4.0 RADIOLOGICAL DOSE ASSESSMENT

4.1 Methodology

The potential radiological impacts resulting from the release of radioactivity during 1983 have been estimated by calculating radiation doses received by the maximally exposed off-site individual and the population within an 80 km radius of the WVDP facility. The potential pathways of exposure to the general public from radioactive effluents released by the WVDP operations are shown in Figure 7. The exposure modes considered in the dose calculations are:

- Direct exposure from immersion in air containing radionuclides
- Direct radiation from ground surfaces contaminated by deposited radionuclides
- Immersion in contaminated water
- Inhalation of airborne radionuclides
- Ingestion of contaminated waters and food produced from the land and surface waters in the area.

The radiation dose commitment to the maximally exposed individual and the collective dose to the population within an 80 km radius of the WVDP facility were calculated using the computer code AIRDOS-EPA for the air pathway (Reference 5) and LADTAP II for the water pathway (Reference 6). The gaseous discharges were assumed to occur from a single vent at 10 meters above the ground level to compensate for the uneven terrain in the vicinity of the WVDP site. Meteorological data were collected from July to December 1983 at the WVDP site; however, it had not become available in usable form by the time the preparation of this report was undertaken. The most representative meteorological data available for dispersion calculations were those collected during November 1974 to September 1975. These data were used in this report. Americium-241 was assumed to represent all the

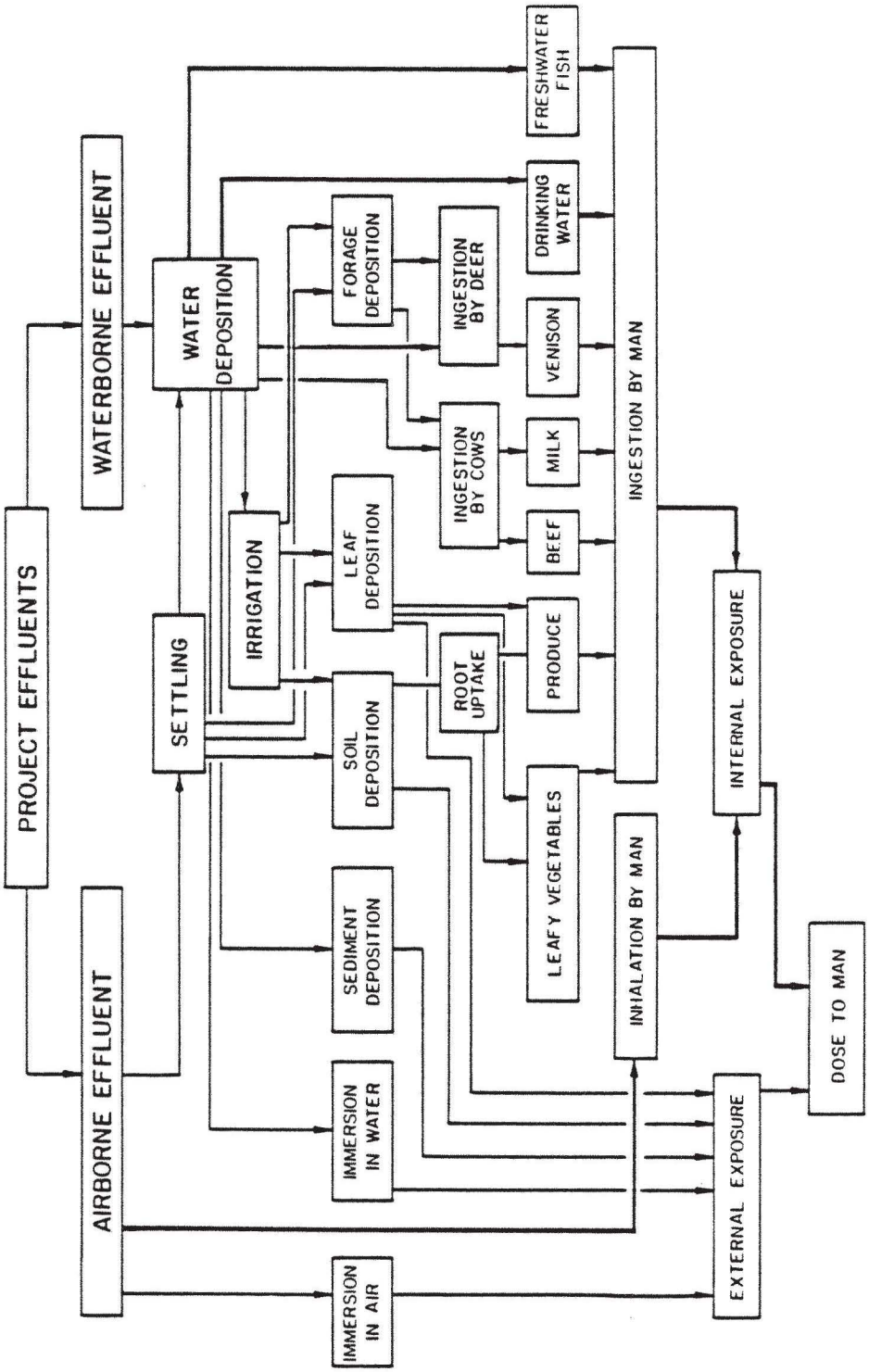

FIGURE 7 - COMPARTMENT MODEL OF PATHWAYS

gross alpha activity in both gaseous and liquid effluents. The gross beta/ gamma activity was assumed to consist of specific radionuclides distributed in the same proportion as the individually identified and measured radionuclides.

The dose estimates were made by calculating radionuclide concentrations in air, rates of deposition on ground surfaces, ground surface concentrations, intake rates via inhalation, and ingestion of meat, milk, and fresh vegetables. Site specific data on production and consumption of milk, meat and agricultural products was used in computing collective population dose.

The area surrounding the facilities is shown in Figure 1. It was overlaid with an 80 km radius grid system with the facility at its center. The grid system was further divided into 10 concentric regions and 16 compass directions. For each sector formed by the grid system, the specific human population, beef and dairy cattle population, and agricultural areas were assumed to be as described in Figures 8 through 15. The values for the sectors within a 10 mile radius are based on data from the FEIS (Reference 7).

For each radionuclide of concern, the inhalation dose conversion factors used are for an activity median aerodynamic diameter (AMAD) of 0.3 micrometer. For alpha emitters, the dose conversion factors are derived by using a quality factor of 20 as per ICRP recommendation (Reference 9). All of the doses from internal exposure are 50-year committed dose equivalents and are calculated for the 50-year period following inhalation or ingestion. The internal dose conversion factors used in this report are from Reference 9.

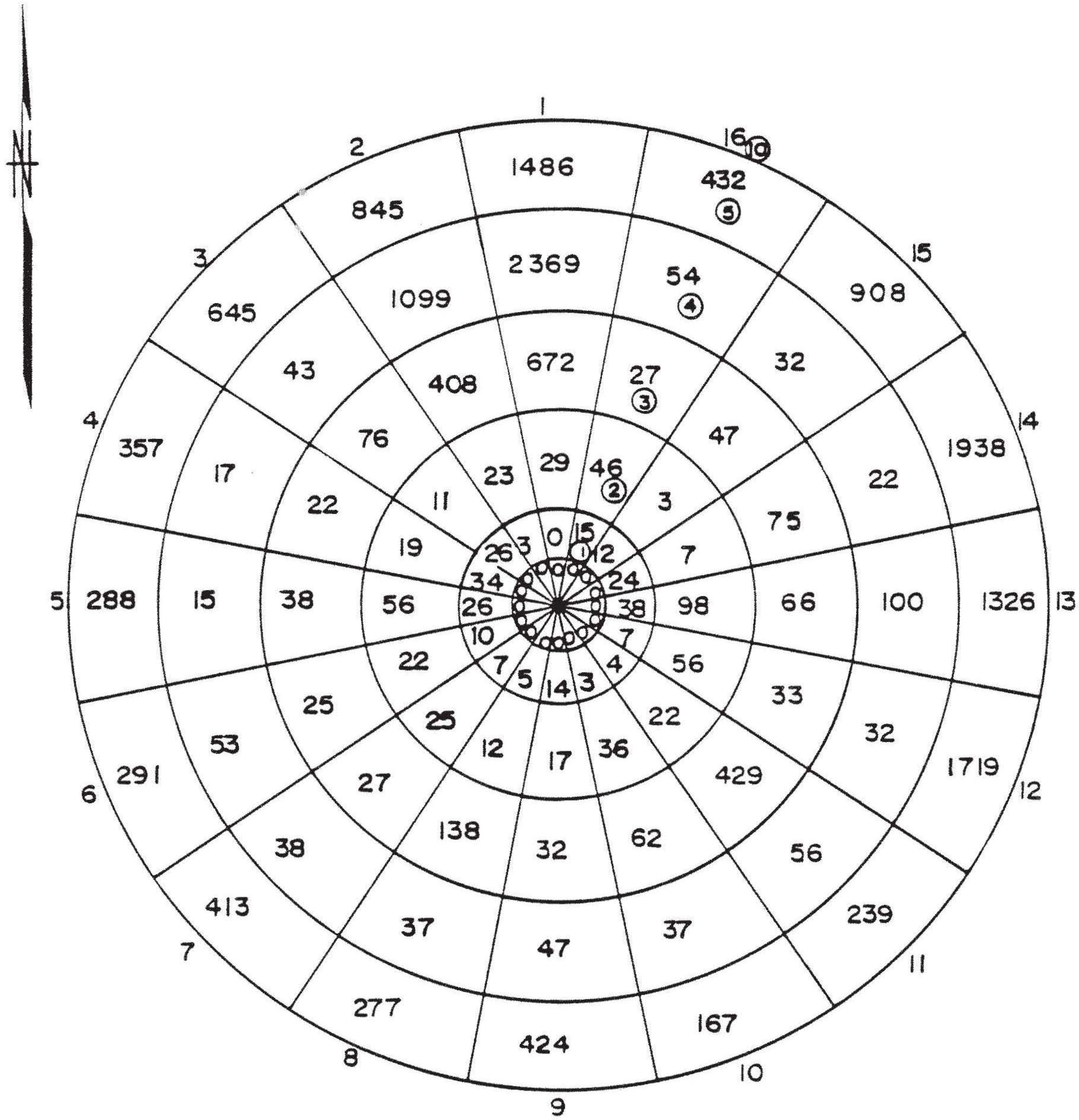

FIG. 8 - POPULATION DISTRIBUTION (0-10 MILES)

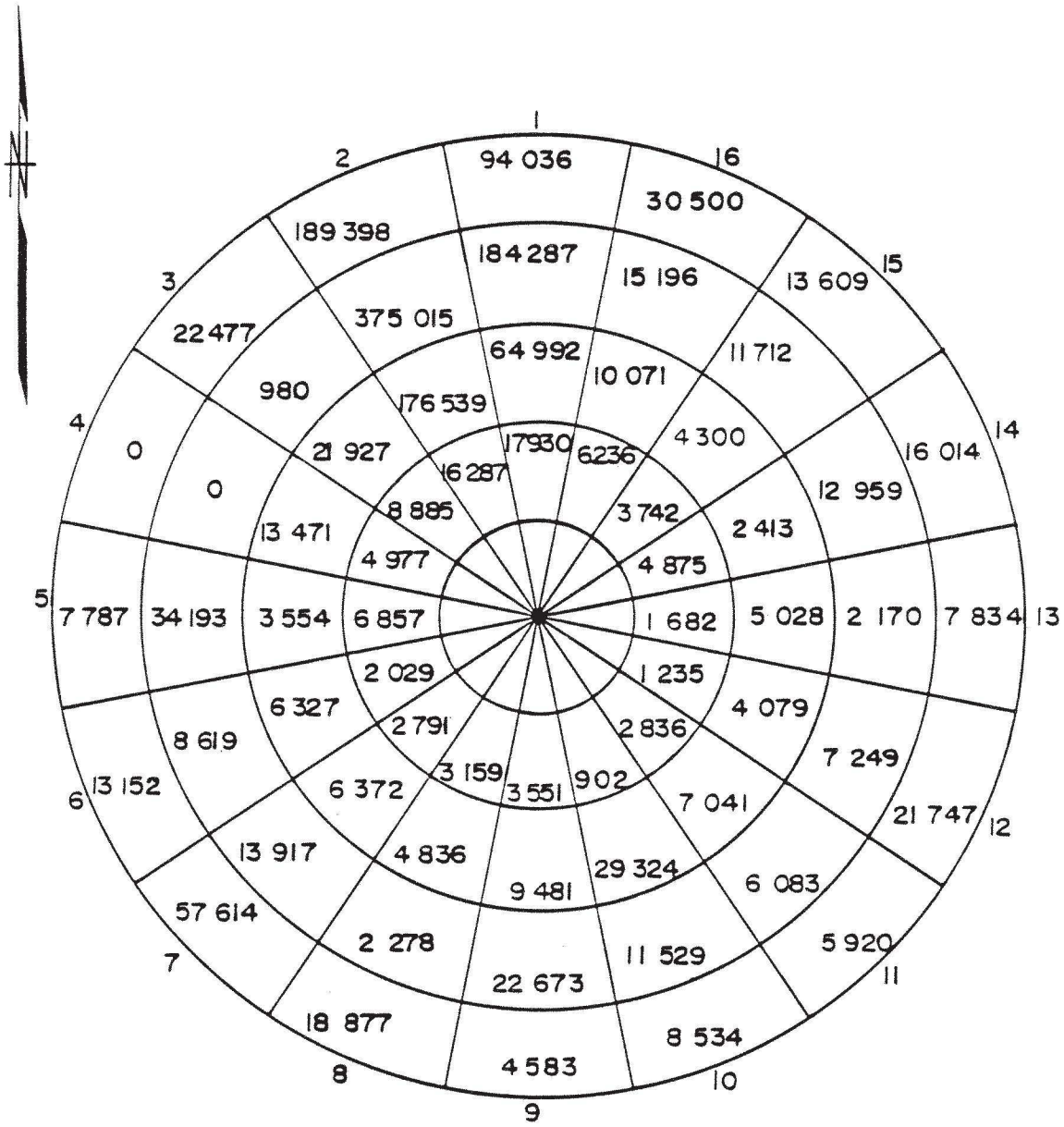

FIG. 9 - POPULATION DISTRIBUTION (10-50 MILES)

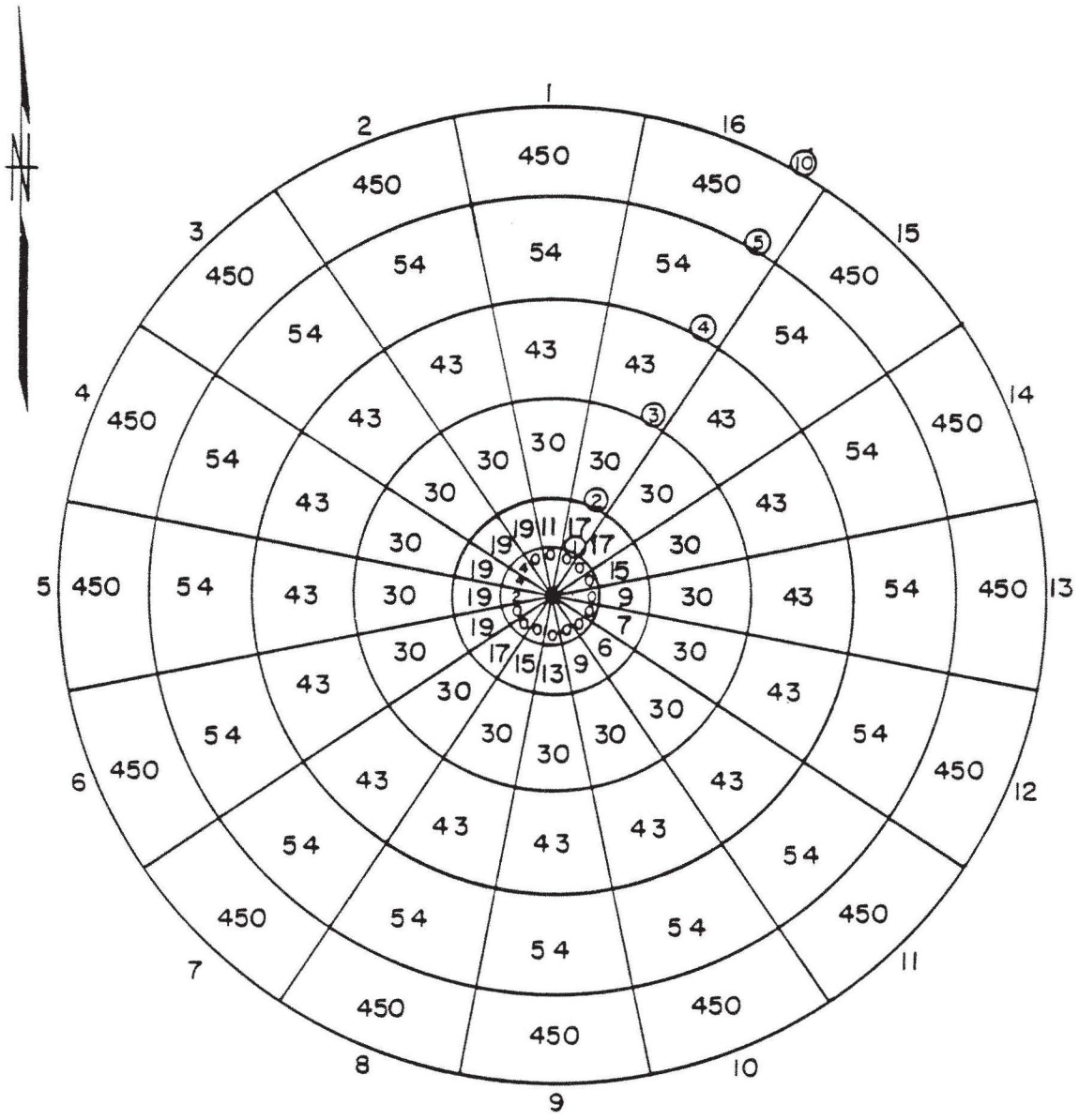

FIG. 10 - DAIRY COWS (0-10 MILES)

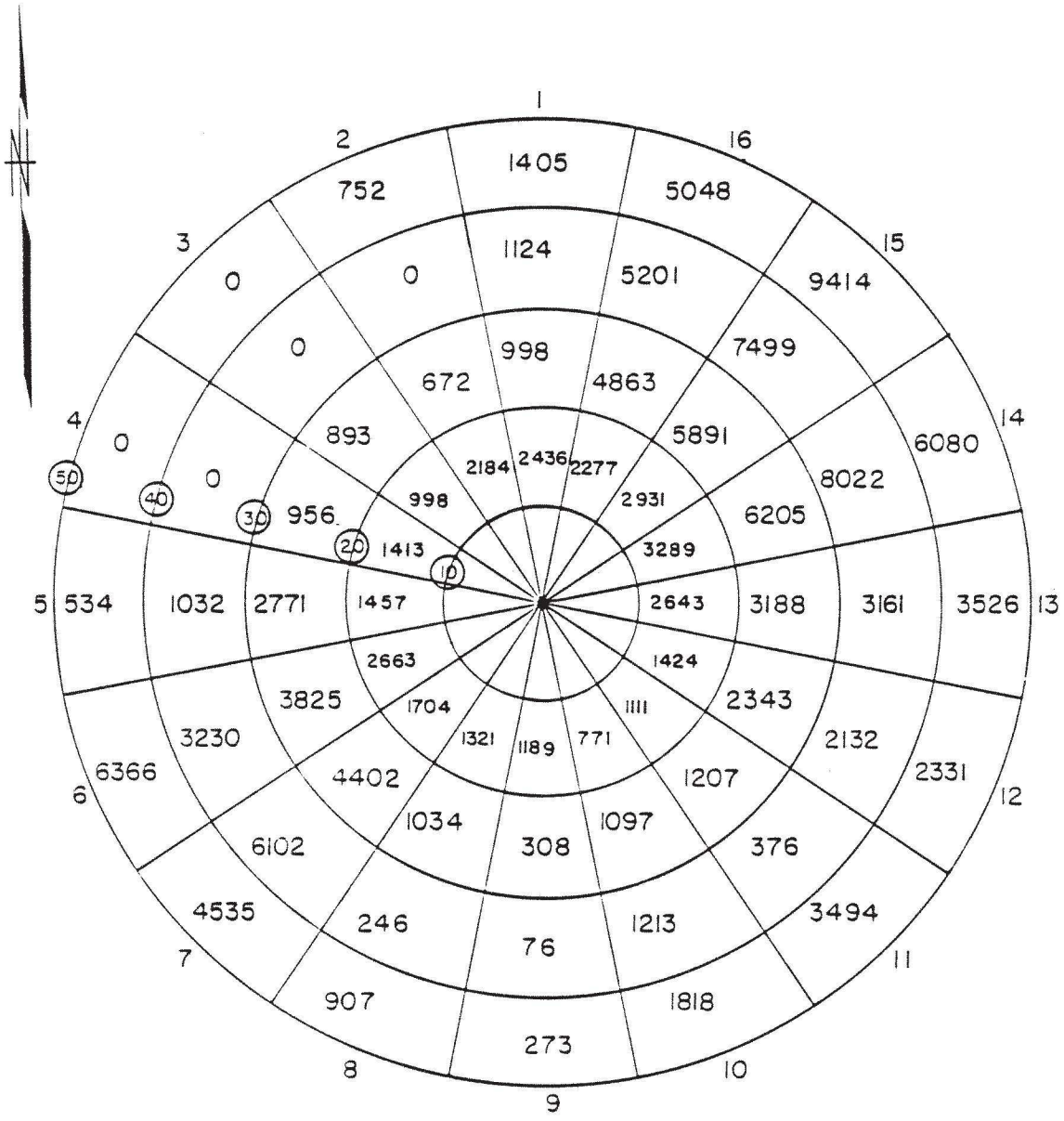

FIG. 11 - DAIRY COWS (10-50 MILES)

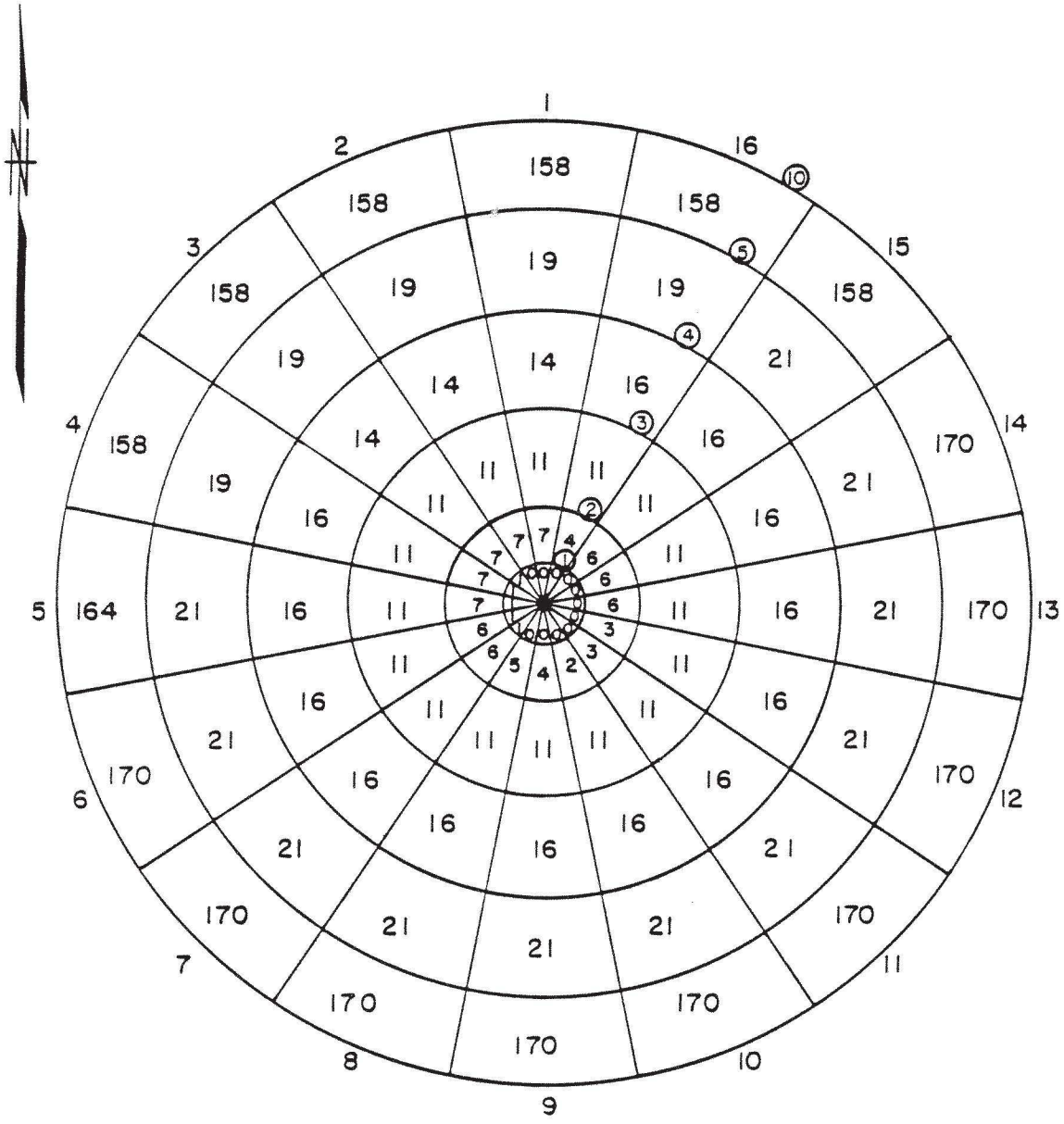

FIG. 12 - MEAT PRODUCING ANIMALS (0-10 MILES)

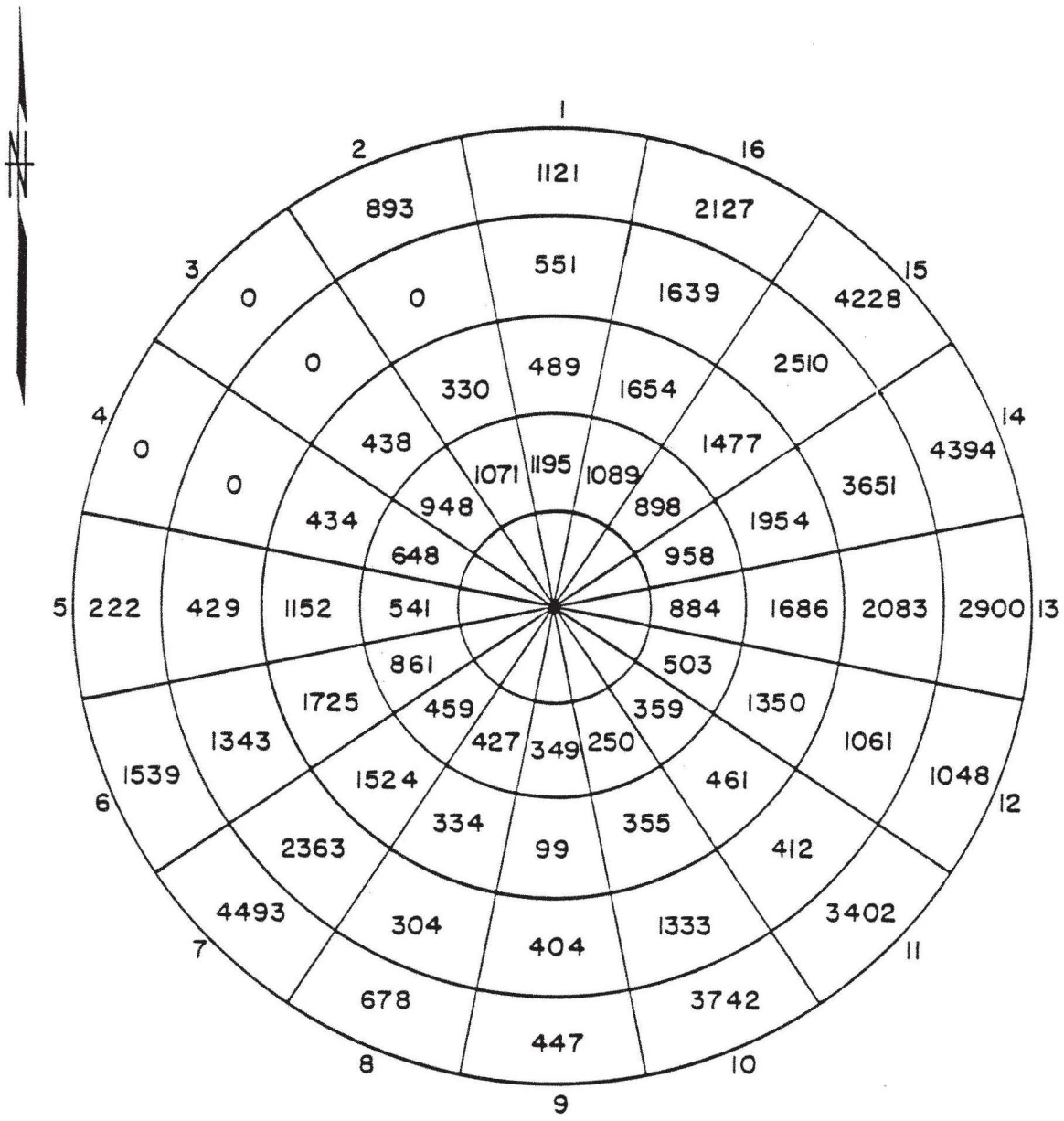

FIG .13- MEAT PRODUCING ANIMALS (10-50 MILES)

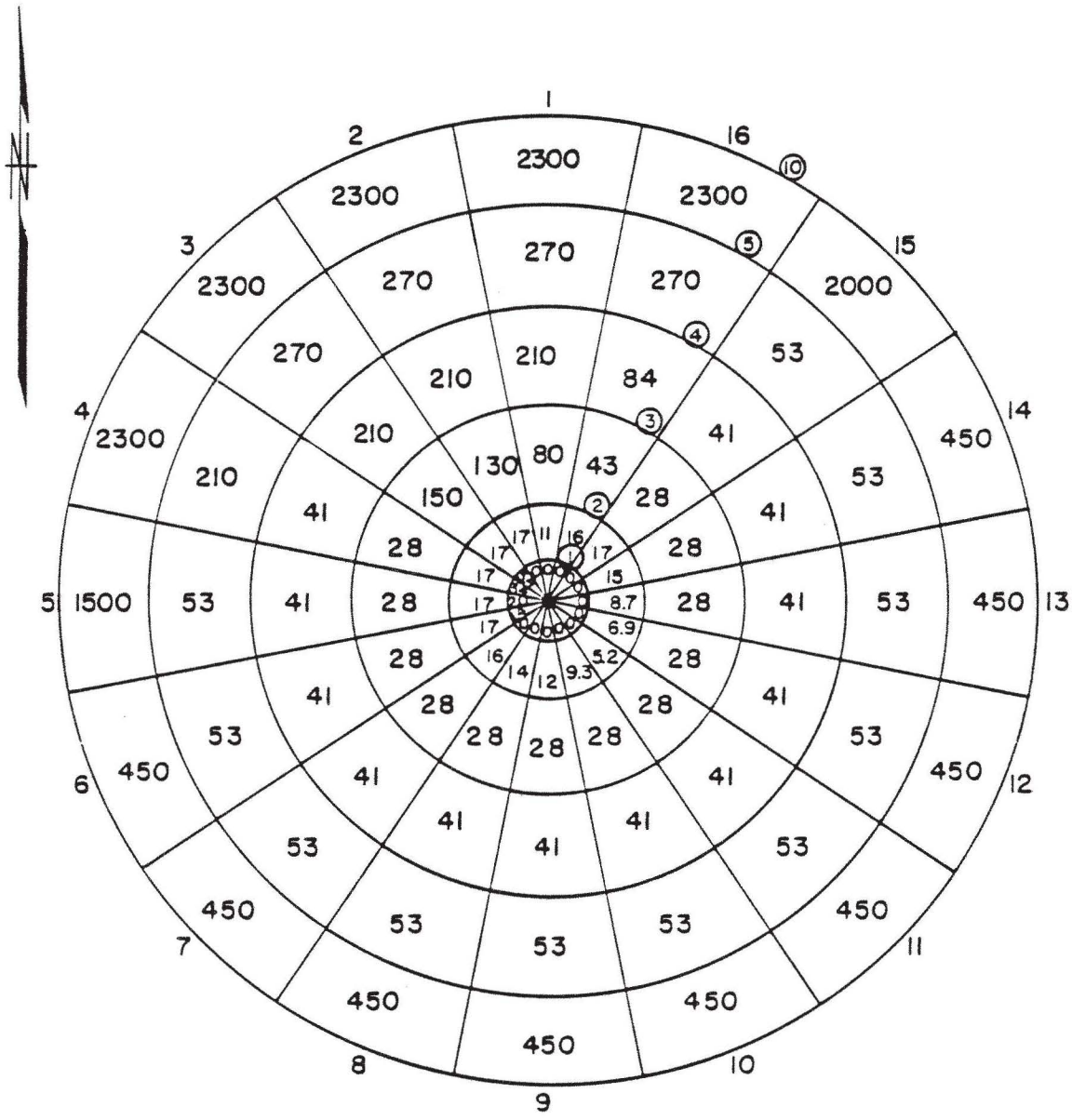

FIG. 14 - AREA USED FOR VEGETABLE CROPS ($Km^2 \times 10^3$) (0-10 MILES)

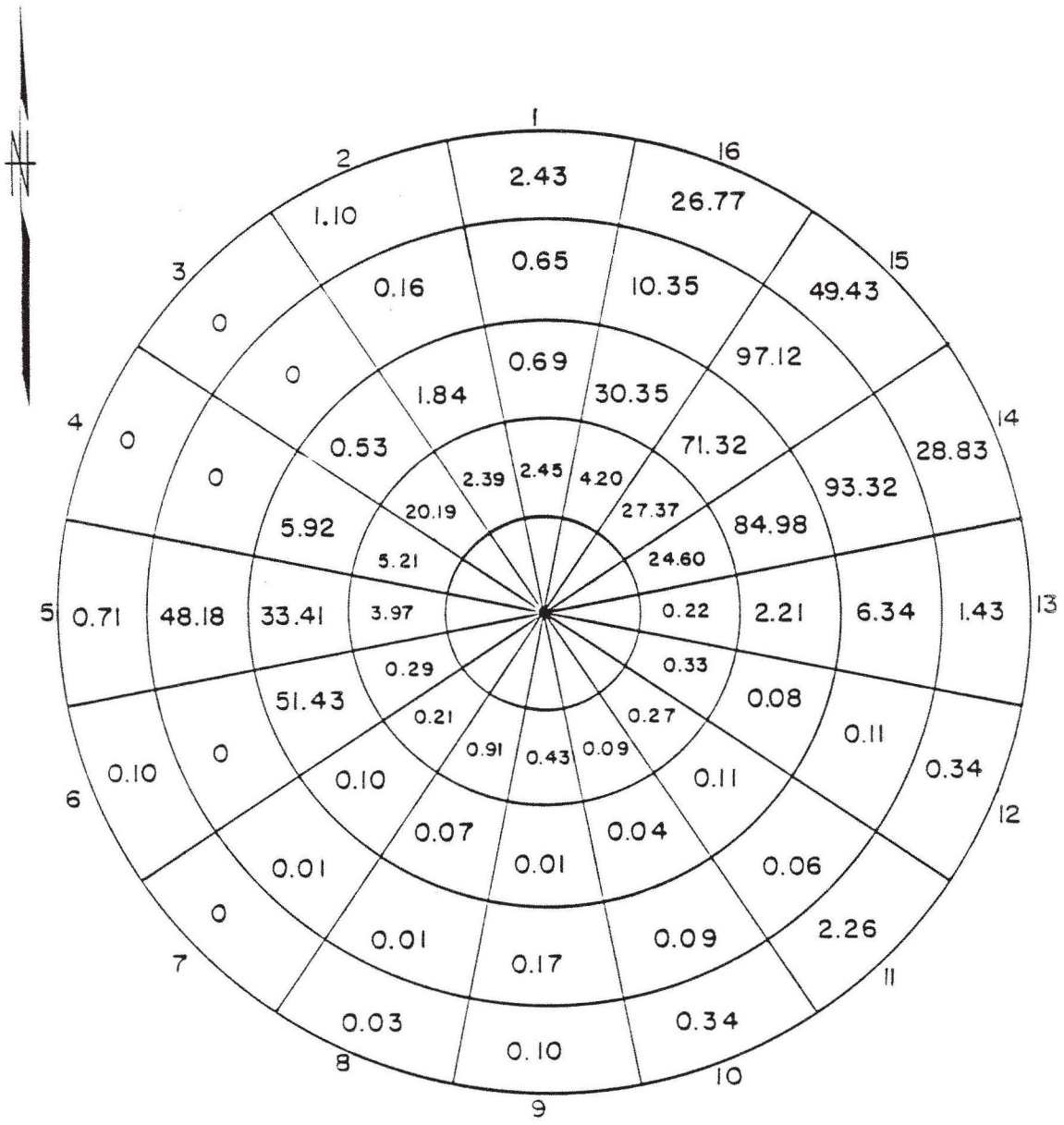

FIG. 15 - AREA USED FOR VEGETABLE CROPS (Km^2) (10-50 MILES)

In this report, the effective dose equivalent, as well as the dose equivalent to the thyroid, lungs, bone, liver, kidneys and gastrointestinal tract were considered to determine the critical organs for various potential pathways of exposure. These estimates were based on parameters applicable to an average adult. The collective population dose estimate in man-rem is the effective dose equivalent to the whole body as calculated in accord with the recommendation of the ICRP (Reference 8).

In addition to these estimates of dose commitments based on dispersion modeling, the dose to a hypothetical maximally exposed individual who consumed locally produced milk, fish and venison (deer) was predicted. Measured radionuclide concentrations from samples of milk, fish and venison were used in these calculations. Many of the nuclides which may be present in these samples are often below the detectable limit. In such cases, the radionuclide concentration was assumed to be the limit of detection.

4.2 Source Term Estimates

4.2.1 Airborne Radioactive Effluents

There are three points on the plant site from which ventilation systems release low levels of airborne radioactivity. These three locations are:

(1) Main plant process stack
(2) Laundry exhaust vent
(3) LLWT ventilation exhaust.

The air released from these vents is sampled continuously and the collected particulates are periodically analyzed. The results of measurements during 1983 are summarized in Table 8. A total of 1.2×10^{-5} Ci of gross alpha activity and 7.5×10^{-4} Ci of gross beta/gamma was released from these three vents during the year. More than 99 percent of the activity was discharged through the main plant stack.

4.2.2 Liquid Radioactive Effluents

There were three sources of liquid effluents from WVDP operations in 1983:

(1) Lagoon No. 3 discharges (in May and November)
(2) Sewage treatment outfall
(3) Ground water releases from the swamp drain and french drain.

The volumes of the liquid effluents and the radioactivity they contained (reported in WVDP 1983 Effluent and On-Site Discharge Report, March 30, 1984) are summarized in Table 9. All liquids were discharged via Buttermilk Creek.

4.3 Potential Radiation Doses to the Public

4.3.1 Maximum Hypothetical Individual Radiation Exposure

The point of maximum potential radiation exposure at the site boundary from airborne radioactivity is located about 1 km WNW of the WVDP plant. A hypothetical maximum effective dose equivalent of 0.09 mrem was estimated to result from WVDP airborne releases during 1983 at this location when all possible pathways were considered. The calculated dose commitment to bone surface (the critical organ) at this location was 0.31 mrem. These maximum hypothetical exposures are about 0.02 percent of the allowable standard promulgated in DOE Order 5480.1.

TABLE 8

RADIOACTIVITY RELEASED TO THE ATMOSPHERE DURING 1983

Release Point	Total Curies Released			
	Gross α	Gross β	Specific Nuclides	
Main Plant Stack	1.2-05	7.4-04	Sr-90	1.3-04
			Ru-106	2.2-05
			I-129	3.4-05
			Cs-134	4.5-06
			Cs-137	8.6-04
Laundry Vent	8.7-08	2.4-06	None Identified	
LLWT Vent	1.4-07	4.1-06	None Identified	

TABLE 9

RADIOACTIVITY RELEASED IN LIQUID

EFFLUENTS DURING 1983

Release Point	Volume Released (Liters)	Released Radioactivity (Ci)					
		Gross α	Gross β	H-3	Sr-90	I-129	Cs-137
Lagoon 3*	2.9+07	6.7-04	3.4-02	3.9	2.6-03	1.5-04	2.3-02
Sewage Treatment Outfall	6.1+06	1.0-05	2.4-04	5.1-03	3.8-05	3.6-07	--
Swamp Drain	9.0+07	--	--	3.6-01	--	--	--
French Drain	6.8+06	--	--	2.2-01	--	--	--
TOTAL	1.3+08	6.8-04	3.4-02	4.5	2.7-03	1.5-04	2.3-02

* Lagoon 3 discharge included 2.3+05 liters containing 2.0-03 Ci of Sr-90 and 4.2-01 Ci of H-3 which originated from the New York State operated low-level waste disposal area. These quantities have not been included in the values tabulated above.

An important potential contributor to the dose commitment from radioactivity in the terrestrial food-chain is the atmosphere-pasture-cow-milk pathway. Measurements of radioactivity in the milk produced at the nearest dairy farm 4 kilometers northeast of the WVDP facility indicated that no Sr-90, I-129, Cs-134, or Cs-137 was present in concentrations above the limits of detection. The maximum dose to an individual from ingestion of about 1 liter of this milk per day was estimated by assuming that the nuclides were present in amounts equal to the detection limits. This conservative calculation predicts a dose commitment of 30 mrem to the thyroid and an effective dose equivalent commitment of 1.6 mrem. These calculated maximum potential doses are less than 2 percent of the allowable standards in spite of their extreme conservatism. Further improvement in the detection limit will permit more realistic estimates to be made of the dose commitment due to consumption of milk produced in the vicinity of the WVDP. These more realistic estimates undoubtedly will be substantially lower than the small maximum values quoted above.

Estimates were made of the hypothetical maximum dose commitments to an adult from consumption of 21 kg per year of fish caught in the Cattaraugus Creek. From the measured concentrations of radionuclides in the edible parts of the fish (see Table 5), the maximum organ dose commitment to an individual was estimated to be 3.2 mrem to bone surfaces. The maximum effective dose equivalent commitment to an individual was calculated to be 1.7 mrem from consumption of 21 kg of fish.

The hypothetical dose commitment also was estimated for an individual who consumed 45 kg of venison. The measured radionuclide concentrations (Table 5) in the flesh of a deer taken about a kilometer from the WVDP in the fourth quarter of 1983 was used as the basis for this estimate. The dose commitment was calculated to be 0.37 mrem to the bone surface and 0.21 mrem for an effective

dose equivalent commitment. Table 10 summarizes the potential radiation doses to individual adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the WVDP facility operations during 1983.

4.3.2 Collective Dose to the Population

The collective effective dose equivalent commitment to the population within an 80-km radius of the WVDP from operations during 1983 was estimated to be 0.05 person-rem and 0.03 person-rem from gaseous effluents and liquid effluents, respectively. These estimates are based on the releases summarized in Tables 8 and 9 and the use of the AIRDOS-EPA and LADTAPII codes as described in Section 4.1.

These collective doses may be compared to an estimated 170,000 person-rem to the same population resulting from natural background radiation. The average effective dose equivalent to individuals residing within 80 km of the WVDP was about 4.7×10^{-5} mrem during 1983 (based on the collective dose given above and a total population of 1.7 million in the region), which is insignificant when compared to the average dose to each individual of approximately 100 mrem per year from natural sources.

TABLE 10

SUMMARY OF HYPOTHETICAL ESTIMATED DOSE COMMITMENTS

TO AN ADULT INDIVIDUAL AT LOCATIONS OF MAXIMUM EXPOSURE DURING 1983

		50-Year Dose Commitment (mrem)		
Pathway	Location	Effective Whole Body Equivalent	Critical Organ	
Gaseous Effluents				
All Pathways*	Nearest residence (1 km WNW)	0.09	0.31	Bone Surface
Milk	Produced 4 km NE	<1.6	<30	Thyroid
Venison	Deer taken within 2 km of WVDP	0.21	0.37	Bone Surface
Liquid Effluents				
Fish	Collected in Cattaraugus Creek Below WVDP	1.7	3.2	Bone Surface

* Estimates based on measured radioactivity in airborne effluents (Table 8) and AIRDOS-EPA computer code. All other values based on measured concentrations in food and consumption rates for maximally exposed individuals recommended in U.S. NRC Regulatory Guide 1.109.

Note: Annual average whole body dose from natural background sources in the U.S. is about 100 mrem.

5.0 STANDARDS AND QUALITY ASSURANCE

5.1 Environmental Standards and Regulations

The following environmental standards and regulations are applicable at the WVDP site boundary:

- DOE Order 5480.1, "Requirements for Radiation Protection," August 1981.

- U.S. Federal Radiation Council, Background Material for the Development of Radiation Protection Standard, Report No. 1, (1960) and Report No. 2 (1961), Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

- U.S. Environmental Protection Agency, National Primary and Secondary Ambient Air Quality Standards, 40 CFR 50, 1980.

- Department of Environmental Conservation, State of New York, Environmental Conservation Law of New York State, Title 8, Article 19, October 18, 1972.

The standards and guides for releases of radionuclides at the WVDP are those of DOE Order 5480.1, Chapter XI, dated August 13, 1981, entitled, "Requirements for Radiation Protection." Radiation protection standards and selected radioactivity concentration guides from Chapter XI are listed in Appendix B. The most restrictive guide is listed when there is a difference between soluble and insoluble chemical forms. These listed guides are virtually identical to those in the Code of Federal Regulations (CFR), Title, 10, Part 20. Ambient air and water quality standards contained in the individual SPDES permits issued for the facility are listed in Table 7.

5.2 Quality Assurance

The radiochemical analyses for the environmental samples collected during 1983 were performed by off-site laboratories. A documented laboratory quality assurance plan is used for these laboratories, including periodic interlaboratory cross-checks, prepared standard and blank analyses, routine instrument calibration, and use of documented procedures. Sample collection and radiometric counting at the site laboratory was in accordance with written procedures, including the use of appropriate calibration techniques, where applicable.

Non-radiological analyses are also performed by a qualified contract laboratory. WVNS subscribes to the SPDES cross-check program sponsored by the U.S. Environmental Protection Agency to assure the continuing accuracy of permitted laboratory results.

5.3 Statistical Reporting of Data

Individual analytical results are reported, except where noted, with plus or minus (±) two analytical standard deviations (2 σ) indicating the counting uncertainty. The arithmetic averages were calculated using actual results, including zero and negative values. In the final results, if the 95 percent confidence interval included zero, the measurement was assumed to indicate no discernible activity. Less than (<) values indicate the lower limit of detection for that analysis.

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5. "AIRDOSEPA: A Computerized Methodology for Estimating Environmental Concentrations and Dose to Man from Airborne Releases of Radionuclides," R. E. Moore, et al, ORNL-5532, June 1979.

6. "LADTAPII: A Computer Program for Calculating Radiation Exposure to Man from Routine Release of Nuclear Reactor Liquid Effluents," D. B. Simpson and B. L. McGill, Technical Data Management Center ORNL/NUREG/TDMC-1.

7. "Long Term Management of Liquid High-Level Radioactive Wastes Stored at the Western New York Nuclear Services Center, West Valley," DOE/EIS-0081, June 1982.

8. ICRP Publication 26. "Recommendations of the International Commission on Radiological Protection," Annals of the ICRP, Vol. 1, No. 3, 1977.

9. "Estimates of Internal Dose Equivalent from Inhalation and Ingestion of Selected Radionuclides," Donald E. Dunning, WIPP-DOE-176, undated.

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APPENDIX A

Effluent, On-Site and Off-Site Radiological Monitoring Program

1984 Implementation

EFFLUENT AND ON-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Monitoring Point	Reason for Monitoring	Sampling Type	Sampling Frequency	Analyses
Airborne				
1 Process Stack	Release point for airborne radioactive waste	Off-line air particulate monitor	Continuous collection, with daily filter tape advance (use to be discontinued during 1984)	Real time gross alpha and beta
		Off-line air particulate monitor[a]	Continuous collection on fixed filter	Real time alpha and beta monitoring
		Off-line air particulate and iodine sampler[a]	Weekly collection of filter paper and charcoal absorber	On collection: filters analyzed for gross alpha/beta Quarterly composites: filters analyzed for Sr-90, Ru-106, Cs-134/137. Charcoal analyzed for I-129
Liquid				
001 Lagoon 3 Weir	Primary point of liquid effluent release	Grab	Daily, during Lagoon 3 discharge	Daily: Gross beta; pH. Every sixth daily sample: gross alpha, gross beta, H-3, Cs-134/137

[a]Isokinetic sampling with probe placed at the 80-foot level within the stack.

EFFLUENT AND ON-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Monitoring Point	Reason for Monitoring	Sampling Type	Sampling Frequency	Analyses
001 Lagoon 3 Weir (continued)				Weighted monthly composite of daily samples: See SPDES 001; gross alpha/beta, H-3, Sr-90, I-129, isotopic gamma Quarterly weighted composite of daily samples: U isotopic, Pu isotopic
2 Drainage Ditch	Swamp drainage	Grab	Weekly	H-3
		Grab	Monthly*	Gross alpha, beta, and H-3
75 French Drain	Drains subsurface water from LLWT lagoon area	Grab	Weekly	H-3
		Grab	Monthly	Gross alpha, beta, and H-3
67 Stream E of Waste Burial	Drains NYS disposal area	Grab	Monthly*	Gross alpha, beta, and H-3
53 Erdman Brook	Drains NYS and NRC disposal areas	Grab	Weekly*	Gross alpha, beta, and H-3
3 Hull Burial Ditch	Drains NRC disposal area	Grab	Weekly	Gross beta and H-3

*Samples to be split (shared with NYSDOH).

EFFLUENT AND ON-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Monitoring Point	Reason for Monitoring	Sampling Type	Sampling Frequency	Analyses
73 Cooling Water Pipe	Discharges sand filter backwash	Grab	Monthly	Gross beta
73 Condensate Pipe	Discharges drainage from utility ditch[b]	Grab	Monthly	Gross beta
005 Condensate and Cooling Water Ditch	Combined drainage from pipes and settling ponds	Grab	Monthly	Gross beta
4 Settling Basin Outfall	Drains settling basins that receive discharge from demineralizer backwash	Grab	Monthly	Gross alpha, beta, and H-3
006 Erdman Brook at security fence	Combined facility discharge	Continuous proportional sample	Monthly* (Composite of biweekly collections)	Gross alpha, beta, H-3, and chemical species; quarterly composite: gamma isotopic, Sr-90
72 Sanitary Waste (004) Discharge	Liquid effluent point	Grab	Weekly	On collection: gross beta Monthly composite: gross alpha, beta, H-3, and Sr-90

[b]Utility ditch drains steam condensate from traps along the south side of the utility room.
*Samples to be split (shared with NYSDOH).

EFFLUENT AND ON-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Monitoring Point	Reason for Monitoring	Sampling Type	Sampling Frequency	Analyses
003 Burial Site Lagoon	See SPDES 003			
5 Interceptors	Untreated liquid to LLWT plant input lagoon	Grab	Once per transfer	Quarterly composite: gross alpha, beta, H-3, and Sr-90
On-Site Wells		Grab	Semiannual	H-3, gross alpha, beta
NFS wells B, D, G, H, L-2, M-5, J-2, J-5, J-8, USGS wells 80-2, 80-3, 80-4, 80-5, 80-6, 80-7, 82-1, 82-2, 82-3, 82-4, 82-5				

OFF-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Media	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
Direct Radiation (TLD)*	(16) at each of 16 previous NFS locations	Quarterly	Quarterly gamma dose
	(2) at corners of NYS LLW disposal area		
	(1) at 1500 m NW of plant		
	(1) at "5 points" landfill (background)		
	(1) at Great Valley (to be added during 1984)		
Surface water	(1) Cattaraugus Creek at Felton Bridge location	Continuous sampler operation with weekly collection	Weekly for gross alpha, beta, and H-3; monthly composite for gamma isotopic and Sr-90
	(1) Cattaraugus Creek upstream of Buttermilk Creek confluence at Bigelow Bridge	Monthly grab	Gross alpha, beta, and H-3 on collection

*Samples to be split (shared with NYSDOH).

OFF-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Media	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
Surface water (continued)	(2) Buttermilk Creek, just upstream of Cattaraugus Creek confluence at Thomas Corners Road; control location near Fox Valley Road	Continuously operating time composite sampler, with monthly collection	Monthly for gross alpha, gross beta, and H-3 analyses. Quarterly for gamma isotopic and Sr-90 analyses
Air	1500 m NW near Preston residence	Continuous sampler operation with weekly collection of filter sample	Weekly (i.e., each filter) for gross alpha and gross beta activity
	(1) Background station 25 km SSW of the site (Great Valley)		
	(3) At the original NFS monitor locations		
Soil	(7) One at each proposed air particulate monitoring station	Once every three years*	At collection, for gamma isotopic, Sr-90, and Pu analyses

*Samples to be split (shared with NYSDOH).

OFF-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Media	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
Soil (continued)	(3) One at each of the NFS air particulate stations		
Stream Sediments	(2) Upstream control locations, one on Cattaraugus Creek (near Bigelow Bridge) and one on Buttermilk Creek (near Fox Valley Road)*	Semiannually	Isotopic gamma and Sr-90
	(1) Buttermilk Creek, near Thomas Corners Road		
	(1) Cattaraugus Creek, near Felton Bridge		
	(1) Behind Springville dam impoundment*		
Fish	(1) Cattaraugus Creek, downstream of the Buttermilk Creek confluence	Semiannually*	Isotopic gamma and Sr-90 in edible portions
	(1) Control sample from nearby stream not affected by the WVNS		

*Samples to be split (shared with NYSDOH).

OFF-SITE RADIOLOGICAL MONITORING PROGRAM
1984 IMPLEMENTATION

Media	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
Milk	(1) Reed farm, outside site boundary due north of the plant	Monthly	Gamma isotopic, Sr-90, and I-129 analyses on quarterly composites
	(1) Control location (sample to be provided by NYSDOH)		
Fruit and Vegetables	(3) Nearby downwind location	Annually, at harvest	Gamma isotopic and Sr-90 analyses of edible portions
	(3) Remote locations		
Meat-Beef	(1) Beef animal from nearby farm in downwind direction	Semiannually*	Gamma isotopic analysis of meat
	(1) Beef animal from control location west of site		
Meat-Deer	(1) In vicinity of the site	Annually, during hunting season*	Gamma isotopic analysis of meat
	(1) Control animal	During year as available*	

*Samples to be split (shared with NYSDOH).

APPENDIX B

Standards and Concentration Guides

DOE Order 5480.1, Chapter XI

STANDARDS AND CONCENTRATION GUIDES
(DOE Order 5480.1, Chapter XI)

Radiation Protection Standards
Annual Whole-Body Dose Equivalent (mrem/year)

Individuals at Points of Maximum Probable Exposure	500
Suitable Sample of the Exposed Population	170

Concentration Guides for Effluent Releases to Uncontrolled Areas (μCi/ml)

Radionuclide	In Air	In Water
Gross alpha[a]	2×10^{-14}	3×10^{-8}
Gross beta	1×10^{-12}	3×10^{-8}
Am-241	2×10^{-13}	4×10^{-6}
Sb-125	9×10^{-10}	1×10^{-4}
Ar-41	4×10^{-8}	--
Ba-140	1×10^{-9}	2×10^{-5}
Cs-134	4×10^{-10}	9×10^{-6}
Cs-137	5×10^{-10}	2×10^{-5}
H-3	2×10^{-7}	3×10^{-3}
I-129	2×10^{-11}	6×10^{-8}
I-131	1×10^{-10}	3×10^{-7}
Kr-85	3×10^{-7}	--
Kr-85m	1×10^{-7}	--
Kr-87	2×10^{-8}	--
Kr-88	2×10^{-8}	--
Pu-238	7×10^{-14}	5×10^{-6}
Pu-239	6×10^{-14}	5×10^{-6}
Pu-240	6×10^{-14}	5×10^{-6}
Ru-106	2×10^{-10}	1×10^{-5}
Sr-90	3×10^{-11}	3×10^{-7}
Xe-133	3×10^{-7}	--
Xe-135	1×10^{-7}	--
Xe-138	3×10^{-8}	--

[a]Based on the most restrictive beta emitter (Ra-228)