Watershed Modeling of Flood and Contaminant Transport

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Kiev, Ukraine

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Possible Climate Change Impacts on Ukrainian Water Resources

- Major Ukraine rivers over time may
  - Be affected by climate changes, e.g., generally
    - warmer air temperature
    - change in precipitation pattern, e.g., less snow, more rain
  - Have less snow-cover and its areas, and change the amount-timing of snow-melting in the upper Dnieper and Pripyat rivers
  - Have reduced river inflow to the Kiev Reservoir
  - Have possibly more flashy floods due to rainfall
- Shortage of water resources affects
  - Municipal and industrial water supplies
  - Hydroelectric power generation
  - Irrigation water for agriculture and southern Ukraine
  - Fishery
  - Transportation
  - Water quality
  - Salt water intrusion in southern Ukraine

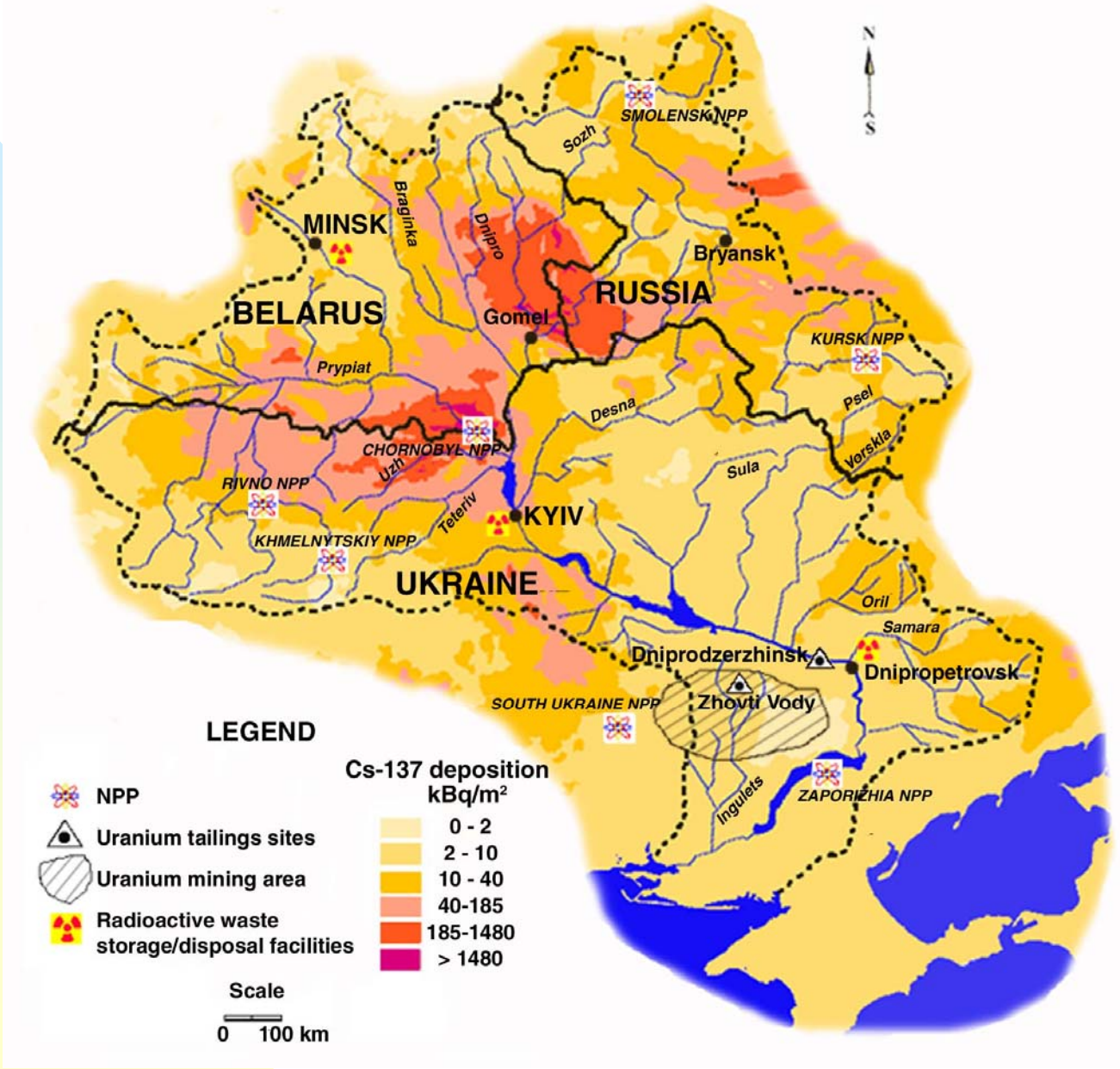
Adaptation to Climate Change Impacts

- Many these adverse impacts of climate change are in addition to natural and man-induced disasters occurring now
- Mitigating and adapting to climate change problems would also address many of current problems, e.g.,
  - Flooding
  - Water pollution caused by radionuclides and toxic chemicals
  - Water security to reduce water shortage and waterlogging
  - Energy security and diversity

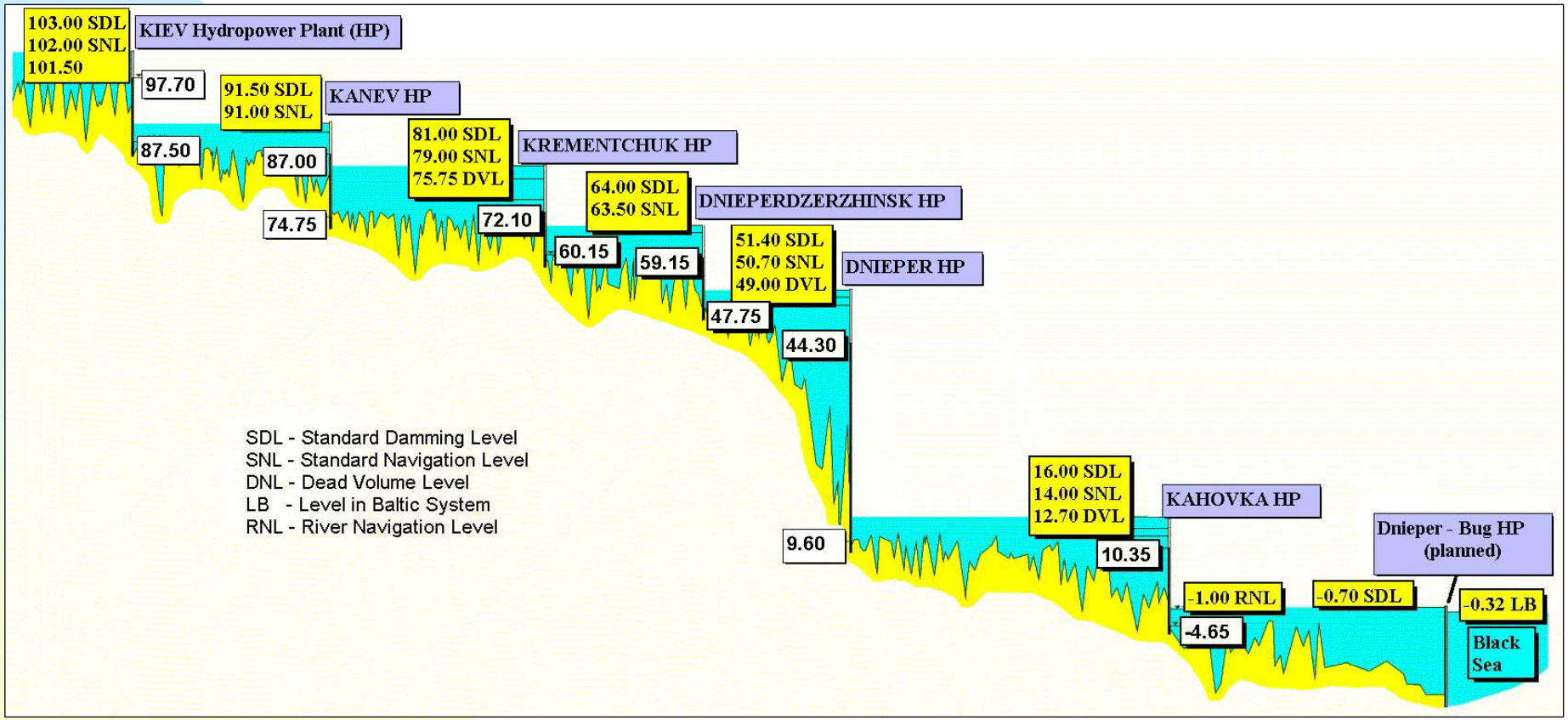
River Flows, Floods and Water Quality Variations of Different Size Watersheds

- Large River
  - the Dnieper River watershed (in Ukraine, Russia, and Belarus)
- Mid Size Rivers
  - The Yakima River watershed (the Columbia River's tributary in Washington)
  - the Yazoo River watershed (the Mississippi River's tributary in Mississippi)
- Small River
  - the Four-Mile Creek (Iowa)
- Ephemeral creeks: Mortandad and South Mortandad Canyons (in Los Alamos National Laboratory, New Mexico)

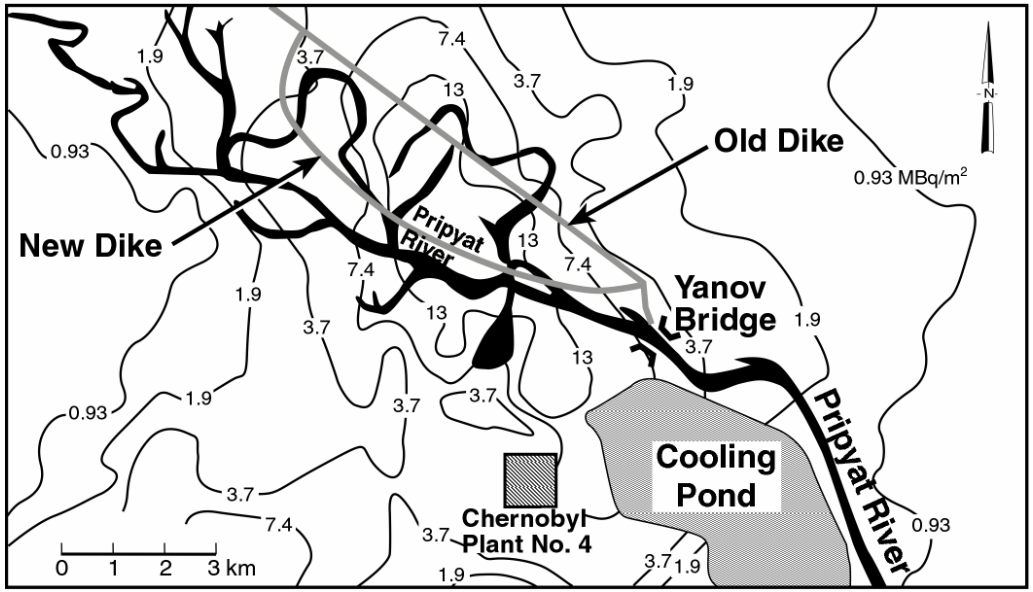
Dnieper River Watershed and Chernobyl Nuclear Accident Contamination



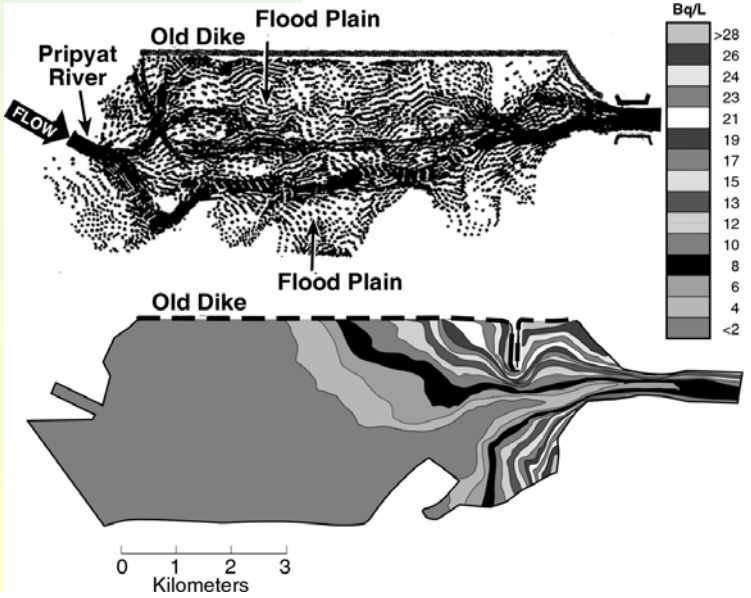
Dnieper River Six Reservoir System



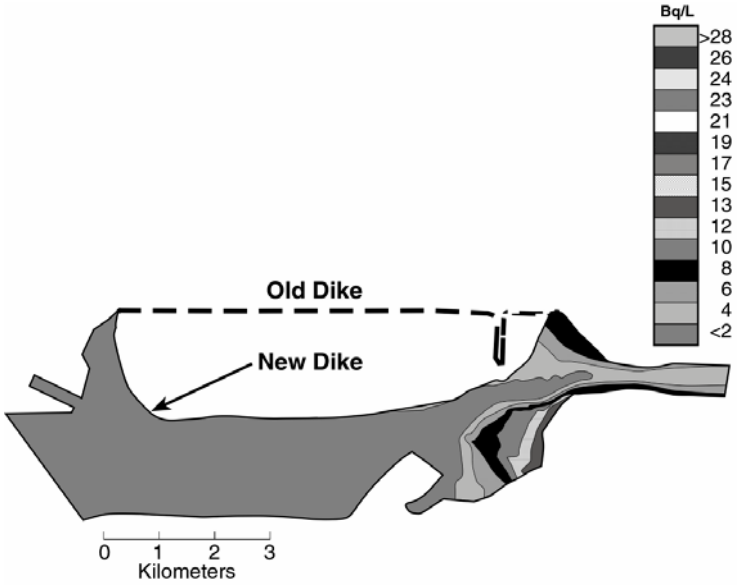
Pripyat River 4-Year Flooding (~ 1991 Ice Jam)



Without the Newer East Bank Dike

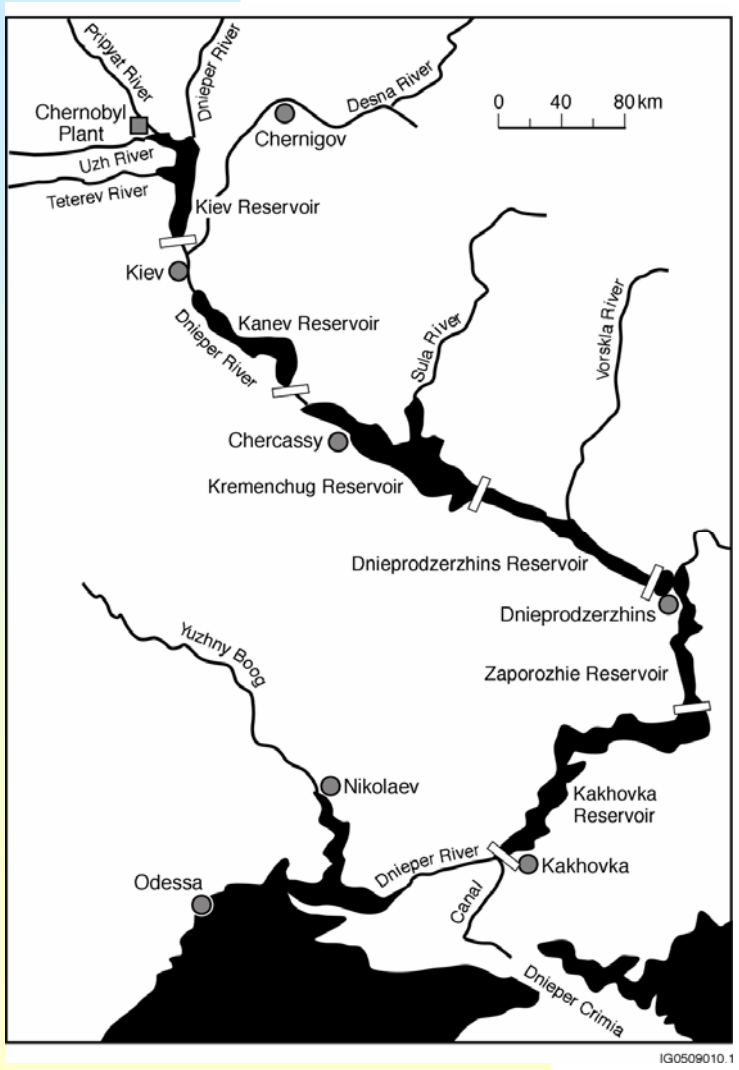


With the Newer East Bank Dike



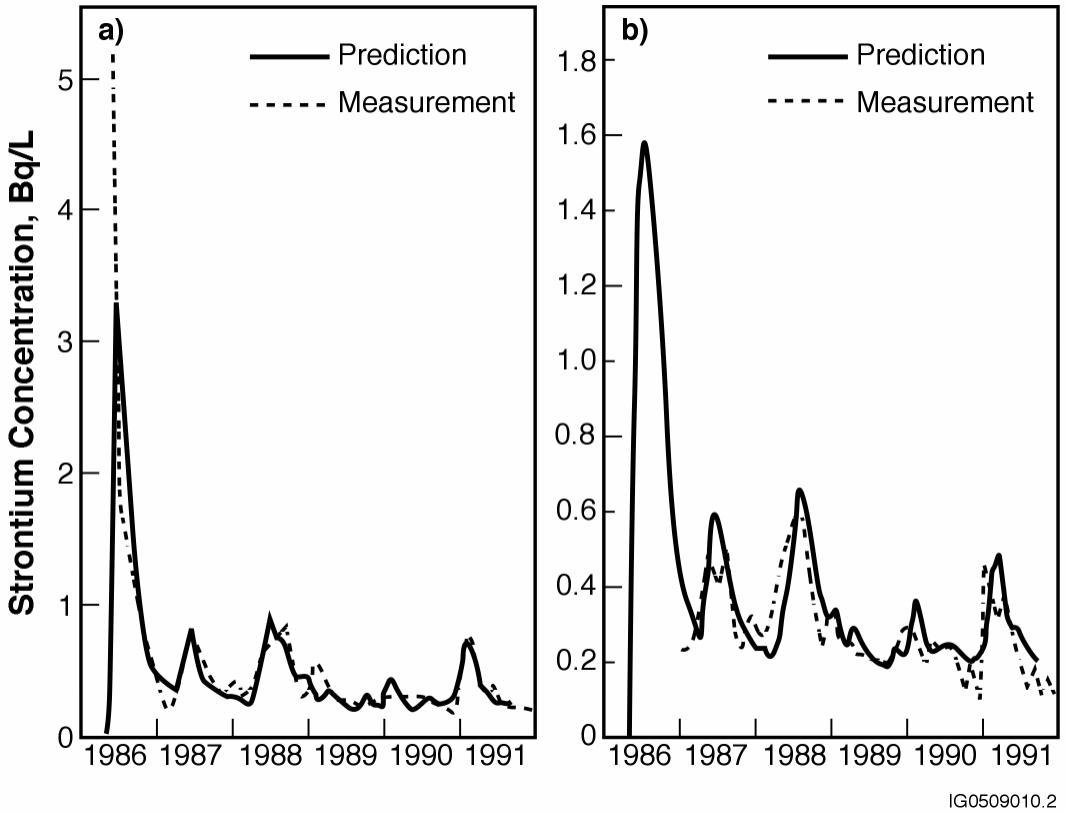
Dnieper River and Its Six Reservoirs

Radionuclide Migration through Dnieper River Reservoirs



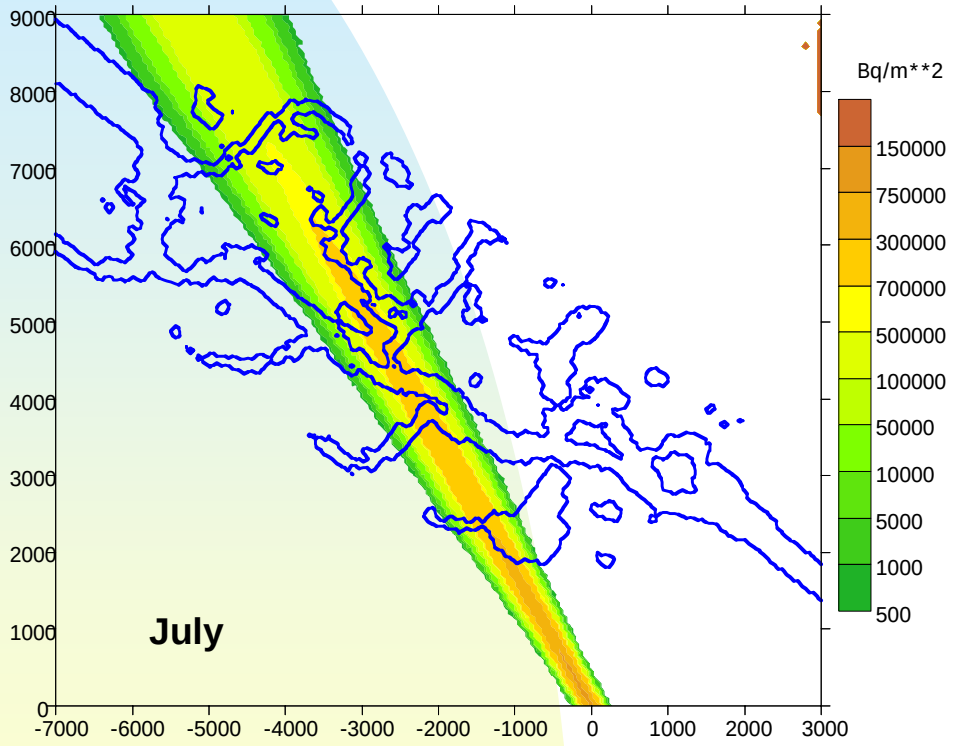
At Kiev Reservoir

At Kanev Reservoir

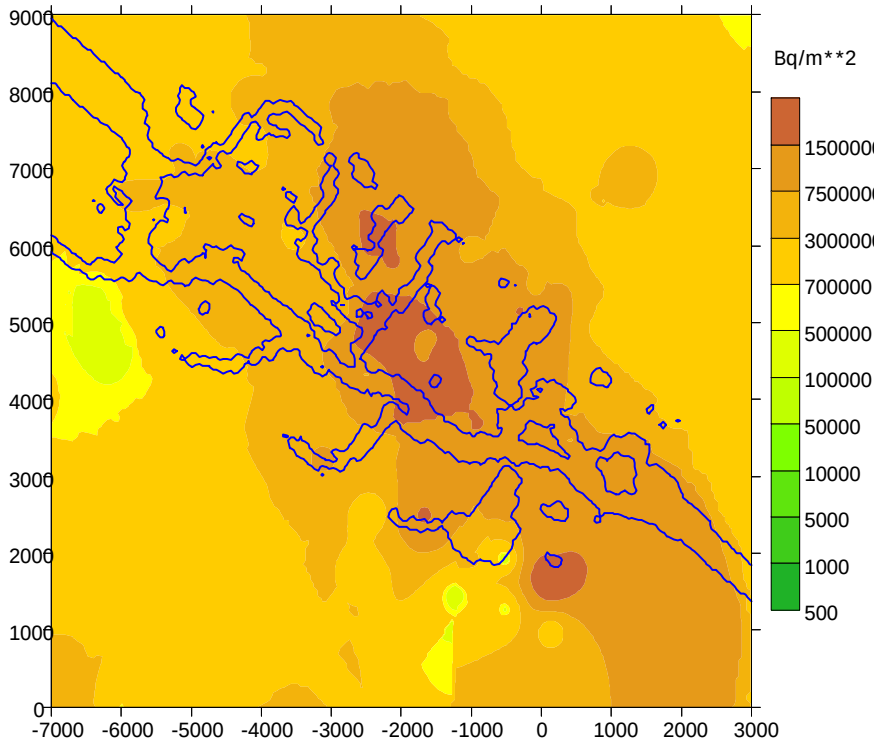


^{90}Sr Distributions if Chernobyl Shelter Should Collapses

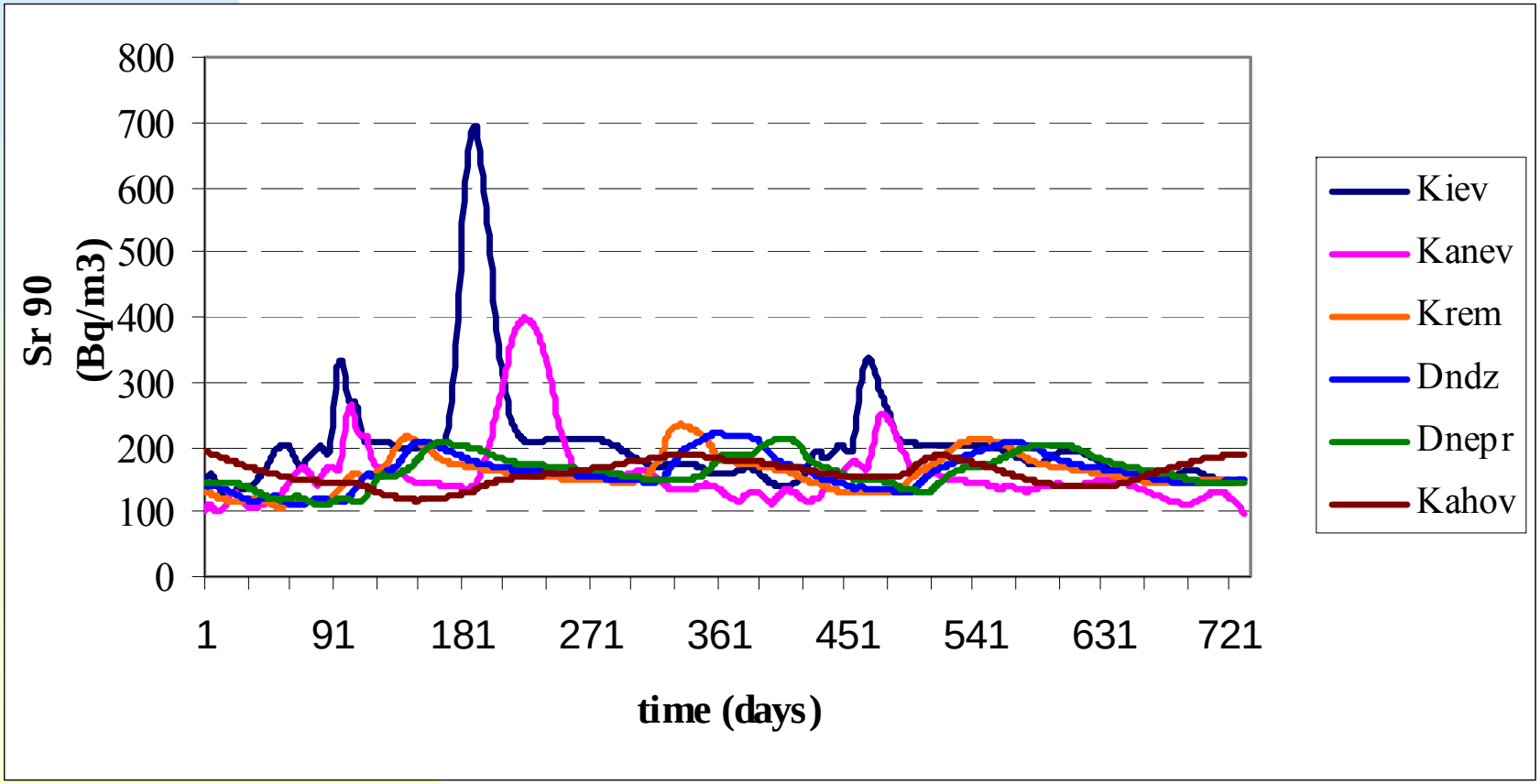
^{90}Sr airborne plume



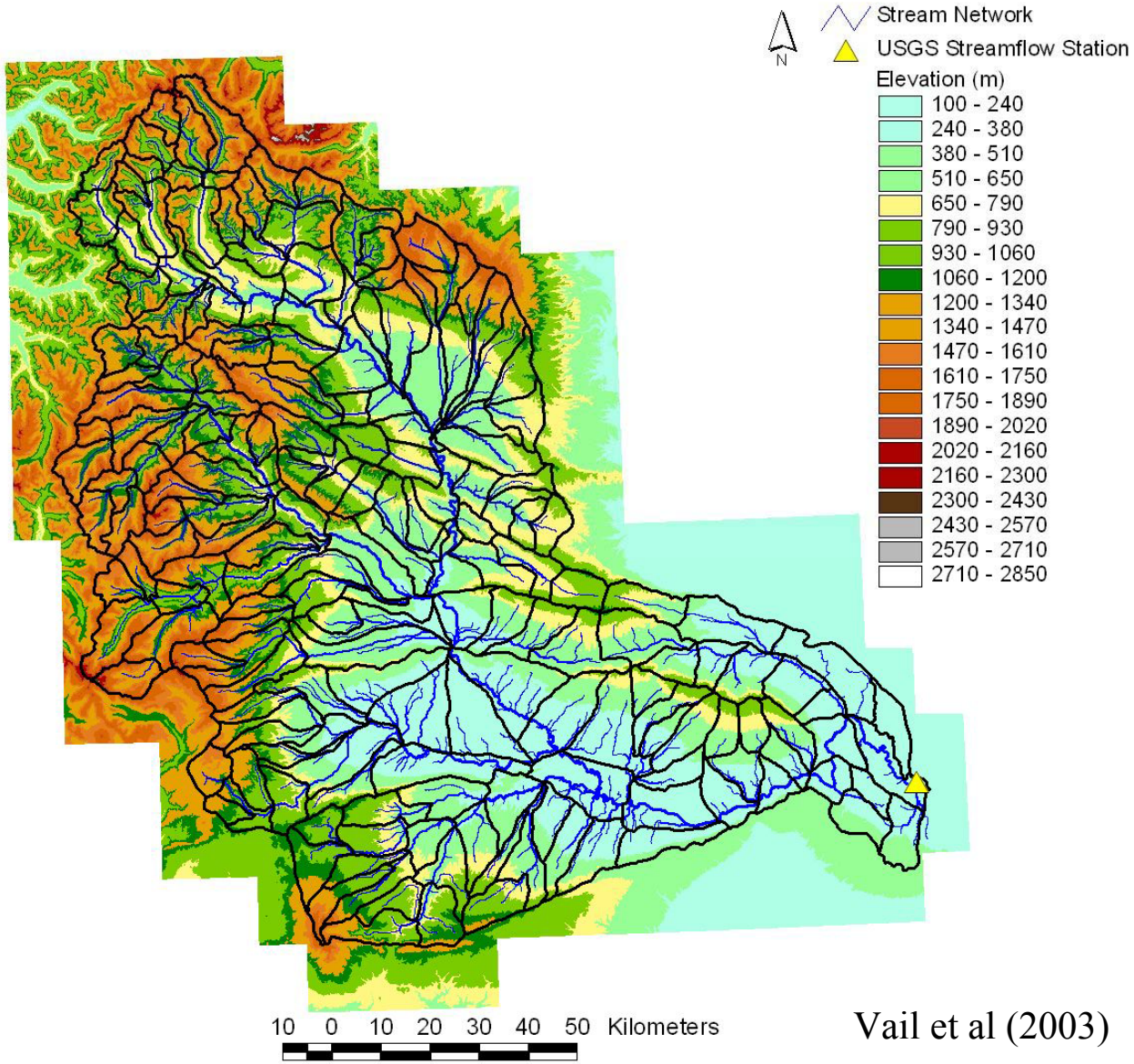
^{90}Sr distribution on land Surface



Propagation of ^{90}Sr in the Dnieper River if the Chernobyl Shelter Should Collapse

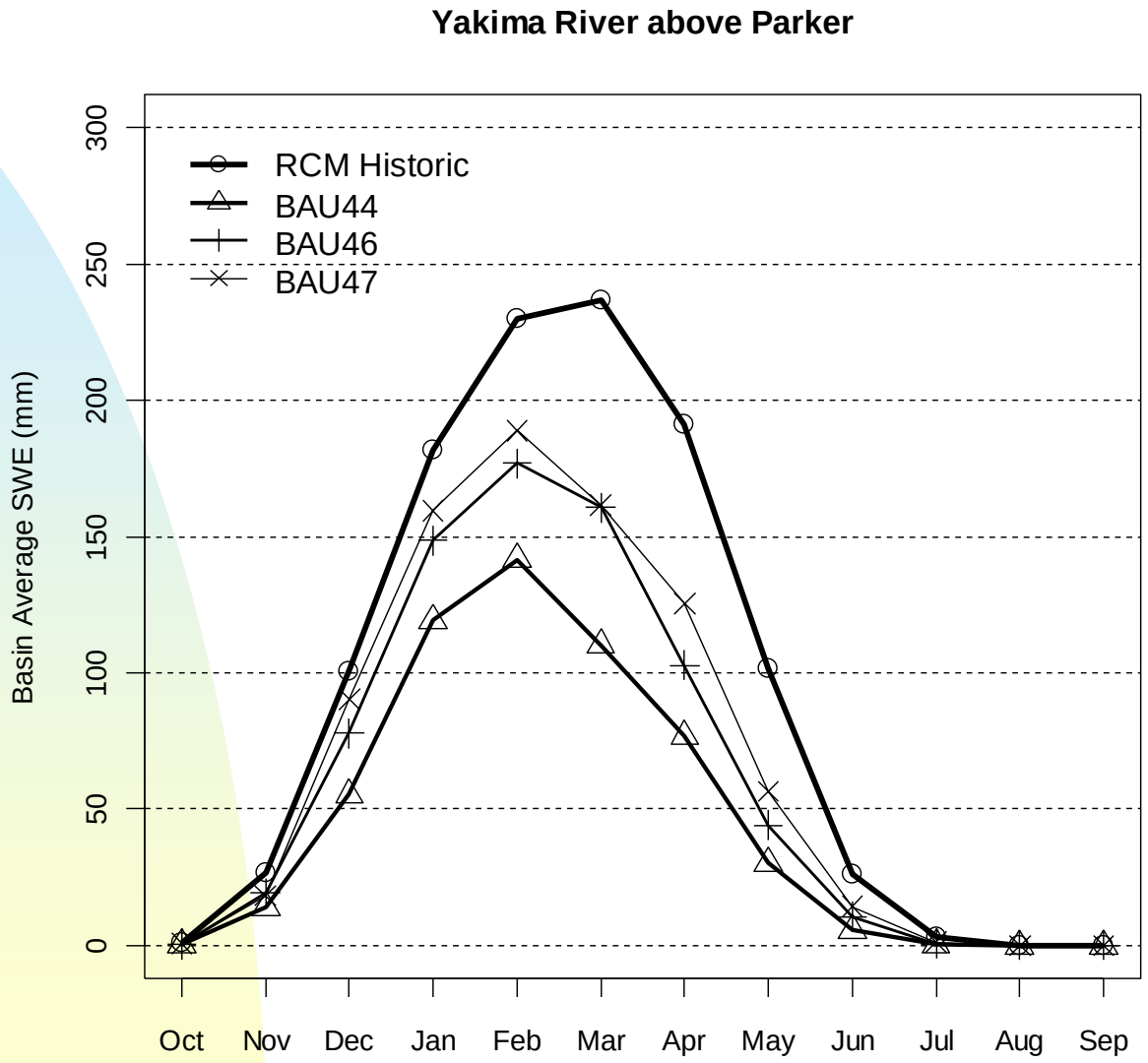


Yakima River Basin – A Medium River



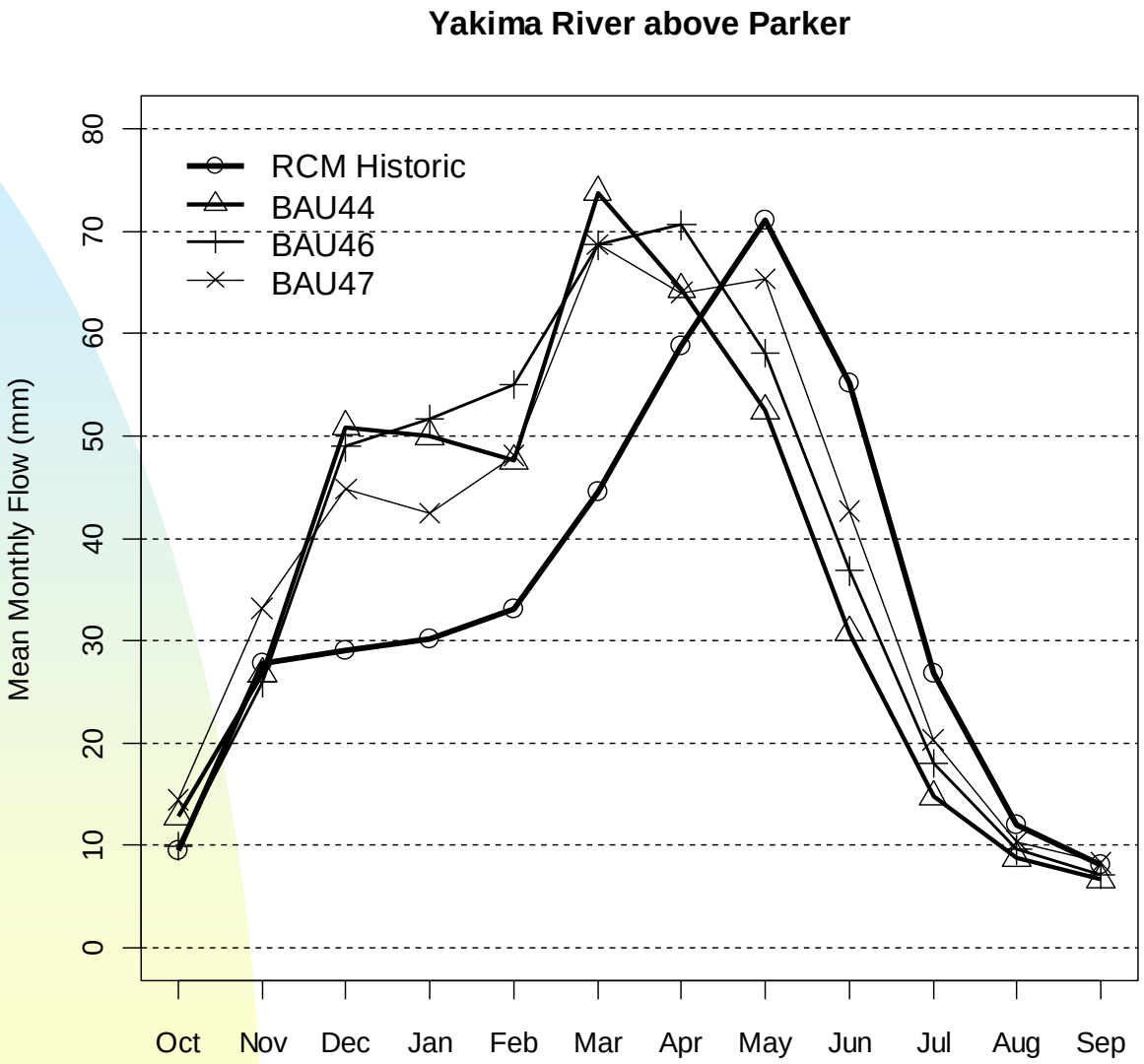
Vail et al (2003)

Yakima River Basin Snow Cover

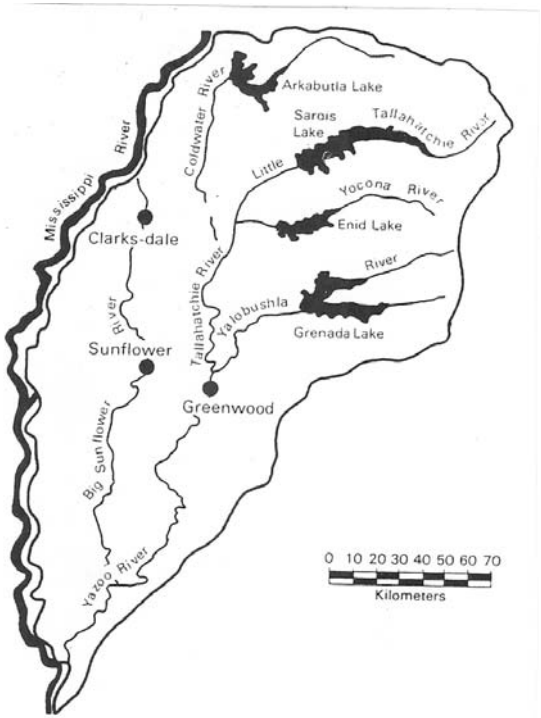


Present Vs
2040~2059

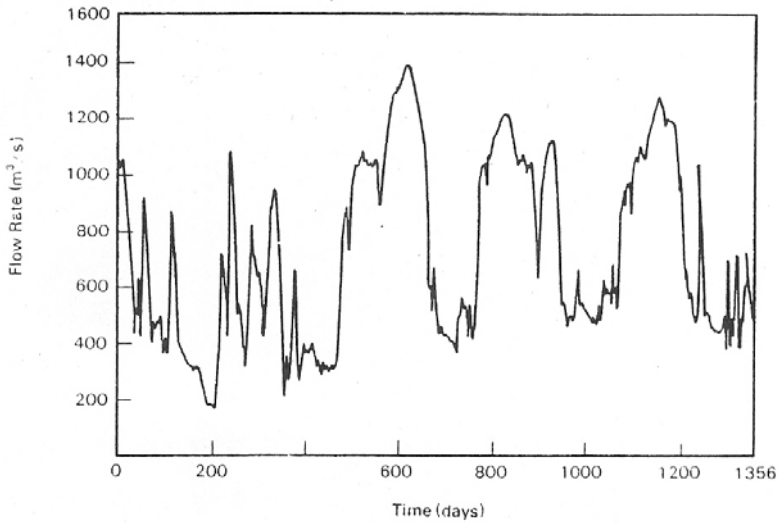
The Yakima River Flow Rate



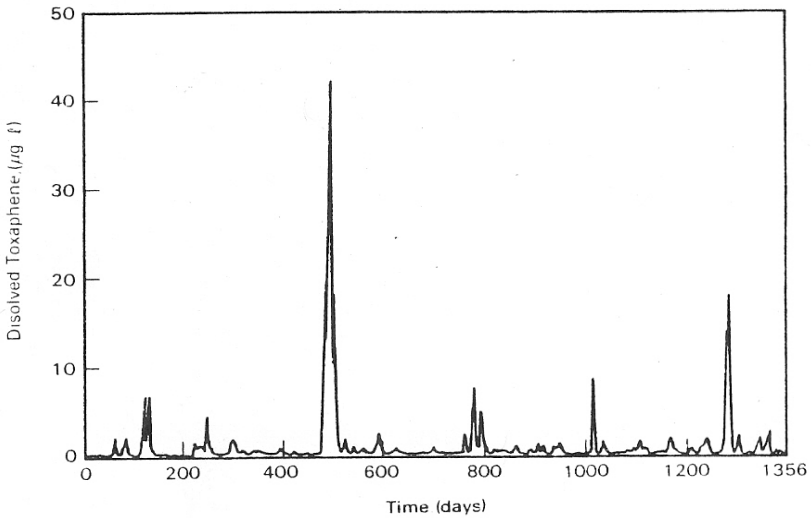
Yazoo River Watershed – A Medium River



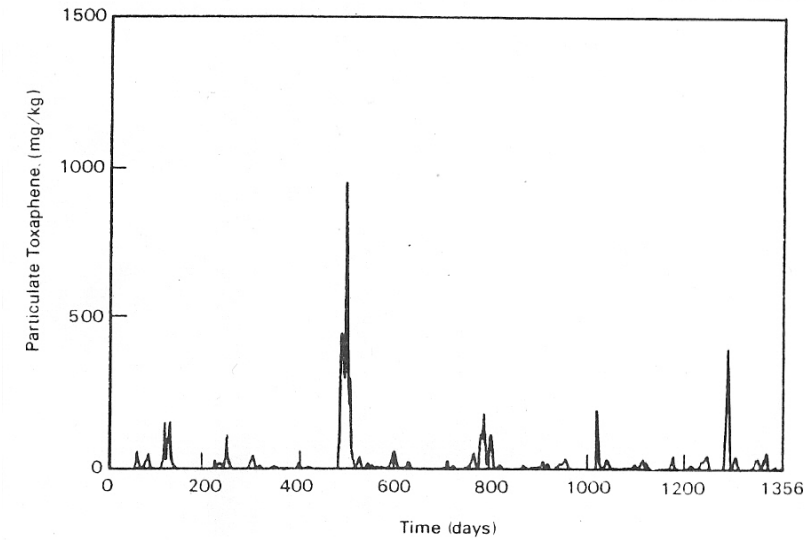
River discharge at the Yazoo River mouth



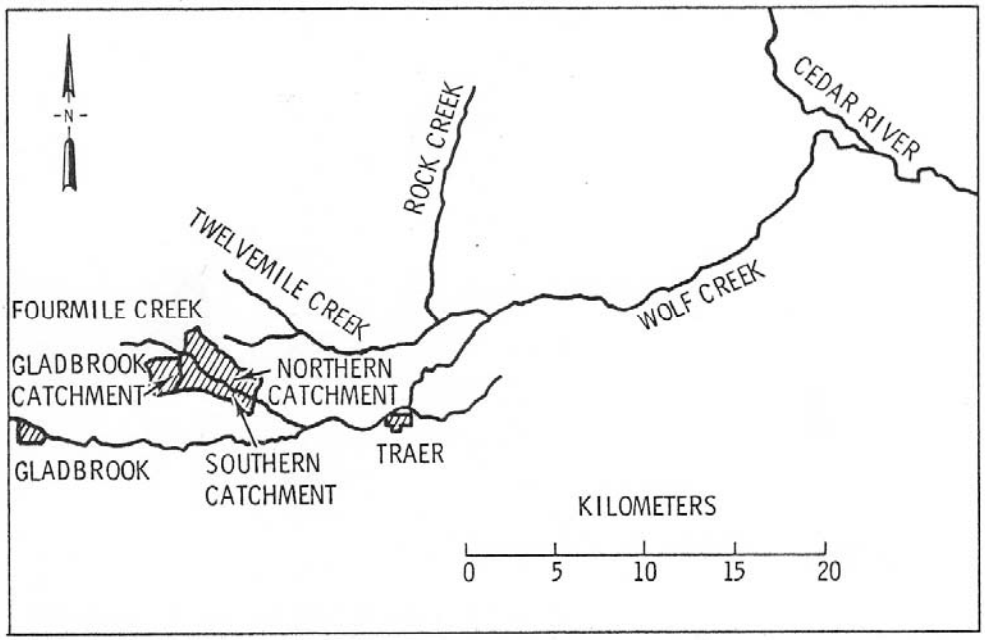
Dissolved Toxaphene



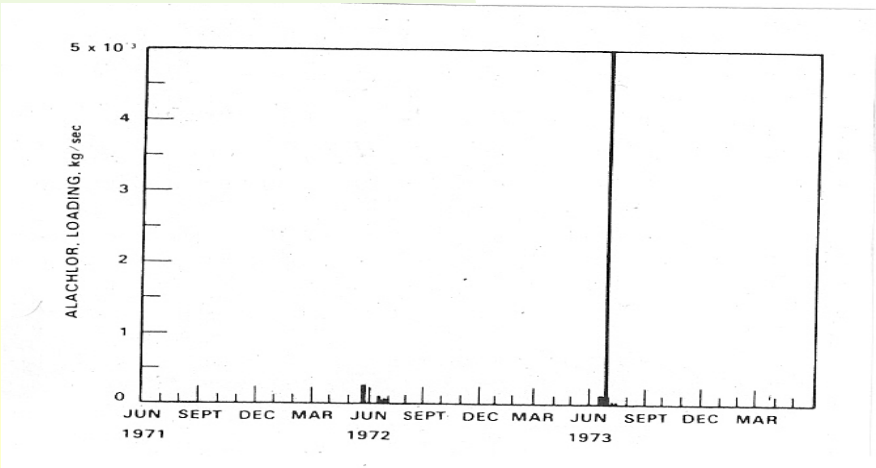
Sediment-sorbed Toxaphene



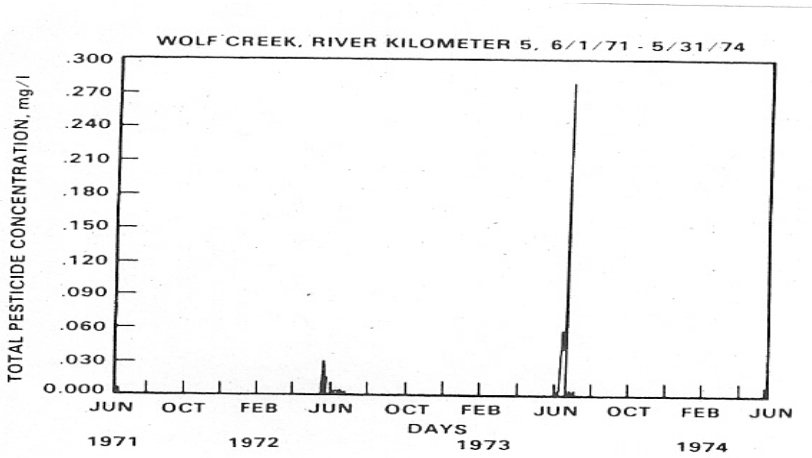
Four-Mile Creek Catchments – A Small River



Alachlor loading at the creek edge



Alachlor concentration in the creek



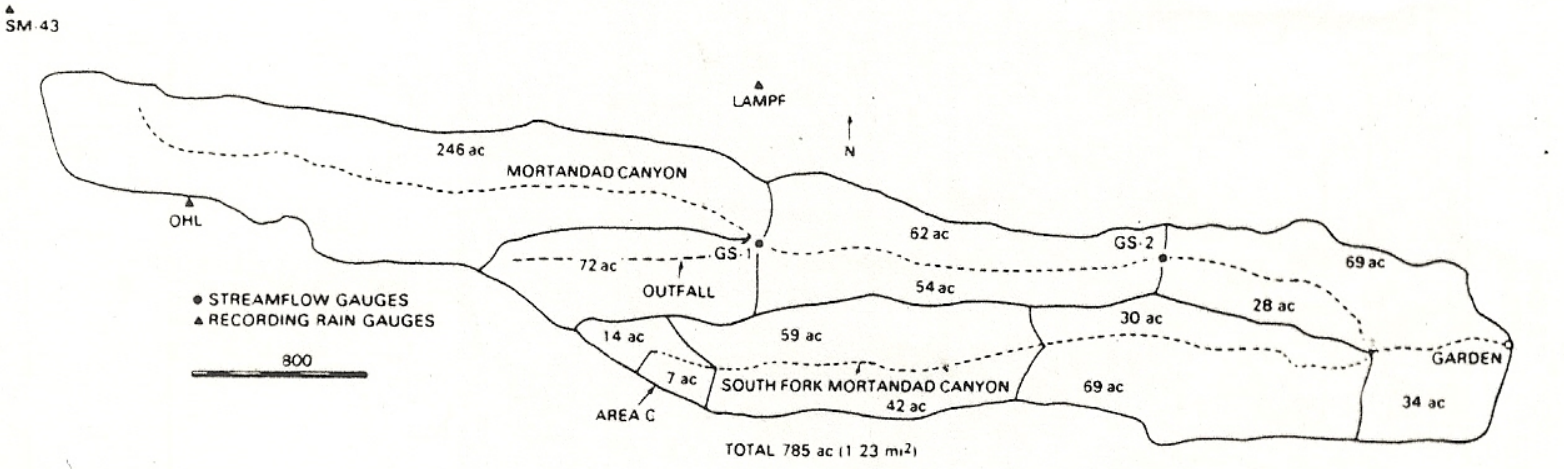
Ephemeral Creeks in Mortandad and South Mortandad Canyons: Combined Biological and Physical Radionuclide Transport

Plant growth/uptake/death → Deposit radionuclides on soil surface in a more easily erodible form → transported by runoff and flash flooding

Simulated

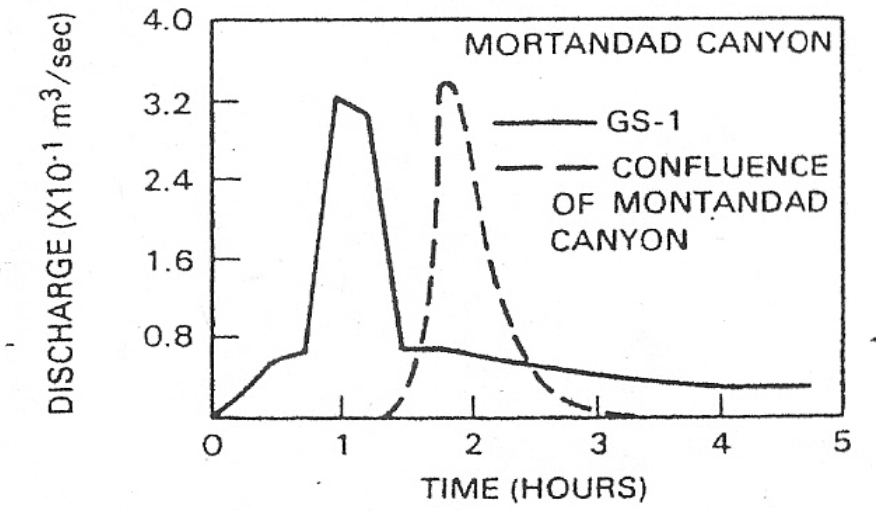
- Plant
  - plant growth/radionuclide uptake/plant death-decay
- Overland:
  - runoff, soil erosion, dissolved radionuclide flux, sediment-sorbed radionuclide flux
- Ephemeral creeks
  - stream flow, transport of sediment, dissolved radionuclide, sediment-sorbed radionuclide, and deposition/resuspension of suspended sediment and radionuclides

Los Alamos National Laboratory's Mortandad and South Mortandad Canyons

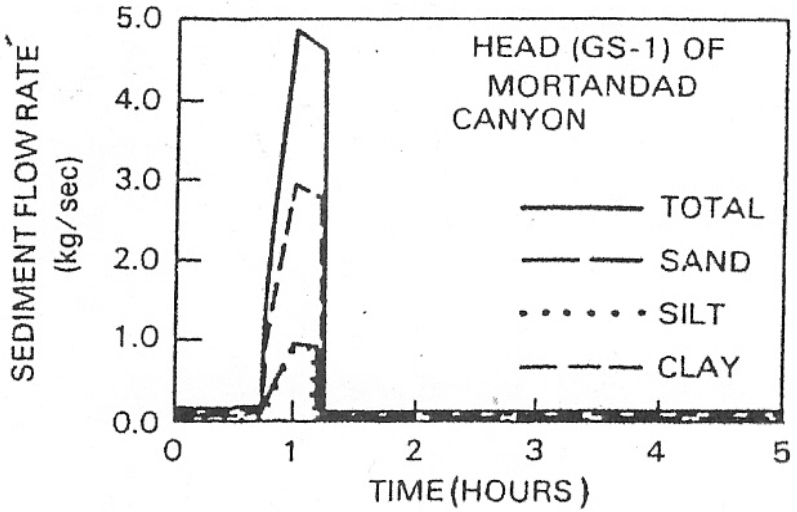


Flooding and Sediment Erosion/Deposition in Mortandad Canyon

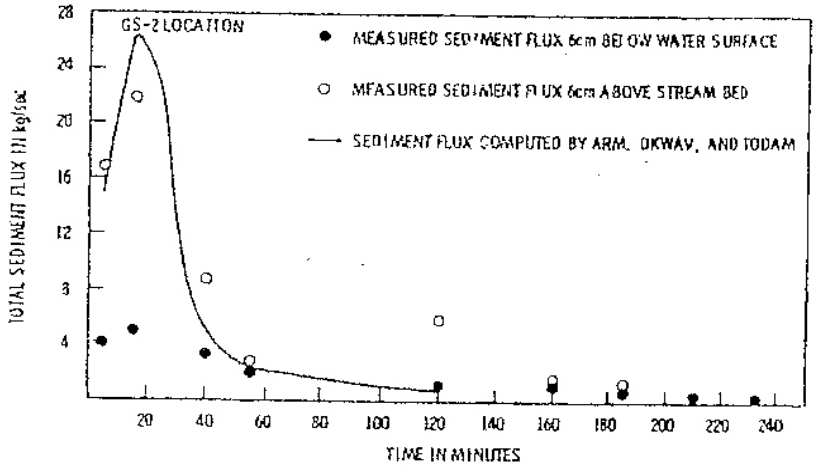
Runoff and fresh flooding



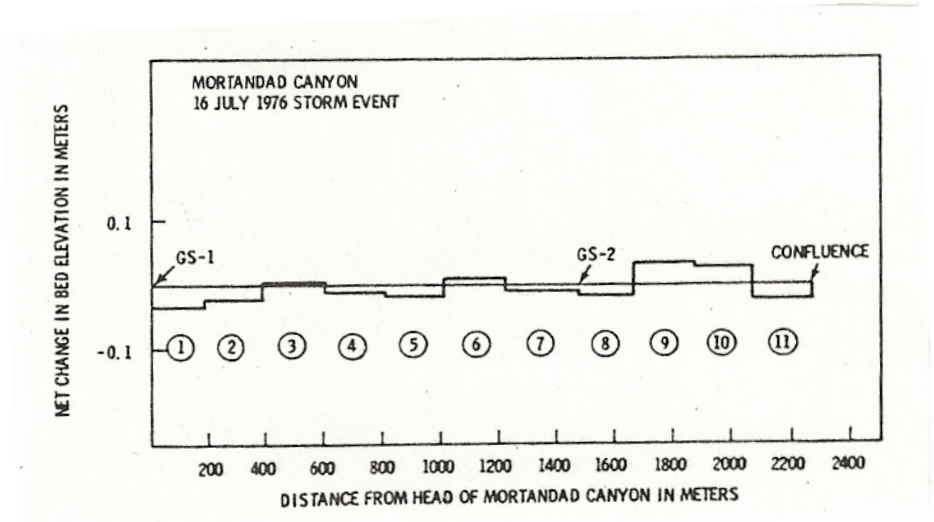
Sediment transport



Sediment flux prediction with measured data

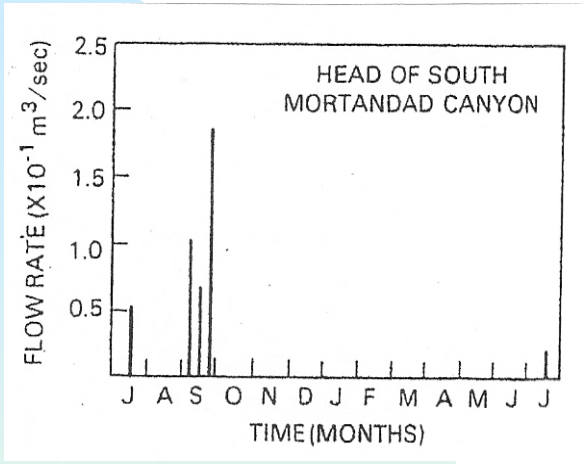


Sediment deposition

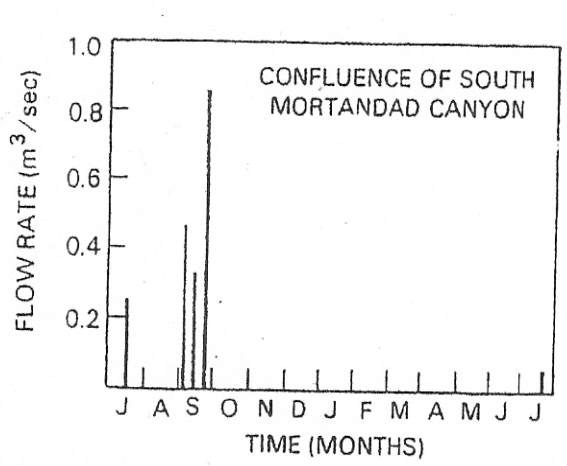


Plutonium Migration in South Mortandad Canyon

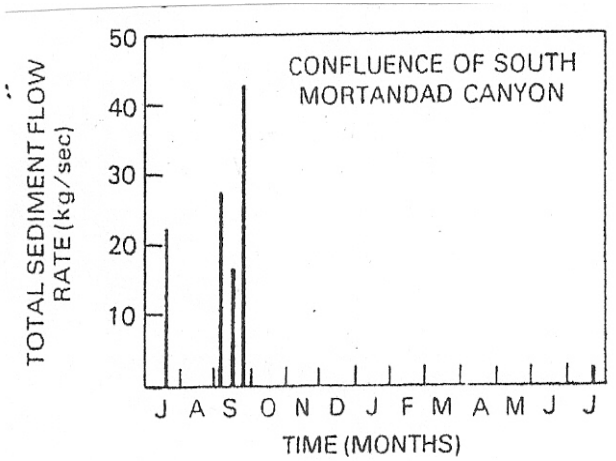
Overland runoff



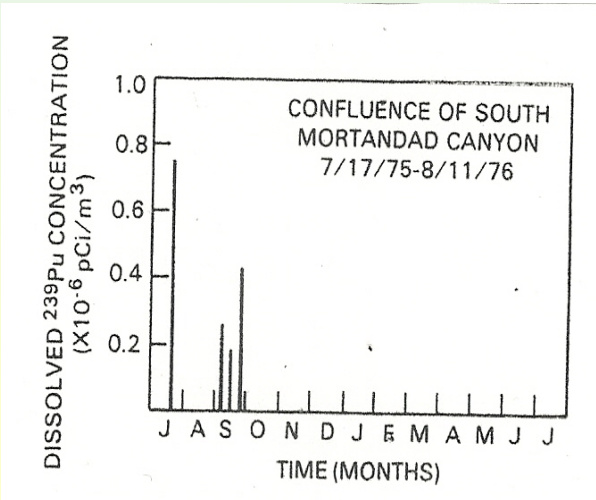
Creek flow discharge



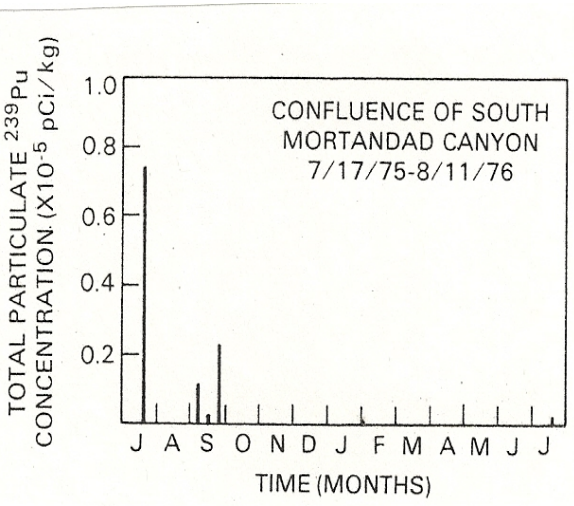
Sediment discharge



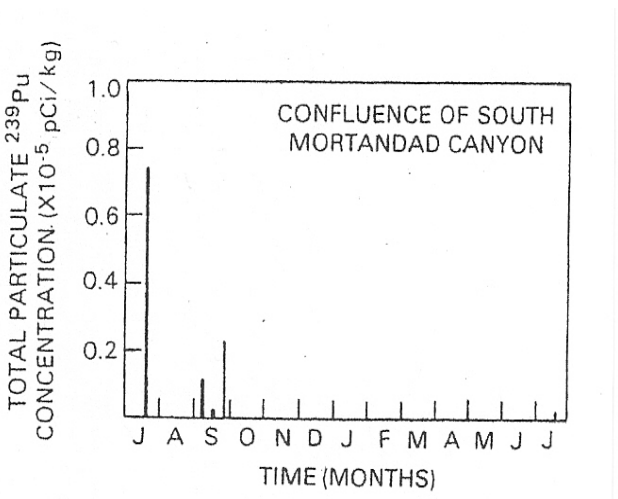
Dissolved Pu concentration



Total Pu concentration

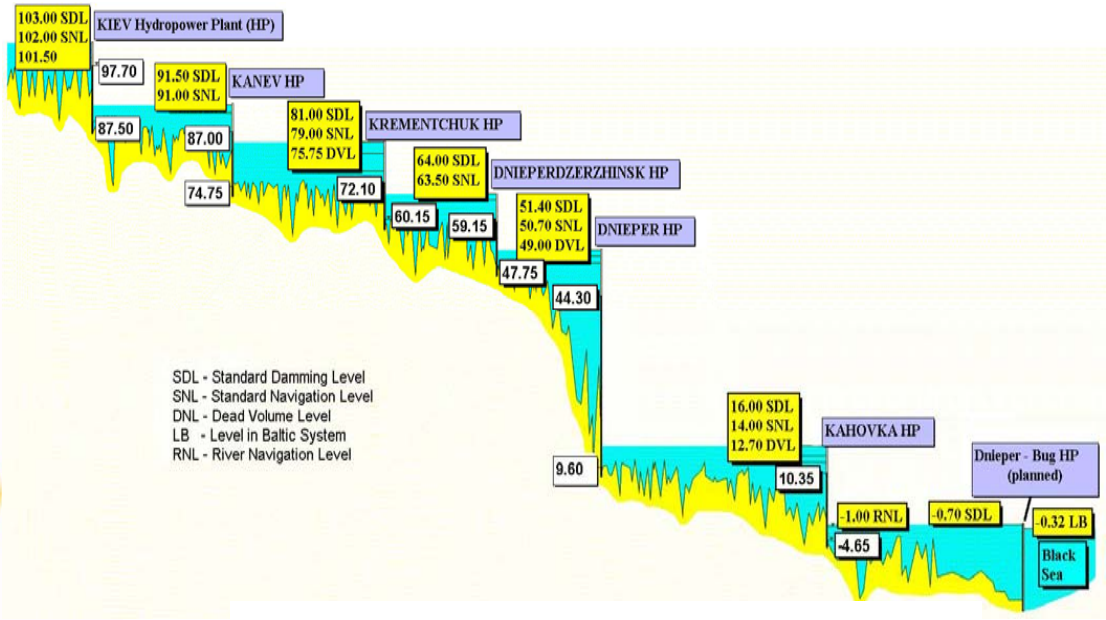


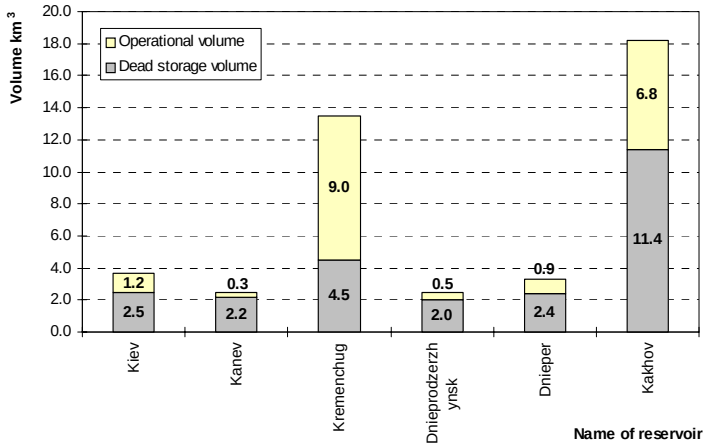
Particulate Pu concentration



Dnieper River Watershed and Six Reservoirs

How to Manage Dnieper River Reservoirs for Flood Control, Water Supply, Pollution Control





Dnieper Reservoir Management and Strategy

- Objectives
  - Flood Control
  - Secure industrial and municipal water supplies
  - Supply irrigation water for agriculture and southern Ukraine
  - Keep good water quality
  - Protect People's health from radionuclides and toxic chemicals
  - reduce saltwater intrusion and waterlogging

- Basic strategy of flood control
  - Empty reservoirs before spring floods at the level adequate to the forecasted flood volume
  - Fill reservoirs during the spring flood periods
  - Subsequent emptying reservoirs until next spring floods come