Hydrologic Modeling of the 300 Area Aquifer
300 Area IFC Workshop

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March 29, 2007

PNNL-SA-54607

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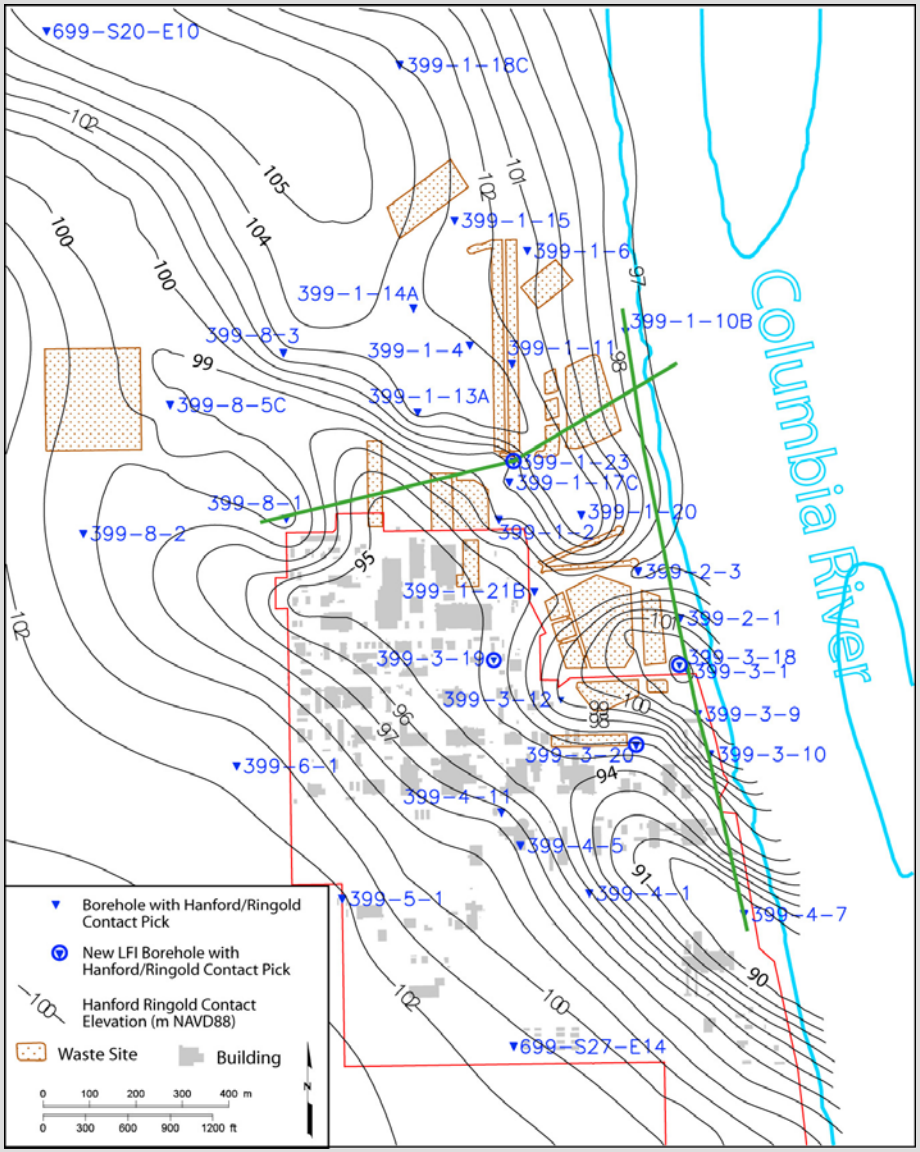
Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

Outline

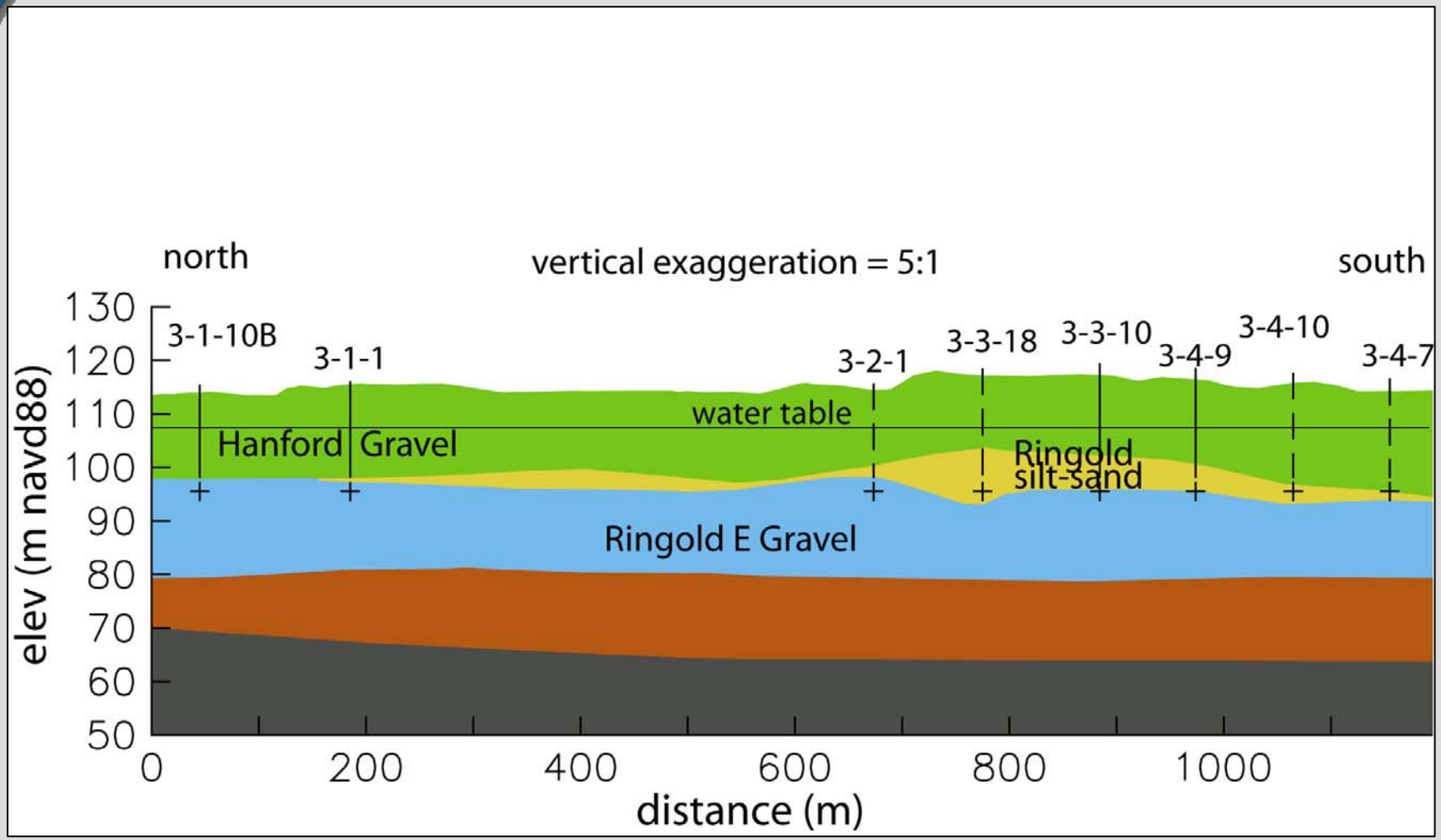
- Hydrogeology
  - Structure contour map
  - Cross Sections
  - 3D Visualization
  - Aquifer Test Summary Map
- Water Level Monitoring Network
  - River stage
  - 2004+ Water Level Monitoring Network
  - Temperature / EC Monitoring Data
- Large Scale Flow Model (brief description)
- Preliminary Flow and Transport Simulations
- Ongoing Work

Hydrogeology – Updated in FY06

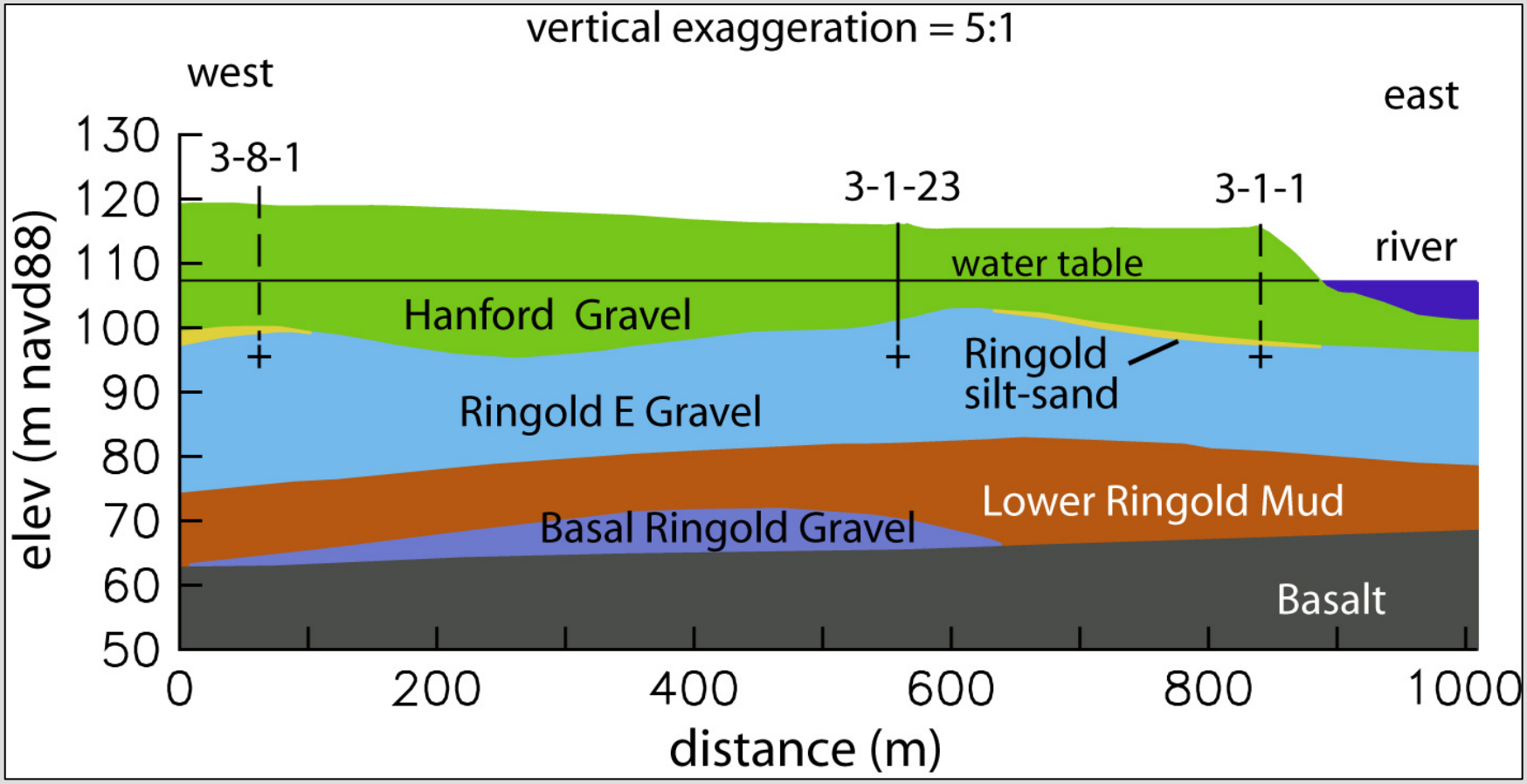


- Data from LFI Wells
- Re-interpretation of older well logs for Hanford/Ringold contact based on detailed analysis of LFI wells (i.e. type sections)
  - Geophysical logs
  - Sediment Descriptions
- Developed in EarthVision with results compared to hand-contoured map

Hydrogeology:
North/South Cross Section Parallel to River

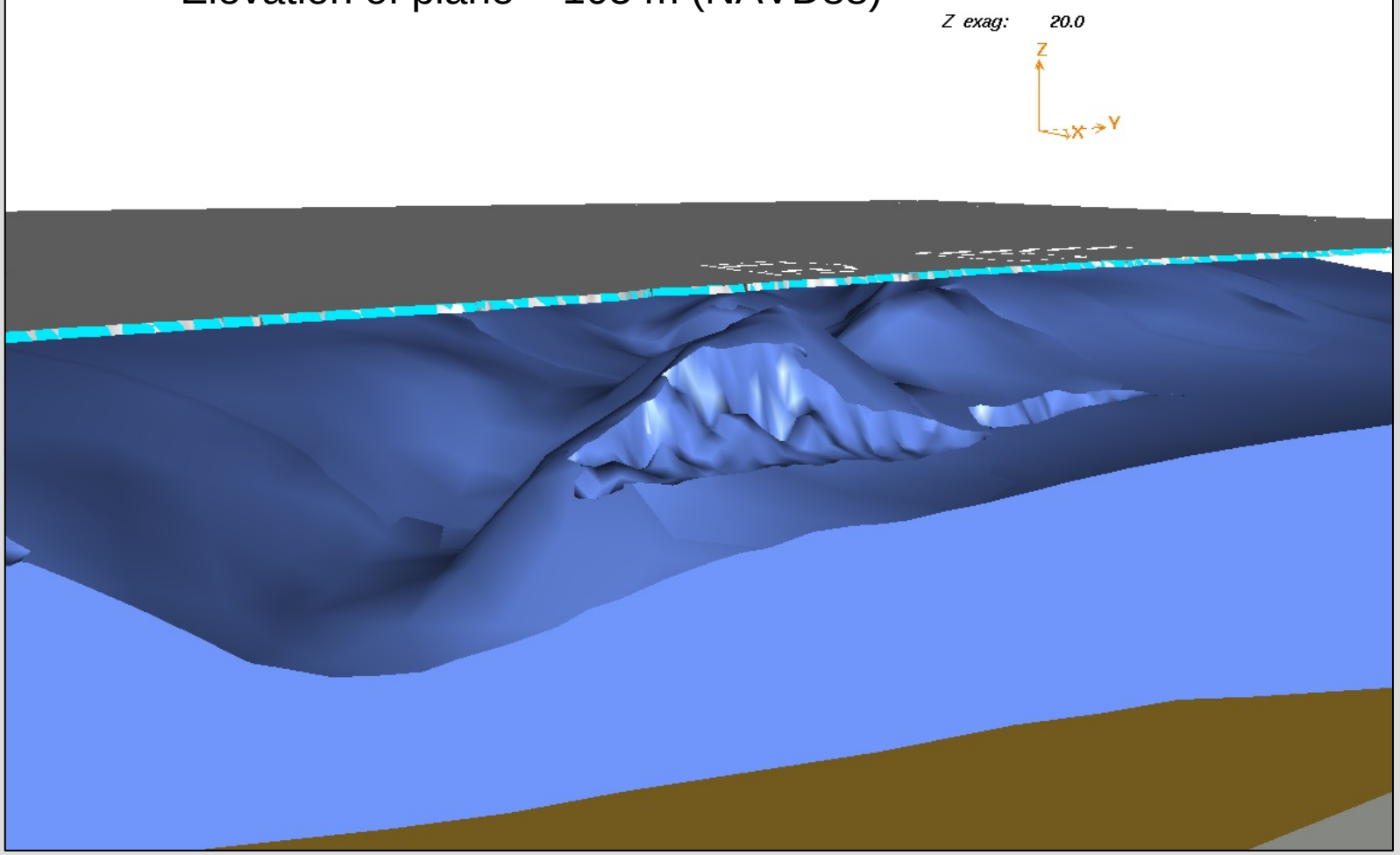


Hydrogeology: West/East Cross Section



Hydrogeology
Top of Ringold Surface

Elevation of plane = 105 m (NAVD88)



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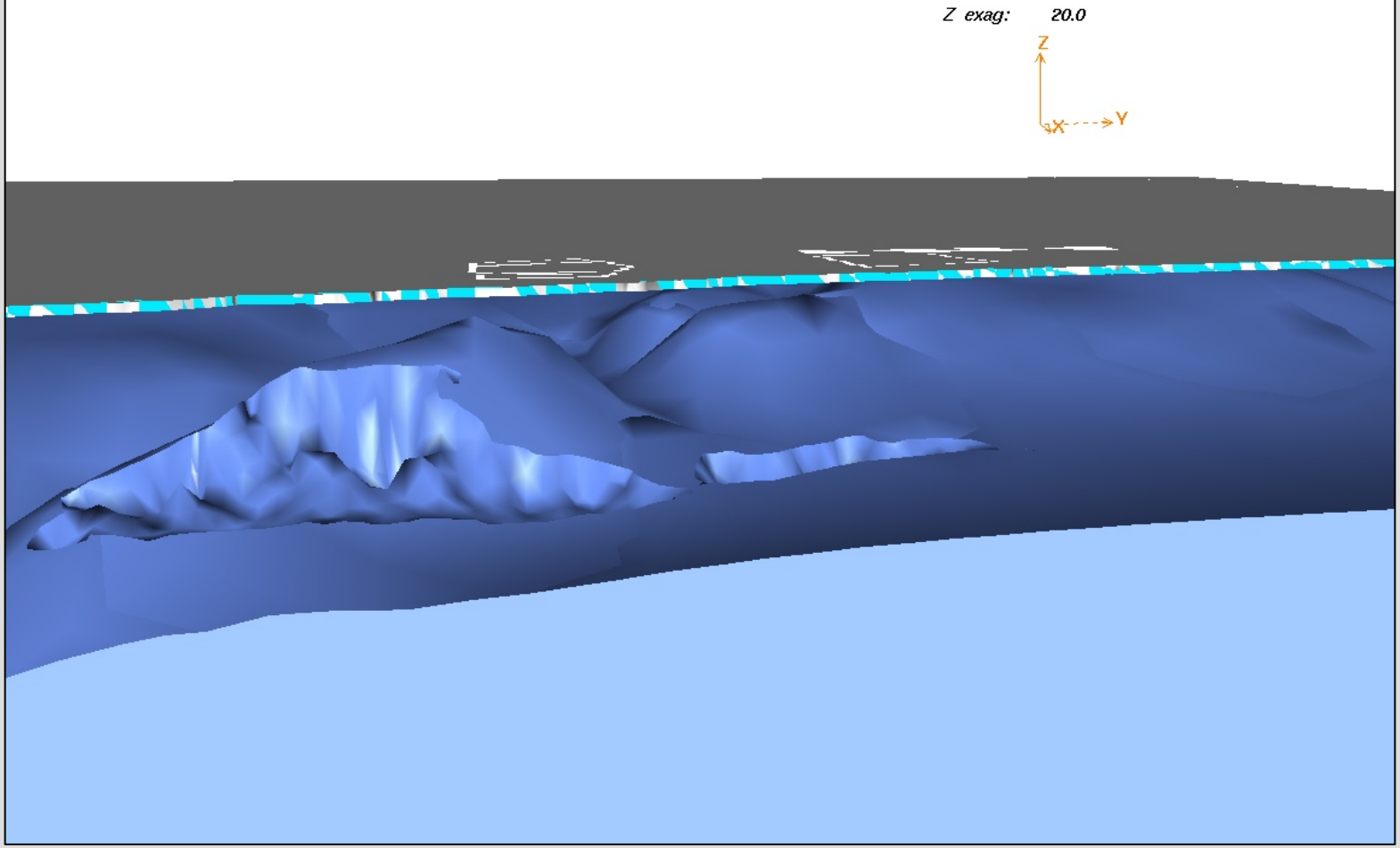
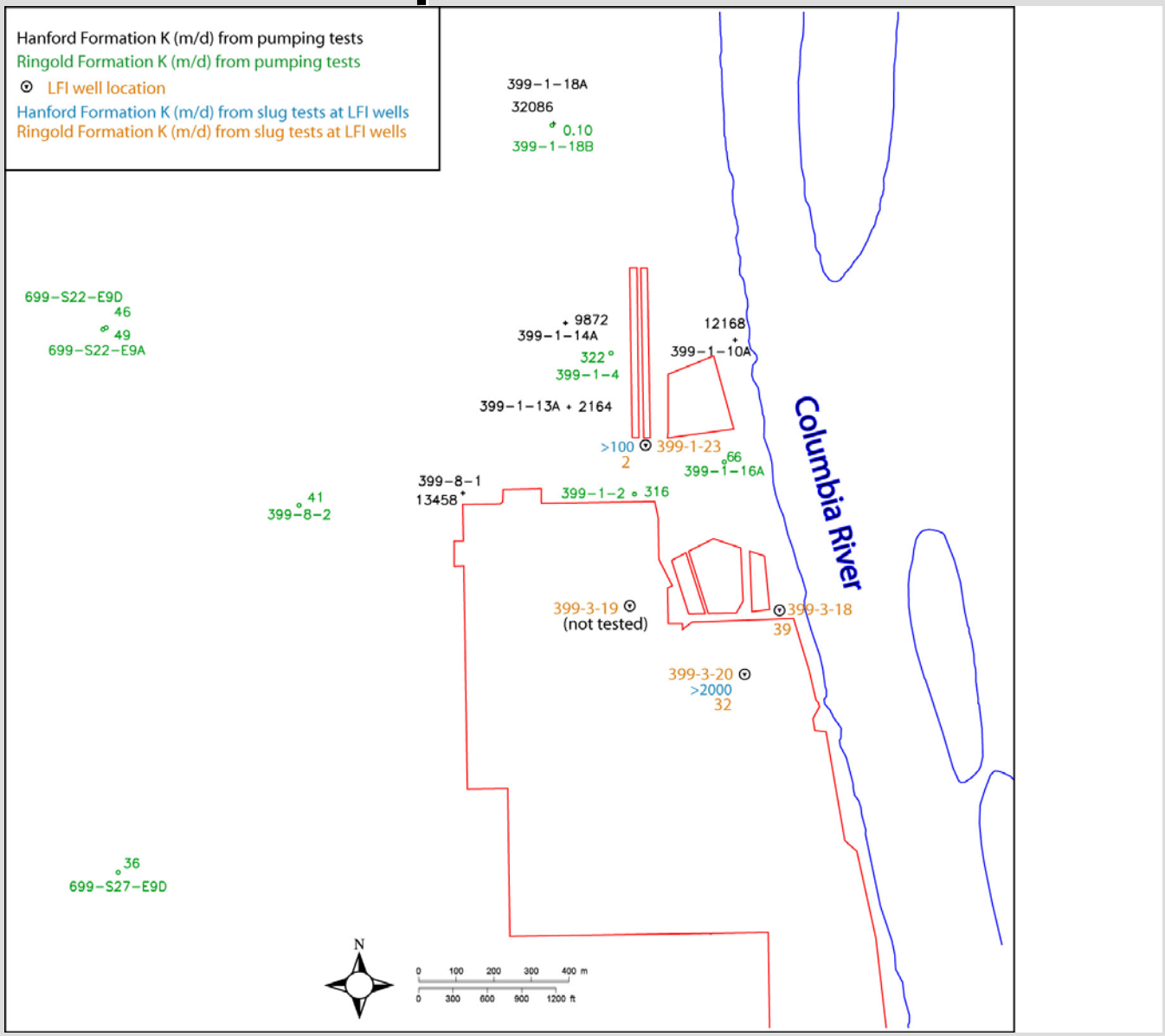
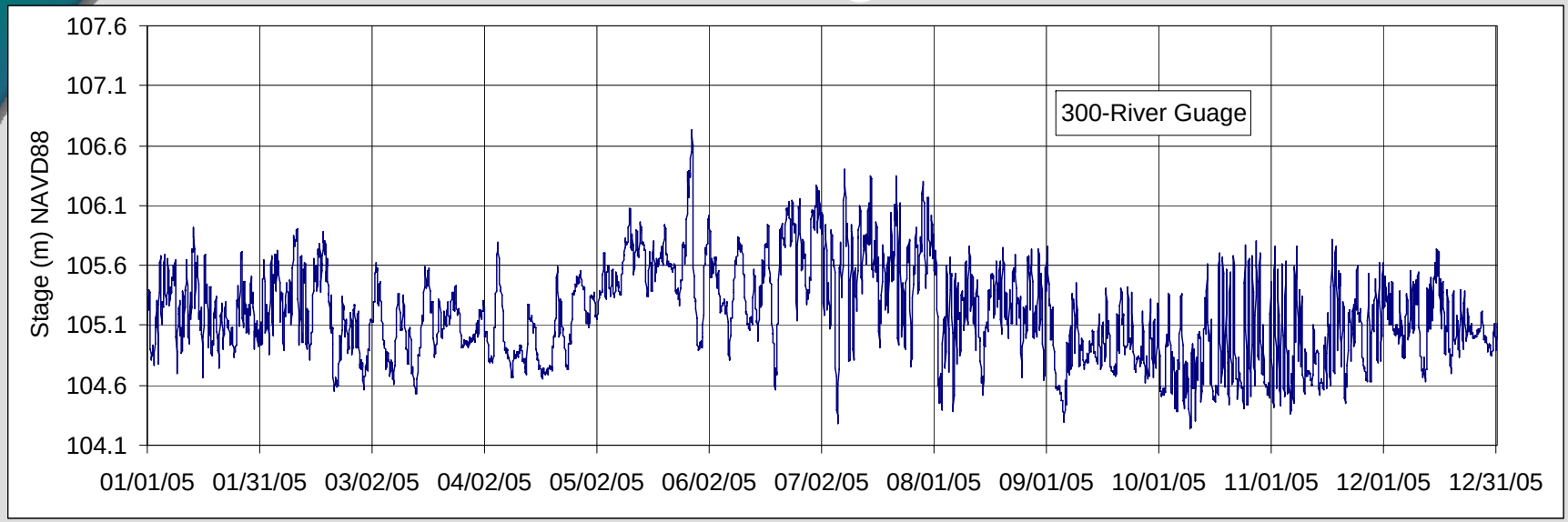
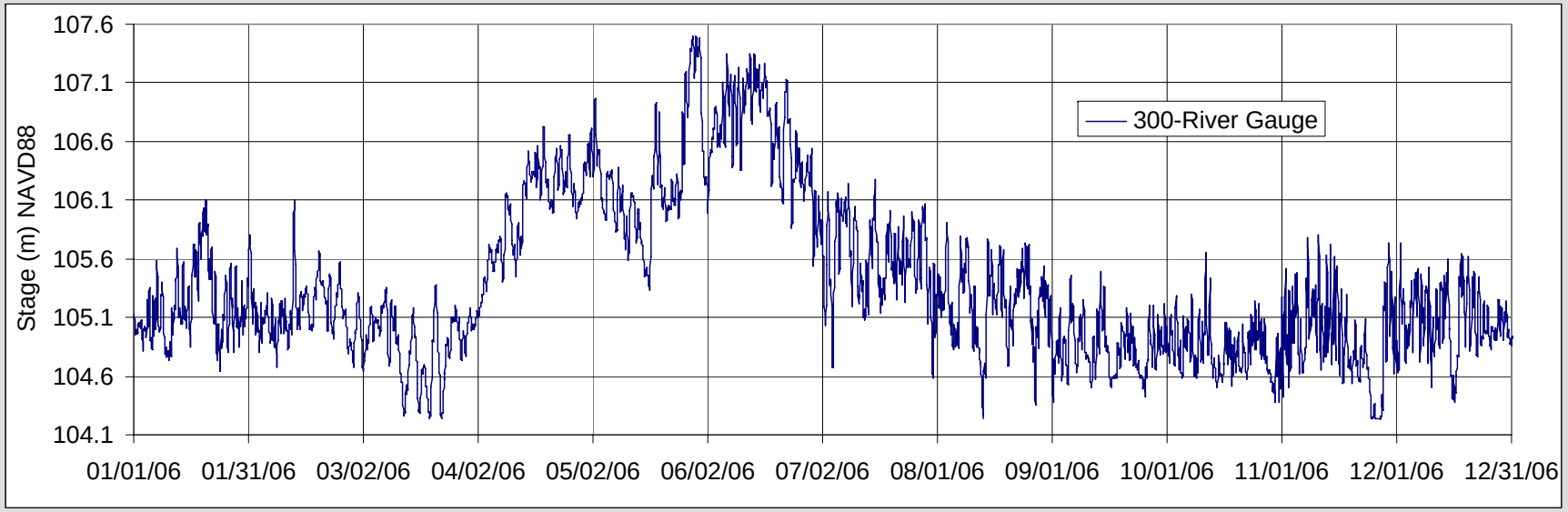


Previous Aquifer Test Results



300 Area River Stage: 2005 and 2006

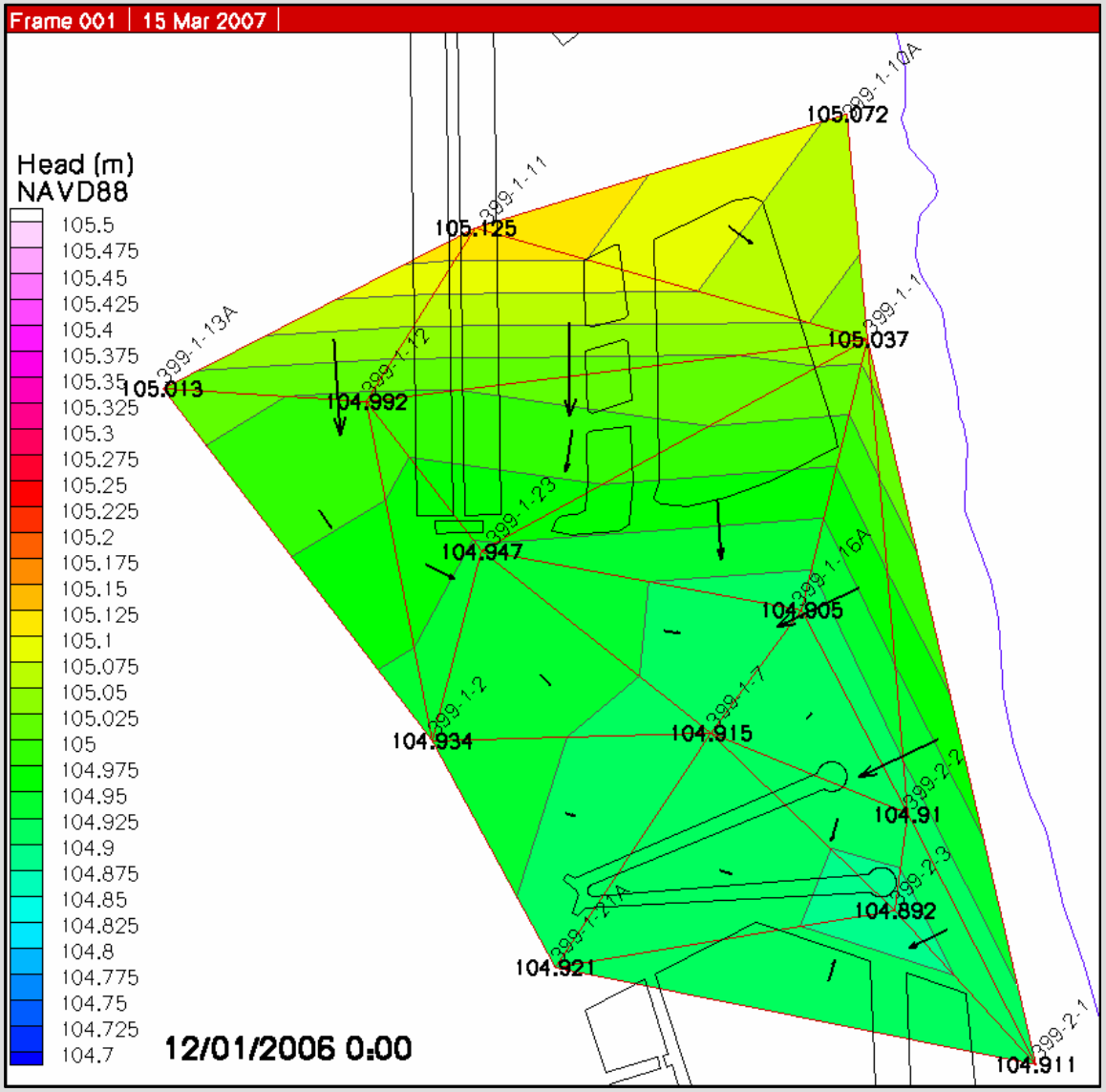




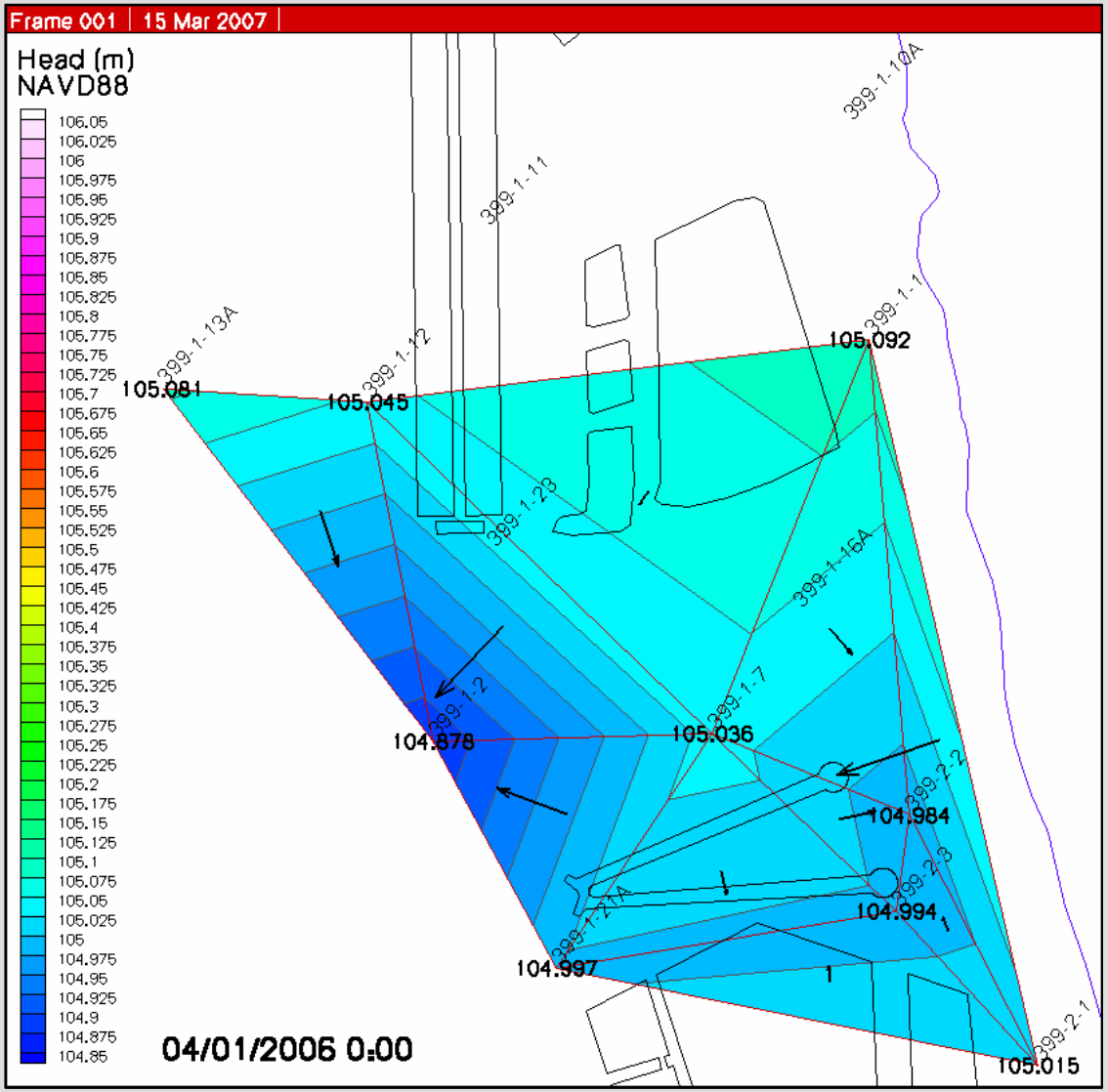
Water Level Network 2004+

- Automated Water Level Monitoring network established in 2004 by the S&T program
  - 9 wells initially
  - 2 wells added in FY06 (July)
  - 2 more wells added in FY07 (October)
  - EC/Temperature also monitored in 6 wells since 2004
- Low hydraulic gradients in area – need better accuracy (< 1cm)
  - Wells resurveyed in Feb 2007
  - Checking / Revising pressure transducer calibrations
  - Cross comparison with two pressure transducers in same well (399-1-23 and 399-1-7)

Hydraulic Gradients from WL Network Low River Period (December 2006)



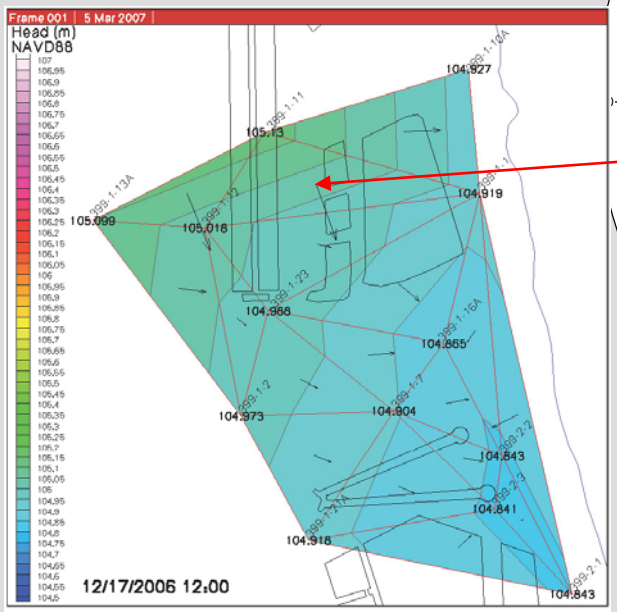
Hydraulic Gradients from WL Network Increasing River Stage Period (April 2006)

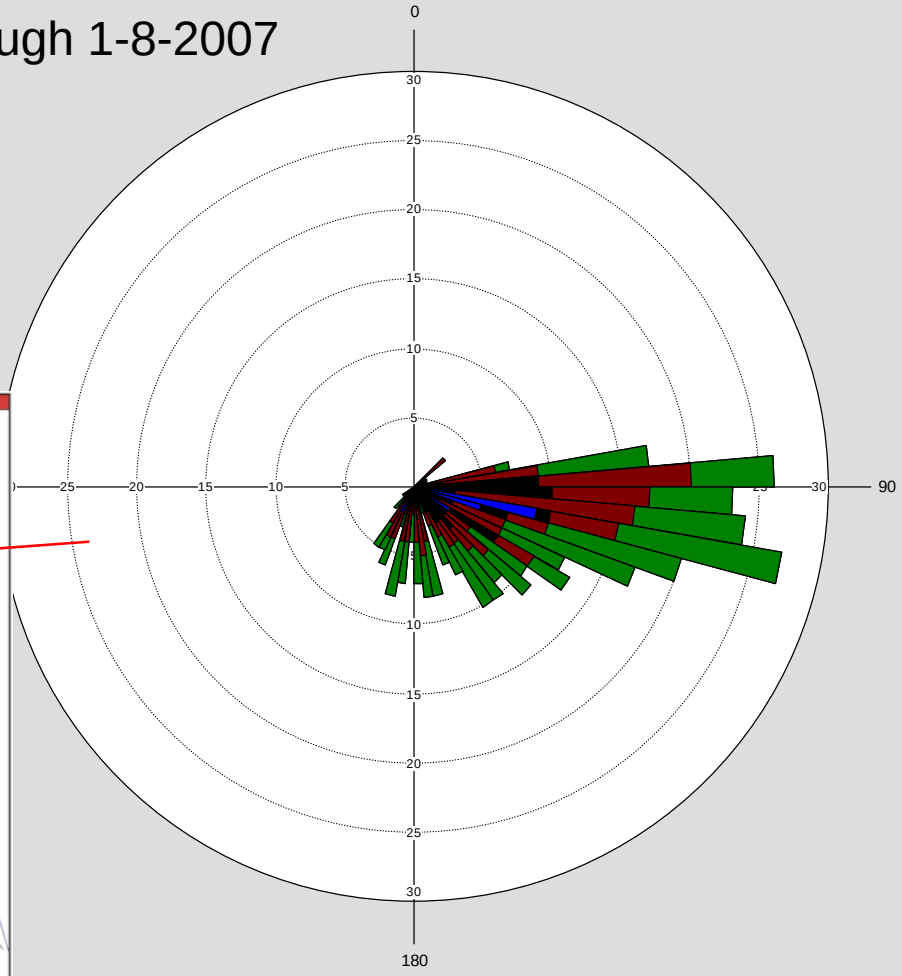


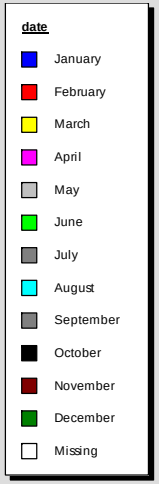
Hydraulic Gradient Directions
Well Cluster Rose Diagrams

Partial Year:
Data from 10-19-2006 through 1-8-2007
(Bearing is direction of flow “to”)

1-1,1-11,1-10a







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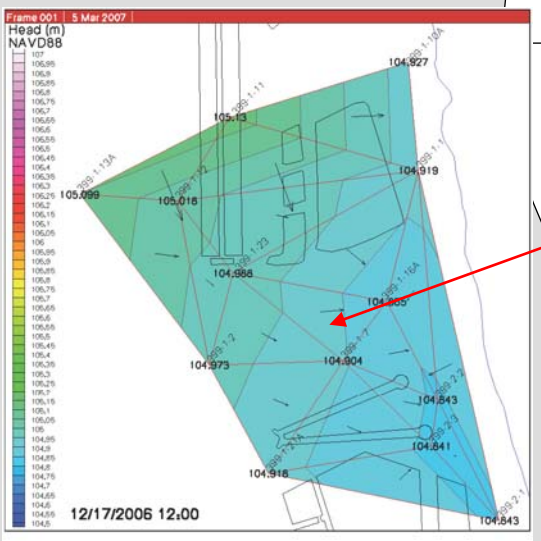
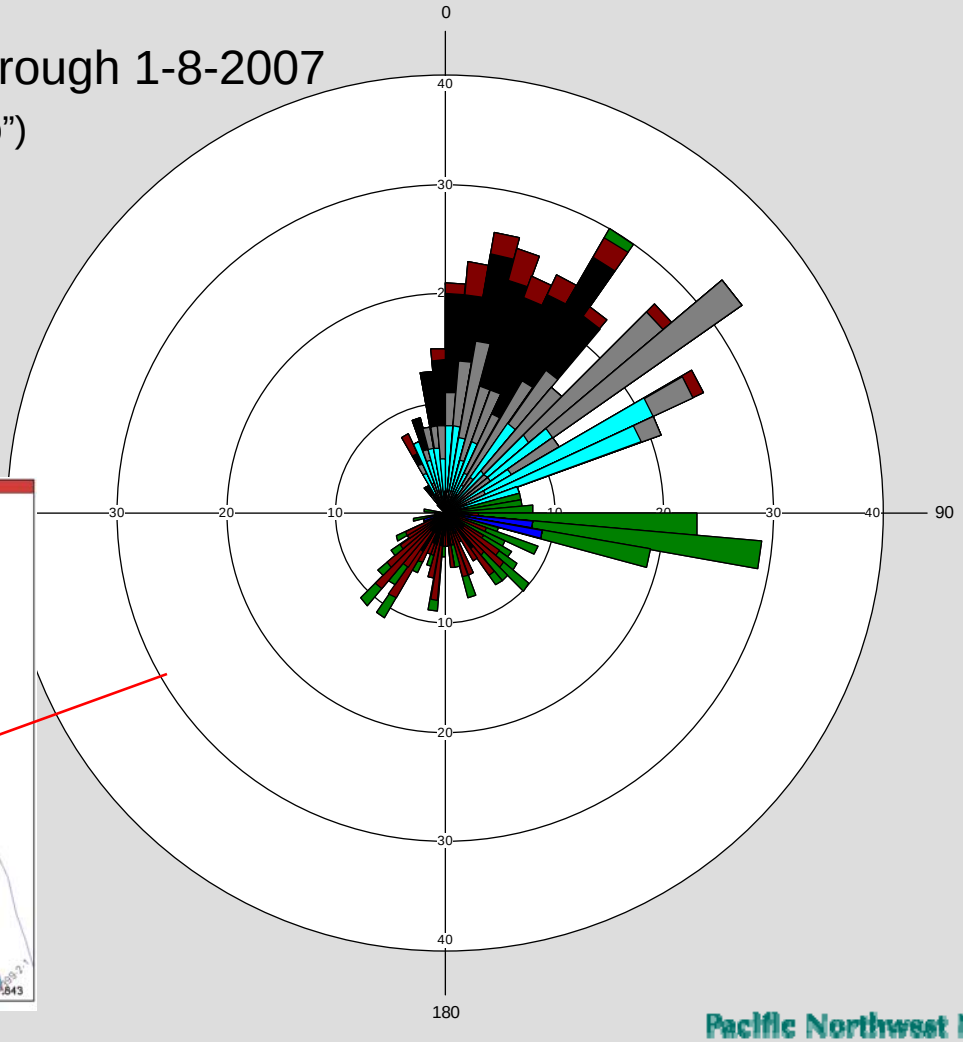
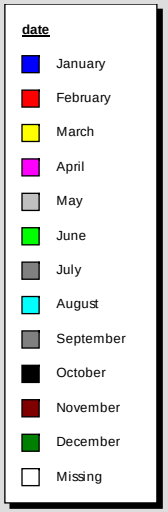
Hydraulic Gradient Directions
Well Cluster Rose Diagrams

1-16a,1-7,1-23

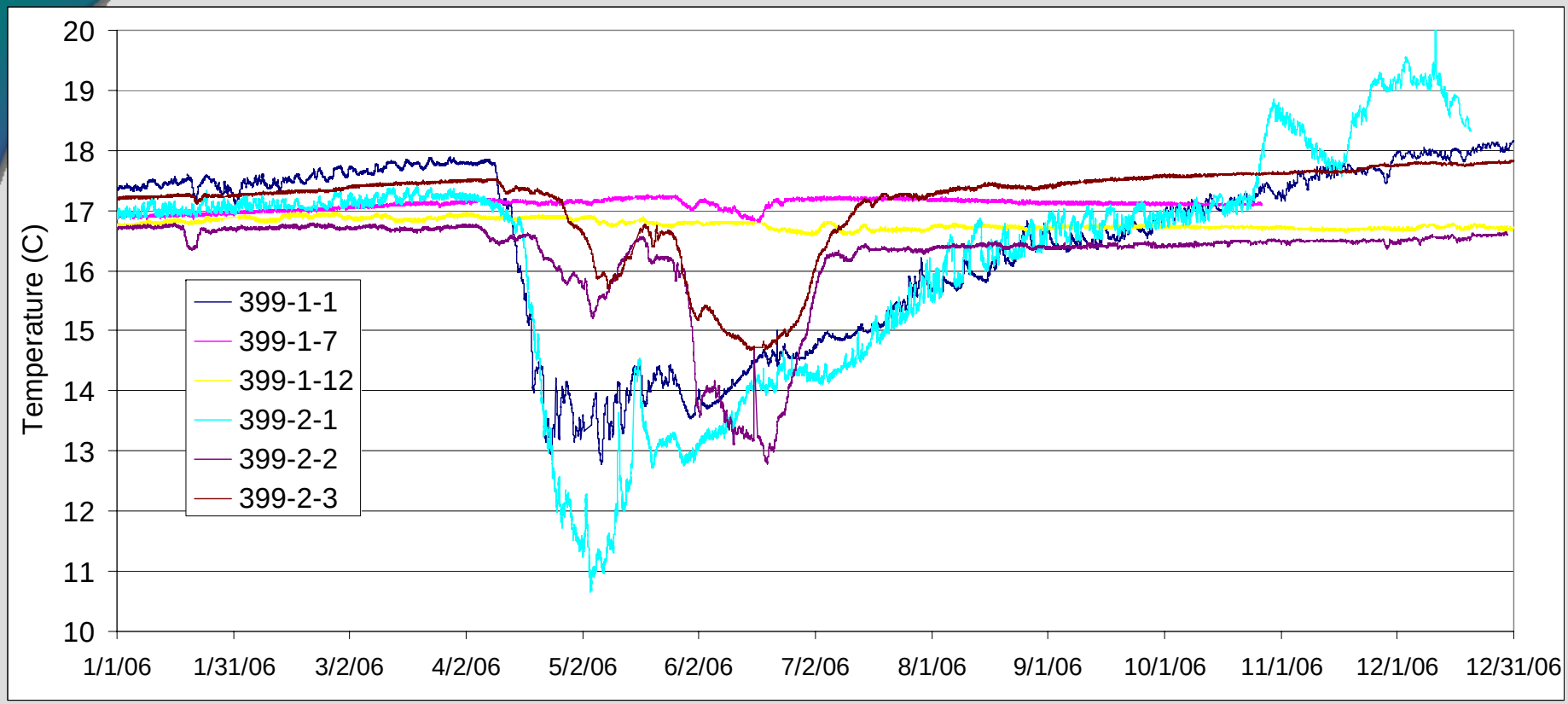
Partial Year:
Data from 7-20-2006 through 1-8-2007
(Bearing is direction of flow “to”)







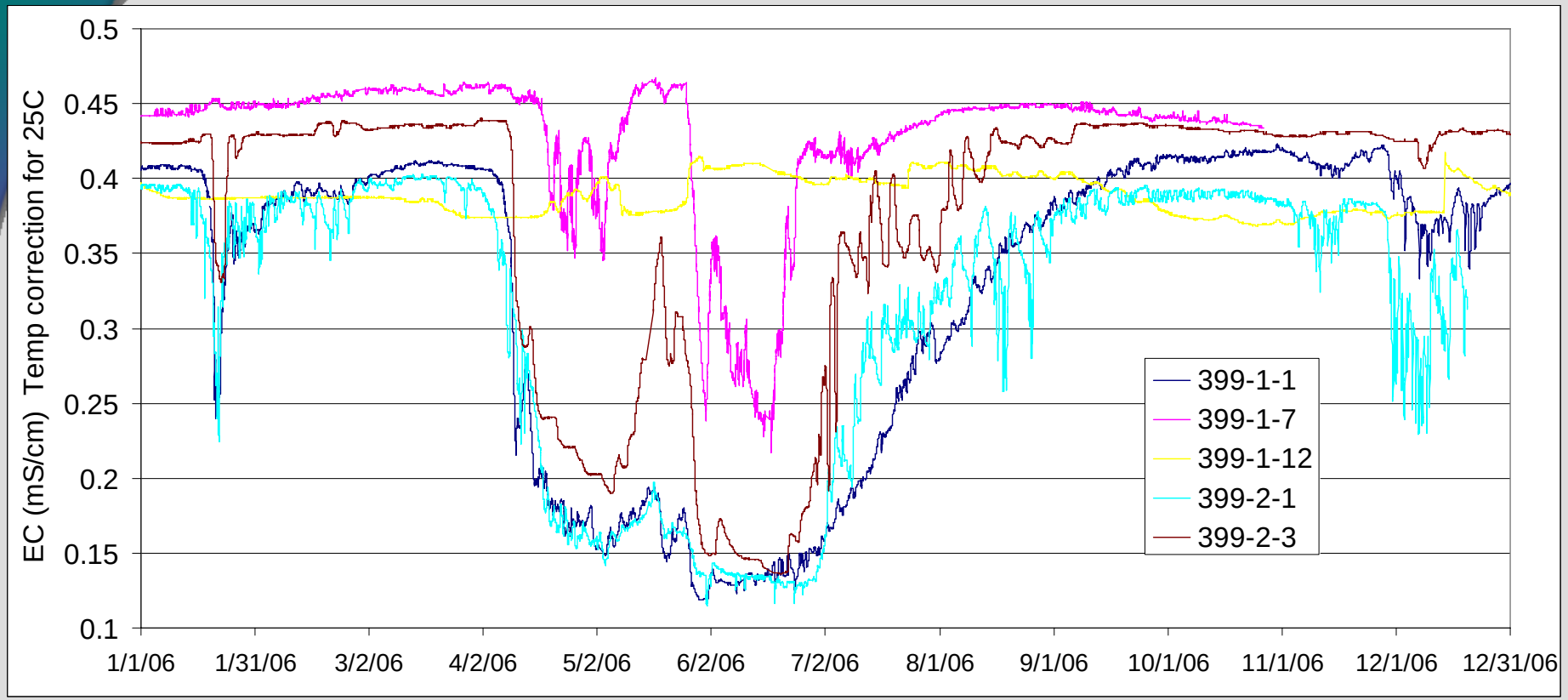
Groundwater/River Water Mixing Zone: Temperature Data



Distance to River:

399-1-1	49.6 m (163 ft)
399-1-7	188 m (617 ft)
399-1-12	363 m (1,190 ft)
399-2-1	46.9 m (154 ft)
399-2-2	77.9 m (256 ft)
399-2-3	105 m (345 ft)

Groundwater/River Water Mixing Zone: EC Data



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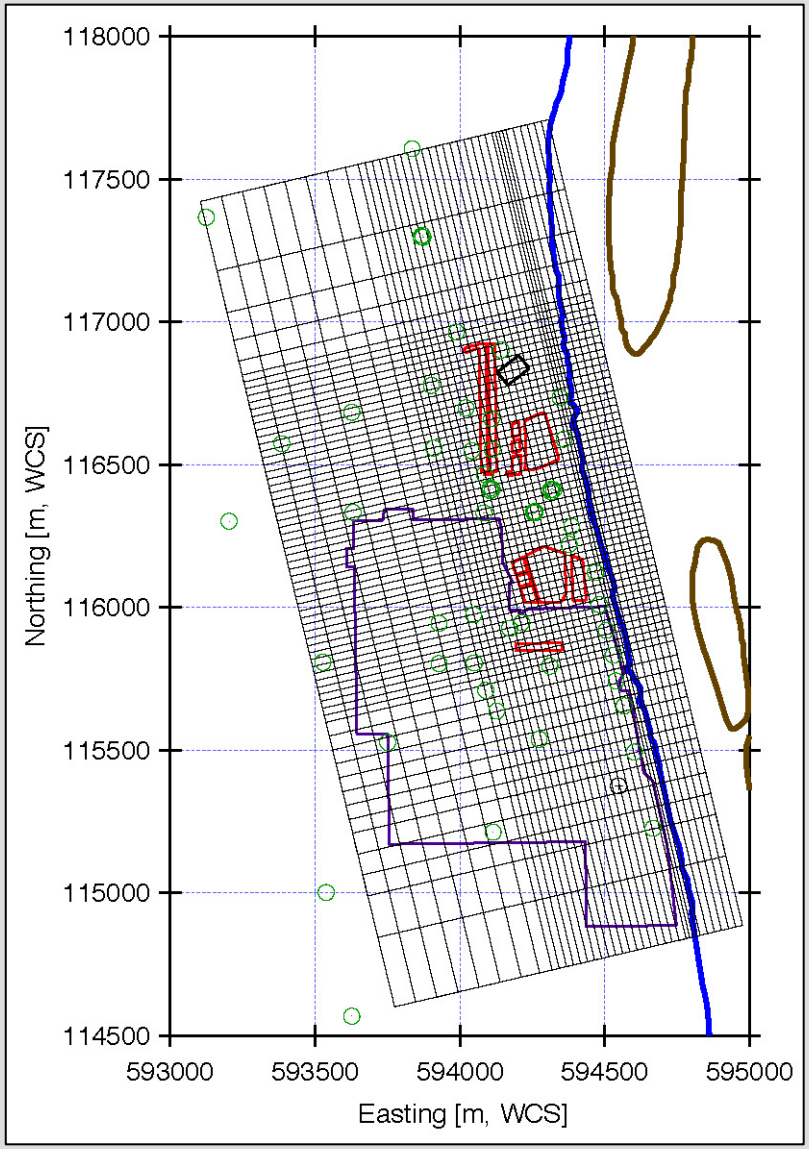
Three Dimensional Flow Model Objectives

- Develop overall hydrogeologic setting
- Parameter estimation (e.g. hydraulic conductivities) using water level data from network collected in the early-mid 1990's
- Groundwater flow directions / magnitudes
- Groundwater flux estimates to river
- Adaptive framework for multi-scale modeling to support remedial investigations
  - Use for more detailed reactive transport simulations

300-FF-5 Flow Model STOMP Grid

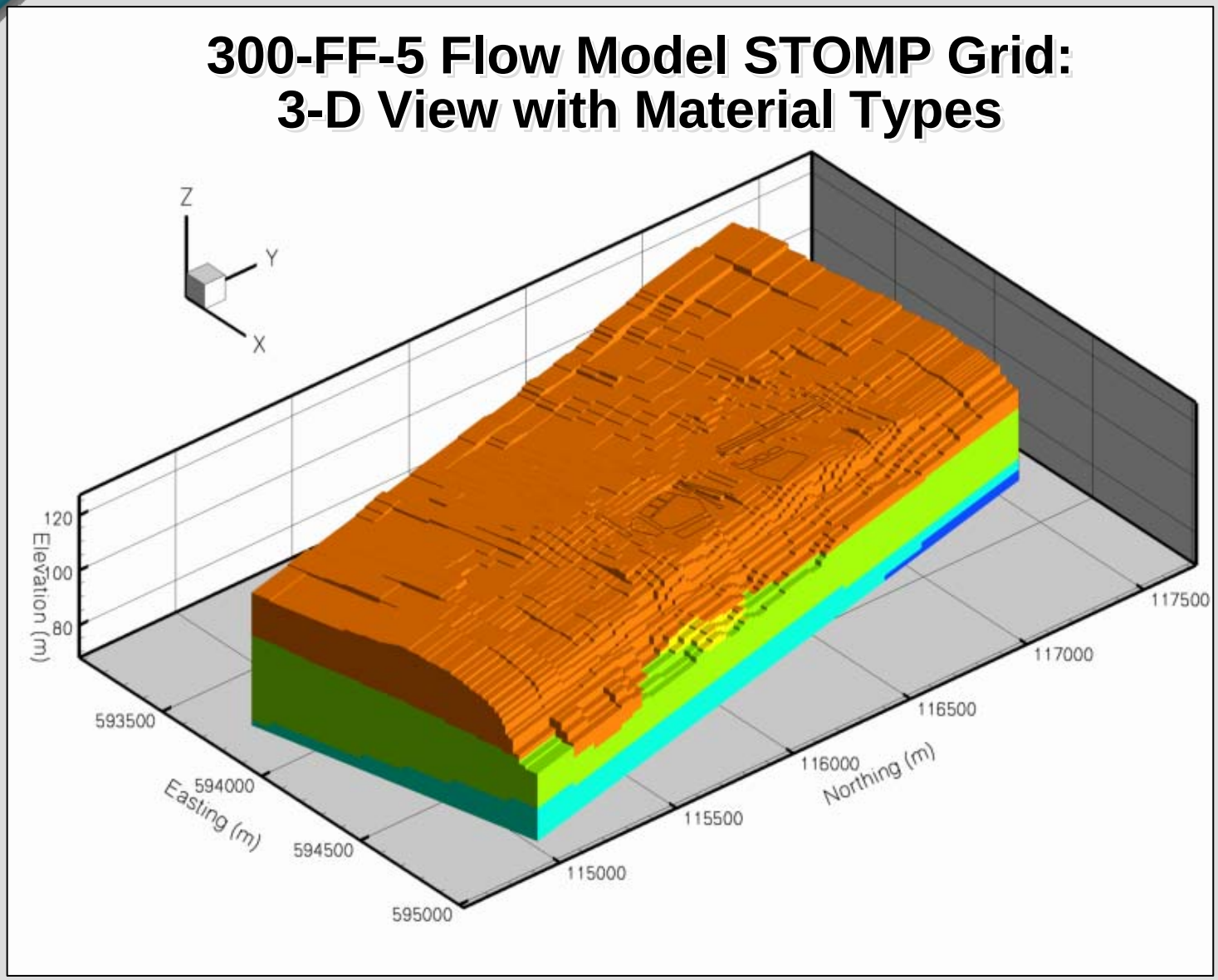


- Aquifer model
  - 37 x 68 x 34 (85,544 total) grid blocks
  - Horizontal extent: 1,235 x 2,900 m
  - Vertical extent: 38 m
    - 70-108 m elevation range
    - 0.5 m spacing in Hanford fm
- Combined vadose zone and aquifer model
  - 37 x 68 x 68 (171,088 total) grid blocks
  - Horizontal extent: 1,235 x 2,900 m
  - Vertical extent: 55 m
    - 70-125 m elevation range
    - 0.5 m vertical spacing in Hanford fm

Boundary Conditions / Source Terms

- River stage on eastern boundary with a stream gradient
- Water level measurements interpolated from wells along western boundary (~monthly manual measurements during simulation period)
- North and south boundary are No-Flow
- Discharge to trenches for 1992-1993 period
- Withdrawal from well 399-4-12
- Uniform natural recharge applied to surface

300-FF-5 Flow Model STOMP Grid: 3-D View with Material Types



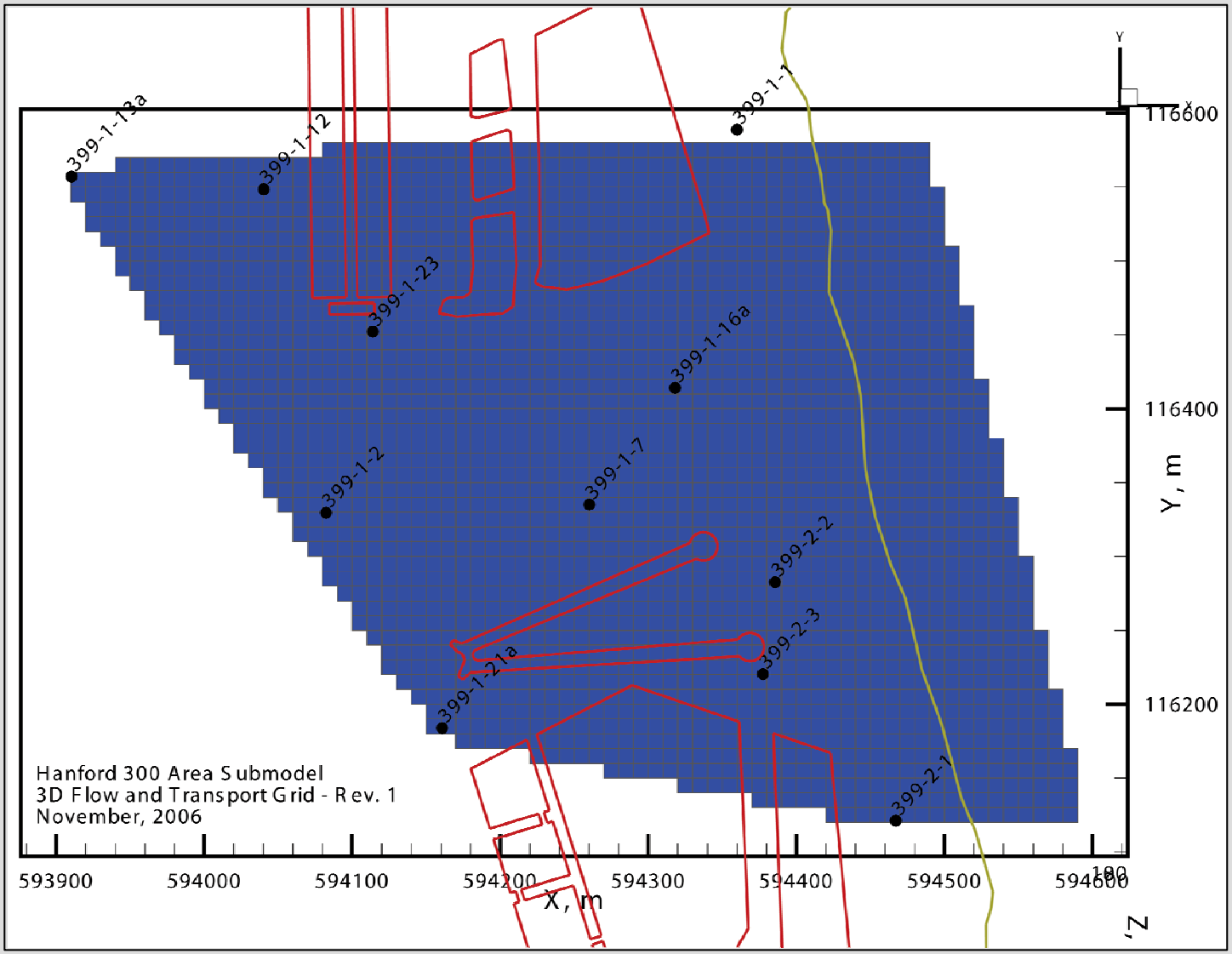
Groundwater Flow Model - Status

- Currently rebuilding model with updated geology
  - posters of FY06 results if interested
- Learned in FY06
  - Near-river wells significantly damped compared to river
    - River alluvium
    - Ringold near shoreline
    - Lower K Hanford near shoreline

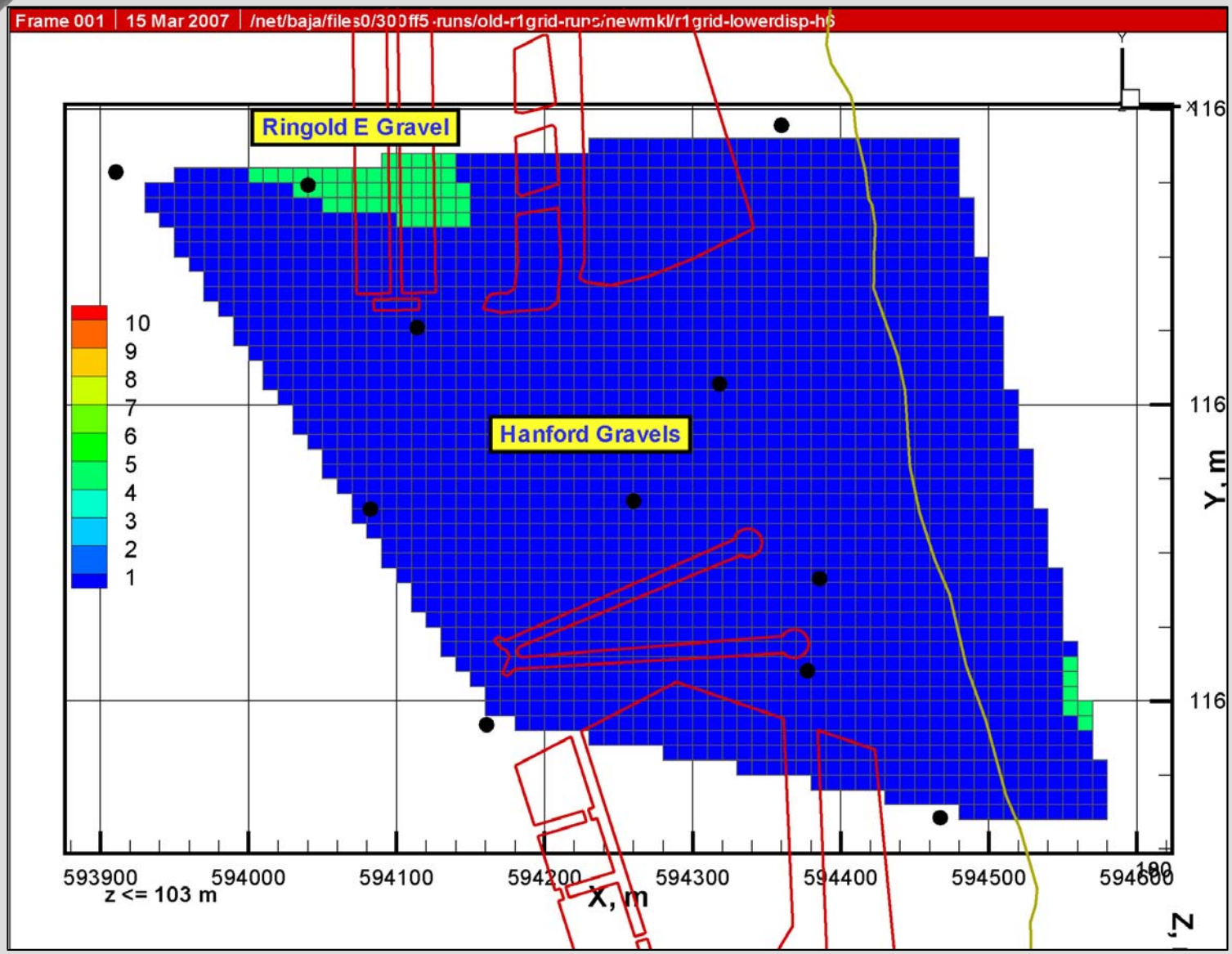
Preliminary 300 Area
Three Dimensional Flow and Transport Model

- STOMP Code – Mode 1 (water)
  - White M.D. and M. Oostrom. 2006. STOMP Subsurface Transport Over Multiple Phases: Version 4.0 User's Guide. PNNL-15782. Pacific Northwest National Laboratory, Richland, WA.
  - http://stomp.pnl.gov/
- Finite Difference Grid: X,Y,Z nodes = 69 x 47 x 35
  - 70,976 active nodes (113,505 total)
  - 10 m xy grid spacing
  - Vertical grid spacing from 2 m to 0.5 m
- Dirichlet Head boundaries defined by hourly water level data from network established in 2004 by the S&T program
  - Head values interpolated between wells along boundaries
  - River stage used for river bottom – hourly data from 300-Area Columbia River stage recorder (from Virtual Library)
- Tracer Pulses introduced at southern end of North Process Trenches
- River tracer used to look at groundwater / river water mixing zone (can constrain hydraulic properties)

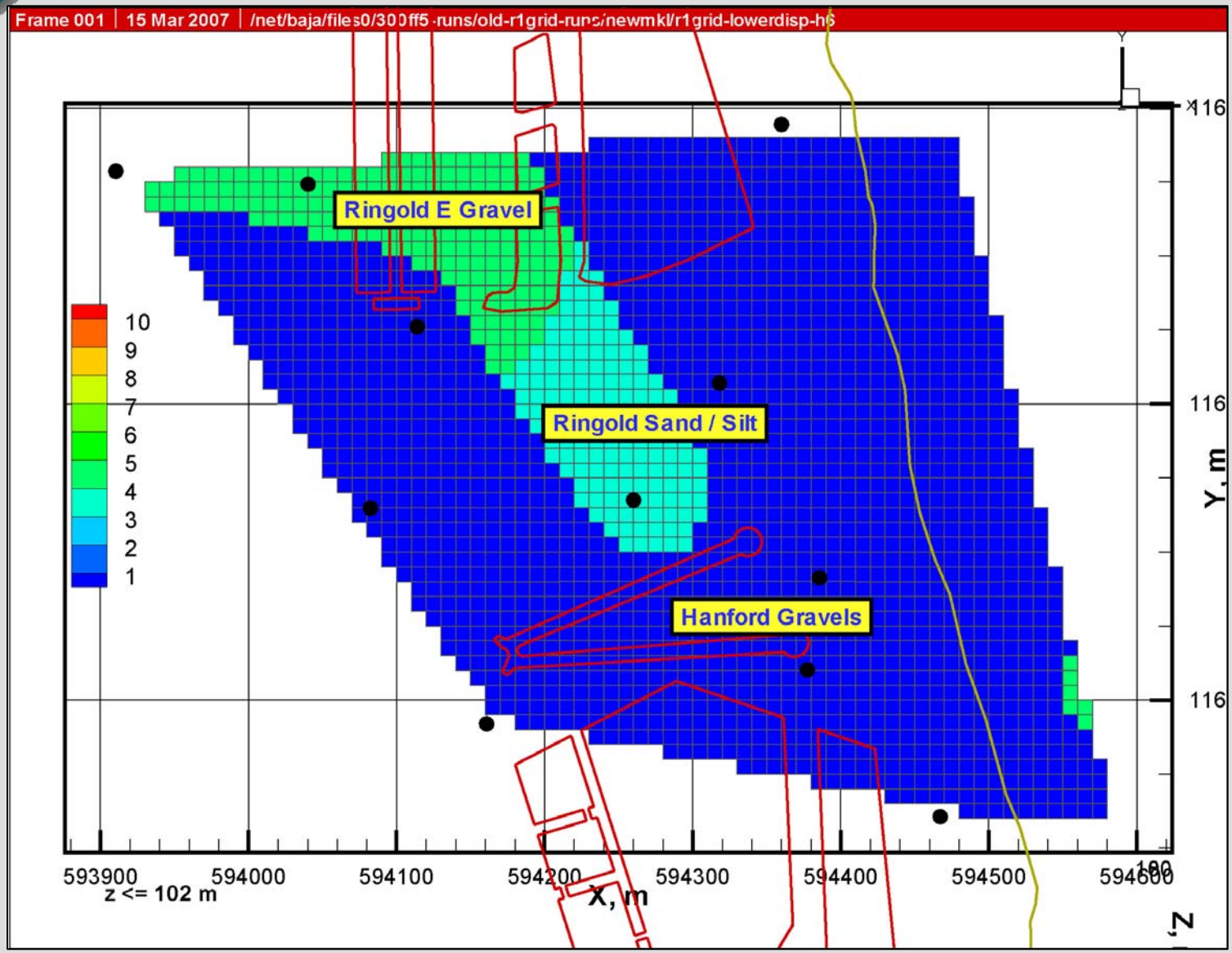
Preliminary Three-Dimensional Transport Studies
10m Grid and Well Locations for Hourly Water Levels



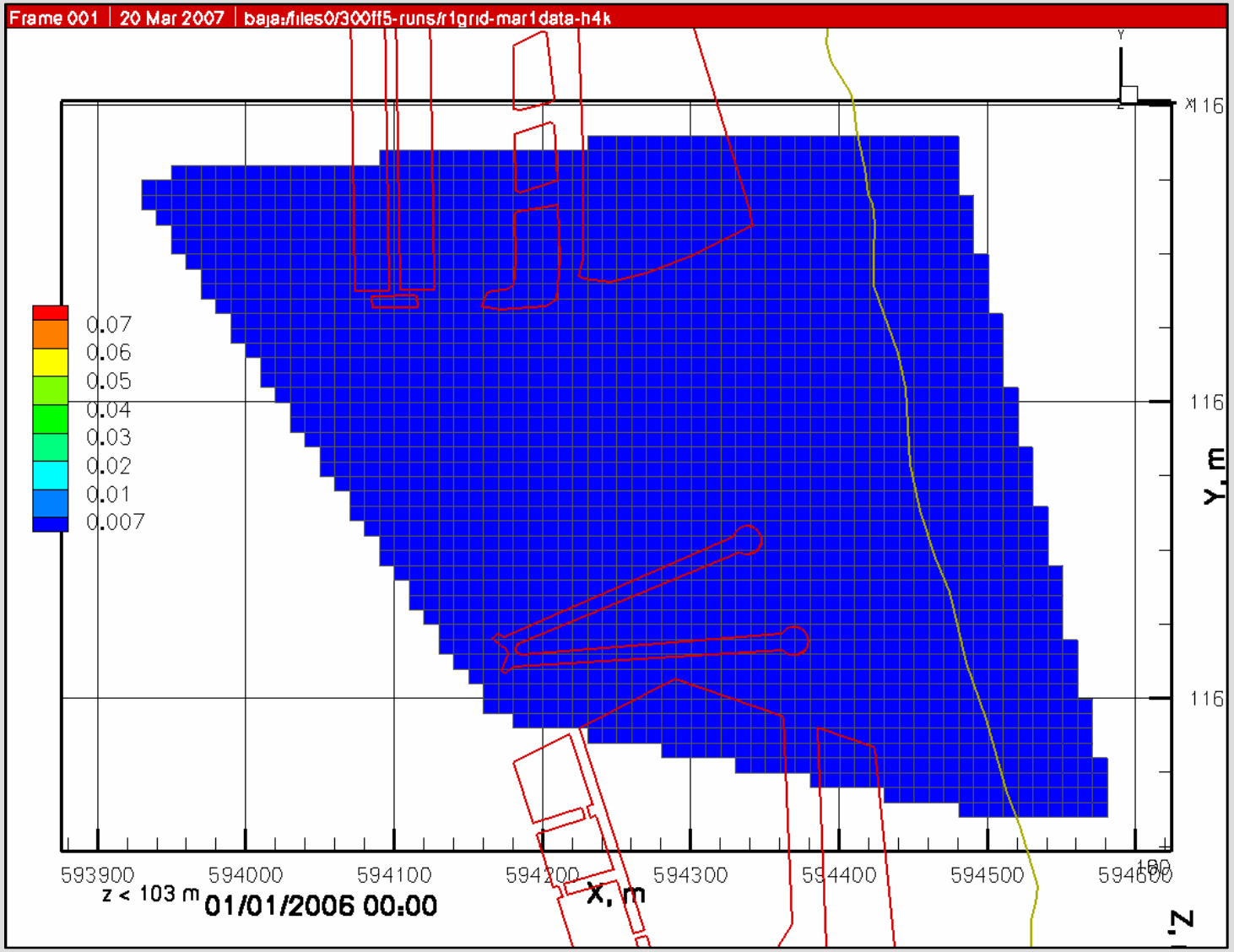
Hydrostratigraphic Units at Z=103 m



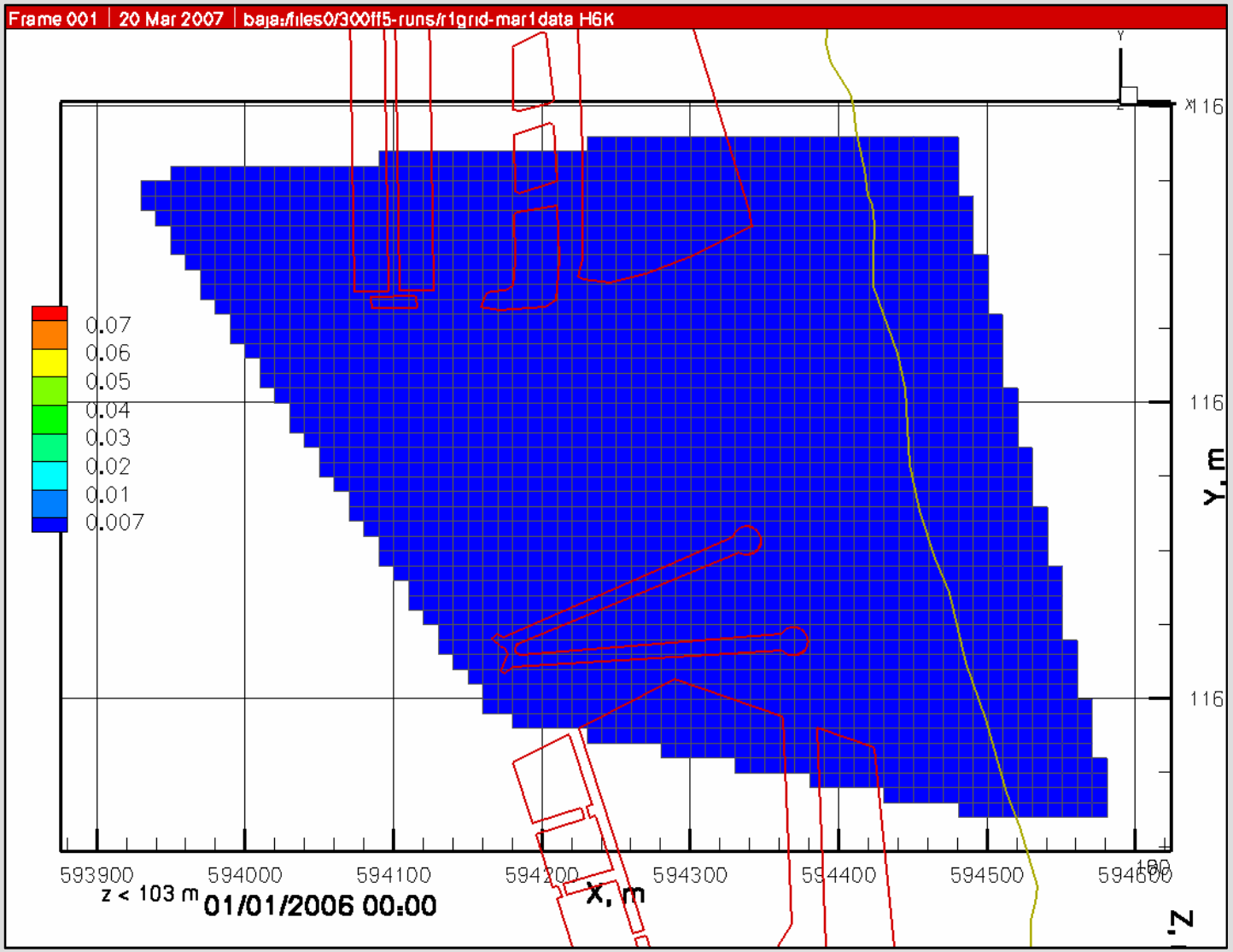
Hydrostratigraphic Units at Z=102 m



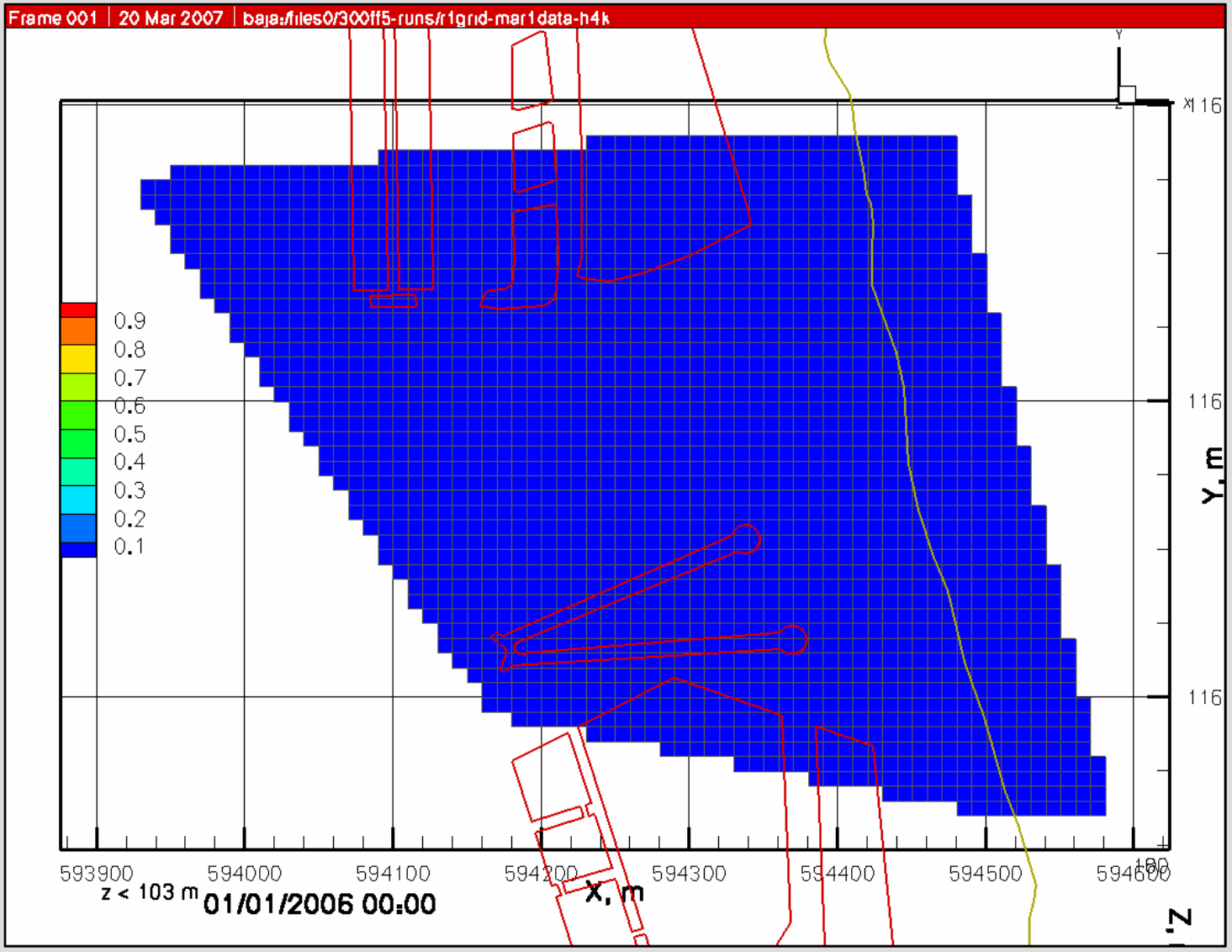
Preliminary Three-Dimensional Transport Studies
Drift from South Trench Area: Hanford K=4,000 m/d case



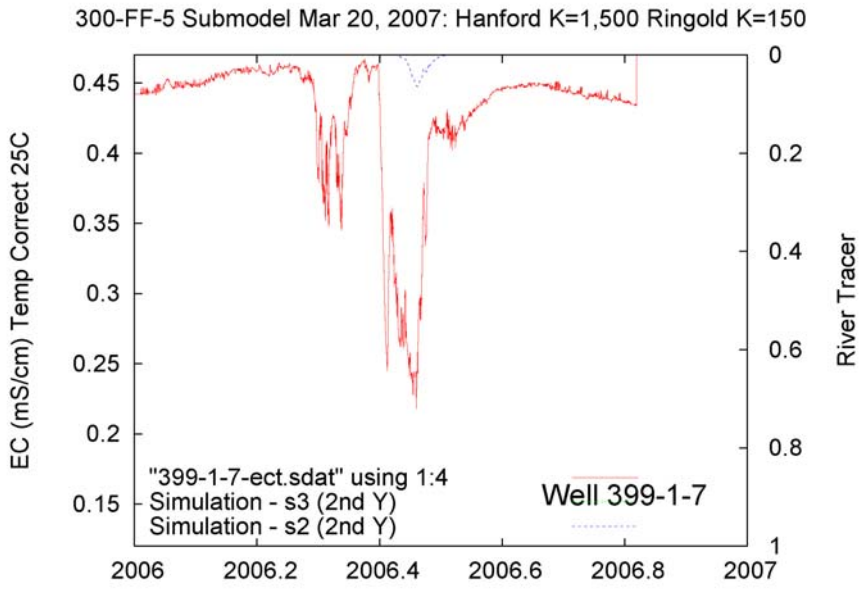
Preliminary Three-Dimensional Transport Studies
Drift from South Trench Area: Hanford K=6,000 m/d case

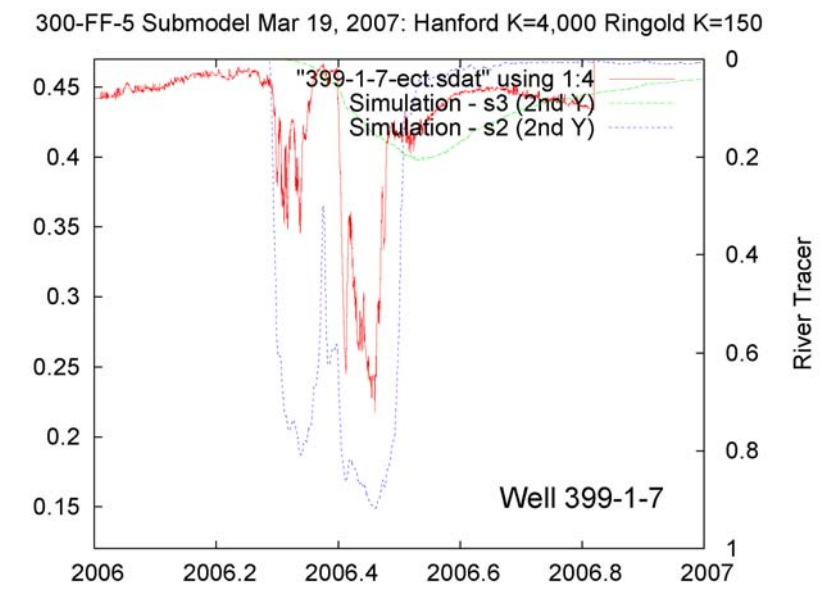


Preliminary Three-Dimensional Transport Studies
River Water Tracer/Mixing: Hanford K=4,000 m/d case



Preliminary Three-Dimensional Transport Studies
Example: Comparison of simulation results with EC data





Hanford K=1,500 m/d case

Hanford K=4,000 m/d case

Ongoing Work

- Refine flow and transport model around river / shoreline
  - Need finer horizontal and vertical node spacing
  - New bathymetry data
  - Characterization of river alluvium (thickness and hydraulic properties – S&T)
- Implement zonations within Hanford Formation
    - Lower permeability on NE side of domain
- Ringold upper Sand/Silt (Unit 4) delineation (3-D in EarthVision™)
- More refined transport models being developed for EM-22 300 Area Polyphosphate Treatability Test
- Restart large-scale flow model simulations
  - Updated hydrostratigraphy
  - Hanford zonations
  - Bathymetry
  - River alluvium
- Working to expand hourly water level monitoring network toward south