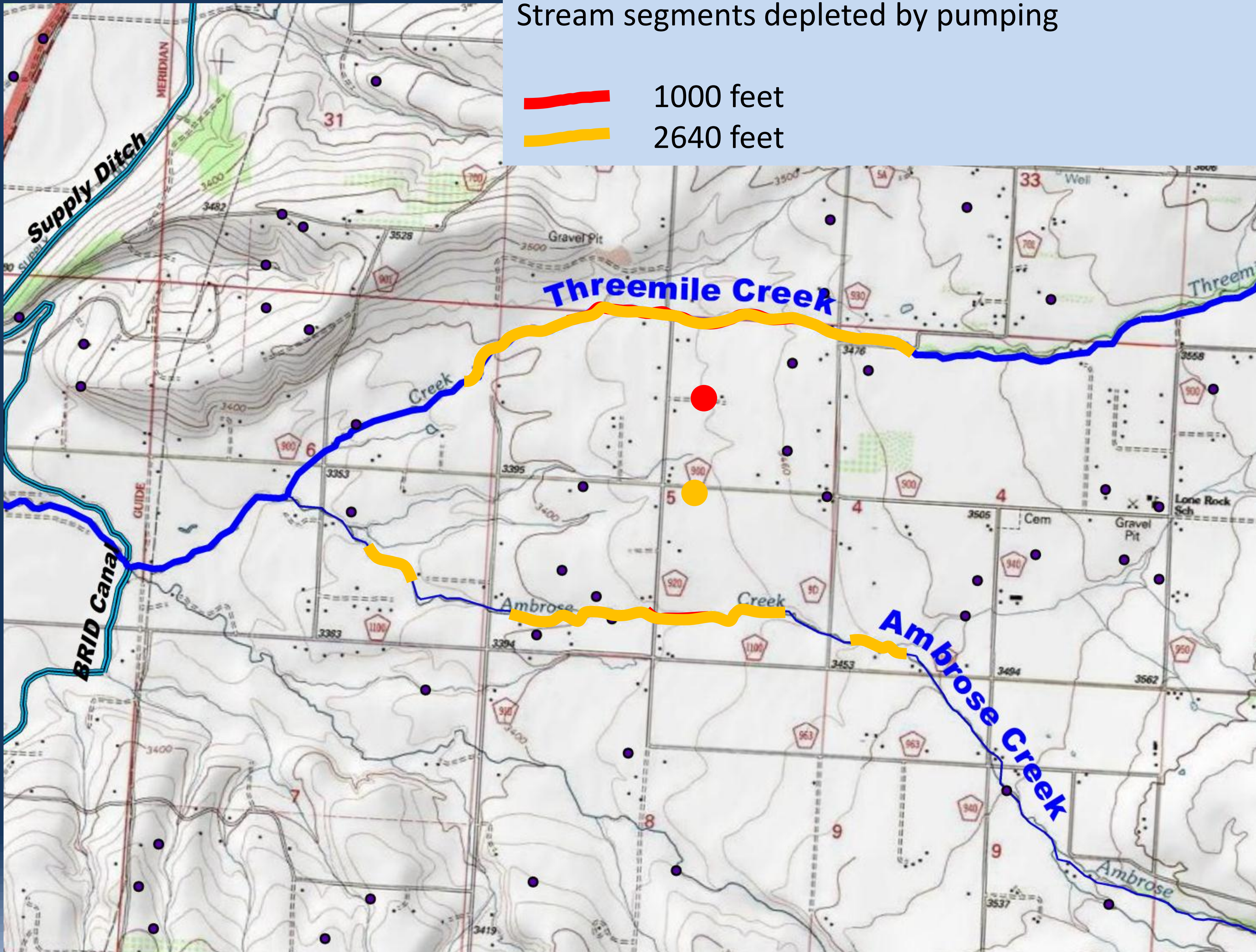
Scenario 2:

- 33 exempt wells
- Supply for 10-acre lots
- 10 years of pumping
- 1-ft area of influence extended 0.87 miles

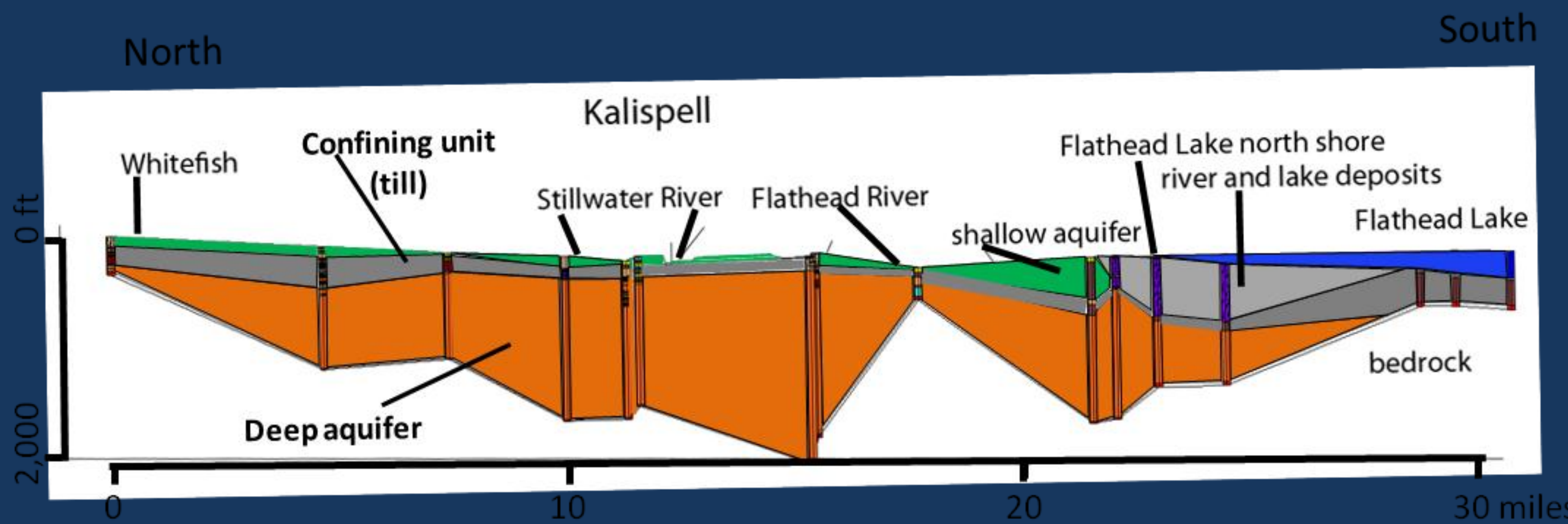
Mitigating with additional canal seepage

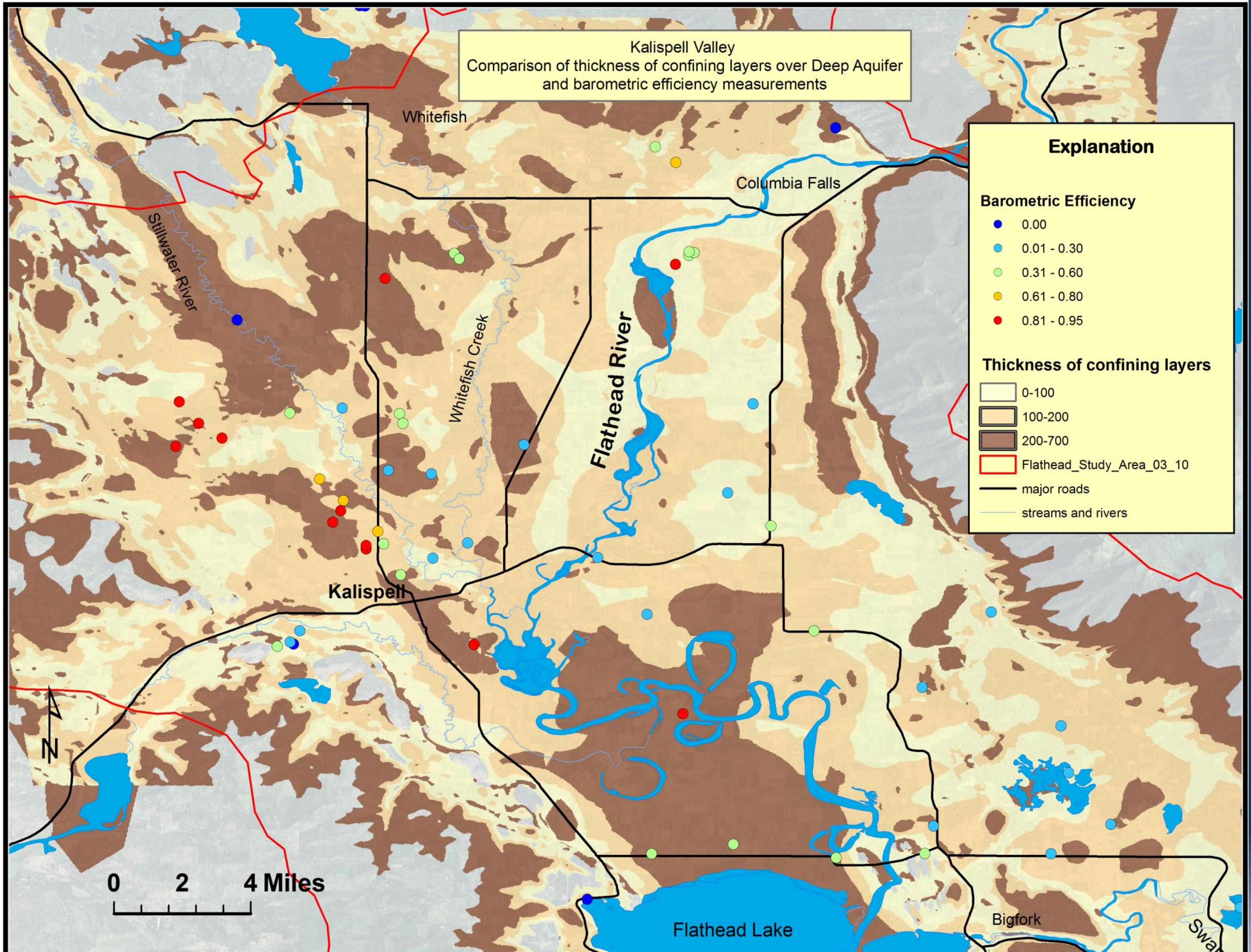


Stream segments depleted by pumping



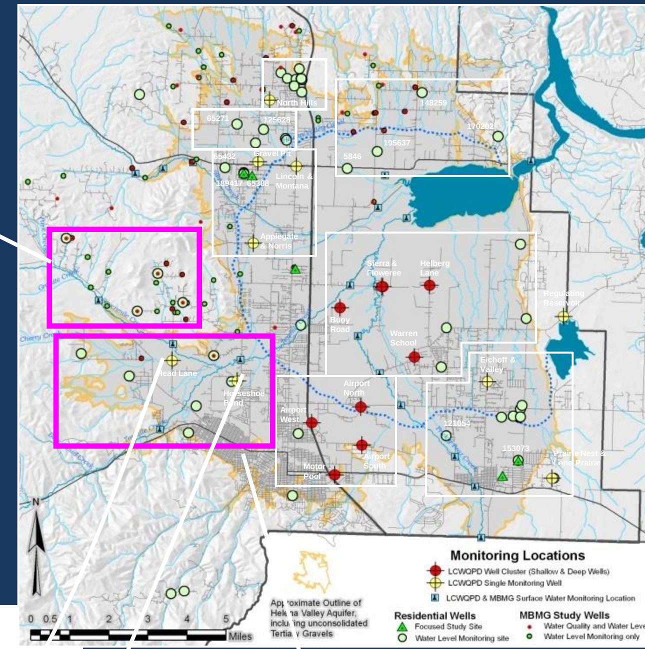

Oct 10, 2006
Columbia Falls
Whitefish
approximate study boundary
Kalispell
Flathead River
Flathead Lake
Big Fork
Image © 2009 GeoEye
Image © 2009 Province of British Columbia
Image NASA
Image © 2009 DigitalGlobe
©2009 Google

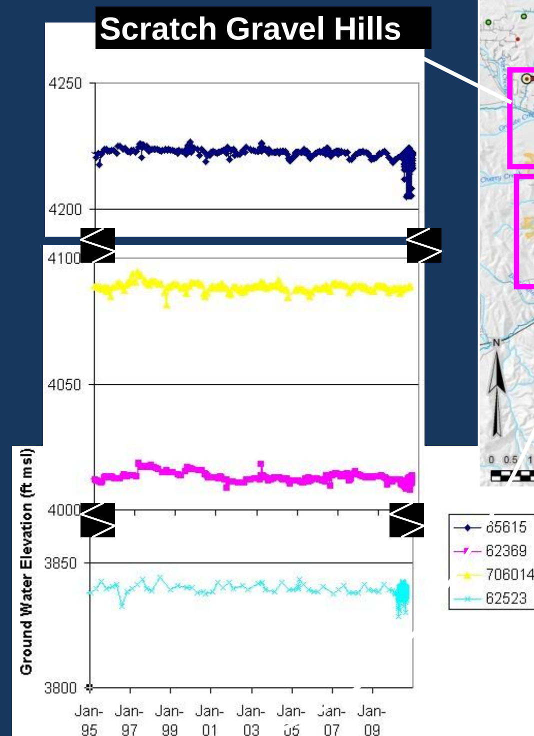

North
South
Kalispell
Whitefish
Confining unit
(till)
Stillwater River
Flathead River
Flathead Lake north shore
river and lake deposits
shallow aquifer
Flathead Lake
bedrock
Deep aquifer
0 ft
2,000
0
10
20
30 miles

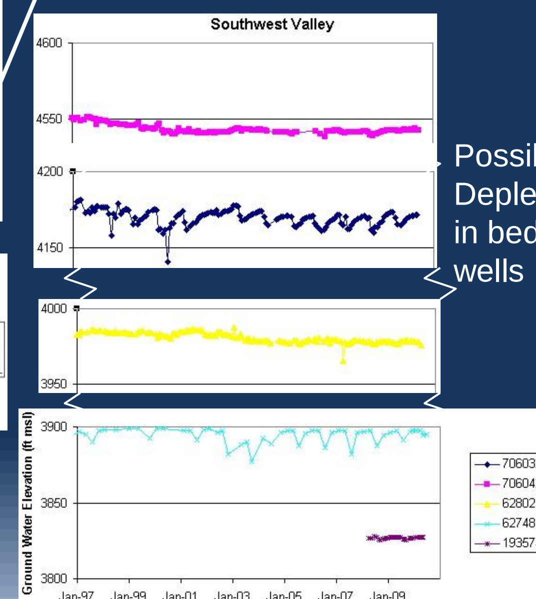

Kalispell Valley
Comparison of thickness of confining layers over Deep Aquifer
and barometric efficiency measurements
Whitefish
Columbia Falls
Stillwater River
Whitefish Creek
Flathead River
Kalispell
Flathead Lake
Bigfork
Swa
0 2 4 Miles
N
Explanation
Barometric Efficiency
0.00
0.01 - 0.30
0.31 - 0.60
0.61 - 0.80
0.81 - 0.95
Thickness of confining layers
0-100
100-200
200-700
Flathead_Study_Area_03_10
major roads
streams and rivers

West Side

- Hydrographs
  - Stable
- Water Quality
  - Head Lane (Bedrock well)
    - Only well with Ammonia
    - Highest Phosphorus

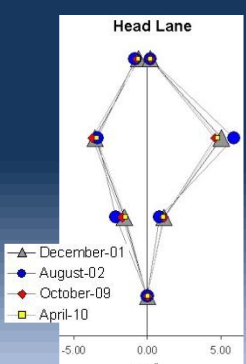


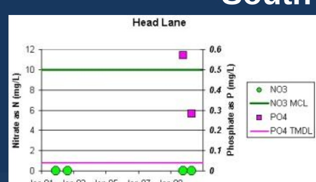


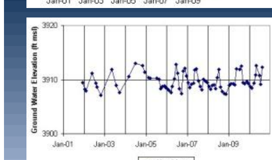


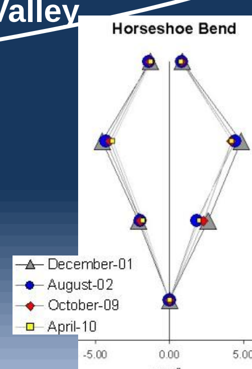
Possible Depletion in bedrock wells

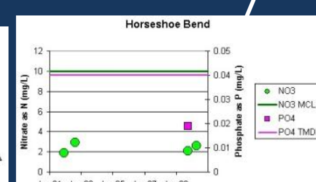
South West Valley

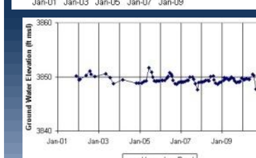


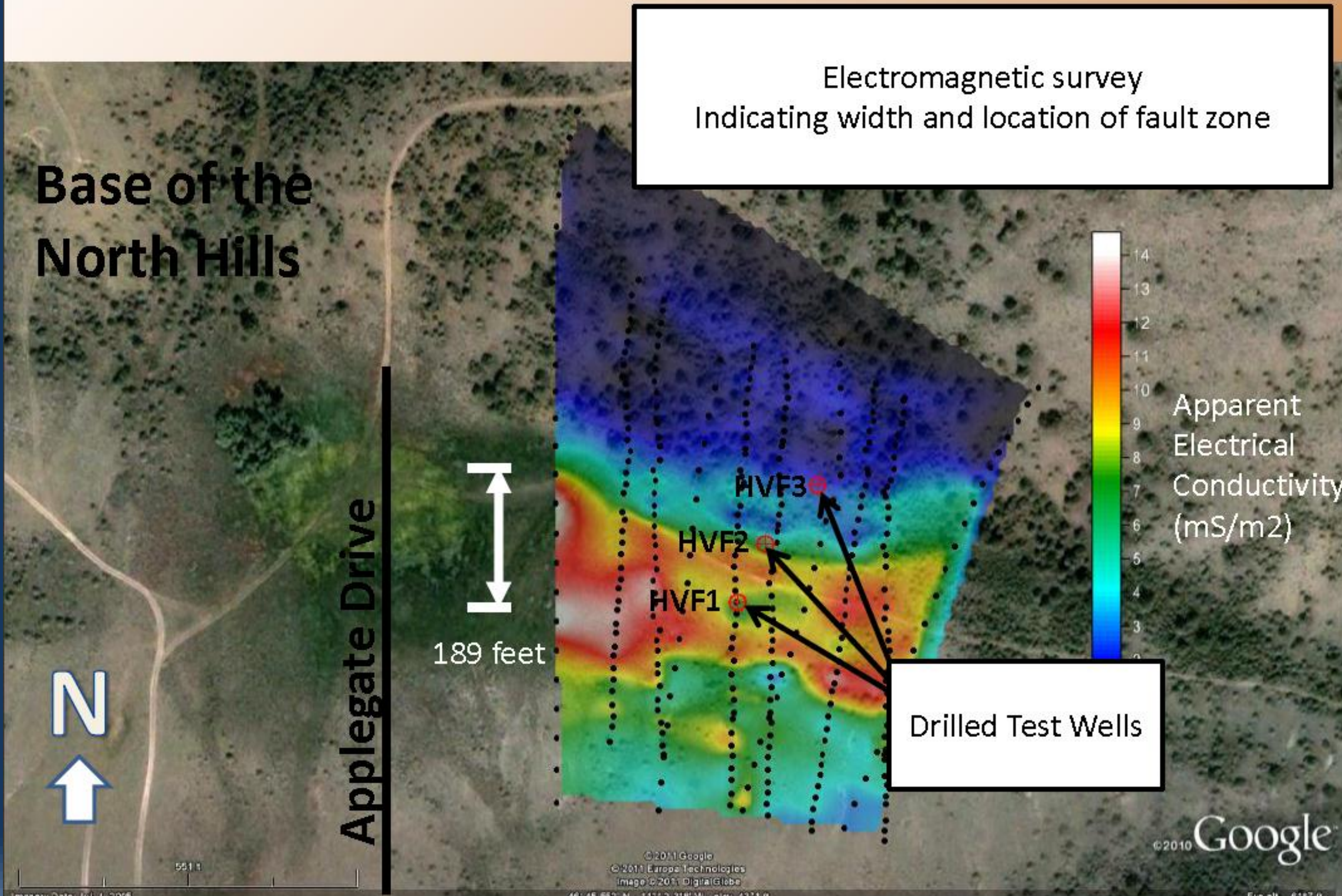











Electromagnetic survey
Indicating width and location of fault zone
Base of the
North Hills
Applegate Drive
189 feet
HVF3
HVF2
HVF1
Drilled Test Wells
14
13
12
11
10
9
8
7
6
5
4
3
Apparent
Electrical
Conductivity
(mS/m2)
N
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