A RISK-BASED SCREENING ANALYSIS FOR RADIONUCLIDES RELEASED TO THE COLUMBIA RIVER FROM PAST ACTIVITIES AT THE U.S. DEPARTMENT OF ENERGY NUCLEAR WEAPONS SITE IN HANFORD, WASHINGTON

Prepared by *Risk Assessment Corporation* (*RAC*) for the Centers for Disease Control and Prevention

The Hanford Environmental Dose Reconstruction (HEDR) Project calculated doses to offsite members of the public from past releases of five radionuclides to the Columbia River from the Hanford Nuclear Site in Washington State between 1944 and 1972. Those five radionuclides were: sodium-24 (^{24}Na), phosphorus-32 (^{32}P), zinc-65 (^{65}Zn), arsenic-76 (^{76}As), and neptunium-239 (^{239}Np). The objective of this work was to develop a risk-based *screening* methodology to determine if doses from the most significant radionuclides released into the Columbia River had been calculated in the HEDR Project. Using this methodology we screened an additional 18 radionuclides that were released into the Columbia River to ensure a comprehensive evaluation.

> ***Screening*** *refers to the process that identifies potentially significant radionuclides or exposure pathways by eliminating those with health risks of probable lesser significance.*

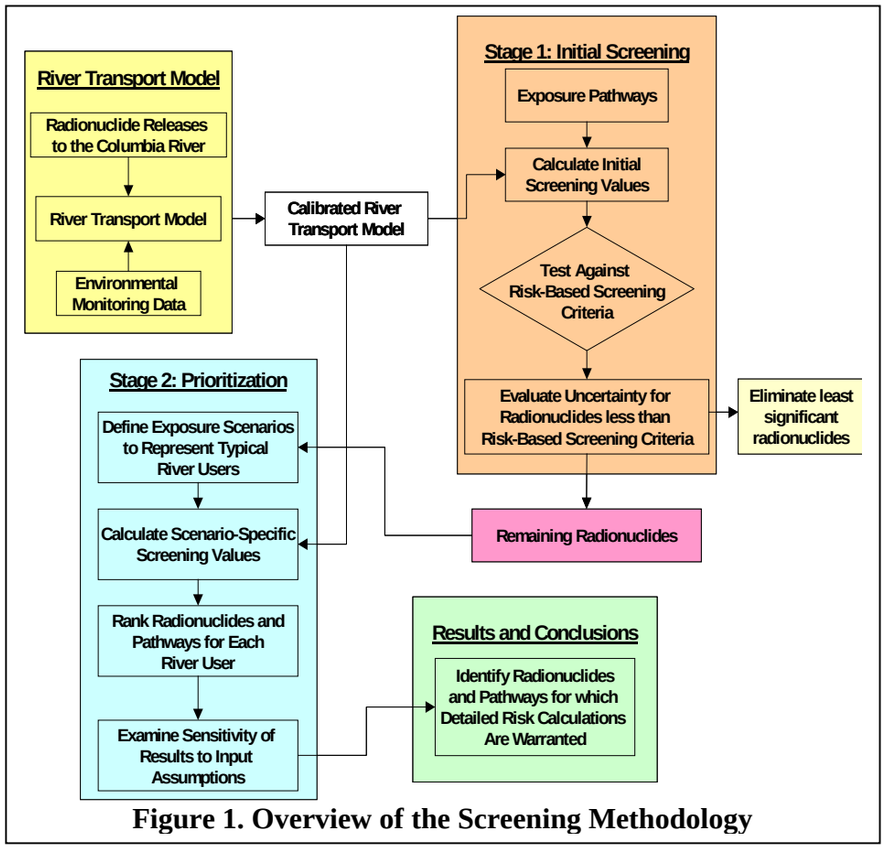

Figure 1. Overview of the Screening Methodology

A two-stage screening process (Figure 1) was developed to determine the most significant radionuclides. The initial screening stage was designed to estimate the maximum lifetime cancer incidence risks for each of the 23 radionuclides. These estimates are called screening values. A computer model was developed to calculate concentrations of radionuclides in water and sediment downstream from the reactors at the Hanford Nuclear Site.

We used the HEDR Project estimates of monthly radionuclide releases to the Columbia River from October 1944 to February 1971 as inputs. When monthly release estimates were unavailable, we based estimates on historical data compiled during the HEDR Project. Historical measurements of radionuclide concentrations in water, sediment, and fish were then used to calibrate the computer model. We determined that the highest radionuclide concentrations in river water and river sediment at a location where a person may have been exposed were at Richland. Therefore, we used river water concentrations at Richland to calculate all exposures during the entire time of the releases to ensure that the potential risks were not underestimated.

> ***Exposure Pathways*** *are the ways in which a person might have been exposed to radionuclides released into the Columbia River.*

Exposure pathways were identified to account for the different types of river users, activities, and practices that may have resulted in exposure to radioactive materials released into the Columbia River. Consideration was given to potential exposures to Native American tribes because they lived near the river and because their lifestyle activities were intimately linked with the river. The following exposure pathways were considered:

- Drinking river water
- Swimming in river water
- Accidentally drinking river water while swimming
- Eating meat from cattle that consumed river water
- External irradiation from shore sediments
- Exposure to sediments on the skin's surface
- Drinking milk from cows that consumed river water
- Accidental ingestion of sediments
- Breathing in aerosols of river water
- External irradiation while boating
- Eating produce irrigated with river water
- Eating waterfowl
- Eating fish from the river

Using the computer model, screening values were calculated for the initial screening scenarios. We recommended that all radioactive materials with lifetime cancer incidence risks less than one chance in ten thousand (10^{-4}) be removed from further consideration. To avoid eliminating a radioactive material when it should have been retained, the uncertainty associated with the screening values also was assessed. Fifteen radionuclides were carried through to the second stage for more detailed analysis (Figure 2).

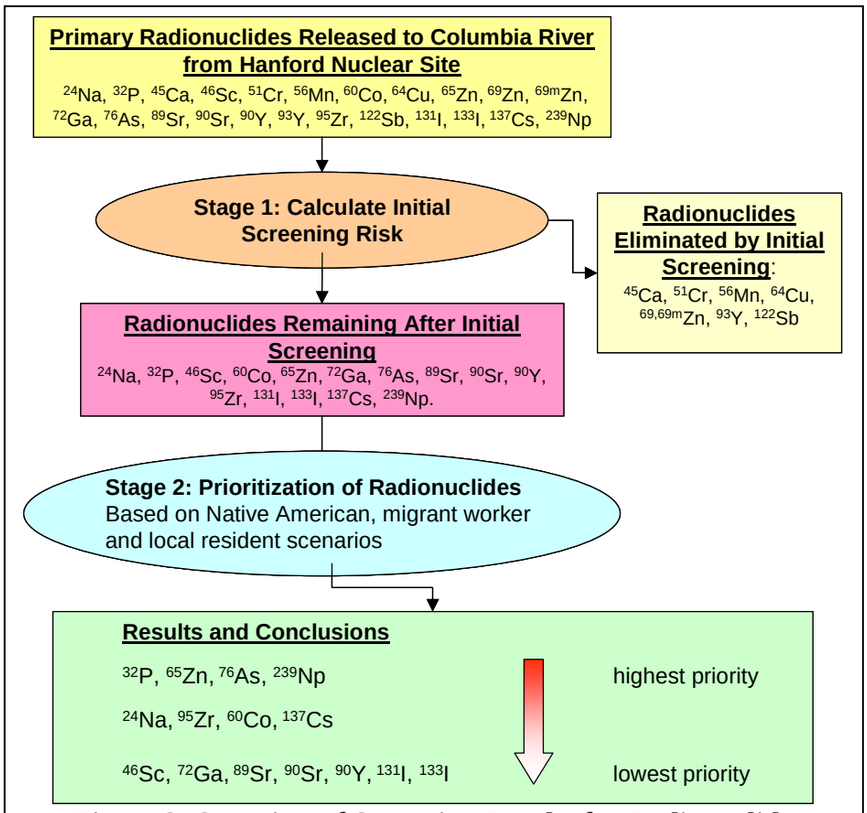

Figure 2. Overview of Screening Results for Radionuclide Releases to the Columbia River

In the second stage of the screening process, three exposure scenarios were defined to represent the different habits and activities of the most exposed river users: Native American, local resident, and migrant worker. The *parameter values* for the scenarios were selected to represent a more typical individual in the group rather than the most exposed individual. The focus was on assigning the parameter values consistently to allow the relative importance of the 15 radioactive materials and the most important exposure pathways to be identified. Again, the screening values were expected to overestimate actual risks because the representative individuals were assumed to be located in Richland and were exposed throughout the entire period of releases from the Hanford Nuclear Site.

Parameter values *are numeric values (such as how much fish a person ate) that determine a person's radiation exposure risk.*

For all three scenarios, ^{76}As accounted for the highest exposure risk. The Native American scenario had the highest calculated screening values; the local resident scenario, the lowest. Four radioactive materials accounted for more than 80 percent of the total risk for all three scenarios. These were ^{76}As, ^{239}Np, ^{32}P, and ^{65}Zn. Therefore, we concluded that the HEDR Project made detailed dose calculations for the most significant radionuclides.

The HEDR Project also calculated doses for ^{24}Na, which we identified as belonging to the next most significant group of radionuclides, together with cobalt-60 (^{60}Co), zirconium-95 (^{95}Zr), and cesium-137 (^{137}Cs) (Figure 2). These radionuclides consistently accounted for a few percentage points of the total risk in all three scenarios. The screening results did not indicate that the HEDR Project should have made dose calculations for iodine-131 (^{131}I) and strontium-90 (^{90}Sr), as had been suggested. They were identified as low priority in all exposure scenarios. We accounted for the consumption of whole fish, including the bones, by Native Americans to address the concern that strontium accumulates in bone.

The screening results also supported the HEDR Project conclusions that fish ingestion was the dominant exposure pathway for releases into the Columbia River and that most of the exposure occurred between 1952 and 1964, the years of highest releases from the Hanford reactors. However, it is likely that the significance of fish ingestion for Native American users of the river was underestimated in the HEDR Project based on information about fish consumption by Native Americans, which area tribes summarized for CDC in greater detail than the earlier information available to the HEDR Project. This information has been provided to The Agency for Toxic Substances and Disease Registry (ATSDR) for possible future study.

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For further information or to obtain a full copy of the report in print or on CD ROM please contact the Centers for Disease Control and Prevention, Division of Environmental Hazards & Health Effects, Radiation Studies Branch, 4770 Buford Highway NE, MS E-39, Atlanta, GA 30341-3724. Tel: (404) 498-1800 or visit our website at www.cdc.gov/nceh/radiation/brochure/profile_Hanford.htm.

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