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Supplementary Documentation for an Environmental Impact Statement Regarding the Pantex Plant

Long-Term Radiological Risk Assessment for Postulated Accidents

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SUPPLEMENTARY DOCUMENTATION FOR AN ENVIRONMENTAL IMPACT STATEMENT REGARDING THE PANTEX PLANT:

LONG-TERM RADIOLOGICAL RISK ASSESSMENT FOR POSTULATED ACCIDENTS

by

W. J. Wenzel and A. F. Gallegos

ABSTRACT

This report documents work performed in support of preparation of an Environmental Impact Statement regarding the Department of Energy's (DOE) Pantex Plant near Amarillo, Texas. The long-term health effects to people farming the areas studied by Wenzel in 1982 are calculated in this report by predicting plutonium transport in the Texas Panhandle, southeastern Iowa, and south central Washington using the BIOTRAN model. Inhalation and ingestion radiation doses are calculated for each hypothetical accident with releases of 120-, 30-, and 0.625-kg plutonium at the Pantex Plant and the Iowa Army Ammunition Plant (IAAP). The greatest radiation dose for the Pantex Plant and IAAP accidents is the inhalation dose, which accounts for greater than 90% of the long-term effect.

Only a 0.625-kg plutonium release is addressed for the Hanford site. Deposited PuO_2 at levels greater than 0.4 μ Ci/m² does not extend offsite. Therefore, health effects were not calculated for Hanford. The estimated number of health effects (cancer deaths) based on 1990 populations was higher for these accidents at the Pantex Plant than the IAAP; but the cancer mortality risk (chance/100 000) was found to be greater at the IAAP because of the larger population density closer to the IAAP.

I. INTRODUCTION

This report documents work performed in support of preparation of an Environmental Impact Statement (EIS) regarding the Department of Energy's (DOE) Pantex Plant near Amarillo, Texas. The EIS addresses continuing nuclear weapons operations at Pantex and the construction of additional facilities to house those operations. The EIS was prepared in accordance with current regulations under the National Environmental Policy Act. Regulations of the Council on Environmental Quality (40 CFR 1500) require

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agencies to prepare concise EISs with fewer than 300 pages for complex projects. This report was prepared by Los Alamos National Laboratory to document details of work performed and supplementary information considered during preparation of the Draft Environmental Impact Statement.

Following an accidental release of plutonium (Pu) at the Pantex Plant, the Iowa Army Ammunition Plant (IAAP), or the Hanford Site, involving a nonnuclear detonation of a nuclear weapon, extensive land area surrounding the site could be contaminated from the deposited plutonium after passage of the cloud. A previous report (Wenzel 1982B), documented the areas contaminated and their cleanup levels for three postulated accidents at the Pantex Plant and IAAP, plus one at the Hanford Site. This report assesses the long-term radiological and health effects to people living on and farming the areas surrounding each site. Three conditions are assumed: no decontamination, decontamination to the proposed Healy soil level, and decontamination to the proposed Environmental Protection Agency (EPA) soil level. The dispersion of the accidental release clouds is presented in Dewart (1982), and the first pass inhalation dose is addressed by Elder (1982B).

To predict the transport of plutonium through the natural and agricultural pathways, a dynamic model developed at Los Alamos by Gallegos (1980), BIOTRAN, was used to estimate the concentration of plutonium in the pathway compartments.

To compare the three sites, three major food pathways and the inhalation pathway were simulated using the BIOTRAN model. The inhalation pathway is the major route for PuO_2 particulates to gain entrance to the body. This results from breathing particles resuspended from soil and vegetation (Healy 1977). Inhalation accounts for about 80-90% of the radiological dose for people living on and farming contaminated areas. Ingestion of homegrown leafy vegetables, wheat products, and beef raised on land contaminated with plutonium is considered for each site. Radiation doses and concomitant health effects are calculated for an "average" individual residing in the contaminated area for 1 yr and for 50 yr.

A. Description of BIOTRAN Model

The BIOTRAN model was originally developed at Los Alamos National Laboratory to simulate radionuclide transport in the Southwest. The BIOTRAN model works on two time steps, daily and yearly. Twenty-two plant types, including both cool (CS) and warm season (WS) grasses, can be simulated at once. Five major portions of the model can be simultaneously called to integrate daily for long-term simulations. Figure 1 depicts the five portions of the model. The main program and the ruminant subroutine were used for this analysis. Data were gathered on the major grass species,



Fig. 1. Major components of BIOTRAN model, which interact on daily and yearly simulation intervals.

farming practices, crop parameters, and soil-water relationships from the Pantex Plant, IAAP, and Hanford Site areas. A comprehensive description of the BIOTRAN model was written by Gallegos (1980).

Figure 2 shows the interdependent nature of the BIOTRAN model and the major food chain pathways simulated for this study. For the Pantex Plant area, simulation of major crops included grain sorghum, garden vegetables, alfalfa, and winter wheat. Beef cattle were simulated grazing CS and WS range grasses as well as winter wheat. Simulations for the IAAP area assumed corn, garden vegetables, alfalfa, winter wheat, CS and WS grasses, and beef cattle. The Hanford Site area simulation was considerably different because of the diverse agricultural economy of the region. For the Hanford Site, simulations included corn, garden vegetables, fruit trees, alfalfa, winter wheat, pasture grass, and cheatgrass. Cattle were simulated grazing on cheatgrass in early spring, and on pasture grass and cut alfalfa in summer and fall.



Fig. 2. BIOTRAN food chain pathways.

For each simulation, meteorological conditions are stochastically generated based on National Oceanic and Atmospheric Administration (NOAA) 40yr record stastistics. Major input parameters are maximum and minimum solar radiation, annual rainfall, monthly fraction of annual rainfall, rainfall events per month, maximum and minimum monthly average temperatures, and frostfree period. Rainfall is generated each month by a random number generator using the monthly average rainfall amount and the coefficient of variation for rainfall. Many model transport functions such as wet and dry resuspension are controlled by rainfall and temperature.

Soils are characterized by specifying generalized soil types. Additional soil moisture properties are specified by inputting the O-bar (holding capacity), -O.3-bar (field capacity), and -15-bar (wilting point) conditions as per cent water for the rooting layers. Multiple 25-cm soil layers are specified for each plant simulated. These soil layers correspond to the rooting depth. Saturated soil from high ground water (such as that at IAAP) or soil water storage (such as that at the Pantex Plant) can be simulated by adjusting the water sink, FLODN, in the last rooting layer. Resuspension processes are simulated by a top 2-cm dynamic resuspension layer and a coupled litter layer.

Agricultural crop and range grass growth is simulated for a $1-m^2$ area on a daily basis. Each plant or plant group has a specific growth strategy characterized by photosynthate produced per day. Rainfall, soil moisture,

temperature, cropping, grazing, and insolation are major variables driving biomass production. Root uptake of plutonium is proportional to evapotranspiration and photosynthate production on a daily basis.

Ruminants are simulated in a separate subroutine. Daily forage and supplemental feed from the plants simulated are intake for beef cattle. Cattle weight gain is estimated based on nitrogen content of intake. Grazing periods and supplemental feed composition are specified as input. Herd parameters, such as number of animals and age distribution, are also specified for each site.

Physical and biological radionuclide transport processes are coupled with plant growth, soil hydrology, meteorology, and ruminant growth to form a daily iterative dynamic simulation. The simulations represent the interactions of about 300 variables simultaneously each "day" and this information is integrated yearly. Daily and yearly values for each variable can be specified for output.

Plutonium dioxide (PuO₂) is considered to be relatively inert in the environment and hence moves (is transported) mainly by physical particle transport. Transport is modeled as particle infiltration into the soil and capillary action up the soil profile. Wet and dry deposition on the resuspension layer and plants are modeled as dependent on rainfall, temperature, crown cover, and plant height. Rain splash and saltation are modeled empirically based on Los Alamos National Laboratory studies (Dreicer 1981). Runoff from the unit simulation area is estimated based on soil type and rainfall.

Field data and literature values for plant biomass are carefully compared in this report to simulated biomass values for the simulated crops at each site. Comparison of the simulated biomass to those reported in the literature substantiates close agreement between BIOTRAN model simulations and actual biomass found in the environment. Since these comparisons are in close agreement, the plutonium concentrations simulated by BIOTRAN are also assumed to be valid.

B. Plutonium Dynamics in Agricultural Areas

Garten (1978) recently reviewed the transport values used to assess long-term plutonium environmental behavior simulations and dose calculations. Use of compartment models such as the USNRC Regulation Guide 1.109 (1977) gives acceptable estimates for the general case. Garten argues that many of the values used in compartment models actually are ranges of values dependent on local meteorology, soil characteristics, farming practices, and plant phenology. Another review (Nielson 1981) indicates the wide range in transport process values reported in the literature. Hanson (1980) gives a major overview of the research on plutonium dynamics in several different terrestrial environments. A recent review for the Savannah River, North Carolina, area by Corey (1982) gives plutonium transport values for wheat and other crops from soil to man.

The major plutonium contamination compartments for plants are 1) uptake by roots and movement to above-ground plant parts, 2) deposition of airborne plutonium-bearing particulates on above-ground plant surfaces, and 3) deposition of soil resuspended plutonium-bearing particles on plant surfaces from saltation and rain splash. Surface contamination of plant tissue is about 2-3 orders of magnitude greater than root uptake of plutonium. Concentration ratios (CR) derived from greenhouse experiments show 0.00061 ^{239,240}Pu for root uptake and about 0.05 for root uptake plus surface contamination under field conditions for wheat (Corey 1982). This illustrates the dominance of surface contamination of plants compared to the total concentration in and on plants. Corey estimates that root uptake of plutonium only accounts for 2-4% of the total plutonium found on and in plants. Corey also found for tuber crops (potatoes, turnips, onions, radishes, and carrots) that scrubbing reduced contamination by one-half and peeling reduced contamination by at least a factor of 10. The CR for scrubbed tuber crops was about 10^{-2} . BIOTRAN simulation for the second and fifth year after a potential PuO, release and contamination of farmland at the Pantex site gave CRs for wheat of 0.045 and 0.037 and for garden vegetables 0.025 and 0.011. These values are listed in Table I compared to those of Corey (1982). The results of the Pantex simulation are also given in Section II and Appendix A. The utility of the BIOTRAN model is demonstrated by the close agreement between the field measurements and the simulation.

C. Calculation Methods for Dose and Health Effects

Figure 3 depicts the overall calculation methods described in this section to evaluate both doses and health effects from long-term concentrations of plutonium in the environment following postulated accidents.

BIOTRAN was used to predict the plutonium concentration in foodstuffs after 100 yr. The specific input used to run BIOTRAN is given in the next three sections and the appendixes. Tables A-III, B-I, and C-I are the BIOTRAN inputs used for 100-yr simulation for the Pantex Plant, IAAP, and Hanford Site areas. These tables are followed by a referenced listing of the input in Table A-IV, B-II, and C-II. Plutonium oxide deposition concentrations on the soil and vegetation were calculated for hypothetical accidents [these accidents are described in Dewart (1982), Elder (1982B), and Wenzel (1982B)]. Crops were simulated growing on the contaminated soil, and cattle were simulated grazing on contaminated range grass.



Fig. 3. Calculation flow for long-term health effects.

TABLE I

		239,240Pu	239, 240 _{Pu}		
		Soil	Plant		Simulation
Reference	Crop	Concentration	Concentration	CR	Time
Corey 1982	wheat (greenhouse)	-	-	0.00061	
	wheat (field)	-	-	0.05	
	tubers (scrubbed)	<0.0002- 0.0012	1.21	0.0002- 0.001	
BIOTRAN (simulation)	wheat (field)	76 400	3 420	0.045	2nd year
	wheat (field)	78 160	2 860	0.037	5th year
	vegetables (field)	76 400	1 880	0.025	2nd year
	vegetables (field)	78 230	885	0.011	5th year

COMPARISON OF FIELD MEASUREMENTS AND BIOTRAN SIMULATION CONCENTRATION RATIOS

To simulate the multiple contamination levels, i.e., many isopleths at various concentrations, one BIOTRAN run was done for the Pantex Plant, one for IAAP, and one for Hanford Site. For each run, the initial condition was 10^6 disintegrations per minute per gram (dpm/g) of PuO₂ in the top 2 cm of dry soil. For tilled crops, the contamination was assumed homogeneously mixed in the top 27 cm of the soil. BIOTRAN-simulated plutonium concentrations in plants and beef cattle were scaled by ratio up or down to the initial soil PuO₂ source term on a μ Ci/m² basis to evaluate the seven postulated accident isopleth concentrations of PuO₂.

1. Unit PuO_2 Soil Radioactivity Concentrations for BIOTRAN Simulations. The unit soil contamination level used (13 514 μ Ci/m²) was chosen to ensure that the simulated concentrations were greater than any of the accidents to be considered. Setting the soil source term to 13 514 μ Ci/m² enabled detailed investigation of the plutonium dynamics through the entire 100-yr simulation period and allowed simulated concentrations in the soil, plants, and cattle to be scaled down to match the soil decontamination conditions as specified in Wenzel (1982B).

Two soil profile radioactivity concentration conditions were specified for each site as initial BIOTRAN conditions: 10^6 dpm/g dry soil in the top 2 cm of soil (equal to 13 514 μ Ci/m²) for untilled soil under native grasses and 74 074 dpm/g to 27 cm (resuspension layer plus first 25-cm layer) for the tilled case under crops (equal to 13 514 μ Ci/m²). Plutonium oxide was assumed to dry deposit on the soil surface and then to be homogeneously plowed under before simulation of the tilled crops. Transport was therefore different under native grasses than for tilled crops in the same simulation period owing to the different layering of PuO₂.

2. Plutonium Dose Factors and Health Effects for 1-yr and 50-yr Exposure and 50-yr Dose Integration Time. Table II summarizes the DACRIN (Houston 1974) and INREM (Dunning 1979) dose factors for plutonium for the 1-yr and 50-yr exposure time. For inhalation dose factors, a $1-\mu m$ Activity Median Aerodynamic Diameter (AMAD) was assumed. A quality factor of 20 was assumed for alpha particle radiation and 5000-g bone mass for the standard man. Tables A-I and A-II in the appendix give additional data for the plutonium mix dose factor calculations. The health effects assumed from the radiation doses were calculated on the basis of 15 x 10^{-6} cancer mortalities/rem for liver, 1.4×10^{-6} cancer mortality/rem for bone, and 43 x 10^{-6} cancer mortality/rem for lung (Elder 1982B). Once the amount of plutonium ingested or inhaled by a person living in the contaminated area was calculated using the BIOTRAN estimated concentrations in air and food, then the radiation dose was calculated using these dose factors. The health effects are then calculated using the above health effects/rem.

3. Inhalation and Ingestion Rates for Man. It was assumed that leafy vegetables, wheat products, and beef consumed by residents in the contaminated areas were produced locally. The ingestion rates chosen for the analysis were 150 kg/yr for leafy vegetables, 90 kg/yr for wheat products, and 79 kg/yr for beef (Walker 1981). In addition, the dust in the air was assumed to be produced by resuspension from over the nontilled soils (much higher surface concentration of PuO₂ than the tilled soils but lower resuspension rate). A moderate work inhalation rate of 3.5 x 10^{-4} m³/s resulting in 11 038 m³/yr of air inhaled was used for the analysis. These conservative assumptions represent a maximum individual adult case.

TABLE II

Dose Model	lose Pathway lode1		Dose Integration Time	Organ	rem/uC1 Ingested or Inhaled
DACRIN	Inhalation (lum AMAD)	l yr	50 yr	Lung Liver Bone	976 841 1810
DACRIN	Inhalation (lum AMAD)	50 yr	50 yr	Lung Liver Bone	937 447 895
INREM	Ingestion	Acute	50 yr	Liver Bone	0.340 0.777

DOSE FACTORS (rem/µCi) FOR PLUTONIUM

II. LONG-TERM RADIOLOGICAL RISK ASSESSMENT AT PANTEX PLANT

A. BIOTRAN Simulation for Pantex Plant Postulated Accidents

Table A-III is formatted BIOTRAN input for the Pantex Plant postulated accidents. Table A-IV is the referenced input listing. Farming practices in use today are assumed to remain constant over the 100-yr simulation period. Simulated crops are grain sorghum (BIOTRAN plant 1), WS vegetables (2), WS grasses (8), alfalfa (11), winter wheat (12), and CS grasses (18). Perennial range grasses are primarily WS grasses, such as blue grama and buffalo grass. Biomass is characterized by two peaks - one in May from CS annuals and perennials and one in late July from WS perennials (Pettit 1974).

Figure 4 represents the irrigated biomass on a yearly basis for the four crops simulated for the Pantex Plant. Grain sorghum and alfalfa were cropped and fed to the beef cattle when they were not ranged or when the simulated range grass became overgrazed. Figure 5 depicts the two range grass types, CS and WS perennials for the Pantex Plant. Cattle preferentially graze the blue grama grass (WS perennial) in the scenario. Note the dynamic nature of



Fig. 4. Live above-ground biomass (LAGB) for four irrigated crops simulated for the Pantex region.



Fig. 5. LAGB for two perennial (Per) warm season (WS) and cool season (CS) range grasses for the Pantex region.

the unirrigated grasses, which depend on rainfall for their seasonal blooms. Both figures represent the yearly maximum above-ground living biomass.

Table A-V lists the planting, harvesting, and irrigation schedules for each crop* [Texas A&M (1981)]. Uniform growth year to year can be expected in the Panhandle under irrigated conditions. Most farmers optimize production by watering when needed, which is in contrast to the arid Northwest (Hanford Site Region), where irrigation is done frequently and by schedule. For Pullman soil about 24 h is needed on half-mile furrows with end dikes to put 5-6 in. of irrigation water into the soil. Water storage was simulated by adjusting the soil water loss from the bottom of the rooting zone (FLODN variable) to 0.005, 1/4 of that of Hanford. (Hanford has sandy soils.) This left more water in the rooting layers and consequently represented the clay loam water-storage capacity. Water is stored in Pullman soil by allowing a season to go unplanted (fallow). Weeds are controlled by herbicides. Since Pullman soil is a clay loam and can store water, wheat and grain sorghum are prewatered or planted when sufficient moisture is stored in the soil profile. Fallowing was simulated by increasing the amount of prewatering. This gave sufficient soil water to give reasonable productivity for alfalfa and winter wheat.

Table A-VI gives the root fraction estimates for the simulated soil layers. Root fractions were estimated from Gallegos (1980) and Rodgers (1980) for crops and Pettit (1974) for grasses. Each plant type has different root mass at each soil layer, which must be known to estimate root uptake of minerals and radionuclides. This information was estimated for most crops because of the lack of these data in the literature.

Table III shows the average farming productivity from the literature compared to those simulated by BIOTRAN for the irrigated crops. Matching simulated productivity to literature values is difficult because of the variation in per cent water at harvest for each crop. Constants assumed to make conversions include the following.

(a) l bu wheat = 60 lb of grain
(b) dry alfalfa/wet (in field) alfalfa = 0.6
(c) grain sorghum at harvest = 5% moisture
(d) l bu soybeans = 55 lb of beans

Agreement between the simulated biomass and the crop biomass reported in the literature is considered good. The success of the simulation can be measured by the agreement with expected productivity. The grams per square meter for vegetables is high because these are generalized WS vegetables in

^{*}W. L. Harmon, Agricultural Economist, Texas A&M Research and Extension Center, Amarillo, Texas; and H. Wilson, Farm Manager, Texas Tech Research Center, Panhandle, Texas.

TABLE III

PANTEX FARMING PRODUCTIVITY DATA

Crop and Description	Reported Amount/Acre	Estimated g/m ² Dry	100-yr Range BIOTRAN g/m² Dry*	References
Grain sorghum (irrig.) Residue Grain Grain Grain Average grain Average range grain and residue	4 ton/acre 3000-5000 lb/acre 4440 lb/acre 4540-7480 lb/acre 5500 lb/acre	897 336-560 497 509-839 617 1300-1800	1660-1950	Undersander** Jacquot 1962 USDA 1979, 1980 Texas A&M 1981 Harmon***
Soybeans (irrig.) Average range soybeans and residue	32 bu/acre	395	828-984	USDA 1979, 1980
Range grasses (Carson)	750-1200 lb/acre	84-135	26.8-77.9 (grazed) LAGB ⁺	Jacquot 1962
Blue grama, LABG ⁺ plus dead, grazed LAGB ⁺ plus dead, ungrazed	265 g/m ² dry 320 g/m ² dry		9.5-61 (grazed) LAGB ⁺	Pettit 1974
Alfalfa (irrig.) 3 cuttings	3.2-5.0 ton/acre 4.0 ton/acre 6.0 ton/acre	718-1120 897 1350		Jacquot 1962 USDA 1979, 1980 Texas A&M 1981
Average range all 3 cuttings		718-1350	924-1220	
Winter wheat (irrig.) (Carson)	32-50 bu/acre 34.9 bu/acre 45 bu/acre grazed	215-337 235 303		Jacquot 1962 USDA 1979, 1980 Harmon***
Average range grain and residue		430-606	256-481	

*Maximum live above-ground biomass during one year.

D. J. Undersander, Forage Specialist, Texas A&M Research and Extension Center, Amarillo, Texas. *W. L. Harmon, Agricultural Economist, Texas A&M Research and Extension Center, Amarillo, Texas. *See also Fig. 4.

an "average" garden. The simulation values in all cases are for the entire live plant biomass on the $1-m^2$ plot that includes grain or fruit. Biomass ratios of grain to stem and leaves for various crops are needed to simulate the grain or fruit production. A ratio of 1:1 was assumed for fruit to residue (stems, leaves) biomass when not found in the literature.

B. Long-Term Calculations for Radiological Health Effects

Table A-VII lists 50 simulation years of plutonium concentration values from BIOTRAN for air as disintegrations per minute per meters cubed, garden vegetables as disintegrations per minute per gram dry, winter wheat as disintegrations per minute per gram dry and 2-yr old beef cattle muscle for meat as disintegrations per minute per gram wet. Highest values were used for the 1-yr exposure dose calculations (usually in first 3 yr), and average values were used for the 50-yr calculations.

<u>Dose Calculations</u>. For inhalation dose to man, the two calculations are given.

$$\frac{(a)}{m^{3}/yr} \left(\frac{11037.6 \text{ m}^{3} \text{ inhaled}}{yr}\right) \left(\frac{11037.6 \text{ m}^{3} \text{ inhaled}}{yr}\right) \left(\frac{yr}{2.22 \text{ x} 10^{6} \text{ dpm}}\right) = 0.47 \text{ uCi inhaled}$$
for 1-yr exposure

(b)
$$\left(\frac{4.43 \text{ dpm}}{\text{m}^3/50 \text{-yr average}}\right) \left(\frac{11037.6 \text{ m}^3 \text{ inhaled}}{\text{yr}}\right) \left(50 \text{ yr} \frac{\mu\text{Ci}}{2.22 \text{ x } 10^6 \text{ dpm}}\right) = 1.1 \mu\text{Ci inhaled}$$
for 50-yr exposure

As a check, this compares favorably with another calculation based on dust loading. The annual average dust mass loading at Pantex is $57 \ \mu g/m^3$.

(a)
$$\left(\frac{57 \ \mu q}{m^3}\right) \left(\frac{11037.6 \ m^3 \ inhaled}{yr}\right) = 6.3 \ x \ 10^5 \ \frac{\mu q}{yr}$$
 dust inhaled

If we assume the soil resuspension layer to be $1 \times 10^6 \frac{dpm}{g} \frac{Pu}{dry}$, then

$$\frac{1 \times 10^6 \text{ dpm Pu}}{\text{g dry soil}} \frac{6.3 \times 10^5 \text{ ug inhaled}}{\text{yr}} \frac{g}{10^6 \text{ ug}} \frac{\mu \text{Ci}}{2.22 \times 10^6 \text{ dpm}} = \frac{0.28 \ \mu \text{Ci inhaled}}{\text{in first yr}}$$

Comparison of the BIOTRAN simulated air concentration and subsequent inhalation, 0.47 μ Ci inhaled, to the dust loading calculation of 0.28 μ Ci inhaled indicates the close agreement the BIOTRAN simulation has with the actual measured dust mass loading.

For ingestion doses, the calculations follow.

$$(a) \left(\frac{1880 \text{ dpm}}{(\text{g-dry vegetables})} \left(\frac{0.2 \text{ g dry}}{\text{g wet}}\right) \left(\frac{150 000 \text{ g}}{\text{yr}}\right) \left(\frac{\nu\text{Ci}}{2.22 \times 10^6 \text{ dpm}}\right) = \frac{25.4 \text{ }\mu\text{Ci ingested}}{1 \text{ yr}}$$

$$(b) \left(\frac{173 \text{ dpm}}{(50 \text{ yr average g-dry veg.})} \left(\frac{0.2 \text{ g dry}}{\text{g wet}}\right) \left(\frac{7.5 \times 10^6 \text{ g}}{50 \text{ yr}}\right) \left(\frac{\nu\text{Ci}}{2.22 \times 10^6 \text{ dpm}}\right) = \frac{117 \text{ }\mu\text{Ci ingested}}{50 \text{ yr}}$$

$$(c) \left(\frac{5870 \text{ dpm}}{\text{g-dry wheat}}\right) \left(\frac{0.5 \text{ g dry}}{\text{g wet}}\right) \left(0.5 \text{ PF*}\right) \left(\frac{92 000 \text{ g}}{\text{yr}}\right) \left(\frac{\nu\text{Ci}}{2.22 \times 10^6 \text{ dpm}}\right) = \frac{60.8 \text{ }\mu\text{Ci ingested}}{1 \text{ yr}}$$

$$(d) \left(\frac{508 \text{ dpm}}{50 \text{ -yr avg. g-dry wheat}}\right) \left(\frac{0.5 \text{ g dry}}{\text{g wet}}\right) \left(0.5 \text{ PF*}\right) \left(\frac{92 000 \text{ g}}{\text{yr}}\right) \left(\frac{50 \text{ yr}}{\text{yr}}\right) \left(\frac{50 \text{ yr}}{2.22 \times 10^6 \text{ dpm}}\right) = \frac{263 \text{ }\mu\text{Ci ingested}}{1 \text{ yr}}$$

$$(e) \left(\frac{314 \text{ dpm}}{\text{g-wet meat}}\right) \left(\frac{79 000 \text{ g}}{\text{yr}}\right) \left(\frac{\mu\text{Ci}}{2.22 \times 10^6 \text{ dpm}}\right) = \frac{11 \text{ }\mu\text{Ci ingested}}{1 \text{ yr}}$$

$$(f) \left(\frac{31 \text{ dpm}}{\text{g-wet meat}}\right) \left(\frac{79 000 \text{ g}}{\text{yr}}\right) \left(50 \text{ yr}\right) \left(\frac{\mu\text{Ci}}{2.22 \times 10^6 \text{ dpm}}\right) = \frac{55 \mu\text{Ci ingested}}{50 \text{ yr}}$$

*Processing factor for wheat.

Tables A-VIII and A-IX give the rem dose for the baseline inventory (labeled BIOTRAN) and three other scaled inventories. These data are scaled for the other isopleth concentrations and summed to get the man-rem doses and health effects per 100 000 people. Tables A-X through A-IX give the summary radiological doses and health effects for "average" individuals residing in the contaminated areas for 120-, 30-, and 0.625-kg postulated accidental releases. These values appear in the accident sections of the Pantex Plant EIS.

Table IV gives the values for health effect risk for each of the decontamination conditions. Postulated accident designations, such as I for the 120-kg release, were assigned by Chamberlin (1982) and used throughout the accident analysis by Dewart (1982), Elder (1982B), and Wenzel (1982B). Note that if no decontamination were to occur (this is certainly not likely), then the potential health effect risks are the greatest to the people living and farming in the contaminated areas. If the area were to be decontaminated to the Healy levels, then the potential health effect risk would be about 1-4 times lower than the no-decontamination case and about 3-90 times higher than

TABLE IV

PANTEX HEALTH EFFECT RISK SUMMARY LONG-TERM NO-DECONTAMINATION, DECONTAMINATION TO HEALY, AND DECONTAMINATION TO EPA LIMITS (Cancer Mortality per 100 000 people)

	. 120-kg Pu Açcident I			30-kg Pu Açcident H				0.625-kg Pu Accident K			nt K	
	Median	Met.*	Unfav.	Met**	Median Met. Unfav. Met.			Median Met.		Unfav. Met.		
	<u>l</u> yr	50 yr	<u>lyr</u>	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr_	<u>1</u> yr	<u>50 yr</u>
No decontamination (4 major isopleths)	0.85	1.7	3.6	7.2	0.40	0.82	2.0	4.0	0.31	0.65	0.11	0.22
Healy*** proposed limits (7.5 µCi/m ²)	0.57	1.1	0.92	1.8	0.39	0.78	0.73	1.5	0.31	0.65	0.11	0.22
EPA proposed limits (0.2 µCi/m ²)	0.040	0.080	0.041	0.080	0.040	0.080	0.041	0.081	0.041	0.081	0.041	0.082

*Median Met. - most likely meteorological dispersion condition.

**Unfav. Met.- meteorological dispersion condition, which could occur 5% of the time.
***Healy 1977.

decontamination to the more restrictive EPA proposed limits. Risks were considerably higher for people exposed for 50 yr instead of 1 yr.

The highest risk for 1-yr exposure is 3.6 cancer deaths per 100 000 people exposed. The highest risk for 50-yr exposure is 7.2 deaths per 100 000 people. These cancer mortality risks can be compared to the U.S. population lifetime cancer mortality risk of 0.20; one person in five succumbs from cancer.

III. LONG-TERM RADIOLOGICAL RISK ASSESSMENT AT IAAP

A. BIOTRAN Simulation for IAAP Postulated Accidents

Table B-I documents the BIOTRAN formatted input for the IAAP scenario. The referenced input follows in Table B-II. This is essentially the same scenario as that for Pantex Plant, except corn is simulated instead of sorghum (strategy for plant growth is assumed the same for sorghum and corn in BIOTRAN). Biomass on the tall grass prairie is predominantly CS perennials instead of WS perennials.*

^{*}This information supplied by W. Cooper, Agronomist, IAAP Farm Manager, Burlington, Iowa.



Fig. 6. LAGB for two perennial WS and CS grasses for the IAAP. The biomass from the ungrazed CS grasses were higher than shown below and surpassed the WS grasses.

BIOTRAN simulation for the IAAP showed CS grasses to predominate. However, when cattle were simulated grazing on the WS and CS grasses, and grazing preference was set to graze CS grasses preferentially, the WS grasses had higher yearly biomass. This is the case for grazed grasses shown in Fig. 6.

Figure 7 depicts the simulated crop Live Above-Ground Biomass (LAGB) for the IAAP. Because of the 35-in. annual rainfall, no irrigation is practiced in the area. Corn, soybeans, WS garden vegetables, alfalfa, winter wheat, and CS and WS range grasses are simulated.

Table B-III lists the planting and harvesting schedule for each crop.* For the IAAP region high ground water was assumed to give saturated soil conditions in the lower rooting layers. Ground water at 4-5 ft is common on the IAAP and tile drains must be installed in some fields to allow drainage. The saturated Mahaska clay-loam soil was simulated by adjusting the lower boundary conditions to reflect fully saturated soil conditions. FLODN was set at 0.0.

*W. Cooper, Agronomist, IAAP Farm Manager, Burlington, Iowa.



Fig. 7. LAGB for four crops simulated for the IAAP. These are unirrigated crops. See tables for planting and harvesting schedules.

Table B-IV lists the root fraction estimates for the crops and grasses. The same root fractions for the 25-cm soil layers were assumed at IAAP as for Pantex Plant.

Table V compares the BIOTRAN biomass estimates to the literature values for the crops from the IAAP region. The BIOTRAN biomass values are for the whole live plant. These constants were assumed for biomass conversions* for IAAP.

- (a) 1 bu wheat = 52 lb
- (b) dry silage/wet silage = 0.2
- (c) 1 bu corn grain = 56 1b (5% moisture)

The weight difference between bushels at the Pantex Plant and the IAAP probably reflect wheat (Triticum sp.) variety differences.

The simulated alfalfa productivity is somewhat low, but is near the values given for southeast Iowa. The amount of rainfall in the growing

^{*}W. Cooper, Agronomist, IAAP Farm Manager, Burlington, Iowa.

TABLE V

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IAAP PRODUCTIVITY DATA

Crop and Description	Reported Amount/Acre	Estimated g/m ² Dry	100-yr Range* BIOTRAN	References
Corn grain, Lee, Henry, and	108.1-119 bu/acre	606-650		Skow 1981
Des Moines County grain, IAAP	150 bu/acre	841		Cooper**
Corn silage (wet), Lee, Henry, and Des Moines County	15-19.5 tons/acre	673-875		Skow 1981
Corn grain on Mahaska soil	125 bu/acre	761		USDA 1972
Average range, grain plus residue		673-875	838-1351	
Soybeans, Lee, Henry, and Des Moines County	38-39.9 bu/acre	200-210		Skow 1981
Soybeans, Mahaska soil	48 bu/acre	253		USDA 1972
Average range, soybeans plus residue		400-506	441-670	
Alfalfa, 4 cuttings	4.0 tons/acre	897		Cooper**
Alfalfa-brome on Mahaska soil	5.2 tons/acre	1170		USDA 1972
Average range, all four cuttings		897-1170	380-828	
Wheat grain, Lee, Henry, and Des Moines County	39.9-43.8 bu/acre	210-231		Skow 1981
Average range, grain plus residue		440-460	298-526	

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*Maximum Live Above-Ground Biomass during one year. **W. Cooper, Agronomist, Farm Manager at IAAP, Burlington, Iowa.

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season is sufficient to give low yields of most crops. The high yields such as 150 bu/acre of corn under no irrigation reported at the IAAP are for Mahaska soil with saturated soil water conditions.

B. Long-Term Calculations for Radiological Health Effects

Table B-V lists 50 simulation years of plutonium concentration values from BIOTRAN for air in dpm/m³, garden vegetables, and winter wheat in dpm/g dry and beef muscle in dpm/g wet. The same dose calculation assumptions as for the Pantex Plant were used. The inhalation and ingestion rates and the rem doses are given in Tables B-VI and B-VII.

Tables B-VIII through B-XIII give the summary radiological dose and health effects for an "average" individual residing in the contaminated area. These values appear in the accident section of the Pantex Plant EIS. Table VI summarizes the health effect risk for each of the decontamination criteria.

The conclusions are that there are considerably higher cancer mortality risks for the no-decontamination case for the same postulated accidents at the IAAP than at the Pantex Plant. This is due to the higher population density near IAAP than there is near the Pantex Plant. However, the decontamination costs are similar between Pantex Site and IAAP because the land areas involved and methods used are similar (Wenzel 1982B).

TABLE VI

IAAP HEALTH EFFECT RISK SUMMARY LONG-TERM NO-DECONTAMINATION, DECONTAMINATION TO HEALY, AND DECONTAMINATION TO EPA LIMITS (Cancer Mortality per 10^S People)

	120-kg Pu Accident R			30-kg Pu Accident Q				0.625-kg Pu_Accident S			nt S _	
	Median	Met.*	Unfav.	Met.**	Median Met. Unfav. Met.			. Met.	Median	Met.	Unfav. Met.	
I	l yr	50 yr	lyr	50 yr	1 yr	50 yr	<u>1 yr</u>	50 yr	1 yr	50 yr	l yr	50 yr
No decontamination (4 major isopleths)	5.9	9.6	8.5	14.	1.2	2.0	3.1	5.2	0.34	0.54	0.22	0.36
Healy*** proposed limits (7.5 µCi/m ²)	0.50	0.83	0.70	1.2	0.32	0.52	0.67	1.1	0.34	0.54	0.22	0.36
EPA proposed limits (0.2 µC1/m ²)	0.036	0.075	0.036	0.054	0.036	0.058	0.036	0.057	0.037	0.056	0.036	0.056

*Mediar Met.- most likely meteorological dispersion condition.

**Unfav. Met. - meteorological dispersion condition, which could occur 5% of the time.
***Healy 1977.

IV. LONG-TERM RADIOLOGICAL RISK ASSESSMENT AT HANFORD SITE

A. BIOTRAN Simulations for Hanford Site Postulated Accident

Table C-I documents the formatted input for the Hanford Site postulated accident. Table C-II lists the referenced input for this scenario. Note that fruit trees (BIOTRAN plant 4), pasture grass (13), and cheatgrass (22) are added to the simulation. Cattle are pastured on cheatgrass in winter and/or early spring, then on pasture grass, and finally on alfalfa. At Pantex Plant and IAAP, cattle are only pastured on native grasses and winter wheat. The growth strategy for cheatgrass is considerably different from most plants; cheatgrass is a CS annual optimally suited for areas with winter and spring rainfall, such as the Hanford Site area. Cheatgrass has shallow, dense roots, and it quickly seeds in late spring. Figure 8 illustrates cheatgrass growth as modeled by BIOTRAN for approximately 14 cm of annual rainfall. Note the growth peaks at late spring and mid-November in agreement with studies done by Uresk (1979) and Cline (1974).

Figures 9 and 10 depict the irrigated crops and cheatgrass over the 100yr simulation period for the Hanford Site region. Fruit trees are cycled (replanted) every 25 years.



Fig. 8. Cheatgrass biomass (LAGB) at Hanford during one simulation year. Note the spring and late-fall peaks corresponding to rainfall.



Fig. 9. Irrigated crop LAGB for Hanford region. Apple trees are planted on a 25-yr cycle.



Fig. 10. Irrigated pasture grass and wheat crops compared with annual grass cheatgrass; a CS plant.

The lower layer boundary condition on drainage was tuned by setting FLODN to 0.02 for the sandy soil at Hanford Site. This is consistent with frequent irrigation, which is characteristic of sandy soils. Sprinkler irrigation is used extensively in the Hanford Site area. Table C-III lists the planting and harvesting schedules for each crop, as well as the irrigation schedules. Table C-IV gives the estimated root fraction and soil layers. Table VII gives the Hanford area productivity for the crops and grass compared to the BIOTRAN simulations. The constants used for biomass conversions for Hanford Site were assumed to be the same as those at the IAAP.

B. Long-Term Calculations for Radiological and Health Effects

Table C-V lists 50 simulation years of plutonium concentration values from BIOTRAN for air in dpm/m³, garden vegetables and winter wheat in dpm/g, and dry and beef muscle in dpm/g wet.

For the 0.625-kg plutonium release at Hanford Site, only the fourth isopleth (0.4 μ Ci/m²) for the median case reached beyond the Hanford Site boundary. For the other accidents, the contamination was initially deposited within the Hanford Site boundary; therefore, no long-term doses were calculated.

V. CONCLUSIONS

Table VIII summarizes the computer model BIOTRAN food chain plutonium concentration predictions for air, vegetables, wheat, and beef muscle for the three sites. The Hanford Site is considered an arid site with windblown particles that are the major cause of high air concentration (103 dpm/m³ in first year) and high particle loading on plants and forage, giving the highest meat value (95.9 dpm/g wet beef muscle). The IAAP region is considered a wet region with over five times the annual precipitation of the Hanford Site. This gives correspondingly lower air, plant, and muscle plutonium concentrations because particle loading is reduced. This difference between arid and wetter climates needs field verification with more data on rain splash, particle loading with height on plants, and correlation of storm intensities, particle size, and plant phenology. The no-decontamination case for the Hanford 0.625-kg release may not be acceptable even though the initial deposition pattern indicates most will remain on site. This is because of the windblown particle transport dominance and also the wind direction pattern. Stabilization or decontamination of on-site deposited PuO, may be necessary at Hanford Site to reduce the possibility of resuspension into the air and subsequent dispersion toward the townsite.

TABLE VII

HANFORD PRODUCTIVITY DATA - ALL IRRIGATED CROPS

			<u> </u>	· · · · · · · · · · · · · · · · · · ·	+
Crop and Descriptio	n	Reported Amount/Acre	Estimated g/m ² Dry	100-yr Range* BIOTRAN g/m ² Dry	References
Corn, grain, Frankli Columbi	n County, a Basin	133 bu/acre 130.5 bu/acre	746 732		CES 1982A CES 1982B
Corn, silage, Columb	ia Basin	23. ton/acre 25-30 ton/acre	1072 1122–1346		CES 1982B
Average range grain residue	plus		1072-1346	1163-1423	Cline**
Beans, "dry" Franklin Columbi	n County a Basin	21.2 cwt/acre 21.1 cwt/acre	238 237		CES 1982A CES 1982B
Pea seed, Columbia	a Basin	30.4 cwt/acre	341		CES 1982B
Average range bean p residue	lus		476-682	614-741	
Apples, Columbia Benton	a Basin City	6.3 tons/acre 600 box/acre	1415	12 340-12 966 (whole tree)	CES 1982B
Alfalfa, Franklin (3 cuttings) Columbia Benton (n County a Basin City	5.7 tons/acre 5.1 tons/acre 5-6 tons/acre 6 tons/acre	767 687 673-808 808		CES 1982A CES 1982B Cline**
Average range three o	cuttings		673-808	801-990	
Wheat Franklir Columbia Benton (n County a Basin City	90 bu/acre 90.8 bu/acre 90 bu/acre	475 479 475		CES 1982A CES 1982B
Average range grain p residues	olus		950-957	222-404	
Irrigated Columbia Pasture Benton (a Basin City	9.8 AUM ⁺ 15 AUM ⁺		109-315 (grazed)	CES 1982B
Cheatgrass, <u>Bromus te</u> (Unirrigated)	<u>ectorum</u>	-	254 <u>+</u> 205	112-276 (grazed)	Sauer***

*Maximum Live Above-Ground Biomass during 1 yr.
**J. F. Cline, Ecologist, Battelle Pacific Northwest Laboratory, Richland, Washington.
***R. Sauer, Ecologist, Battelle Pacific Northwest Laboaratory, Richland, Washington.
[†]AUM = animal unit month.

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TABLE VIII

Site	A dpm]yr	ir /m ³ 50-yr average	Leafy V dpm/ l yr	eget able g dry 50-yr average	Wh dpm/ ו yr	eat g dry 50-yr average	Beef Muscle dpm/g wet 50-yr 1 yr average		
Pantex Region	94.3	4.43	1880	173	5870	508	314	31.0	
IAAP Region	82.9	3.04	3620	304	3626	309	672	3.04	
Hanford Region	103	2.48	9690	2000	5870	608	811	95.9	

SUMMARY OF BIOTRAN FOOD CHAIN PU CONCENTRATION PREDICTIONS

Table IX summarizes the risk of long-term health effects as risk of cancer mortality per 100 000 people at each site for the three hypothetical accidents. If an accident occurred in the 30- to 120-kg plutonium released range, a risk of 14 cancer mortalities per 100 000 people could be expected for IAAP and a risk of 7.2 mortalities per 100 000 people for the Pantex Plant, if no decontamination of farmland occurred. Note that this study is limited to farmland. Individuals were assumed to consume garden and farm products grown in the contaminated regions. Decontamination using the Healyproposed level would decrease health effects by 1 to 4 times for Pantex Plant, and from 1 to 12 times for IAAP. Decontamination to the EPA level decreases health effects by divisions of 1 to 90 for the Pantex Plant and by 1 to 259 for IAAP. The reason for the larger long-term risk at IAAP is the closer proximity of a large population to the release point. Population density is the major variable influencing risk.

In Table X a comparison can be made between decontamination cost (Wenzel 1982B) and estimated health effects, which can be calculated based on 1990 population estimates. Cost to decontaminate to EPA levels the Pantex Plant (120-kg Pu, unfavorable meteorology) was \$890 million. The IAAP for the same accident was \$490 million. For the no-decontamination case, the estimated health effects were greater at the Pantex Plant (4.4 cases/61 200 people) than at IAAP (3.6 cases/25 800 people). However, the <u>risk</u> was greater at the IAAP than at the Pantex Plant when conversion is made to cases/100 000 people (equivalent to chance of cancer mortality per 100 000 chances).

VI. ACKNOWLEDGMENTS

The authors express their appreciation to Wayne R. Hansen for his positive encouragement and suggestion for this study. We also appreciate the

TABLE	TX
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SUMMARY OF HEALTH EFFECT RISK (CANCER MORTALITY/10⁵ PEOPLE)

		120-	kg Pu							0.625-k			
C 11	Median Met.* Unfavorable Met.**		Media	Median Met. Unfavor			. Median Met.		Unfavorable Met.		Decontamination		
Site	l yr	<u>50 yr</u>	<u> </u>	<u>50 yr</u>	<u> l yr </u>	<u>50 yr</u>	<u> yr</u>	<u>50 yr</u>	l yr	<u>50 yr</u>	l 1 yr	<u>50 yr</u>	Criteria
Pantex	0.85	1.7	3.6	7.2	0.40	0.82	2.0	4.0	0.31	0.65	0.11	0.22	No decontamination
	0.57	1.1	0.92	1.8	0.39	0.78	0.73	1.5	0.31	0.65	0.11	0.22	Healy level
	0.040	0.080	0.041	0.080	0.040	0.080	0.041	0.081	0.041	0.081	0.041	0.082	EPA level
IAAP	5.9	9.6	8.5	14.0	1.2	2.0	3.1	5.2	0.34	0.54	0.22	0.36	No decontamination
	0.50	0.83	0.70	1.2	0.32	0.52	0.67	1.1	0.34	0.54	0.22	0.36	Healy level
	0.036	0.075	0.36	0.054	0.036	0.058	0.036	0.057	0.037	0.056	0.036	0.056	EPA level
Hanford	-	-	-	-	-	-	-		0.0	0.0	0.0	0.0	No decontamination
									0.0	0.0	0.0	0.0	Healy level
									0.0	0.0	0.0	0.0	EPA level

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*Median Met. - most likely meteorological dispersion condition.
**Unfav. Met. - meteorological dispersion condition, which could occur 5% of the time.

TABLE X

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SUMMARY OF ESTIMATED HEALTH EFFECTS AND DECONTAMINATION COSTS (Dollars x 10⁶)

			120-	-ka Pu	30-kg Pu				0.625-kg Pu					
		Median	Met. U	Infav.	Met.	Median	Met.	Unfav.	Met.	Median	Met.	Unfavor.	Met.	Decontamination
Sit	e	<u>l yr</u>	50 yr	l yr	50 yr	l yr	50 yr	<u>l yr</u>	50 yr	<u>1 yr</u>	50 yr	<u> 1 yr</u>	<u>50 yr</u>	Criteria
Pantex	EHE*	0.059	0.12	2.2	4.4	0.029	0.059	1.2	2.4	0.000052	0.00011	0.0046	0.0092	No decontamination
	EHE Cost	0.040 170	0.080	0.56 190	1.1	0.028 81	0.056	0.44 97	0.88	0.000052 2.9	0.00011	0.0046 3.3	0.0092	Healy level
	EHE Cost	0.0028 740	0.040	0.025 890	0.049	0.0029 510	0.0058	0.025 590	0.049	0.0000069 18	0.000014	0.0017 22	0.0034	EPA level
IAAP	EHE	0.57	0.93	2.2	3.6	0.063	0.10	0.66	1.1	0.0016	0.0025	0.017	0.028	No decontamination
	EHE Cost	0.048 180	0.080	0.18 190	0.30	0.016 45	0.026	0.14 48	0.24	0.0016 2.7	0.0025	0.017 2.0	0.028	Healy level
	EHE Cost	0.0035 740	0.0073	0.0093 490	0.014	0.0018 270	0.0029	0.0076 260	0.012	0.00017 17	0.00026	0.0028 13	0.0044	EPA level
Hanfor	d EHE									0	0	0	0	No decontamination
	EHE Cost									0 3.2	0	0 1.6	0	Healy level
•	EHE Cost	_								0 21	0	0 10	0	EPA level

*EHE = Estimated health effects, number of cancer mortalities expected based on potential population exposed.

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many contributions John Rodgers, Life Sciences Group (LS-6), has given to this effort, particularly in development of the BIOTRAN hydrological, metabolic, and climatic transport portions of the model. The word processing skills of Verna Halloran, Kathy Derouin, Lois Schneider, and Mary Lou Keigher are greatly appreciated.

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APPENDIX A

PANTEX PLANT SUPPLEMENTARY DATA

4

Т	A	В	L	E	А	- I
		_	_	_		_

DACRIN INHALATION DOSE FACTORS FOR WEAPONS GRADE PLUTONIUM

WG-Pu*	Wt% in	Ci/g***	µCi/µg	Lung		Liver		Bone	
Nuclide	Mix**	Nuclide	of Mix	a b		a b		a b	
238pu	0.05	17.4	0.0087	111	106	75.9	41.0	155.0	78.7
239pu	93.6	0.0614	0.0575	692	664	557	287	1201	575
240pu	6.0	0.226	0.0136	163	157	132	67.9	283.0	136
241pu	0.4	112	0.448	9.43	9.10	63.2	43.0	146.0	95.1
242pu	0.5	0.0039	1.95x10 ⁻⁶	0.0225	0.0216	0.0182	0.00938	0.0376	0.0181
241 _{Am}	~0.02	3.24	6.48x10 ⁻⁴	0.847	0.843	13.3	7.62	20.0	10.6
WG-Pu Mix		Σ	0.0804	976	937	841	447	1805	895

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a. DACRIN 1-yr Exposure, 50-yr dose integration (186000 days DOSTIM).

b. DACRIN 50-yr Exposure, 50-yr dose integration (183000 days DOSTIM).

* Weapons Grade Plutonium.

** Los Alamos 1979.

*** Healy 1970.

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TABLE A-II

WG-Pu Nuclide	WG-Pu Mix (µCi∕µg)	Nuclio (rem/µ	de Ci)	Mix (rem/µC	i)
		Liver	Bone	Liver	Bone
²³⁸ Pu	0.0087	0.225	0.504	0.0243	0.0545
²³⁹ Pu	0.0575	0.249	0.566	0.178	0.405
^{24 0} Pu	0.0136	0.250	0.567	0.0423	0.0959
^{24 1} Pu*	0.448	0.00483	0.117	0.0269	0.0652
²⁴² Pu	1.95x10 ⁻⁶	0.237	0.539	5.75x10-6	1.31x10-5
²⁴¹ Am	6.48x10 ⁻⁴	8.55	19.4	0.0689	0.156
L					
			Σ	0.340	0.777

INREM INGESTION DOSE FACTORS FOR WEAPONS GRADE PLUTONIUM

*Includes ²⁴¹Am in-growth for 50 years.

TABLE A-III

FORMATTED BIOTRAN INPUT FOR PANTEX SIMULATION

277.0 7.3	723.0 45.5	90.0 0.0	36.2 2.0 3500 0	78.0 0.0 0.04	120.0 0.0	1.0	1.0
0.023	0.026	0.037	0.062	0.149	0.161	0.143	0.150
21.0	3538.0	0.039	26.1	16.8	27.5	0.0	100.0
1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0
0.0	0.0	0.0 0.0	1.0 0.0	1.0 0.0	1.0 0.0	1.0 0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0		
1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0		
3000.	3000.0	0.0	0.0	0.0	0.0	0.0	3000.
0.0	0.0	3000.	3000.	0.0	0.0	0.0	0.0
914 4	914 4	0.0	0.0	0.0	0.0	0.0	1500 0
0.0	0.0	2000.	1500.	0.0	0.0	0.0	0.0
0.0	1500.0	0.0	0.0	0.0	0.0		
0.0	0.0	0.0	0.0	0.0	0.0	0.0	
202.0		4.0	99.0	1.0			
9 700p-02	0 6 920e-04	0.000e+01	1 0.000e+01)			
4.000e-02	4.000e-09	4.000e-09	4.000e-02	<u>,</u>			
7.407e+04	7.407e+04	0.000e+01	0.000e+0	ĺ			
9.700e-02	6.920e-01	2.210e-01	6.800e-02	2			
4.000e-09	4.000e-09	4.000e-09	4.000e-09				
1.000e+06	0.000e+01	0.000e+01	0.000e+0	0.000e+0	1 0.000e+0	1 0.000e+0	1
4 000e-02	4 000e-09	4 000e-09	4 000e-04	4 000e-04	4 000e-0	9 4 000e-00	3
7.407e+04	7.407e+04	0.000e+01	0.000e+0	0.000e+0	1 0.000e+0	1 0.000e+0	1 0.000e+01
0.000e+01							
5.010e-02	2 5.530e-0'	4.270e-0	3.100e-0'	1 2.300e-0	1 1.700e-0	1 1.320e-0	1 1.000e-01
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	9 4.000e-09	9 4.000e-09
4.000e-09			0.0000+0	0 0000+0	0.0000+0	1 0 0000+0	4
9.700e-02	7.4078404 7.700e-04	• 0.000e+0 2 300e-0'	6.500e+0	2 000e-02	7 6 000e+0	3 1 800e-0	י ז
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-0	9 4.000e-09	9
1.000e+06	6 0.000e+0	0.000e+0	1 0.000e+0 [.]	1 0.000e+0	1 0.000e+0	1 0.000e+0	1
9.700e-02	2 7.700e-0	2.300e-0	6.500e-02	2 2.000e-02	2 6.000e-0	3 1.800e-03	3
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4,000e-09	€ 4.000e-09	9_4.000e-09	9
302.0	302.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	/.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.0	150.0	201.0	229.0	243.0	257.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
302.0	302.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0

TABLE A-III (cont)

2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
198.0	205.0	212.0	219.0	226.0	233.0	240.0	247.0
254.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	300.0	531.0	577.0	5.0	5.0	5.0	5.0
5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
215.0	215.0	470.0	485.0	502.0	514.0	527.0	533.0
544.0	559.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	560.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	16.0	5.0	5.0	5.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	425 0	0.0	0.0	0.0	0.0
250.0	230.0	285.0	423.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0				
1.0	600.	1.0	1.0	3.0	0.0	0.0	0.0
3.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	73.0	74.0	319.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600	600	600	600	600	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	.0.0	0.0	1.0
0.0	2.0	4.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	2.0						
1.0	11.0	12.0	0.0	0.0	0.0	0.0	0.0
4.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0
4.0	8.0	4 0	2.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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TABLE A-IV

REFERENCED BIOTRAN INPUT FOR PANTEX

<u> </u>	1	
Variable Name	Value	Reference and Notes
and Description		
T1, min. insolation, ly/d	277.0	Map 53, Baldwin 1973
T2, max. insolation, ly/d	723.0	Map 54, Baldwin 1973
Ll, lag insolation period	90.0	Gallegos 1980
T3, min.mo. daily temp F	36.2	Map 10, Baldwin 1973
T4, max.mo. daily temp *F	78.0	Map 10, Baldwin 1973
L2, lag temp. period	120.0	Gallegos 1980
pH of soil	7.3	Unger 1981 , Jacquot 1962
% clay of soil	45.5	Unger 1981 , Jacquot 1962
Soil type	2.0	Loam, Unger 1981
Nuclide	1.0	Pu
Saltation/rain splash	1.0	Process modeled
TRE, rainfall events/mo	5.0	Map 24, Baldwin 1973
TMXV, max temp variation	1.98	NOAA 1980-Amarillo, Texas
PRCV, rain coeff. variation	1	
RELV, elevation, ft	3500	
ALPSR, lapse rate, *F/ft	0.004	Gallegos 1980
X(1,12) ppt fraction -	J.023	NOAA 1980 - Amarillo, Texas
each mo. as function of	F.026	USDA 1979 - Bushland, Texas
total	M.037	-
	A.062	
	M.149	
	J.161	
	J.143	
	A.150	
	5.093	
	0.089	
	N.039	
(D.029	
R, annual ppt, in.	21	NOAA 1980 - Amarillo, Texas
Gl. site elevation. ft	3538	
13. latitude to reference	0.0	
F_{1} =0.3 bar, soil %H_0	26.1	Unger 1981
W]15 bar. soil H_0	16.8	Unger 1981
$H_{\rm o}$ 0 bar, soil % $H_{\rm o}$	27.5	Unger 1981
Y2. simulation interval vr	100.0	
RHFRB ruminant	2 0	More than one grazing interval
	2.0	nore than the grazing interval

.

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TABLE A-IV (cont)

	·	p
Variable Name and Description	Value	Reference and Notes
RANDN, number seed	528	Random number seed
ARIG, irrigation	2.0	32 columns of irrigation values
AICHE niche competition	1 0	Niche competion between ws and cs grass
SELECT(15) output	Vomly	Voarly output only
DCCPLT(12), DUCPUL	liany	Dianta plattad computer(1) up and a
RGCPLI(22), plants plot	1,2,8	(Plants plotted - sorgnum(1), ws garden
	11,12,18	vegetables(2), ws grass(8), alfalfa(11),
		winter wheat (12), cs grass(18)
RGC(22), plants sim.	Same	Plants simulated, USDA 1979-80, Pettit 1974
RIRRC(22), irrig. sch.	1,2,11,12	Irrigation schedules, Texas A&M 1981 ,
		Johnson and Davis 1980 , Unger
		1981 , Harmon*
RSS(22), niche	8, 18	Ws and cs grass niche competition
ACRES(22), area in acres	1.2.8.11.	Area simulated - food, grazing and feed
	12.18	· · · · · · · · · · · · · · · · · · ·
RCODF(22) soil depth	1 2 8 11	Soil rooting depth for plants
sorr depen	12 18	
FEP frost_free period d	202	NOAA 1980 - Amarillo Toyas
INTE Du moot untako	202	Num 1960 - Alla IIIO, lexas
iorike, ru root uptake	4.0	$r_{\rm u}$ root uptake, fraction/u/mi of
		f transpirate/m ² = 4x10 ²
XPLNI, daily output ir	99.0	Year for daily output
XHERB, Ruminant mode	1.0	Yearly data
[Z1, dpm/g soil	1,2,8,11	Activity specified each layer at t _o
ZF, root fraction/layer	same	Gallegos 1980, Rodgers 1980, Pettit 1974
ZU, root uptake coeff.	4x10 ⁻⁹	Gallegos 1980 (for plutonium)
CUTA, harvest sch.	1,2,11,12	Wilson**, Harmon*, Undersander***
AWATA, irrig, acre-in/	1.2.11.12	Wilson**. Harmon*. Texas A&M 1981
app].		······
DIRA, irrig, sch.	1.2.11.12	Same
RR. Ruminant	1 1 0	Reef cattle simulated
P5 fraction consumed		Fraction raised & consumed in study
in a structure consumed		anda
NE hord size	600	
AA2 fraction mared	1 0	Enaction study area grazed
reupt fraction grazed	1.0	Fraction Study area grazed
Insur, traction feed	1.0	praction teed from study area
AGE, yr or herd	3.0	3.0 specifies 2-year-old cattle
YRGRZ, yr on pasture	1-100	
ONRNG, d on range	1-73	[Horton [™]
	74-319	4
ANMAL, herd size	600,600	
PUTZD, feed	1,11=4	Days 1-73, 4 is supplemental feed, 1 is
	12=1.0	graze
1	1,11=4	Days 74-319
	8,18=1.0	
	1 -	

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TABLE A-V

PANTEX CROP PLANTING(P), HARVESTING(H), AND IRRIGATION SCHEDULE

Grain Sorghum		Garden Veg.		Alf	ạlfa	Winter Wheat		
P-H-& Irrig(d)	(Acre-in.) PW=Prewater	P,H,& Irrig(d)	(Acre-in.)	P,H,& Irrig(d)	(Acre-in.)	P,H,& Irrig(d)	(Acre-in.)	
1,1,0,0,2,9(0)								
150(P)	7 (PW)	150(P)	1	215(P)	20.6 (PW)	250(P)	16(PW)	
		157	1	470	5	285	5	
201	6	164	1	485	5	425	5	
		171	1	500(H)		500	5	
229	6	177	1	502	5	560(H)		
		184	1	514	5			
243	6	191	1	527	5			
		198	1	531(H)				
257	6	205	1	533	5			
		212	2	544	5			
302(H)		219	2	559	5			
		226	2	577(H)				
		233	2					
		240	2					
		247	2					
		254	2					
		261	2					

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TABLE A-VI

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ROOT FRACTION ESTIMATES FOR PANTEX SIMULATED PLANTS

Simulated Soil Layer	Depth (cm)	Grain Sorghum(1) Root Frac.	WS Garden Vegetables(2) Root Frac.	WS Perennial Grass(8) Root Frac.	Alfalfa(ll) Root Frac.	Winter Wheat(12) Root Frac.	CS Perennial Grass(18) Root Frac.
Resuspension 1 2 3 4 5 6 7 8 9 10 11 11 12	0-2 2-27 27-52 52-77 77-102 102-127 127-152 152-177 177-202 202-227 227-252 252-277 277-302	0.097 0.692 0.221 0.068	0.097 0.692 0.221 0.068	0.097 0.770 0.230 0.650 0.020 0.0060 0.0018	0.0501 0.553 0.427 0.310 0.230 0.170 0.132 0.100	0.097 0.770 0.230 0.650 0.020 0.0060 0.0018	0.097 0.770 0.230 0.650 0.020 0.0060 0.0018

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Years	Air Concentration Above Grazed Grasses dpm/m ³ Yearly Average	Garden Veget ab les dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet	Years	Air dpm/m ³ Yearly Average	Garden Vegetables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet
1	94.3	-	-	-	26	0.0248	6.61	15.3	0.657
2	30.2	1880	3420	-	27	0.0201	6.01	8.85	0.519
3	22.5	1560	5870	288	28	0.0146	5.84	10.8	0.337
4	19.8	1150	2910	314	29	0.0108	5.49	7.39	0.209
5	14.1	885	2860	212	30	0.00865	5.13	8.51	0.160
6	10.8	660	2090	176	31	0.00672	4.96	6.12	0.129
7	7.91	513	1570	134	32	0.00500	4.57	4.97	0.0859
8	5.38	392	1660	102	33	0.00407	4.13	4.76	0.0854
9	4.25	295	1040	77.2	34	0.00291	4.56	3.72	0.0703
10	3.00	227	867	52.7	35	0.00217	4.52	4.02	0.0619
11	2.24	178	554	32.0	36	0.00162	4.01	2.83	0.0551
12	1.69	149	468	20.5	37	0.00120	4.11	2.77	0.0420
13	1.41	108	292	14.2	38	0.000903	4.67	2.93	0.0386
14	1.08	82.6	293	8.98	39	0.000659	4.38	2.61	0.0305
15	0.780	68.4	212	6.09	40	0.000458	4.80	2.02	0.0250
16	0.686	50.4	184	6.26	41	0.000341	5.26	2.46	0.0197
17	0.486	38.4	106	7.68	42	0.000249	5.48	2.24	0.0243
18	0.282	31.1	73	6.11	43	0.000197	5.54	2.03	0.0263
19	0.207	23.2	93.7	4.42	44	0.000153	5.67	1.53	0.0180
20	0.150	19.1	67.5	2.74	45	0.000128	5.42	1.55	0.0211
21	0.114	16.4	40.6	1.62	46	0.0000954	5.55	1.98	0.0225
22	0.103	13.3	38.5	1.26	47	0.0000709	5.55	1.59	0.0175
23	0.0763	10.6	23.7	1.15	48	0.0000499	5.15	1.71	0.0161
24	0.0556	8.94	19.9	1.11	49	0.0000392	5.08	1.57	0.0162
25	0.0367	8.08	13.4	0.852	50	0.0000280	5.19	1.53	0.0174
Σ	261.6366	8 367.52	24 766.30	1 470.872	Σ	0.1060114	127.68	105.79	2.705
			<u> </u>	_	X	4.43	173.0	508.0	31.0

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PuO2 CONCENTRATION IN AIR, VEGETABLES, WHEAT, AND CATTLE MUSCLE FROM BIOTRAN SIMULATION OF PANTEX

TABLE A-VII

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TABLE A-VIII

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CHRONIC 1-yr EXPOSURE, 50-yr DOSE COMMITMENT FOR PANTEX

PuO ₂ Deposited µCi/m ²	Organ	Resuspe ⊮Ci Inhaled	ension rem	Leafy ICi Ingested	/egetables	Wheat Products µCi Ingested rem		Meat µCi Ingested rem		Total rem
13514 (BIOTRAN	lung liver bone	0.47	460 400 850	25.4	8.6 20	60.8	- 21 47	11.2	- 3.8 8.7	460 433 926
400	lung liver bone	0.014	14. 12. 25.	0.75	0.26 0.58	1.8	0.61 1.4	0.33	- 0.11 0.26	14 13 27
7.5	lung liver bone	2.6x10-4	0.25 0.22 0.47	0.014	0.0048 0.011	0.034	0.012 0.026	0.0062	_ 0.0021 0.0048	0.25 0.24 0.51
0.2	lung liver bone	7.0x10 ⁻⁶	0.0068 0.0059 0.013	0.00038	0.00013 0.00030	0.00090	0.00031 0.00070	0.00017	- 0.000058 0.00013	0.0068 0.0064 0.014

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PuO ₂ Deposited µCi/m ²	Organ	Resuspension µCi Inhaled rem		Leafy Vegetables µCi Ingested rem		Wheat Products µCi Ingested rem		Meat µCi Ingested rem		Total rem
13514 (BIOTRAN)	lung liver bone	1.10	1030 492 985	117	- 40 91	263	- 89 204	55.2	- 19 43	1030 640 1323
400	lung liver bone	0.033	31 15 30	3.5	1.2 2.7	7.8	- 2.7 6.1	1.6	- 0.54 1.2	31 19 40
7.5	lung liver bone	0.00061	0.57 0.27 0.55	0.065	0.022 0.051	0.15	- 0.51 0.12	0.31	- 0.011 0.024	0.57 0.35 0.75
0.2	lung liver bone	0.000016	0.015 0.0072 0.014	0.0017	0.00058 0.0013	0.0039	- 0.0013 0.0030	0.00082	_ 0.00028 0.00064	0.015 0.0094 0.019

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TABLE A-IX

CHRONIC 50-yr EXPOSURE, 50-yr DOSE COMMITMENT FOR PANTEX

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TABLE A-X

Isopleth	Number of People	μCi m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	4	786	lung liver bone	107 101 215	0.0046 0.0015 0.00030		240 149 308	0.010 0.0022 0.00043	
1	4	400	lung liver bone	56 52 108	0.0024 0.00078 0.00015	-	124 76 160	0.0053 0.0011 0.00022	
2	140	40	lung liver bone	196 182 378	0.0084 0.0027 0.00053		434 266 560	0.019 0.0040 0.00078	
3	4255	4.0	lung liver bone	596 553 1149	0.026 0.0083 0.00016		1319 808 1702	0.057 0.012 0.0024	
4	2559	0.4	lung liver bone	36 33 69 Σ	0.0015 0.00050 0.000097 0.059	0.85	79 49 102 Σ	0.0034 0.00074 <u>0.00014</u> 0.12	1.7
Healy	148	7.5	lung liver bone	37 36 75	0.0016 0.00054 0.00011		84 52 111	0.0036 0.00078 0.00016	
3	4255	4.0	lung liver bone	596 553 1149	0.026 0.0083 0.0016		1319 808 1702	0.057 0.012 0.0024	
4	2559	0.4	lung liver bone	36 33 69 Σ	0.0015 0.00050 <u>0.000097</u> 0.040	0.57	79 49 102 Σ	0.0034 0.00074 <u>0.00014</u> 0.080	1.1
EPA	6962	0.2	lung liver bone	47 45 97	0.0020 0.00068 0.00014		104 65 97	0.0045 0.00098 0.00014	
				Σ	0.0028	0.040	Σ	0.0056	0.080

120-kg Pu CASE, MEDIAN METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL" FOR PANTEX

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TABLE A-XI

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Isopleth	Number of People	μCi m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	78	1101	lung liver bone	2923 2752 5884	0.13 0.041 0.0082		6545 4067 8407	0.28 0.061 0.012	
1	78	400	lung liver bone	1092 1014 2106	0.047 0.015 0.0029		2418 1482 3120	0.10 0.022 0.0044	
2	20448	40	lung liver bone	28630 26580 55210	1.23 0.40 0.077		63390 38850 81790	2.73 0.58 0.11	
3	28730	4.0	lung liver bone	4022 3735 7757	0.17 0.056 0.011		8906 5459 11490	0.38 0.082 0.016	
4	11862	0.4	lung liver bone	166 154 320 Σ	0.0071 0.0023 <u>0.00045</u> 2.2	3.6	368 225 474 Σ	0.016 0.0034 <u>0.00066</u> 4.4	7.2
<u>Healy</u>	20604	7.5	lung liver bone	5151 4975 10510	0.22 0.074 0.015		11744 7211 14423	0.50 0.11 0.020	
3	28730	4.0	lung liver bone	4022 3735 7757	0.17 0.056 0.011		8906 5459 11490	0.38 0.082 0.016	
4	11862	0.4	lung liver bone	166 154 320 Σ	0.0071 0.0023 <u>0.00045</u> 0.56	0.92	368 225 474 Σ	0.016 0.0034 <u>0.00066</u> 1.1	1.8
<u>EPA</u>	61196	0.2	lung liver bone	416 392 857 Σ	0.018 0.0059 0.0012 0.025	0.041	918 575 1163	0.039 0.0086 0.0016 0.049	0.080
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120-kg Pu CASE, UNFAVORABLE METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL" FOR PANTEX

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TABLE A-XII

30-ka	Pu CASE, I	MEDIAN ME	ETEOROLOGY	', SUMMARY O	F RAI	DIOLOGICAL	AND
5	HEALTH ÉF	FECTS TO	"AVERAGE	INDIVIDUAL"	FOR	PANTEX	

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Isopleth	Number of People	μCi m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	0	150	lung liver bone						
1	0	400	lung liver bone						
2	22	40	lung liver bone	30.8 28.6 59.4	0.0013 0.00043 0.000083		68.2 41.8 88	0.0029 0.00063 0.00012	
3	2862	4.0	lung liver bone	401 372 773	0.017 0.0056 0.0011		887 544 1145	0.038 0.0082 0.0016	
4	4334	0.4	lung liver bone	60.7 56.3 117	0.0026 0.00084 <u>0.00016</u> 0.029 Σ	0.40	134 82 173	0.0058 0.0012 <u>0.00024</u> 0.059 Σ	0.82
<u>Healy</u>	22	7.5	lung liver bone	5.5 5.3 11.2	0.00024 0.000080 0.000016		12.5 7.7 16.5	0.00054 0.00012 0.000023	
3	2862	4.0	lung liver bone	401 372 773	0.017 0.0056 0.0011		887 544 1145	0.038 0.0082 0.0016	
4	4334	0.4	lung liver bone	60.7 56.3 117	0.0026 0.00084 0.00016 0.028 Σ	0.39	134 82 173	$\begin{array}{c} 0.0058 \\ 0.0012 \\ \underline{0.00024} \\ 0.056 \end{array} $	0.78
EPA	7218	0.2	lung liver bone	49.1 46.2 101	0.0021 0.00069 0.00014 0.0029 z	0.040	108 67.8 137	$\begin{array}{c} 0.0046 \\ 0.0010 \\ \underline{0.00019} \\ 0.0058 \end{array} $	0.080

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TABLE A-XIII

Isopleth	Number of People	μCi m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									1
١	0	166	lung liver bone	5.6 5.3 11.4	0.00024 0.000084 0.000016		12.7 7.86 16.3	0.00055 0.00012 0.000023	
1	0	400	lung liver bone	14 13 27	0.00060 0.00020 0.000038		31 19 40	0.0013 0.00029 0.000056	
2	11068	40	lung liver bone	15495 14388 29884	0.67 0.22 0.042		34310 21029 44272	1.5 0.32 0.062	
3	30107	4.0	lung liver bone	4215 3914 8129	0.18 0.059 0.011		9333 5720 12043	0.40 0.086 0.017	
4	19335	0.4	lung liver bone	271 251 522	0.012 0.0038 <u>0.00073</u> 1.2 ε	2.0	599 367 773	0.026 0.0055 <u>0.0011</u> 2.4 Σ	4.0
<u>Healy</u>	11070	7.5	lung liver bone	2768 2657 5646	0.12 0.040 0.0079		6310 3875 8303	0.27 0.058 0.012	
3	30107	4.0	lung liver bone	4215 3914 8129	0.18 0.059 0.011		9333 5720 12043	0.40 0.086 0.017	
4	19335	0.4	lung liver bone	271 251 522	0.012 0.0038 <u>0.0073</u> 0.44 Σ	0.73	599 367 773	0.026 0.0055 <u>0.0011</u> 0.88 Σ	1.5
<u>EPA</u>	60512	0.2	lung liver bone	411 387 847	0.018 0.0058 <u>0.0012</u> 0.025 Σ	0.041	908 567 1150	0.039 0.0085 <u>0.0016</u> 0.049 Σ	0.081
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30-kg Pu CASE, UNFAVORABLE METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL" FOR PANTEX

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TABLE A-XIV

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Isopleth	Number of People	μCi m²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	0	400	lung liver bone						
2	0	40	lung liver bone						
3	5	4	lung liver bone	0.70 0.65 1.35	0.000030 0.0000098 0.0000019		1.55 0.95 2.00	0.000067 0.000014 0.0000028	
4	12	0.4	lung liver bone	0.168 0.156 0.324	$\begin{array}{c} 0.0000072\\ 0.0000023\\ 0.00000045\\ \hline 0.000052 \ \Sigma \end{array}$	0.31	0.372 0.228 0.480	0.000016 0.0000034 <u>0.00000067</u> 0.00011 Σ	0.65
Healy									
3	5	4	lung liver bone	0.70 0.65 1.35	0.000030 0.0000098 0.0000019		1.55 0.95 2.00	0.000067 0.000014 0.0000028	
4	12	0.4	lung liver bone	0.168 0.156 0.324	0.0000072 0.0000023 0.0000045 0.000052 2	0.31	0.372 0.278 0.480	$\begin{array}{c} 0.000016\\ 0.0000034\\ 0.0000067\\ \hline 0.00011 \end{array}$	0.65
<u>EPA</u>	17	0.2	lung liver bone	0.116 0.109 0.238	0.0000050 0.0000016 0.00000033 0.0000069 z	0.041	0.255 0.159 0.323	$\begin{array}{c} 0.000011\\ 0.0000024\\ 0.00000045\\ \hline 0.000014 \end{array}$	0.081

0.625-kg Pu CASE, MEDIAN METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL" FOR PANTEX

TABLE A-XV

Isopleth	Number of People	μCi m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	0	400	lung liver bone						
2	0	40	lung liver bone						
3	154	4.0	lung liver bone	21.6 20.0 41.6	0.00093 0.00030 0.000058		47.7 29.3 61.6	0.0021 0.00044 0.000086	
4	3970	0.4	lung liver bone	55.6 51.6 107.0	0.0024 0.00077 <u>0.00015</u> 0.0046 Σ	0.11	123.0 75.4 159.0	0.0053 0.0011 0.00022 0.0092 Σ	0.22
Healy									
3	154	4.0	lung liver bone	21.6 20.0 41.6	0.00093 0.00030 0.000058		47.7 29.3 61.1	0.0021 0.00044 0.000086	
4	3970	0.4	lung liver bone	55.0 51.6 107.0	0.0024 0.00077 <u>0.00015</u> 0.0046 Σ	0.11	123.0 75.5 159.0	0.0053 0.0011 <u>0.00022</u> 0.0092 Σ	0.22
<u>EPA</u>	4124	0.2	lung liver Þone	28.0 26.4 57.7	0.0012 0.00040 <u>0.000081</u> 0.0017 Σ	0.041	61.9 38.8 78.4	0.0027 0.00058 0.00011 0.0034 Σ	0.082

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0.625-kg Pu CASE, UNFAVORABLE METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL" FOR PANTEX

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APPENDIX B

IAAP SUPPLEMENTARY DATA

TABLE B-I

FORMATTED BIOTRAN INPUT FOR IAAP SIMULATIONS

175.0 5.2	525.0 40.0 2.27	90.0 0.0	24.0 2.0	76.5 0.0	120.0 0.0	1.0	1.0
0.049	0.042	0.076	0.097	0.110	0.133	0.102	0.098
35.11	600.0	0.054	26.0	15.6	30.2	o.o	020.0
0.0	2.0	528.0	0.0	1.0	1.0	0.0	
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
0.0	0.0	0.0	1.0	1.0	1.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
0.0	1.0	0.0	0.0	0.0	0.0		••••
1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0		
0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
3000.	3000.	0.0	0.0	0.0	0.0	0.0	3000.
0.0	0.0	3000.	3000.	0.0	0.0	0.0	0.0
0.0	3000.	0.0	0.0	0.0	0.0	0.0	0.0
914.4	914.4	0.0	0.0	0.0	0.0	0.0	1500.
0.0	0.0	2000.	1500.	0.0	0.0	0.0	0.0
0.0	1500.	0.0	0.0	0.0	0.0	0.0	
183.0	0.0	4.0	17.0	1.0	0.0	0.0	
7.407e+04	17.407e+04	0.000e+01	0.000e+0	1			
9.700e-02	2 6.920e-0 ⁴	2.210e-01	16.800e-02	2			
4.000e-09	4.000e-09	4.000e-09	4.000e-09	9			
7.40/e+04	4 7.40/e+04	+ 0.000e+0*	1 0.000e+0	1			
4 000e-02	4 000e-04	1 2.210e-0	4 000e-02	2			
1.000e+06	5 0.000e+0	1 0.000e+0	1 0.000e+0	, 1 0.000e+0	1 0.000e+0	1 0.000e+0	1
9.700e-02	2 7.700e-0	1 2.300e-01	6.500e-02	2 2.000e-02	2 6.000e-0	3 1.800e-0	3
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	9 4.000e-0	9 4.000e-09	9
7.407e+04	7.407e+04	• 0.000e+01	0.000e+0	1 0.000e+0	1 0.000e+0	1 0.000e+0	1 0.000e+01
5 010e-02	1 2 5 5300-01	4 2700-01	1 3 100a-0	2 3000-0	1 1 7000-0	1 1 3200-0	1 1 0000-01
7.700e-02	2	4.2/08 0	1 J. 100e U	2.3008 0	1 1.7008 0	11.3208 0	1.0008-01
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	9 4.000e-09
4.000e-09)						-
7.407e+04	7.407e+04	0.000e+01	0.000e+0	0.000e+0	1 0.000e+0	1 0.000e+0	1
9.700e-02	2 7.700e-01	2.300e-01	6.500e-02	2 2.000e-02	2 6.000e-0	3 1.800e-0	3
1 000e+06	3 0 000e+01	4.000e-0:	4.000e-0:	4.000e-0:	4.000e-0	4.000e-0	9
9.700e-02	2 7.700e-01	2.300e-01	6.500e-02	2 2.000e-02	2 6.000e-0	3 1.800e-0	3
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-0	4.000e-09	9
307.0	307.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130 0	130.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
307.0	307.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
130.0	130.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	500.0	531.0	577.0	623.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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TABLE B-I (cont)

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
200.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	623.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
250.0	250.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0				
1.0	600.	1.0	1.0	3.0			
3.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	73.0	74.0	319.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	600.	600.	600.	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
0.0	2.0	0.0	0.0	0.0	0.0		
2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	2.0						
1.0	11.0	12.0	0.0	0.0	0.0	0.0	0.0
4.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0
1.0	8.0	11.0	18.0	0.0	0.0	0.0	0.0
4.0	2.0	4.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE B-II

HE LICENSED BIOHRIN IN OF FOR INT	REFERENCED	BIOTRAN	INPUT	FOR	IAAP
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Variable Name and Description	. Value	, Reference and Notes
TI min lu/d	175	
11, 11, 19/0		Map 53, Baldwin 1973
iz, max iy/u	525	Map 54, Baldwin 1973
ILI, U ITO °E Min	90	Gallegos 1980
		Map 10, Baldwin 1973
114, F, MdX	/0.5	Map 10, Baldwin 1973
LL, F Soil Tumo	1 120	Gallegos 1980
Sull Type	2	Loam, USDA 1972
[NUC] Ide Soltation/Dain enlach		
Sallalion/Rain Splasn		Process modeled
TMYV Temp Verification	9.9	Map 24, Baldwin 1973
IMAN, Temp. Variation	2.2/	NUAA 1981
DELV SH	0.15	Baldwin 1973
KELV, TL	600	
(ALFSR, F/I)	0.004	NO44 1001
	0.049	NUAA 1981
	0.042	
	0.09/	
	0.133	
	0.102	
	0.098	
	0.054	
P in	0.40	
[], [], [], [], [], [], [], [], [], [],	600	
13 latitude to ref	000	
$F_1 = 0.3$ har	26	Fontont
$W_{1} = 15$ ban	15 6	Fentont
$H \cap bar$		Fontont
V2 Simulation interval	100	Voars Simulated
	100	

*T. Fenton, Soil Scientist, Iowa State University, Ames, Iowa.

TABLE B-II (cont)

Variable Name and Description	, Value	Reference and Notes
RANDN, number seed ARIG AICHE, SELECT (15), output RGCPLT (22), plant plot	528 2.0 1.0 Yearly 1,2,8,11 12,18	Same plants as Pantex, corn(1), ws garden veg(2), ws grass(8), alfalfa(11), winter
RGC (22), plants sim. RIRRC (22), irrig. sch. RSS (22), niche	Same None 8,18	Wheat(12), cs grass(18) Ws and cs grass niche
Acres, area in acre RCODE(22), soil depth	1,2,8,11, 12,18 1,2,8,11,	Area simulated - crops, grazing, feed. Soil rooting depth for
FFP, d UPTAKE XPLNT, Yr XHERB, Ruminant mode Z1, dpm/g soil ZF, root fraction/layer ZU, root uptake coefficient CUTA, harvest sch. AWATA, ring DIRA, irrig. sch. RR, Ruminant P5, Fraction Consumed N5, herd size AA2, frac. grazed FSUPF, frac. feed AGE wr of herd	12,18 183.0 4.0 99.0 1.0 1,2,8,11 12,18 same 4x10-9 1,2,11,12 None None 1.0 1.0 600 1.0 1.0 3.0	plants. NOAA 1981 Pu root uptake = 4x10 ⁻⁹ Yearly Dpm/g specified each layer at t _o Gallegos 1980, Rodgers 1980, Pettit 1974 Gallegos 1980 (for Pu) Cooper* Cooper* Beef Cattle simulated
YRGRZ, yr on pasture ONRNG, d on range ANMAL, herd size PUTZD, feed	3-100 1-73 74-319 600 600 1,11=4 12=1.0	Days 1-73, 4=supple.feed l=graze
	1,11=4 8,18=1.0	Days 74-319

*W. Cooper, Agronomist, Farm Manager at IAAP, Burlington, Iowa.

TABLE B-III

Corn	WS Garden Vegetables	Alfalfa	Winter Wheat	
130(P)	130(P)	200(P)	250(P)	
307(H)	307(H)	500(H)	623(H)	
		531(H)		
		577(H)		I
		623(H)		

IAAP CROP PLANTING(P) AND HARVESTING(H) SCHEDULE (NO IRRIGATION)

TABLE B-IV

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Alfalfa(11) CS Perennial WS Perennial Winter Corn(1) Simulated WS Garden Grass(18) Vegetables(2) Grasses(8) Root Frac. Wheat Root Soi1 Depth Root Frac. Root Frac. (cm) Fraction Root Frac. Root Frac. Layer 0.097 0.097 0.097 0.0501 0.097 0-2 0.097 Resuspension 0.77 0.53 0.77 2-27 0.692 0.692 0.77 1 0.23 0.427 27-52 0.221 0.221 0.23 0.23 2 0.31 0.065 0.065 52-77 0.068 0.068 0.065 3 0.23 0.02 0.02 0.02 77-102 4 0.17 0.006 0.006 0.006 102-127 5 0.0018 0.0018 0.0018 0.132 127-152 6 152-177 7 177-202 8 9 202-227 10 227-252

ROOT FRACTION ESTIMATES FOR IAAP SIMULATED PLANTS

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TAB	LE	B-V

PuO2 CONCENTRATION IN AIR, VEGETABLES, WHEAT, AND CATTLE MUSCLE FOR BIOTRAN SIMULATION OF IAAP

Years	Air Concentration above grazed grasses dpm/m ³ yearly Average	Garden Vegetables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet	Years	Air dpm/m ³	Garden Veget ables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet
1	82.9	-	_	_	26	0.0172	17	16.7	1.17
	20.1	3621	-	-	27	0.0135	16.2	13.1	0.954
3	12.6	2737	3626	672	28	0.0107	17.1	12.2	0.596
ă	9.06	1661	2379	600	29	0.00697	16.3	11.4	0.465
5	6.36	1757	2569	318	30	0.0051	16.4	9.6	0.526
6	4.96	1099	1360	308	31	0.0043	16.1	9.5	0.436
7	4.2	745	1067	213	32	0.00315	14.7	8.3	0.243
8	3.75	630	923	178	33	0.00238	14.9	9.6	0.176
ğ	2.17	474	576	166	34	0.00182	16.5	8.9	0.265
10	1.69	392	569	136	35	0.00142	15.2	7.6	0.176
lii	1.13	286	378	74.4	36	0.000826	13.3	9.2	0.0646
12	0.865	278	331	37.6	37	0.000735	14.2	8.5	0.042
13	0.654	183	232	34.3	38	0.000652	15.2	7.6	0.0579
14	0.509	140	176	20.7	39	0.000568	15	7.3	0.0877
15	0.410	125	161	14.9	40	0.000398	14.8	7.3	0.0917
16	0.293	99.6	103	17.4	41	0.000323	15.5	9.7	0.0693
17	0.220	68.8	97.6	16	42	0.000261	15.7	10.7	0.0496
18	0.163	58.9	70.5	12.2	43	0.000214	14.8	9.5	0.0505
19	0.115	44.9	53.1	8.62	44	0.000166	15.9	9	0.0393
20	0.0845	41.8	48.4	7.47	45	0.00015	14.9	9.9	0.035
21	0.0704	34.3	33.8	5.59	46	0.000118	15.5	8.1	0.0416
22	0.0516	27.4	29.1	4.28	47	0.000096	15.2	8.5	0.0351
23	0.0364	22.8	22.5	3.21	48	0.000086	14.2	8.7	0.0294
24	0.0291	20	21.4	2.47	49	0.000058	13.8	8.7	0.023
25	0.0191	21.1	16.9	1.83	50	0.0000467	13.7	8.4	0.0246
Σ	151.9401	14517.6	14843.3	2838.07	Σ	0.0709477	382.1	238	5.7483
					x	3.04	304	309	59.2

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TABLE B-VI

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CHRONIC 1-yr EXPOSURE, 50-yr DOSE COMMITMENT AT IAAP

		Resusp	pension	Leafy Ve	egetables	Wheat	Products	Meat		
µCi/m²	Organ	µCi Inhaled	rem	µCi Ingested	rem	µCi Ingested	rem	µCi Ingested	rem	Total
13514	lung liver bone	0.41	400 345 742	49	 17 38	38	 13 30	24	 8.2 19.	400 383 829
400	lung liver bone	0.012	12 10 22	1.5	.51 1.2	1.1	0.37 0.85	0.71	 0.24 0.55	12 11 25
7.5	lung liver bone	0.00023	0.22 0.19 0.42	0.027	0.0092 0.021	0.021	0.0071 0.016	0.013	0.0044 0.01	0.22 0.21 0.47
0.2	lung liver bone	6.1x10 ⁻⁶	0.0060 0.0051 0.011	0.00073	0.00025 0.00057	0.00056	0.00019 0.00044	0.00036	0.00012 0.00028	0.006 0.0057 0.012

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TABLE	B-V	II
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IAAP	CHRONIC	50-yr	EXPOSURE,	50-yr	DOSE	COMMITMENT
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		Resus	pension	Leafy Vegetables		Wheat Products		Meat		
µCi/m²	Organ	µCi Inhaled	rem	µCi Ingested	rem	µCi Ingested	rem	µCi Ingested	rem	Total rem
13514	lung liver bone	0.76	712 340 680	205	70 159	160	 54 124	105	 36 82	712 500 1045
400	lung liver bone	0.022	21 9.8 20	6.1	 2.1 4.7	4.7	 1.6 3.7	3.1	 1.1 2.4	21 15 31
7.5	lung liver bone	0.00042	0.39 0.19 0.38	0.11	0.037 0.085	0.089	0.03 0.069	0.058	0.02 0.045	0.39 0.28 0.58
0.2	lung liver bone	1.1x10 ⁻⁵	0.010 0.0049 0.0098	0.0030	0.001 0.0023	0.0024	0.00082 0.0019	0.0016	0.00054 0.0012	0.01 0.0073 0.015

TABLE B-VIII

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Isopleth	Number of People	μCi m²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	123	1739	lung liver bone	6330 6062 13121	0.27 0.091 0.018		11270 7913 16540	0.48 0.12 0.023	
1	123	400	lung liver bone	1476 1353 3075	0.063 0.021 0.0043		2583 1845 3813	0.11 0.028 0.0053	
2	921	40	lung liver bone	1105 1013 2303	0.048 0.015 0.0032		1934 1382 2855	0.083 0.021 0.004	
3	4246	4	lung liver bone	510 467 1062	0.022 0.007 0.0015		892 637 1316	0.038 0.0096 0.0018	
4	4277	0.4	lung liver bone	51 47 107 Σ	0.0022 0.00071 0.00015 0.57	-5.9	90 64 133 Σ	0.0039 0.00096 <u>0.00019</u> 0.93	9.6
<u>Healy</u>	1167	7.5	lung liver bone	257 245 548	0.011 0.0036 0.00077		455 327 677	0.02 0.0049 0.00095	
3	4246	4	lung liver bone	510 467 1062	0.022 0.007 0.0015		892 637 1316	0.038 0.0096 0.0018	
4	4277	0.4	lung liver bone	51 47 107 Σ	0.0022 0.00071 <u>0.00015</u> 0.048	· 0.5	90 64 133 Σ	0.0039 0.00096 <u>0.00019</u> 0.080	0.83
<u>EPA</u>	9690	0.2	lung liver bone	58 55 116 Σ	0.0025 0.00083 0.00016 0.0035	0.036	97 71 145 Σ	0.0042 0.0011 0.0002 0.0073	0.075
1		{		4		1			

IAAP, 120-kg Pu CASE, MEDIAN METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL"

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TABLE B-IX

Isopleth	Number of People	μCi m²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	192	4197	lung liver bone	23851 22837 49432	1.03 0.34 0.069	-	42456 29814 62312	1.8 0.45 0.087	5
1	192	400	lung liver bone	2304 2112 4800	0.099 0.032 0.0067		4032 2880 5952	0.17 0.043 0.0083	
2	8057	40	lung liver bone	9668 8863 20142	0.42 0.13 0.028		16919 12085 24977	0.73 0.18 0.035	
3	9227	4	lung liver bone	1107 1015 2307	0.048 0.015 0.0032		1938 1384 2860	0.083 0.021 0.004	
4	8168	0.4	bone liver lung	98 90 204 Σ	0.0042 0.0014 0.00029 2.2	8.5	172 123 253 Σ	0.0074 0.0018 <u>0.00035</u> 3.6	14-
<u>Healy</u>	8441	7.5	lung liver bone	1857 1773 3767	0.08 0.027 0.0056		3291 2363 4896	0.14 0.035 0.0069	
3	9227	4	lung liver bone	1107 1015 2307	0.048 0.015 0.0032		1938 1384 2860	0.083 0.021 0.004	
4	8168	0.4	lung liver bone	98 90 204 Σ	0.0042 0.0014 0.00029 0.18	0.70	172 123 253 Σ	0.0074 0.0018 0.00035 0.30	1.2
<u>EPA</u>	25836	0.2	lung liver bone	155 147 310 Σ	0.0067 0.0022 0.00043 0.0093	0.036	258 189 388 Σ	0.011 0.0028 0.00054 0.014	0.054

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120-kg Pu CASE, UNFAVORABLE METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL"

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TABLE B-X

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Isopleth	Number of People	<u>µci2</u> m²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	17	232	lung liver bone	117 112 242	0.005 0.0017 0.00034	-	208 146 305	0.0089 0.0022 0.00043	
1	17	400	lung liver bone	204 187 425	0.0088 0.0028 0.0006		357 255 527	0.015 0.0038 0.00074	
2	482	40	lung liver bone	578 530 1205	0.025 0.008 0.0017		1012 723 853	0.044 0.011 0.0012	
3	927	4	lung liver bone	111 102 232	0.0048 0.0015 0.00032		195 139 287	0.0084 0.0021 0.00040	
4	3598	0.4	lung liver bone	43 40 90 Σ	0.0018 0.0006 0.00013 0.063	1.2	76 54 112 Σ	0.0033 0.00081 0.00016 0.1	2
Healy	516	7.5	lung liver bone	114 108 243	0.0049 0.0016 0.00034		201 144 299	0.0086 0.0022 0.00042	
3	927	4	lung liver bone	111 102 232	0.0048 0.0015 0.00032		195 139 287	0.0084 0.0021 0.0004	
4	3598	0.4	lung liver bone	43 40 90 Σ	0.0018 0.0006 0.00013 0.016	0.32	76 54 112 Σ	0.0033 0.00081 <u>0.00016</u> 0.026	0.52
<u>EPA</u>	5041	0.2	lung liver bone	30 29 60 Σ	0.0013 0.00044 0.000084 0.0018	0.036	50 37 76 Σ	0.0022 0.00056 0.00011 0.0029	0.058

30-kg Pu CASE, MEDIAN METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL"

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TABLE B-XI

Isopleth	Number of People	<u>uCi</u> m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
1	77	682	lung liver bone	1554 1488 3221	0.067 0.022 0.0045	-	2767 1943 4061	0.12 0.029 0.0057	
1	77	400	lung liver bone	924 847 1925	0.04 0.013 0.0027		1617 1155 2387	0.07 0.017 0.0033	
2	6250	40	lung liver bone	7500 6875 15625	0.32 0.11 0.022		13125 9375 15000	0.56 0.14 0.021	
3	7261	4	lung liver bone	871 799 1815	0.037 0.012 0.0025		1525 1089 2251	0.066 0.016 0.0032	
4	7373	0.4	lung liver bone	88 81 184 Σ	0.0039 0.0012 <u>0.00026</u> 0.66	3.1	155 111 229 Σ	0.0067 0.0017 <u>0.00032</u> 1.1	5.2
<u>Healy</u>	6404	7.5	lung liver bone	1408 1345 3010	0.061 0.02 0.0042		2498 1793 3714	0.11 0.027 0.0052	
3	7261	4	lung liver bone	871 799 1815	0.037 0.012 0.0025		1525 1089 2251	0.066 0.01 0.0032	
4	7373	0.4	lung liver bone	88 81 184 Σ	0.0039 0.0012 <u>0.00026</u> 0.14	0.67	155 111 229 Σ	0.0067 0.0017 <u>0.00032</u> 0.24	1.1
<u>EPA</u>	21038	0.2	lung liver bone	126 120 252 Σ	0.0054 0.0018 <u>0.00035</u> 0.0076	0.036	210 154 316 Σ	0.009 0.0023 <u>0.00044</u> 0.012	0.057

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30-kg Pu CASE, UNFAVORABLE METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE INDIVIDUAL"

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TABLE B-XII

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0.625-kg Pu CASE, MEDIAN METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE" INDIVIDUAL (IAAP)

Isopleth	Number of People	<u>µCi</u> m²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
3	189	4	lung liver bone	23 21 47	0.00099 0.00032 0.000066	-	39 28 59	0.0017 0.00042 0.000083	
4	275	0.4	lung liver bone	3.3 3 6.9 Σ	0.00014 0.000045 <u>0.0000097</u> 0.0016	0.34	5.8 4.1 8.5 Σ	0.00025 0.000062 <u>0.000012</u> 0.0025	0.54
<u>Healy</u>	189	4	lung liver bone	23 21 47	0.00099 0.00032 0.000066		39 28 59	0.0017 0.00042 0.000083	
4	275	0.4	lung liver bone	3.3 3 6.9 Σ	0.00014 0.000045 <u>0.0000097</u> 0.0016	0.34	5.8 4.1 8.5 Σ	0.00025 0.000062 0.000012 0.0025	0.54
<u>EPA</u>	464	0.2	lung liver bone	2.8 2.6 5.6 Σ	0.00012 0.000039 0.0000078 0.00017	0.037	4.6 3.4 7 Σ	0.0002 0.000051 0.000098 0.00026	0.056

TABLE B-XIII

Isopleth	Number of People	<u>µCi</u> m ²	Organ	Man-rem 1 Year	Estimated HE 1 Year	Cases/10 ⁵ HE 1 Year	Man-rem 50 Years	Estimated HE 50 Years	Cases/10 ⁵ HE 50 Years
No Decon.									
3	1819	4	lung liver bone	218 200 455	0.0094 0.003 0.00064	-	382 273 564	0.016 0.0041 0.00079	
4	6048	0.4	lung liver bone	73 67 151 Σ	0.0031 0.001 <u>0.00021</u> 0.017	0.22	127 91 187 Σ	0.0055 0.0014 <u>0.00026</u> 0.028	0.36
<u>Healy</u>	1819	4	lung liver bone	218 200 455	0.0094 0.003 0.00064		382 273 564	0.016 0.0041 0.00079	
4	6048	0.4	lung liver bone	73 67 151 Σ	0.0031 0.001 <u>0.00021</u> 0.017	0.22	127 91 187 Σ	0.0055 0.0014 <u>0.00026</u> 0.028	0.36
<u>EPA</u>	7867	0.2	lung liver bone	47 45 94 Σ	0.002 0.00068 <u>0.00013</u> 0.0028	0.036	79 57 118 Σ	0.0034 0.00086 <u>0.00017</u> 0.0044	0.056

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0.625-kg Pu CASE, UNFAVORABLE METEOROLOGY, SUMMARY OF RADIOLOGICAL AND HEALTH EFFECTS TO "AVERAGE" INDIVIDUAL (IAAP)

APPENDIX C

HANFORD SITE SUPPLEMENTARY DATA

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TABLE C-I

FORMATTED BIOTRAN INPUT FOR HANFORD SIMULATION

150.0 7.1	650.0 10.7	90.0 0.0	29.4 3.0	76.4 0.0	120.0 0.0	1.0	1.0
2.0	2.20	0.26	476.0	0.004	0.091	0 022	0.030
0.048	0.093	0.136	0.138	0.072	0.051	0.022	0.050
6.25	476.0	0.0	16.0	4.0	20.0	0.0	100.0
0.0	3.0	528.0	0.0	2.0	0.0	0.0	
1.0	0.0	0.0	0.0	1.0	1.0	0.0	1.0
0.0	0.0	0.0	1.0	0.0	1.0	1.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0		
1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0
1.0	1.0	1.0	1.0	0.0	0.0	0.0	0 0
0.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0		0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0		
3000.	3000.	3000.	50.0	0.0	0.0	0.0	0.0
0.0	0.0	3000.	3000.	3000.	2000	0.0	0.0
914.4	914.4	1500.	2500.	0.0	0.0	0.0	0 0
0.0	0.0	2000.	1500.	1500.	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1500.		
0.0	0.0	0.0	0.0	0.0	0.0	0.0	
176.0		4.0	99.0	1.0			
9 7000-02	6 920a-04	+ 0.000e+01	6 800e+01	1			
4.000e-09	4 000e-09	4 000e-09	4 000e-04	2			
7.407e+04	7.407e+04	0.000e+01	0.000e+01	Í			
9.700e-02	2 6.920e-01	2.210e-01	6.800e-02	2			
4.000e-09	4.000e-09	4.000e-09	4.000e-09	9			
7.407e+04	7.407e+04	0.000e+01	0.000e+0	0.000e+01	0.000e+0	0.000e+0	1 0.000e+01
9.470e-02	4.100e-01	1 2.300e-01	1.500e-01	9.000e-02	2 5.300e-02	2 4.000e-0	2 2.900e-02
4.000e-09	6 0 000e+01	4.000e-0e	4.000e-0:	9 4.000e-05	4.000e-0	4.000e-0	9 4.000e-09
0.000e+01	0.000e+01	0.000e+01	0.000000	0.0000000	0.000000	0.000000	1 0.000e+01
7.000e-02	5.800e-01	3.300e-01	1.800e-01	1.000e-01	5.500e-02	2 3.000e-02	2 1.600e-02
9.000e-03	5.000e-03	3 2.900e-03	1				
4.000e-09	4.000e-09	4.000e-09	4.000e-09	9 4.000e-09	4.000e-09	4.000e-09	9 4.000e-09
4.000e-09	4.000e-09	4.000e-09					
7.40/e+04	/.40/e+04	0.000e+01	0.000e+01	0.000e+01	0.000e+0	1 0.000e+0	1 0.000e+01
5 010e-02	5 5300-01	4 2700-01	3 1000-01	2 3000-01	1 7000-01	1 2200-0	1 1 0000-01
7.700e-02		4.2700 01	5.1008 0	2.3000 01	1.7008-0	1.3208-0	1.000e-01
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	9 4.000e-09
4.000e-09)						
7.407e+04	7.407e+04	0.000e+01	0.000e+01	0.000e+01	0.000e+0	0.000e+0	1 0.000e+01
9.470e-02	4.100e-01	2.300e-01	1.500e-01	9.000e-02	2 5.300e-02	2 4.000e-02	2 2.900e-02
4.000e-09	4.000e-05	4.000e-09	4.000e-05	4.000e-09	4.000e-0	4.000e-09	9 4.000e-09
9.470e-02	4.100e-01	2.300e-01	1.500e-01	9 000e-02	5 300e-02	2 4 000e+0	2 2 900e-02
4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09
1.000e+06	0.000e+01	0.000e+01	0.000e+01	0.000e+01	0.000e+0	0.000e+0	1 0.000e+01
9.700e-02	8.230e-01	9.500e-02	2.600e-02	2.300e-02	1.700e-02	2 1.110e-02	2 3.500e-03
4.000e-09	4:000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	4.000e-09	9 4.000e-09
201.0	201.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	2.0	2.0	2.0	2.0	2.0	2.0 2.0	2.0
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TABLE C-I (cont)

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0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0	0.0 0.0
157.0	157.0	164.0	171.0	178.0	185.0	192.0	199.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	255.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
157.0	157.0	164.0	171.0	178.0	185.0	192.0	199.0
206.0	0.0	0.0	0.0	234.0	241.0	248.0	255.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
157.0	157.0	171.0	185.0	199.0	213.0	227.0	241.0
255.0	470.0	485.0	499.0	514.0	521.0 0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
259.0	259.0 2.5	0.0	0.0	0.0	0.0	0.0	0.0
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	157.0	164.0	171.0	178.0	185.0	192.0	199.0
206.0	213.0 0.0	220.0 0.0	227.0 0.0	234.0	241.0 0.0	248.0 0.0	255.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	500.0	531.0	577.0	0.0	0.0	0.0	0.0
3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
255.0	255.0	453.0	460.0	467.0	474.0	481.0	488.0
495.0 554 0	502.0	509.0	516.0	523.0	533.0	540.0	547.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	560.0 6 0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
244.0	244.0	272.0	300.0	453.0	485.0	505.0	533.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	521.0	0.0	0.0	0.0	0.0	0.0	0.0
2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
157.0	157.0	171.0	185.0	199.0	213.0	227.0	241.0
255.0	470.0	485.0	499.0	514.0	521.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	3.0			
3.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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TABLE C-I (cont)

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0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	90.0	91.0	230.0	231.0	245.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
600.	600.	600.	600.	600.	600	600.	600.
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.0		
3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	2.0	3.0					
1.0	11.0	22.0	0.0	0.0	0.0	0.0	0.0
4.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0
1.0	11.0	03.0	0.0	0.0	0.0	0.0	0.0
4.0	4.0	1.0	0.0	0.0	0.0	0.0	0.0
1.0	11.0	03.0	0.0	0.0	0.0	0.0	0.0
4.0	1.0	4.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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TABLE C-II	TΑ	BLI	ΕI	C-	I	I
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Variable Name and Description	Value	Reference and Notes
Tl, min ly/d T2, max ly/d L1, d T3, °F min T4, °F max L2, d pH, soil Soil type Decay factor	150.0 650.0 90.0 29.4 76.4 120.0 7.1 3.0 0 0	Map 53, Baldwin 1973 Map 54, Baldwin 1973 Gallegos 1980 Map 10, Baldwin 1973, Stone 1972 Map 10, Baldwin 1973, Stone 1972 Gallegos 1980 Cline 1972, Cline 1973 sandy, Cline 1972 None
WATCON, dpm/l Nuclide Saltation/rain splash TRE, events/mo TMXV, °F PRCV RELV, ft ALPSR,°F/ft	0.0 1.0 1.0 2.0 2.20 0.26 476.0 0.004	For Pu in H ₂ O = 0.0 Pu Process modeled Map 24, Baldwin 1973 Stone 1972 , Phillips 1970 Baldwin 1973 Reference elevation
x(1,12)	0.148 0.099 0.058 0.064 0.072 0.091 0.022 0.030 0.048 0.093 0.136 0.138	Stone 1972 , Phillips 1970
R, in. Gl, ft L3, latitude to ref Fl, -0.3 bar Wl, -15 bar H, O bar Yl, dpm/g Y2, simulation years	6.25 476.0 0.0 16.0 4.0 20.0 0.0 100.0	Stone 1972 , Phillips 1970 Site elevation Sauer*, Hagood 1970 Sauer*, Hagood 1970 Sauer*, Hagood 1970

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REFERENCED BIOTRAN INPUT FOR HANFORD

*R. Sauer, Ecologist, Battelle Pacific Northwest Laboratory, Richland, Washington.

TABLE C-II (cont)

Variable Name	Value	Reference and Notes
and Description		
KANUN, number seed	528	
ARIG	2.0	
AICHE	1.0	
SELECI(15), output	Yearly	
DAYPLT(10), output	0.0	
RGCPLT(22), plant plot	1,2,4,11 12,3,22	Corn(1), vegetables(2), fruit trees(4), alfalfa(11), wheat(12), pacture grass(3) and cheatgrass (22)
DCC(22) plants simulated	6.3000	pastare grass(5), and encatigrass (22)
DIDC(22), profile simulated		Ponton City (CES 1092A) Dacco (CES
RIRRU(22), ITTIG. SCI.	1,2,4,11,	1982B)
ACRES(22), area in access	1,2,4,11	Acres for grazing crops
RCODE(22), soil depth	12,3,22	Soil rooting depth
	12,13,22	
FFD, d	176.0	Stone 1972, Phillips 1970
UPTKE,	4.0	Pu root uptake - 4x10 ⁻⁹
XPLNT, Yr	99.0	
XHERB, ruminant model	1.0	
Zl, dpm/g soil	1,2,4,11	dpm/g specified for each
ZF, root frac/layer	same	Gallegos 1980 , Rodgers 1980 , Pettit 1974 , Cline 1977
7u, root uptake coeff.	4x10-9	Gallegos 1980
CUTA, harvest schedule	1.2.4.11.	Rickard*, Cline**
AWATA, irrig, schedule	12	Middleton 1975 Jensen 1970 .
hann, in g. soneaure	same	Middleton 1967, Jensen 1969
DIRA irrig days	same	
PP Ruminant	1 0	beef cattle simulated
P5 fraction consumed	1 1 0	
NE hard size	600	
AA2 fraction grazed		
ESUDE fraction food	1.0	
Insur, inaction reed	1 1.0	
AGE, yr of herd	2 3.0	
YRGRZ, yr on pasture	3-100	
UNKNG, d on range	1-90	
	91-230	
	230-245	
ANMAL, herd size	600	
PUTZD, plants as graze	[1,1]=4.0	day 1-90, 4≖supple feed
and feed	22=1.0	l∞graze
	1,11=4.0)day 91-230
	3=1.0	
]	1,3=4.0	day 230-245
	11=1.0	

*W. H. Rickard, Ecologist, Battelle Pacific Northwest Laboratory, Richland, Washington.
**J. F. Cline, Ecologist, Battelle Pacific Northwest Laboratory, Richland, Washington.

Co	Corn Garden Vegetables		egetables	Warm Season Pasture Grass		Fruit Trees (25-yr cycle)		Alfalfa		Winter Wheat PW = Prewater	
P H, & Irrig.(d)	(Acre-in.)	P,H, & Irrig.(d)	(Acre-in.)	P & irrig(d)	(Acre-in.)	H & Irrig. (d)	(Acre-in.)	P,H, & irrig.(d	(Acre-in.))	P,H, & irrig.(d)	(Acre-in.)
157(P) 164 171 178 185 192 199 206 213 220 227 234 241 248 259 267(H)	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	157(P) 164 171 178 185 192 199 206 213 220 227 234 241 248 255 267(H)	2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	157(P) 171 185 199 213 227 241 255 470 485 499 514 521	2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5	157 164 171 178 185 192 199 206 213 220 227 234 241 248 255 259(H)	2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5 2.5	255(P) 453 460 467 474 481 488 495 500(H) 502 509 516 523 531(H) 533 540 547 554 554 561 577(H)	3(P) 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	244(P) 453 477 485 505 533 560(H)	6(PW) 4 4 4 4

TABLE C-III

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HANFORD CROP PLANTING(P), HARVESTING(H), AND IRRIGATING SCHEDULES FOR BIOTRAN INPUT

Simulated Soil Layer	Depth (cm)	Corn (1)	Garden Vegetables(2)	Warm Season Pasture Grass (3)	Fruit Tree(4)	Alfalfa(11)	Winter Wheat(12)	Cheatgrass (22)
Resuspension 1 2 3 4 5 6 7 8 9 10 11	0-2 2-27 27-52 52-77 77-102 102-127 127-152 152-177 177-202 202-227 227-252 252-277	0.097 0.692 0.221 0.068	0.097 0.692 0.221 0.068	0.097 0.770 0.230 0.650 0.020 0.0060 0.0018	0.070 0.580 0.330 0.180 0.100 0.055 0.030 0.016 0.009 0.005 0.0029	0.0501 0.553 0.427 0.310 0.230 0.170 0.132 0.100	0.097 0.770 0.230 0.650 0.020 0.006 0.0018	0.097 0.823 0.095 0.026 0.023 0.017 0.011 0.0038

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TABLE C-IV

HANFORD ROOT FRACTION ESTIMATES FOR SIMULATED PLANTS

Yr	Air Above Grazed Cheatgrass dpm/m ³ yearly average	Garden Vegetables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet	Yr	Air dpm/m ³ yearly average	Garden Vegetables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet
1	103	-	_	_	26	0.0168	404	129	6.34
2	5.47	2852	2167	-	27	0.0167	401	103	6.21
3	4.64	2149	5873	747	28	0.0185	397	115	6.72
4	2.62	1708	4382	811	29	0.0132	393	109	6.74
5	1.87	1314	2960	535	30	0.0146	398	108	5.81
6	1.33	1063	2186	391	31	0.0137	404	120	5.40
7	1.19	878	1890	315	36	0.0109	567	104	5.86
8	0.833	703	1211	256	33	0.0110	566	136	6.34
9	0.506	593	1236	183	34	0.00865	550	126	6.30
10	0.516	494	792	153	35	0.00709	547	125	5.52
11	0.406	432	762	108	36	0.00611	535	121	5.49
12	0.368	380	558	88.9	37	0.00610	538	123	5.26
13	0.270	340	442	73.6	38	0.00473	580	121	5.34
14	0.180	316	387	56.9	39	0.00423	535	122	4.99
15	0.157	356	284	46.3	40	0.00483	518	113	5.19
16	0.123	461	241	29.3	41	0.00483	510	108	5.08
17	0.0947	457	230	29.4	42	0.00494	1275	121	54.8
18	0.0712	442	193	24.7	43	0.00499	9690	119	211.0
19	0.0630	429	182	20.6	44	0.00500	9270	58	49.7
20	0.0414	421	172	16.1	45	0.00444	9090	101	42.7
21	0.0424	431	156	12.2	46	0.00361	8762	102	44.4
22	0.0325	439	164	10.5	47	0.00324	8843	122	50.4
23	0.0299	428	140	11.1	48	0.00267	8728	114	39.2
24	0.0271	421	136	9.37	49	0.00314	8498	129	39.4
25	0.0170	410	142	7.81	50	0.00218	8059	180	44.7
Σ	123.8982	17917	26886	3935.78	Σ	0.19618	80108.	2929.7	668.89
				· · · · · · · · · · · · · · · · · · ·	×	2.48	2000	608	95.9

PuO2 CONCENTRATIONS IN AIR, VEGETABLES, WHEAT, AND CATTLE MUSCLE FOR BIOTRAN SIMULATION AT HANFORD

TABLE C-V

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