Hydrology and Current Status of the 300 Area Uranium Plume

R. E. Peterson and J. W. Lindberg

Pacific Northwest National Laboratory

K. Mike Thompson

U.S. Department of Energy

"Conceptual Model Development and Reactive Transport Modeling for the 300 Area Uranium Plume"

May 10-11, 2004, Richland, Washington

PRESENTATION OUTLINE:

I. Brief introduction to the Hanford Site

II. Hydrogeology of the 300 Area

III. Uncertainties associated with conceptual model for the uranium plume

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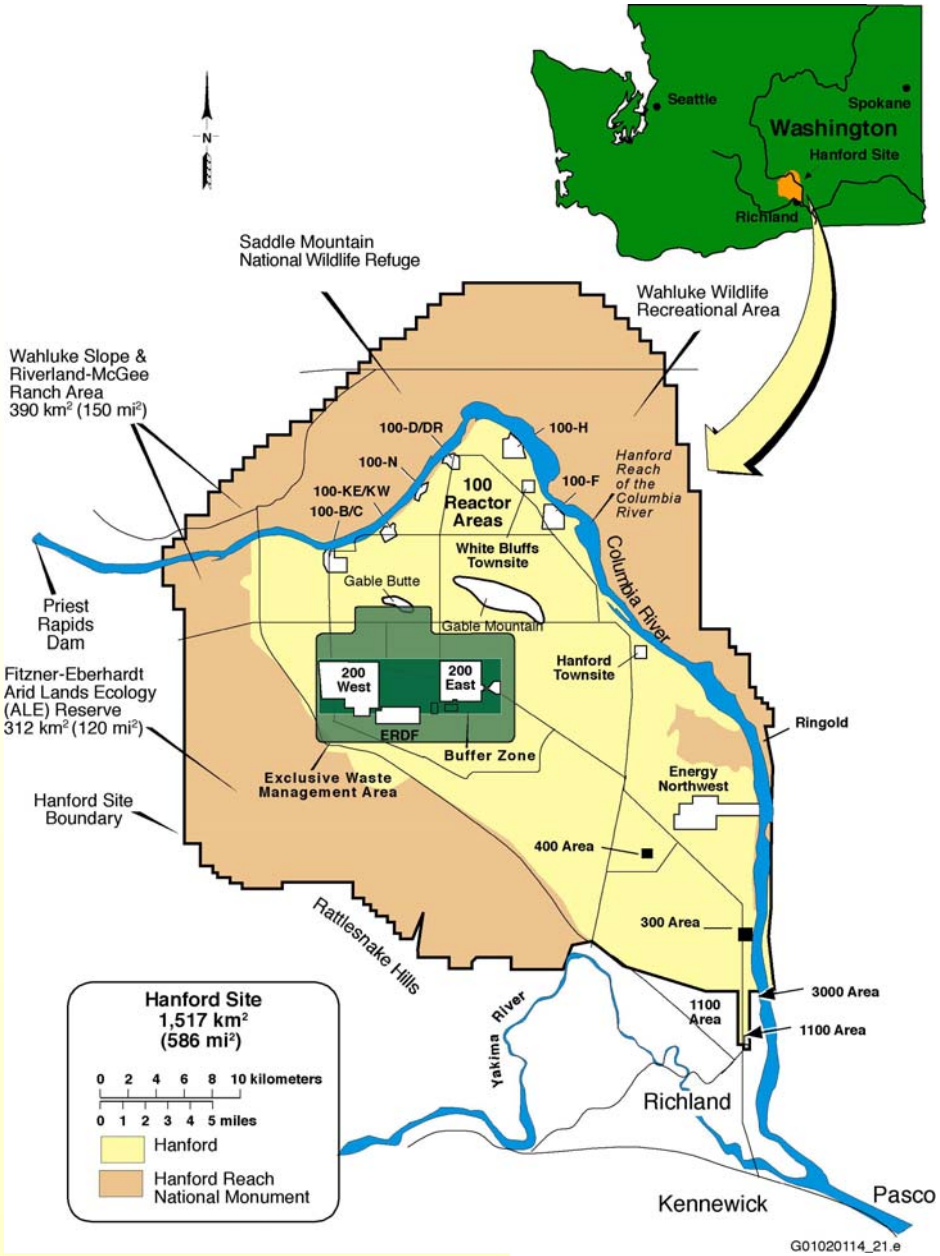

- **Established in 1943 to produce plutonium for nuclear weapons.**
- **Major buildup during the Cold War Years, late ’40s thru mid ’60’s.**
- **The cycle: Fabricate fuel (300 Area), irradiate fuel (100 Area), and separate strategic radionuclides (200 Areas).**
- **Current DOE mission is to manage legacy wastes and perform environmental cleanup.**

For more information:
“Hanford: A Conversation about Nuclear Waste and Cleanup,” by Roy E. Gephart, Battelle Press, 2003

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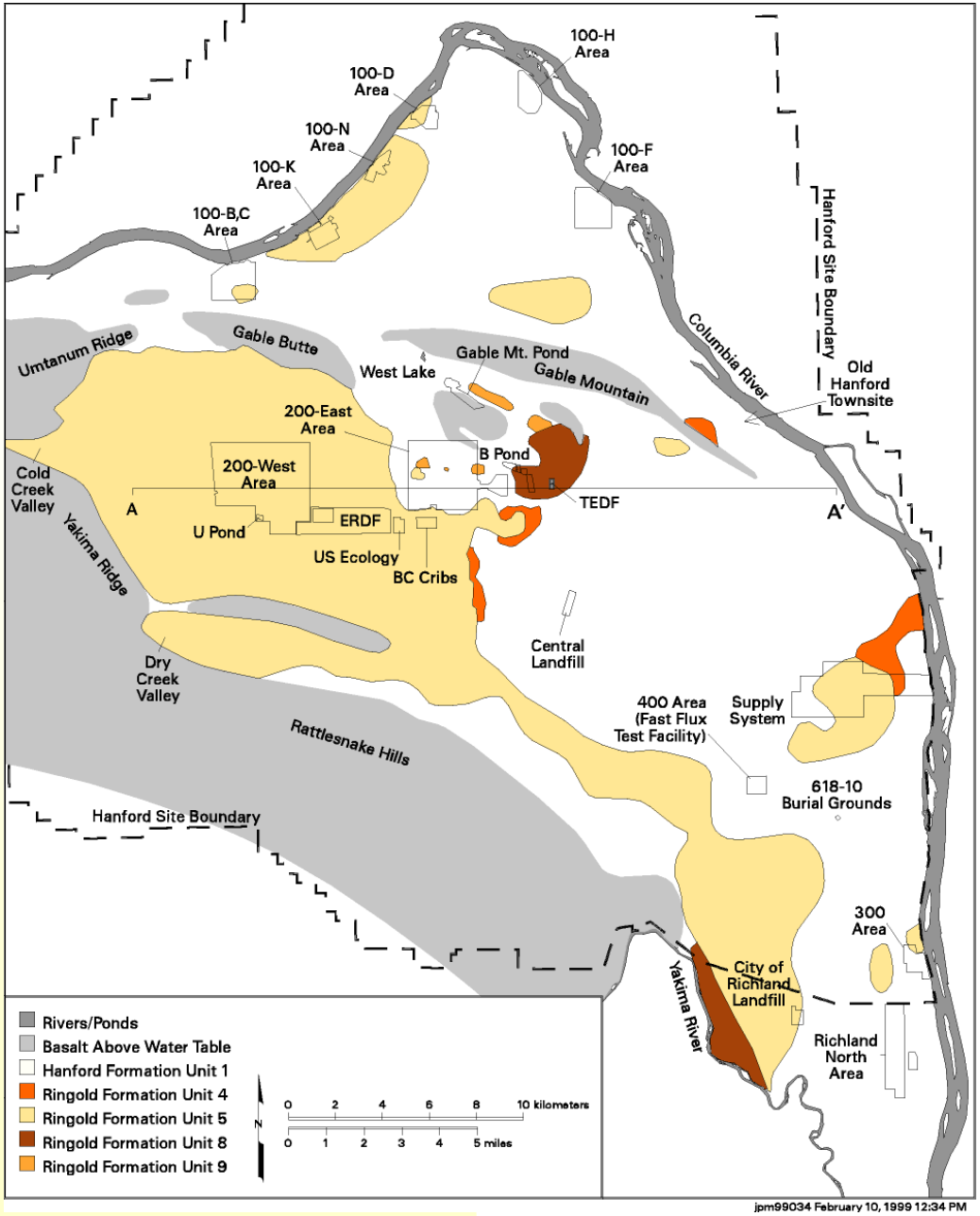

UPPERMOST HYDROLOGIC UNITS

- Situated in a structural basin, surrounded by higher terrain on all sides
- Stratigraphic units at the water table are fluvial in origin; paleochannels and overbank deposits; some basalt
- Unconfined aquifer discharges to the Columbia River, the last free-flowing stretch of the river ("Hanford Reach")

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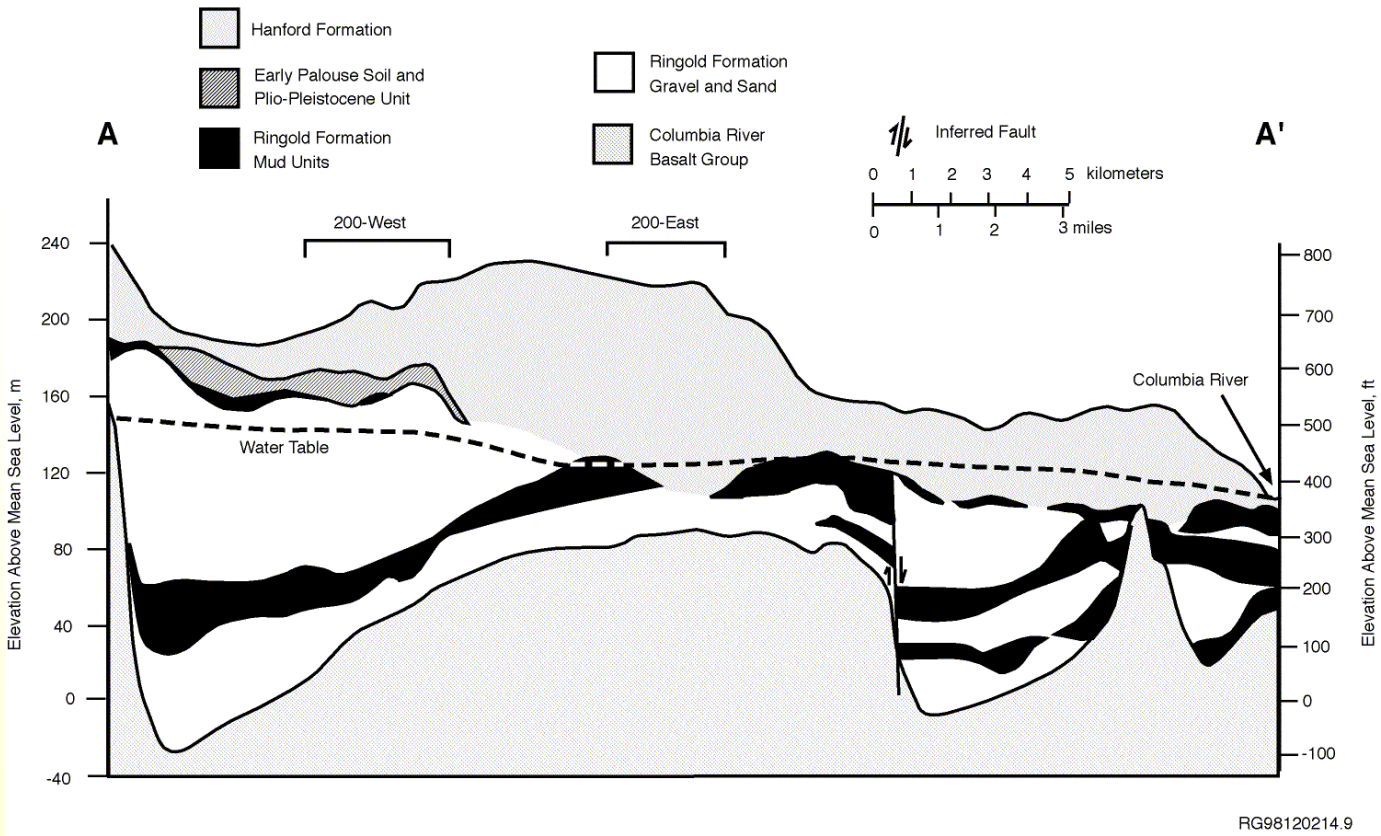

- **Discharge from the Hanford Site aquifer to the Columbia River is probably 100 cfs or less.**
- **River flow typically ranges between 60,000 and 250,000 cfs during a seasonal cycle.**

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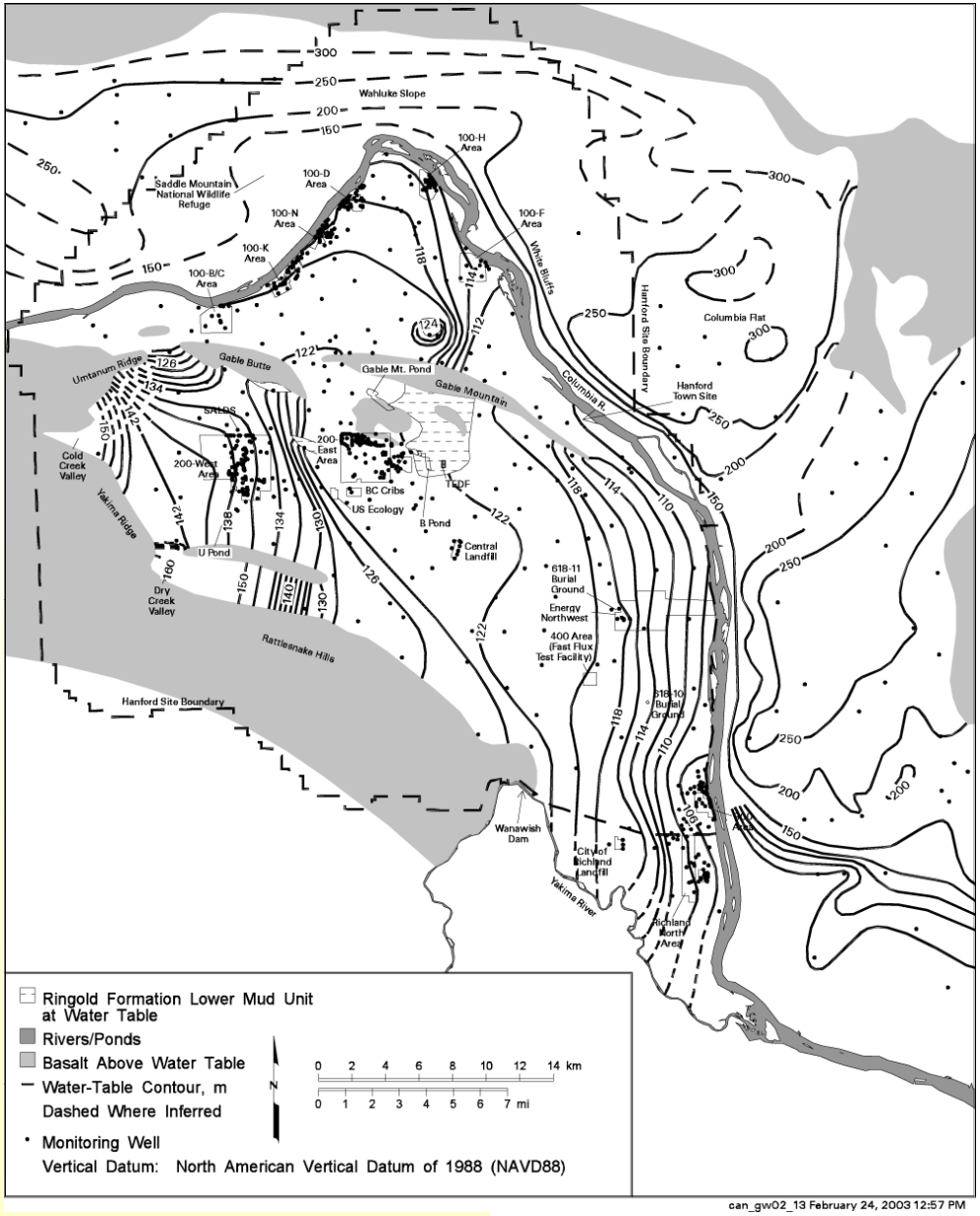

GROUNDWATER FLOW

- **Groundwater flow is generally west-to-east, and toward the river.**
- **Typical rates at the water table are 0.5 to several ft/d, except in the 300 Area where high rates exist, and the 200 West Area where movement is slower.**
- **Approximately 650 wells are involved in the groundwater monitoring project annually.**

Reference:
"Hanford Site Groundwater Monitoring for Fiscal Year 2002" PNNL-14187, March 2003
http://groundwater.pnl.gov

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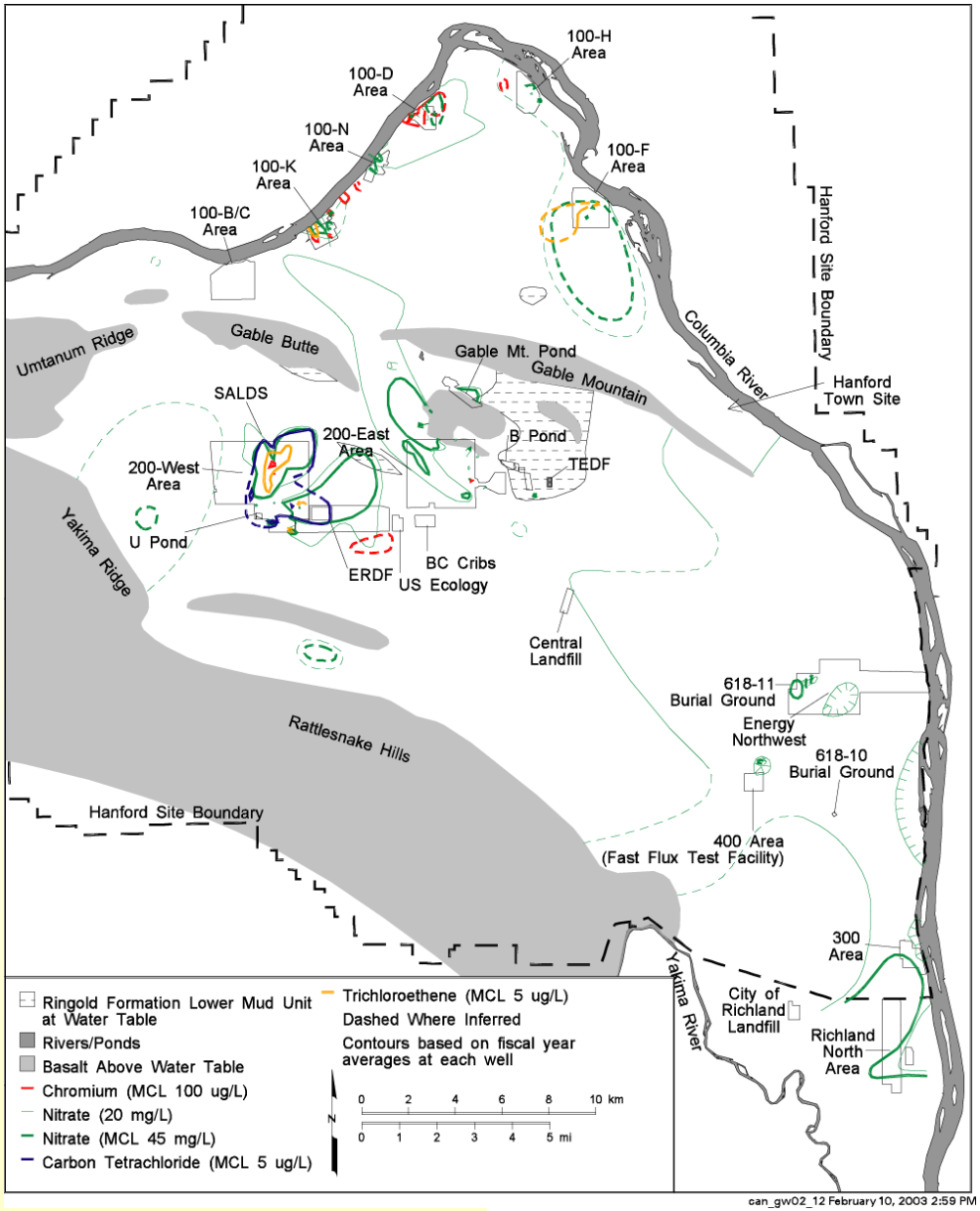

CHEMICAL PLUMES

- **Principal contaminants of concern are chromium, nitrate, carbon tetrachloride, and trichloroethene.**
- **Active pump-and-treatment systems for chromium at the 100-K, 100-D, and 100-H Areas. Also, *in situ* barrier using Redox manipulation.**
- **Active pump-and-treat and vapor extraction systems address carbon tetrachloride in the 200 West Area.**

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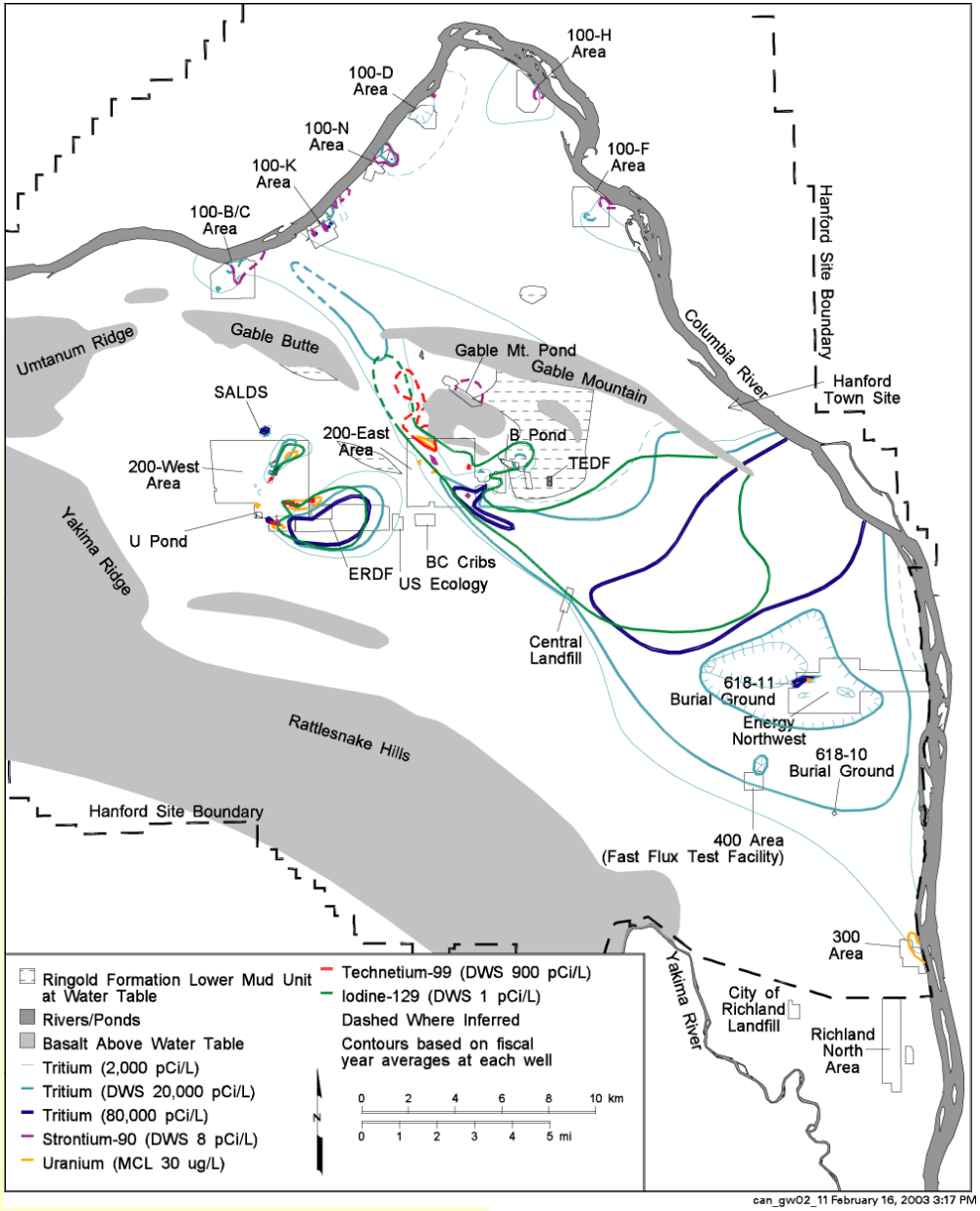

RADIONUCLIDE PLUMES

- **Principal radiological contamination involves tritium, strontium-90, technetium-99, iodine-129, and uranium.**
- **Active remediation using pump-and-treatment systems at:**
  - **100-N Area, strontium-90**
  - **200 West Area, technetium-99 and uranium.**
- **Remaining plumes are being monitored until source removal actions are complete.**

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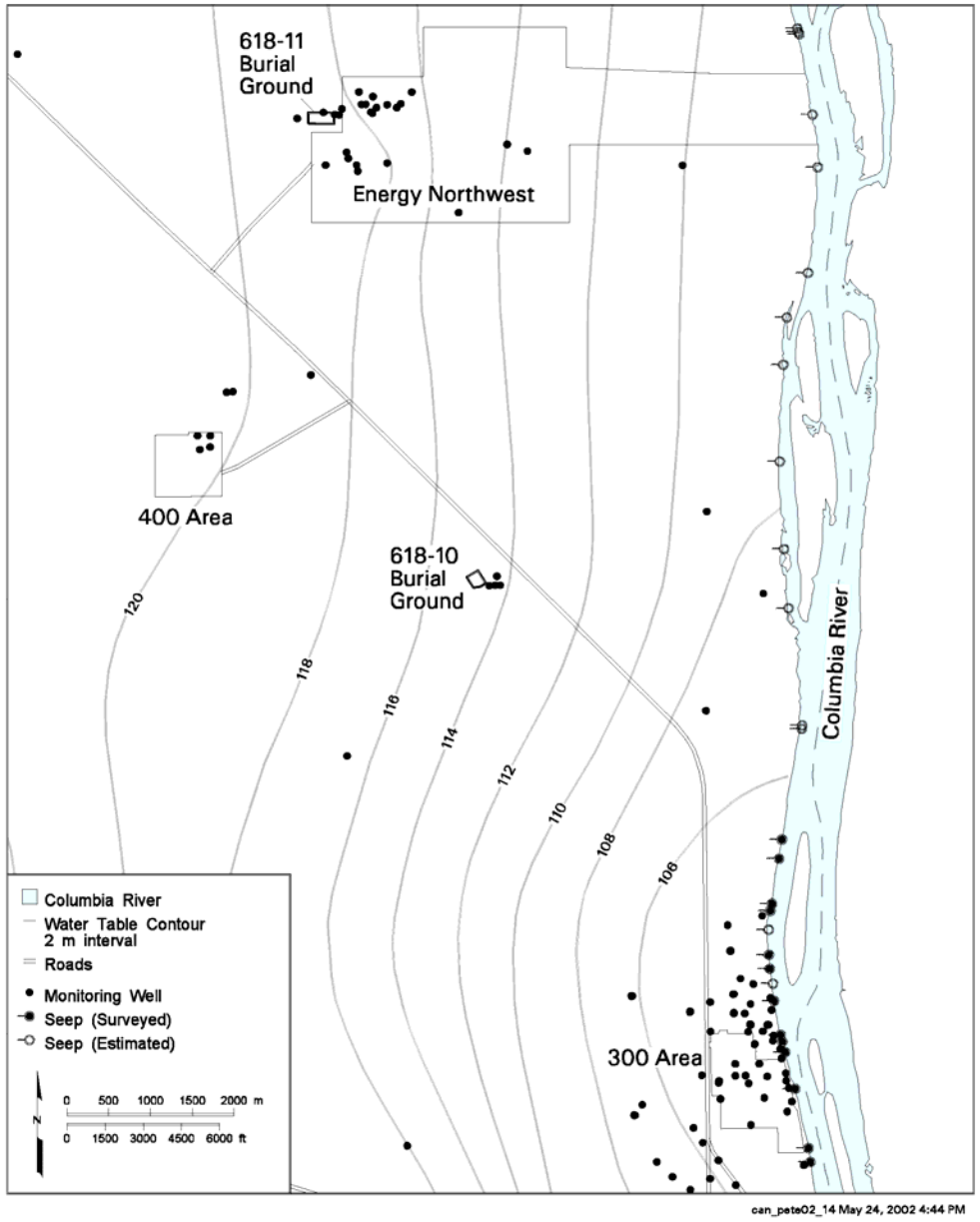

GROUNDWATER FLOW

- **Regional long-term average flow is towards the east, with a shift towards southeast near the 300 Area.**
- **In the 300 Area, flow patterns are variable, because of heterogeneous aquifer properties and short-term gradient changes caused by river stage fluctuations.**
- **Flow velocities beneath the 300 Area are high, with some estimates suggesting 10 m/d.**

(Source: Hanford Groundwater Monitoring Project. Water table for March 2002)

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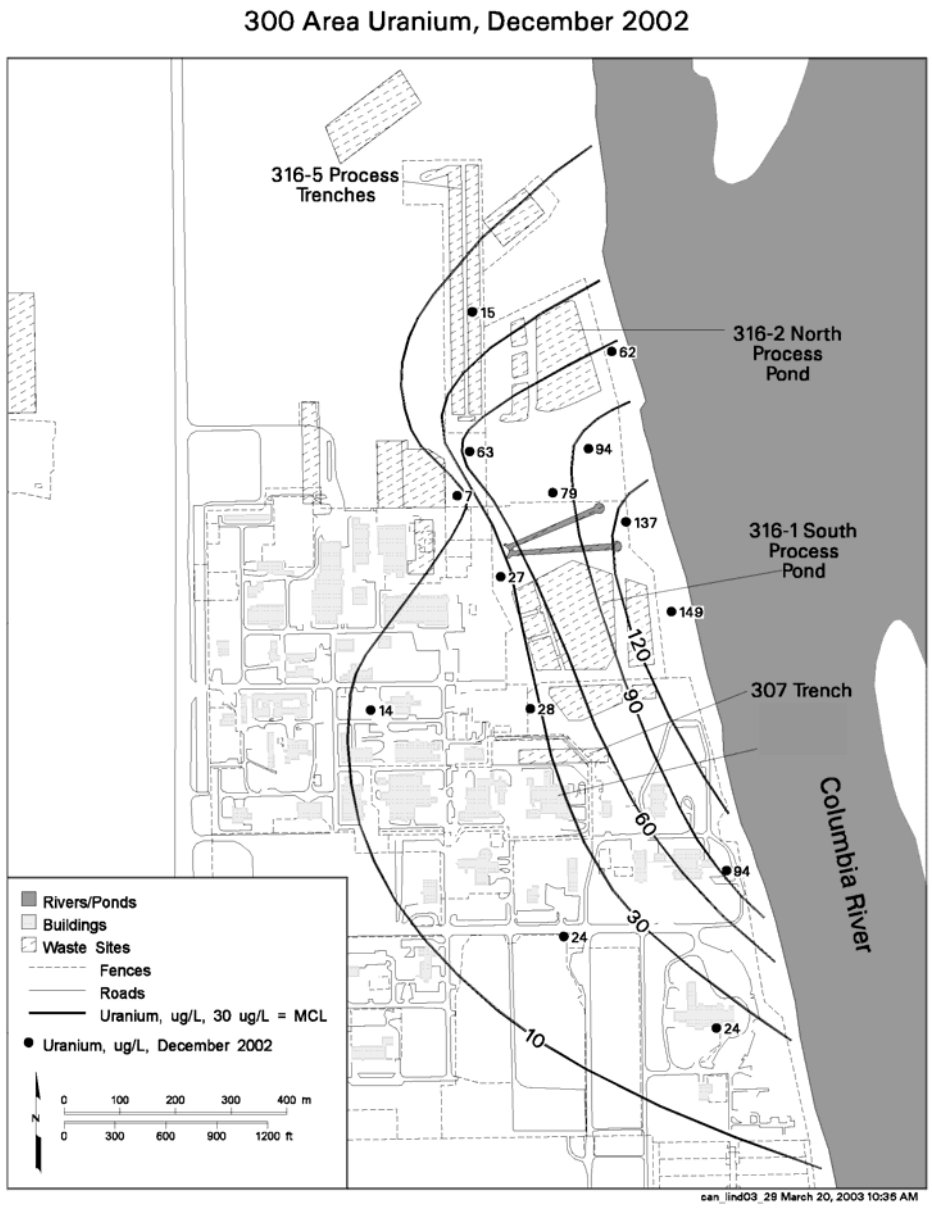

URANIUM

(DWS is 30 ug/L)

- **Early contributors to this plume included disposal at the 307 Trenches, which were decommissioned in 1964.**
- **Subsequent contributors included disposal to the North and South Process ponds. The most recent active source was the 316-5 Process Trenches.**
- **Removal of contaminated soils has taken place at all waste sites. Some residual uranium remains in lower vadose zone.**

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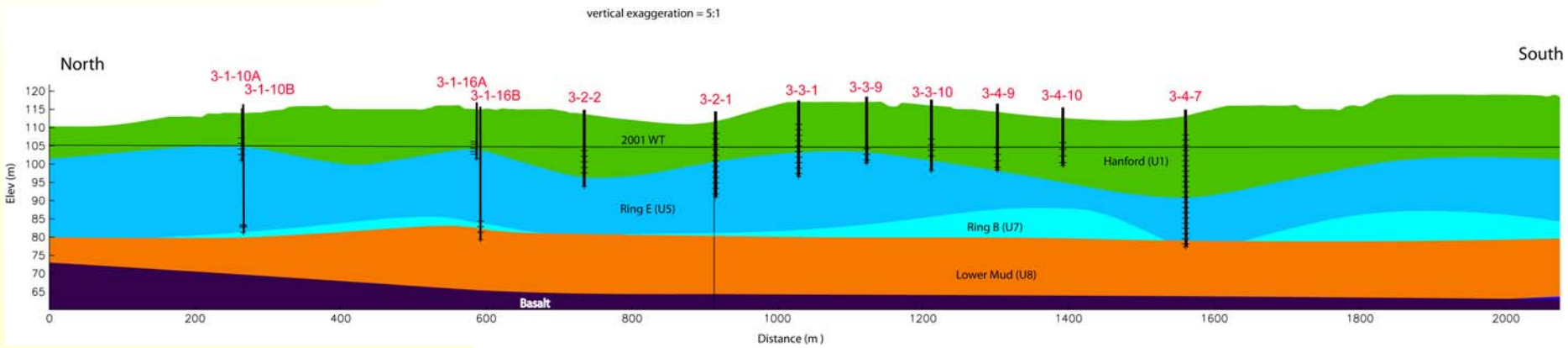
Cross Section Parallel to River Channel



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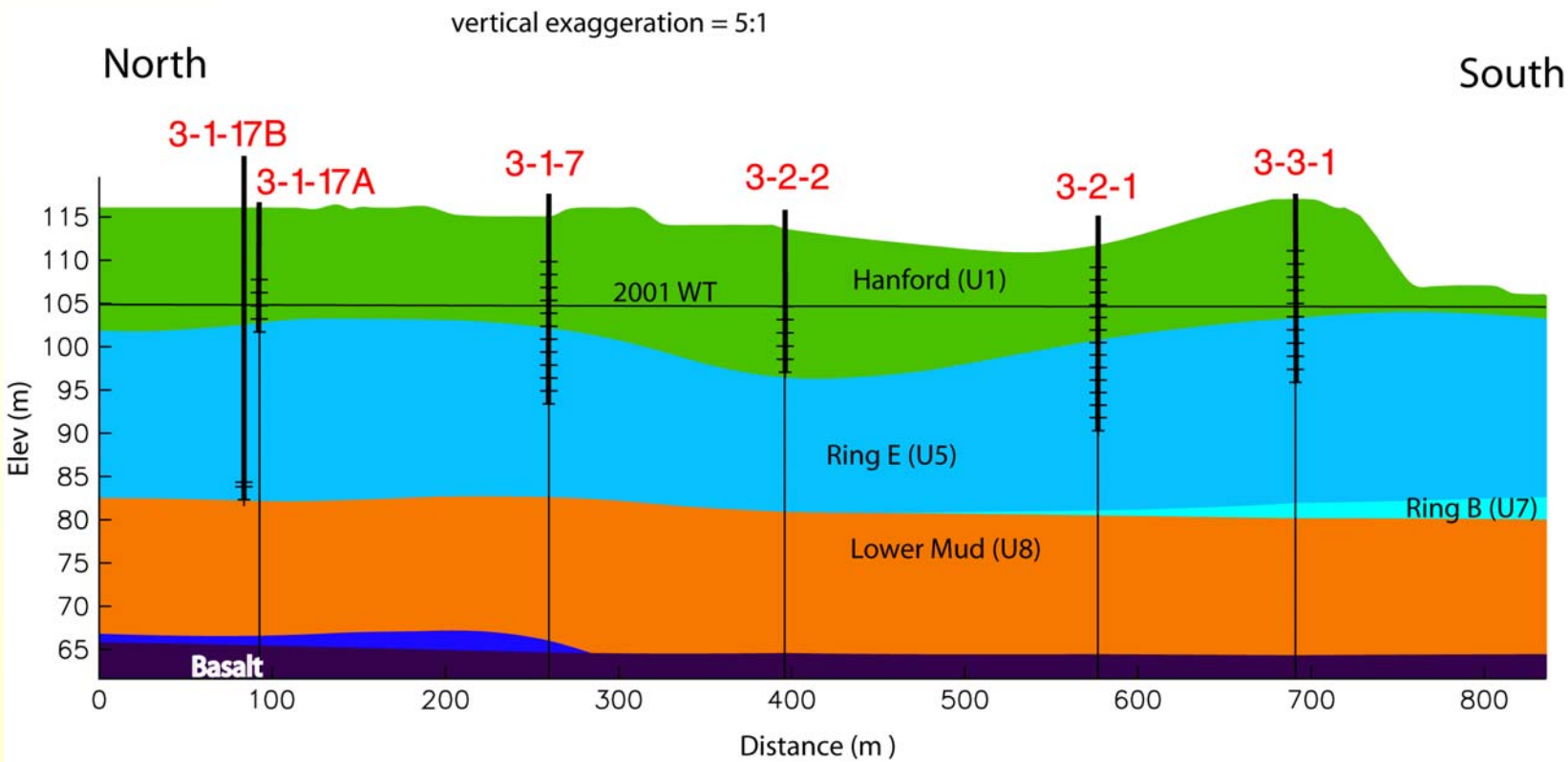
Cross Section along Flow Path from Process Trenches



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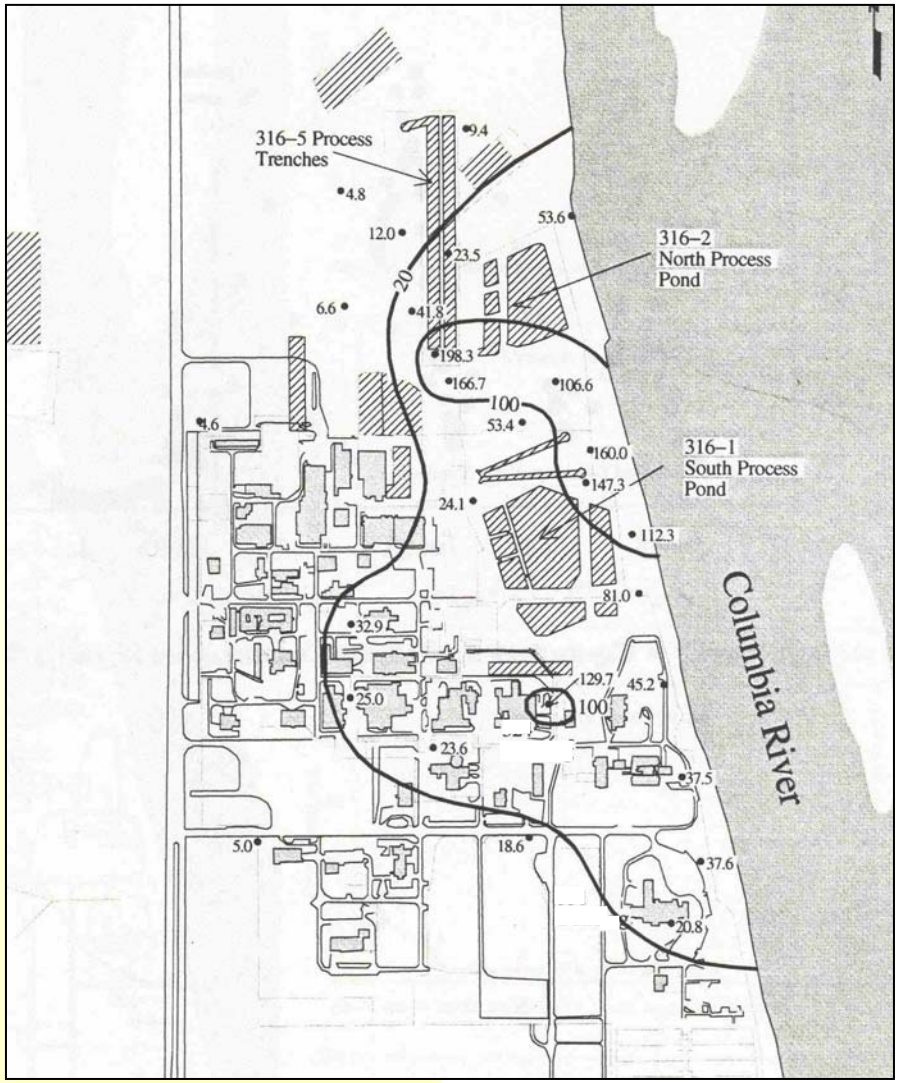
300 Area Uranium Plume, 1995



- **The 316-5 Process Trenches received uranium-bearing effluent between 1975 and 1991.**
- **Expedited Response Action in 1991 removed contaminated soil from trenches. Discharge of "clean" effluent continued until 1994.**
- **The RI/FS Report (May 1995) suggested that the plume would attenuate to meet the drinking water standard in 3 to 10 years from late 1993.**
- **A Record-of-Decision was made in 1996 with that assumption.**

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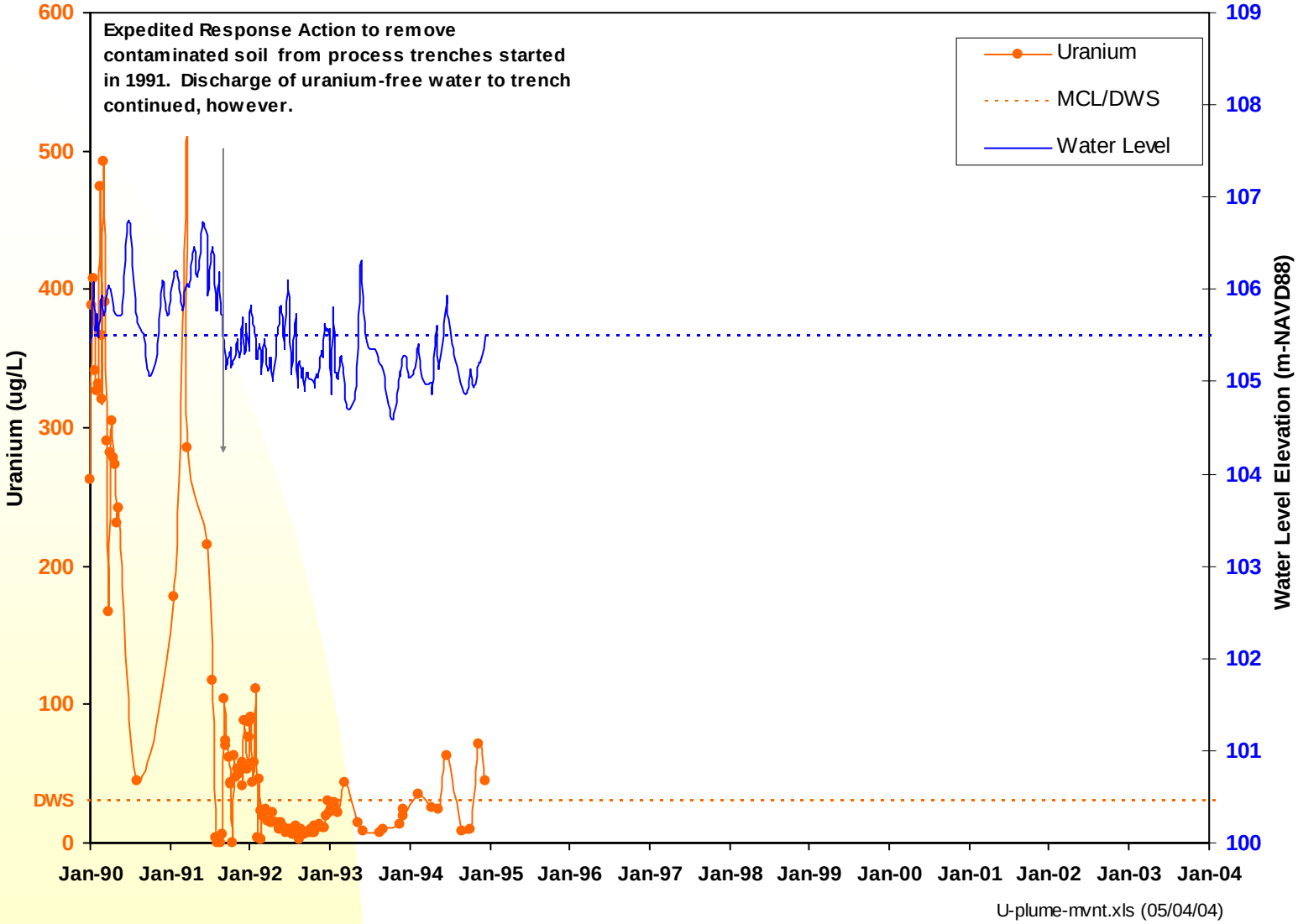
Groundwater Near 300 Area Process Trenches (399-1-17A)



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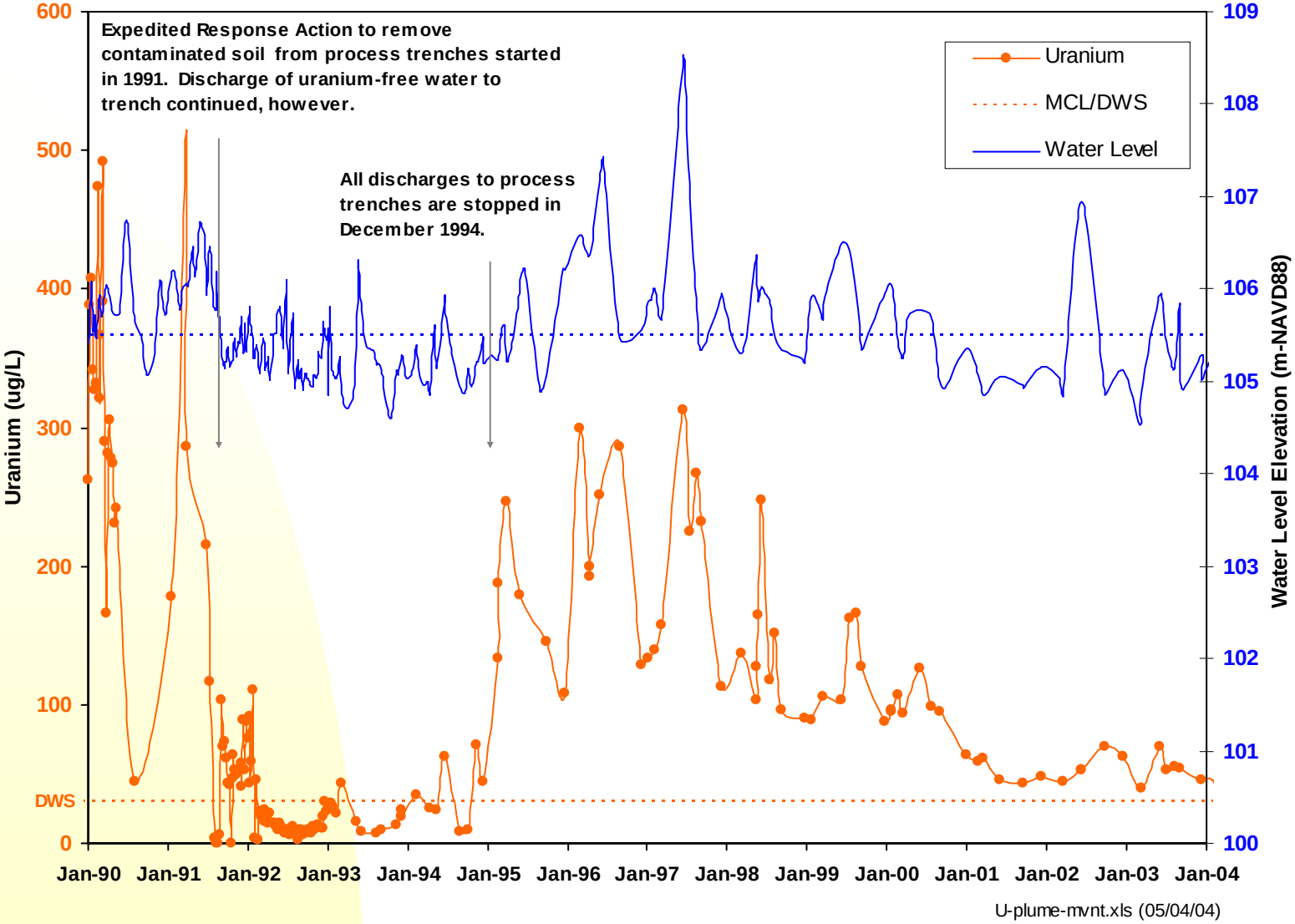
REGULATORY STATUS

- **Following the discovery that the Expedited Response Action resulted in a dramatic reduction in uranium concentrations near the process trenches, a Record-of-Decision for interim remedial action was prepared in 1996.**

- **Interim remedial action included a provision for further investigation of the natural features and processes that contribute to a reduction in the level of contamination.**

- **Murphy's Law then contributed to "… the rest of the story"…**

Groundwater Near 300 Area Process Trenches (399-1-17A)



U-plume-mvnt.xls (05/04/04)

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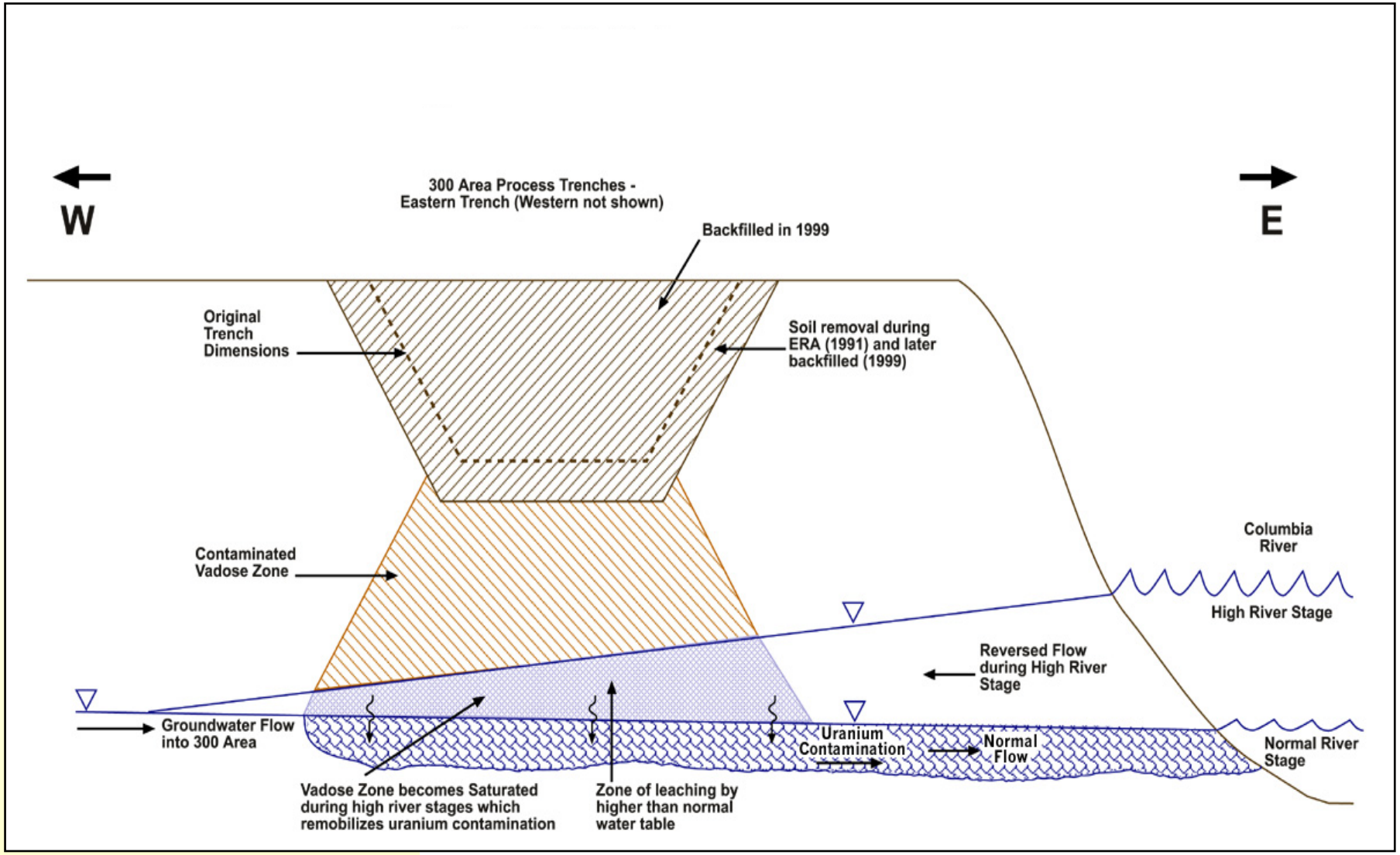

Figure Source: Lindberg 2002

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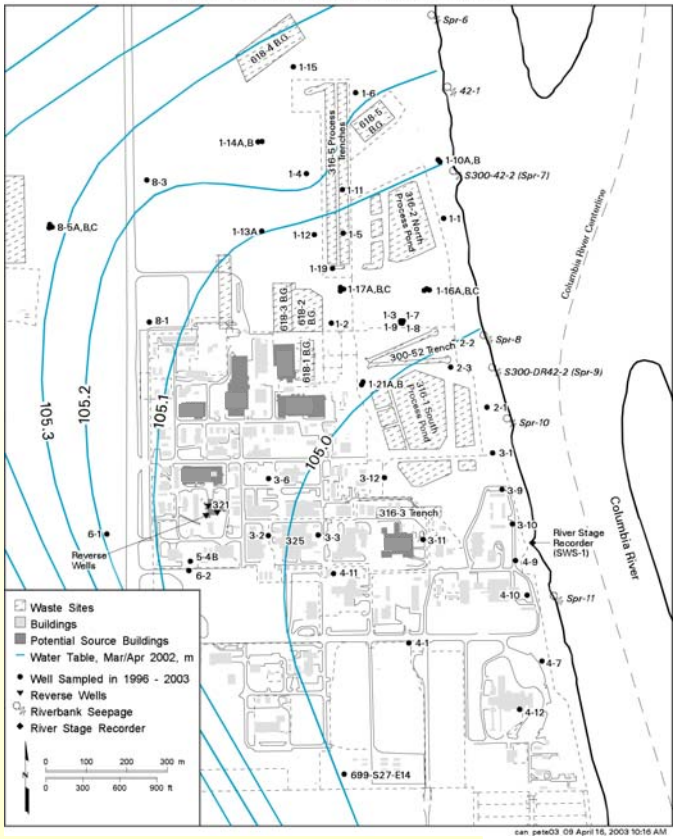
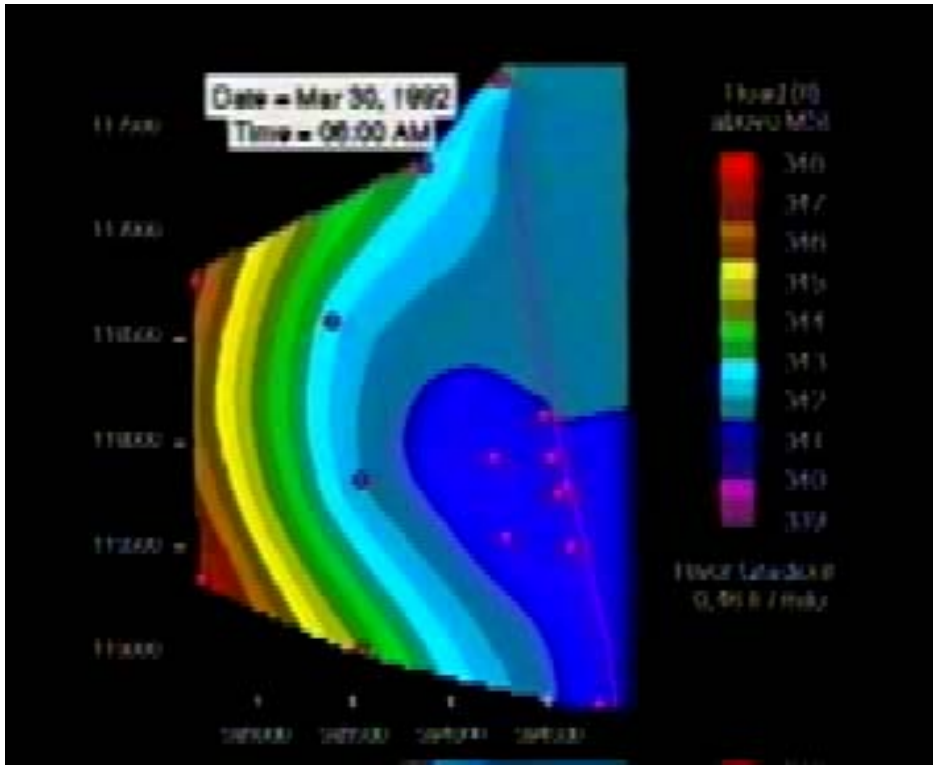
Water Table in 300 Area, March 2002





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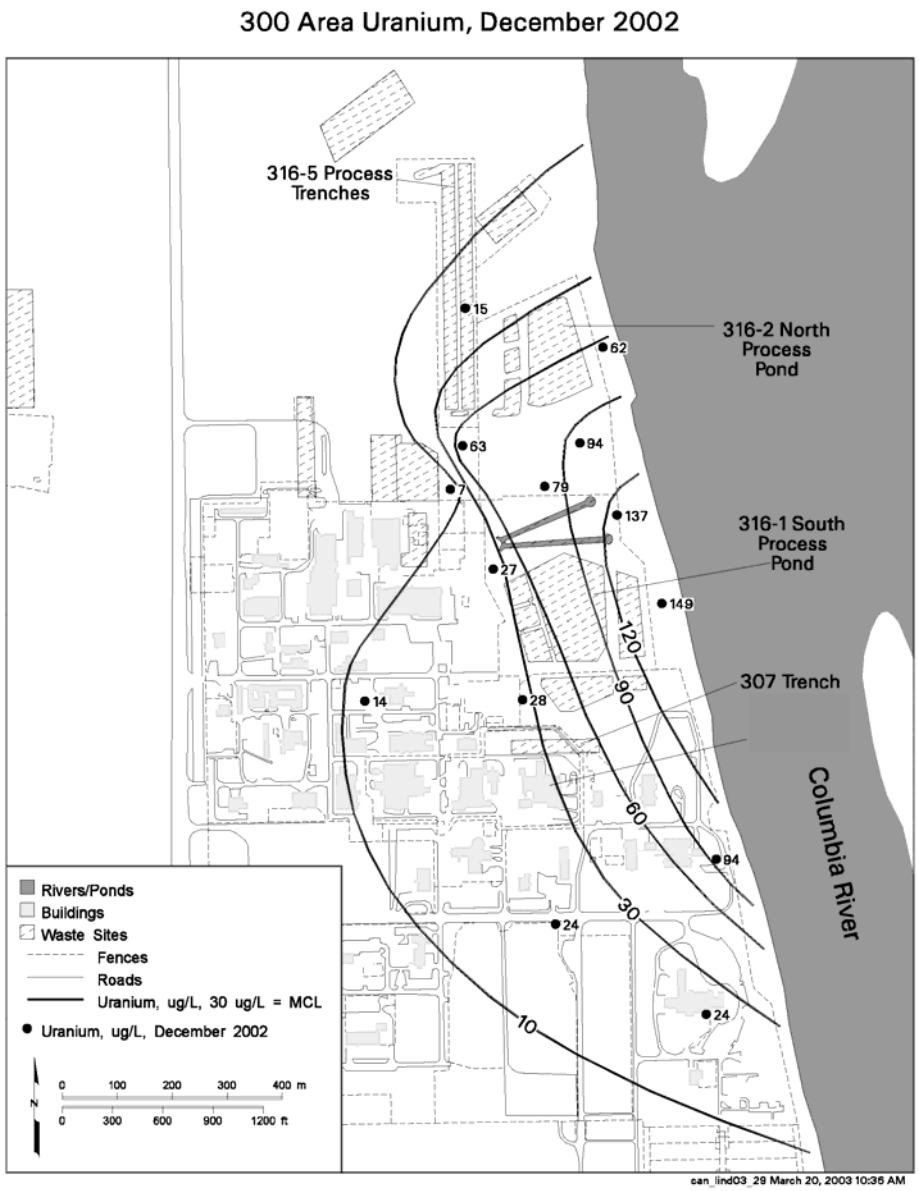

PLUME BOUNDARIES

- **The extent and shape of the uranium plume is determined by:**
  - **Site stratigraphy**
  - **Groundwater movement**
  - **River stage**
  - **Recharge from the vadose zone**
- **Long-term monitoring suggests little variation in plume shape and extent.**
- **Concentrations observed for individual sampling events may show high seasonal variability.**

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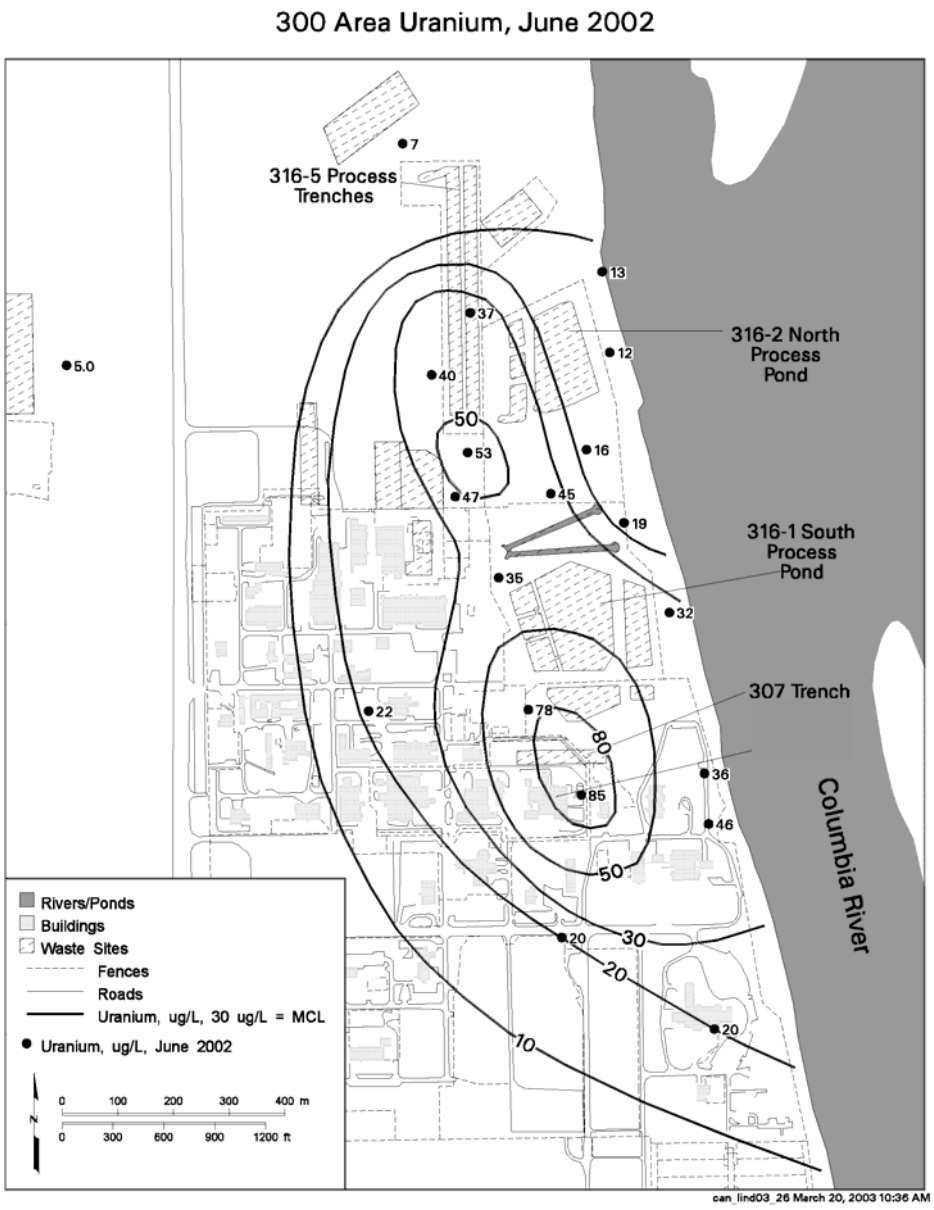

SEASONAL VARIABILITY

- **During high river stage conditions, two processes occur:**
  - **River water infiltrates the banks and dilutes the uranium plume near the river.**
  - **The water table rises, potentially remobilizing contamination in the lower vadose zone.**

- **Areas where elevated uranium concentrations persist during this period may indicate areas where the most residual uranium remains.**

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Uncertainties Regarding Uranium in the Natural System at the 300 Area

- **Amount of uranium remaining in the vadose zone:**
  - **Inventory disposed to various ponds and trenches**
  - **Amount removed during source excavations**

- **Mobility of residual vadose zone uranium under likely future conditions:**
  - **Future land use and long-term waste site covers**
  - **Precipitation/infiltration scenarios**

- **Characteristics of uranium in the vadose zone:**
  - **Residual amounts associated with waste disposal sites**
  - **Amounts possibly sequestered in the capillary fringe**
  - **Chemical form; adsorption/desorption; rate of movement**

Uncertainties Regarding Uranium in the Natural System at the 300 Area, continued…

- **Characteristics of uranium in the aquifer:**
  - **Area and volume of contaminated groundwater**
  - **Mass of uranium in plume and seasonality**
  - **Vertical distribution**
  - **Rate of recharge from vadose zone**

- **Discharge of uranium into the river system:**
  - **Influence of fluctuating river stage on groundwater flow**
  - **Preferential pathways because of heterogeneity in stratigraphy**
  - **Likely areas of upwelling into the riverbed**

- **Potential consequences of uranium in the river ecosystem:**
  - **Columbia River water quality**
  - **Uptake by aquatic organisms**
  - **Exposure risk for humans**

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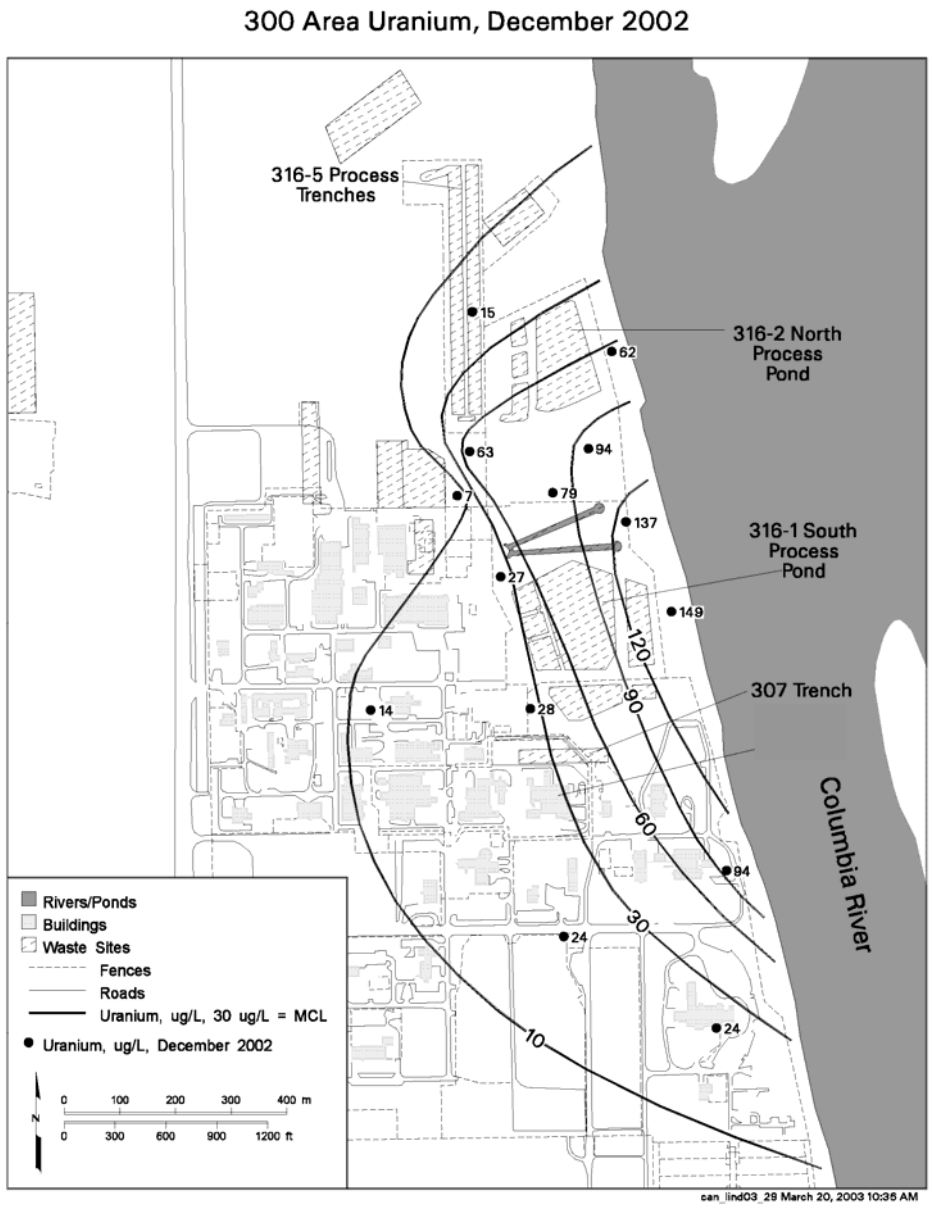

- **316-5 Process Trenches received uranium-bearing effluent operated between 1975 and 1991, with "clean" effluent continuing until 1994.**
- **Expedited Response Action in 1991 to remove contaminated soil from trenches.**
- **Investigations leading to 1996 record-of-decision suggested that plume would attenuate to drinking water standard in 3 to 10 years (starting in 1992).**
- **Concentrations above the DWS continue to persist.**

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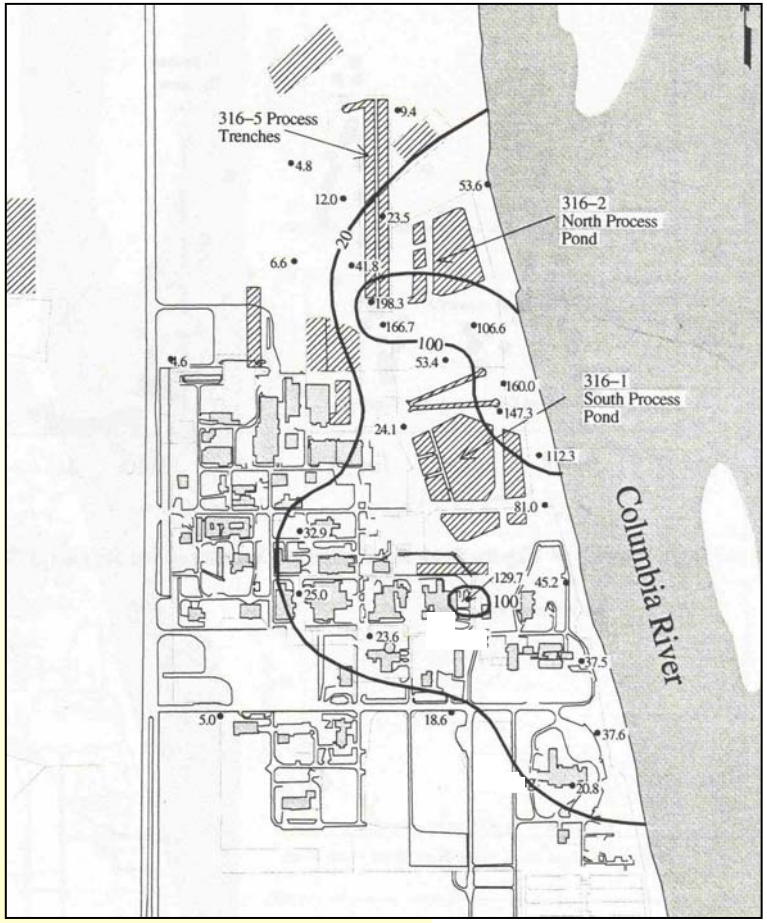
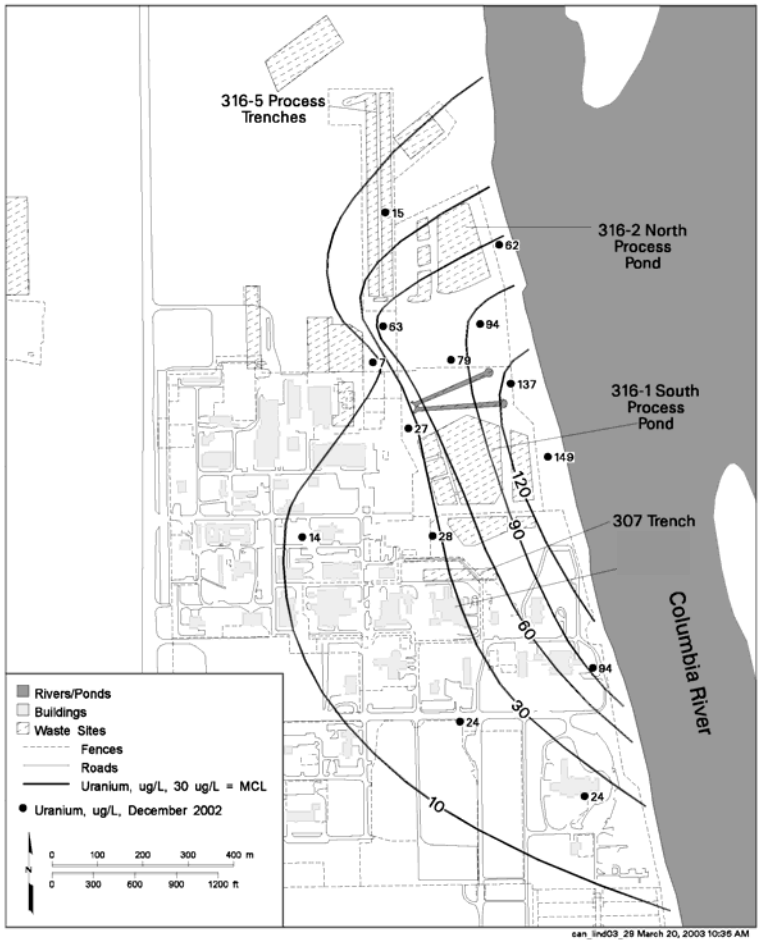
300 Area Uranium Plume, 1995



300 Area Uranium, December 2002



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