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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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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 $\mu Ci/m^2$ 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 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,

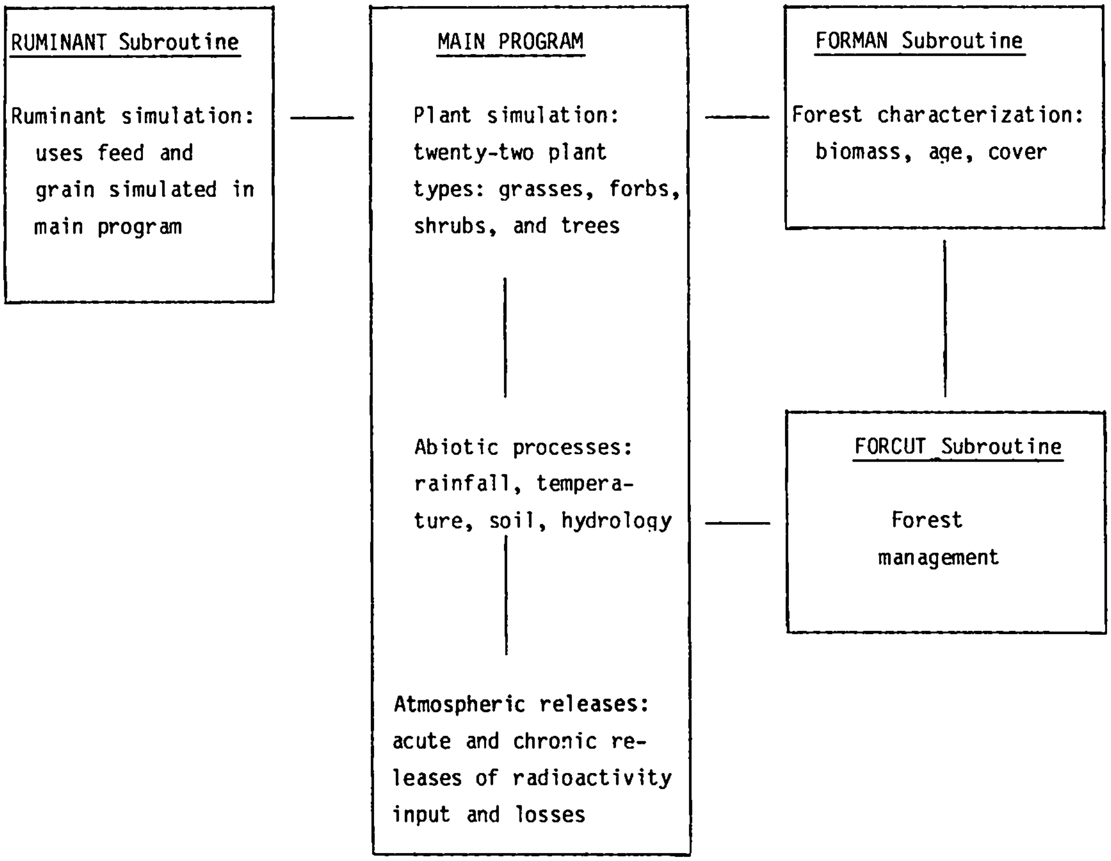

Fig. 1. Major components of BIOTRAN model, which interact on daily and yearly simulation intervals.

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.

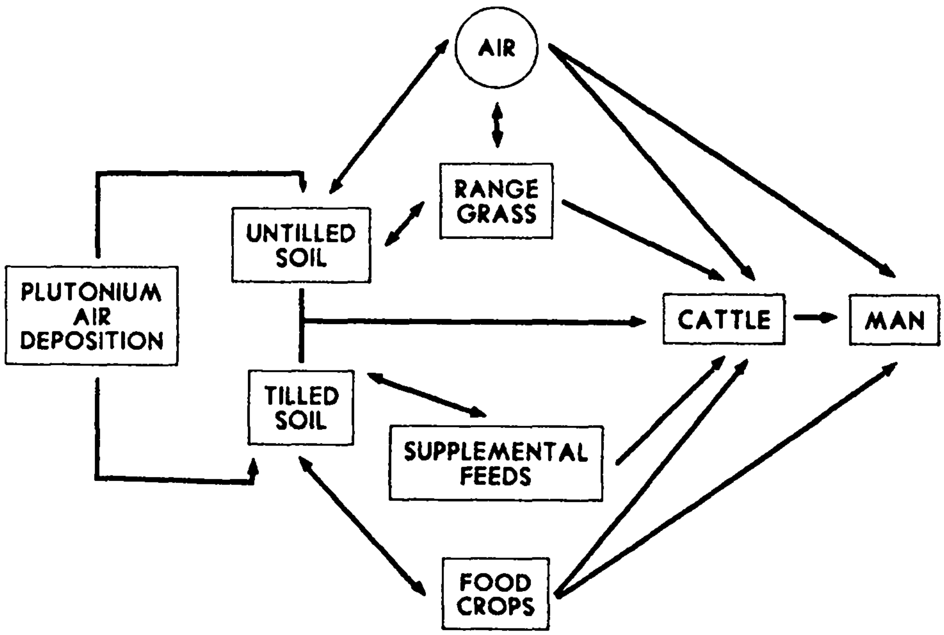

Fig. 2. BIOTRAN food chain pathways.

For each simulation, meteorological conditions are stochastically generated based on National Oceanic and Atmospheric Administration (NOAA) 40-yr 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 frost-free 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 0-bar (holding capacity), -0.3-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 (PuO_2) 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_2 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.

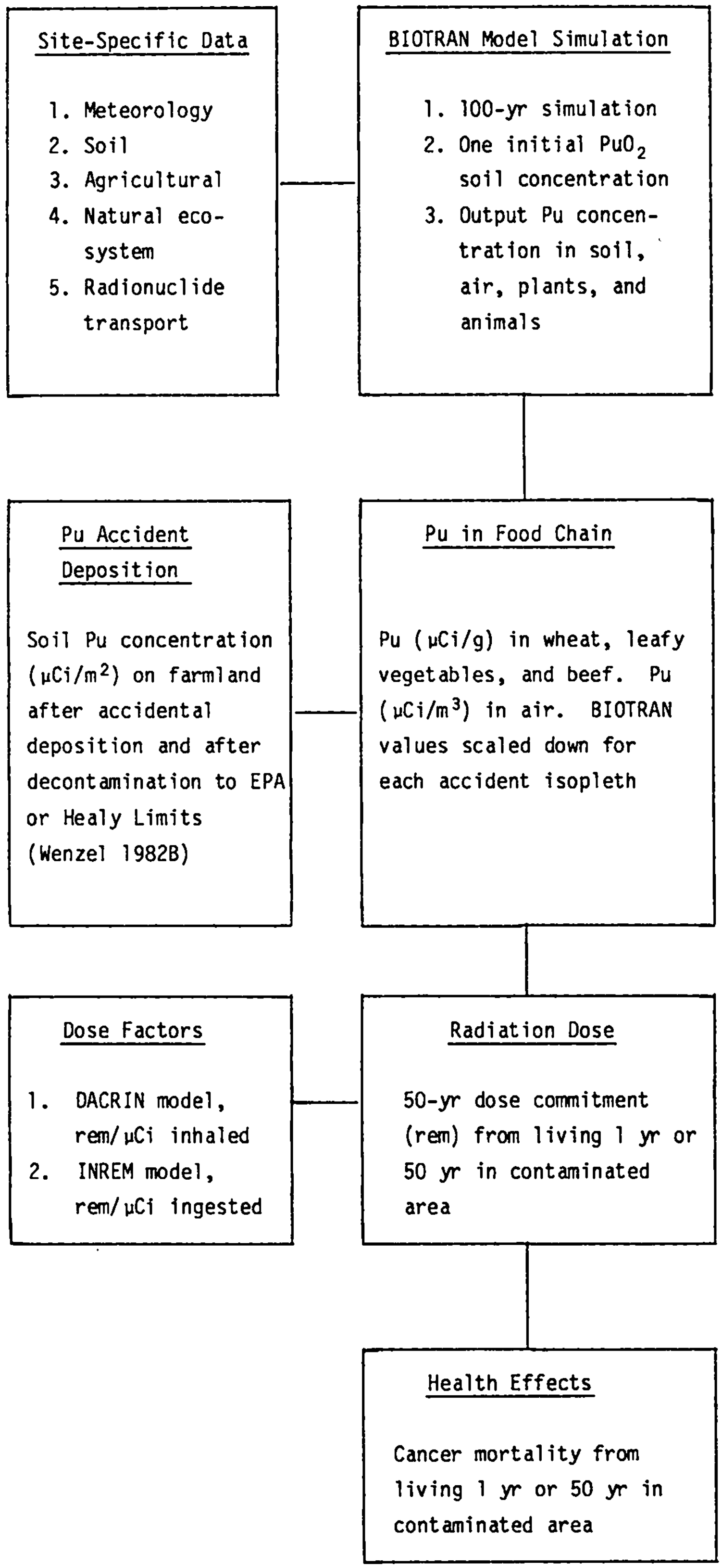

Fig. 3. Calculation flow for long-term health effects.

TABLE I

COMPARISON OF FIELD MEASUREMENTS AND BIOTRAN SIMULATION CONCENTRATION RATIOS

Reference	Crop	$^{239,240}Pu$ dpm/g Soil Concentration	$^{239,240}Pu$ dpm/g Plant Concentration	CR	Simulation 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

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 PuO_2 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 PuO_2 source term on a $\mu Ci/m^2$ basis to evaluate the seven postulated accident isopleth concentrations of PuO_2.

1. Unit PuO_2 Soil Radioactivity Concentrations for BIOTRAN Simulations. The unit soil contamination level used (13 514 $\mu Ci/m^2$) 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 μCi/m^2 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 μCi/m^2) 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 μCi/m^2). 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 PuO_2.

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-μm 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 15×10^{-6} cancer mortalities/rem for liver, 1.4×10^{-6} cancer mortality/rem for bone, and 43×10^{-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 PuO_2 than the tilled soils but lower resuspension rate). A moderate work inhalation rate of 3.5×10^{-4} m^3/s resulting in 11 038 m^3/yr of air inhaled was used for the analysis. These conservative assumptions represent a maximum individual adult case.

TABLE II

DOSE FACTORS (rem/μCi) FOR PLUTONIUM

Dose Model	Pathway	Exposure Time	Dose Integration Time	Organ	rem/μCi Ingested or Inhaled
DACRIN	Inhalation (1 μm AMAD)	1 yr	50 yr	Lung Liver Bone	976 841 1810
DACRIN	Inhalation (1 μm AMAD)	50 yr	50 yr	Lung Liver Bone	937 447 895
INREM	Ingestion	Acute	50 yr	Liver Bone	0.340 0.777

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

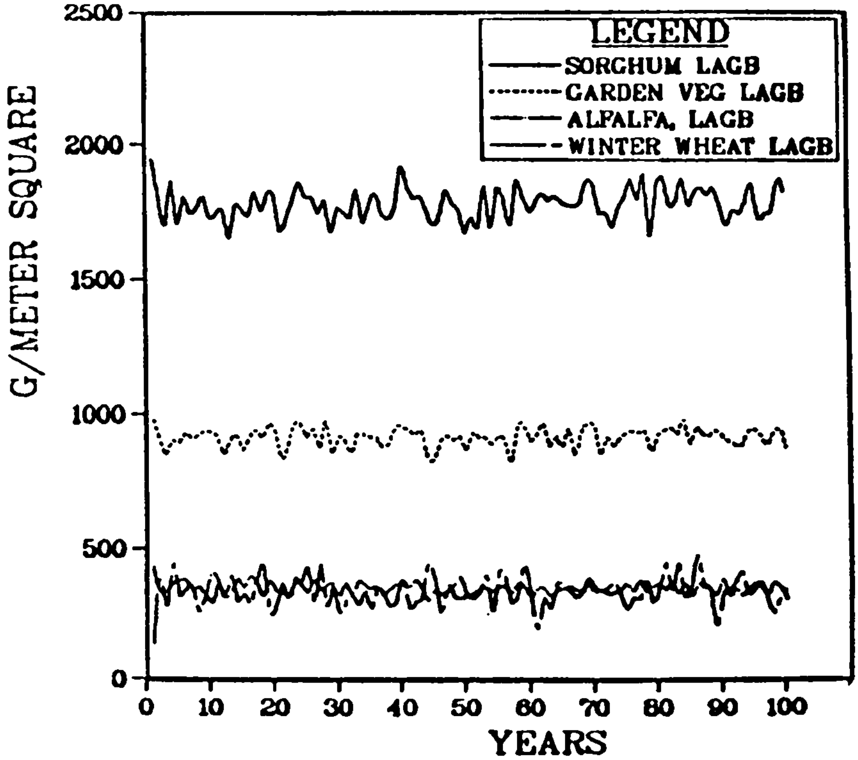

Fig. 4. Live above-ground biomass (LAGB) for four irrigated crops simulated for the Pantex region.

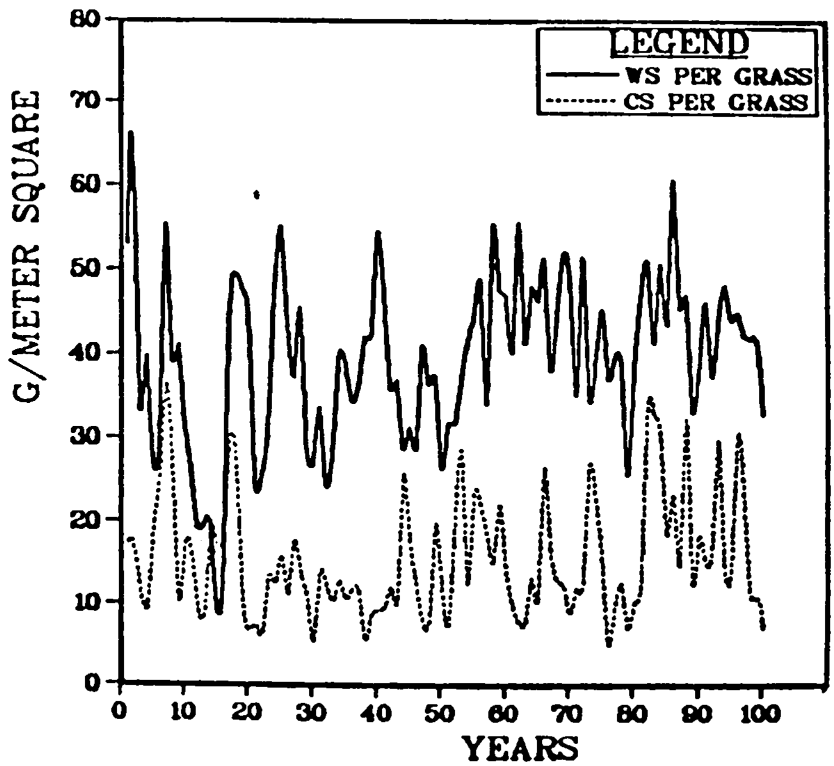

Fig. 5. LAGB for two perennial (Per) warm season (WS) and cool season (CS) range grasses for the Pantex region.

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) 1 bu wheat = 60 lb of grain
(b) dry alfalfa/wet (in field) alfalfa = 0.6
(c) grain sorghum at harvest = 5% moisture
(d) 1 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/m² Dry	100-yr Range BIOTRAN g/m² Dry*	References
Grain sorghum (irrig.)				
Residue	4 ton/acre	897		Undersander**
Grain	3000-5000 lb/acre	336-560		Jacquot 1962
Grain	4440 lb/acre	497		USDA 1979, 1980
Grain	4540-7480 lb/acre	509-839		Texas A&M 1981
Average grain	5500 lb/acre	617		Harmon***
Average range grain and residue		1300-1800	1660-1950	
Soybeans (irrig.)	32 bu/acre			USDA 1979, 1980
Average range soybeans and residue		395	828-984	
Range grasses (Carson)	750-1200 lb/acre	84-135	26.8-77.9 (grazed) LAGB[+]	Jacquot 1962
Blue grama,				
LABG[+] plus dead, grazed	265 g/m² dry		9.5-61 (grazed) LAGB[+]	Pettit 1974
LAGB[+] plus dead, ungrazed	320 g/m² dry			
Alfalfa (irrig.)	3.2-5.0 ton/acre	718-1120		Jacquot 1962
3 cuttings	4.0 ton/acre	897		USDA 1979, 1980
	6.0 ton/acre	1350		Texas A&M 1981
Average range all 3 cuttings		718-1350	924-1220	
Winter wheat (irrig.)	32-50 bu/acre	215-337		Jacquot 1962
(Carson)	34.9 bu/acre	235		USDA 1979, 1980
	45 bu/acre grazed	303		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-m² 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.

Dose Calculations. For inhalation dose to man, the two calculations are given.

(a) $$\left(\frac{94.3\ \text{dpm}}{\text{m}^3/\text{yr}}\right)\left(\frac{11037.6\ \text{m}^3\ \text{inhaled}}{\text{yr}}\right)\left(\frac{\mu\text{Ci}}{2.22 \times 10^6\ \text{dpm}}\right) = 0.47\ \mu\text{Ci inhaled for 1-yr exposure}$$

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

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) $$\left(\frac{57\ \mu\text{g}}{\text{m}^3}\right)\left(\frac{11037.6\ \text{m}^3\ \text{inhaled}}{\text{yr}}\right) = 6.3 \times 10^5\ \frac{\mu\text{g}}{\text{yr}}\ \text{dust inhaled}$$

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

(b) $$\left(\frac{1 \times 10^6\ \text{dpm Pu}}{\text{g dry soil}}\right)\left(\frac{6.3 \times 10^5\ \mu\text{g inhaled}}{\text{yr}}\right)\left(\frac{\text{g}}{10^6\ \mu\text{g}}\right)\left(\frac{\mu\text{Ci}}{2.22 \times 10^6\ \text{dpm}}\right) = \frac{0.28\ \mu\text{Ci inhaled}}{\text{in first yr}}.$$

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

For ingestion doses, the calculations follow.

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

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

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

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

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

(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 Accident I				30-kg Pu Accident H				0.625-kg Pu Accident K			
	Median Met.*		Unfav. Met**		Median Met.		Unfav. Met.		Median Met.		Unfav. Met.	
	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr
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.

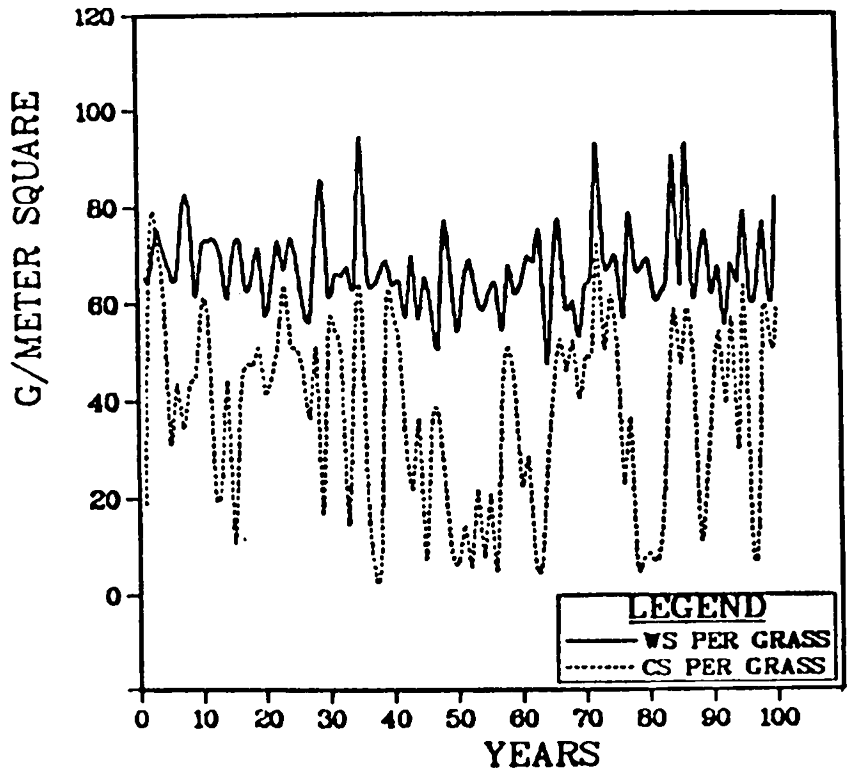

Fig. 6. LAGB for two perennial WS and CS grasses for the IAAP. The biomass from the ungrazed CS grasses were higher than shown below and surpassed the WS grasses.

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.

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

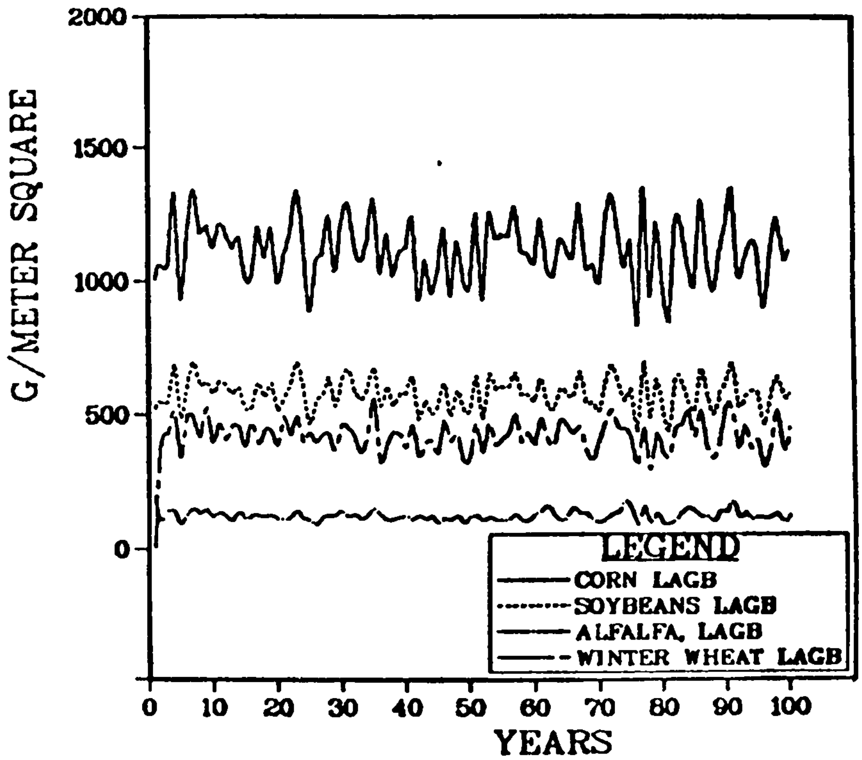

Fig. 7. LAGB for four crops simulated for the IAAP. These are unirrigated crops. See tables for planting and harvesting schedules.

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 lb (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

IAAP PRODUCTIVITY DATA

Crop and Description	Reported Amount/Acre	Estimated g/m^2 Dry	100-yr Range* BIOTRAN	References
Corn grain, Lee, Henry, and Des Moines County	108.1-119 bu/acre	606-650		Skow 1981
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	

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

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/m^3, 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 10^5 People)

	120-kg Pu Accident R				30-kg Pu Accident Q				0.625-kg Pu Accident S			
	Median Met.*		Unfav. Met.**		Median Met.		Unfav. Met.		Median Met.		Unfav. Met.	
	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 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 μCi/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

*Median 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 100-yr simulation period for the Hanford Site region. Fruit trees are cycled (replanted) every 25 years.

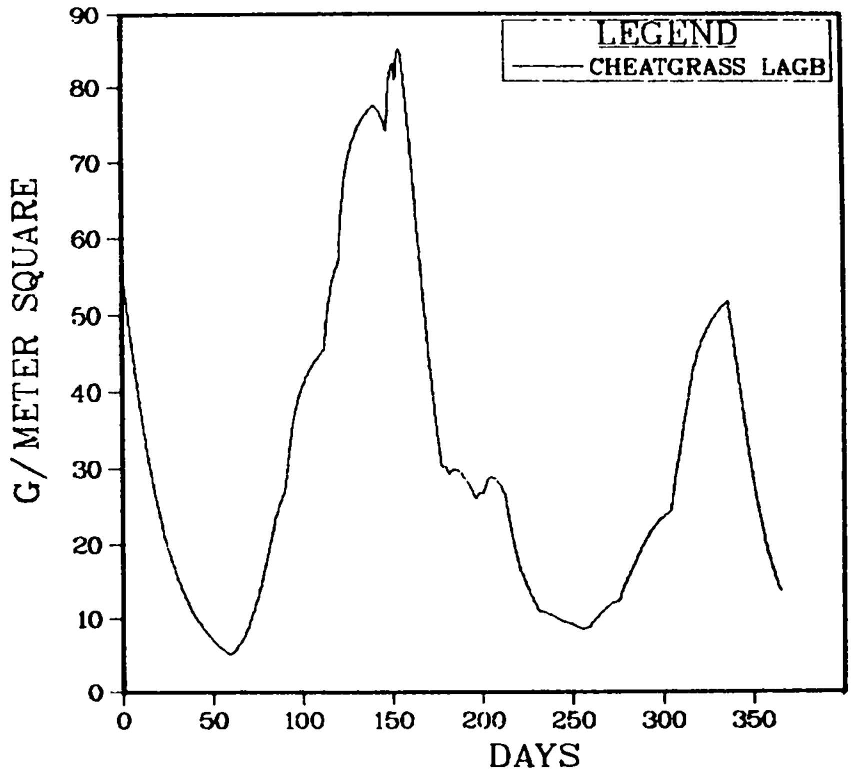

Fig. 8. Cheatgrass biomass (LAGB) at Hanford during one simulation year. Note the spring and late-fall peaks corresponding to rainfall.

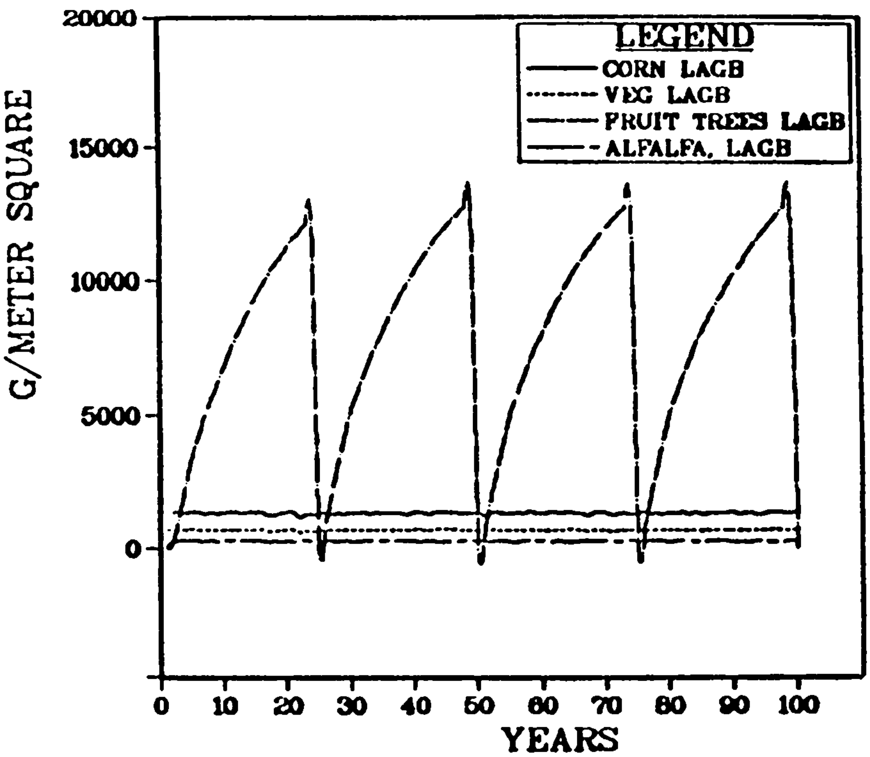

Fig. 9. Irrigated crop LAGB for Hanford region. Apple trees are planted on a 25-yr cycle.

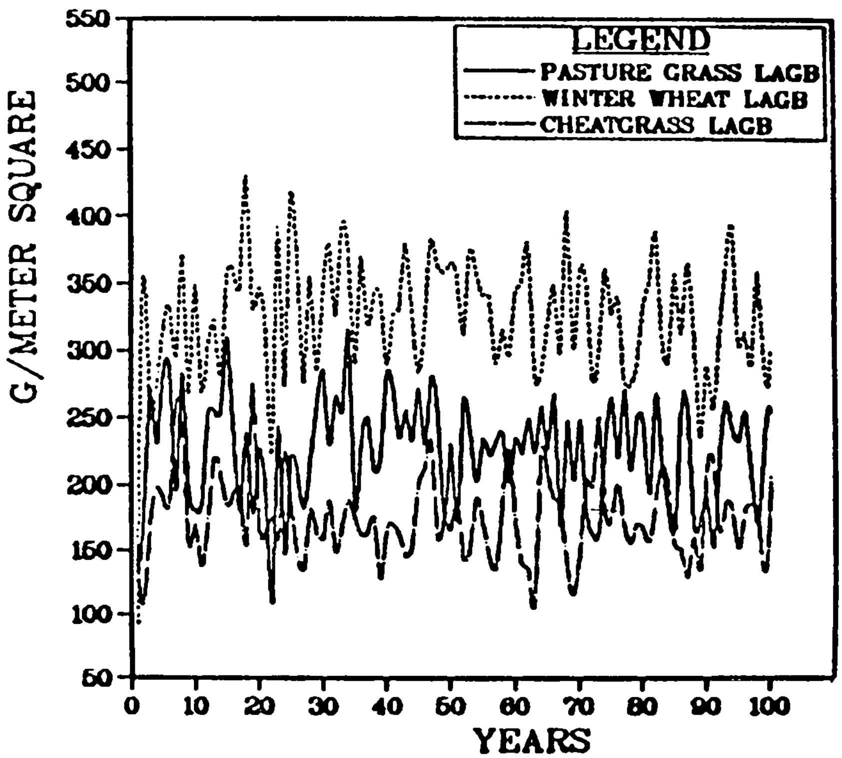

Fig. 10. Irrigated pasture grass and wheat crops compared with annual grass cheatgrass; a CS plant.

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/m^3, 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 μCi/m^2) 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/m^3 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_2 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

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

TABLE VIII

SUMMARY OF BIOTRAN FOOD CHAIN Pu CONCENTRATION PREDICTIONS

Site	Air dpm/m^3		Leafy Vegetable dpm/g dry		Wheat dpm/g dry		Beef Muscle dpm/g wet	
	1 yr	50-yr average	1 yr	50-yr average	1 yr	50-yr average	1 yr	50-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

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 Healy-proposed 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 risk 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 IX

SUMMARY OF HEALTH EFFECT RISK (CANCER MORTALITY/10^5 PEOPLE)

	120-kg Pu				30-kg Pu				0.625-kg Pu				
	Median Met.*		Unfavorable Met.**		Median Met.		Unfavorable Met.		Median Met.		Unfavorable Met.		Decontamination
Site	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	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

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

TABLE X

SUMMARY OF ESTIMATED HEALTH EFFECTS AND DECONTAMINATION COSTS (Dollars x 10^6)

Site		120-kg Pu				30-kg Pu				0.625-kg Pu				Decontamination Criteria
		Median 1 yr	Met. 50 yr	Unfav. 1 yr	Met. 50 yr	Median 1 yr	Met. 50 yr	Unfav. 1 yr	Met. 50 yr	Median 1 yr	Met. 50 yr	Unfavor. 1 yr	Met. 50 yr	
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	0.040	0.080	0.56	1.1	0.028	0.056	0.44	0.88	0.000052	0.00011	0.0046	0.0092	Healy level
	Cost	170		190		81		97		2.9		3.3		
	EHE	0.0028	0.040	0.025	0.049	0.0029	0.0058	0.025	0.049	0.0000069	0.000014	0.0017	0.0034	EPA level
	Cost	740		890		510		590		18		22		
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	0.048	0.080	0.18	0.30	0.016	0.026	0.14	0.24	0.0016	0.0025	0.017	0.028	Healy level
	Cost	180		190		45		48		2.7		2.0		
	EHE	0.0035	0.0073	0.0093	0.014	0.0018	0.0029	0.0076	0.012	0.00017	0.00026	0.0028	0.0044	EPA level
	Cost	740		490		270		260		17		13		
Hanford	EHE									0	0	0	0	No decontamination
	EHE									0	0	0	0	Healy level
	Cost									3.2		1.6		
	EHE									0	0	0	0	EPA level
	Cost									21		10		

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

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

TABLE A-I

DACRIN INHALATION DOSE FACTORS FOR WEAPONS GRADE PLUTONIUM

WG-Pu* Nuclide	Wt% in Mix**	Ci/g*** Nuclide	µCi/µg of Mix	Lung		Liver		Bone	
				a	b	a	b	a	b
^{238}Pu	0.05	17.4	0.0087	111	106	75.9	41.0	155.0	78.7
^{239}Pu	93.6	0.0614	0.0575	692	664	557	287	1201	575
^{240}Pu	6.0	0.226	0.0136	163	157	132	67.9	283.0	136
^{241}Pu	0.4	112	0.448	9.43	9.10	63.2	43.0	146.0	95.1
^{242}Pu	0.5	0.0039	1.95×10^{-6}	0.0225	0.0216	0.0182	0.00938	0.0376	0.0181
^{241}Am	~0.02	3.24	6.48×10^{-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

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.

TABLE A-II

INREM INGESTION DOSE FACTORS FOR WEAPONS GRADE PLUTONIUM

WG-Pu Nuclide	WG-Pu Mix (μCi/μg)	Nuclide (rem/μCi)		Mix (rem/μCi)	
		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
^{240}Pu	0.0136	0.250	0.567	0.0423	0.0959
^{241}Pu*	0.448	0.00483	0.117	0.0269	0.0652
^{242}Pu	1.95×10^{-6}	0.237	0.539	5.75×10^{-6}	1.31×10^{-5}
^{241}Am	6.48×10^{-4}	8.55	19.4	0.0689	0.156
			Σ	0.340	0.777

*Includes ^{241}Am in-growth for 50 years.

TABLE A-III

FORMATTED BIOTRAN INPUT FOR PANTEX SIMULATION

```
277.0     723.0     90.0      36.2      78.0      120.0
7.3       45.5      0.0       2.0       0.0       0.0       1.0       1.0
5.0       1.98      0.2       3500.0    0.004
0.023     0.026     0.037     0.062     0.149     0.161     0.143     0.150
0.093     0.089     0.039     0.029
21.0      3538.0    0.0       26.1      16.8      27.5      0.0       100.0
0.0       2.0       528.0     0.0       2.0       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       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       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       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
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       0.0       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     0.0       4.0       99.0      1.0
 7.407e+04 7.407e+04 0.000e+01 0.000e+01
 9.700e-02 6.920e-01 2.210e-01 6.800e-02
 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01
 9.700e-02 6.920e-01 2.210e-01 6.800e-02
 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+01 0.000e+01
 9.700e-02 7.700e-01 2.300e-01 6.500e-02 2.000e-02 6.000e-03 1.800e-03
 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 0.000e+01
 5.010e-02 5.530e-01 4.270e-01 3.100e-01 2.300e-01 1.700e-01 1.320e-01 1.000e-01
 7.700e-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
 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 9.700e-02 7.700e-01 2.300e-01 6.500e-02 2.000e-02 6.000e-03 1.800e-03
 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+01 0.000e+01
 9.700e-02 7.700e-01 2.300e-01 6.500e-02 2.000e-02 6.000e-03 1.800e-03
 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09
302.0     302.0     0.0       0.0       0.0       0.0       0.0       0.0
0.0       7.0       6.0       6.0       6.0       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       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
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
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
150.0	150.0	157.0	164.0	171.0	177.0	184.0	191.0
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	500.0	531.0	577.0	0.0	0.0	0.0	0.0
0.0	20.6	5.0	5.0	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
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	0.0	0.0	0.0	0.0	0.0
250.0	250.0	285.0	425.0	500.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	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	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	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	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	1.0	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

TABLE A-IV

REFERENCED BIOTRAN INPUT FOR PANTEX

Variable Name and Description	Value	Reference and Notes
T1, min. insolation, ly/d	277.0	Map 53, Baldwin 1973
T2, max. insolation, ly/d	723.0	Map 54, Baldwin 1973
L1, 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		
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	
	S.093	
	0.089	
	N.039	
	D.029	
R, annual ppt, in.	21	NOAA 1980 - Amarillo, Texas
G1, site elevation, ft	3538	
L3, latitude to reference	0.0	
F1, -0.3 bar, soil %H_2O	26.1	Unger 1981
W1, -15 bar, soil %H_2O	16.8	Unger 1981
H, 0 bar, soil % H_2O	27.5	Unger 1981
Y2, simulation interval yr	100.0	
RHERB, ruminant	2.0	More than one grazing interval

TABLE A-IV (cont)

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	Yearly	Yearly, output only
RGCPLT(22), plants plot	1,2,8 11,12,18	Plants plotted - sorghum(1), ws garden 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, 12,18	Area simulated - food, grazing and feed
RCODE(22), soil depth	1,2,8,11, 12,18	Soil rooting depth for plants
FFP, frost-free period,d	202	NOAA 1980 - Amarillo, Texas
UPTKE, Pu root uptake	4.0	Pu root uptake, fraction/d/ml of transpirate/m^2 = 4x10^{-9}
XPLNT, daily output Yr	99.0	Year for daily output
XHERB, Ruminant mode	1.0	Yearly data
Z1, dpm/g soil	1,2,8,11 12,18	Activity specified each layer at t_0
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/ appl.	1,2,11,12	Wilson**, Harmon*, Texas A&M 1981
DIRA, irrig. sch.	1,2,11,12	Same
RR, Ruminant	1.0	Beef cattle simulated
P5, fraction consumed	1.0	Fraction raised & consumed in study area
N5, herd size	600	
AA2, fraction grazed	1.0	Fraction study area grazed
FSUPF, fraction feed	1.0	Fraction feed from study area
AGE, yr of herd	3.0	3.0 specifies 2-year-old cattle
YRGRZ, yr on pasture	1-100	
ONRNG, d on range	1-73 74-319	Horton+
ANMAL, herd size	600,600	
PUTZD, feed	1,11=4 12=1.0 1,11=4 8,18=1.0	Days 1-73, 4 is supplemental feed, 1 is graze Days 74-319

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TABLE A-V

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

Grain Sorghum		Garden Veg.		Alfalfa		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.)
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				

TABLE A-VI

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

TABLE A-VII

PuO_2 CONCENTRATION IN AIR, VEGETABLES, WHEAT, AND CATTLE MUSCLE FROM BIOTRAN SIMULATION OF PANTEX

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 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
					$\overline{X}$	4.43	173.0	508.0	31.0

TABLE A-VIII

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

PuO_2 Deposited µCi/m²	Organ	Resuspension µCi Inhaled	Resuspension rem	Leafy Vegetables µCi Ingested	Leafy Vegetables rem	Wheat Products µCi Ingested	Wheat Products rem	Meat µCi Ingested	Meat rem	Total rem
13514 (BIOTRAN	lung	0.47	460	25.4	-	60.8	-	11.2	-	460
	liver		400		8.6		21		3.8	433
	bone		850		20		47		8.7	926
400	lung	0.014	14.	0.75	-	1.8	-	0.33	-	14
	liver		12.		0.26		0.61		0.11	13
	bone		25.		0.58		1.4		0.26	27
7.5	lung	2.6×10^{-4}	0.25	0.014	-	0.034	-	0.0062	-	0.25
	liver		0.22		0.0048		0.012		0.0021	0.24
	bone		0.47		0.011		0.026		0.0048	0.51
0.2	lung	7.0×10^{-6}	0.0068	0.00038	-	0.00090	-	0.00017	-	0.0068
	liver		0.0059		0.00013		0.00031		0.000058	0.0064
	bone		0.013		0.00030		0.00070		0.00013	0.014

TABLE A-IX

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

PuO_2 Deposited μCi/m²	Organ	Resuspension μCi Inhaled	Resuspension rem	Leafy Vegetables μCi Ingested	Leafy Vegetables rem	Wheat Products μCi Ingested	Wheat Products rem	Meat μCi Ingested	Meat rem	Total rem
13514 (BIOTRAN)	lung	1.10	1030	117	-	263	-	55.2	-	1030
	liver		492		40		89		19	640
	bone		985		91		204		43	1323
400	lung	0.033	31	3.5	-	7.8	-	1.6	-	31
	liver		15		1.2		2.7		0.54	19
	bone		30		2.7		6.1		1.2	40
7.5	lung	0.00061	0.57	0.065	-	0.15	-	0.31	-	0.57
	liver		0.27		0.022		0.51		0.011	0.35
	bone		0.55		0.051		0.12		0.024	0.75
0.2	lung	0.000016	0.015	0.0017	-	0.0039	-	0.00082	-	0.015
	liver		0.0072		0.00058		0.0013		0.00028	0.0094
	bone		0.014		0.0013		0.0030		0.00064	0.019

TABLE A-X

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

Isopleth	Number of People	$\mu Ci / m^2$	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	107	0.0046		240	0.010	
			liver	101	0.0015		149	0.0022	
			bone	215	0.00030		308	0.00043	
1	4	400	lung	56	0.0024		124	0.0053	
			liver	52	0.00078		76	0.0011	
			bone	108	0.00015		160	0.00022	
2	140	40	lung	196	0.0084		434	0.019	
			liver	182	0.0027		266	0.0040	
			bone	378	0.00053		560	0.00078	
3	4255	4.0	lung	596	0.026		1319	0.057	
			liver	553	0.0083		808	0.012	
			bone	1149	0.00016		1702	0.0024	
4	2559	0.4	lung	36	0.0015		79	0.0034	
			liver	33	0.00050		49	0.00074	
			bone	69	0.000097		102	0.00014	
				Σ	0.059	0.85	Σ	0.12	1.7
Healy	148	7.5	lung	37	0.0016		84	0.0036	
			liver	36	0.00054		52	0.00078	
			bone	75	0.00011		111	0.00016	
3	4255	4.0	lung	596	0.026		1319	0.057	
			liver	553	0.0083		808	0.012	
			bone	1149	0.0016		1702	0.0024	
4	2559	0.4	lung	36	0.0015		79	0.0034	
			liver	33	0.00050		49	0.00074	
			bone	69	0.000097		102	0.00014	
				Σ	0.040	0.57	Σ	0.080	1.1
EPA	6962	0.2	lung	47	0.0020		104	0.0045	
			liver	45	0.00068		65	0.00098	
			bone	97	0.00014		97	0.00014	
				Σ	0.0028	0.040	Σ	0.0056	0.080

TABLE A-XI

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	2923	0.13		6545	0.28	
			liver	2752	0.041		4067	0.061	
			bone	5884	0.0082		8407	0.012	
1	78	400	lung	1092	0.047		2418	0.10	
			liver	1014	0.015		1482	0.022	
			bone	2106	0.0029		3120	0.0044	
2	20448	40	lung	28630	1.23		63390	2.73	
			liver	26580	0.40		38850	0.58	
			bone	55210	0.077		81790	0.11	
3	28730	4.0	lung	4022	0.17		8906	0.38	
			liver	3735	0.056		5459	0.082	
			bone	7757	0.011		11490	0.016	
4	11862	0.4	lung	166	0.0071		368	0.016	
			liver	154	0.0023		225	0.0034	
			bone	320	0.00045		474	0.00066	
				Σ	2.2	3.6	Σ	4.4	7.2
Healy	20604	7.5	lung	5151	0.22		11744	0.50	
			liver	4975	0.074		7211	0.11	
			bone	10510	0.015		14423	0.020	
3	28730	4.0	lung	4022	0.17		8906	0.38	
			liver	3735	0.056		5459	0.082	
			bone	7757	0.011		11490	0.016	
4	11862	0.4	lung	166	0.0071		368	0.016	
			liver	154	0.0023		225	0.0034	
			bone	320	0.00045		474	0.00066	
				Σ	0.56	0.92	Σ	1.1	1.8
EPA	61196	0.2	lung	416	0.018		918	0.039	
			liver	392	0.0059		575	0.0086	
			bone	857	0.0012		1163	0.0016	
				Σ	0.025	0.041		0.049	0.080

TABLE A-XII

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	30.8	0.0013		68.2	0.0029	
			liver	28.6	0.00043		41.8	0.00063	
			bone	59.4	0.000083		88	0.00012	
3	2862	4.0	lung	401	0.017		887	0.038	
			liver	372	0.0056		544	0.0082	
			bone	773	0.0011		1145	0.0016	
4	4334	0.4	lung	60.7	0.0026		134	0.0058	
			liver	56.3	0.00084		82	0.0012	
			bone	117	0.00016		173	0.00024	
					0.029 Σ	0.40		0.059 Σ	0.82
Healy	22	7.5	lung	5.5	0.00024		12.5	0.00054	
			liver	5.3	0.000080		7.7	0.00012	
			bone	11.2	0.000016		16.5	0.000023	
3	2862	4.0	lung	401	0.017		887	0.038	
			liver	372	0.0056		544	0.0082	
			bone	773	0.0011		1145	0.0016	
4	4334	0.4	lung	60.7	0.0026		134	0.0058	
			liver	56.3	0.00084		82	0.0012	
			bone	117	0.00016		173	0.00024	
					0.028 Σ	0.39		0.056 Σ	0.78
EPA	7218	0.2	lung	49.1	0.0021		108	0.0046	
			liver	46.2	0.00069		67.8	0.0010	
			bone	101	0.00014		137	0.00019	
					0.0029 Σ	0.040		0.0058 Σ	0.080

TABLE A-XIII

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	166	lung	5.6	0.00024		12.7	0.00055	
			liver	5.3	0.000084		7.86	0.00012	
			bone	11.4	0.000016		16.3	0.000023	
1	0	400	lung	14	0.00060		31	0.0013	
			liver	13	0.00020		19	0.00029	
			bone	27	0.000038		40	0.000056	
2	11068	40	lung	15495	0.67		34310	1.5	
			liver	14388	0.22		21029	0.32	
			bone	29884	0.042		44272	0.062	
3	30107	4.0	lung	4215	0.18		9333	0.40	
			liver	3914	0.059		5720	0.086	
			bone	8129	0.011		12043	0.017	
4	19335	0.4	lung	271	0.012		599	0.026	
			liver	251	0.0038		367	0.0055	
			bone	522	0.00073		773	0.0011	
					1.2 Σ	2.0		2.4 Σ	4.0
Healy	11070	7.5	lung	2768	0.12		6310	0.27	
			liver	2657	0.040		3875	0.058	
			bone	5646	0.0079		8303	0.012	
3	30107	4.0	lung	4215	0.18		9333	0.40	
			liver	3914	0.059		5720	0.086	
			bone	8129	0.011		12043	0.017	
4	19335	0.4	lung	271	0.012		599	0.026	
			liver	251	0.0038		367	0.0055	
			bone	522	0.0073		773	0.0011	
					0.44 Σ	0.73		0.88 Σ	1.5
EPA	60512	0.2	lung	411	0.018		908	0.039	
			liver	387	0.0058		567	0.0085	
			bone	847	0.0012		1150	0.0016	
					0.025 Σ	0.041		0.049 Σ	0.081

TABLE A-XIV

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

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	0.70	0.000030		1.55	0.000067	
			liver	0.65	0.0000098		0.95	0.000014	
			bone	1.35	0.0000019		2.00	0.0000028	
4	12	0.4	lung	0.168	0.0000072		0.372	0.000016	
			liver	0.156	0.0000023		0.228	0.0000034	
			bone	0.324	0.00000045		0.480	0.00000067	
					0.000052 Σ	0.31		0.00011 Σ	0.65
Healy									
3	5	4	lung	0.70	0.000030		1.55	0.000067	
			liver	0.65	0.0000098		0.95	0.000014	
			bone	1.35	0.0000019		2.00	0.0000028	
4	12	0.4	lung	0.168	0.0000072		0.372	0.000016	
			liver	0.156	0.0000023		0.278	0.0000034	
			bone	0.324	0.00000045		0.480	0.00000067	
					0.000052 Σ	0.31		0.00011 Σ	0.65
EPA	17	0.2	lung	0.116	0.0000050		0.255	0.000011	
			liver	0.109	0.0000016		0.159	0.0000024	
			bone	0.238	0.00000033		0.323	0.00000045	
					0.0000069 Σ	0.041		0.000014 Σ	0.081

TABLE A-XV

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	21.6	0.00093		47.7	0.0021	
			liver	20.0	0.00030		29.3	0.00044	
			bone	41.6	0.000058		61.6	0.000086	
4	3970	0.4	lung	55.6	0.0024		123.0	0.0053	
			liver	51.6	0.00077		75.4	0.0011	
			bone	107.0	0.00015		159.0	0.00022	
					0.0046 Σ	0.11		0.0092 Σ	0.22
Healy									
3	154	4.0	lung	21.6	0.00093		47.7	0.0021	
			liver	20.0	0.00030		29.3	0.00044	
			bone	41.6	0.000058		61.1	0.000086	
4	3970	0.4	lung	55.0	0.0024		123.0	0.0053	
			liver	51.6	0.00077		75.5	0.0011	
			bone	107.0	0.00015		159.0	0.00022	
					0.0046 Σ	0.11		0.0092 Σ	0.22
EPA	4124	0.2	lung	28.0	0.0012		61.9	0.0027	
			liver	26.4	0.00040		38.8	0.00058	
			bone	57.7	0.000081		78.4	0.00011	
					0.0017 Σ	0.041		0.0034 Σ	0.082

APPENDIX B

IAAP SUPPLEMENTARY DATA

TABLE B-I

FORMATTED BIOTRAN INPUT FOR IAAP SIMULATIONS

```
175.0    525.0    90.0     24.0     76.5     120.0
5.2      40.0     0.0      2.0      0.0      0.0      1.0      1.0
9.9      2.27     0.15     600.0    0.004
0.049    0.042    0.076    0.097    0.110    0.133    0.102    0.098
0.115    0.077    0.054    0.046
35.11    600.0    0.0      26.0     15.6     30.2     0.0      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      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      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      0.0      0.0      0.0      0.0      0.0      0.0      0.0
0.0      3.0      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      0.0      0.0      0.0      0.0      0.0      0.0
183.0    0.0      4.0      17.0     1.0
 7.407e+04 7.407e+04 0.000e+01 0.000e+01
 9.700e-02 6.920e-01 2.210e-01 6.800e-02
 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01
 9.700e-02 6.920e-01 2.210e-01 6.800e-02
 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+01 0.000e+01
 9.700e-02 7.700e-01 2.300e-01 6.500e-02 2.000e-02 6.000e-03 1.800e-03
 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 0.000e+01
 5.010e-02 5.530e-01 4.270e-01 3.100e-01 2.300e-01 1.700e-01 1.320e-01 1.000e-01
 7.700e-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
 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 9.700e-02 7.700e-01 2.300e-01 6.500e-02 2.000e-02 6.000e-03 1.800e-03
 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+01 0.000e+01
 9.700e-02 7.700e-01 2.300e-01 6.500e-02 2.000e-02 6.000e-03 1.800e-03
 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09
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
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
0.0      0.0      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
```

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

REFERENCED BIOTRAN INPUT FOR IAAP

Variable Name and Description	Value	Reference and Notes
T1, min ly/d	175	Map 53, Baldwin 1973
T2, max ly/d	525	Map 54, Baldwin 1973
L1, d	90	Gallegos 1980
T3, °F, Min	24	Map 10, Baldwin 1973
T4, °F, Max	76.5	Map 10, Baldwin 1973
L2, °F	120	Gallegos 1980
Soil Type	2	Loam, USDA 1972
Nuclide	1	Pu
Saltation/Rain splash	1	Process modeled
TRE, events/mo	9.9	Map 24, Baldwin 1973
TMXV, Temp. Variation	2.27	NOAA 1981
PRCV, rain coef. var.	0.15	Baldwin 1973
RELV, ft	600	
ALPSR, °F/ft	0.004	
X(1,12)ppt frac	0.049	NOAA 1981
	0.042	
	0.076	
	0.097	
	0.11	
	0.133	
	0.102	
	0.098	
	0.115	
	0.077	
	0.054	
	0.46	
R, in.	35.11	
G1, ft	600	
L3, Latitude to ref	0	
F1, -0.3 bar	26	Fenton*
W1, -15 bar	15.6	Fenton*
H, 0 bar	30.2	Fenton*
Y2, Simulation interval	100	Years Simulated

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

TABLE B-II (cont)

Variable Name and Description	Value	Reference and Notes
RANDN, number seed	528	
ARIG	2.0	
AICHE,	1.0	
SELECT (15), output	Yearly	
RGCPLT (22), plant plot	1,2,8,11 12,18	Same plants as Pantex, corn(1), ws garden veg(2), ws grass(8), alfalfa(11), winter wheat(12), cs grass(18)
RGC (22), plants sim.	Same	
RIRRC (22), irrig. sch.	None	
RSS (22), niche	8,18	Ws and cs grass niche competition
Acres, area in acre	1,2,8,11, 12,18	Area simulated - crops, grazing, feed.
RCODE(22), soil depth	1,2,8,11, 12,18	Soil rooting depth for plants.
FFP, d	183.0	NOAA 1981
UPTAKE	4.0	Pu root uptake = $4x10^{-9}$
XPLNT, Yr	99.0	
XHERB, Ruminant mode	1.0	Yearly
Z1, dpm/g soil	1,2,8,11 12,18	Dpm/g specified each layer at t_0
ZF, root fraction/layer	same	Gallegos 1980, Rodgers 1980, Pettit 1974
ZU, root uptake coefficient	$4x10^{-9}$	Gallegos 1980 (for Pu)
CUTA, harvest sch.	1,2,11,12	Cooper*
AWATA, ring	None	Cooper*
DIRA, irrig. sch.	None	
RR, Ruminant	1.0	Beef Cattle simulated
P5, Fraction Consumed	1.0	
N5, herd size	600	
AA2, frac. grazed	1.0	
FSUPF, frac. feed	1.0	
AGE, yr of herd	3.0	3.0 specifies 2-yr-old cattle
YRGRZ, yr on pasture	3-100	
ONRNG, d on range	1-73 74-319	
ANMAL, herd size	600 600	
PUTZD, feed	1,11=4 12=1.0	Days 1-73, 4=supple.feed 1=graze
	1,11=4 8,18=1.0	Days 74-319

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

TABLE B-III

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

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)	
		623(H)	

TABLE B-IV

ROOT FRACTION ESTIMATES FOR IAAP SIMULATED PLANTS

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

TABLE B-V

PuO_2 CONCENTRATION IN AIR, VEGETABLES, WHEAT, AND CATTLE MUSCLE FOR BIOTRAN SIMULATION OF IAAP

Years	Air Concentration above grazed grasses dpm/m³ yearly Average	Garden Vegetables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet	Years	Air dpm/m³	Garden Vegetables dpm/g Dry	Winter Wheat dpm/g Dry	Cattle Muscle dpm/g Wet
1	82.9	-	-	-	26	0.0172	17	16.7	1.17
2	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
4	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
9	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
11	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
					$\bar{X}$	3.04	304	309	59.2

TABLE B-VI

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

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

TABLE B-VII

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

		Resuspension		Leafy Vegetables		Wheat Products		Meat		
µCi/m²	Organ	µCi Inhaled	rem	µCi Ingested	rem	µCi Ingested	rem	µCi Ingested	rem	Total rem
13514	lung	0.76	712	205	--	160	--	105	--	712
	liver		340		70		54		36	500
	bone		680		159		124		82	1045
400	lung	0.022	21	6.1	--	4.7	--	3.1	--	21
	liver		9.8		2.1		1.6		1.1	15
	bone		20		4.7		3.7		2.4	31
7.5	lung	0.00042	0.39	0.11	--	0.089	--	0.058	--	0.39
	liver		0.19		0.037		0.03		0.02	0.28
	bone		0.38		0.085		0.069		0.045	0.58
0.2	lung	1.1×10^{-5}	0.010	0.0030	--	0.0024	--	0.0016	--	0.01
	liver		0.0049		0.001		0.00082		0.00054	0.0073
	bone		0.0098		0.0023		0.0019		0.0012	0.015

TABLE B-VIII

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	123	1739	lung	6330	0.27		11270	0.48	
			liver	6062	0.091		7913	0.12	
			bone	13121	0.018		16540	0.023	
1	123	400	lung	1476	0.063		2583	0.11	
			liver	1353	0.021		1845	0.028	
			bone	3075	0.0043		3813	0.0053	
2	921	40	lung	1105	0.048		1934	0.083	
			liver	1013	0.015		1382	0.021	
			bone	2303	0.0032		2855	0.004	
3	4246	4	lung	510	0.022		892	0.038	
			liver	467	0.007		637	0.0096	
			bone	1062	0.0015		1316	0.0018	
4	4277	0.4	lung	51	0.0022		90	0.0039	
			liver	47	0.00071		64	0.00096	
			bone	107	0.00015		133	0.00019	
					Σ 0.57	5.9		Σ 0.93	9.6
Healy	1167	7.5	lung	257	0.011		455	0.02	
			liver	245	0.0036		327	0.0049	
			bone	548	0.00077		677	0.00095	
3	4246	4	lung	510	0.022		892	0.038	
			liver	467	0.007		637	0.0096	
			bone	1062	0.0015		1316	0.0018	
4	4277	0.4	lung	51	0.0022		90	0.0039	
			liver	47	0.00071		64	0.00096	
			bone	107	0.00015		133	0.00019	
					Σ 0.048	0.5		Σ 0.080	0.83
EPA	9690	0.2	lung	58	0.0025		97	0.0042	
			liver	55	0.00083		71	0.0011	
			bone	116	0.00016		145	0.0002	
					Σ 0.0035	0.036		Σ 0.0073	0.075

TABLE B-IX

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	192	4197	lung	23851	1.03	-	42456	1.8	
			liver	22837	0.34		29814	0.45	
			bone	49432	0.069		62312	0.087	
1	192	400	lung	2304	0.099		4032	0.17	
			liver	2112	0.032		2880	0.043	
			bone	4800	0.0067		5952	0.0083	
2	8057	40	lung	9668	0.42		16919	0.73	
			liver	8863	0.13		12085	0.18	
			bone	20142	0.028		24977	0.035	
3	9227	4	lung	1107	0.048		1938	0.083	
			liver	1015	0.015		1384	0.021	
			bone	2307	0.0032		2860	0.004	
4	8168	0.4	bone	98	0.0042		172	0.0074	
			liver	90	0.0014		123	0.0018	
			lung	204	0.00029		253	0.00035	
				Σ	2.2	8.5	Σ	3.6	14
Healy	8441	7.5	lung	1857	0.08		3291	0.14	
			liver	1773	0.027		2363	0.035	
			bone	3767	0.0056		4896	0.0069	
3	9227	4	lung	1107	0.048		1938	0.083	
			liver	1015	0.015		1384	0.021	
			bone	2307	0.0032		2860	0.004	
4	8168	0.4	lung	98	0.0042		172	0.0074	
			liver	90	0.0014		123	0.0018	
			bone	204	0.00029		253	0.00035	
				Σ	0.18	0.70	Σ	0.30	1.2
EPA	25836	0.2	lung	155	0.0067		258	0.011	
			liver	147	0.0022		189	0.0028	
			bone	310	0.00043		388	0.00054	
				Σ	0.0093	0.036	Σ	0.014	0.054

TABLE B-X

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

Isopleth	Number of People	μci2/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	17	232	lung	117	0.005	-	208	0.0089	
			liver	112	0.0017		146	0.0022	
			bone	242	0.00034		305	0.00043	
1	17	400	lung	204	0.0088		357	0.015	
			liver	187	0.0028		255	0.0038	
			bone	425	0.0006		527	0.00074	
2	482	40	lung	578	0.025		1012	0.044	
			liver	530	0.008		723	0.011	
			bone	1205	0.0017		853	0.0012	
3	927	4	lung	111	0.0048		195	0.0084	
			liver	102	0.0015		139	0.0021	
			bone	232	0.00032		287	0.00040	
4	3598	0.4	lung	43	0.0018		76	0.0033	
			liver	40	0.0006		54	0.00081	
			bone	90	0.00013		112	0.00016	
				Σ	0.063	1.2	Σ	0.1	2
Healy	516	7.5	lung	114	0.0049		201	0.0086	
			liver	108	0.0016		144	0.0022	
			bone	243	0.00034		299	0.00042	
3	927	4	lung	111	0.0048		195	0.0084	
			liver	102	0.0015		139	0.0021	
			bone	232	0.00032		287	0.0004	
4	3598	0.4	lung	43	0.0018		76	0.0033	
			liver	40	0.0006		54	0.00081	
			bone	90	0.00013		112	0.00016	
				Σ	0.016	0.32	Σ	0.026	0.52
EPA	5041	0.2	lung	30	0.0013		50	0.0022	
			liver	29	0.00044		37	0.00056	
			bone	60	0.000084		76	0.00011	
				Σ	0.0018	0.036	Σ	0.0029	0.058

TABLE B-XI

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	1554	0.067	-	2767	0.12	
			liver	1488	0.022		1943	0.029	
			bone	3221	0.0045		4061	0.0057	
1	77	400	lung	924	0.04		1617	0.07	
			liver	847	0.013		1155	0.017	
			bone	1925	0.0027		2387	0.0033	
2	6250	40	lung	7500	0.32		13125	0.56	
			liver	6875	0.11		9375	0.14	
			bone	15625	0.022		15000	0.021	
3	7261	4	lung	871	0.037		1525	0.066	
			liver	799	0.012		1089	0.016	
			bone	1815	0.0025		2251	0.0032	
4	7373	0.4	lung	88	0.0039		155	0.0067	
			liver	81	0.0012		111	0.0017	
			bone	184	0.00026		229	0.00032	
				Σ	0.66	3.1	Σ	1.1	5.2
Healy	6404	7.5	lung	1408	0.061		2498	0.11	
			liver	1345	0.02		1793	0.027	
			bone	3010	0.0042		3714	0.0052	
3	7261	4	lung	871	0.037		1525	0.066	
			liver	799	0.012		1089	0.01	
			bone	1815	0.0025		2251	0.0032	
4	7373	0.4	lung	88	0.0039		155	0.0067	
			liver	81	0.0012		111	0.0017	
			bone	184	0.00026		229	0.00032	
				Σ	0.14	0.67	Σ	0.24	1.1
EPA	21038	0.2	lung	126	0.0054		210	0.009	
			liver	120	0.0018		154	0.0023	
			bone	252	0.00035		316	0.00044	
				Σ	0.0076	0.036	Σ	0.012	0.057

TABLE B-XII

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	189	4	lung	23	0.00099	-	39	0.0017	
			liver	21	0.00032		28	0.00042	
			bone	47	0.000066		59	0.000083	
4	275	0.4	lung	3.3	0.00014		5.8	0.00025	
			liver	3	0.000045		4.1	0.000062	
			bone	6.9	0.0000097		8.5	0.000012	
					Σ 0.0016	0.34		Σ 0.0025	0.54
Healy	189	4	lung	23	0.00099		39	0.0017	
			liver	21	0.00032		28	0.00042	
			bone	47	0.000066		59	0.000083	
4	275	0.4	lung	3.3	0.00014		5.8	0.00025	
			liver	3	0.000045		4.1	0.000062	
			bone	6.9	0.0000097		8.5	0.000012	
					Σ 0.0016	0.34		Σ 0.0025	0.54
EPA	464	0.2	lung	2.8	0.00012		4.6	0.0002	
			liver	2.6	0.000039		3.4	0.000051	
			bone	5.6	0.0000078		7	0.0000098	
					Σ 0.00017	0.037		Σ 0.00026	0.056

TABLE B-XIII

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

Isopleth	Number of People	$\frac{\mu Ci}{m^2}$	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	218	0.0094	-	382	0.016	
			liver	200	0.003		273	0.0041	
			bone	455	0.00064		564	0.00079	
4	6048	0.4	lung	73	0.0031		127	0.0055	
			liver	67	0.001		91	0.0014	
			bone	151	0.00021		187	0.00026	
				Σ	0.017	0.22	Σ	0.028	0.36
Healy	1819	4	lung	218	0.0094		382	0.016	
			liver	200	0.003		273	0.0041	
			bone	455	0.00064		564	0.00079	
4	6048	0.4	lung	73	0.0031		127	0.0055	
			liver	67	0.001		91	0.0014	
			bone	151	0.00021		187	0.00026	
				Σ	0.017	0.22	Σ	0.028	0.36
EPA	7867	0.2	lung	47	0.002		79	0.0034	
			liver	45	0.00068		57	0.00086	
			bone	94	0.00013		118	0.00017	
				Σ	0.0028	0.036	Σ	0.0044	0.056

APPENDIX C

HANFORD SITE SUPPLEMENTARY DATA

TABLE C-I

FORMATTED BIOTRAN INPUT FOR HANFORD SIMULATION

```
150.0     650.0     90.0      29.4      76.4      120.0
7.1       10.7      0.0       3.0       0.0       0.0       1.0       1.0
2.0       2.20      0.26      476.0     0.004
0.148     0.099     0.058     0.064     0.072     0.091     0.022     0.030
0.048     0.093     0.136     0.138
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       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
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
0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
0.0       0.0       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.     0.0       0.0       0.0
0.0       0.0       0.0       0.0       0.0       3000.
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     0.0       4.0       99.0      1.0
 7.407e+04 7.407e+04 0.000e+01 0.000e+01
 9.700e-02 6.920e-01 2.210e-01 6.800e-02
 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01
 9.700e-02 6.920e-01 2.210e-01 6.800e-02
 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 9.470e-02 4.100e-01 2.300e-01 1.500e-01 9.000e-02 5.300e-02 4.000e-02 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+01 0.000e+01 0.000e+01
 0.000e+01 0.000e+01 0.000e+01
 7.000e-02 5.800e-01 3.300e-01 1.800e-01 1.000e-01 5.500e-02 3.000e-02 1.600e-02
 9.000e-03 5.000e-03 2.900e-03
 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09
 4.000e-09 4.000e-09 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 0.000e+01
 5.010e-02 5.530e-01 4.270e-01 3.100e-01 2.300e-01 1.700e-01 1.320e-01 1.000e-01
 7.700e-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
 4.000e-09
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 9.470e-02 4.100e-01 2.300e-01 1.500e-01 9.000e-02 5.300e-02 4.000e-02 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
 7.407e+04 7.407e+04 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01 0.000e+01
 9.470e-02 4.100e-01 2.300e-01 1.500e-01 9.000e-02 5.300e-02 4.000e-02 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+01 0.000e+01 0.000e+01
 9.700e-02 8.230e-01 9.500e-02 2.600e-02 2.300e-02 1.700e-02 1.110e-02 3.500e-03
 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09 4.000e-09
267.0     267.0     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
```

TABLE C-I (cont)

0.0	0.0	0.0	0.0	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
206.0	213.0	220.0	227.0	234.0	241.0	248.0	255.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
267.0	267.0	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
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	213.0	220.0	227.0	234.0	241.0	248.0	255.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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
0.0	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
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0
259.0	259.0	0.0	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	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	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	220.0	227.0	234.0	241.0	248.0	255.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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
0.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
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
0.0	0.0	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	502.0	509.0	516.0	523.0	533.0	540.0	547.0
554.0	561.0	0.0	0.0	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	6.0	4.0	4.0	4.0	4.0	4.0	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	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
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
0.0	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
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	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

TABLE C-I (cont)

0.0	0.0	0.0	0.0	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

TABLE C-II

REFERENCED BIOTRAN INPUT FOR HANFORD

Variable Name and Description	Value	Reference and Notes
T1, min ly/d	150.0	Map 53, Baldwin 1973
T2, max ly/d	650.0	Map 54, Baldwin 1973
L1, d	90.0	Gallegos 1980
T3, °F min	29.4	Map 10, Baldwin 1973 , Stone 1972
T4, °F max	76.4	Map 10, Baldwin 1973 , Stone 1972
L2, d	120.0	Gallegos 1980
pH, soil	7.1	Cline 1972 , Cline 1973
Soil type	3.0	sandy, Cline 1972
Decay factor	0.0	None
WATCON, dpm/l	0.0	For Pu in H_2O = 0.0
Nuclide	1.0	Pu
Saltation/rain splash	1.0	Process modeled
TRE, events/mo	2.0	Map 24, Baldwin 1973
TMXV, °F	2.20	Stone 1972 , Phillips 1970
PRCV	0.26	Baldwin 1973
RELV, ft	476.0	Reference elevation
ALPSR, °F/ft	0.004	
X(1,12)	0.148	Stone 1972 , Phillips 1970
	0.099	
	0.058	
	0.064	
	0.072	
	0.091	
	0.022	
	0.030	
	0.048	
	0.093	
	0.136	
	0.138	
R, in.	6.25	Stone 1972 , Phillips 1970
G1, ft	476.0	Site elevation
L3, latitude to ref	0.0	
F1, -0.3 bar	16.0	Sauer*, Hagood 1970
W1, -15 bar	4.0	Sauer*, Hagood 1970
H, 0 bar	20.0	Sauer*, Hagood 1970
Y1, dpm/g	0.0	
Y2, simulation years	100.0	

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

TABLE C-II (cont)

Variable Name and Description	Value	Reference and Notes
RANDN, number seed	528	
AR1G	2.0	
AICHE	1.0	
SELECT(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), pasture grass(3), and cheatgrass (22)
RGC(22), plants simulated	same	
RIRRC(22), irrig. sch.	1,2,4,11, 12,3	Benton City (CES 1982A), Pasco (CES 1982B)
ACRES(22), area in access	1,2,4,11 12,3,22	Acres for grazing crops
RCODE(22), soil depth	1,2,4,11, 12,13,22	Soil rooting depth
FFD, d	176.0	Stone 1972 , Phillips 1970
UPTKE,	4.0	Pu root uptake - 4×10^{-9}
XPLNT, Yr	99.0	
XHERB, ruminant model	1.0	
Z1, dpm/g soil	1,2,4,11 12,3,22	dpm/g specified for each
ZF, root frac/layer	same	Gallegos 1980 , Rodgers 1980 , Pettit 1974 , Cline 1977
Zu, root uptake coeff.	4×10^{-9}	Gallegos 1980
CUTA, harvest schedule	1,2,4,11, 12	Rickard*, Cline**
AWATA, irrig. schedule	same	Middleton 1975 , Jensen 1970 , Middleton 1967 , Jensen 1969
DIRA, irrig. days	same	
RR, Ruminant	1.0	beef cattle simulated
P5, fraction consumed	1.0	
N5, herd size	600	
AA2, fraction grazed	1.0	
FSUPF, fraction feed	1.0	
AGE, yr of herd	3.0	
YRGRZ, yr on pasture	3-100	
ONRNG, d on range	1-90 91-230 230-245	
ANMAL, herd size	600	
PUTZD, plants as graze and feed	1,11=4.0 22=1.0	day 1-90, 4=supple feed 1=graze
	1,11=4.0 3=1.0	day 91-230
	1,3=4.0 11=1.0	day 230-245

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

TABLE C-III

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

Corn		Garden Vegetables		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)	2	157(P)	2	157(P)	2.5	157	2.5	255(P)	3(P)	244(P)	6(PW)
164	2	164	2	171	2.5	164	2.5	453	3	453	4
171	2	171	2	185	2.5	171	2.5	460	3	477	4
178	2	178	2	199	2.5	178	2.5	467	3	485	4
185	2	185	2	213	2.5	185	2.5	474	3	505	4
192	2	192	2	227	2.5	192	2.5	481	3	533	4
199	2	199	2	241	2.5	199	2.5	488	3	560(H)	
206	2	206	2	255	2.5	206	2.5	495	3		
213	2	213	2	470	2.5	213	2.5	500(H)			
220	2	220	2	485	2.5	220	2.5	502	3		
227	2	227	2	499	2.5	227	2.5	509	3		
234	2	234	2	514	2.5	234	2.5	516	3		
241	2	241	2	521	2.5	241	2.5	523	3		
248	2	248	2			248	2.5	531(H)			
259	2	255	2			255	2.5	533	3		
267(H)		267(H)				259(H)		540	3		
								547	3		
								554	3		
								561	3		
								577(H)			

TABLE C-IV

HANFORD ROOT FRACTION ESTIMATES FOR SIMULATED PLANTS

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	0-2	0.097	0.097	0.097	0.070	0.0501	0.097	0.097
1	2-27	0.692	0.692	0.770	0.580	0.553	0.770	0.823
2	27-52	0.221	0.221	0.230	0.330	0.427	0.230	0.095
3	52-77	0.068	0.068	0.650	0.180	0.310	0.650	0.026
4	77-102			0.020	0.100	0.230	0.020	0.023
5	102-127			0.0060	0.055	0.170	0.006	0.017
6	127-152			0.0018	0.030	0.132	0.0018	0.011
7	152-177				0.016	0.100		0.0038
8	177-202				0.009			
9	202-227				0.005			
10	227-252				0.0029			
11	252-277							

TABLE C-V

PuO_2 CONCENTRATIONS IN AIR, VEGETABLES, WHEAT, AND CATTLE MUSCLE FOR BIOTRAN SIMULATION AT HANFORD

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
					$\bar{X}$	2.48	2000	608	95.9

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