Department of Energy

St. Louis Site Office
9170 Latty Avenue
Berkeley, MO 63134
(314) 524-4083

08/27/97
116-EPA-EAM-000027
SL-1253

Mr. Larry Erickson
Missouri Department of Natural Resources
P.O. Box 176
Jefferson City, Missouri 65102-0176

Dear Mr. Erickson:

RESPONSE TO MISSOURI DEPARTMENT OF NATURAL RESOURCES' COMMENTS ON THE REMEDIAL ACTION PLAN FOR BUILDINGS AT THE ST. LOUIS DOWNTOWN SITE

The purpose of this letter is to address Missouri Department of Natural Resources'(MDNR) concerns regarding the remedial action plans for buildings at the St. Louis Downtown Site (SLDS). Additionally, this letter is intended to clarify the Department of Energy's (DOE) position on the technical issues identified by MDNR after review of the demolition work plan and the supporting National Emission Standards for Hazardous Air Pollutants (NESHAPS) calculation.

As you are aware, activities are currently underway at the site to demolish SLDS Buildings 100, 116, 117, 700, and 704 through 708. These activities will also include the size reduction or crushing of building rubble. The current plan for crushed building rubble, with radionuclide concentrations below the SLDS site specific DOE guidelines for radioactive contaminants in soil, is to stockpile the material to ultimately use as backfill material after future subgrade excavations at SLDS.

During the planning and design process for the building demolition at SLDS, various data were compiled and reviewed. This included a review of historical information for each building, direct and tranferable contamination surveys for residual radioactivity on building surfaces, determination of the isotopic uranium concentrations of representative test cores, and the calculation of the potential doses to demolition workers or members of the public that would result from exposure to airborne radioactively contaminated particles resulting from the work activities. Concurrent with MDNR briefings on the demolition plans, copies of all the above data and evaluation have been provided for your review.

Your recent correspondence identified several questions and concerns regarding the methods and assumptions utilized to calculate the resulting uranium concentration in rubblized building debris, as well as the estimated doses resulting from the demolition activity. The assumptions made when calculating these values are based on Environmental Protection Agency (EPA) protocol, specifically, the EPA Office of Air Quality and Standards, *Compilation of Air Pollutant Emission Factors, Fifth Edition*, 1995, and the EPA Office of Radiation Programs, *Clean Air Assessment Package (CAP88)*, 1988. When performing these calculations, all assumptions were validated or assumed to be " worst-case-scenario" in order to provide conservative estimates of radionuclide concentrations or potential doses. These calculations have been performed for the subject buildings, and a completed calculation package is enclosed, showing the steps involved in deriving these values. For these buildings, it was shown that maximally exposed individuals outlined in the calculation would receive less than 1 millirem (mrem) per year above naturally occurring background from airborne radioactively contaminated particles. The derivation of the radionuclide concentrations utilized in this calculation is also outlined. The concentration of residual uranium in crushed building rubble is shown to be to be less than 1 pCi/g above naturally occurring background. The calculation procedure, in addition to the input parameters, are shown on page three of the enclosed calculation package.

More than ninety percent of the residual radioactive contamination associated with these buildings is on the floors. The floor slabs of these buildings are not included in the current demolition work scope. At the conclusion of the current demolition activities, the slabs will have a fixative material applied to the surface followed by a gravel layer, to ensure contamination is not transferred during the interim period. The floor slabs will then remain in place until future remedial action is performed on subgrade soils. The radioactive contamination associated with the slabs will be assessed at that time to determine the appropriate disposal option and potential exposures.

An exhaustive research of the process history, including review of process documentation and employee interviews, has concluded that work with radioactive materials in the buildings currently being demolished was limited to the production of uranium tetrafluoride or "green salt". Direct and transferable readings collected during preremediation surveys indicate primarily beta contamination. Isotopic radionuclide analytical results further demonstrate that uranium is the contaminant of concern. These analytical results have also shown that the uranium present is in natural abundance and is neither depleted nor enriched. As you have requested, in order to verify the similarity of processes within the buildings, a representative core from each building has been obtained and is being analyzed for verification. These results will be forwarded as soon as they are available.

In order to facilitate your evaluation of upcoming remediation plans and characterizations, I have enclosed a "Data Checklist" which outlines the items which will be forwarded to you. Please review the checklist and provide any additions or comments to Joe Wood at (314) 524-4083.

Sincerely,

S. H. McCracken
DOE Site Manager

Enclosures (2):

1. Draft Data Checklist
2. Calculation 116-CV-018, Dose From Demolition of Buildings 100, 116,117,700,704 - 708 SLDS

cc: Mr. Dan Wall, USEPA Region VII

PROPOSED DATA CHECKLIST

1. Work Plan

2. Project Schedule

3. Representative Characterization Data
   - radiation survey data
   - waste classification data
   - process knowledge specific to area of remediation

4. Applicable Calculations
   - NESHAPS
   - Volume
   - Specific Activity

5. Applicable References
   - Official Correspondence (designation letters, remediation guidelines, etc.)

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE	6/26/97	CALC. NO.	116-CV-018	REV.	0
				CHECKED	MMC	DATE	6/30/97
PROJECT	FUSRAP - SLDS			JOB NO.	14501	SHEET	1 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS						

PURPOSE

This calculation estimates the inhalation dose from airborne radioactivity releases at the St. Louis Downtown Site (SLDS) generated during demolition and subsequent crushing of buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708. Throughout the remainder of this calculation these nine buildings will be referred to as the buildings.

SCOPE

This calculation uses results of surface radiation surveys to calculate radioactive concentrations of building materials. These concentrations are then used to calculate radioactivity releases associated with the demolition and crushing of the buildings and inputs them to the Clean Air Act Assessment Package - 1988 - Personal computer (CAP88-PC) model to estimate air doses to the hypothetical maximally exposed individual.

REFERENCES

Bechtel National, Inc. (BNI), 1990. *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site in St. Louis, Missouri*, DOE/OR/20722-258, Revision 1, Oak Ridge, TN (September).

BNI, 1995. "Natural Uranium Specific Activity," 14501-191-CV-005 rev 2, Oak Ridge, TN.

BNI, 1997. "SLD - Building Demolition Volume Estimate," 116-I0A-GET-00003, Oak Ridge, TN (April).

Environmental Protection Agency (EPA), 1992. *User's Guide for CAP88-PC, Version 1.0*, 402-B-92-001, Office of Radiation Programs, Las Vegas, NV (March).

EPA, 1995. *Compilation of Air Pollutant Emission Factors, Fifth Edition*, AP-42, Office of Air Quality and Standards, Research Triangle Park, NC (January).

EPA, 1988. *Gap Filling PM10 Emission Factors for Selected Open Dust Sources*, EPA-450/4-88/003, Office of Air Quality and Standards, Research Triangle Park, NC (February).

National Oceanic and Atmospheric Administration (NOAA), 1996. *Preliminary Local Climatological Data for St. Louis, MO*, National Climatic Data Center, Ashville, NC.

Shleien, B., 1992. *The Health Physics and Radiological Health Handbook, Revised Edition*, Scinta Inc., Silver Springs, MD.

ASSUMPTIONS

The building demolition process includes the mechanical dismemberment of the structure, debris loading, and onsite demolition equipment traffic. The debris crushing process can be approximated by the tertiary stone crushing process used in quarries.

The work area for the demolition and crushing of the buildings is the entire area of SLDS containing the buildings and their surrounding grounds. This area is approximately equal to 8100 m^2.

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE	6/26/97	CALC. NO.	116-CV-018	REV.	0
				CHECKED	MRL	DATE	6/30/97
PROJECT	FUSRAP - SLDS			JOB NO.	14501	SHEET	2 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS						

The maximally exposed individual is based on the nearest resident 150 meters west (W) and the nearest nonradiation worker 30 meters in all directions. Resident occupancy is 24 hr/day. Worker occupancy is 8 hr/day, 5 days/wk, 50 wk/yr.

Daughters in the decay chains of radionuclides are considered to be in secular equilibrium with their parents until a radionuclide in the chain is encountered with a measured concentration, in which case the measured concentration is used. Radium daughters are not included since the immediate daughter of Radium is Radon, a gas, which is not applicable to the analysis of particulate behavior.

Assumptions for the CAP88-PC computer model are documented in the user's guide (EPA 1992).

The radioactive contamination at SLDS is attributed to the U-238, U-235, and Th-232 decay chains in secular equilibrium. The ratio of U-238, U-234, and U-235 to total uranium is based on natural uranium (BNI 1995). The ratio of U-238 to Th-232 is based on samples collected in buildings 704, 705, 706, and 707 (BNI 1990).

The beta-gamma readings (BNI 1990) indicate the total beta-gamma contamination on the building surfaces to the full depth that the contamination penetrated into the building material. This is reasonable based on the negligible shielding provided by the building material over the small depth of contamination.

CALCULATIONS

CAP88-PC Computer Program

The CAP88-PC model is a set of computer programs, databases, and associated utility programs that estimate the dose and risk from airborne radioactivity emissions. The EPA National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance procedures for airborne radioactivity emissions at Department of Energy facilities (40 CFR 61.93a) require the use of the CAP88-PC model, or other approved procedures, to calculate the effective dose equivalents to members of the public. CAP88-PC is a Bechtel Standard Application Program, number EV101. A detailed description of CAP88-PC is provided in the user's guide (EPA 1992).

Computer Hardware Configuration

The CAP88-PC program was run on a COMPAQ Deskpro 5133 which is a pentium microcomputer running at 133 Mhz using Windows 95 and networked through a Digital Equipment Corporation VAX using PCSA/Pathworks for print and file services.

Input

The input parameters are listed in the attached "Synopsis Report." Input includes nearest resident and offsite worker (assumption), weather (NOAA 1996), and emission data calculated below.

Output

The output results are listed in the attached "Summary Report." Output includes the annual doses for individuals at given distances and direction from the source.

Test Problem

Prior to running this calculation, a test run was successfully completed using the Reactive Metals data set described in the CAP88-PC user's guide (EPA 1992).

Calculation of radionuclide concentrations for Building 100

This calculation is performed using known beta/gamma surface residual radioactivity measurement results (BNI 1990). These results are converted to pCi of total beta/gamma and then divided by the weight of the material to obtain an activity concentration of beta/gamma residual radioactivity. Based on calculated isotopic ratios the concentration of ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{235}U, and ^{232}Th are calculated.

$$\beta\gamma_{eff} = \frac{(929.03 A_w)(4.505x10^{-6}\,\beta\gamma_{w-surf}) + (929.03 A_c)(4.505x10^{-6}\,\beta\gamma_{c-surf})}{907185(W_w + W_c)}$$

$\beta\gamma_{eff}$ = Effective Beta/Gamma Activity in pCi/g
A_w = Surface Area of Walls in ft^2
A_c = Surface Area of Ceiling in ft^2
$\beta\gamma_{w-surf}$ = Wall Beta/Gamma Surface Contamination in dpm/100 cm^2
$\beta\gamma_{c-surf}$ = Ceiling Beta/Gamma Surface Contamination in dpm/100 cm^2
$W_w + W_c$ = Weight of Wall and Ceiling Material in tons (Assumed to be Crushable Material Weight)
929.03 = Conversion from ft^2 to cm^2
$4.505x10^{-6}$ = Conversion from dpm/100 cm^2 to pCi/cm^2
907185 = Conversion of tons to grams

$$\beta\gamma_{eff} = \frac{(929.03 \cdot 2670)(4.505x10^{-6} \cdot 6200) + (929.03 \cdot 1890)(4.505x10^{-6} \cdot 3800)}{907185(189)} = 5.8x10^{-4}\,\frac{pCi}{g}$$

The average concentrations ($C_{sXX###}$) of ^{238}U, ^{230}Th, ^{226}Ra, and ^{232}Th from samples taken in Buildings 704, 705, 706 and 707 (BNI 1990) where:

C_{sU238} = 55.6 pCi/g
C_{sTh230} = 1.35 pCi/g
C_{sRa226} = 0.92 pCi/g
C_{sTh232} = 0.54 pCi/g

The ratios ($R_{xx###}$) of ^{230}Th, ^{226}Ra, and ^{232}Th to ^{238}U in residual radioactive material in the buildings are the ratios of the average concentrations from Buildings 704, 705, 706 and 707.

$$R_{Th230} = \frac{C_{sTh230}}{C_{sU238}} = \frac{1.35}{55.6} = 0.024$$

$$R_{Ra226} = \frac{C_{sRa226}}{C_{sU238}} = \frac{0.92}{55.6} = 0.017$$

$$R_{Th232} = \frac{C_{sTh232}}{C_{sU238}} = \frac{0.54}{55.6} = 0.010$$

The percentage contributions ($P_{xx###}$) of ^{238}U, ^{234}U, and ^{235}U to the total specific activity of natural uranium are:

$$P_{U238} = 47.249\%$$
$$P_{U234} = 50.539\%$$
$$P_{U235} = 2.212\%$$

The ratios ($R_{xx###}$) of ^{234}U and ^{235}U to ^{238}U are the ratios of these percentages:

$$R_{U234} = \frac{P_{U234}}{P_{U238}} = \frac{50.539\%}{47.249\%} = 1.070$$

$$R_{U235} = \frac{P_{U235}}{P_{U238}} = \frac{2.212\%}{47.249\%} = 0.047$$

Based on the following information of the natural decay series of ^{238}U, ^{235}U, and ^{232}Th plus previous information in this calculation a series of equations was developed to calculate the individual radionuclide activity concentrations. ^{238}U undergoes 15 decays of which 7 are beta/gamma emitters. ^{235}U undergoes 11 decays of which 4 are beta/gamma emitters. ^{232}Th undergoes 10 decays of which 4 are beta/gamma emitters. Therefore the effective beta/gamma concentration ($\beta\gamma_{eff}$) can be distributed between concentrations of ^{238}U, ^{234}U, ^{235}U, and ^{232}Th as follows:

$$\beta\gamma_{eff} = 7 \cdot C_{U238} + 4 \cdot C_{U235} + 4 \cdot C_{Th232}$$

Substituting

$$C_{U235} = (R_{U235})(C_{U238})$$
$$C_{Th232} = (R_{Th232})(C_{U238})$$

$$\beta\gamma_{eff} = 7 \cdot C_{U238} + 4 \cdot (R_{U235})(C_{U238}) + 4 \cdot (R_{Th232})(C_{U238})$$

$$\beta\gamma_{eff} = (7 + 4 \cdot R_{U235} + 4 \cdot R_{Th232}) C_{U238}$$

$$C_{U238} = \frac{\beta\gamma_{eff}}{(7 + 4 \cdot R_{U235} + 4 \cdot R_{Th232})}$$

$$C_{U238} = \frac{5.8x10^{-4}}{(7 + 4 \cdot 0.047 + 4 \cdot 0.010)} = 8.0x10^{-5} \frac{pCi}{g}$$

Then using the concentration of ^{238}U calculated above solve for ^{234}U, ^{230}Th, ^{226}Ra, ^{235}U, and ^{232}Th.

$$C_{U234} = (R_{U234})(C_{U238}) = (1.070)(8.0x10^{-5}) = 8.6x10^{-5} \frac{pCi}{g}$$

$$C_{Th230} = (R_{Th230})(C_{U238}) = (0.024)(8.0x10^{-5}) = 1.9x10^{-6} \frac{pCi}{g}$$

$$C_{Ra226} = (R_{Ra226})(C_{U238}) = (0.017)(8.0x10^{-5}) = 1.4x10^{-6} \frac{pCi}{g}$$

$$C_{U235} = (R_{U235})(C_{U238}) = (0.047)(8.0x10^{-5}) = 3.8x10^{-6} \frac{pCi}{g}$$

$$C_{Th232} = (R_{Th232})(C_{U238}) = (0.010)(8.0x10^{-5}) = 8.0x10^{-7} \frac{pCi}{g}$$

Calculations for the remaining buildings were performed using the same equation set as those for Building 100. The following tables are summarize the input parameters and the results of the radionuclide concentration calculations:

Input Parameters Used for Calculation of Radionuclide Concentrations

Building Number	Ceiling Area ft^2	Wall Area ft^2	Average Ceiling Surface β/γ Reading $dpm/100cm^2$	Average Wall Surface β/γ Reading $dpm/100cm^2$	Weight of Crushable Material tons
100	1890	2670	3800	6200	189
116	25850	17940	13000	2600	3470
117	8700	10816	3900	1500	1384
700	12533	8424	2500	2100	1013
704	1640	7344	1400	1400	251
705	9600	23200	7600	4200	2026
706	6960	7120	5400	1000	635
707	1040	1872	2500	2600	162
708	3600	3770	920	930	282

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE	6/26/97	CALC. NO.	116-CV-018	REV.	0
				CHECKED	mrl	DATE	6/30/97
PROJECT	FUSRAP - SLDS			JOB NO.	14501	SHEET	6 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS						

Calculated Radionuclide Concentrations

Building Number	^{238}U pCi/g	^{234}U pCi/g	^{230}Th pCi/g	^{226}Ra pCi/g	^{235}U pCi/g	^{232}U pCi/g
100	8.0×10^{-5}	8.6×10^{-5}	1.9×10^{-6}	1.4×10^{-6}	3.8×10^{-6}	8.0×10^{-7}
116	5.5×10^{-5}	5.9×10^{-5}	1.3×10^{-6}	9.4×10^{-7}	2.6×10^{-6}	5.5×10^{-7}
117	2.3×10^{-5}	2.5×10^{-5}	5.6×10^{-7}	3.9×10^{-7}	1.1×10^{-6}	2.3×10^{-7}
700	3.1×10^{-5}	3.3×10^{-5}	7.4×10^{-7}	5.3×10^{-7}	1.5×10^{-6}	3.1×10^{-7}
704	3.2×10^{-5}	3.4×10^{-5}	7.7×10^{-7}	5.4×10^{-7}	1.5×10^{-6}	3.2×10^{-7}
705	5.4×10^{-5}	5.7×10^{-5}	1.3×10^{-6}	9.1×10^{-7}	2.5×10^{-6}	5.4×10^{-7}
706	4.5×10^{-5}	4.8×10^{-5}	1.1×10^{-6}	7.6×10^{-7}	2.1×10^{-6}	4.5×10^{-7}
707	2.9×10^{-5}	3.1×10^{-5}	7.1×10^{-7}	5.0×10^{-7}	1.4×10^{-6}	2.9×10^{-7}
708	1.5×10^{-5}	1.7×10^{-5}	3.7×10^{-7}	2.6×10^{-7}	7.3×10^{-7}	1.5×10^{-7}

Calculation of Radionuclide Emissions for Building 100

The radionuclide emissions is calculated using emission factors for open dust sources obtained from EPA 1988 and the tertiary crushing emission factor from EPA 1995. These are empirical factors based on the floor area (BNI 1997) of the buildings. The total particulate emission is then multiplied by the radionuclide concentrations (assumptions) to obtain the radionuclide releases for this activity.

$$E_d = 0.4536 \cdot A \cdot f_d$$
$$E_l = 0.4536 \cdot A \cdot f_l$$
$$E_e = 0.4536 \cdot A \cdot f_e$$
$$E_c = 0.4536 \cdot W \cdot f_c$$

E_d = Dismemberment Emission in kg
f_d = Dismemberment Emission Factor in lb/ft^2 0.000051 lb/ft^2 (EPA 1988 Section 10.2.2 Page 28)
E_l = Loading Emission in kg
f_l = Loading Emission Factor in lb/ft^2 0.0093 lb/ft^2 (EPA 1988 Section 10.2.3 Page 28)
E_e = Equipment Traffic Emission in kg
f_e = Equipment Traffic Emission Factor in lb/ft^2 0.01 lb/ft^2 (EPA 1988 Section 10.2.4 Page 29)
E_c = Crushing Emission in kg
f_c = Tertiary Crushing Emission Factor in lb/ton 0.0024 lb/ton (EPA 1995 Table 11.19.2.2 page 11.19.2-6)
A = Floor Area of Building in ft^2
W = Weight of Crushable Material in tons
0.4536 = Conversion for lbs to kg

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE	6/26/97	CALC. NO.	116-CV-018	REV.	0
				CHECKED	[illegible]	DATE	6/30/97
PROJECT	FUSRAP - SLDS			JOB NO.	14501	SHEET	7 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS						

The floor area (BNI 1997) and weight of crushable material (BNI 1997) for building 100 is 1890 ft^2 and 189 tons.

$$E_d = 0.4536 \cdot 1890 \cdot 0.000051 = 0.044kg$$
$$E_l = 0.4536 \cdot 1890 \cdot 0.0093 = 7.973kg$$
$$E_e = 0.4536 \cdot 1890 \cdot 0.01 = 8.573kg$$
$$E_c = 0.4536 \cdot 189 \cdot 0.0024 = 0.206kg$$

The total emission for Building 100 is:

$$E = E_d + E_l + E_e + E_c = 0.044 + 7.973 + 8.573 + 0.206 = 16.795kg$$

The radionuclide source concentrations for Building 100 listed below are those calculated earlier in this calculation.

$$C_{U238} = 8.015x10^{-5}\frac{pCi}{g}$$
$$C_{U234} = 8.576x10^{-5}\frac{pCi}{g}$$
$$C_{Th230} = 1.924x10^{-6}\frac{pCi}{g}$$
$$C_{Ra226} = 1.363x10^{-6}\frac{pCi}{g}$$
$$C_{U235} = 3.767x10^{-6}\frac{pCi}{g}$$
$$C_{Th232} = 8.015x10^{-7}\frac{pCi}{g}$$

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE	6/26/97	CALC. NO.	116-CV-018	REV.	0
				CHECKED	mrr	DATE	6/30/97
PROJECT	FUSRAP - SLDS			JOB NO.	14501	SHEET	8 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS						

Utilizing the following equations the radionuclide emission are calculated for building 100.

$$R_{U238} = E \cdot C_{u238} = 1.346x10^{-12}\,Ci$$
$$R_{Th234} = R_{U238} = 1.346x10^{-12}\,Ci$$
$$R_{Pa234m} = R_{Th234} = 1.346x10^{-12}\,Ci$$
$$R_{Pa234} = 0.9987(R_{Pa234m}) = 1.344x10^{-12}\,Ci$$
$$R_{U234} = E \cdot C_{U234} = 1.440x10^{-12}\,Ci$$
$$R_{Th230} = E \cdot C_{Th230} = 3.231x10^{-14}\,Ci$$
$$R_{Ra226} = E \cdot C_{Ra226} = 2.288x10^{-14}\,Ci$$
$$R_{U235} = E \cdot C_{U235} = 6.327x10^{-14}\,Ci$$
$$R_{Th231} = R_{U235} = 6.327x10^{-14}\,Ci$$
$$R_{Pa231} = R_{Th231} = 6.327x10^{-14}\,Ci$$
$$R_{Ac227} = R_{Pa231} = 6.327x10^{-14}\,Ci$$
$$R_{Th227} = 0.9862(R_{Ac227}) = 6.240x10^{-14}\,Ci$$
$$R_{Fr223} = 0.0138(R_{Ac227}) = 8.731x10^{-16}\,Ci$$
$$R_{Ra223} = R_{Th227} + R_{Fr223} = 6.327x10^{-14}\,Ci$$
$$R_{Th232} = E \cdot C_{Th232} = 1.346x10^{-14}\,Ci$$
$$R_{Ra228} = R_{Th232} = 1.346x10^{-14}\,Ci$$
$$R_{Ac228} = R_{Ra228} = 1.346x10^{-14}\,Ci$$
$$R_{Th228} = R_{Ac228} = 1.346x10^{-14}\,Ci$$
$$R_{Ra224} = R_{Th228} = 1.346x10^{-14}\,Ci$$

CAP88-PC Results

The CAP88-PC annual doses for the nearest resident (d_r) at 150 m north and nonradiation worker (d_w) at 30 m in all directions (the maximum nonradiation worker dose occurred in the northerly direction) are:

$$d_r = 3.4x10^{-7}\ \frac{mrem}{yr}$$

$$d_w = 8.6x10^{-6}\ \frac{mrem}{yr}$$

The occupancy factors for residents (f_r) and nonradiation workers (f_w) (assumptions) are:

$$f_r = \frac{\left(24\frac{hr}{day}\right)\left(7\frac{day}{wk}\right)\left(52\frac{wk}{yr}\right)}{\left(24\frac{hr}{day}\right)\left(7\frac{day}{wk}\right)\left(52\frac{wk}{yr}\right)} = 100\%$$

$$f_w = \frac{\left(8\frac{hr}{day}\right)\left(5\frac{day}{wk}\right)\left(50\frac{wk}{yr}\right)}{\left(24\frac{hr}{day}\right)\left(7\frac{day}{wk}\right)\left(52\frac{wk}{yr}\right)} = 23\%$$

Multiplying the annual doses by the occupancy factors, the actual doses (D_r and D_w) are:

$$D_r = f_f d_r = (100\%)\left(3.4x10^{-7}\right) = 3.4x10^{-7}\ \frac{mrem}{yr}$$

$$D_w = f_w d_w = (23\%)\left(8.6x10^{-6}\right) = 2.0x10^{-6}\ \frac{mrem}{yr}$$

SUMMARY OF RESULTS

The dose from inhalation of airborne radioactive releases of particulate matter from the demolition and crushing of the buildings at SLDS to the hypothetical maximally exposes individual (worker 30 m north) is $2.0x10^{-6}$ mrem.

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE	6/26/97	CALC. NO.	116-CV-018	REV. 0
PROJECT	FUSRAP - SLDS			JOB NO.	14501	CHECKED DATE 6/30/97
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS					SHEET 9 of 17

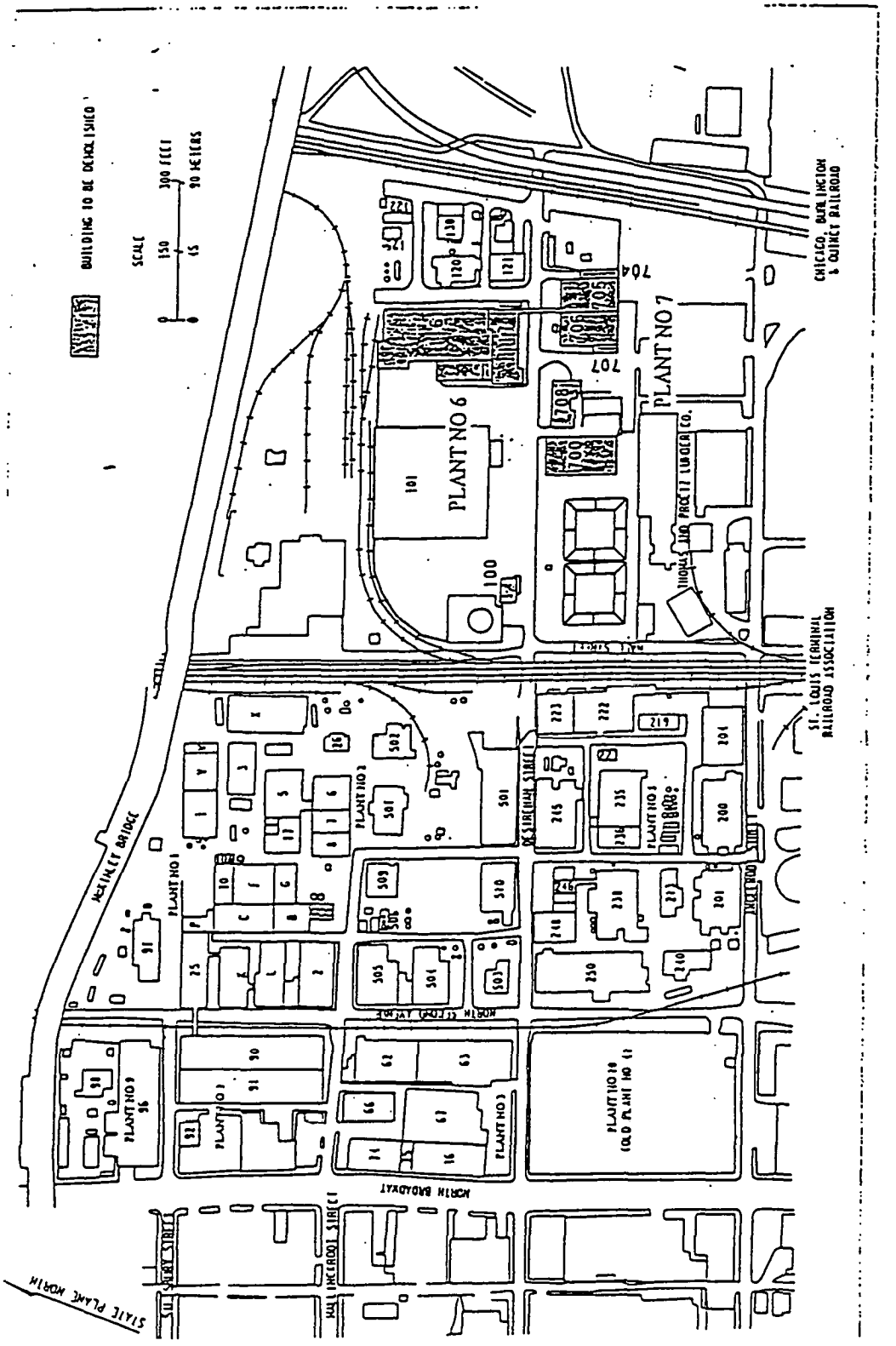
Calculations for the remaining buildings were performed using the same equation set as those for Building 100. The following table is a summary of the input parameters and the results of the radionuclide emission calculations:

Building	100	116	117	700	704	705	706	707	708	Total
INPUT PARAMETERS										
Area - ft^2	1890	25850	8700	12533	1640	9600	6960	1040	3600	[redacted]
Mass - tons	189	3470	1384	1013	251	2026	635	162	282	[redacted]
f_d - lb/ft^2	0.000051	0.000051	0.000051	0.000051	0.000051	0.000051	0.000051	0.000051	0.000051	[redacted]
E_d - kg	0.044	0.598	0.201	0.290	0.038	0.222	0.161	0.024	0.083	[redacted]
f_i - lb/ft^2	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	0.0093	[redacted]
E_i - kg	7.973	109.048	36.701	52.870	6.918	40.497	29.361	4.387	15.187	[redacted]
f_e - lb/ft^2	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	[redacted]
E_e - kg	8.573	117.256	39.463	56.850	7.439	43.546	31.571	4.717	16.330	[redacted]
f_c - lb/ton	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	[redacted]
E_c - kg	0.206	3.778	1.507	1.103	0.273	2.206	0.691	0.176	0.307	[redacted]
E - kg	16.795	230.679	77.872	111.113	14.669	86.471	61.783	9.305	31.906	[redacted]
SOURCE CONCENTRATIONS										
^{238}U - pCi/g	8.02×10^{-5}	5.53×10^{-5}	2.31×10^{-5}	3.09×10^{-5}	3.20×10^{-5}	5.37×10^{-5}	4.49×10^{-5}	2.94×10^{-5}	1.54×10^{-5}	[redacted]
^{234}U - pCi/g	8.58×10^{-5}	5.91×10^{-5}	2.47×10^{-5}	3.30×10^{-5}	3.42×10^{-5}	5.74×10^{-5}	4.81×10^{-5}	3.15×10^{-5}	1.65×10^{-5}	[redacted]
^{230}Th - pCi/g	1.92×10^{-6}	1.33×10^{-6}	5.55×10^{-7}	7.41×10^{-7}	7.68×10^{-7}	1.29×10^{-6}	1.08×10^{-6}	7.06×10^{-7}	3.70×10^{-7}	[redacted]
^{226}Ra - pCi/g	1.36×10^{-6}	9.39×10^{-7}	3.93×10^{-7}	5.25×10^{-7}	5.44×10^{-7}	9.13×10^{-7}	7.64×10^{-7}	5.00×10^{-7}	2.62×10^{-7}	[redacted]
^{235}U - pCi/g	3.77×10^{-6}	2.60×10^{-6}	1.09×10^{-6}	1.45×10^{-6}	1.50×10^{-6}	2.52×10^{-6}	2.11×10^{-6}	1.38×10^{-6}	7.25×10^{-7}	[redacted]
^{232}Th - pCi/g	8.02×10^{-7}	5.53×10^{-7}	2.31×10^{-7}	3.09×10^{-7}	3.20×10^{-7}	5.37×10^{-7}	4.49×10^{-7}	2.94×10^{-7}	1.54×10^{-7}	[redacted]
RESULTS										
^{238}U - Ci	1.35×10^{-12}	1.27×10^{-11}	1.80×10^{-12}	3.43×10^{-12}	4.69×10^{-13}	4.64×10^{-12}	2.78×10^{-12}	2.74×10^{-13}	4.92×10^{-13}	2.80×10^{-11}
^{234}Th - Ci	1.35×10^{-12}	1.27×10^{-11}	1.80×10^{-12}	3.43×10^{-12}	4.69×10^{-13}	4.64×10^{-12}	2.78×10^{-12}	2.74×10^{-13}	4.92×10^{-13}	2.80×10^{-11}
^{234m}Pa - Ci	1.35×10^{-12}	1.27×10^{-11}	1.80×10^{-12}	3.43×10^{-12}	4.69×10^{-13}	4.64×10^{-12}	2.78×10^{-12}	2.74×10^{-13}	4.92×10^{-13}	2.80×10^{-11}
^{234}Pa - Ci	1.34×10^{-12}	1.27×10^{-11}	1.80×10^{-12}	3.43×10^{-12}	4.68×10^{-13}	4.64×10^{-12}	2.77×10^{-12}	2.73×10^{-13}	4.92×10^{-13}	2.79×10^{-11}
^{234}U - Ci	1.44×10^{-12}	1.36×10^{-11}	1.93×10^{-12}	3.67×10^{-12}	5.02×10^{-13}	4.97×10^{-12}	2.97×10^{-12}	2.93×10^{-13}	5.27×10^{-13}	2.99×10^{-11}
^{230}Th - Ci	3.23×10^{-14}	3.06×10^{-13}	4.32×10^{-14}	8.24×10^{-14}	1.13×10^{-14}	1.11×10^{-13}	6.66×10^{-14}	6.57×10^{-15}	1.18×10^{-14}	6.71×10^{-13}
^{226}Ra - Ci	2.29×10^{-14}	2.17×10^{-13}	3.06×10^{-14}	5.83×10^{-14}	7.97×10^{-15}	7.89×10^{-14}	4.72×10^{-14}	4.65×10^{-15}	8.37×10^{-15}	4.76×10^{-13}
^{235}U - Ci	6.33×10^{-14}	5.99×10^{-13}	8.46×10^{-14}	1.61×10^{-13}	2.20×10^{-14}	2.18×10^{-13}	1.30×10^{-13}	1.29×10^{-14}	2.31×10^{-14}	1.31×10^{-12}
^{231}Th - Ci	6.33×10^{-14}	5.99×10^{-13}	8.46×10^{-14}	1.61×10^{-13}	2.20×10^{-14}	2.18×10^{-13}	1.30×10^{-13}	1.29×10^{-14}	2.31×10^{-14}	1.31×10^{-12}
^{231}Pa - Ci	6.33×10^{-14}	5.99×10^{-13}	8.46×10^{-14}	1.61×10^{-13}	2.20×10^{-14}	2.18×10^{-13}	1.30×10^{-13}	1.29×10^{-14}	2.31×10^{-14}	1.31×10^{-12}
^{227}Ac - Ci	6.33×10^{-14}	5.99×10^{-13}	8.46×10^{-14}	1.61×10^{-13}	2.20×10^{-14}	2.18×10^{-13}	1.30×10^{-13}	1.29×10^{-14}	2.31×10^{-14}	1.31×10^{-12}
^{227}Th - Ci	6.24×10^{-14}	5.91×10^{-13}	8.35×10^{-14}	1.59×10^{-13}	2.17×10^{-14}	2.15×10^{-13}	1.29×10^{-13}	1.27×10^{-14}	2.28×10^{-14}	1.30×10^{-12}
^{223}Fr - Ci	8.73×10^{-16}	8.27×10^{-15}	1.17×10^{-15}	2.23×10^{-15}	3.04×10^{-16}	3.01×10^{-15}	1.80×10^{-15}	1.78×10^{-16}	3.19×10^{-16}	1.81×10^{-14}
^{223}Ra - Ci	6.33×10^{-14}	5.99×10^{-13}	8.46×10^{-14}	1.61×10^{-13}	2.20×10^{-14}	2.18×10^{-13}	1.30×10^{-13}	1.29×10^{-14}	2.31×10^{-14}	1.31×10^{-12}
^{232}Th - Ci	1.35×10^{-14}	1.27×10^{-13}	1.80×10^{-14}	3.43×10^{-14}	4.69×10^{-15}	4.64×10^{-14}	2.78×10^{-14}	2.74×10^{-15}	4.92×10^{-15}	2.80×10^{-13}
^{228}Ra - Ci	1.35×10^{-14}	1.27×10^{-13}	1.80×10^{-14}	3.43×10^{-14}	4.69×10^{-15}	4.64×10^{-14}	2.78×10^{-14}	2.74×10^{-15}	4.92×10^{-15}	2.80×10^{-13}
^{228}Ac - Ci	1.35×10^{-14}	1.27×10^{-13}	1.80×10^{-14}	3.43×10^{-14}	4.69×10^{-15}	4.64×10^{-14}	2.78×10^{-14}	2.74×10^{-15}	4.92×10^{-15}	2.80×10^{-13}
^{228}Th - Ci	1.35×10^{-14}	1.27×10^{-13}	1.80×10^{-14}	3.43×10^{-14}	4.69×10^{-15}	4.64×10^{-14}	2.78×10^{-14}	2.74×10^{-15}	4.92×10^{-15}	2.80×10^{-13}
^{224}Ra - Ci	1.35×10^{-14}	1.27×10^{-13}	1.80×10^{-14}	3.43×10^{-14}	4.69×10^{-15}	4.64×10^{-14}	2.78×10^{-14}	2.74×10^{-15}	4.92×10^{-15}	2.80×10^{-13}

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE 6/26/97	CALC. NO. 116-CV-018	REV.	0
			CHECKED	DATE	6/30/97
PROJECT	FUSRAP - SLDS		JOB NO. 14501	SHEET	12 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS				

SLDS Site Plan Showing Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708



CALCULATION SHEET

ORIGINATOR	Robert G. Robbins	DATE 6/26/97	CALC. NO. 116-CV-018	REV.	0
			CHECKED mrw	DATE	6/30/97
PROJECT	FUSRAP - SLDS		JOB NO. 14501	SHEET	13 of 17
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS				

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Individual Assessment
Jul 26, 1997 11:56 am

Facility: St. Louis Downtown Site
Address: Mallinckrodt and Second Streets
City: St. Louis
State: MO Zip: 63147

Source Category: Airborne Radioactive Particulates
Source Type: Area
Emission Year: 1996

Comments: Bechtel National Inc. for
U.S. Department of Energy

At This Location: 30 Meters North

Dataset Name: SLDS Bldg Demo
Dataset Date: Jun 24, 1997 03:36 pm
Wind File: C:\CAP88PC2\WNDFILES\STL0603.WND

Jul 26, 1997 11:56 am

SYNOPSIS
Page 2

RADIONUCLIDE EMISSIONS DURING THE YEAR 1996

Nuclide	Class	Size	Source #1 Ci/y	TOTAL Ci/y
U-238	Y	1.00	2.8E-11	2.8E-11
TH-234	Y	1.00	2.8E-11	2.8E-11
PA-234M	Y	1.00	2.8E-11	2.8E-11
PA-234	Y	1.00	2.8E-11	2.8E-11
U-234	Y	1.00	3.0E-11	3.0E-11
TH-230	Y	1.00	6.7E-13	6.7E-13
RA-226	W	1.00	4.8E-13	4.8E-13
U-235	Y	1.00	1.3E-12	1.3E-12
TH-231	Y	1.00	1.3E-12	1.3E-12
PA-231	Y	1.00	1.3E-12	1.3E-12
AC-227	Y	1.00	1.3E-12	1.3E-12
TH-227	Y	1.00	1.3E-12	1.3E-12
FR-223	D	1.00	1.8E-14	1.8E-14
RA-223	W	1.00	1.3E-12	1.3E-12
TH-232	Y	1.00	2.8E-13	2.8E-13
RA-228	W	1.00	2.8E-13	2.8E-13
AC-228	Y	1.00	2.8E-13	2.8E-13
TH-228	Y	1.00	2.8E-13	2.8E-13
RA-224	W	1.00	2.8E-13	2.8E-13

SITE INFORMATION

Temperature: 13 degrees C
Precipitation: 111 cm/y
Mixing Height: 1000 m

Jul 26, 1997 11:56 am

SYNOPSIS
Page 3

SOURCE INFORMATION

Source Number: 1

Source Height (m): 0.
Area (sq m): 8100.

Plume Rise Pasquill Cat:	A	B	C	D	E	F	G
Zero:	0.	0.	0.	0.	0.	0.	0.

AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.076	0.000	0.008
Fraction From Assessment Area:	0.924	1.000	0.992
Fraction Imported:	0.000	0.000	0.000

Food Arrays were not generated for this run.
Default Values used.

DISTANCES (M) USED FOR MAXIMUM INDIVIDUAL ASSESSMENT

30 50 100 150 200 250 300

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Jul 26, 1997 11:56 am

Facility: St. Louis Downtown Site
Address: Mallinckrodt and Second Streets
City: St. Louis
State: MO Zip: 63147

Source Category: Airborne Radioactive Particulates
Source Type: Area
Emission Year: 1996

Comments: Bechtel National Inc. for
U.S. Department of Energy

Dataset Name: SLDS Bldg Demo
Dataset Date: Jun 24, 1997 03:36 pm
Wind File: C:\CAP88PC2\WNDFILES\STL0603.WND

CALCULATION SHEET

ORIGINATOR	Robert G. Robbins (por)	DATE	6/26/97	CALC. NO.	116-CV-018
CHECKED	mrw	REV.	0		
PROJECT	FUSRAP - SLDS	JOB NO.	14501	DATE	6/30/97
SUBJECT	Dose From Demolition of Buildings 100, 116, 117, 700, 704, 705, 706, 707, and 708 at SLDS			SHEET	17 of 17

Jul 26, 1995 11:56 am

SUMMARY
Page 5

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	30	50	100	150	200	250	300
N	8.6E-06	2.8E-06	6.8E-07	3.7E-07	2.6E-07	2.1E-07	1.7E-07
NNW	8.4E-06	3.2E-06	9.2E-07	4.5E-07	2.9E-07	2.2E-07	1.8E-07
NW	7.8E-06	3.4E-06	9.8E-07	5.3E-07	3.6E-07	2.8E-07	2.2E-07
WNW	7.3E-06	3.2E-06	8.6E-07	4.3E-07	2.8E-07	2.1E-07	1.7E-07
W	7.2E-06	3.0E-06	6.5E-07	3.4E-07	2.3E-07	1.8E-07	1.6E-07
WSW	7.4E-06	2.4E-06	6.1E-07	3.1E-07	2.1E-07	1.7E-07	1.5E-07
SW	7.7E-06	2.1E-06	6.0E-07	3.3E-07	2.4E-07	1.9E-07	1.6E-07
SSW	7.9E-06	1.8E-06	5.2E-07	2.9E-07	2.0E-07	1.6E-07	1.4E-07
S	7.3E-06	1.8E-06	4.1E-07	2.3E-07	1.7E-07	1.4E-07	1.3E-07
SSE	6.9E-06	1.9E-06	4.1E-07	2.3E-07	1.7E-07	1.4E-07	1.3E-07
SE	6.7E-06	2.5E-06	5.8E-07	3.0E-07	2.1E-07	1.7E-07	1.5E-07
ESE	6.9E-06	2.8E-06	8.5E-07	4.4E-07	3.0E-07	2.3E-07	1.9E-07
E	7.2E-06	3.0E-06	9.3E-07	5.0E-07	3.4E-07	2.6E-07	2.1E-07
ENE	7.9E-06	2.8E-06	7.4E-07	3.7E-07	2.5E-07	1.9E-07	1.6E-07
NE	8.3E-06	2.5E-06	5.1E-07	2.8E-07	1.9E-07	1.6E-07	1.4E-07
NNE	8.5E-06	2.3E-06	5.2E-07	2.7E-07	1.8E-07	1.5E-07	1.3E-07