4.0 RADIOLOGICAL DOSE ASSESSMENT

4.0 INTRODUCTION

This chapter reports the methodology used to estimate the potential radiation dose to members of the public from airborne and liquid effluents released by the West Valley Demonstration Project (WVDP) during 1988. The resulting dose estimates are based on the effluent monitoring data and various air and biological samples collected throughout 1988. These estimates are then compared to the environmental standards established by the Department of Energy (DOE) and the Environmental Protection Agency (EPA) to determine whether members of the public received significant radiation doses as a result of WVDP activities. The radiation doses reported for 1988 are compared to the doses reported in previous years.

Computer models were used to calculate the dispersion of radioactive effluents in the environment and the potential pathways of exposure to the public. Radionuclide concentrations in air and biological samples collected near the site were compared to background concentrations. For concentrations in excess of background, an estimate was made of the maximum radiation dose that would be incurred by a nearby resident from breathing or ingesting that radionuclide.

The following sections define some key terms and units used to measure radiation and radiation dose. The magnitude and potential health effects of the public's exposure to radiation from natural and man-made sources are also discussed. The radiation dose to members of the public contributed by WVDP activities can thus be placed in the proper perspective.

4.1.1 Sources of Exposure to Radiation

As defined here, radiation is the emission of energy in the form of particles (alpha and beta rays, neutrons) or electromagnetic waves (gamma rays) from the nuclei of atoms. X-rays are also a form of electromagnetic radiation emitted when electrons lose energy rapidly. The emission of radiation can occur as a result of nuclear fission (all forms of radiation). It can be induced by accelerating electrons across an electric field and into a target (x-rays). Only the random emission as the result of spontaneous nuclear decay (alpha, beta, gamma and x-rays) is of concern in WVDP effluents.

Radionuclides are defined as the unstable isotopes of an element, such as carbon, iodine, or uranium, which decay by the emission of radiation. The resulting nuclide may be either stable (non-radioactive) or radioactive. The amount of a radioactive material is measured by its activity, expressed in units of curies (Ci) or becquerels (Bq), and represents the rate at which the radioactive atoms in the material are decaying. One becquerel of activity corresponds to one decay per second; one curie equals 37 billion becquerels. Over a fixed period, a constant fraction of the radioactive atoms in a material will decay. Each radioactive isotope has a unique half life which represents the time in which half of the atoms of that isotope have decayed. Strontium-90 and cesium-137 have half-lives of about 30 years, while plutonium-239 has a 24,000 year half-life.

Most of the radiation dose affecting the public occurs as part of the earth's natural radiation background. All members of the public are constantly being bombarded by cosmic and terrestrial radiation. Some naturally occurring radionuclides are incorporated in foods, body tissues, organs and bones. Naturally occurring radon gas and its radioactive daughters concentrate in closed areas such as basements and poorly ventilated buildings. The concentration in air depends on such factors as geographic location and building ventilation. The annual radiation dose to an average person living in the United States contributed by naturally occurring radiation is shown in Figure 4-1.

Man-made sources of radiation may also contribute to the radiation dose of individual members of the public. Such sources include diagnostic and therapeutic x-rays, nuclear medicine, consumer products (such as smoke detectors and cigarettes), fallout from atmospheric nuclear weapons tests, and effluents from the nuclear fuel

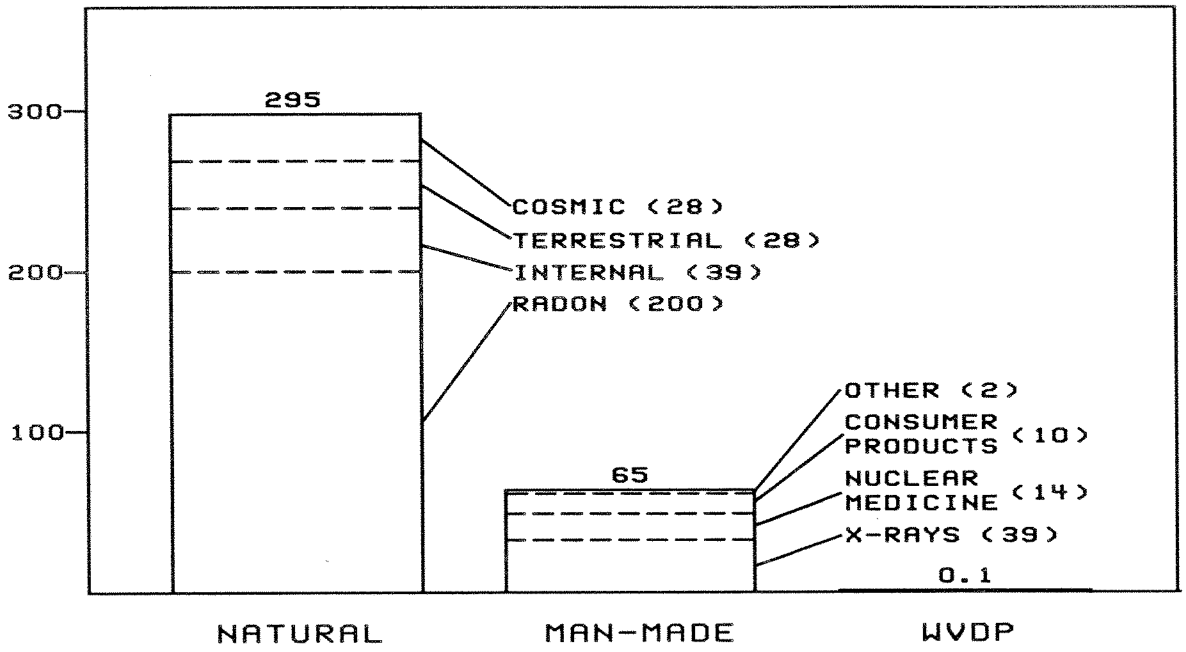

Figure 4-1
Comparison of annual radiation doses (mrem) to an average member of the U.S. population [NCRP 1987] with the maximum dose to an off-site resident from 1988 WVDP ef-

cycle (of which the WVDP is a part). The extent to which any member of the public is exposed to these sources is variable and depends on such factors as health, personal habits, and geographic location. The annual radiation dose to an average person living in the U.S. contributed by man-made radiation is shown in Figure 4-1.

4.1.2 Potential Health Effects from Exposure to Radiation

The health effects of radiation depend on the amount and type of radiation energy deposited in living cells. The radiation may originate from sources outside the body or from radionuclides inside the body (resulting from inhalation or ingestion of contaminated air, water, or food). External or internal irradiation of the body by alpha rays or beta, gamma, and x-rays produce significantly different biological effects for the same amount of energy absorbed in tissue. The concept of dose equivalent (DE) was developed by the radiation protection community to allow direct comparison or addition of doses from different types of radiation. The SI unit of dose equivalent is the sievert (Sv), which is equal to 100 rem. One mSv or one mrem is equal to one thousandth of one Sv or rem, respectively. The National Council on Radiation Protection and Measurements (NCRP) Report 93 [NCRP 1987] estimates that the average annual DE received by a person living in the U.S. is about 360 mrem (3.6 mSv) from natural and man-made sources of radiation (Figure 4-1). This number is based on the collective DE, defined as the total DE received by a population (expressed in units of person-Sv or person-rem). The average individual DE is obtained by dividing the collective DE by the population number.

Radionuclides entering the body through inhalation of contaminated air or ingestion of contaminated food or water are usually distributed unevenly in different tissues and organs in the body. Isotopes of iodine concentrate in the thyroid gland. Strontium, plutonium and americium isotopes concentrate in the skeleton. Uranium and plutonium isotopes, when inhaled, stay in the lungs for a long time. On the other hand cesium isotopes and tritium, an isotope of hydrogen usually tied up in a water molecule, will be distributed uniformly throughout the body.

Publication 2 of the International Commission on Radiological Protection (ICRP) [ICRP 1959] considered, for each radionuclide, the effects of uniform irradiation of the whole body and of the organ receiving the highest DE (the "critical organ") for either ingestion or inhalation of radionuclides. Limits were placed on the permissible dose to the whole body or any individual organ and the allowable radionuclide concentrations in air and water.

Current ICRP recommendations issued in Publications 26 and 30 [ICRP 1977, 1979] employ a risk-based methodology rather than the critical organ concept. The risk factor for fatal cancer induction in certain organs (per unit DE) is divided by the risk factor for a cancer fatality when the whole body is irradiated uniformly at that dose. This weighting factor represents the relative sensitivity of a particular organ to develop a fatal cancer. The DE to each organ is multiplied by the respective weighting factor. These weighted DEs are then summed to obtain the effective DE. The latter represents the increased risk of fatal cancer induction (based on a probability of 165 per million person-rem) over a 50 year period following the exposure to radiation.

The Committee on Biological Effects of Ionizing Radiations (BEIR) estimated that the lifetime risk of a cancer fatality from a single exposure to 10 rem (0.1 Sv) of radiation ranges from 0.5 to 1.4 percent of the background cancer mortality risk. In the U.S. the cancer mortality rate from all causes is currently about one in eight. The BEIR Committee stressed that the health effects at very low levels of radiation exposure are not clear, and any extrapolation of risk estimates at these levels is subject to great uncertainty [BEIR 1980]. As will be shown in the following sections, the estimated maximum DE received by a member of the public from WVDP activities during 1988 is many orders of magnitude lower than the exposures considered in the BEIR report.

4.2 ESTIMATED RADIATION DOSE FROM AIRBORNE EFFLUENTS

As reported in Section 2.1.1, five stacks and vents were monitored for radioactive air emissions during 1988. The activity that was released to the atmosphere from these stacks and vents is listed in Tables C-2.1.1 through C-2.1.11 in Appendix C. In addition, the laundry and LLWT vents were monitored for gross alpha and beta emissions. Except for the main plant stack, which vents to the atmosphere at a height of 60 m, (197 ft.) all releases were at ground level 10 m (33 ft).

Two methodologies were employed to calculate the radiation dose to the public from airborne effluents. The first method considers the specific terrain around the site and the effect of that terrain on wind flow. The second method does not consider terrain and uses the older dose models.

The hills and valleys in the vicinity of the site frequently channel the winds. To realistically account for terrain effects on wind flow, the Dames & Moore computer code WNDSRF3 was used to develop a two-dimensional wind field. The wind field data were then used as input to EPM3, a variable-trajectory Gaussian puff dispersion computer code, to calculate the relative radioactive effluent concentrations in areas within an 80-km (50 mile) radius of the site. Relative concentrations were calculated for elevated (60 m) and ground level (10 m) releases. These relative concentrations (also known as X/Qs) were used as input to AIRDOS-EPA, a version of AIRDOS that uses the current ICRP risk-based dose models. AIRDOS [Moore et al. 1979] is a pathway analysis computer code for airborne radioactive effluents. It is used to estimate the radiation dose from direct exposure to radioactivity in the air and on the ground. It also computes the dose from inhalation of contaminated air and ingestion of contaminated water and foods produced near the site. A detailed discussion of the computer codes WNDSRF3, EPM3 and AIRDOS-EPA is given in "Radiological Parameters for Assessment of West Valley Demonstration Project Activities" [Yuan and Dooley 1987].

The Clean Air Act Code (CAAC) was used to comply with the requirements of EPA regulations contained in 40 CFR 61, "National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H" [USEPA 1983a]. This version of the AIRDOS pathway analysis computer code uses simplified straight-line Gaussian methodology, which does not account for terrain effects on wind flow, and implements the dose models of ICRP Publication 2. The NESHAP regulations are currently undergoing revisions which, if adopted, will implement the current ICRP dose models. A detailed discussion of the CAAC is given in "WVDP Radioactive Air Emissions Permit Application - General Information" [WVDP 1987].

Both methodologies were used to estimate the maximum potential DE to an off-site resident, the maximum organ DE, and the collective DE to the population within 80 km (50 miles) of the site. In the following sections, the doses calculated using AIRDOS-EPA will be presented first, followed by the dose computed using the CAAC (in square brackets). They are then compared to the EPA regulatory standards contained in 40 CFR 61. Table 4-1 includes a summary of the estimated radiation doses to the public from effluents released to the atmosphere.

4.2.1 Maximum Dose to an Off-Site Resident

Based on the airborne radioactivity released from the site during 1988, a person living in the vicinity of the WVDP was estimated to receive an effective DE of 0.00033 mrem (0.0000033 mSv) [0.00035 mrem (0.0000035 mSv) whole body DE]. This maximally exposed individual was assumed to reside continuously about 2.1 km WSW [3.4 km SE] from the site, eating locally produced foods at the maximum consumption rates for an adult.

The NESHAP limit on the whole body (or effective) DE to the maximally exposed off-site resident is 25 mrem (0.25 mSv). The doses reported above are well below this limit (0.0013% [0.0014%]) and are much lower than the 300 mrem (3 mSv) that an average member of the U.S. population receives in one year from natural background radiation.

The potential dose from airborne effluents incurred by the maximally exposed off-site resident was

Table 4-1. Summary of Calculated Radiation Doses from Effluents Released by the WVDP during 1988

Type of Release	Maximum Off-Site Resident Dose (mrem) Effective	Maximum Off-Site Resident Dose (mrem) Maximum Organ	Collective Dose(5) (person-rem)
Airborne, Elevated (60 m)(1)	0.00032 [0.000048]*	0.0032 Thyroid [0.0022 Thyroid]	0.0028 [0.0074]
Airborne, Ground level (10 m)(2)	0.000083 [0.00031]	0.0012 Thyroid [0.0035 Bone surfaces]	0.00016 [0.042]
Airborne, Combined(3)	0.00033 [0.00035]	0.0033 Thyroid [0.0039 Bone surfaces]	0.0030 [0.05]
Liquid(4)	0.1	Not Applicable	0.028
All	0.1	Not Applicable	0.031

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* Numbers in brackets calculated with Clean Air Act Code version of AIRDOS.

(1) Maximally exposed resident lives 2.1 km WSW [3.4 km SE] from WVDP.

(2) Maximally exposed resident lives 1.4 km NW [1.9 km NNW] from WVDP.

(3) Same as (1). Note that contributions from ground-level releases to maximum resident doses are not fully additive.

(4) Calculated using LADTAP II.

(5) Estimated population of 1.7 million living within 80 km of site.

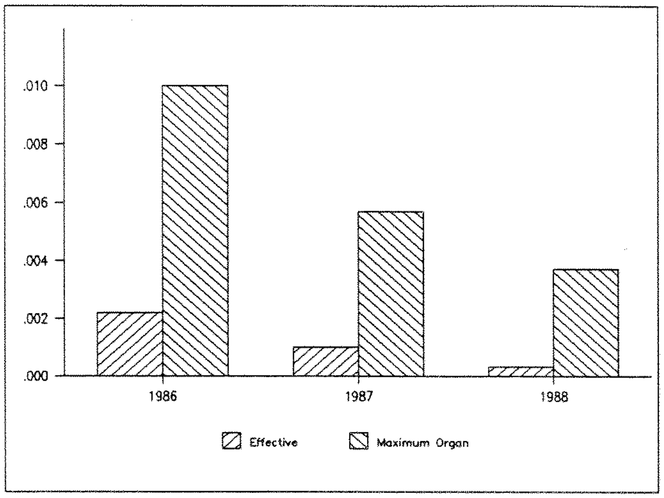

Figure 4-2
Maximum dose equivalent (mrem) to an individual residing near the WVDP from airborne effluents (calculated using AIRDOS-EPA).

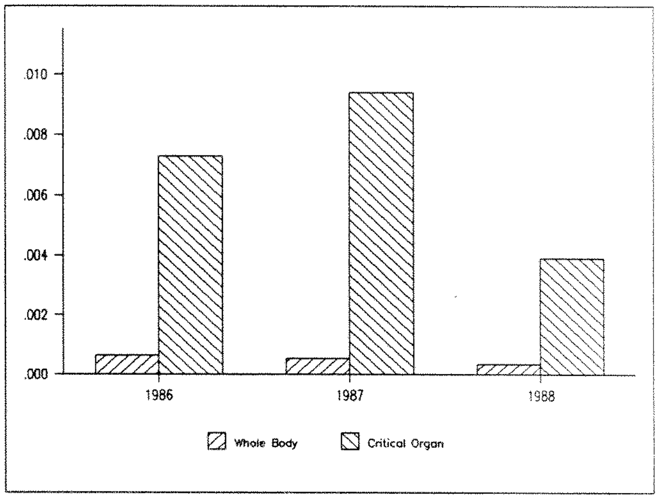

Figure 4-3
Maximum dose equivalent (mrem) to an individual residing near the WVDP from airborne effluents (calculated using the Clean Air Act Code).

67% lower [35% lower] in 1988 when compared to the previous year's estimate. Dose estimates from the past three years are presented for comparison in Figures 4-2 and 4-3.

4.2.2 Maximum Organ Dose

As a result of radioactivity in airborne effluents released from the site during 1988, the maximally exposed off-site individual incurred an estimated DE of 0.0033 mrem (0.000033 mSv) [0.0039 mrem (0.000039 mSv)] to the thyroid [bone surfaces], the organ receiving the highest dose.

The NESHAP limit on the DE to any organ of the body is 75 mrem (0.75 mSv). The doses reported above are well below this limit (0.0044% [0.0051%]).

The potential maximum organ dose from airborne effluents was 42% lower [59% lower] in 1988 when compared to the previous year's estimate. Dose estimates from the past three years are presented for comparison in Figures 4-2 and 4-3.

4.2.3 Collective Dose to the Population

As a result of airborne radioactivity released from the WVDP during 1988, the population living within 80 km (50 miles) from the site received an estimated collective effective DE of 0.0030 person-rem (0.000029 person-Sv) [collective whole body DE of 0.05 person-rem (0.0005 person-Sv)]. This estimate is based on a population of 1.7 million within this radius. The resulting average effective DE per individual is 0.0000018 mrem (0.000000018 mSv) [0.00003 mrem (0.0000003 mSv) average whole body DE].

There are no regulations limiting collective doses to the population. However, the calculated average individual dose is insignificant when compared to the 300 mrem (3 mSv) that an average member of the U.S. population receives in one year from natural background radiation.
The collective dose from airborne effluents was 68% lower [138% higher] in 1988 when compared to the previous year's estimate. Dose estimates from the past three years are presented for comparison in Figures 4-4 and 4-5.

4.3 ESTIMATED RADIATION DOSE FROM LIQUID EFFLUENTS

As reported in Section 2.1.2, five batch releases of liquid radioactive effluents were monitored during 1988. The radioactivity that was discharged in these effluents is listed in Table C-1.1.1.

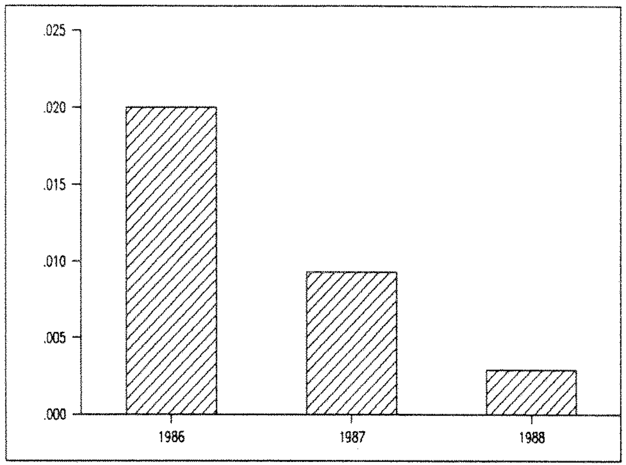

Figure 4-4
Collective effective dose equivalent (person-rem) to the population within 80 km of the WVDP from airborne effluents (calculated using AIRDOS-EPA).

The computer code LADTAP II [Simpson and McGill 1980] was used to calculate the dose to the maximally exposed off-site individual and the collective dose to the population from routine releases and dispersion of these effluents. Since the effluents eventually reach Cattaraugus Creek, which is not used as a source of drinking water, the primary exposure pathway calculated by the code is from the consumption of 21 kg (46 lbs.) of fish caught in the creek. A detailed description of LADTAP II is given in Yuan and Dooley, 1987.

Currently there are no EPA standards establishing limits on the radiation dose to members of the public from liquid effluents except as applied in the 40 CFR 141 and 40 CFR 143 Drinking Water Guidelines [USEPA 1984b,c]. The potable water wells sampled for radionuclides are located upgradient of the WVDP and are not considered a realistic pathway in the dose assessment. Since Cattaraugus Creek is not designated as a drinking water supply, the radiation dose estimated using LADTAP II was compared with the limits stated in DOE Order 5480.1 [USDOE 1981].

4.3.1 Maximum Dose to an Off-Site Individual

Based on the radioactivity in liquid effluents released from the WVDP during 1988, an off-site individual was estimated to receive a maximum effective DE of 0.1 mrem (0.001 mSv). This dose is 0.1% of the 100-mrem (1-mSv) limit in DOE Order 5480.1 and is much lower than the 300 mrem (3 mSv) that an average member of the U.S. population receives in one year from natural background radiation.

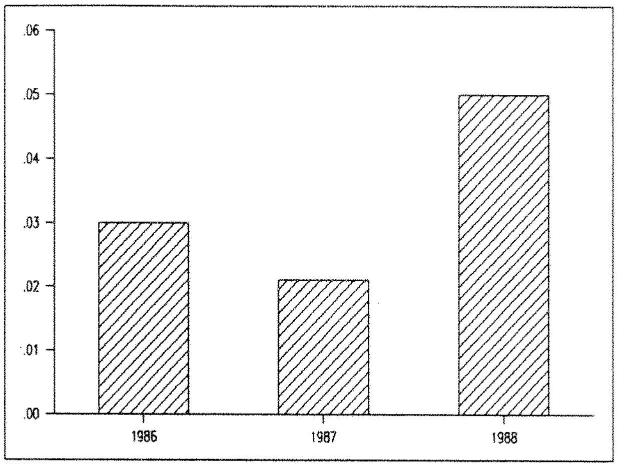

Figure 4-5
Collective whole-body dose equivalent (person-rem) to the population within 80 km of the WVDP from airborne effluents (calculated using the Clean Air Act Code).

The potential dose from liquid effluents incurred by the maximally exposed off-site individual was 60% lower in 1988 when compared to the previous year's estimate. Dose estimates from the past three years are presented for comparison in Figure 4-6.

No maximum organ dose was computed since LADTAP II employs the risk-based methodology currently recommended by the ICRP rather than the critical organ methodology of the older ICRP guidance.

4.3.2 Collective Dose to the Population

As a result of radioactivity released in liquid effluents from the WVDP during 1988, the population living within 80 km from the site received a collective effective DE of 0.028 person-rem (0.00028 person-Sv). This estimate is based on a population of 1.7 million living within this radius. The resulting average effective DE per individual is 0.000017 mrem (0.00000017 mSv). This dose is in-

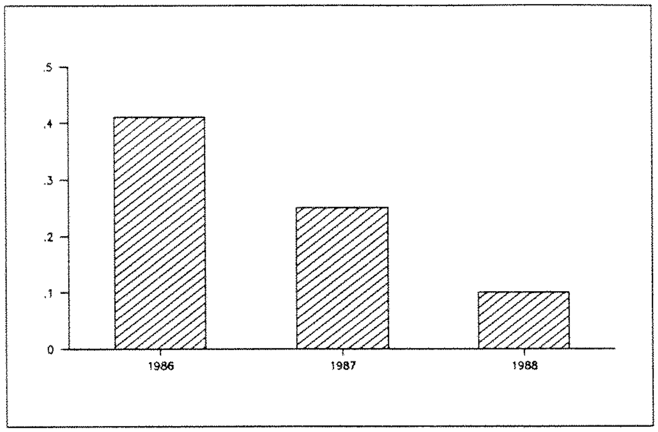

Figure 4-6
Maximum effective dose equivalent (mrem) to an individual residing near the WVDP from liquid effluents (calculated using LADTAP II).

significant when compared to the 300 mrem (3 mSv) that an average person receives in one year from natural background radiation.

The collective dose from liquid effluents was 40% lower in 1988 when compared to the previous year's estimate. Dose estimates from the past three years are presented for comparison in Figure 4-7.

Figure 4-7
Collective dose equivalent (person-rem) to the population within 80 km of the WVDP from liquid effluents (calculated using LADTAP II).

4.4 ESTIMATED DOSE FROM ALL PATHWAYS

The potential dose to the public from both airborne and liquid effluents released from the WVDP during 1988 is simply the sum of the individual dose contributions. The potential effective DE from all pathways to the maximally exposed individual was 0.1 mrem (0.001 mSv). The total collective DE to the population within 80 km (50 miles) of the site was 0.031 person-rem (0.00031 person-Sv), with an average effective DE of 0.000018 mrem (0.00000018 mSv) per individual.

The maximum dose to an individual was 0.1% of the 100 mrem (1 mSv) annual limit in DOE Order 5480.1.

The 1988 estimated total individual and collective effective DEs from all pathways were lower than 1987 estimates by 60% and 45%, respectively. Figure 4-8 shows the trend in total collective DE to the surrounding population. The calculated DE to the maximally exposed individual from liquid effluents was much greater relative to the contribution from airborne effluents. Thus, Figure 4-6 also represents the total estimated maximum DE during the past three years.

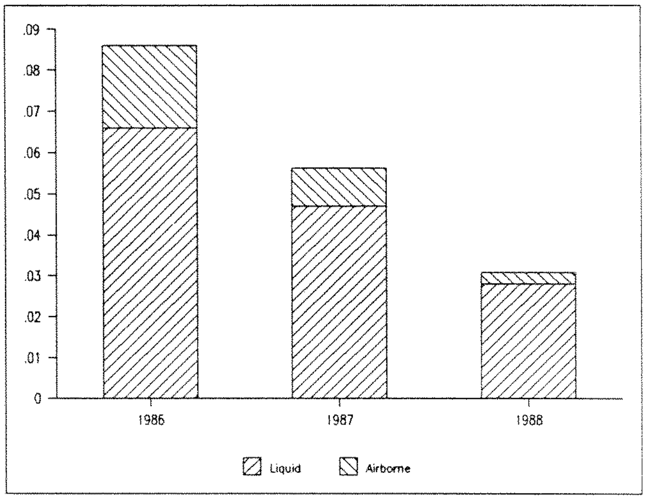

Figure 4-8
Total collective dose equivalent (person-rem) to the population within 80 km of the WVDP.

4.5 ESTIMATED RADIATION DOSE FROM LOCAL FOOD CONSUMPTION

In addition to dose estimates based on dispersion modeling, the maximum DE to a nearby resident was estimated based on consumption of locally produced food. Doses estimated using the computer models already incorporate the food pathway. Therefore, the following doses should not be added to doses reported in previous sections, but should serve as an additional means to measure the impact of WVDP operations.

Near-site and control samples of fish, milk, beef, venison, fruit, vegetables and cereal were collected. The samples were analyzed for various radionuclides, including tritium, potassium-40, cobalt-60, strontium-90, iodine-129, cesium-134 and cesium-137, as described in Section 2.1.3. The measured radionuclide concentrations reported in Tables C-3.1 through C-3.4 are the basis for these dose estimates.

With the exception of milk samples, all radionuclide concentrations are reported in terms of the dry sample weight. Prior to any dose calculations, the concentration per wet weight was reconstituted by factoring in the moisture content of the samples.

When statistically significant differences were found between near-site and background sample concentrations, the excess near-site sample concentration was used as a basis for the dose estimate. Most of the measured radionuclides were found to be under the minimum detectable concentration (MDC). When this was the case for both near-site and control samples, the concentrations in both were assumed to be at background levels.

The DE to a nearby resident was estimated for the consumption of foods with radionuclide concentrations found above background. The potential dose was calculated by multiplying the excess concentration by the maximum adult annual consumption rate for each food and the ingestion unit dose factor for the measured radionuclide. The consumption rates are based on site-specific data and recommendations in the NRC Regulatory Guide 1.109 for terrestrial food-chain dose assessments [USNRC 1977]. The unit dose factors for ingested radionuclides are based on current ICRP methodology [Yuan and Dooley 1987].

The results of the dose estimates for each food type are reported in the following sections. A summary of the estimated maximum DE to a nearby resident from consumption of locally produced food is presented in Table 4-2. The three-year trend in total DE from consumption of all the sampled food products is plotted in Figure 4-9. All of the calculated doses are well below both the EPA and DOE limits discussed in the previous sections.

4.5.1 Milk

Milk samples were collected from various nearby dairy farms throughout 1988. Control samples were collected from farms 25-30 km (15-20 miles) to the south and north of the WVDP. As reported in Table C-3.1, milk samples were measured for tritium, strontium-90, iodine-129, cesium-134, and cesium-137. Only strontium-90 was found above MDC levels. To obtain a conservative estimate, the average background concentration was subtracted from the near-site sample with the highest reported concentration. Based on an annual consumption rate of 310 liters, (327 quarts) the maximum effective DE from drinking this milk was estimated to be 0.18 mrem (0.0018 mSv). The highest organ DE (to bone surfaces) was estimated to be 1.9 mrem (0.019 mSv). Estimated doses resulting from the consumption of milk for the past three years are shown in Figure 4-10.

4.5.2 Beef

Near-site and control samples of locally raised beef were collected during middle and late 1988. As reported in Table C-3.2, these samples were measured for strontium-90, cesium-134 and cesium-137 concentrations. Only strontium-90 was detected above MDC levels, with the highest excess concentration reported in beef sampled during late 1988. Based on an annual consumption rate of 110 kg (242 pounds), the maximum effective DE from eating this meat was estimated to be 0.063 mrem (0.00063 mSv). The highest organ DE (to bone surfaces) was estimated to be 0.68 mrem (0.0068 mSv). Estimated doses resulting

TABLE 4-2. Summary of Maximum Radiation Doses to an Individual from Consumption of Food Produced in the Vicinity of the WVDP

Food	Sample Location	Maximum Annual Consumption(1)	Dose Equivalent (mrem) Effective	Dose Equivalent (mrem) Maximum Organ(2)
Milk	Dairy Farm 3.8 km NNW of WVDP	310 liters	0.18	1.9
Beef	Farm 3.5 km N of WVDP	110 kg	0.063	0.68
Venison	Within 2 km of WVDP	45 kg	0.0053	0.057
Apples	Collected 1 km S of WVDP	52 kg	0.08	0.86
Fish	Cattaraugus Creek downstream of Springville Dam	21 kg	0.041	0.44
TOTAL			0.37	3.9

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(1) From NRC Regulatory Guide 1.109 (except venison)
(2) Bone surfaces

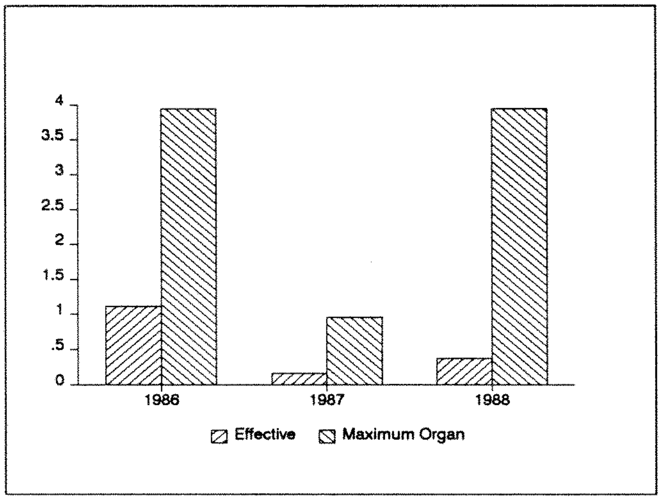

Figure 4-9
Maximum dose equivalent (mrem) to an individual from foods produced near the WVDP.

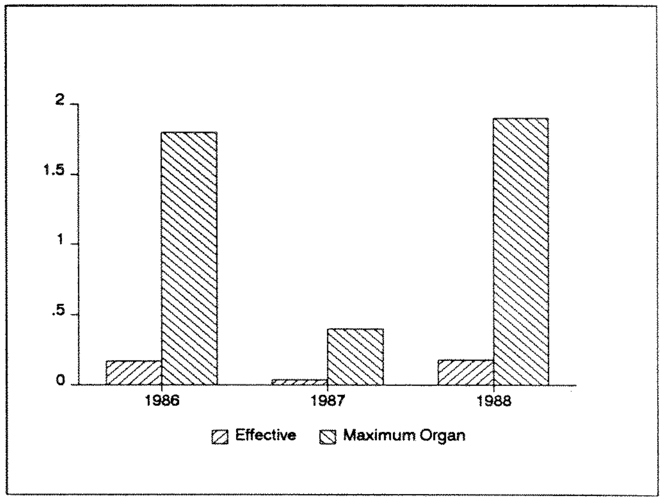

Figure 4-10
Maximum dose equivalent (mrem) to an individual from consumption of milk produced near the WVDP.

from the consumption of beef for the past three years are shown in Figure 4-11.

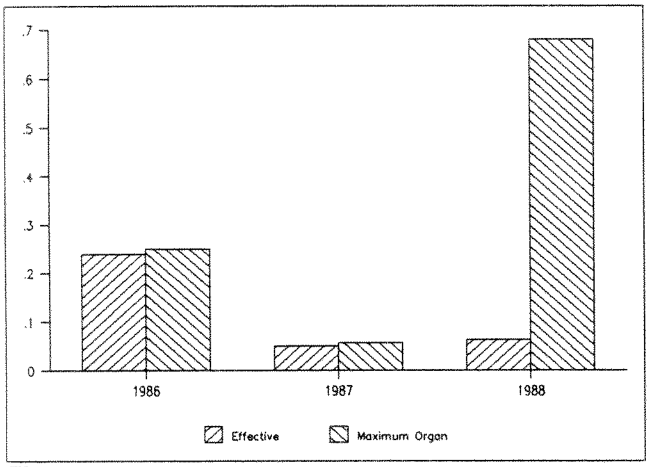

Figure 4-11
Maximum dose equivalent (mrem) to an individual from consumption of beef from cattle raised near the WVDP.

4.5.3 Venison (Deer)

Meat samples from three near-site and three control deer were collected in the last months of 1988. As reported in Table C-3.2, these samples were measured for strontium-90, cesium-134 and cesium-137 concentrations. Strontium-90 and cesium-137 were detected above MDC levels; however, average cesium-137 concentrations in background specimens were slightly higher than average concentrations in near-site specimens. Based on an annual consumption rate of 45 kg (100 pounds), the maximum effective DE from eating this meat was estimated to be 0.0053 mrem (0.000053 mSv). The highest organ DE (to bone surfaces) was estimated to be 0.057 mrem (0.00057 mSv). Estimated doses resulting from the consumption of venison for the past three years are shown in Figure 4-12.

4.5.4 Produce (Apples, Tomatoes and Corn)

Near-site and control samples of apples, tomatoes, and corn were collected in the third quarter of 1988. Samples of hay were also collected, but were not considered in the dose assessment because hay contributes only indirectly to the human food chain. As reported in Table C-3.3, these samples were measured for tritium, strontium-90, potassium-40, cobalt-60 and cesium-137 concentrations. Samples are analyzed for potassium-40, since it provides a built-in calibration spike from a natural isotope of potassium not released in WVDP effluents. Of all the samples and radionuclides analyzed, only strontium-90 in near-site apples was found at levels above the MDC and at a concentration higher than control specimens. In all other cases either the radionuclides were below MDC levels, or no statistically significant differences were found between near-site and control specimens. Based on an annual produce consumption rate of 52 kg (114 pounds), the maximum effective DE from eating this quantity of apples was estimated to be 0.08 mrem (0.0008 mSv). The highest organ DE (to bone surfaces) was estimated to be 0.86 mrem (0.0086 mSv). Estimated doses from ingestion of local produce from previous years are not available for comparison.

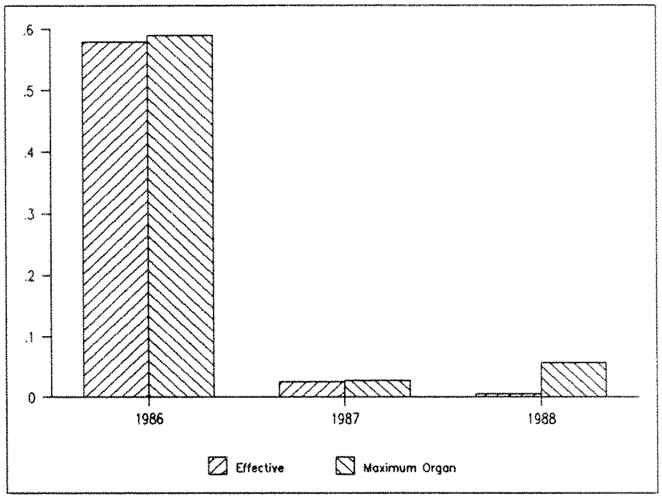

Figure 4-12
Maximum dose equivalent (mrem) to an individual from consumption of venison from deer taken near the WVDP.

4.5.5 Fish

Fish were caught in the second and third quarters of 1988 in Cattaraugus Creek upstream (control samples) and downstream (above and below the Springville dam) from the site. As reported in Table C-3.4, samples of fish flesh were measured for strontium-90, cesium-134 and cesium-137 concentrations. Only strontium-90 was detected above MDC levels, with the highest excess concentration reported in fish caught during the second quarter downstream of the Springville dam. Based on an annual consumption rate of 21 kg (46 lbs.), the maximum effective DE from eating this fish was estimated to be 0.041 mrem (0.00041 mSv). This compares well with the 0.1 mrem (0.001) estimated using the LADTAP II liquid effluent dispersion code. The highest organ DE (to bone surfaces) was estimated to be 0.44 mrem (0.0044 mSv). Estimated doses resulting from the consumption of fish for the past three years are shown in Figure 4-13.

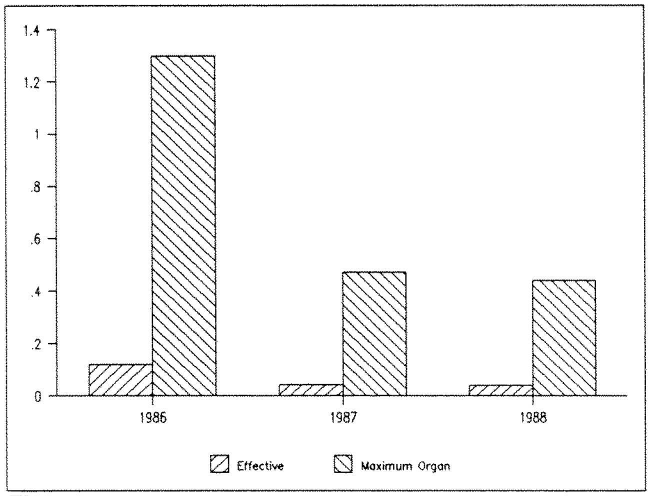

Figure 4-13
Maximum dose equivalent (mrem) to an individual from consumption of fish caught in Cattaraugus Creek downstream of the WVDP.

4.6 STATISTICAL ANALYSIS OF AIR SAMPLER DATA

Environmental air samplers are located in the vicinity of the site and at background locations. These samplers measure gross alpha, gross beta, strontium-90 and cesium-137 concentrations in air as reported in Tables C-2.2.1 through C-2.2.9 (Appendix C). To see if any measurable increases in airborne radionuclide concentrations could be detected in the air sampler data, a simple one-way analysis of variance (ANOVA) statistical test was performed. At the 99 percent confidence level, no statistically significant differences were found in any of the sampler data, indicating that these samplers are measuring background concentration levels. These findings agree with the conclusions drawn from the dispersion models. Average concentrations of radionuclides contributed by WVDP airborne effluents would be five to six orders of magnitude below the measured background levels at the sampler locations. Such small increments are impossible to detect within the variability of background radionuclide concentrations in air.

4.7 CONCLUSIONS

In summary, the dose assessment shows that during 1988 the WVDP was in compliance with all applicable emission standards and dose limits. The doses to the public estimated from effluent dispersion models and radionuclide concentrations in food samples were well below these limits, resulting in an insignificant impact on the public's health.