Radiological Data Methodologies

DOSE CALCULATION - ATMOSPHERIC RELEASE PATHWAY

The effective dose equivalent for low levels of airborne radioactive materials dispersed into the environment was calculated for each of the 16 compass sectors using the CAP88-PC, version 2.0 dose model program (EPA 1992). Site meteorology data were used to calculate annual dispersions for the midpoint of a given sector and distance. Facility-specific radionuclide release rates (in curies per year [Ci/yr]) were also used. All annual site boundary and collective dose values were generated using the CAP88-PC v.2 computer code, which calculates the total dose due to contributions from the immersion, inhalation, and ingestion pathways. The dose and risk estimates were based on low levels of chronic intake of radionuclides.

DOSE CALCULATION - FISH INGESTION PATHWAY

To estimate the effective dose equivalent from the fish consumption pathway, the following procedure was used:

Intake.

The average fish consumption for an individual engaged in recreational fishing in the Peconic River was based on a study done by the New York State Department of Health (NYSDOH 1996), which estimates the consumption rate at approximately 15 pounds (7 kg) per year.

Activity in Flesh.

Radionuclide data for fish samples were all converted to picocuries per gram (pCi/g) wet weight, since this is the form in which the fish are caught and consumed.

Dose Factor.

DOE Order 5400.5 (1990) 50-year committed dose equivalent factors (in rem per microcurie [rem/µCi] intake) were applied. The committed dose equivalent factor for Cs-137 is 5.0E-02 rem/µCi.

Calculation:

$$\textbf{Dose}\text{ (rem/yr)} = \textbf{Intake}\text{ (kg/year)} \times \textbf{Activity in Flesh}\text{ (}\mu\text{Ci/kg)} \times \textbf{Dose Factor}\text{ (rem/}\mu\text{Ci)}$$

DOSE CALCULATION - DEER MEAT CONSUMPTION

This calculation is performed in exactly the same way as shown in the previous section. The same DOE Order 5400.5 dose conversion factors are used. The only change is the estimate of total pounds ingested during the course of a year. For deer meat, the consumption rate of 64 pounds (29 kg) per year is based on the Environmental Protection Agency *Exposure Factors Handbook* (EPA 1996).

RADIOLOGICAL DATA PROCESSING

Radiation events occur in a random fashion such that if a radioactive sample is counted multiple times, a distribution of results will be obtained. This spread, known as a Poisson distribution, will be centered about a mean value. If counted multiple times, the background activity of the instrument (the number of radiation events observed when no sample is present) will also be seen to have a distribution of values centered about a mean. The goal of a radiological analysis is to determine whether the sample in question contains activity in excess of the instrument or method blank background. Since the activity of the sample and the background are both Poisson distributed, subtraction of background activity from the measured sample activity results in a value that may vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) was established to determine the statistical likelihood that the sample contains activity that is truly greater than the instrument background.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. As with most laboratories, the BNL Analytical Services Laboratory sets its acceptance of a Type I error at 5 percent when calculating the MDL for a given analysis. That is, for any value that is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values that are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all validated or verified radiological data are reported, regardless of their value.

At very low sample activity levels that are close to the instrument background, it is possible to obtain a sample result that is less than zero. This occurs when the background activity is subtracted from the sample activity to obtain a net value, and a negative value results. Due to this situation, a single radiation event observed during a counting period could have a significant effect on the average (mean) value result. Subsequent analysis may produce a sample net result that is positive. All results must be averaged; therefore, all negative values are retained for reporting as well. This data handling practice is consistent with the guidance provided in the *Handbook of Radioactivity Measurements Procedure,* NCRP Report No. 58 (NCRP 1985), and the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance,* DOE/EH-0173T (1991). Typical MDLs for the various analyses performed on environmental and effluent samples are shown in Tables C-1, C-2, and C-3.

Table C-1. Typical Minimum Detection Limits for Gross Activity and Tritium Concentrations in Water.

Analysis	**Aliquot** (mL)	**MDL** (pCi/L)
Gross alpha	100	4
	200	1
Gross beta	100	9
	200	2
Tritium	1	3,900
	7	350

Table C-2. Typical Minimum Detection Limits for Gamma Spectroscopy Analysis.

Nuclide	**300 g Soil** (mCi/mL)	**300 mL Water** (mCi/mL)	**3L Marinelli** (mCi/mL)
Be-7	7E-08	1E-07	1E-08
Na-22	9E-09	1E-08	1E-09
K-40	2E-07	2E-07	2E-08
Sc-48	1E-08	1E-08	3E-08
Cr-51	8E-08	1E-07	1E-08
Mn-54	8E-09	1E-08	1E-09
Mn-56	2E-07	3E-07	2E-08
Co-57	7E-09	9E-09	1E-09
Co-60	1E-08	1E-08	1E-09
Zn-65	2E-08	2E-08	2E-09
Cs-134	1E-08	1E-08	1E-09
Cs-137	9E-09	1E-08	1E-09
Ra-226	3E-08	3E-08	4E-08
Th-228	2E-08	3E-08	1E-07
Br-82	1E-08	2E-08	8E-08
I-131	9E-09	1E-08	3E-09
I-133	1E-08	2E-08	3E-09

Note: All MDLs shown above are approximate. For gamma spectroscopy, the MDL of the analysis is dependent upon several variables, such as the efficiency of the particular detector and the activity of the sample. These factors will vary between analyses and instrumentation.

Table C-3. Typical Minimum Detection Limits for Chemical Analyses by BNL Analytical Services Lab and Off-Site Analytical Laboratories.

Constituent	**BNL Laboratory**	**Offsite Laboratories**
Ag	0.025	0.010
Cd	0.0005	0.005
Cr	0.005	0.010
Cu	0.050	0.025
Fe	0.075	0.100
Hg	0.0002	0.0002
Mn	0.050	0.015
Na	1.0	5.0
Pb	0.005	0.003
Zn	0.02	0.020
Ammonia-N	NA	0.02
Nitrite-N	NA	0.01
Nitrate-N	1.0	NA
Specific Conductance	10 mmhos/cm	NA
Chlorides	4.0	NA
Sulfates	4.0	NA
1,1,1-trichloroethane	0.002	0.005
trichloroethylene	0.002	0.005
tetrachloroethylene	0.002	0.005
chloroform	0.002	0.005
chlorodibromomethane	0.002	0.005
bromodichloromethane	0.002	0.005
bromoform	0.002	0.005
benzene	0.002	0.005
toluene	0.002	0.005
xylene	0.002	0.005

Notes:
All concentrations in mg/L except where noted.
NA = Not Applicable (Laboratory does not perform analysis for constituent)

Average values are calculated using actual analytical results, regardless of whether they are above or below the MDL, or even equal to zero. The uncertainty of the mean, or the 95 percent confidence interval, is determined by multiplying the population standard deviation of the mean by the $t_{(0.05)}$ statistic.

REFERENCES

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