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TITLE: SIMULATING A MULTISPECTRAL NEUTRON LOGGING INSTRUMENT TO MAP ENVIRONMENTAL CONTAMINANTS

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Simulating a Multispectral Neutron Logging Instrument to Map Environmental Contaminants

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The primary purpose of the Multispectral Neutron Logging project is to assess the effectiveness of applying of neutron-induced spectral gamma-ray logging techniques to map environmental contaminants along boreholes, adapt the technology to further improve this capability, and to transfer that technology to industry. Multispectral neutron logging instruments use a pulsed 14-MeV neutron source and a HPGe detector to detect discrete energy gamma-rays from thermal-neutron capture reactions. These discrete energy gamma-rays are used to identify and estimate the concentration of nuclides in the formation. This type of technique is potentially useful for environmental restoration, where characterization of contaminated sites is required before cleanup can begin and long-term monitoring is needed for many years following cleanup or stabilization. Nuclear borehole logging techniques have advantages and disadvantages that are complementary to those of physical sampling, which can help address some of the drawbacks of physical sampling. These drawbacks include high costs, lengthy delays in obtaining results of analyses from overburdened laboratories, under sampling, sample handling problems, and ambiguity in long-term monitoring.

Since performing experimental tests for a large number of contaminants is not feasible, given the high cost and environmental issues associated with eventual disposal of contaminated materials, an enhanced version of MCNPTM was tested and benchmarked with experimental data. MCNP must be benchmarked against experimental data to show that the code can accurately estimate minimum detection thresholds for a variety of contaminants. Once the code has been benchmarked, computer simulations may then be used to estimate detection thresholds for a large number of contaminants for which experimental tests will not be performed.

Computer simulations performed over the past year indicated a number of areas in which the code and cross-section libraries could be improved to optimize them for type of project. A number of enhancements to MCNP have been developed for this project that will tally the photon flux for individual nuclides as well as the total, estimate the flux

difference due to changes in material specification, and allow online analysis of the simulation. Of particular importance is the representation of photon-production from thermal-neutron capture reactions. For most nuclides, the photon-production spectrum is binned in 250-keV energy bins, where the strength of each bin represents the sum of the strengths of the gamma-rays present over that energy range. A number of cross-section libraries have been modified to include the discrete energy gamma-rays from thermal-neutron capture reactions. Figure 1 shows a sample energy region from the computer simulations for cadmium using both the standard and modified cross-section library. Preliminary results from the computer simulations indicate that minimum detection thresholds of 1 ppm, 0.02 ppm, and 80 ppm for mercury, cadmium and chlorine respectively might be obtained by further optimizing the prototype design. Additional enhancements such as a larger and more efficient detector, a more intense neutron source, and advanced data processing are available currently and could be applied relatively easily.

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**Figure 1. Capture Spectrum for Cadmium using the
Standard and Modified Cross-section Libraries with MCNP**

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