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

EXECUTIVE SUMMARY

The Hanford Environmental Dose Reconstruction (HEDR) Project reconstructed doses to offsite members of the public resulting from radionuclide releases since 1944 from operation of U.S. Government facilities at the Hanford Nuclear Site, in Washington State. This report focuses on radionuclide releases to the Columbia River only. Initially, the HEDR Project considered all radionuclides released to the Columbia River between 1944 and 1972. Following a series of scoping calculations, doses were calculated for five radionuclides: sodium-24, phosphorus-32, zinc-65, arsenic-76, and neptunium-239. The radionuclide exposure pathways were also selected on the basis of scoping calculations.

In a review of the HEDR dose estimates for the Agency for Toxic Substances and Disease Registry (ATSDR), it was suggested that ^{131}I, ^{60}Co, and ^{90}Sr should have been included in the HEDR dose calculations for the Columbia River. The objective of this report is to develop and apply a risk-based screening methodology that can be used to evaluate this recommendation. However, the screening methodology is applied to 23 radionuclides to ensure a comprehensive evaluation, rather than limiting the screening to only the 5 HEDR radionuclides with dose estimates and the 3 radionuclides identified in the ATSDR review.

A two-stage screening methodology is developed. In the first-stage, radionuclides and pathways are compared with a predefined risk-based screening value. Only those radionuclides and pathways with screening values above the screening criterion are considered further in the analysis. Conservative assumptions[1] are made to characterize the exposure pathways and the radionuclide parameter values to ensure that no potentially important ones are removed from the analysis. Eight exposure pathways are considered. These are designed to account for the different types of individuals, activities, and practices that may have resulted in exposure to radionuclides released to the Columbia River. Explicit consideration is given to Native American tribes potentially impacted by releases from the Hanford Site because they lived in close proximity to the river and their lifestyle activities were intimately linked with the river. Due to the conservative assumptions, the screening values are generally over estimates of risk to the most at-risk individuals and are expected to overestimate the risks to all real individuals.

In the second-step, exposure scenarios are defined to represent the most exposed river users. More than one exposure scenario is required because of the differing habits and activities of the various river users. Three exposure scenarios are developed: Native American, local resident, and migrant worker. The risk-based screening values do not represent an actual risk because there is

[1] A conservative assumption in this type of analysis is one that is unlikely to underestimate the exposure to a certain nuclide, but may, in fact, overestimate the exposure to that nuclide. For example, if it is known that the average person on the river spent between 2 and 8 hours a day by the riverside, a conservative assumption might be that we assume everyone spent 8 hours a day there.

still significant conservatism built into the calculations. The conservatism includes factors such as location and time. However, because this is consistent across pathways, we can develop a relative ranking and, therefore, prioritization of the radionuclides and exposure pathways

A 2-dimensional advection-dispersion river transport model is developed to calculate radionuclide concentrations in river water and sediment from the downstream Hanford Site boundary to the McNary Dam below the confluence of the Snake River. Transport of radionuclides in both the dissolved and sorbed phase is considered, and is coupled to conservative assumptions for receptor exposure pathways to estimate screening risk values. The river transport model is calibrated to measured river water and sediment concentrations.

An absolute risk-based criterion of 10^{-4} is recommended[2] for the initial screening of 23 radionuclides released to the Columbia River from the Hanford Nuclear Site. Application of this criterion identifies 4 radionuclides (^{45}Ca, ^{51}Cr, ^{93}Y, and ^{122}Sb) that can be removed from further consideration. It also identifies a number of exposure pathways that can be eliminated from the analysis including external exposure to contaminated sediments, ingestion of contaminated sediments and inhalation of contaminated aerosols. Combined, these pathways contribute less than 0.5% to the total screening risk value calculated for all pathways. Of the remaining pathways, exposure to contaminated sediments through dermal contact, and ingestion of contaminated river water during swimming are low priority.

The screening results support the HEDR Project conclusion that fish ingestion is the dominant exposure pathway for releases to the Columbia River. For most radionuclides, fish ingestion is the dominant exposure pathway, in a few cases (^{56}Mn, ^{93}Y, ^{133}I) water ingestion is dominant, and for ^{24}Na, boating is the dominant pathway. For total risk (all nuclides), fish ingestion accounts for over 90% of the total risk. Most of the exposure is incurred over the years 1952 to 1964. These years correspond to the years of highest release from the Hanford reactors.

The relative ranking of radionuclides in the second-stage screening based on the 3 scenarios (local resident, migrant worker, and Native American) shows that some radionuclides are more significant than others. In all 3 scenarios, ^{76}As is the highest contributor to risk. In addition to the five radionuclides (^{76}As, ^{32}P, ^{239}Np, ^{65}Zn, and ^{24}Na) for which detailed dose calculations were made in the HEDR Project, ^{69}Zn and ^{95}Zr emerge as important risk contributors for all 3 scenarios. Strontium-89 and ^{90}Sr are important for the Native American scenario where they contribute ~16% and ~5%, of the total risk, respectively, because consumption of whole fish rather than fish filets is assumed. If further evaluation of risks from radionuclides released to the Columbia River is undertaken, these nine radionuclides should be considered as most important for the analysis.

The significance of fish ingestion for Native American users of the river may have been underestimated in the HEDR Project because fish consumption rates reported for Native Americans tend to be higher than the value assumed for the maximum representative individual in the HEDR Project. Furthermore, contrary to the HEDR assumptions, it is reasonable to assume the entire fish was consumed which increases the dose and risk for a number of radionuclides, in particular ^{89,90}Sr. The second-stage screening also indicates that ^{60}Co can be eliminated from further analysis because it contributes <1% to the total risk for all pathways in all 3 scenarios.

[2] We apply this screening value to demonstrate its application, and its use does not represent endorsement by the Centers for Disease Control and Prevention.