Idaho National Laboratory OU 10-08 Sitewide Ground Water Model

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INL

Idaho National Laboratory

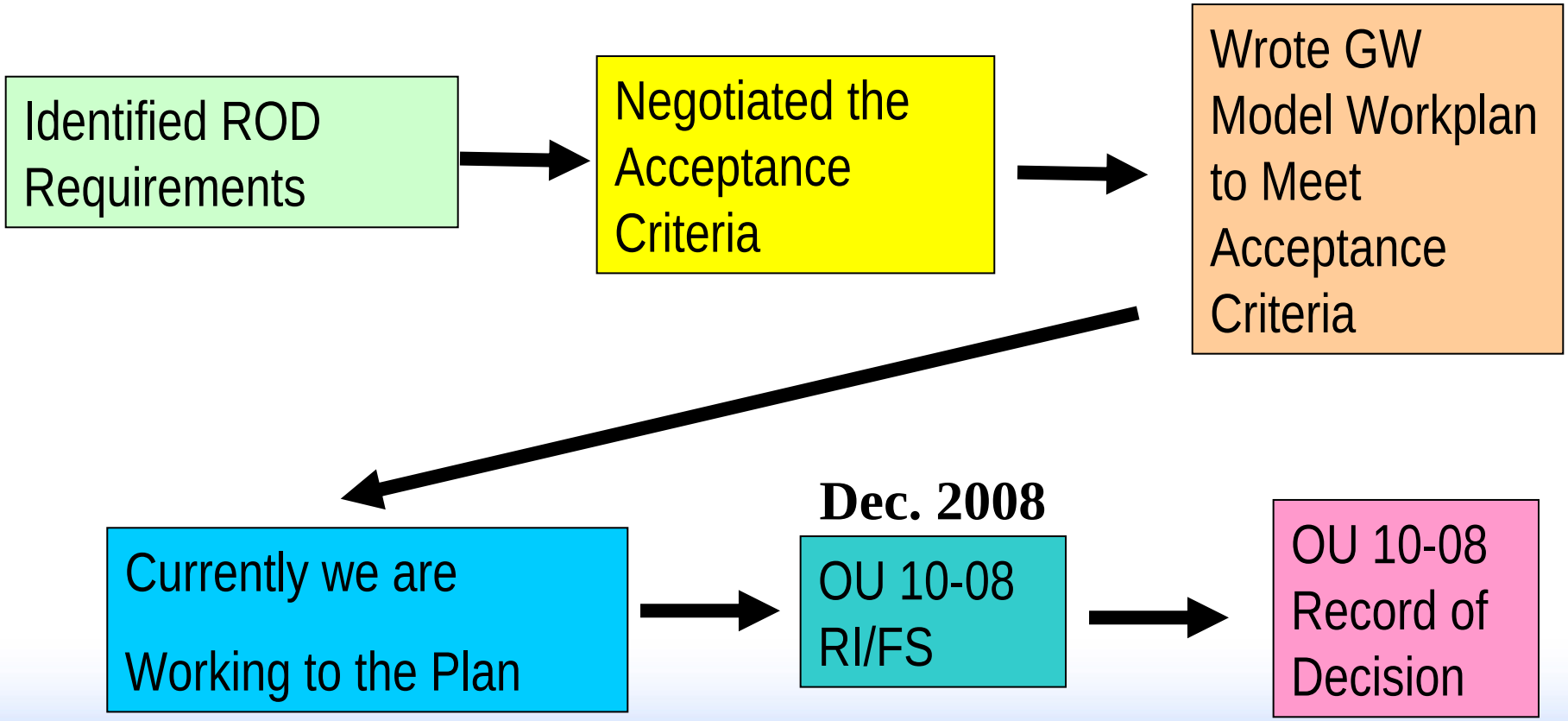
Presentation Outline

- Model Purpose and OU 10-08 RI/FS Process
- Model Strategy and Elements
- Ancillary Data and Information
- Ground Water Model
- Data Gaps and Research Needs

The WAG-10 model is being constructed to:

- Provide a credible basis for the prediction of cumulative risk from all contaminant sources at the INL to satisfy requirements of the OU 10-08 RI/FS
- Synthesize and integrate knowledge into one comprehensive aquifer model
- Document recent advances in aquifer understanding.
- Communicate water and contaminant movement issues beneath the INL to a wide range of audiences

OU 10-08 RI/FS Process



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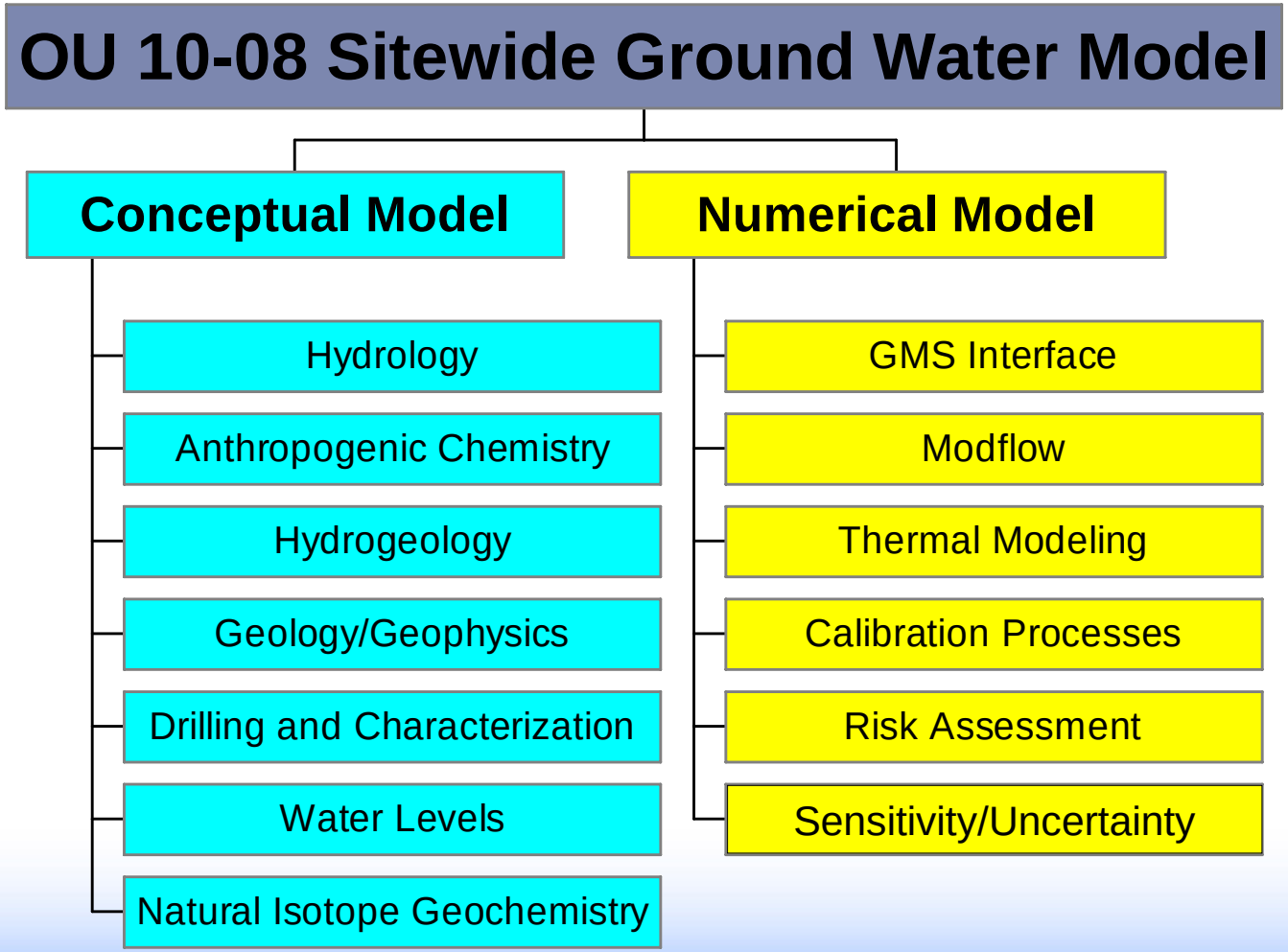
Strategy for Conceptual and Numerical Groundwater Models

- **Utilize all available data**
- **Parallel Development**
  - **Conceptual model**
  - **Numerical model**
- **Phased approach**
  - 2-D model developed first
  - 3-D models overlap and guided by 2-D models
- **Employ an approach capable of hypothesis testing**
  - Automated calibration
- **Iterations are scheduled**
- **Collaborate with USGS and IDWR**

Bottom Line

"Balance conservative modeling for risk assessment while maintaining technical credibility at a reasonable cost"

Elements of RI/FS Model



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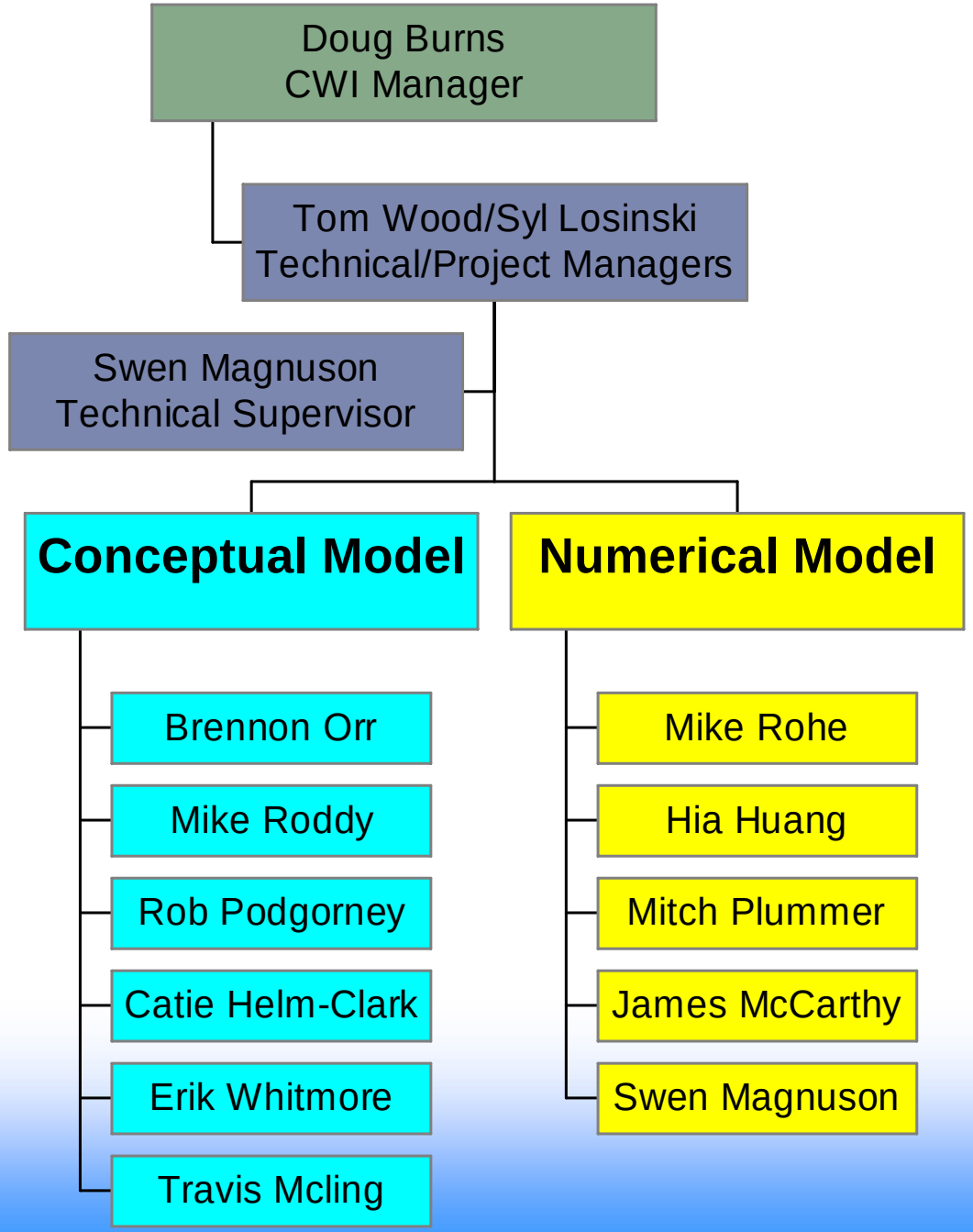
Model Organization and Supporting Staff



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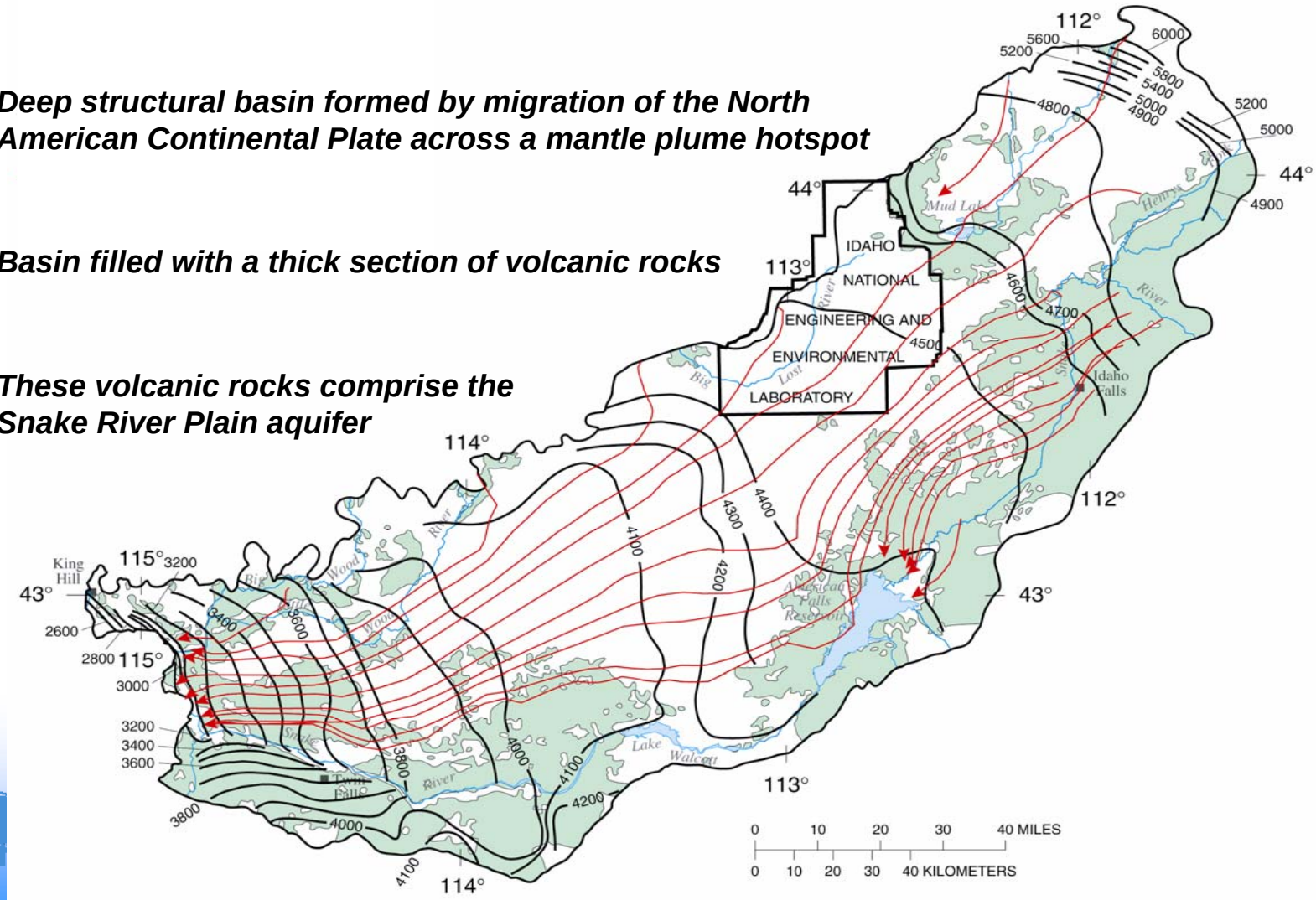
GEOHYDROLOGY OF THE EASTERN SNAKE RIVER PLAIN

Approximately 170 miles in length and 60 miles across

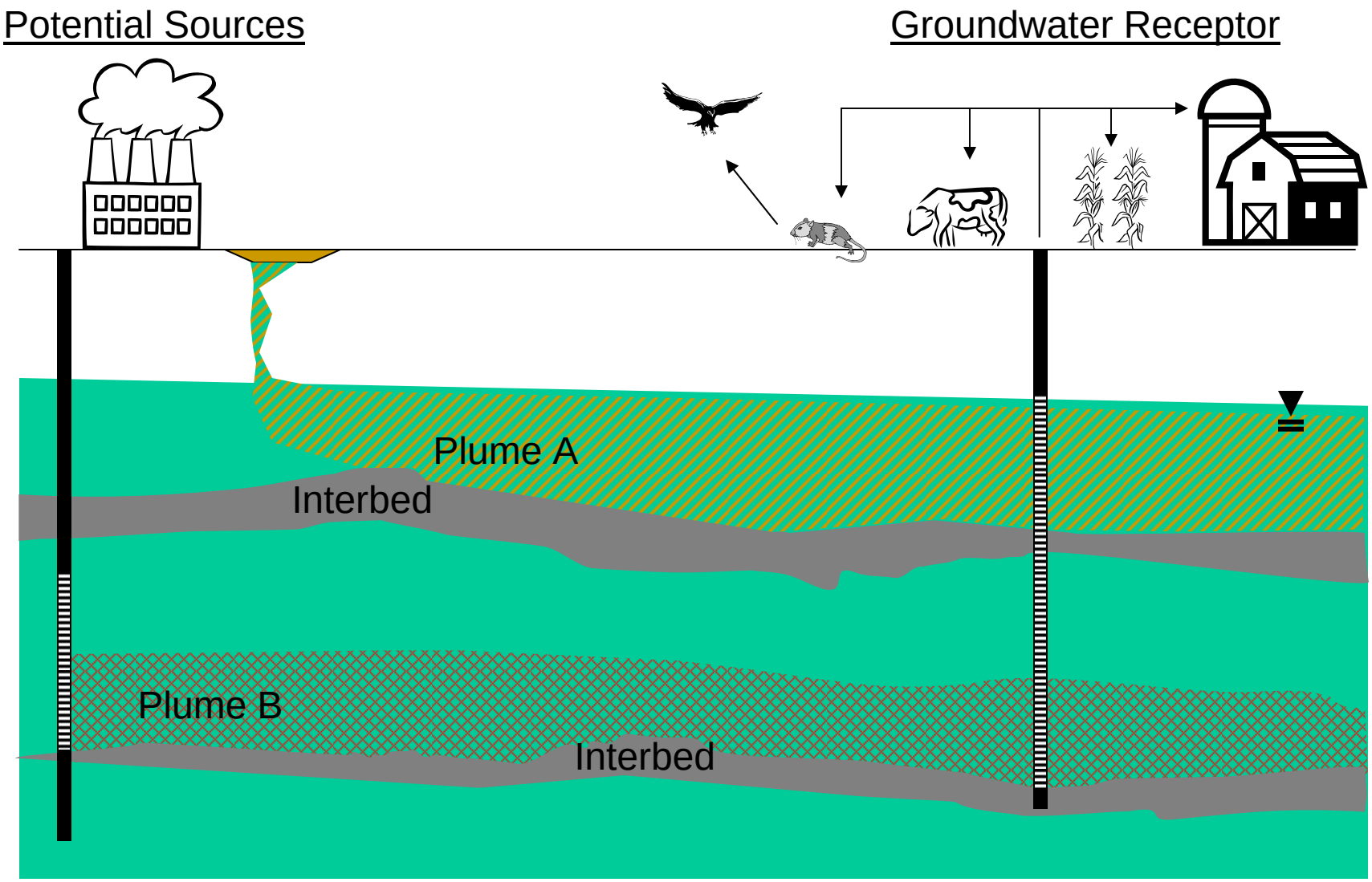
Deep structural basin formed by migration of the North American Continental Plate across a mantle plume hotspot

Basin filled with a thick section of volcanic rocks

These volcanic rocks comprise the Snake River Plain aquifer



End Product is Calculation of Risk



Ancillary Data and Information

- Historical Information
  - Historic regional groundwater models
  - WAG specific models folded into WAG 10 Modeling Effort
  - Impacts to the aquifer from INL Operations

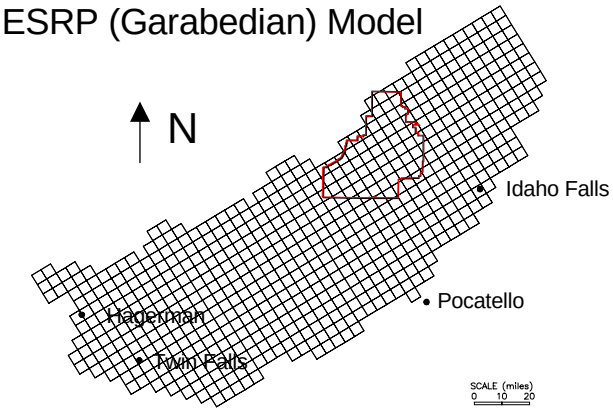
- Aquifer inflows/outflows

- Ground Water Monitoring/Characterization Data
  - Water Levels
  - Contaminant plumes
  - Aquifer test data
  - Wells

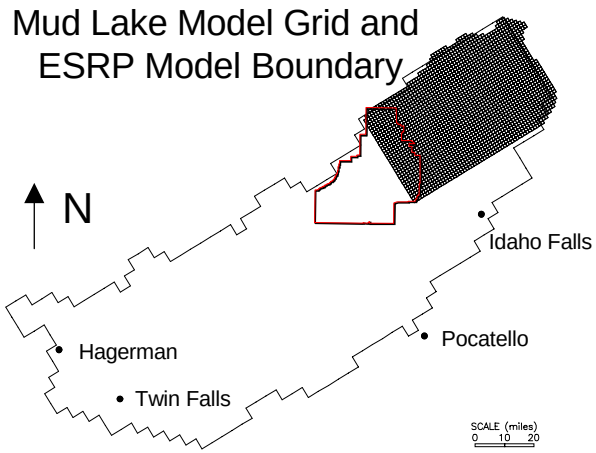
- Conceptual Model Advances
  - Interpreted preferential flow pathways
  - Aquifer heat flow
  - Geologic Subdomains

Historic Models, INL-scale or Larger

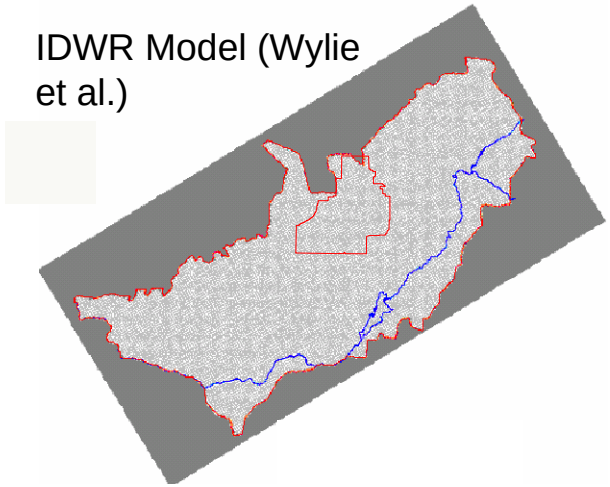
ESRP (Garabedian) Model



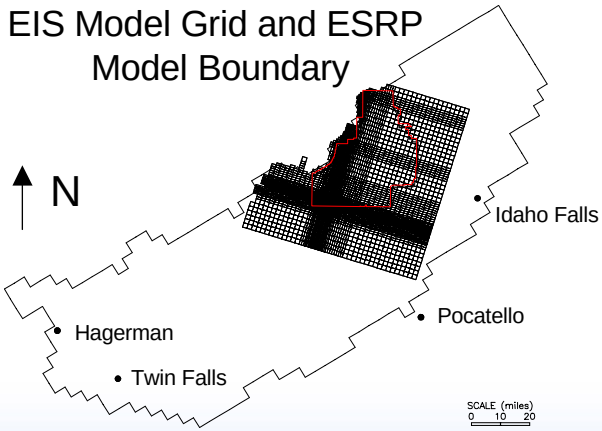
Mud Lake Model Grid and ESRP Model Boundary



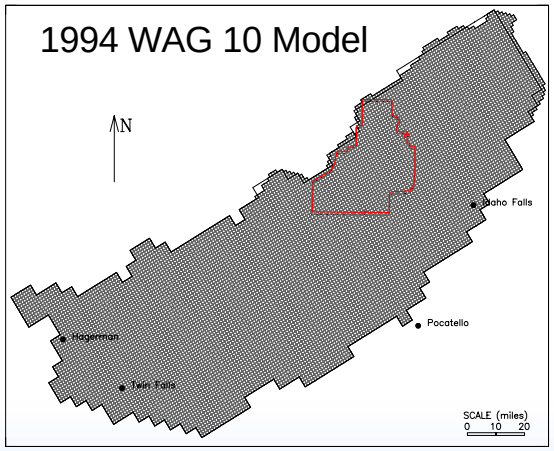
IDWR Model (Wylie et al.)

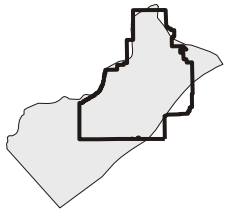


EIS Model Grid and ESRP Model Boundary



1994 WAG 10 Model





USGS Conceptual Model (Ackerman et al.)

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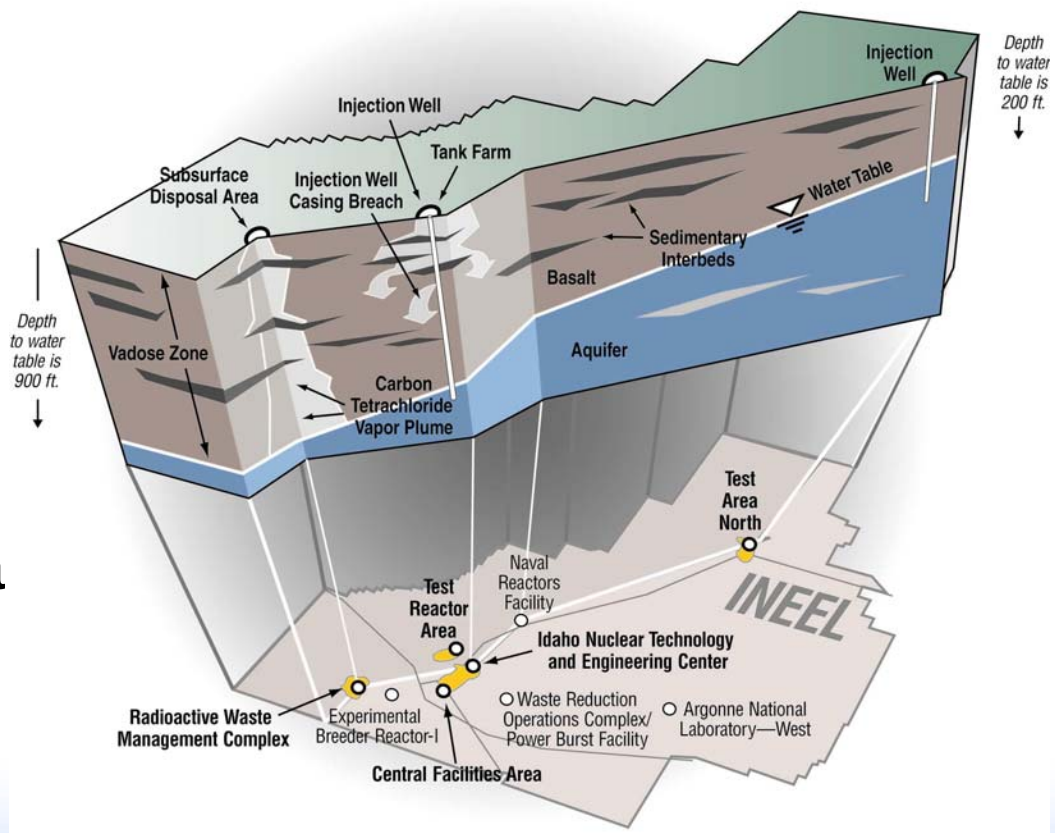
Impacts to SRPA at the INL

Contaminants that exceed MCLs

- **Test Area North – ^{3}H, ^{137}Cs, ^{90}Sr, PCE, TCE, and DCE**
- **Reactor Technology Complex – ^{3}H and Cr**
- **INTEC - ^{129}I, and ^{90}Sr**
- **Central Facilities Area – nitrate**
- **SDA – CCl_4**



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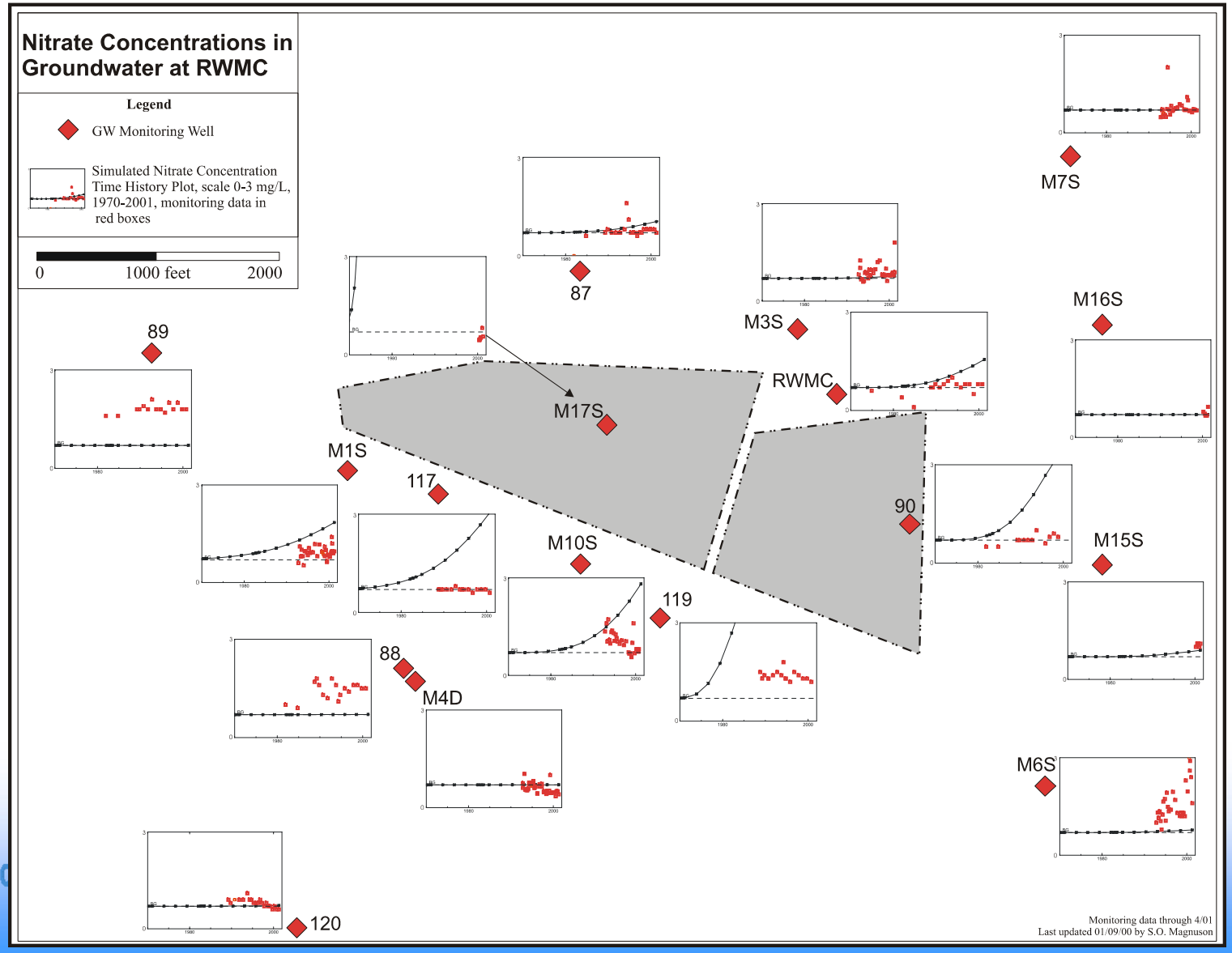
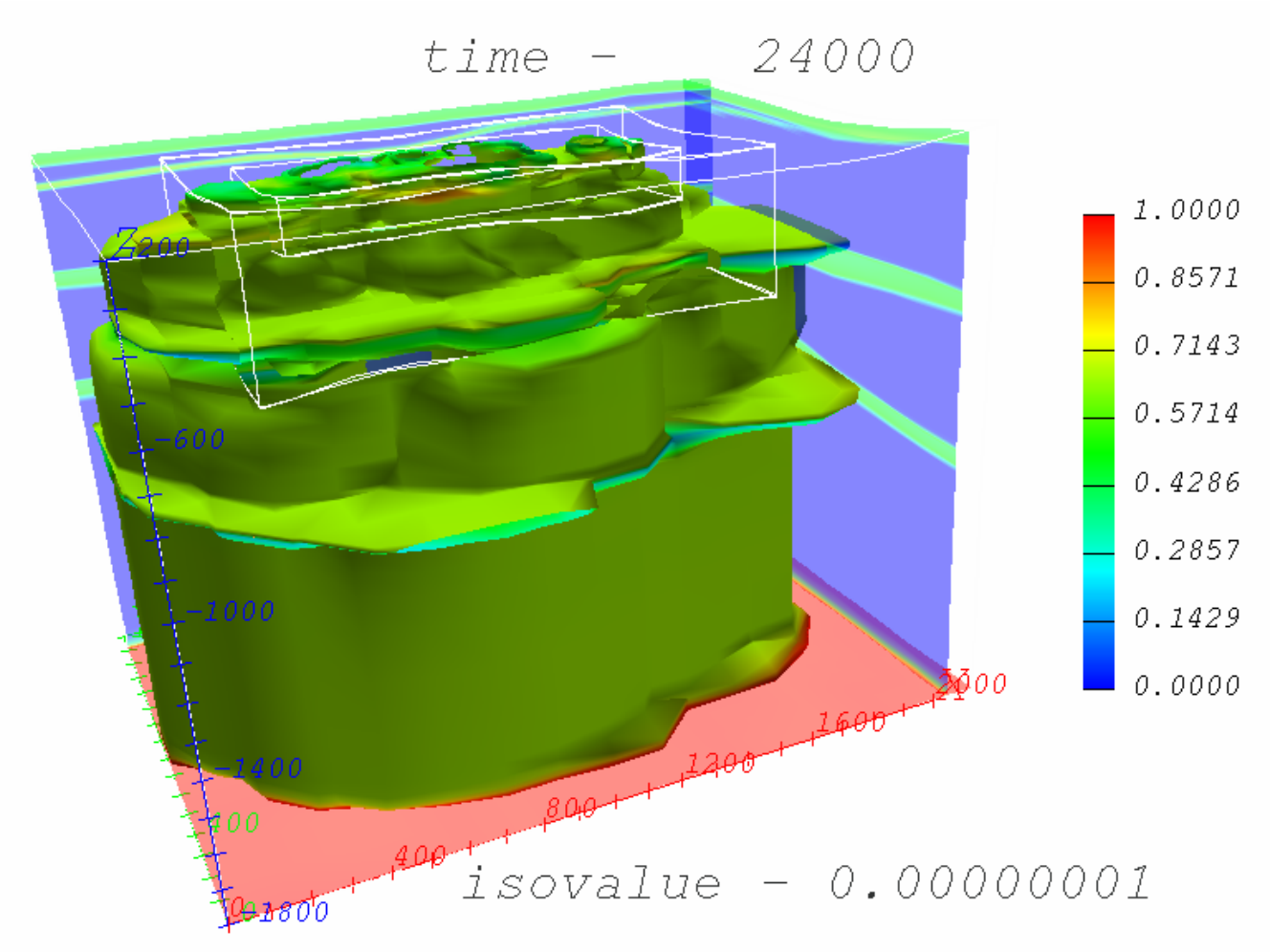
WAG Specific Models Folded into WAG 10 Model



Utilize WAG Specific Contaminant Flux to the Aquifer



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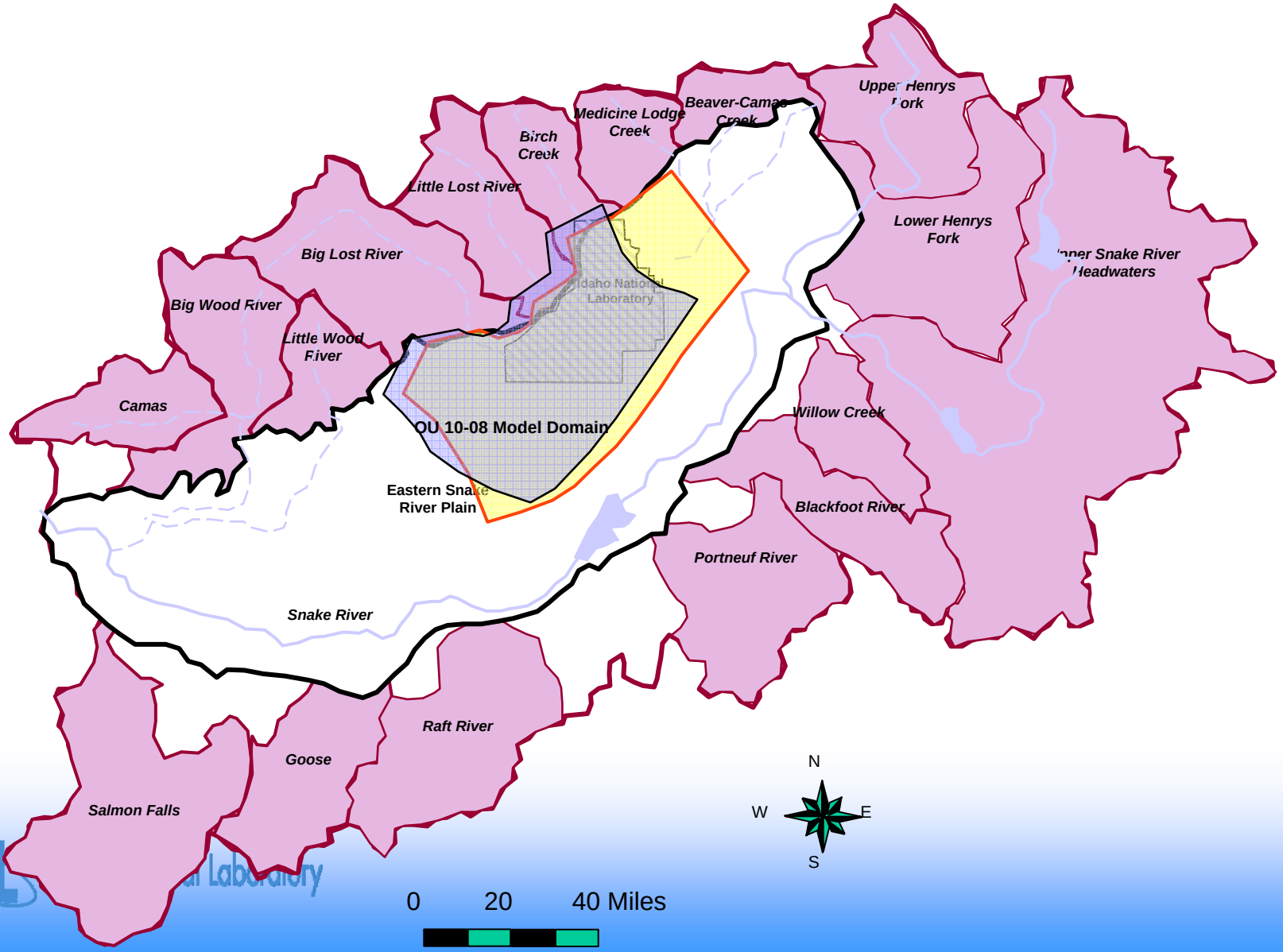
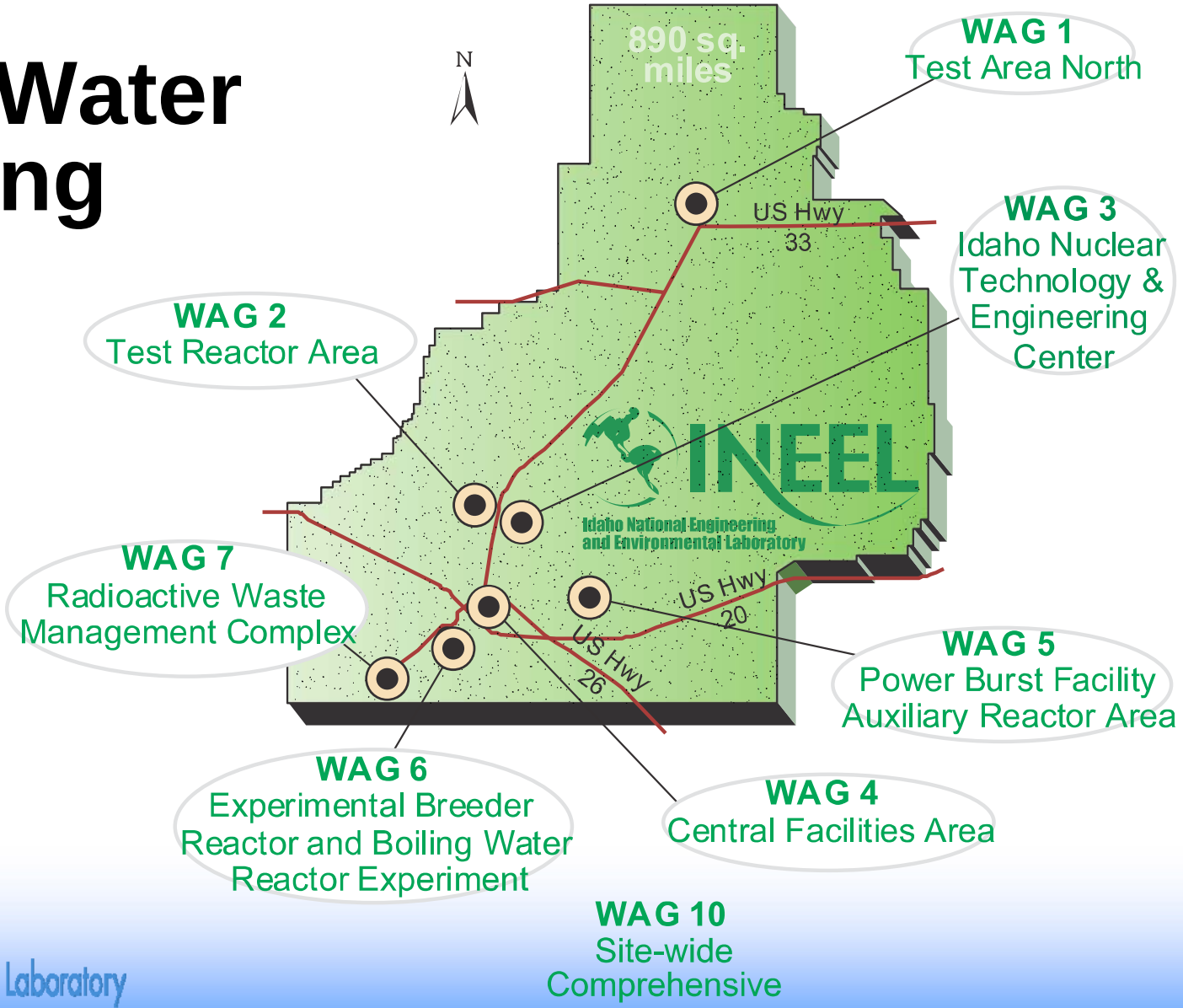
Aquifer Inflows/Outflows



Ground Water Monitoring Data



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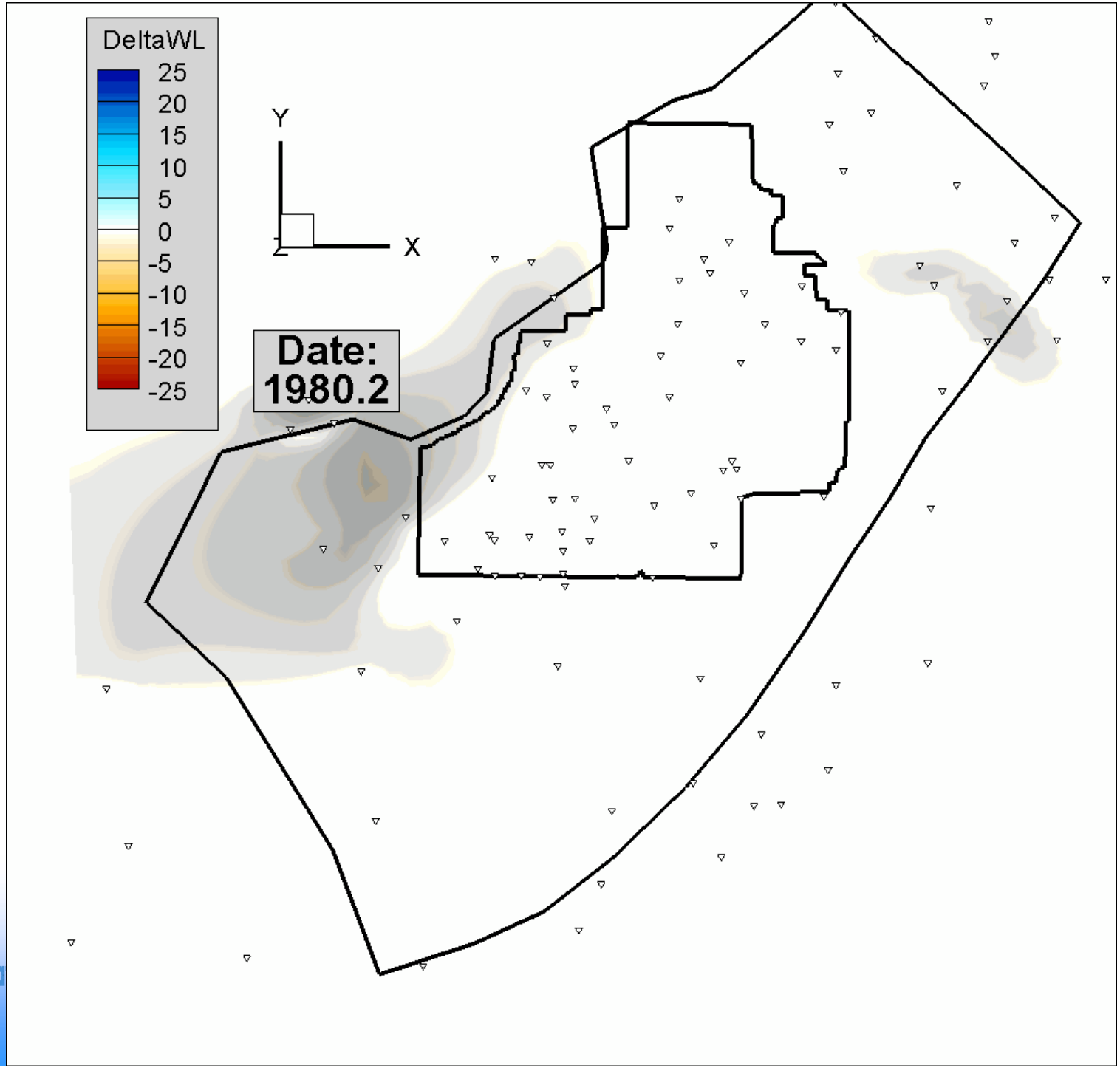
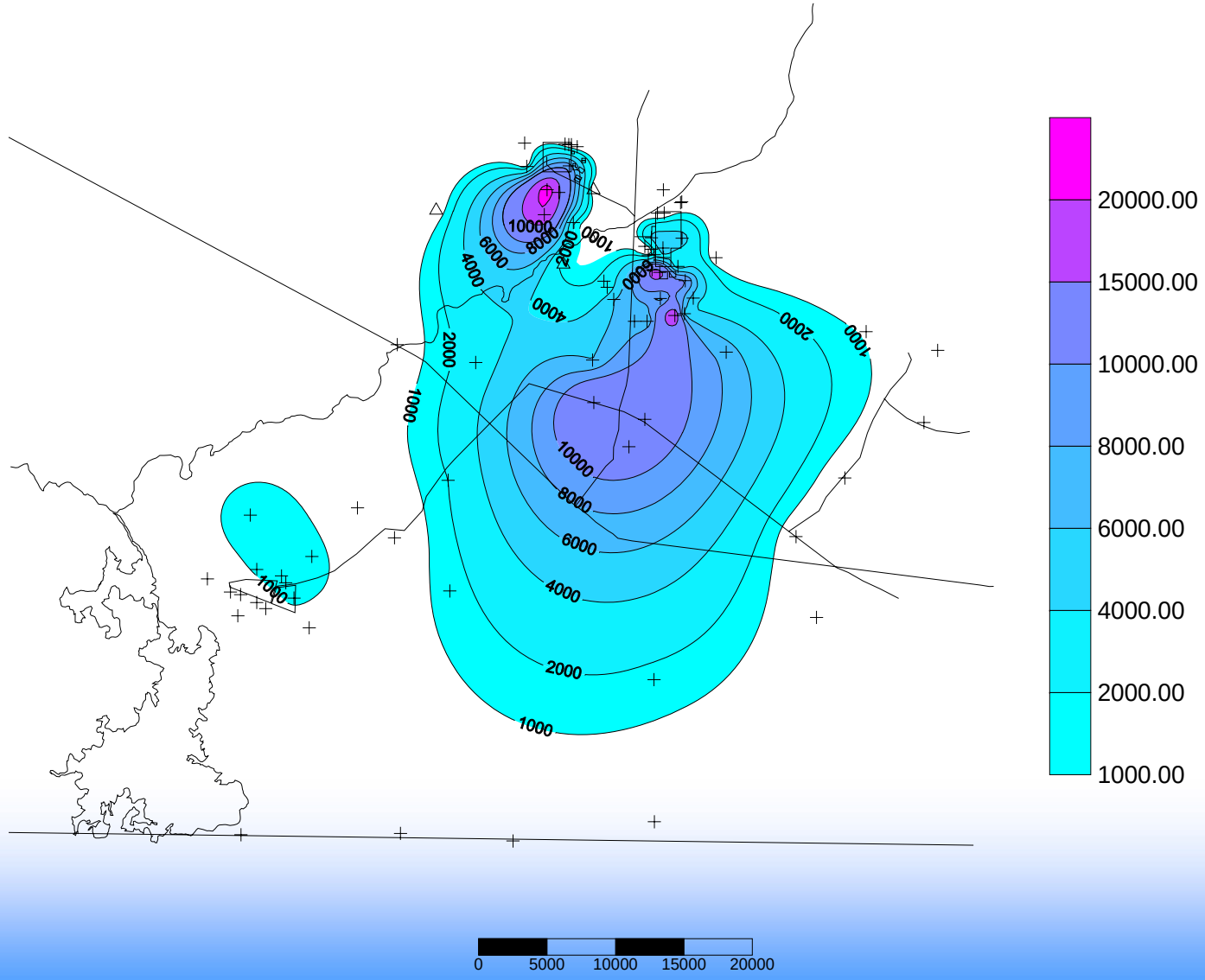
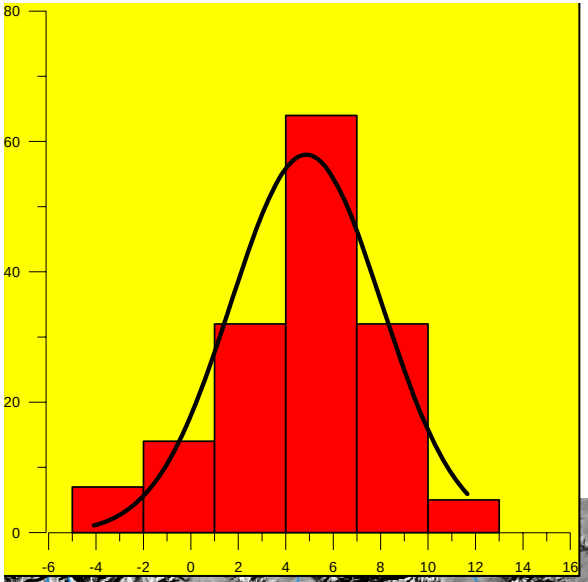
Water Levels over time



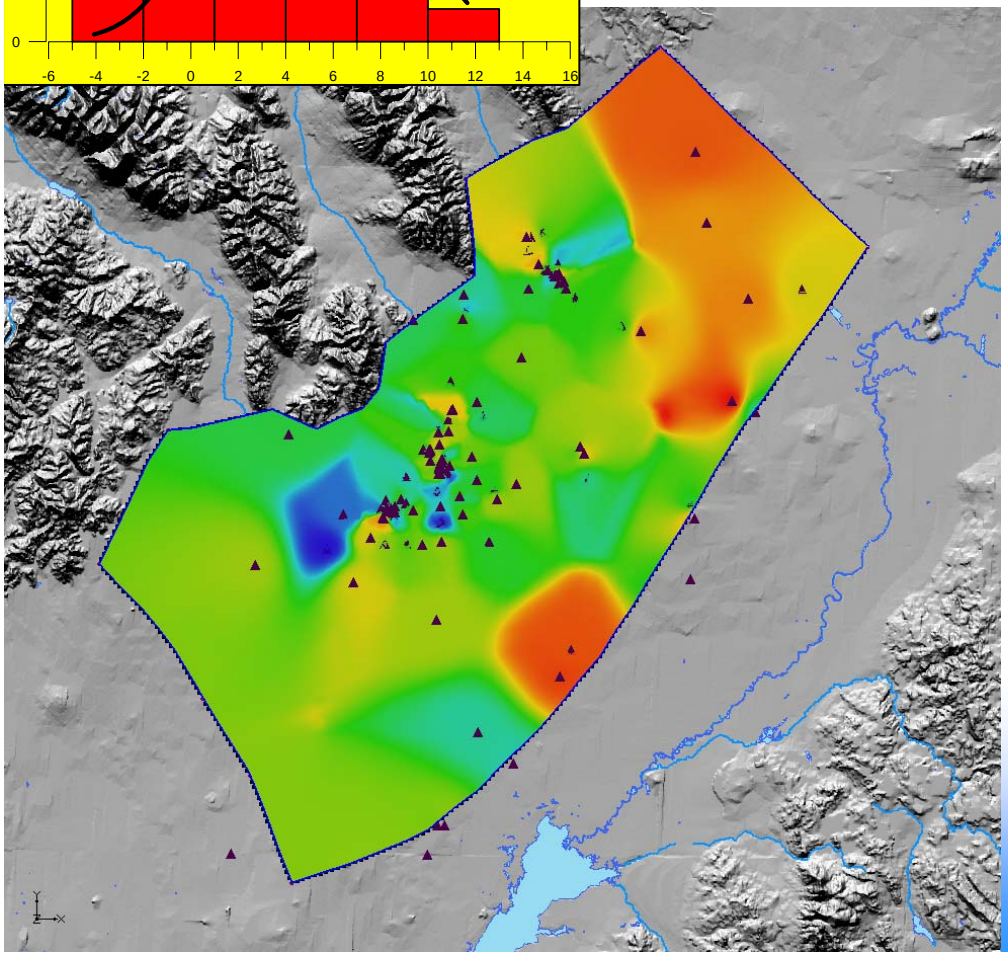
Tritum Contours - Spring 1998 (pCi/L)

Contaminant Plumes



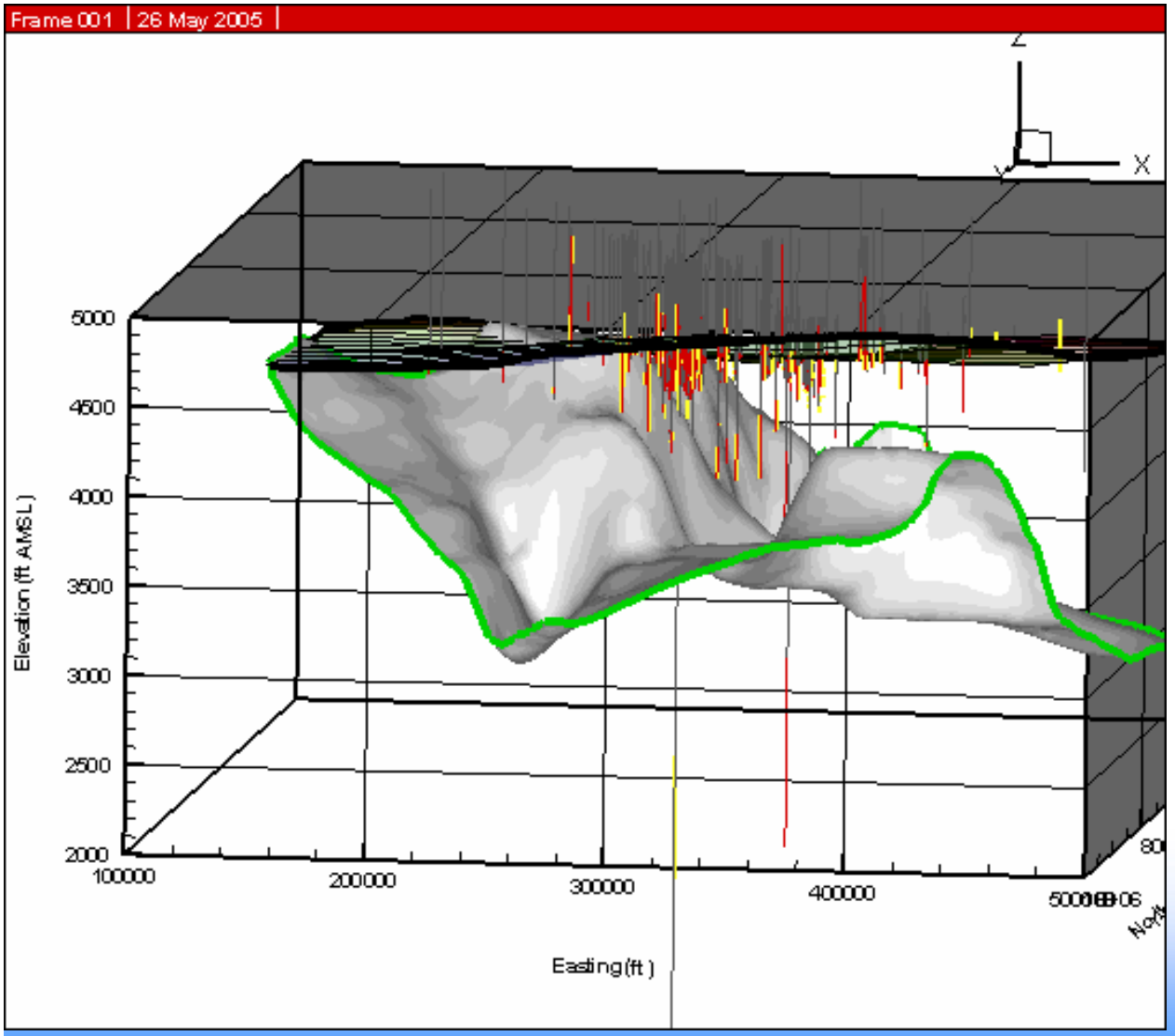


Aquifer Test Data



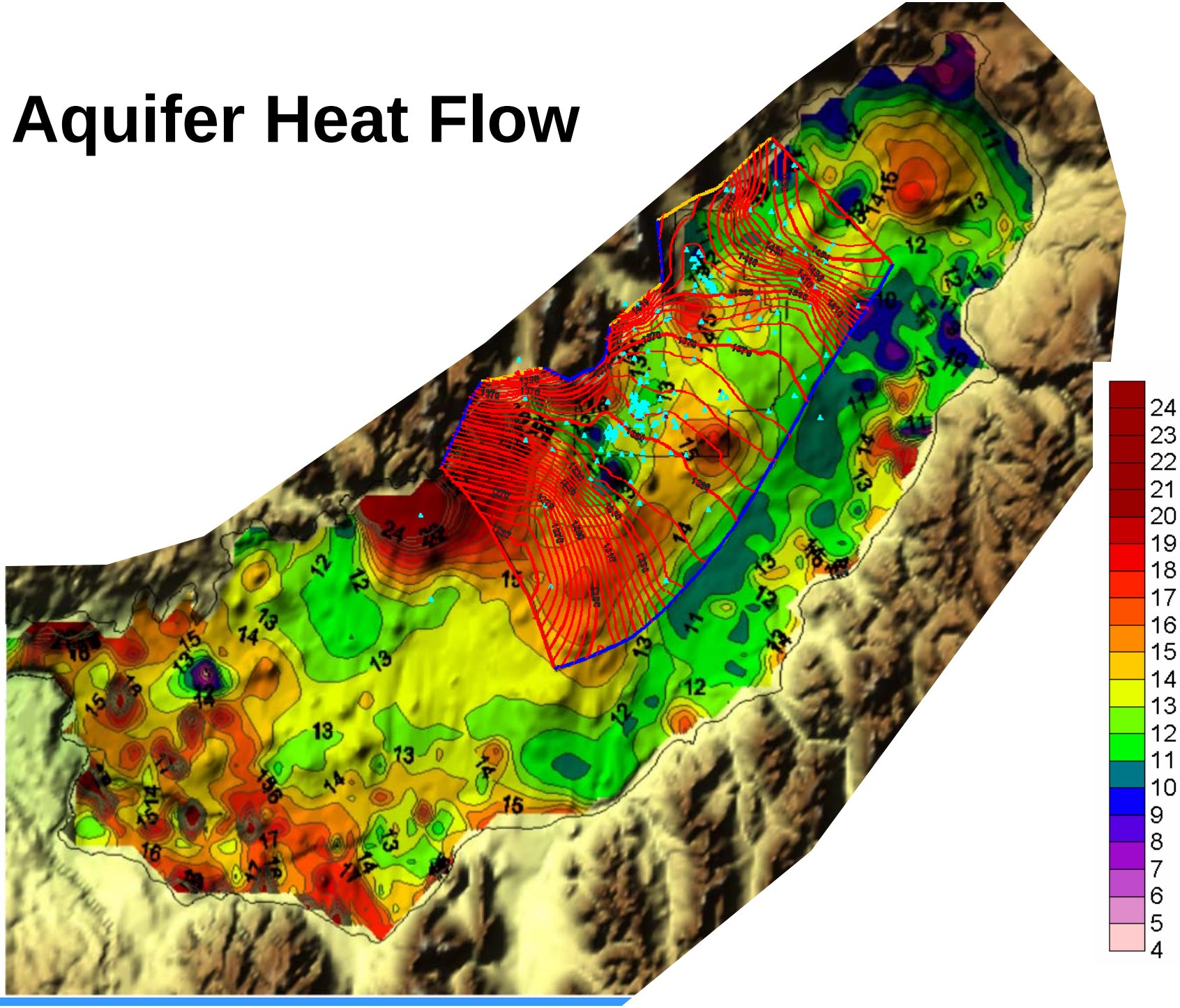
- 2-D map of 3-D data
- ~ 7 order of magnitude spread
  - 10^{-2} to 10^{5} ft/day
  - values representative of silt/loess/dense basalt to fractured basalt/interflow zones/coarse gravels
- High spatial variability
  - Hotter colors = higher K
- Gaussian Distribution
  - Mean LN(K) = 4.7 ft/day
  - Median LN(K) = 5.5 ft/day

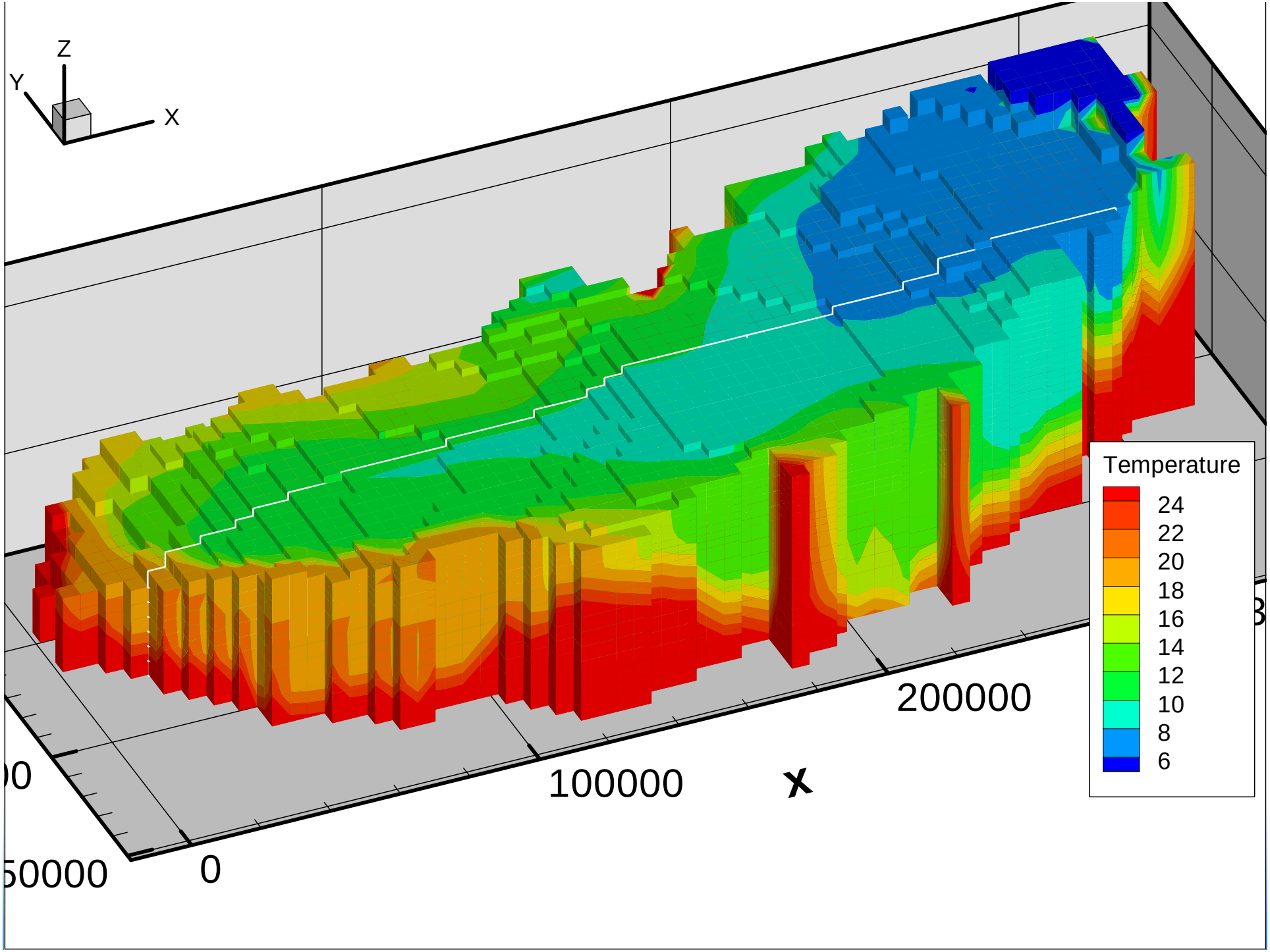
Well Completion/Tested Intervals



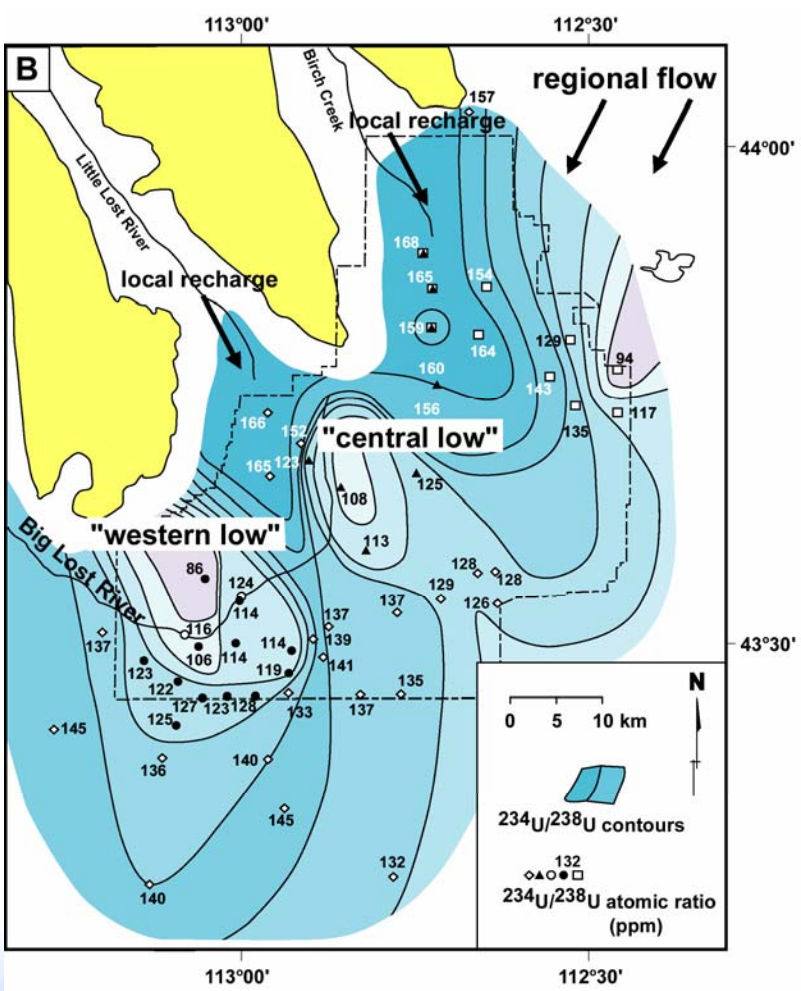
- **Graphic example of well completion intervals**
  - **Gray: cased well**
  - **Red: Open interval**
  - **Yellow: have aquifer test information from the interval**

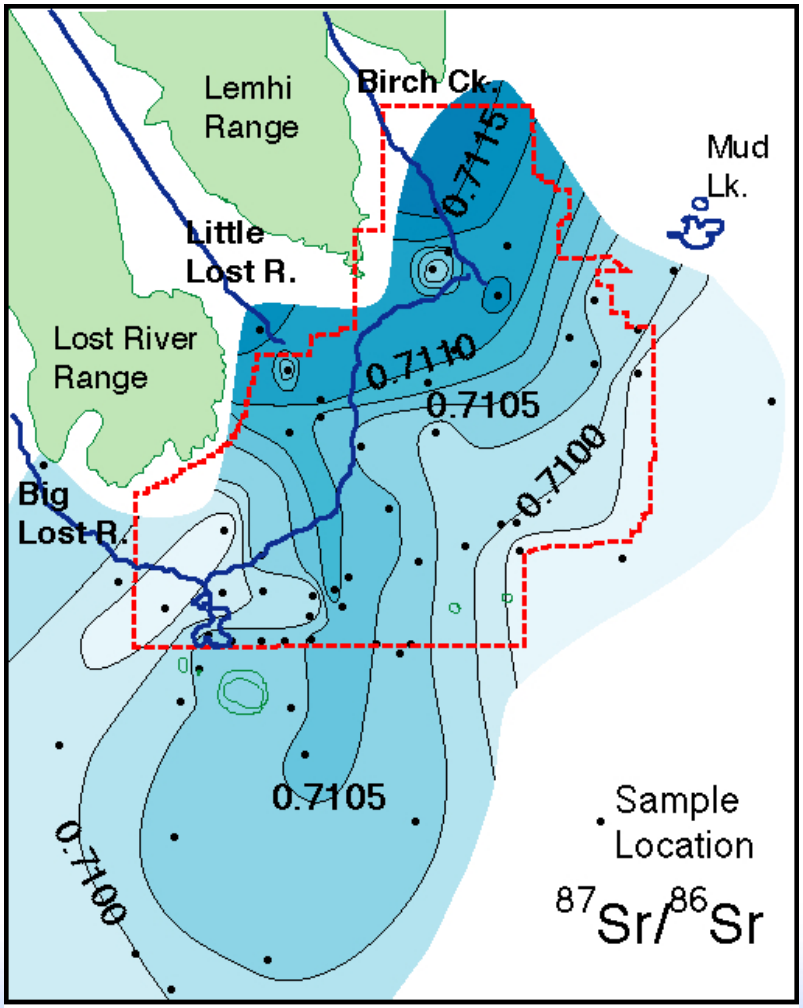
Aquifer Heat Flow




Z
Y
X
Temperature
24
22
20
18
16
14
12
10
8
6
200000
100000
x
0

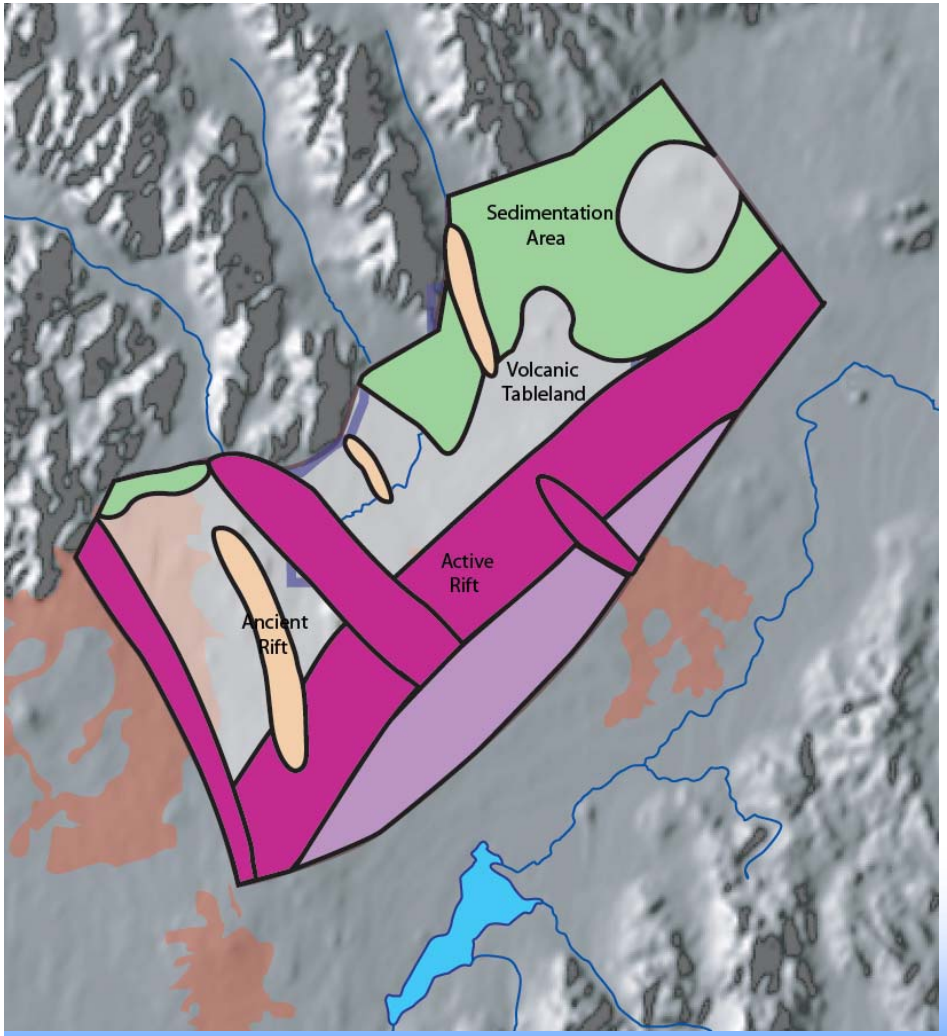
PREFERENTIAL FLOW WITHIN THE SNAKE RIVER PLAIN AQUIFER





Variations of natural isotope ratios suggest preferential flow paths originate from the Birch Creek and Little Lost River drainage basins (Luo et al. 2000).

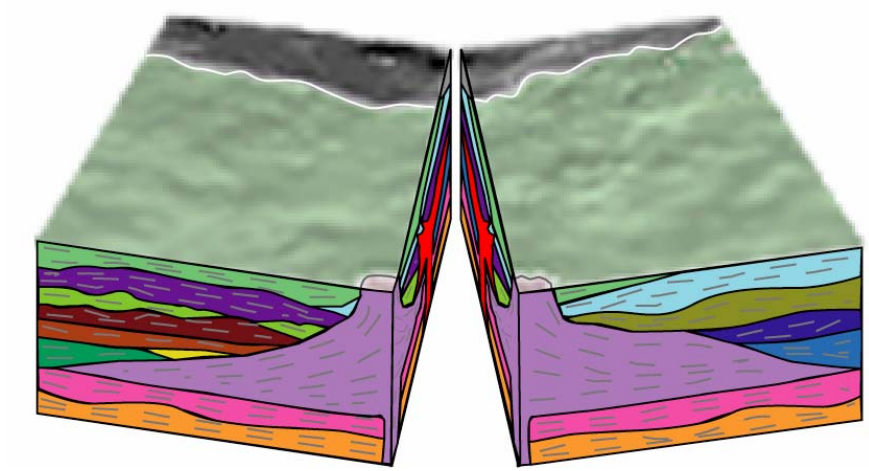
Structural/Depositional Sub-Domains

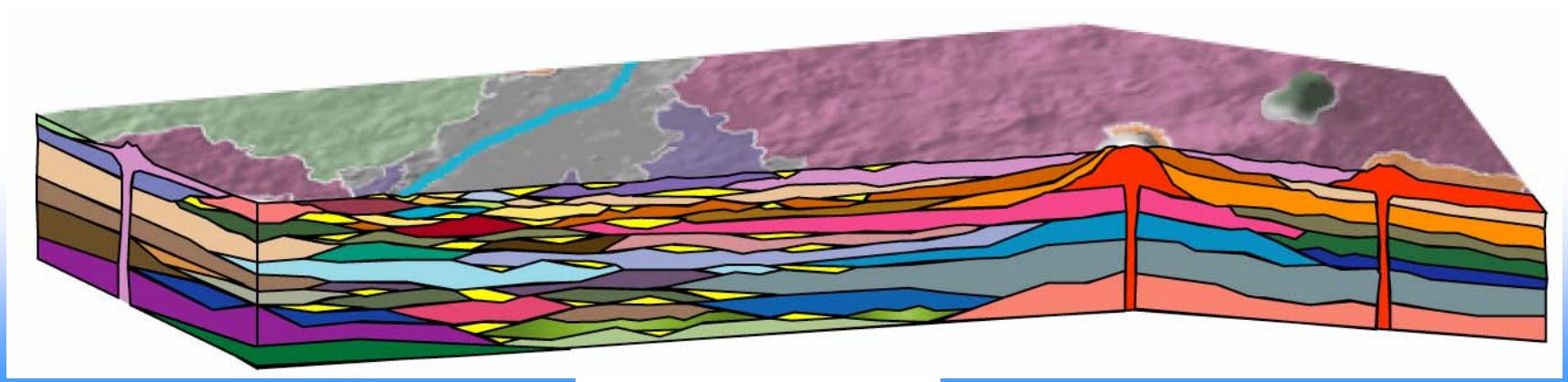


- **Conceptual model divided into areas of specific styles of surface/subsurface processes**
- **Use directly for 2D case**
  - **Compare with other 2D modeling results**
  - **Also condition 3D case to this dataset**

Geologic Sub-Domains

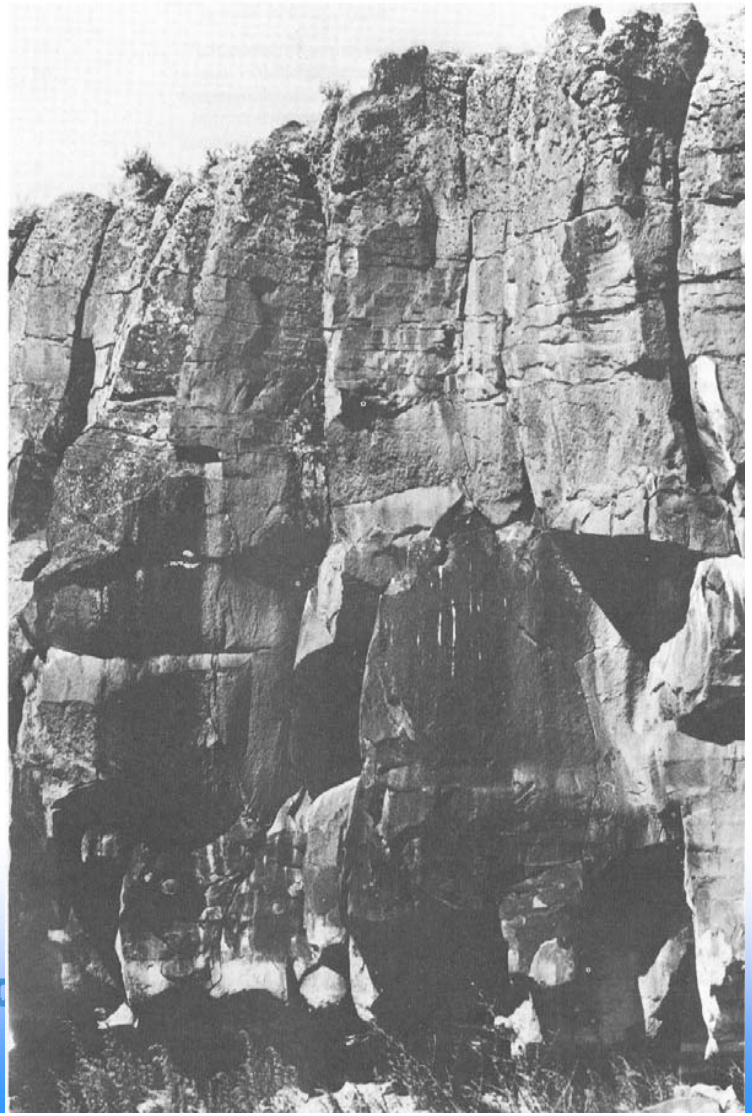
- ❖Active Rifts
- ❖Older Rifts
- ❖Big Lost River Flood Plain
- ❖Buried Lake Beds
- ❖Volcanic Tablelands





RKP1

HYDRAULIC PROPERTIES AT THE SCALE OF AN INDIVIDUAL FLOW



FLOW TOP

FLOW CENTER

FLOW BASE

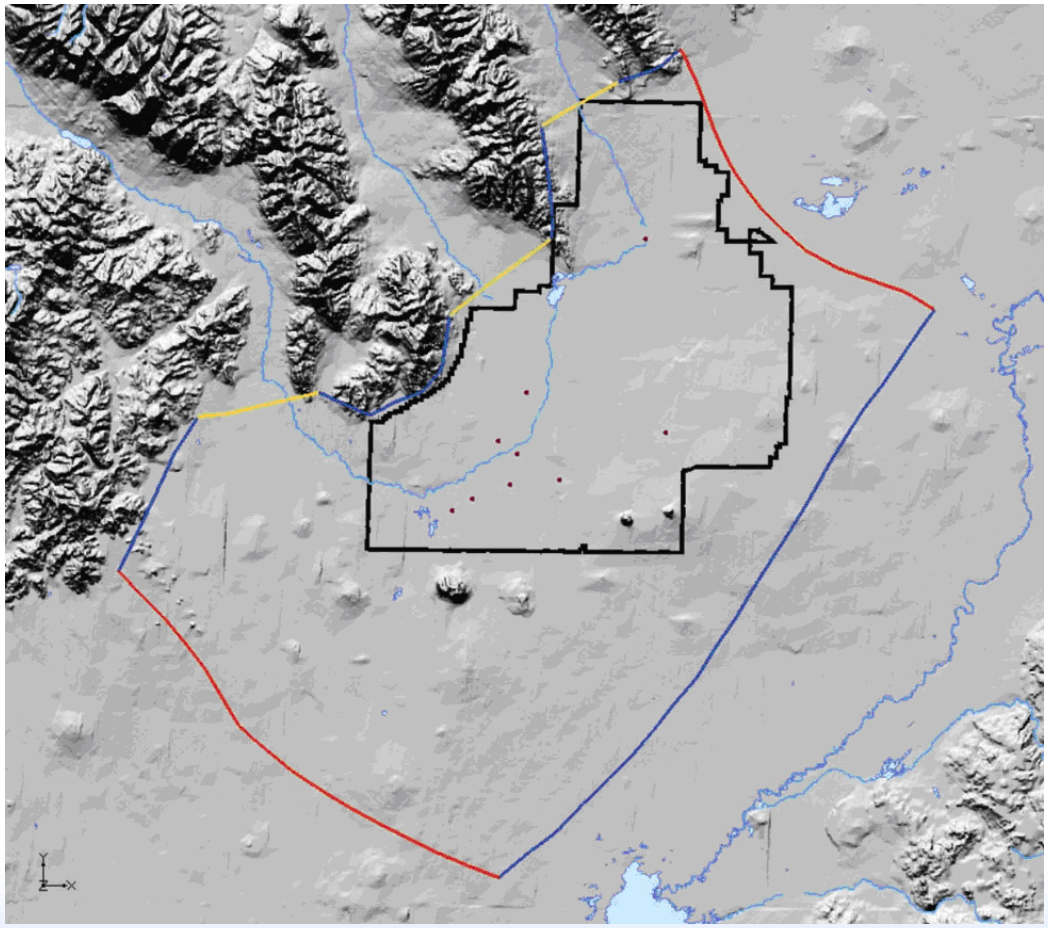
Slide 26

RKP1 not sure where this fits
Rob Podgorney, 6/12/2006

RKP2

Groundwater Model

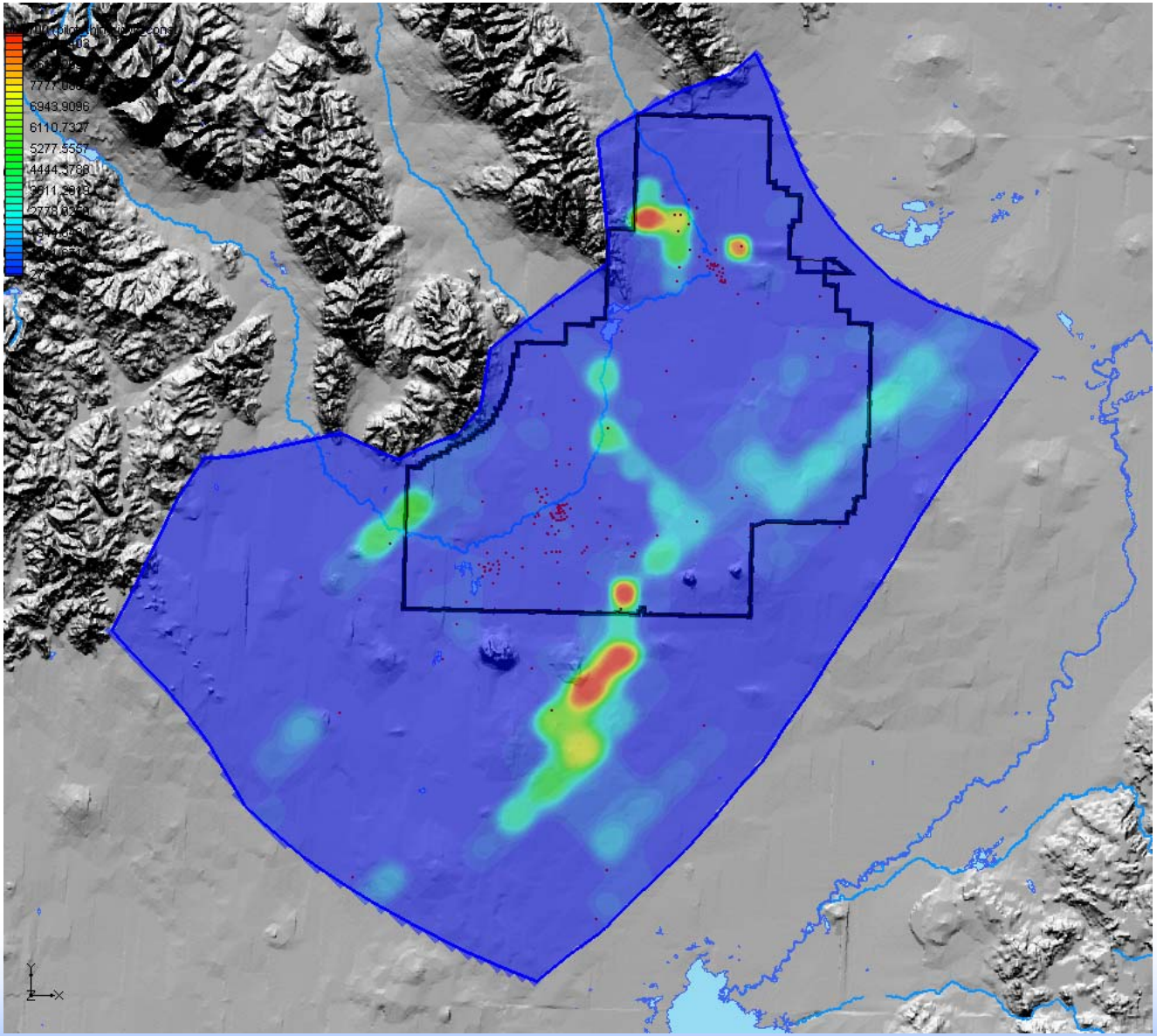
- **Coupled Modflow MT 3-D MS and PEST**
  - **Uses a pilot point approach for calibration**



Slide 27

RKP2 the points shown are NOT pilot points, they are WAG centroids….Hai has a better graphic for this
Rob Podgorney, 6/12/2006

K field after calibration with pilot points



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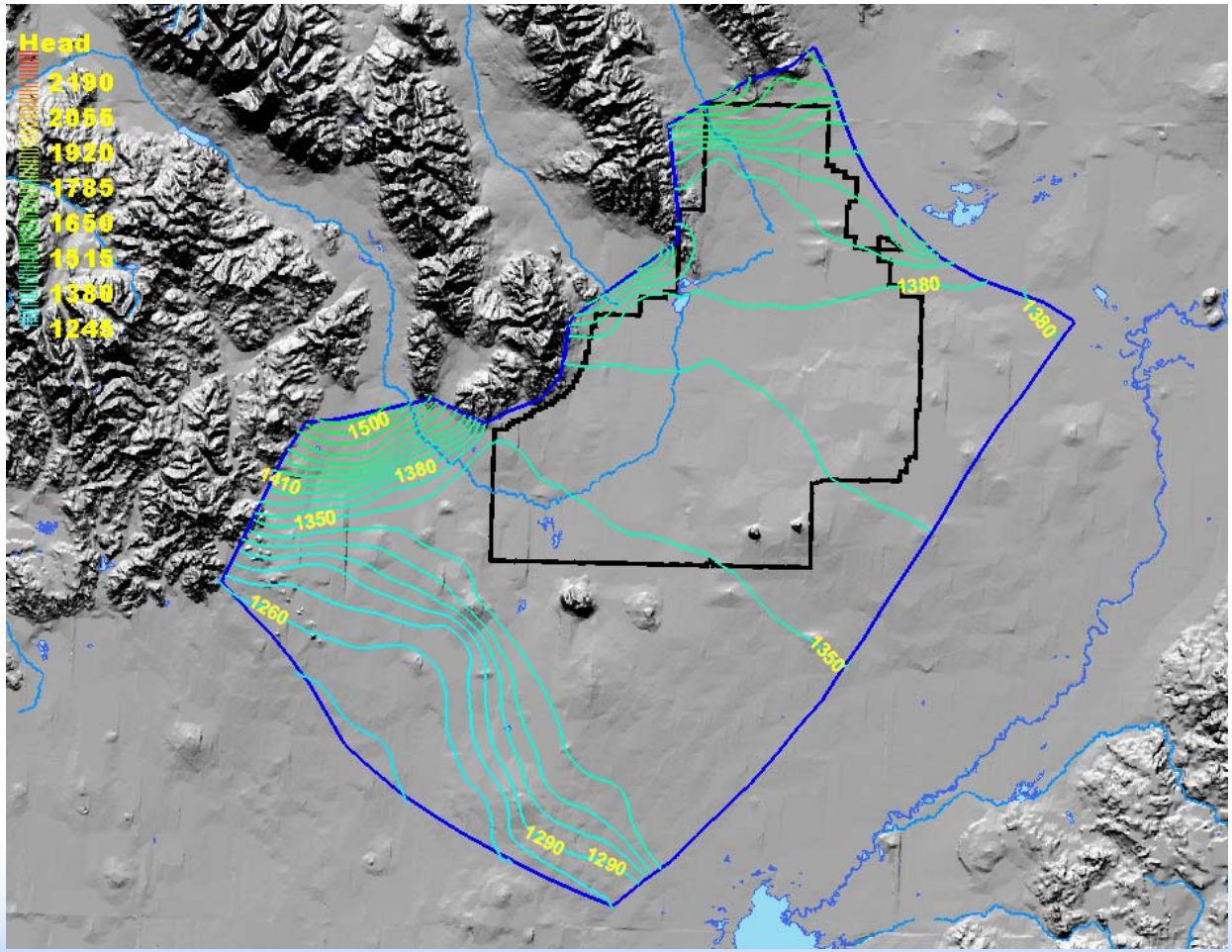
Final Simulated Head Distribution 2-D



Response Surface Modeling Method for Dose Calculation Scenarios

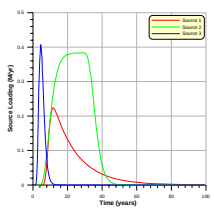
The convolution integral coupled with source-receptor response functions and contaminant source terms to the aquifer are used to estimate groundwater concentrations at selected receptor locations in the groundwater modeling domain.

$$C_{i,j,k}(t) = \frac{1}{Rd_k}\int_0^t RF_{i,j}\left(\frac{t-\tau}{Rd_k}\right) S_{i,k}(\tau)\, DIF_k(t-\tau)\, d\tau$$

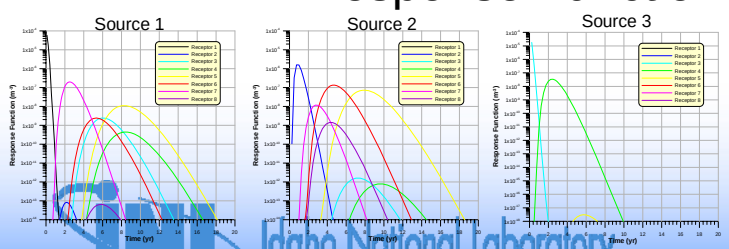
Equation 1. Convolution Integral
[*i* = source index, *j* = receptor index, *k* = contaminant index, *n* = number of sources]

$$CTOTAL_{i,j}(t) = \sum_{k=1}^{n} C_{i,j,k}(t)$$

Source

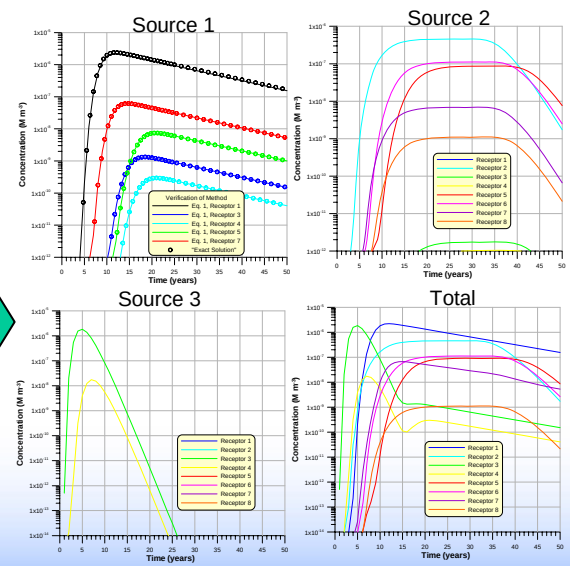


Response Function



Convolution Integral

Concentrations



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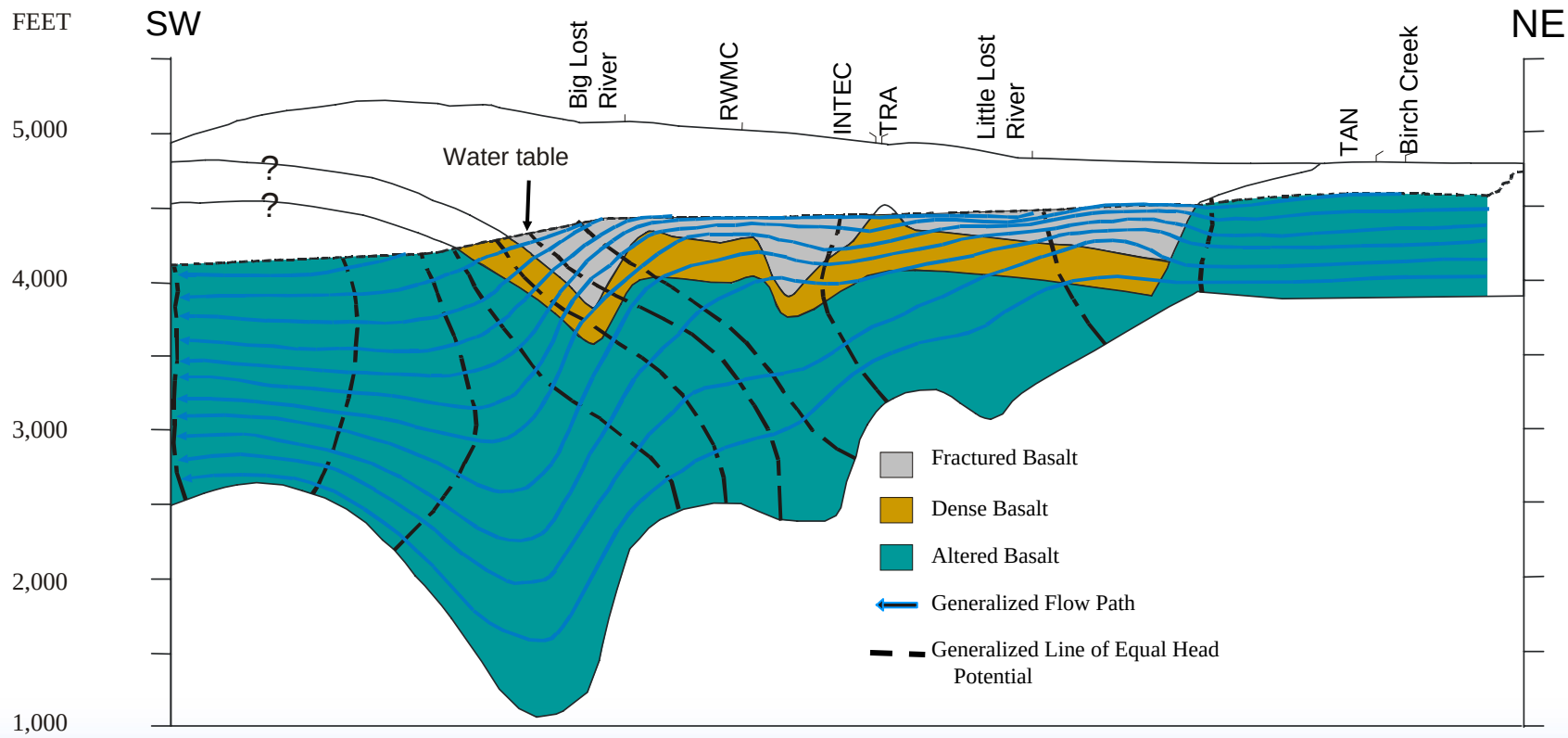
Research Needs/Data Gaps (see handout)

Data Gap	Activity to fill Gap
Aquifer thickness	New Deep Coreholes
Stratigraphic Gaps	New Deep Coreholes
3-D Natural Geochemistry	Depth discrete sampling in New Coreholes
Anthropogenic sources	Anthropogenic tracer study Sample New Coreholes
Define hydrogeologic Units	Summarize pumping test database Correlate to stratigraphy
Assumption of equivalent porous media, boundary conditions	Sensitivity studies
Calibration to temperature in GW	Perform temperature simulation
Spatially varying infiltration	Vary infiltration based on geologic media exposed at land surface
Steady-state or transient flow?	Evaluate quasi steady-state water table versus transient simulations
Hydraulic head data	Evaluate data set, well deviations, time scale, equipment, QA/QC

Research Need: How large is the REV or is there such a thing?

Research Need: Effects of Geologic Structure on Flow and Transport



Adapted from the USGS

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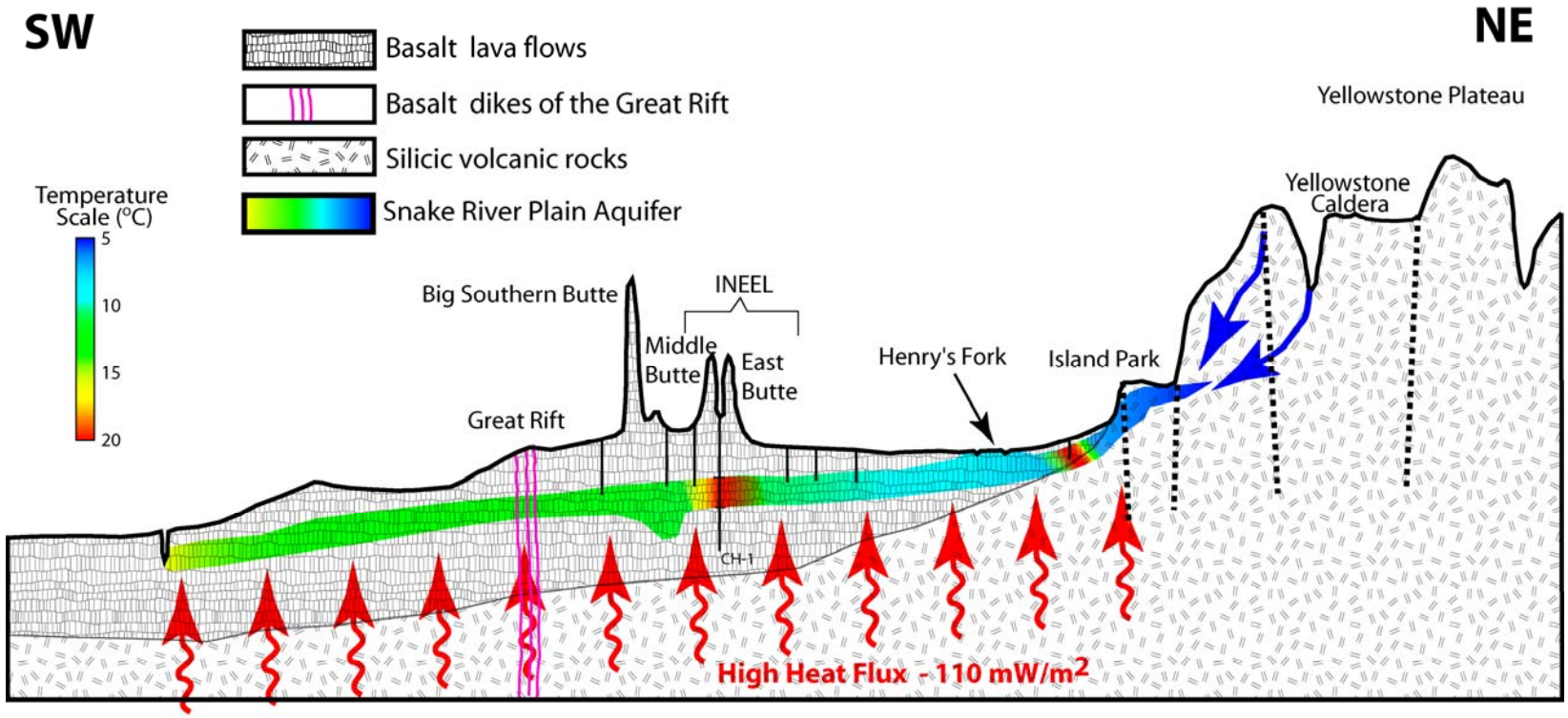
Research Need: Thermal Conceptual Model, Can we use this for Calibration?



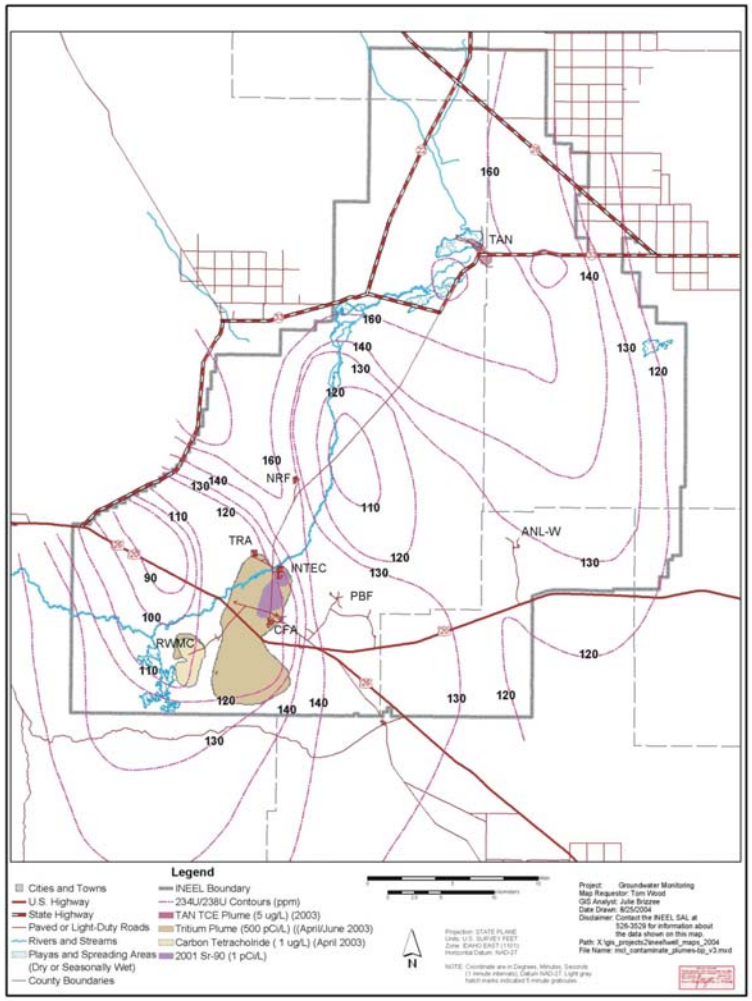
SW to NE Longitudinal Section, Snake River Plain Aquifer

0 100

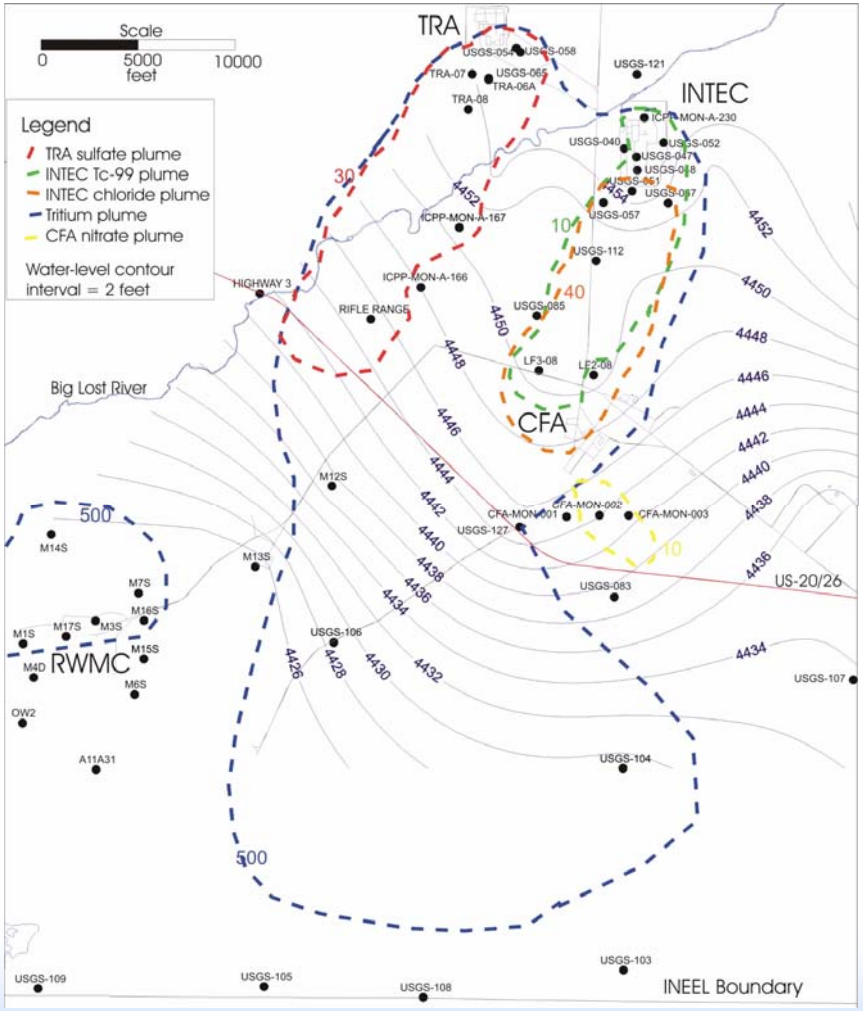
Scale (km)

Extreme Vertical Exaggeration

Research Need: How to Resolve Flowpaths?



Contaminant plumes and distribution of uranium-234/-238 in groundwater 2003



Approximate distribution contaminants in groundwater near INTEC, TRA, and CFA in 2003.

Modeling Research Needs:

- **Account for heterogeneities at various scales: from 10-100's m at facilities to 1,000 to 10,000 m at the subregional scale**
- **Computational challenge of solving large inverse problem with hundreds of parameters to be estimated.**
- **Inverse modeling should be conditioned to various types of information: lithology info, pumping test data, head, concentrations and travel times.**